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Review study of Ecodesign and Energy Labelling for Cooking appliances

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Correction Table 82
Editorial corrections Tables 114 and 115
Correction Figure 350
Clarification added in Section 7.8.3.7

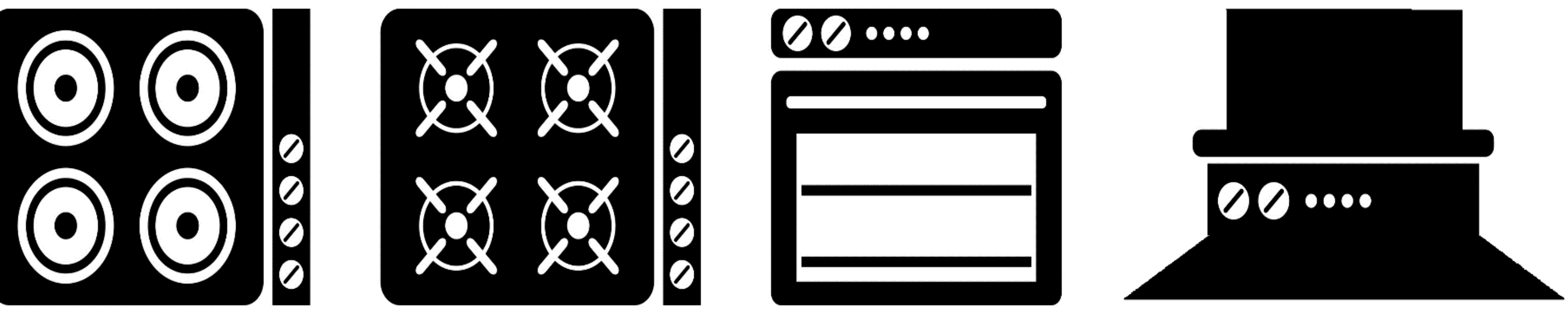

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Table of Acronyms

AC – Alternating Current
ACD – Acidification
AEC – Annual Energy Consumption
APPLIA -
ASTM – American Society for Testing and Materials
BAT – Best Available Technology
BAU – Business as Usual
BC – Base Case
BEP – Best Efficiency Point
BM – Brick Method
BNAT - Best Not Available Technology
CE – Circular Economy
CE – Conformité Europèene
CFL – Compact Fluorescent Light
CLP – Classification, labelling and Packaging
CO – Carbon monoxide
CUT – Cookware Under Test
DG – Directorate Generale
DO – Design Option
DOE – Department of Energy
EC – European Commission
ECD – Environmental conscious design
ECHA – European Chemical Agency
ED – Ecodesign
EE – Energy Efficiency
EEE – Electrical and Electronic Equipment
EEI – Energy Efficiency Index
EF – Energy factor
EL – Energy labelling
EMC – Electromagnetic compatibility
EN - European Norm
EOL – End of Life
EPA – Environmental Protection Agency
EPCA – Energy Policy and Conservation Act
EPS – Expanded Polystyrene
EU – European Union
EUR – Euro
FDE – Fluid Dynamic Efficiency
GFE – Grease Filtering Efficiency
GHG – Greenhouse Gas Emission
GOST - Gosudarstvennyy Standart
GPP – Green Public Procurement
HDPE – High Density polyethylene
HM – Heavy Metals
ICT – Information and Communication Technology
IEC - International Electrotechnical Commission
ISO - International Standardization for Organisation
JRC – Joint Research Center
LCA – Life Cycle Assessment
LCC – Life Cycle Cost
LDPE – Low Density Polyethylene
LED – Light Emitting Diode
LLCC – Least Life Cycle Cost
LPG – Liquified Petroleum Gas

LVD – Low Voltage Directive
MADE – Manufacture, assembly, disassembly and end of life
MAX – Maximum
ME – Material Efficiency
MEErP - Methodology for Ecodesign of Energy-related Products
MEK – Methyl ethyl ketone
MEPS – Minimum Efficiency Performance Standards
MIN – Minimum
MW - Microwave
NRVU – Non-residential ventilation unit
NTP – Non-thermal Plasma
OE – Operating Expense
OEM – Original Equipment Manufacturer
PAH – Polycyclic Aromatic Hydrocarbons
PBB – Polybrominated biphenyls
PBDE – Polybrominated diphenyl ethers
PCBA – Printed Circuit Board Assembly
PEF – Primary Energy Factor
PET – Polyethylene terephthalate
PM – Particulate Matter
PM – Permanent magnet
POP – Persistent Organic Pollutants
PP – Purchase Price
PV - Photovoltaic
PVC – Polyvinyl chloride
PVC – Polyvinyl Chloride
PWF – Present Worth Factor
REACH – Registration, evaluation, authorisation and restriction of chemicals
REG - Regulation
RFID – Radio Frequency Identification
RRR – Recyclability, recoverability, reusability
RVU – Residential ventilation unit
SAEC – Standard Annual Energy Consumption
SEC – Specific Energy Consumption/Standard Energy Consumption
SMR – Steam Methane Reforming
SVHC – Substance of very high concern
TFT – Thin Film Transistor
TWG – Technical working group
UN-GHS – Globally Harmonised system
USA – United States of America
USB – Universal Serial Bus
VOC – Volatile Organic Compounds
VSD – Variable speed drive
VU – Ventilation unit
WEEE – Waste of Electrical and Electronic Equipment
WG – Working Group
WHO – World Health Organization

Introduction

Background

In 2016, households in the European Union (EU) accounted for a quarter of the total final energy consumption, and from this the energy used for the main cooking appliances represented 5.4% in 2016 and 5.6% in 2017[1].

The Directive 2009/125/EC on Ecodesign established a framework for EU Ecodesign requirements for energy-related products with a significant potential for reduction for energy consumption. The implementation of such requirements would contribute to reach the target of saving 32.5% of primary energy by 2030 as identified in the Commission's Communications on Energy 2030 and on the Directive 2018/2002 on energy efficiency. Ecodesign measures may be reinforced also trough the Regulation 2017/1369/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

The European Commission has launched the revision of the eco-design and energy-/resource label implementing measures for the product group "domestic ovens, hobs and range hoods". The revision study is coordinated by the European Commission's Directorate General (DG) Energy and is undertaken by the European Commission's DG Joint Research Center (JRC).

The methodology of the revision follows the Commission's Methodology for the Evaluation of Energy related Products (MEErP) (COWI and VHK 2011), consisting of the following steps:

- Task 1: Scope definition, standard methods and legislation
- Task 2: Market analysis
- Task 3: Analysis of user behaviour and system aspects
- Task 4: Analysis of technologies
- Task 5: Environmental and economic assessment of base cases
- Task 6: Assessment of design options
- Task 7: Assessment of policy scenarios

The comprehensive analysis of the product group following the steps above will feed as research evidence basis into the revision of existing Energy Label Regulation (EC) 65/2014 on domestic ovens and range hoods (European Commission 2010) and the Ecodesign Regulation (EC) 66/2014 on domestic ovens, hobs and range hoods (European Commission 2009).

The research is based on available scientific information and data, uses a life-cycle thinking approach, and is engaging stakeholder experts in order to discuss on key issues and to develop wide consensus.

A set of information of interest has been collected. Starting from the initial preparatory studies (so-called "ENER Lot 22" and "ENER Lot 23") prepared in 2011 and the resulting Regulations listed above on energy label and eco-design for domestic ovens, hobs and range hoods. Against this background, information is being revised, updated and integrated to reflect the current state of play, following the MEErP methodology.

As final result, the JRC produces an updated review study including a comprehensive techno-economic and environmental assessment for this product group. This will provide policy makers with an evidence basis for assessing whether and how to revise the existing regulations.

A Technical Working Group (TWG) has been created to support JRC along the study. This TWG is composed of experts from Member States, industry, NGOs and academia who have voluntarily requested to be registered as stakeholders of the study through the project website.

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[1] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20180322-1

The TWG is contributing to the study data, information and written feedback to questionnaires and working documents. Interaction with stakeholders, has also taken through meetings organized by JRC. The contribution of stakeholders has been integrated in this report and is indicated as such.

Objectives and structure of this report

The review study on domestic ovens, hobs and range hoods builds on existing knowledge as far as possible. However, additional and complementary investigation is required to achieve the goals of the study. With this respect, the objective of this report is to:

- summarise the background information so far gathered for domestic ovens, hobs and range hoods
- identify areas which need to be revised, updated and integrated to reflect the current state of play and to align with the MEErP methodology.

This document is structured in the following chapters, following Task 1 to 7 of MEErP

- Chapter 1: Scope definition, standard methods and legislation
- Chapter 2: Market analysis
- Chapter 3: Analysis of user behaviour and system aspects
- Chapter 4: Analysis of technologies
- Chapter 5: Environmental and economic assessment of base cases
- Chapter 6: Assessment of design options
- Chapter 7: Assessment of policy scenarios

1 Task 1: Scope, legislation and standardisation

1.1 Product scope and definitions

1.1.1 Technical description of domestic cooking appliances

The following section provides a technical description of domestic ovens, hobs and range hoods.

1.1.1.1 Domestic ovens

An oven is an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared (Regulation 65/2014). In a general way, the main components of domestic ovens are:

- Cavity, where the food is located for cooking.
- Chassis, the structure that supports the cavity and the rest of the oven assemblies
- Door, which enables access to the cavity
- Heating elements, which will differ depending on heat source
- Thermostat, used to control the temperature in the cavity
- Fans, used to distribute heat evenly in convection oven
- Fans, used to cool the system
- Cables/pipes, which transfer energy from heat source to electrical resistance or heating element.

Depending on the characteristics of the main components, domestic ovens can be classified in multiple ways. In Table 1, a classification is provided considering four different criteria: heat source, cooking mode, number of cavities and mounting.

Table 1. Types of ovens

Heat Source	Cooking mode	Number of cavities	Mounting
Gas	Conventional	Single	Free-standing
Electricity	Fan-forced	Multiple	Built-in
	Steam		Portable
	Microwave		

Considering heat source**,** domestic ovens can be powered either by gas or electricity. In principle, the main components of a gas or an electric oven (cavity, chassis, door, fans) are essentially the same, the only differences being in the way the heat is generated and the fuel transported through the appliance. Gas ovens generate heat via gas-fuelled burners, and therefore will need special pipes to transport it, outlet for expulsion of fumes and gas-related control/safety systems. Electric ovens generate heat by using an electric resistance, so they will need cables to transport electricity (Landi, 2019).

Considering cooking modes, domestic ovens can be classified, for instance, as conventional, fan-forced, steam, or microwave. Other cooking modes offered in domestic ovens are grill and roasting. Ovens can also offer a combination of these cooking modes.

In conventional cooking mode, a stationary heat source radiates heat in the oven and therefore uses only natural convection for the circulation of heated air inside the cavity. The heat source is generally (but not necessarily) at the bottom of the oven, although in some models additional burners can be found at the top and at the back of the cavity. This heating modes is sometimes referred to as “static” or “top/bottom”.

In fan-forced cooking mode, a built-in fan circulates heated air inside the cabin, distributing it evenly throughout the cavity. They can run at slightly lower temperatures as they do not need to be as hot to heat up the inside of the oven. Ovens with fan-forced mode will need a motor to operate the fan, increasing slightly the complexity of the appliance.

A steam oven operates by leading steam, which is produced by injecting water in a steam generator, into the cavity, or directly generating steam inside the cooking cavity by evaporating water by means of one or more heating elements. The steam heats up the cavity of the oven, creating a very moist cooking environment within the device.

A microwave oven heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range, inducing polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating. The cavity of the ovens is the enclosed compartment in which the temperature can be controlled for preparation of food.

In terms of number of cavities, the most common configuration is single-cavity oven, although multiple-cavity ovens (those with two or more cavities) can also be found.

Considering mounting configuration, ovens can be classified as built-in or free-standing (Figure 1). Free-standing ovens can be either installed separated from cabinets or by sliding them into an open space into the kitchen cabinetry. These appliances can also be known as cookers, since they include both an oven and a hob.

Free-standing (electric)

Free-standing (gas)

Built-in

Portable

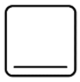
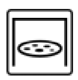
Figure 1. Types of ovens based on mounting (APPLIA)

Built-in ovens are installed at a comfortable height in the wall, embedded between other kitchen cabinets or appliances.

Ovens can also be classified in terms of their size. According to Regulation 65/2014, a portable oven is one with a product mass of less than 18 kilograms.

Ovens usually offer a wide variety of heating modes or settings in which they can be operated. Some of these settings are common to the majority of ovens in the market today, whereas others are more specialized and can only be found on a few models. The names of these settings are usually marketing driven and may not necessarily be common around the industry. Although not universal, symbols used to represent each of those settings tend to be similar and recognisable. The most common oven settings, their symbols and a brief description can be seen in Table 2.

Table 2. Typical oven heating modes

Symbol	Mode	Description
	Conventional – bottom heating only	Heat will come solely from the heating element at the bottom of the oven. The fan won't be used to circulate the heat.
	Conventional – Top and bottom heating	Heat will be generated by elements in the top and bottom of the oven. Heat spreads through the oven by natural convection.
	Fan-forced heating	Heat comes from a circular element surrounding the fan at the back of the oven and the fan then circulates this heat around.
	Fan-forced with lower heating	Heat produced at the base and will be wafted around by the fan. In some occasions, heat can also be produced from the top (in that case, the symbol would include an additional horizontal line on top)
	Full grill	Heat is produced by the whole grill element.
	Part grill	Only one section of the grill element gets hot
	Grill and fan	Grill and fan are alternating. The fan spreads the grill's heat
	Defrost	Fan is on but no heat is produced, so no cooking takes place. The moving air defrosts food much more quickly than simply leaving it on the kitchen table
	Plate warming	Plate-warming function. This gently warms plates or other dishes to prevent food from cooling too quickly when served.
	Pyrolytic cleaning	This program heats up the oven to around 500°C, which has the effect of incinerating burnt-on cooking grime
	Eco	This is generally understood as the most energy-efficient mode of the oven. They are also commonly known as energy saving modes and generally use residual heat. In some occasions, it is a function for cooking small quantities of food, activating only a limited amount of the heating elements.
	Pizza	This is a heating mode of the oven specifically designed to cook pizza
	Microwave	A heating mode where microwaves are used in the cooking cycle in order to speed-up the process and save energy

	Steam-assisted	A heating mode where steam is added to the cooking cycle in order to add specific characteristics to the food related to steam-cooking
	Automatic functions	Some appliances have pre-programmed setting values that the consumer can use, in order to use the most appropriate temperature and time, according to the type of food being cooked.

The definition of the most common oven heating modes is relevant at this point because they are directly related to certain aspects of current standards and legislation. For instance, current standard for energy consumption of gas ovens (EN 15181) requires that the standard load is heated in “conventional” and “forced-air” heating functions. In a similar way, current standard for energy consumption of electric ovens (EN 60350-1) requires that the standard load is heated in those two methods and in hot steam mode (if the appliance has it).

Current Ecodesign (REG 66/2014) and energy labelling regulation (REG 65/2014) is also related to heating modes. In both of them, it is established that energy consumption of a cavity oven shall be measured and declared in a conventional and fan-forced mode. Then, “energy consumption per cycle corresponding to the best performing mode shall be used in the calculations” for determining the energy class. This freedom of choice for manufacturers has been highlighted by some stakeholders as an aspect to improve in future revisions of current regulation. This aspect will be covered in more detail in subsequent sections of this report.

1.1.1.2 Domestic hobs

A hob is a domestic appliance used for heating food. It generally works as a primary heat source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heating source, transferring heat to the food within it. In the definitions section of Regulation 65/2014, European Commission differentiates between electric hobs, gas hobs and mixed hobs.

- Electric hob. Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity
- Gas hob. Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners of a minimum power of 1.16 kW.
- Mixed hob. Appliance with one or more electrically heated cooking zones/areas and one or more cooking zones heated by gas burners.

Depending on the characteristics of the main components, domestic hobs can be classified in different ways. In **Table 3**, a classification is provided considering three criteria: heat source, heating element, and mounting.

Table 3. Types of hobs

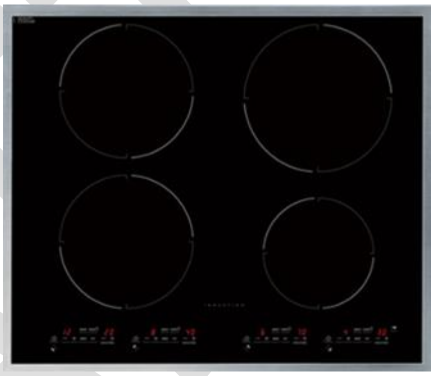
Heat Source	Heating element	Mounting
Gas	Burners (gas)	Built-in
Electricity	Solid plate (electric)	Integrated in a cooker
	Radiant (electric)	Portable or table top
	Induction (electric)	

Considering heat source, domestic hobs can be powered either by gas or electricity. Gas hobs imply the use of burners that, after being ignited, maintain a flame that transfer heat to a cooking vessel. Although they can differ in size, configuration and ignition type, gas burners are relatively similar between them. On the other hand, there are more differences between electric powered hobs, depending on the heating element they use (Figure 2).

Gas

Solid plate

Radiant



Induction

Figure 2. **Different types of hobs according their heating element (APPLIA)**

In terms of heating element, electric hobs can be classified in three different types:

- **Solid plate** hobs contain a sealed electric resistance, through which circulates electrical current, transferring heat to the cooking vessel on top of it.

- **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by infrared radiation via a glass-ceramic surface

- **Induction hobs** are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food.

1.1.1.3 Domestic range hoods

A range hood can be defined as an appliance installed near the hob in the kitchen which uses a mechanical fan to collect steam, smoke, fumes and extract other airborne particles that may be generated while cooking. The extraction system consists of a centrifugal blower composed on an impeller coupled to an electric motor, both housed inside a scroll. The energy is provided to the exhausts to expel the fumes. The system can work in multiple conditions of airflow rate, velocity and pressure (Bevilacqua, 2010). Generally, range hoods are manufactured with a combination of stainless steel, copper, bronze, nickel, zinc, tempered glass, aluminium, brass and heat resistant plastics. The main components of a range hood are:

- Capture panel and effluent plume, which are the elements that direct the thermal plume coming out of the cooking area towards the filter and ducting
- Filters, which are the elements of the range hood that capture the impurities when the cooking appliance is in operation
- Fans, which provide an active pressure gradient for ventilation
- Lighting, which provide illumination onto the cooking area

Due to their predominantly visible location in kitchens, range hoods are increasingly seen not only as an appliance, but more as a piece of furniture. This is the main reason why a market for decorative hoods has been growing in the past years. Some hoods are also being offered with the ability to hold tools and objects, distributed on different levels. They may include hooks, shelves and even electrical outlets and Universal Serial Bus (USB) ports capable of charging electronic devices (Di Meo, 2018).

A typical classification of range hoods is in terms of **ventilation** system used. According to this, range hoods can either be ducted or ductless. A ducted range hood is connected to a duct with pipes that carry the airborne particles away from the kitchen to the outdoors (Gannaway, 2015). On the other hand, in a ductless hood, air is pushed through filters that scrub the fumes, removing grease and odours, venting them back into the room (Dooley, 2019).

In terms of **installation** method (**Figure 3**), range hoods can be defined as:

Built-in: hoods are built into or concealed within a cupboard or fitted kitchen so they are less noticeable to the eye.

- Under cabinet, when it is mounted underneath of the cabinets which are positioned above the stove. This is one of the most common and compact options: the design of the venting system is simple; it is versatile enough with almost any kitchen style and tends to save some wall space.
- Built-in means an under cabinet hood fully integrated in the kitchen cabinet.
- Telescopic means an under cabinet hood fully integrated in the kitchen cabinet and one of the grease filters slides out of the cabinet. .

Non built-in: they are stand-alone units, which have not been integrated into a fitted kitchen.

- T-shape hood and chimney hood, when it is attached to the wall above the cooktop. In this case, the range hood is installed instead of a cabinet in the space over the stove. They often come with a chimney that helps with ventilation, typically venting out through an exterior wall behind them. This configuration can serve as a design element in the kitchen.
- Vertical hood, when the hood is installed vertically almost in parallel to the wall.
- Island mounted or suspended, for kitchens where the cooktop is located on an island or not against a wall. This is the configuration generally used for larger, professional style cooktops, in order to handle the extra output.
- Downdraft, when the range hood is kept inside the cook space, integrated into the worktop and hidden away until it is used. According to manufacturers, their main advantage is that they eliminate steam and odour right at the source. This is a less

common configuration, a good solution for kitchens with limited space and when maintaining a clear sightline is a priority.

- Downdraft integrated, an appliance that combines range hood and hob –usually induction- in just one. The working principles are similar to a downdraft hood.

- Ceiling mounted, when the hood is installed directly into the ceiling. The configuration is similar of that of an island mounted hood, but in this case the result is a completely smooth surface rather than a hanging appliance in the centre of the kitchen.

Pictures provided by APPLiA

Figure 3. Types of range hoods in terms of installation

1.1.2 Existing definitions and categories for domestic cooking appliances

The following section provides an analysis of existing definitions of domestic ovens, hobs and range hoods using as a starting point the following categorisations:

- Ecodesign preparatory study Lot 22 and Lot 23
- European statistics
- Legislations, such as the current EU Ecodesign and energy label regulations, or third country regulations
- Standards and
- Other voluntary initiatives such as ecolabels

The product scope and definition is analysed within the frame of the Ecodesign and Energy label Directives, in turn for each of the three sub-products that are a focus for the Review Study. Based on this information and further research and evidence, a preliminary revised scope and revised definitions are proposed. This proposal will take into account stakeholder feedback.

1.1.2.1 Ecodesign preparatory study Lot 22 and Lot 23

The *Preparatory study for Ecodesign requirements of energy-using product Lot 22: Domestic and commercial ovens (electric, gas, microwave) including when incorporated in cookers, Task 1* (section 1.1.1) defines

> "*an oven as an enclosed compartment where the power/temperature can be adjusted for heating, baking and drying food and used for cooking*"

The study provides further detail on the end-use of the ovens if they are domestic, commercial or industrial and provides several definitions:

> "*domestic oven includes ovens that are designed to be used in households. EN 30-1-1 defines domestic cooking appliances as "used by private individuals in domestic dwelling"*
>
> *"commercial oven (e.g. impinge oven to cook pizza) include ovens that are designed to heat or bake product that are supplied directly to the end-consumers such as in restaurant, hotels, bakeries, canteens in factories, offices, hospitals, etc retailers such as supermarkets, etc"*
>
> *"industrial ovens includes ovens whose primary use is to be used in an industrial setting, i.e. manufacture food that is sold to shops or other businesses and not directly to end-customers*

The *Preparatory study for Ecodesign requirements of energy-using product Lot 23: Domestic and commercial hobs and grills, included when incorporated in cookers, Task 1* (section 1.4) defines

- *A hob as an appliance or part of an appliance which incorporates one or more cooking zones, where a cooking zone is part of the hob or area marked on the surface of the hob which pans are placed for heating".*

Additionally, this study provides several definitions for a cooker or a range cooker.

- *A cooker is defined as a large metal device for cooking food using gas and/or electricity. A cooker usually consists of an oven and a gas and/or electric hob*.

1.1.2.2 European statistics

The European statistical database for manufactured goods PRODCOM classifies the products included in this product group under the following NACE Rev2 codes:

- NACE 27.51 "Manufacture of electric domestic appliances"
- NACE 27.52 "Manufacture of non-electric domestic appliances"

In its subcategories different types of ovens, hobs and range hoods are listed, as presented in Table 4.

Table 4. PRODCOM classification for cooking appliances

Product	NACE code	Category
Domestic ovens	27.51.28.10	Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)
	27.51.24.50	Domestic electric toasters (including toaster ovens for toasting bread, potatoes or other small items)
	27.51.28.70	Domestic electric ovens for building-in
	27.51.28.90	Domestic electric ovens (excluding those for building-in, microwave ovens)
	27.52.11.13	Iron or steel gas domestic cooking appliances and plate warmers, with an oven (including those with subsidiary boilers for central heating, separate ovens for both gas and other fuels)
Domestic Hobs	27.51.28.10	Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)
	27.51.28.30	Electric cooking plates, boiling rings and hobs for domestic use
	27.51.28.33	Domestic electric hobs for building-in
	27.51.28.35	Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)
	27.52.11.13	Iron or steel gas domestic cooking appliances and plate warmers, with an oven (including those with subsidiary boilers for central heating, separate ovens for both gas and other fuels)
	27.52.11.15	Iron or steel gas domestic cooking appliances and plate warmers (including those with subsidiary boilers for central heating, for both gas and other fuels; excluding those with ovens)
	27.52.11.90	Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric
Range hoods	27.51.15.80	Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side ≤ 120 cm

In the *Preparatory study for Ecodesign requirements of energy-using products, Lot 22: Domestic and commercial ovens (electric, gas, microwave), including when incorporated in cookers* (Mudgal et al, 2011a), the classification of the domestic ovens corresponds with the classification presented in this section. Besides, the preparatory study Lot 22 included the classification of commercial ovens as well as those with a microwave function.

In the *Preparatory study for Ecodesign requirements of energy-using products, Lot 23: Domestic and commercial hobs and grills, included when incorporated in cookers* (Mudgal et al, 2011b), the classification separates those hobs that are built-in (NACE 27.51.28.33) from those which are free-standing, integrated in cookers or not (NACE 27.51.28.10 and NACE 27.51.28.35). Additionally, this preparatory study includes the classification of commercial hobs as well as grills and roasters, domestic and commercial.

1.1.2.3 EU Regulation

Regulation (EC) No 66/2014 with regard to eco-design requirements for domestic ovens, hobs and range hoods (European Commission 2009) applies to:

> *"domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes*.
>
> *This regulation shall not apply to*

- *appliances that use energy sources other than electricity or gas;*
- *appliances which offer ‘microwave heating’ function;*
- *small ovens;*
- *portable ovens;*
- *heat storage ovens;*
- *ovens which are heated with steam as primary heating function;*
- *covered gas burners in hobs;*
- *outdoor cooking appliances;*
- *appliances designed for use only with gases of the “third family” (propane and butane);*
- *grills”*

Regulation (EC) No 65/2014 with regard to energy labelling of domestic ovens and range hoods (European Commission, 2010) applies to:

> *“domestic electric and gas ovens (including when incorporated into cookers) and for domestic electric range hoods, including when sold for non-domestic purposes.*
>
> *This Regulation shall not apply to:*

- *ovens that use energy sources other than electricity or gas;*
- *ovens which offer ‘microwave heating’ function;*
- *small ovens;*
- *portable ovens;*
- *heat storage ovens;*
- *ovens which are heated with steam as primary heating function;*
- *ovens designed for use only with gases of the “third family” (propane and butane)*

For domestic ovens, hobs and range hoods the following definitions are given

> “*oven means an appliance or part of an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared by use of a conventional or fan-forced mode*”
>
> *“range hood means an appliance, operated by a motor which it controls, intended to collect contaminated air from above a hob, or which includes a downdraft system intended for installation adjacent to cooking ranges, hobs and similar cooling products, that draws vapour down into an internal exhaust duct*”
>
> *“hob means an electric hob, a gas hob or a mixed hob*”
>
> *“electric hob means an application or part of an appliance which incorporates one or more cooking zones and/or cooking areas including a control unit and which is heated by electricity*”
>
> *“gas hob means an appliance or part of an appliance which incorporates one or more cooking zones including a control unit and which is heated by gas burners of a minimum power of 1.16 kW*”
>
> *“mixed hob means an appliance with one or more electrically heated cooling zones or areas and one or more cooking zones heated by gas burners”*

The regulation includes the definitions of some products that are not included in its scope, such as:

> *“Small oven means an oven where all cavities have a width and depth of less than 250mm or a height less than 120mm”*

“Portable oven mean an oven with a product mass of less than 18 kilograms, provided it is not designed for built-in installations”

“Microwave heating means heating of food using electromagnetic energy”

For range hoods, definitions within Regulation (EU) No 1253/2014 with regard to ecodesign requirements for ventilation are also relevant:

- *‘Ventilation unit (VU)’ means an electricity driven appliance equipped with at least one impeller, one motor and a casing and intended to replace utilised air by outdoor air in a building or a part of a building;*

  ‘Residential ventilation unit’ (RVU) means a ventilation unit where:

  (a) the maximum flow rate does not exceed 250 m3/h;

  (b) the maximum flow rate is between 250 and 1 000 m3/h, and the manufacturer declares its intended use as being exclusively for a residential ventilation application;

  ‘Non-residential ventilation unit’ (NRVU) means a ventilation unit where the maximum flow rate of the ventilation unit exceeds 250 m3/h, and, where the maximum flow rate is between 250 and 1 000 m3/h, the manufacturer has not declared its intended use as being exclusively for a residential ventilation application;

1.1.2.4 Third country regulations

In the United States, the Department of Energy (DOE) Regulations define kitchen ranges and ovens, or “cooking products” as

> “*consumer products that are used as the major household cooking appliances. They are designed to cook or heat different types of food by one or more of the following sources of heat: gas, electricity or microwave energy. Each product may consist of a horizontal cooking top containing one or more surface units and/or more heating compartments*”

In addition, in an amendment carried out in 2016, the DOE proposed to define a combined cooking product as

> “*a household cooking appliance that combines a conventional cooking top and/or conventional oven with other appliance functionality, which may or may not include another cooking product*”.

The DOE’s regulation limits its scope to domestic cooking tops and domestic ovens (called as *conventional cooking tops* or *conventional ovens*).

United States of America (USA) regulation separated residential conventional cooking products into product classes. The classification followed refers to the following criteria: a) type of energy used, and b) capacity or other performance-related features such as those provide utility to the consumers.

For **gas cooking tops**, are defined as those equipped with gas cooking tops with burner inputs rates equal or lower than 14000 Btu/h.

The product classes for electric cooking tops are:

- low or high wattage open (coil) elements and
- smooth elements.

For **electric ovens,** the DOE determined that the type of oven-cleaning is a utility feature that affects performance. The product classes are:

- standard oven with or without a catalytic line, and
- self-clean oven.

For **gas ovens**, the DOE determined that conventional gas ovens are those equipped with burner input rates equal or lower than 22500 Btu/h. For the classification, the same reasons as for electric ovens are followed. The product classes are:

- Standard oven with or without a catalytic line, and
- self-clean oven.

1.1.2.5 Standards

International standards

Three international standards have been identified as relevant for this product group:

- *IEC 60350-1:2016 on household electric cooking appliances – Part 1: ranges, ovens, steam ovens and grills – Methods for measuring performance*
- *IEC 60705:2015 Household microwave ovens – methods for measuring performance*
- *IEC 60350-2:2011 on household electric cooking appliances – Part 2: hobs – Methods for measuring performance.*
- *IEC 61591:2019 Cooking fume extractors – methods for measuring performance. Methods for measuring performance.*

The standards IEC 60350 specify methods for measuring the performance of electric cooking ranges, ovens, steam ovens, grills and electric hobs for household use. The hobs covered may be built-in or for placing on a working surface or the floor. The hob can also be a part of a cooking range.

The standard 60705 describes methods for measuring the performance of microwave ovens. Its scope covers both solo microwave and combination ovens, though the methods are only meant to test the microwave function. The last amendment of the standard provides the following definitions:

- Microwave oven: appliance using electromagnetic energy in one or several of the ISM frequency bands between 300 MHz and 30 GHz for heating food and beverages in a cavity.
- Combination microwave oven: microwave oven in which microwave energy is combined with energy transfer by forced air circulation, by conventional heating, by hot steam and by steam.

The standard IEC 61591 includes definitions for cooking fume extractors:

- Cooking fume extractor: appliance with a fan and filter intended to collect and treat cooking fumes, which can be operated in recirculation mode or extraction mode.
- Range hood: cooking fume extractor installed over a cooking appliance.
- Recirculating air mode: mode of a cooking fume extractor that discharges air back into the room, which includes an odour-reduction filter.
- Extraction moded: mode of a cooking fume extractor that discharges the air to the outside of the building by means of a ducting.
- Down-draft system: cooking fume extractor intended for installation adjacent to a cooking appliances or integrated in a cooking appliance that draws vapour down into a duct.

European standards

The standard *EN60350* "*Electric cooking ranges, hobs, ovens and grills for household use – Methods for measuring performance*" defines:

- An *oven* as *an appliance or compartment of a range cooker in which food is cooked by radiation, by natural convention, by forced-air convection or by a combination of these heating methods*.

- A <u>hob</u> is defined as *an appliance or part of an appliance which incorporates one or more cooking zones, where a cooking zone is part of the hob or area marked on the surface of the hob which pans are placed for heating.*

1.1.2.6 Labels and schemes

European labels

<u>Range hoods</u>

The scope of the German Ecolabel Blue Angel DE-UZ-147 for Household cooker hoods is given as follows:

> *"These Basic Award Criteria apply to household cooker hoods with an inbuilt fan for either recirculation operation[2] or exhaust operation[3] exhibiting a maximum air flow volume of 800 m^3/h at maximum continuous operation[4]*

Specific requirements on energy efficiency of the fan and the lighting, power consumption of the off-mode and standby mode, automatic reset, grease and odour removal and noise emissions are not differentiated by the size of the appliance.

US energy star labels

There is no ENERGY STAR label for residential ovens, ranges, or microwave ovens at this time. However, there are ENERGY STAR labelled commercial ovens

1.1.3 Feedback from stakeholders regarding definitions and scope

The project team distributed a questionnaire in October 2019. Stakeholders submitted their feedback on ''Task 1: Scope'' via this questionnaire.

Existing definitions

The stakeholders proposed a set of modifications of the existing definitions in order to clarify primary and secondary functions of the products, and also the different technologies.

In the case of ovens, stakeholders proposed to include secondary functions as keeping the food warm. Proper definitions of the standardised cycle to be tested and of what an eco-mode is were also requested.

Regarding hobs, some modifications are suggested to better reflect induction technology.

The definition of range hoods should take into account the filtration and recirculation of air, which are not properly covered by current definitions. The definitions should take into account the ones within EN 61591 Regarding functions, the main function is removing airborne grease, odours, combustion products, fumes, smoke, heat, and steam from the air by evacuation of the air and/or filtration. However, recirculation would require a development of a test method that enables the rating of recirculation hoods. A secondary function mentioned by stakeholders is lighting, which should be also incorporated in the definitions.

Commercial and professional products

Some stakeholders proposed different options to define commercial and professional products and to make a clear distinction from domestic products. One suggestion was to include the different technologies that are common in the professional sector:

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[2] Recirculating operation: The cooker hood removes impurities to filters and returns the air to the kitchen

[3] Exhaust operation: The cooker hood guides the intake air to the outside via an exhaust system

[4] The calculation is based on the air flow volume (free air delivery) determined in accordance with DIN EN 61591, as amended, at maximum rotational speed for normal use. If the hood offers a high-speed or intensive power mode this mode shall not be considered as a normal use mode

“Commercial ovens”: static ovens, forced-conventional ovens, combi-steamer ovens, deck oven (bakery ovens), rotatory rack ovens, in-store bakery convection ovens, impinge ovens, hot food holding cabinets, convection steamers and convection ovens.

“Commercial hobs”: catering equipment manufacturers usually design series of modular elements with standard dimensions, so that appliances can be placed side by side to form a worktop or succession of pans. The main technologies are commercial gas open burners, gas solid tops, electric boiler tables, electric hobs, electric infrared hobs, electric induction hobs, griddles, tilt braising pans, pasta cookers, deep fryers, freestanding pressure cookers and Bain-Maries.

Another proposal was based on the type of users and location where the appliance is to be used:

- Domestic. Appliances to be used in a household environment with an intended non-professional use.
- Commercial. Appliances to be used in an area accessible to the public (not a household) with an intended non-professional use.
- Professional. Appliances to be used in an area not accessible to the public with an intended professional use, with low scale production.
- Industrial. Appliances to be used in an area not accessible to the public, with an intended professional use, for large scale production.

Some stakeholders supported the development of Ecodesign/Energy labelling measures of professional products attending to their potential significant impact and its inclusion of Article 7 of the current Ecodesign regulation. These stakeholders considered these measures as an important driver of the sector towards more efficient products. On the other hand, other stakeholders had a complete different view and are against the development of Ecodesign/Energy labelling measures. One of the main arguments for the exclusion is that professional appliances are completely different from household appliances with regards of:

- Cooking behaviour, user needs and pattern of use
- Cooking mode, in particular for ovens, is much more complex and with many cooking options
- Professional and commercial cooking appliances are in many cases part of cooking system and not stand-alone-products.
- Household appliances have much less variability in models differentiation and they are produced in high quantity; commercial and professional cooking appliances have high variability in models differentiation and they are produced in smaller quantities.

The Danish Technological Institute has tested a few professional appliances and the results support these arguments: usage and control options are very different from domestic appliances. Besides, it was easy to determine whether a product is a household appliance or a professional.

To the question whether commercial and professional products should be separated from domestic, some stakeholders suggest that since the function is the same, they should not be split up, which on top would delay the development and adoption of measures. Other stakeholders pointed out the need of different standard tests from domestic and different requirements, since the professional use patterns diverge from domestic, and consequently the design of the product. In their opinion, professional cooking appliances cannot be covered under the same regulatory instrument as domestic. Professional cooking appliances cannot be analysed as a spin-off of the discussion on household cooking appliances, they must be studied separately under a specific research project.

This topic will be developed further in sections 1.1.3 and 7.3.2.5.

Exclusions of the current regulation

Some stakeholders support that appliances excluded from the current regulations are part of the review study, since their impact may be significant and they are similar appliances to the ones already within the scope. Other responses were more detailed and provided information about each niche product. These comments are summarised below:

- Products proposed to be excluded:
  - Steam ovens: Some stakeholders indicate that there is not enough data available to evaluate, and they are not market relevant. Technical aspects of steam ovens will be covered in section 4.1.4.6 and policy recommendations in section 7.3.2.1.
  - Grills and grill ovens: Stakeholders indicate that they are not market relevant and their use is limited. Moreover, there is no method to measure energy efficiency.
  - Only recirculation hood: it is a niche product with 1% of the market.
  - Hoods without integrated fan for use with a central fan.
- Products proposed to be included:
  - Combi steam oven: they are market relevant, though they are often only used in their conventional heating function. Technical aspects of combi-steam ovens will be covered in section 4.1.4.6 and policy recommendations in section 7.3.4.6.
  - Gas-cooking appliances designed for use only with Liquified Petroleum Gas (LPG). They are excluded from Regulation 66/2014 because at that time they were not covered by standard EN 15181, but this will change soon with an amendment.
  - Aspiration hob: it is a domestic hob (induction, radiant or gas) integrating a blower and grease filter to remove airborne grease, combustion products, fumes, smoke, heat and steam from the air by evacuation of the air and filtration. It is an all in one product merging the functionality of a cooktop and of a range hood. The product has to satisfy both the requirement for range hood and for induction/radiant/gas cooktop. Products already in the market are sold with energy label and product fiche for the range hood section and with product information for the domestic hob section according to Regulations 65/2014 and 66/2014.
  - Range hoods with mood lights
- Products for which there is no clear agreement:
  - Table top hobs or portable hobs
  - Ovens with microwave function: some stakeholders argue that they should be excluded since their frequency of use is very little. Their classification (solo microwave oven, combi microwave ovens, ovens with integrated microwave, and microwave ovens with grill) may be very challenging, often designed in combination with other heating function. A measurement method for the combi modes is not available. The highest challenge is to measure the portion of microwave power. On the other hand, other stakeholders argue that combined ovens including microwave function should be covered by ecodesign and energy labelling regulations for the conventional and/or fan-forced mode, in order to prevent loopholes. Technical aspects of ovens with MW-combi mode will be covered in section 4.1.4.8 and policy recommendations in sections 7.3.2.3 and 7.3.4.6.

  - Solo microwave ovens: according to results from the French monitoring campaign “Étude de mesure des consommations d’énergie pour l'usage cuisson domestique”-ADEME (2016), the electricity consumption of (solo) microwaves is larger than range hoods. However, manufacturers state that the improvement potential and the similar technology used do not seem to allow for Ecodesign or Energy labelling measures. Technical aspects of solo-MW ovens will be covered in section 4.1.4.7 and policy recommendations in 7.3.2.2.

- Small and portable ovens. Some stakeholders argue that their overall energy consumption may not be negligible so their inclusion should be considered. Policy recommendations on small and portable ovens will be covered in section 7.3.2.4.

- Level of inclusion into scope. Some of the products above, currently excluded from ecodesign and energy labelling regulation, might be included in next version of those regulations. The level of inclusion of the appliances is also a matter to be considered (Figure 4).

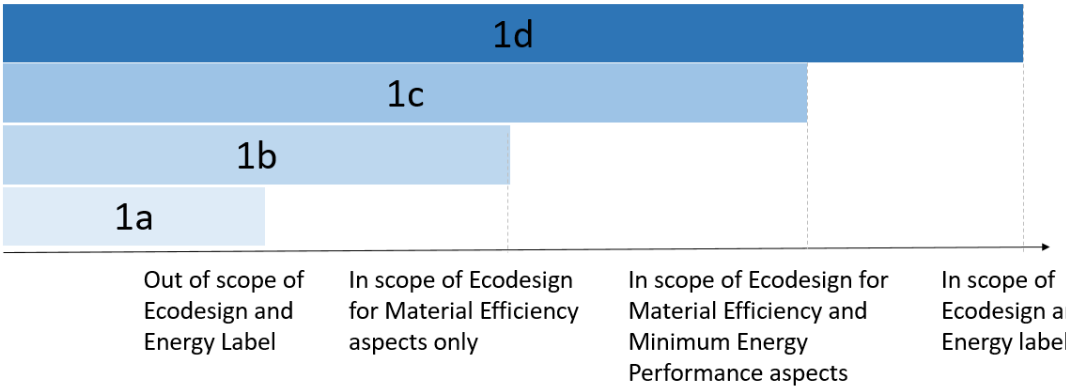


Figure 4. Level of inclusion in scope

For instance, some of the appliances mentioned above will remain in level 1a (out of scope of ecodesign or energy label). Some others might be included in scope of ecodesign regulation, but just in terms of material efficiency aspects (1b). Some others might be included in terms of material effiency and minimum energy performance requirements (1c). Finally, some of the products mentioned above may be included into the scope of both ecodesign and energy labelling (1d). Policy options related to scope will be discussed in more detail in section 7.3.2 of this report.

1.2 Test standards

The following section aims to provide an overview regarding the most recent and relevant existing standards which are applicable to domestic and professional cooking appliances. A higher level of detail will be provided for functional performance, use of resources and durability standards. This section has been completed with feedback from relevant stakeholders.

1.2.1 Functional performance standards of household appliances

1.2.1.1 EN 60350-1 Household electric cooking appliances – Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance

This document consists of the text of IEC 60350-1:2011 and the corrigendum of February 2012 prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances"

IEC 60350-1:2011 specifies methods for measuring the performance of electric cooking ranges, ovens, steam ovens and grills for household use. The ovens covered by this standard may be with or without microwave function. Manufacturers should define the primary cooking function of the appliance – microwave function or thermal heat. The primary cooking function has to be measured with an existing method according to energy consumption. If the primary cooking function is declared in the instruction manual as a microwave function, IEC 60705 is applied for energy consumption measurement. If the primary cooking function is declared as thermal heat, then IEC 60350-1 is applied for energy consumption measurement. This standard defines the main performance characteristics of these appliances which are of interest to the user and specifies methods for measuring these characteristics. It does not specify requirements for performance.

For energy consumption according to EN 60350-1: 2011, the test consists in assessing the amount of energy required to heat a standard load. The load is a water saturated brick which simulates both the thermal properties and the water content of food. For that, a standard clay brick is placed in the geometrical centre of the oven. The temperature of the oven settings is risen for 3 different levels and 3 different cooking modes: conventional, convection and hot steam (see Table 2 for definitions of oven modes). The temperature of the brick is measured until it increases 55K, when test finishes. The electricity consumption required to conduct that temperature increase in the brick is measured. This test method is commonly known within the industry as the Brickmethod 1.0 (BM1.0).

1.2.1.2 Circumvention and jeopardy effects related to EN 60350-1

In a report published in 2020, the project named "Anti-Circumvention of Standards for better market Surveillance", also known as the ANTICSS project (Martin et al, 2020), the authors provide definitions for circumvention and jeopardy effects.

Circumvention is the act of designing a product or prescribing test instructions, leading to an alteration of the behaviour or the properties of the product, specifically in the test situation, in order to reach more favourable results for any of the parameters specified in the relevant delegated or implemented act, or included in any of the documentations provided for the product. The act of circumvention is relevant only under test conditions and can be executed:

a) by automatic detection of the test situation and alteration of the product performance

b) by pre-set or manual alteration of the product affecting performance during test

c) by pre-set alteration of the performance within a short period after putting the product into service

Jeopardy effects encompass all aspects of products or test instructions, or interpretation of test results, which do not follow the goal of the EU ecodesign and/or energy labelling legislation of setting ecodesign requirements and providing reliable information about the resource consumption and/or performance of a product. These effects may not be classified as circumvention, but become possible due to loopholes or other weaknesses in standards or regulations.

One of the objectives of the ANTICSS project is to test product categories and cases that showed signs of circumvention or jeopardy effects. One of those product categories is domestic ovens. In the publication released in October 2020 (Martin et al, 2020), three topics are discussed (they are summarized in this section).

<u>The removal of non-essential items during volume measurement</u>

In the harmonised standard (EN 60350-1), the paragraph related to the measurement of the volume states the following: "Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out". According to stakeholders, this sentence is ambiguous, as it is not clear whether ovens elements (such as shelf guides, for instance) must be removed to measure the volume. This is relevant because higher volume implies better Energy Efficiency Index. Various stakeholders highlight that this sentence should be revised as it may lead (and in many cases does lead) to higher declared volumes and thus better EEI compared to real-life usage of the ovens.

The authors of the ANTICSS report indicate that in some ovens, in order to achieve better EEI results, the measurement of the volume had been done removing the shelf guides, because according to some recipes included in the user manual the cooking compartment must be empty. This issue was categorised as a jeopardy effect. The objective of the authors was to quantify if and how the difference in the measurement of the volume affects the EEI (and the corresponding energy class).

From the analysis of the tests conducted, the authors concluded that the use of an oven without the shelf guides seems to be an exceptional use and not the operation of the appliance in the manner for which it is usually intended. In their view, there is a loophole in the standard that should be solved. Their recommendation is that all relevant parameters should be measured in the same conditions. Therefore, if the shelf guides are needed for the measurement of the energy consumption, then the volume should be measured with the shelf guides.

On this topic, members of CENELEC Working Group 17 working on standard methods for ovens indicate that in the new version of the energy consumption test, the rule will be to measure cavity volume after removing the side racks. According to these members of WG17, conducting the energy consumption test with the side racks adds reproducibility issues, that could be eliminated by just conducing the test without them.

Policy recommendations on this topic will be made in section 7.3.4.7 of this report.

The maximum temperature of the oven during the energy consumption test

In current version of the regulation, energy consumption declaration is based on the energy consumption observed using different heating functions and temperature settings. However, if the highest of these temperatures cannot be reached by the oven, the standard requires using the maximum reachable value by the appliance. According to the authors of the ANTICSS project, this situation implies lower energy consumption results for those ovens that are not able to reach these temperatures – a situation of which manufacturers might take advantage. Allowing some ovens not to reach the highest temperature set in the standards might not be fair for those ovens that are capable to reach it.

After conducting tests on ovens, the authors concluded that the initial suspicion of jeopardy effect could not be confirmed. They explained that the energy consumption used for ecodesign and energy label is calculated using a linear regression based on the temperature and the energy consumption for the different temperature rises. This implies that there is a linear relation between the temperature rise and corresponding energy consumption, and that therefore the effect of a slightly lower temperature rise of the last of the three data points does not change the calculated energy consumption. The exception given for some ovens not to reach that maximum temperature has been allowed because it does not give any advantage to manufacturers.

In any case, in order to gain same conditions for all tested appliances, CENELEC is considering to remove that exception and to change the temperatures that have to be reached in the centre of the oven.

The temperature of the oven during the energy consumption test

Many ovens have an electronic control that continuously readjusts the oven cavity temperature according to the manufacturer's program setting and adapts it to the respective situation. The test cycle of EN-60350-1 consists of an energy consumption measurement (with the wet brick) followed by another cycle for temperature measurement with the oven empty (the oven needs to be opened between the two phases of the test to remove the brick).

The authors or ANTICSS, in accordance with feedback provided by some stakeholders pointed out that in some tested ovens, the first opening of the loaded oven was a control-relevant event and led to a changed regulatory behaviour: during the first step (the energy consumption measurement) the temperature in the oven was considerably lower than the temperature setting. The opening and re-closing of the oven door caused a significant increase of the temperature in the interior of the oven and the set temperature was reached. An example of oven tested showing this behaviour can be seen in Figure 5. The length of the first phase of the test was 54 minutes. During that phase, the temperature setting (190C) was only reached for 20 minutes. It can also be seen that the temperature decreases down to around 90C, and it only increases after the door is opened (indicated with red circle) to remove the brick and start with phase 2 of the test. In that second phase, the appliance increases the temperature until it reaches the temperature setting (190C) and keeps it constant until the end.

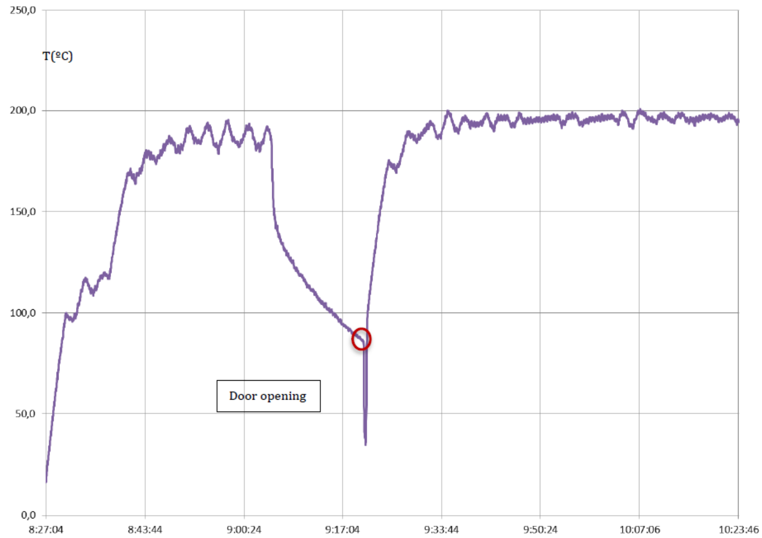


Figure 5. Temperature of oven tested as part of the ANTICSS project

In other words, these products may identify when a specific part of the testing procedure is interrupted/finished and as response changed their temperature automatically to fulfil the requirement of the next testing step. The issue with the current standard test is that it specifies only the temperature and not the time how long this temperature has to be maintained.

This issue was initially categorised in ANTICSS as a jeopardy effect, although different ovens tested showed slightly different behaviour. In some models, due to their irregular behaviour, they were considered as borderline with circumvention.

This irregular behaviour was observed fundamentally in energy saving modes, heating modes that make use of residual heat by lowering the temperature of the oven in some stages of the cycle (as seen in Figure 5). According to the authors of ANTICSS one could theoretically think of the reduced temperature as an energy saving function. However, an excessive use of this technique will not allow to achieve the required baking performance. In their view, in some of the tested models, this energy saving mode was only designed to reach favourable results in the test situation and was only included in the appliance to be used during the test.

Some of these issues will be tackled with the development of a new method to measure energy consumption. This topic will be covered in more detail in section 1.2.1.4. Policy options will be presented as well in section 7.3.4.2.

1.2.1.3 Other weaknesses of EN-60350-1 identified by stakeholders

In this section, other weaknesses of the current version of EN-60350-1, not included in the ANTICSS report, but mentioned by stakeholders, are presented.

<u>Heating mode used to declare energy consumption and to determine energy class of ovens</u>

A common topic mentioned by stakeholders for the revision of current regulation is a clearer indication of which heating mode should be used to declare energy consumption of ovens and to determine their energy class. An oven can provide different heating modes. In the current regulation on ecodesign, manufacturers can choose which mode shall be considered for energy labelling. REG 66/2014 states that "the energy consumption per cycle corresponding to the best performing mode shall be used for the calculations".

Some stakeholders indicate that the "standard" heating function to use for energy declaration shall be clearly defined and indicated. The way it works today, the best declared energy consumption is usually reached with energy saving modes –also known as ecomodes- that do not allow to cook some dishes and therefore, are not representative of a standard use. These modes use different strategies to reduce energy consumption (use of steam, oven totally airtight for a certain period of the cycle, lower the temperature within the oven for a certain part of the cycle, etc.).

Another stakeholder provides two potential solutions for this issue (A and B below).

> Option A) Test in one "standard" mode (compulsory) and in one "ecomode" (optional). These modes would need to be very precisely defined. The test in normal/standard usage condition should be on a mode available on every oven and relevant from consumer practice. The test with the ecomode should be optional. The manufacturer could declare its consumption as a way of differentiating their product in terms of energy consumption. They should clearly indicate on the oven the cycle to be chosen in order to get the lowest energy consumption and the limit of this programme (regarding cooking performance). It could be seen as a bonus to stimulate the innovation.
>
> Option B) To calculate energy consumption of the oven as a weighted average of the consumptions of different modes.

Another stakeholder points out that for standardization it is enough to consider one or two modes, since the results of one or two modes give an indication of the efficiency also of the other modes. Currently, high-specialised modes for limited applications are applied for energy consumption measurements. Surveys show that hot air (fan-forced) is the most common mode. However, so called eco modes provide an energy saving application for certain dishes and shall be taken into account for future regulation. These eco modes will be more challenged by the new brickmethod 2.0 and consequently ensure a better performance than today. From their point of view the new classification should be triggered by a mix of eco mode and hot air function. The same stakeholder drew the attention to the fact that a change of the addressed heating mode and the change to brickmethod 2.0 will lead to different energy consumption values than declared today. A change in the classification system and the minimum requirements is consequently essential.

The topic of energy saving modes will be developed in more detailed in Section 4.1.4.4 of this report. Policy recommendations regarding which heating mode to use for energy declaration will be covered in section 7.3.4.3.

<u>Cooking real food as a quality check for energy consumption measurements</u>

Other debate triggered by the use of "eco-mode" is whether it is capable to reach a sufficient cooking quality. Some stakeholders suggest that in some occasions, eco-modes lead to raw or burnt food, due to the way how the oven delivers the heating to optimise the energy consumption. In this regard, CENELEC is working to develop a test for measuring the cooking quality (so called Energy cake test). However, there are several issues to resolve to come up with a robust and reliable test, mainly related to the standardisation of ingredients and recipe and the reproducibility of the test. Policy recommendations on this topic will be presented in section 7.3.4.5.

<u>The need of a different standard for steam ovens</u>

Regarding steam ovens, there is certain debate around the need of a different standard to test their energy consumption and efficiency. Currently, steam function is tested with the same function as conventional and fan-forced convection.

On this issue, one stakeholder firstly indicates that pure steam ovens have less market relevance in Europe and should not be in scope of the upcoming regulation. For combi steam ovens (ovens with conventional and/or forced circulation functions and a steam function), have a higher market share. Since these combi ovens are mainly used by their conventional and/or forced circulation function, these combi ovens should be covered only in these functions and not in their steam function. They also add that the energy measuring method for hot steam function will be withdrawn from EN 60350-1. This measurement leads to an unfair comparison of different hot steam modes because the amount of steam is not measured.

A second stakeholder agrees with this reasoning: "taking into account that steam is not a primary function, both types of oven can have the same requirement".

A third stakeholder shows an intermediate position on the topic, indicating that it should be the same standard with slightly different boundary conditions, but mainly with the same equipment and strategy.

As indicated previously, technical aspects of steam ovens will be covered in section 4.1.4.6 and policy recommendations on their heating functions in section 7.3.4.6.

1.2.1.4 A new standard method to measure energy consumption of electric ovens

With the aim of addressing some of the issues presented in the previous two sections related to EN-60350-1, CENELEC WG 17 is currently developing a new standard testing method that tries to prevent that irregular behaviour. This new method is commonly known within the industry as brickmethod 2.0. Policy recommendations related to the adoption of this method will be evaluated in section 7.3.4.2 of this report.

The main differences between brickmethod 1.0 (BM 1.0) and brickmethod 2.0 (BM 2.0) are related to four aspects: a new definition of heating functions, a new energy consumption measurement, a separation of phases to measure energy consumption and temperature, and the calculation of a new parameter called c-factor. These aspects are described briefly below.

A new definition of heating functions

BM 1.0 contains separate definitions for conventional heating function and forced-air heating functions. BM 2.0 provides a joint definition for every heating mode. The reason for merging definitions is that in some cases it is not possible to easily discriminate conventional and forced-air modes (for instance, in multi-phase functions, heating modes which have a phase with conventional and a phase with forced-air). With this approach, all heating functions are considered identical for energy consumption measurements.

A new energy consumption measurement method

As a consequence of the merging between conventional and forced-air modes, the temperature rises in BM 2.0 are the same for every mode tested (Figure 7). This constrasts with BM 1.0 (Figure 6), where each heating mode has a different temperature rise to achieve.

temperature rise	Heating functions		
	Conventional (ic)	Forced air circulation (if)	Hot steam (ih)
ΔT_1^i	(140 ± 10) K	(135 ± 10) K	(135 ± 10) K
ΔT_2^i	(180 ± 10) K	(155 ± 10) K	(155 ± 10) K
ΔT_3^i	(220 ± 10) K[a]	(175 ± 10) K[a]	(175 ± 10) K[a]

[a] or the maximum temperature rise if this value cannot be reached.

Figure 6. Heating functions and temperature rises in BM 1.0

Temperature rise	
ΔT_1	(135 ± 15) K
ΔT_2	(165 ± 15) K
ΔT_3	(195 ± 15) K[a]

[a] or the maximum temperature rise if this value cannot be reached.

Figure 7. Temperature rises in BM 2.0

Separation of phases

In current method (BM 1.0), the energy consumption measurement is conducted in two phases. In the first phase, energy consumption is measured with the brick placed in the centre of the oven. After the required temperature rise is achieved, phase 1 ends, the oven is opened, the brick removed and phase 2 begins, where the temperature of the cavity is measured (Figure 8). This cannot be measured in phase 1 due to reproducibility issues caused by the presence of the brick, so phase 2 is essential to determine whether the required temperatures are achieved and maintained.

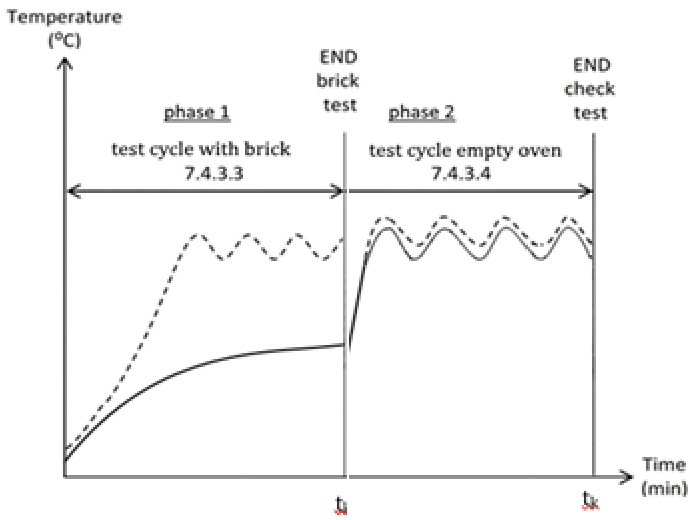


Figure 8. Phases of energy consumption measurement in BM 1.0

As explained ealier in this report, circumvention issues have been detected in some ovens, related to the removal of the brick between phase 1 and phase 2, where some appliances might detect that the test is being conducted. To avoid this and assure that the checking of the temperature (empty oven, phase 2) is done on the same setting than with the brick (phase 1), BM 2.0 mandates a cooling down and switching off of the appliance between phase 1 and phase 2 (Figure 9).

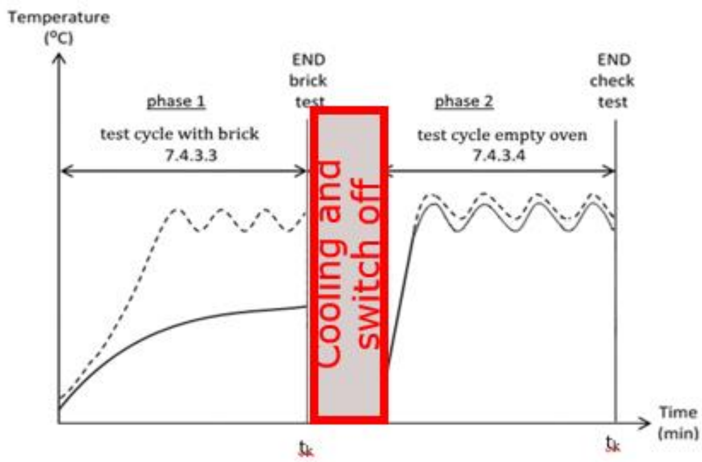


Figure 9. Phases of energy consumption measurement in BM 2.0

C-factor

Related to the separation of phase 1 and phase 2 is the definition of a new parameter: c-factor, the ration between the temperature observed in the cabin in phase 1 and the temperature observed in phase 2

(Figure 10). The main reason to include this factor is to evaluate the deviations of the temperature profile with and without brick. A pass/fail criteria still needs to be defined.

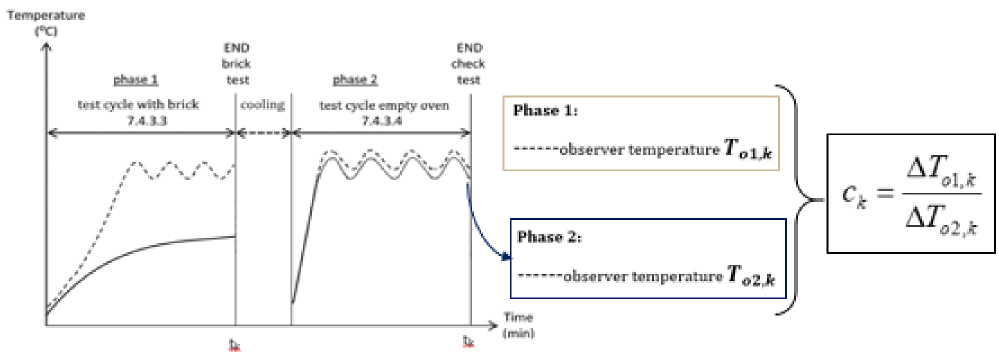


Figure 10. Definition of c-factor in BM 2.0

1.2.1.5 <u>EN 60350-2</u> Household electric cooking appliances – Part 2: Hobs – Methods for measuring performance

This document consists of the text of IEC 60350-2:2018, prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances". EN60350-2:2018 is based on the IEC 60350-2:2017.

IEC 60350-2:2011 defines methods for measuring the performance of electric hobs for household use. This standard defines the main performance characteristics of these appliances which are of interest to the user and specifies methods for measuring these characteristics. This standard does not specify requirements for performance.

For energy consumption, the test consists in assessing the amount of energy required to heat a standard amount of water. A standardised, stainless-steel cookware with lid is used. The hob under test is only pre-heated once after the appliance is installed in the lab. This is requested to ensure that there is no humidity in the system that could cause uncertainties. Before starting the energy consumption measurement the hob shall be at ambient temperature. The cookware is filled with water as specified in standard at 15C. The energy consumption is measured including the preheating phase starting from ambient temperature and water at 15 °C heating up to 90 °C plus 20 min simmering time.. The power control is set to maximum power until water reaches 90C and simmering starts. The energy consumed after 20 minutes of simmering is measured. The amount of energy consumed is normalized per 1000 grams of water.

The indicator used for standardization is energy consumption, measured as Wh/kg water.

<u>Potential issues with water simmering test method</u>

A stakeholder highlights that the current method is difficult for unexperienced testers (market surveillance, external laboratories, etc.) to find the right setting (power) to get $T_{simmering}$. So it is proposed to give some indications in an informative annex.

Another stakeholder disagrees with the position above, indicating that for electric hobs, the testing method is currently well applied. Different amounts and different selection of cookware sizes is already considered. Improvement potential so far is not known. Besides, there is an amendment in progress (CD status), which includes an informative annex describing in details the pre-test to simplify the determination of the $T_{simmering}$ setting.

The same stakeholder adds that regarding gas hobs, the test method for gas burners is given in EN 30-2-1. It is a robust method that has been used for a long time to measure the efficiency. It already considers different pot sizes and amount of water depending on the power of the burner. The only concern they have is related with the lack of repeatability due to the new rounding included in the version of 2015, in correspondence with Reg. 66/2014.

1.2.1.6 EN 60705 Household microwave ovens – methods for measuring performance

This document consists of the text of IEC 60705 prepared by IEC/SC 59K "Ovens and microwave ovens, cooking ranges and similar appliances", of IEC/TC 59 "Performance of household and similar electrical appliances".

IEC 60705 defines methods for measuring the output power and efficiency of microwave ovens. The output power is measured with a water load in a glass container. The water is heated until it raises the final temperature. The output power is calculated based on the temperature difference and the heating time. The efficiency is calculated as the ratio between the output energy (output power multiplied by time) and the input energy, including the energy consumed for heating up the magnetron filament.

The standard also includes test to measure other performance parameters such as uniformity of heating, evenness of temperature when heating beverages, uniformity of heating using simulated food and cooking performance using foodstuff.

1.2.1.7 EN 30-2-1 Domestic gas cooking appliances – Rational use of energy

This European Standard sets out the requirements and the test method for the rational use of energy of gas burning domestic cooking appliances. It covers type testing only, providing minimum requirements in terms of efficiencies of burners and ovens, indicating the necessary formulas to calculate efficiency in each case. It also provides guidance on how to conduct the test in terms of type of pans to be used, temperatures and conditions of the environment.

For gas hobs, the test consists in assessing how efficient the hob is in heating certain amount of water up to a specific temperature. For that, an aluminium test pan with a matt base, polished walls, no handles, with lid, is used. Different amount of water is used according a range of power consumption of burners. Burner is pre-heated for 10 minutes. Water is burned from 20C to 90C. The volume of gas required to reach this temperature increase is measured. This amount of gas is compared to a theoretical amount of gas needed to conduct this temperature increase. The efficiency of the hob is calculated as the ration between the theoretical amount of gas needed and the actual amount of gas consumed. The efficiency is measured in terms of percentage (%).

For gas ovens, the maintenance consumption of the oven is defined as the quantity of heat to be released per unit of time (power) by the gas combustion to maintain the oven temperature constant. Maintenance consumption of the oven is calculated as follows: with the oven empty, the burner central device is adjusted so that under steady-state conditions, the temperature rise at the geometrical center of the oven is 180K above ambient temperature. The standard indicates that the maintenance combustion of the oven shall not exceed the value obtained according a formula dependent on useful oven volume. Maintenance consumption of the oven is measured in kW.

1.2.1.8 EN 30-2-2:1999 Domestic cooking appliances burning gas – Part 2-2: Rational use of energy – Appliances having forced-convection ovens and/or grills.

This European Standard sets out the requirements and test method for the rational use of energy of gas cooking appliances having forced-convection ovens and/or grills using combustible gases. It covers type testing only, providing minimum requirements in terms of efficiencies of ovens, indicating the necessary formulas to calculate efficiency. It also provides guidance on how to conduct the test in terms of temperatures and conditions of the environment.

This standard is equivalent to EN 30-2-1, in this case applicable to gas ovens with forced convection air. As in EN 30-2-1, maintenance consumption of the oven is the quantity of heat to be released per unit of time by the gas combustion to maintain the oven temperature constant. It shall not exceed the value obtained according a formula dependent on useful oven volume. This energy consumption is calculated as follows: with the oven empty, the burner central device is adjusted so that under steady-state conditions, the temperature rise at the geometrical centre of the oven is 155K above ambient temperature. Maintenance consumption of the oven is measured in kW.

1.2.1.9 EN 15181 Measuring method of the energy consumption of gas fired ovens

This European Standard specifies the method of test for determining the gas energy consumption in gas-fired domestic ovens. It applies to gas-fired domestic ovens which are capable of utilizing gases of group H or group E, possibly after conversion according to instructions for use. It is applicable to gas-fired domestic ovens, whether they are separate appliances or component parts of domestic cooking appliances. It also applies to domestic appliances that can utilize gas and/or electrical energy to provide heat for cooking when the ovens are utilizing gas energy to provide heat for cooking, but not when electric energy is used to provide any or all of the heat for cooking in the oven. Amendments and modifications to this Standard are provided in EN 15181:2017/prA1.

The test consists in assessing the amount of energy required to heat a standard load. The load is a water saturated brick which simulates both the thermal properties and the water content of food. For that, a standard clay brick is placed in the geometrical centre of the oven. The temperature of the oven settings is risen for 3 different levels and 2 different cooking modes: conventional and convection (see Table 2 for definition of oven modes). The temperature of the brick is measured until it increases 55K, when test finishes. The volume of gas required to reach this temperature increase is measured. The amount of energy contained in this volume of gas is calculated.

1.2.1.10 EN 61591 Cooking fume extractors – Methods for measuring performance

EN 61591:1997 is based on the text of IEC 61591:1997, prepared by IEC TC 59, Performance of household electrical appliances, without any modification.

IEC 61591:1997 applies to range hoods incorporating a fan for the recirculation or forced removal of air from above a hob situated in a household kitchen. This standard defines the main performance characteristics of range hoods and specifies methods for measuring these characteristics, for the information of users. This standard does not specify required values for performance characteristics.

Performance is measured in terms of input power, pressure, flow, capacity of grease absorption, capacity of odour extraction and effectiveness of hob light.

New edition of the standard

According to stakeholders, EN 61591 is to be updated in 2020 based on the already published IEC 615915:2019.

The main improvements of this new version are:

a) new subclause about instruments and measurements

b) new procedure for measuring the fluid dynamic efficiency (FDE),

c) revised procedure for determining the odour reduction for cooking fume extractors in recirculation mode

d) modification to the measurement of the effectiveness of the lighting system

e) clearer procedure to measure the grease absorption

Grease absorption:

This test is used to measure the efficiency of the grease filter. The mass of range hood is measured without grease filter and odour extraction filter. A hob is placed 600 mm below the range hood, heating a pan of 200 mm at 250C. Range hood is operated at highest setting control. Corn oil is dripped onto the heated pan at constant rate together with water. Hob is working for 30 minutes and range hood for additional 10 minutes. Range hood is weighed again after removal of grease filter. Mass of oil retained is determined. The test is carried out twice. Absorption factor is calculated as the ration between mass of oil in grease filter and total mass of oil in the system. Grease absorption capacity is measured as a percentage (%).

Concerning the performance rating of range hoods (EN 61591:1997/A12:2015), a manufacturer has asked for clarification on how to measure the grease filtering efficiency for a range hood with centrifugal filtering system. The applicable standard contains no defined method for this kind of product.

The formula used in the regulation implies that the mass of oil in the grease filter and all removable covers is compared to the total mass of oil in the range hood, the ducting and the absolute filter used during testing. A product that has no removable filter but uses a fixed part that is cleaned with a cloth to remove grease would be at a disadvantage in the rating even when the grease filtering works well.

According to NOVY, the test method as also at a disadvantage for hoods with 'hidden' grease filters, e.g. hoods with perimetral extraction. In such hoods the grease filters are behind the cover plate. In many cases the cover plate is not removable. Moreover, a lot of grease deposits on the cover plate and parts of the hood upstream of the grease filters, which are easily accessible for cleaning. For hoods with perimetral extraction this means that the grease filter efficiency class may be F, even though downstream of the grease filters the oil concentration is less than 5% (and thus a class A is justifiable). One should take into account that the main goal of the grease filters is avoiding grease in fans and ducting. The grease filter efficiency would be better defined as all oil in the grease filters and on cleanable parts upstream of the grease filters divided by the total oil mass in the system.

Odour reduction:

This test is used to assess effectiveness of odour filters of recirculating-air range hoods and capacity of air-extraction range hoods to remove odours. Test is carried out in sealed room of 22 m3. Range hood is installed along one of the longer walls of the room, centrally above a hob, 600 mm above it. A solution containing certain mass of methyl-ethyl ketone (MEK) in distilled water is continually dripped on the pan, and then evenly dispersed throughout the room by means of a fan. The concentration of MEK at that point will be C1. The room is then ventilated until concentration is less than 1%. Then, the same amount of MEK and distilled water is dripped on the pan, with the range hood in operation for 30 minutes. The air in the room is again evenly dispersed with a fan and the concentration C2 measured when the value has stabilized. The odour reduction factor is measured as the ration between C1-C2 and C1. Odour reduction capacity is measured as a percentage (%).

An issue pointed out by stakeholders is that this test method was designed for activated carbon filters. Plasma filters can eliminate odours as well but not the test substance MEK. Therefore, the rating with MEK would create a technical barrier for plasma filters. However, plasma filters are not used in domestic appliance because they emit high level of ozone.

BAM indicates that in general MEK is not a representative cooking smell. MEK is used as solvent and in cleaning agents, but is not a dominant smell while cooking. Typical smells while cooking are e.g. fish smell (which is also experienced as very annoying). Fish smell (i.e. trimethylamine) would thus be a better substance for testing the odour reduction.

On the field of range hoods, a stakeholder highlighted that a revised or new test for the evaluation of the capture efficiency of pollutants could improve the consumer relevance of the performance test. The same flow rates can lead to different capture rates depending on the shape of the airflow and where the range hood is positioned in relation to the hob. Therefore, the capture efficiency cannot be determined by the flow rate but requires a test method with a standardized kitchen and a source of pollution that is representative for cooking fumes. The test should determine the share of pollutants that was removed from the air. Such a test is similar to the odour reduction test in the standard EN 61591. However, the odour reduction test has a small standardized test room that is not representative for an average kitchen and uses the polluting substance MEK which is harmful to the test personnel and might not be representative enough for cooking fumes.

According to BAM Federal Institute for Materials Research and Testing, concerning the performance rating of range hoods (harmonized standard: EN 61591:1997/A12:2015):

- It uses the polluting substance MEK which might be harmful to the test personnel.
- The odour reduction test has a small standardised test room that is not representative for an average kitchen and facilitates air-extraction range hoods to remove MEK. Therefore, according to IEC 69159:2019 the test is only intended for recirculation range hoods.
- In recirculation mode, the reduction of MEK is not only dependent on the capturing ratio but also on the adsorption in the active charcoal filter or the decomposition in the plasma filter. Therefore,

it must be clarified if MEK is representative for the cooking emissions concerning its adsorption in an active charcoal filter and the decomposition in a plasma filter.

- The odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. If a cooking fume extractor operates in extraction mode it should be acknowledged that the indoor air is replaced by outdoor air, which is polluted to some degree too. Thus, in reality the operation in extraction mode does not purify the air as well as it seems in the test with MEK where the replaced air contains none of the examined pollutant.

Other views suggests that a test on the recirculation filter itself may be more representative (and also easier/cheaper to perform) then a test on the complete hood system in recirculation mode. Such tests on filters only are e.g. breakthrough tests which are frequently used in automotive.

Effectiveness of the lighting system

The range hood is positioned 600 mm above a hob. Adjacent worktops are covered with a sheet of matt-black plywood or similar. The hob light is switched on and a lux meter used to measure the luminance at four point on the board. The average of the values of lux are measured. Effectiveness of light is measured in lux.

1.2.1.11 EN 50564 Electrical and electronic household and office equipment - Measurement of low power consumption

The standby consumption of household electrical appliances is measured according to the European standard EN 50564:2011 including the common modification agreed at European level to the international IEC 62301:2011, prepared by CENELEC TC59X.

EN 50564 is intended to define requirements for the measurement of low power and:

- addresses issues associated with measuring electrical power, in particular low power (in the order of a few Watts or less), consumed by mains powered products

- describes in detail the requirements for testing single phase products with a rated input voltage in the range of 100 V a.c. to 250 V a.c. but it may, with some adaptations, also be used with three phase products (relevant from professional)

- may also be of assistance in determining the energy efficiency of products in conjunction with other, more specific, product standards.

The value of energy consumed depends on the operating mode of the product under test, for instance whether the equipment is in an off mode, in a standby mode or in an active mode. This standard does not specify these modes, instead, it provides a method of measurement with a variety of modes which are defined elsewhere. The test method is applicable to other low power modes where the mode is steady state or providing a background or secondary function (e.g. monitoring or display).

Electric ovens and electric heat plates (electric hobs) are already covered by the standby – off mode electric power consumption by the Commission Regulation (EC) No 1275/2008[5] amended by Commission Regulation (EU) No 801/2013[6]. It is required to switch into a low power mode (such as standby) after a reasonable amount of time and they must not consume more than 0.5 Watts in standby or in off mode. The power consumption in any condition providing only information or status display, or providing only a combination of reactivation function and information or status display shall not exceed 1,00 W.

[5] Available at : https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32008R1275

[6] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32013R0801

1.2.1.12 <u>EN 50643</u> Electrical and electronic household and office equipment – Measurement of networked standby power consumption of edge equipment

This European Standard specifies methods of measurement of electrical power consumption in networked standby and the reporting of the results for edge equipment. Power consumption in standby (other than networked standby) is covered by EN 50564, including the input voltage range. This Standard also provides a method to test power management and whether it is possible to deactivate wireless network connection(s).

1.2.2 Functional performance standards of professional cooking appliances

In terms of functional performance standards applicable to professional cooking appliances, according to a relevant stakeholder, CENELECT TC59X WG18 is currently developing a standard on professional ovens. Three cooking modes are under evaluation: convection, steam and combi. Currently, no standards are available for professional gas hobs, gas ovens, electric hobs or range hoods.

Although currently there are no European harmonized standards on commercial cooking appliances, at a national level DIN 18873 standards do cover most of the equipment available in the market:

- **<u>DIN 18873</u>** Methods for measuring of the energy use from equipment for commercial kitchens

    - Part 1: Convection steamers
    - Part 2: Commercial coffee machines
    - Part 3: Deep fat fryers
    - Part 4: Convection ovens
    - Part 5: Tilting frying pans and stationary frying pans
    - Part 6: Tilting pressure braising pans and stationary pressure braising pans
    - Part 7: Multiple deck ovens
    - Part 8: Regenerating systems
    - Part 9: Cooking zones
    - Part 10: Ice machines
    - Part 11: Beverage cooler
    - Part 12: Ovens
    - Part 13: Microwave combination oven
    - Part 14: Point of use water dispenser for cooling and carbon dioxide enrichment
    - Part 15: Double jacketed boiling and quick boiling pans
    - Part 16: Kitchen Machinery
    - Part 17: Noodle cookers
    - Part 18: Wafflebaker
    - Part 19: Frying and grilling appliances
    - Part 20: Crepe and Poffertjes-Bakers

However,DIN Standards series 18873 deal mainly with energy consumption and their content is not suitable to be used for the objective analysis and test of cooking performance and energy efficiency parameters.

1.2.3 Product safety standards indirectly addressing durability

There are some standards which are related to the safety of products and components and seem to address quality and/or durability of those components at least indirectly (**Table 5**). For example, EN 60335 addresses product safety as commented in the previous section, whereas the Part 2 of the standard is divided into specific sub-parts each containing appropriate appliance specific safety requirements.

Table 5. Safety standards and indirect requirements for quality and durability of components

Standard	Component	Requirement
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, Annex C	Motors	Ageing-check for motors (in device-specific parts are modifications possible)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 25	Power supply and external cables	(In device-specific parts are modifications possible regarding the number of operating cycles)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014; section 23	Inner cables	The flexible part is being moved with 30 bends per minute backwards and forwards, so that the conductor is bended by the feasible biggest angle, enabled with this construction. The number of bends accounts: 10 000 for conductors, which are bended during proper use 100 for conductors, which are bended during users-maintenance (In device-specific parts are modifications possible, concerning the number of bends)
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for switches: IEC 61058-1	Components: Switches	Number of operating cycles have to add up to at least 10 000
Household and similar electrical appliances - Safety - Part 1: General requirements; EN 60335-1:2012/FprAD:2014, section 24; standard for Regulation- and control systems is IEC 60730-1	Components: Regulation and control systems	Minimum number of required operating cycles for example for temperature controllers: 10 000; for operating temperature limiter – 1 000 (In device-specific parts are modifications possible regarding the number of operating cycles)
Domestic cooking appliances burning gas fuel - Part 1-1: Safety – General, EN 30-1-1	Gas taps, glass, etc.	Minimum number of operations requested to gas taps, requirements for glass, etc.)

1.2.4 Horizontal durability, reparability and recyclability standards

Mandate M/543

On a horizontal level, Mandate M/543 (European Commission 2015a) had the objective to develop generic standards, for any product group covered by Ecodesign, in support of Ecodesign requirements related to material efficiency aspects.

Standardization bodies CEN and CENELEC developed generic methodologies and terminology related to material efficiency, such as durability, reusability, recyclability and recoverability. Related aspects, such as upgradeability, reversible disassembly time, end of life dismantling time, part mass or value, calculation of recycled and re-used content in products, or other relevant characteristics relevant for the product groups under consideration, were also investigated and included if appropriate. As a results of this work, the following standards have been published.

EN 45552 General method for the assessment of the durability of energy-related products

As energy-related products (ErP) can often not be completely recycled, and the benefits associated with material recovery cannot fully compensate the energy (and material) demand of the whole production chain, each disposed ErP also means losses in energy and materials. Therefore, increasing the durability of ErPs can contribute to a reduction in the quantity of raw materials used and energy required for the production/disposal of ErPs and consequently reduces adverse environmental impacts.

When considering durability, the trade-off between longer lifetime (reducing impacts related to the manufacturing and disposal of the product) and reduced environmental impacts of new products (compared to worse/decreasing energy efficiency of older products) needs to be considered. In addition, consumer behaviour and advances in technology have to be taken into account.

This document covers a general method for the assessment of the reliability and the durability of ErPs. Reliability represents the assessment of a probability of duration from first use to first failure or in-between failures. Durability is the whole expected time for this same period and not a probability.

This document describes a general assessment method that is intended to be adapted for application at a product or product-group level, in order to assess the reliability/the durability of ErPs.

EN 45553 General method for the assessment of the ability to remanufacture energy-related products

This document provides a general method for assessing the ability of an energy-related product to be remanufactured. In this document, remanufacturing is identified as an industrial process where at least one change, which influences the safety, original performance, purpose or type of the product, is applied to the energy-related product. This document is intended to be used by technical committees when producing horizontal, generic, and product-specific, or product-group, publications.

EN 45554 General methods for the assessment of the ability to repair, reuse and upgrade energy related products

In this document, common elements for the ability of an ErP to be repaired, reused or upgraded are addressed at component and product level. For instance, it includes an evaluation of the ability of certain parts to be disassembled.

EN 45555 General methods for assessing the recyclability and recoverability of energy related products

To close the loop in a circular economy, an efficient handling of waste is paramount. Recovering materials and energy can reduce environmental impacts over the product lifecycle, including reduced extraction of natural resources and associated emissions of primary material production.

While recycling of ErPs aims at closing the circular economy loop, trade-offs might arise between different material efficiency related topics. For instance mass of an ErP, durability, reparability, reusability and energy efficiency, need to be balanced in order to improve the environmental benefit.

Once an ErP has reached its end-of-life (EoL) and has become waste, the ErP can be either prepared for reuse, recycled/recovered. This document elaborates on the product characteristics which are relevant for recyclability and recoverability of an entire ErP. The focus is therefore on the recyclability/recoverability of the product itself rather than the recycling or recovery processes. The general method presented in this document takes into account the availability and efficiency of state-of-the-art recycling and recovery processes to determine the recyclability/recoverability rate of an ErP.

<u>EN 45556</u> General method for assessing the proportion of reused components in energy-related products

This document provides general methods for assessing the proportion of reused components in an energy related product. Four calculation methods based on mass of reused components and in the amount of reused components, are presented.

<u>EN 45557</u> General method for assessing the proportion of recycled material in energy related products

This document facilitates the provision of substantiated claims of the recycled materials content of energy-related products (ErPs). Key for substantiated claims for new products is the recognition of the chain of custody (CoC), which allows the tracing of recycled materials from different sources. The recycled material content of a new product is a characteristic of the product and its parts, which contributes to material efficiency, in addition to the potentials of reusability, recyclability and recoverability. With a focus on the efficient and effective use of natural resources, primary materials are often able to be substituted by recycled materials, reducing the demand for primary materials, with related potential environmental, social and economic implications. These could include reduced mining and consumption of natural resources, reduced landfill, reduced emissions and energy savings. The overall environmental impact will depend on the difference in the impacts of making materials from primary sources (oil, ore, etc.) vs. reprocessing waste into secondary materials which would directly substitute primary materials. The benefit of increasing recycled materials content in products is, in many cases, the incentivisation of recycling of end-of-life (EoL) waste material through the stimulation of demand for recycled materials. In other cases, where there is already high demand for recycled materials compared to the available supply, the link between specification of higher recycled materials content and the incentivisation of recycling is weaker. In that case, specification of recycled materials content may not be relevant to eco-design. The rationale for specifying recycled materials content, therefore needs to be considered for each material individually depending on the specific supply/demand situation.

<u>EN 45558</u> General method to declare the use of critical raw materials in energy-related products

The European Commission has created a list of critical raw materials (CRMs). CRMs combine a high economic importance to the EU with a high risk associated with their supply, both of which are determined according to an objective methodology. The list of CRMs is regularly updated. The availability of information on the use of CRMs in energy-related products is intended to improve the exchange of information. CRMs are identified as a priority area of the European Commission's Circular Economy Action Plan.

As information on the use of CRMs in energy-related products by Member States and industry is still very scarce, efforts need to be made to acquire such knowledge. The objective of this document is to provide a general methodology for declaration of the use of CRMs in energy-related products in support of the implementation of the Ecodesign Directive (2009/125/EC) in product-specific measures. Additionally, this document supports the implementation of the Raw Materials Initiative by the EU.

This document specifies a method for the declaration of CRMs, based on EN IEC 62474. Therefore, this document will be essential in supporting manufacturers of energy-related products to obtain information and report on the use of certain CRMs needed to comply with specific requirements in product-specific legislations in the future.

<u>EN 45559</u> Methods for providing information relating to material efficiency aspects of energy-related products

This document describes a general method for the communication of material efficiency (ME) aspects of energy-related products (ErP). It is intended to be used when developing a communication strategy in horizontal, generic, product-specific, or product-group publications. This document relates to the standards in the numerical range of “EN 45552 – 45558

Mandate M/518 for standardisation in the field of Waste Electrical and Electronic Equipment (WEEE)

In January 2013, the European Commission sent Mandate M/518 to the European standardisation organisations with the purpose to develop one or more European standard(s) for the treatment (including recovery, recycling and preparing for re-use) of waste electrical and electronic equipment, reflecting the state of the art. The European standard(s) requested by this mandate shall assist relevant treatment operators in fulfilling the requirements of the WEEE Directive.

EN 50625 standard series: Collection, logistics & treatment requirements for WEEE

CENELEC, through its Technical Committee ‘Environment’ (CLC/TC 111X), is leading the development of standards (and other deliverables) that will support the implementation of the EU Directive on Waste Electrical and Electronic Equipment. These standards cover various aspects of the treatment of electronic waste (including collection, treatment requirements, de-pollution and preparing for re-use). TC111X works on standards related to the environment and set up Working Group 6 for the EN 50625 series.

The standard on general treatment requirements includes on the one hand administrative and organisational requirements for the treatment operator and the treatment facility such as management, infrastructural pre-conditions, training and monitoring. On the other hand, technical requirements regarding the handling of WEEE, the storage of WEEE prior to treatment, the de-pollution process, the determination of recycling and recovery targets and documentation requirements. The technical specification further details different methodologies for monitoring of de-pollution.

If appliances are equipped at some point with control panels greater than 100 cm^2, also EN 50625-2-2 and TS 50625-3-3 would apply. Precious metals, for which the technical specification TS 50625-5 is planned, can be found for example in PWBs, containing palladium, silver and gold.

Whereas the standards and according technical specifications define requirements regarding the removal and further treatment of certain substances, mixtures and components such that they are contained as an identifiable stream or part of a stream by the end of the treatment process, they do not specify requirements for better identification or ease of dismantling of those components to facilitate the end-of-life treatment process itself.

IEC/TR 62635 Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment

The Technical Report IEC/TR 62635:2012 ed1.0 provides a methodology for information exchange involving EEE manufacturers and recyclers, and for calculating the recyclability and recoverability rates to

- Provide information to recyclers to enable appropriate and optimized end-of-life treatment operations,
- Provide sufficient information to characterize activities at end-of-life treatment facilities in order to enable manufacturers to implement effective environmental conscious design (ECD),
- Evaluate the recyclability and recoverability rates based on product attributes and reflecting real end-of-life practices.

Furthermore this technical report includes:

- Criteria to describe EoL treatment scenarios;
- Criteria to determine product parts that might require removal before material separation and related information to be provided by manufacturers (location and material composition);
- A format for information describing EoL scenarios and the results of EoL treatment activities;

- A method for calculating the recyclability and recoverability rate of EEE. The calculation is limited to EoL treatment and does not cover collection. The recyclability rate is expressed as a percentage of the mass of the product that can be recycled or reused, whereas the recoverability rate in addition includes a portion derived from energy recovery. This technical report can be applied to all electrical and electronic equipment;
- Some example data corresponding to identified scenarios.

IEC/TC 111 PT 62824 Guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

Further, under the IEC Technical Committee 111, Project Team 62824 has been established to provide guidance on consideration and evaluation on material efficiency of electrical and electronic products in environmentally conscious design.

ISO 11469 Plastics - Generic identification and marking of plastics products

This International Standard, published in 2000, specifies a system of uniform marking of products that have been fabricated from plastics materials. The marking system is intended to help identify plastics products for subsequent decisions concerning handling, waste recovery or disposal. Generic identification of the plastics is provided by the symbols and abbreviated terms given in ISO 1043, parts 1 to 4.

The standard includes requirements on the marking system and the method of marking. The marking system is subdivided into marking of products, of single-constituent products, of polymer blends or alloys, and of compositions with special additives (fillers or reinforcing agents, plasticizers, flame retardants and products with two or more components difficult to separate).

The standard is often referred to in ecolabels containing requirements on resource efficiency and end-of-life treatment of appliances.

British standard BS 8887 Design for Manufacture, assembly, disassembly and end-of-life processing ("MADE")

The British Standards Institution has developed a design for manufacture standards series BS 8887 (Design for Manufacture, Assembly, Disassembly and End-of-life processing MADE) first in 2006. The series contains of following sub-standards:

- BS 8887-1: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 1: General concepts, process and requirements (01 February 2012, superseding BS 8887-1:2006)
- BS 8887-2: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 2: Terms and definitions (01 July 2014)
- BS 8887-220: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 220: The process of remanufacture – specification. It outlines the steps required to change a used product into an 'as-new' product, with at least equivalent performance and warranty of a comparable new replacement product (BSI Group [n.d.]).
- BS 8887-240: Design for manufacture, assembly, disassembly and end-of-life processing (MADE) – part 240: Reconditioning (March 2011)

According to BSI Group [n.d.],

> In 2012, BS 8887-1 was put forward to the ISO and it has been accepted onto the work programme of the ISO committee with responsibility for technical product documentation. A new working group is being set up, which will be led by the UK, and work to convert BS 8887-1 into an international standard.

The international standard BS ISO 8887-1 Design for manufacture, assembly, disassembly and end-of-life processing (MADE) Part 1: General concepts, process and requirements is currently in development, by the BSI committee TDW/4 'Technical Product Realization' being responsible.

Austrian standard ONR 192102:2014 on durable, repair-friendly designed electrical and electronic appliances

This standard describes a label for repair-friendly designed appliances. Manufacturers of electrical and electronic equipment who intend to label their products have to test their products according to the requirements of ONR 192102 verifying compliance with a test report. According to Ricardo-AEA (2015), this standard suggests a labelling system with three levels of achievement (good, very good, excellent) based mostly upon reparability criteria. The standard includes ca. 40 criteria for white goods (such as hobs or ovens), and 53 criteria for small electronics (brown goods). The aim is to consider reparability to ensure products are not discarded sooner than is necessary as the result of a fault or inability to repair a fault.

The 40 criteria for white goods are split into mandatory criteria and other criteria for which a certain scoring can be achieved. To comply, products have to fulfil all mandatory requirements and achieve a minimum number of scores for common criteria and for service documentation.

The types of requirements include criteria such as accessibility of components, ease of disassembly, use of standard components, achievable service life (at least 10 years for white goods), availability of spare parts (at least 10 years after the last production batch), facilitation of regular maintenance, and further service information (inter alia free access for all repair facilities (not only authorized repairers) to repair-specific information). Each requirement is underpinned with some examples of realisation; however, no specific testing procedures and techniques are detailed.

British PAS 141 re-use standard

The PAS 141 specification has been developed by British Standards Institution (BSI) to increase the re-use of electrical and electronic equipment and to ensure that they are tested and repaired to a minimum level. The British non-for-profit company WRAP has developed a set of protocols based on industry experience highlighting tests and procedures to be carried out. The product protocols form a baseline for electrical product assessment and repair for re-use and can be used as a guideline to product assessment and testing.

1.2.5 Emissions Standards

- **EN 60335-2-6** (for ovens) regarding radiation, toxicity and similar hazards
- **EN 62233** Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure
- **EN 62311** Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)

1.2.6 Safety standards

Household cooking appliances

- **EN 60335-1** Household and similar electrical appliances - Safety - Part 1: General requirements
- **EN 60335-2-6** Household and similar electrical appliances - Safety - Part 2-6: Particular requirements for stationary cooking ranges, hobs, ovens and similar appliances (IEC 60335-2-6:2014, modified)

- **EN 60335-2-9** Household and similar electrical appliances - Safety - Part 2-9: Particular requirements for grills, toasters and similar portable cooking appliances

- **EN 60335-2-13** Household and similar electrical appliances - Safety - Part 2-13: Particular requirements for deep fat fryers, frying pans and similar appliances

- **EN 60335-2-25** Household and similar electrical appliances - Safety - Part 2-25: Particular requirements for microwave ovens, including combination microwave ovens

- **EN 60335-2-31** Household and similar electrical appliances - Safety - Part 2-31: Particular requirements for range hoods and other cooking fume extractors

- **EN 60335-2-102** Household and similar electrical appliances - Safety - Part 2-102: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections

- **EN 30-1-1** Domestic cooking appliances burning gas - Part 1-1: Safety – General

- **EN 30-1-2** Domestic cooking appliances burning gas - Safety - Part 1-2: Appliances having forced-convection ovens and/or grills

- **EN 30-1-3** Domestic cooking appliances burning gas - Part 1-3: Safety - Appliances having a glass ceramic hotplate

- **EN 30-1-4** Domestic cooking appliances burning gas - Safety - Part 1-4: Appliances having one or more burners with an automatic burner control system

Professional cooking appliances

In terms of safety standards applicable to professional cooking appliances, a relevant stakeholder indicated that Safety of gas and electric products is fully covered by the following standards, which are endorsed by the Machinery directive and Gas appliances regulation:

- **Machinery Directive**
- **EN 60335-1** Safety of household and similar electrical appliances - Part 1: General requirements
- **EN 60335-2-36** Particular requirements for commercial electric cooking ranges, ovens, hobs and hob elements
- **EN 60335-2-42** Particular requirements for commercial electric forced convection ovens, steam cookers and steam-convection ovens
- **EN 60335 -2-90** Household and similar electrical appliances - Safety - Part 2-90: Particular requirements for commercial microwave ovens
- **EN 60335-2-99** Particular requirements for commercial electric hoods
- **EN 60335-2-102** Household and similar electrical appliances - Safety Part 2: Particular requirements for gas, oil and solid-fuel burning appliances having electrical connections

Gas Appliances Regulation

- **EN 203-1** Gas heated catering equipment - Part 1: General safety rules
- **EN 203-2-1** Gas heated catering equipment - Part 2-1: Open burners and wok burners
- **EN 203-2-2** Gas heated catering equipment - Part 2-2: Ovens

1.2.7 Noise and vibrations standards

- **EN 60704-2-13** Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 2-13: Particular requirements for range hoods and other cooking fume extractors
- **EN 60704-2-10** Household and similar electrical appliances – Test code for the determination of airborne acoustical noise – Part 2-10: Particular requirements for electric cooking ranges, ovens, grills, microwave ovens and any combination of these

1.2.8 Other applicable standards

- **EN 50581** Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
- **EN 55011** Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
- **EN 55014-1** Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission
- **EN 55014-2** Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 2: Immunity
- **EN 55015** Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
- **EN 61000-3-2** Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)
- **EN 61000-3-3** Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection
- **EN 61000-3-11** Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection
- **EN 61000-3-12** Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and <= 75 A per phase
- **EN 301 489-1** ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 1: Common technical requirements
- **EN 301 489-17** ElectroMagnetic Compatibility (EMC) standard for radio equipment and services - Part 17: Specific conditions for Broadband Data Transmission Systems
- **EN 50614** Requirements for the preparing for re-use of waste electrical and electronic equipment.

1.2.9 Third country test standards

1.2.9.1 USA

Household appliances

The standard for conventional cooking products establish provisions for determining estimated annual operating costs, cooking efficiency (defined as the ratio of cooking energy output to cooking energy input), and energy factor (EF) (defined as the ratio of annual useful cooking energy output to total annual energy input)[7]. Its scope covers cooking tops both electrical and gas, a microwave ovens.

The standards were amended to include the standby and off mode power, according the consideration of IEC 62301 and IEC 62087. DOE introduced additionally a methodology to measure certain active modes such as fan-only mode for residential conventional cooking products. The inclusion of methods to measure these additional modes allows for the calculation of integrated annual energy consumption.

In 2013, DOE published an amendment proposing the measurement for testing the active mode energy consumption of induction cooling products. DOE proposed to incorporate induction cooking tops by amending the definition of conventional cooking top to include induction heating technology. Furthermore, DOE proposed to require for all cooking tops the use of test equipment compatible with induction technology. Specifically, DOE proposed to replace aluminium test blocks for cooking tops with hybrid test blocks comprising two separate pieces: an aluminium body and a stainless steel base.

In 2014, introduced another modification in which DOE proposed to specify different test equipment that would allow for measuring the energy efficiency of induction cooking tops, and would include an additional test block size for electric surface units with large diameters. DOE also proposed methods to test non-circular electric surface units, electric surface units with flexible concentric cooking zones, and full-surface induction cooking tops.

In 2016, DOE proposed to amend its standard to incorporate the relevant sections of EN 60350-2:2013 which provide a water-heating test method to measure the energy consumption of electric cooking tops. The test method specifies the quantity of water to be heated in a standardized test vessel whose size is selected based on the diameter of the surface unit under test. The test vessel specified in EN 60350-2:2013 are compatible with all cooking top technologies and surface unit diameters available on the US market.

Finally, DOE proposed to extend the test methods provided in EN 60530-2:2013 to gas cooking tops by correlating the burner input rate and test vessel diameters specified in EN 30-2-1:1998 to the test vessel diameter and water loads already included in EN 60350-2:2013. The range of gas burner input rates covered by EN 30-2-1 includes surface units with burners exceeding 14000Btu/h, and thus EN 30-2-1 provides a method to test gas surface units with high input rate burners, which previously had not been addressed in US standards.

Professional appliances

Energy Star for Commercial Food Service Equipment is based on the following American Society for Testing and Materials (ASTM) standards:

- *ASTM F2140 - 11(2019) Standard Test Method for Performance of hot food holding cabinets*

  This test method evaluates the preheat energy consumption and idle energy consumption of hot food holding cabinets. A hot food holding cabinet is described as a commercial kitchen appliance that is used to hold hot food that has been cooked in a separate appliance at a specified temperature.

  The hot food holding cabinet can be evaluated with respect to the following (where applicable):

  - Energy input rate
  - Temperature calibration
  - Preheat energy consumption and time
  - Energy consumption (idle energy rate)
  - Energy consumption with water (humidity pan) device and relative humidity (if applicable)
  - Temperature uniformity

- *ASTM F1275 - 14 Standard Test Method for Performance of Griddles*

[7] https://www.law.cornell.edu/cfr/text/10/appendix-I_to_subpart_B_of_part_430

This test method evaluates the energy consumption and cooking performance of griddles. It is applicable to thermostatically controlled, single-source (bottom) gas and electric griddles.

The griddle can be evaluated with respect to the following parameters:

- Energy input rate
- Temperature uniformity across the cooking surface and accuracy of the thermostats,
- Preheat energy and time
- Idle energy rate
- Pilot energy rate,
- Cooking energy rate and efficiency
- Production capacity and cooking surface temperature recovery time

- *ASTM F1605 - 14(2019) Standard Test Method for Performance of Double-Sided Griddles*

This test method covers the energy consumption and cooking performance of double-sided griddles. It is applicable to thermostatically controlled, double-sided gas and electric (or combination gas and electric) contact griddles with separately heated top surfaces.

This test method is applicable to thermostatically controlled, double-sided gas and electric (or combination gas and electric) contact griddles with separately heated top surfaces.

The double-sided griddle can be evaluated with respect to the following (where applicable):

- Energy input rate
- Temperature uniformity across the cooking surface(s) and thermostats accuracy
- Preheat energy and time
- Idle energy rate
- Pilot energy rate, if applicable
- Cooking energy rate and efficiency
- Production capacity and cooking surface temperature recovery time

- *ASTM F1496 - 13(2019) Standard Test Method for Performance of Convection Ovens*

This test method covers the energy consumption and cooking performance evaluation of convection ovens. The test method is also applicable to convection ovens with limited moisture injection. It applies to general purpose, full-size, and half-size convection ovens and bakery ovens used primarily for baking food products. It is not applicable to ovens used primarily for slow cooking and holding food product, to large roll-in rack-type ovens, or to ovens that can operate in a steam-only mode (combination ovens).

This test method is intended to be applied to convection ovens that operate close to their rated input in the dry heating mode, with the circulating fan operating at its maximum speed.

The oven's energy consumption and cooking performance are evaluated in this test method specifically with respect to the following:

- Thermostat
- Energy input rate and preheat energy consumption and time
- Pilot energy rate (if applicable)
- Idle energy rate
- Cooking energy efficiency and production capacity
- Cooking uniformity
- White sheet cake browning
- Bakery steam mode, if applicable

- *ASTM F2861 - 17 Standard Test Method for Enhanced Performance of Combination Oven in Various Modes*

This test method covers the evaluation of the energy and water consumption and the cooking performance of combination ovens that can be operated in hot air convection, steam, and the combination of both hot air convection and steam modes. The test method is also applicable to convection ovens with moisture injection. It is applicable to gas and electric combination ovens that can be operated in convection, steam and combination modes.

The combination oven can be evaluated with respect to the following (where applicable):

- Energy input rate and thermostat calibration
- Preheat energy consumption and time
- Idle energy rate in convection, steam and combination modes
- Pilot energy rate (if applicable)
- Cooking-energy efficiency, cooking energy rate, production capacity, water consumption and condensate temperature in steam
- Cooking-energy efficiency, cooking energy rate, and production capacity in convection mode
- Cooking uniformity in combination mode

- *ASTM F1484 - 18 Standard Test Methods for Performance of Steam Cookers*

These test methods are applicable to the following steam cookers: high-pressure, low-pressure, pressureless and vacuum steam cookers; convection and non-convection steam cookers; steam cookers with self-contained gas-fired, electric, or steam coil steam generators, and those connected directly to an external potable steam source.

The steam cookers will be tested for the following (where applicable):

- Maximum energy input rate
- Preheat energy consumption and duration
- Idle energy rate
- Pilot energy rate
- Frozen green pea cooking energy efficiency
- Frozen green pea production capacity
- Whole potato cooking energy efficiency
- Whole potato production capacity
- Water consumption
- Condensate temperature
- Cooking uniformity

1.2.9.2 Canada

CAN/CSA-C358 (Energy Consumption Test Methods for Household Electric Ranges) applies to household electric ranges that are intended to be used on a 60 Hz ac supply with a nominal system voltage of 120/240 V. This Standard specifies the methods to be used in measuring the capacity, the energy consumption, and the energy efficiency of electrically operated ranges. It does not apply to:

(a) microwave cooking appliances;
(b) portable units designed for an electrical supply of 120 V;
(c) induction heating elements; or
(d) warming compartments or zones that are not intended for cooking

1.2.9.3 Switzerland

In the professional sector, the Swiss organism ENAK provides a certification system based on test definitions and procedures set by themselves, available for turbo-ovens, cooking hobs, cooking and frying pans, deep fryers and pasta cookers, combi-steamers, convection ovens, bain-maries and heated display cabinets

1.2.9.4 Comparative analysis for overlapping test standards on performance

In the previous sections, overlapping test standards on performance have been identified and described. Table 6 gathers the differences between these standards.

Table 6: Differences between overlapping test standards on performance

EN standard	Overlaps with	Differences
EN 60350-1 Household electric cooking appliances – Part 1: Ranges, ovens, steam ovens and grills – Methods for measuring performance	DOE 10 CFR part 430, subpart B, appendix I (USA)	US standards measures the annual energy consumption of the oven taking into account the different modes of the oven.
	CAN/CSA-C358 Energy Consumption Test Methods for Household Electric Ranges	CAN/CSA Standard sets a normal bake mode to reach 130C and then then the oven is allowed to operate a full thermostat cycle until reaching 205C. EN Standard sets a temperature rise of 55K.
EN 60350-2 Household electric cooking appliances – Part 2: Hobs – Methods for measuring performance	DOE 10 CFR part 430, subpart B, appendix I (USA)	US standards measures the annual energy consumption of the hob taking into account the stand-by and off-modes.
	CAN/CSA-C358 Energy Consumption Test Methods for Household Electric Ranges	Stardarised test vessels used are made of aluminium and the test is not meant to test induction hobs
EN 30-2-1 Domestic gas cooking appliances – Rational use of energy	DOE 10 CFR part 430, subpart B, appendix I (USA)	No significant differences have been found. US standard incorporate relevant sections of EN standard for gas cooking appliances.. ▪

1.3 Legislation on Ecodesign, energy efficiency, performance and resource efficiency

In the following sections of this chapter, the European legislation with regard to Ecodesign, energy efficiency, performance and resource efficiency are described, followed by a compilation of international and third-country legislation.

1.3.1 EU legislation

Table 7 provides an overview of the European legislation discussed in this section

Table 7. Overview of European legislation on Ecodesign, energy efficiency and performance

European legislation	
Ecodesign Regulation	Ecodesign regulation (EC) No 66/2014 on Ecodesign requirements for domestic ovens, hobs and range hoods.
	Ecodesign regulation (EC) No 1275/2008 for standby and off-mode
	Ecodesign regulation (EC) No 801/2013 on networked standby
	Ecodesign Regulation (EC) No 327/2011 on fans driven by motors with an electric input power between 125 W and 500 kW
	Ecodesign Regulation (EC) No 640/2009 for electric motors

	Ecodesign preparatory study on smart appliances (ENER Lot 33, ongoing)
Energy efficiency and performance	Energy Label Regulation (EC) No 65/2014 on energy label requirements for domestic ovens and range hoods.
	Low Voltage Directive (LVD) 2014/35/EU
	Electromagnetic compatibility directive (ECD) 2014/30/EU

1.3.1.1 Ecodesign regulations relevant for domestic cooking appliances

- **Ecodesign regulation (EC) No 66/2014**

Based on Directive 2009/125/EU with regard to Ecodesign requirements for energy-related products, the Regulation (EC) No 66/2014 with regard to Ecodesign requirements for domestic ovens, hobs and range hoods establishes general and specific requirements that all appliances need to fulfil to be distributed on the European market. General requirements include:

- for domestic ovens

    - energy efficiency requirements for the appliance performance under one standardized cycle in a conventional mode and in a fan-force mode, if available

    - the provision of obligatory information in the booklet

- for domestic hobs

    - maximum energy consumption for domestic electric hobs

    - energy efficiency of gas burners for domestic gas hobs

    - the provision of obligatory information in the booklet

- for domestic range hoods

    - minimum energy efficiency and minimum fluid dynamic efficiency requirements for the appliance performance under standardized cycle.

    - maximum air flow that shall revert to an air flow lower or equal to 650m^3/h in a specified time at the best efficiency point

    - maximum energy consumption of the low power modes off-mode and standby modes

    - minimum average illumination of the lighting system

    - the provision of obligatory information in the booklet

The specific requirements prescribe the minimum limits for energy efficiency or the maximum energy consumption according to the Energy Efficiency Index (EEI), as seen in Table 8.

Table 8. Ecodesign requirements in REG 66/2014

Appliance	Due date	Specific requirements
Domestic ovens	February 2015	EEI_{cavity} <146
	February 2016	EEI_{cavity} <121
	February 2019	EEI_{cavity} <96
Electric domestic hobs	February 2015	$EC_{elect\ hob}$<210 Wh/kg
	February 2017	$EC_{electhob}$<200 Wh/kg
	February 2019	$EC_{elect\ hob}$<195 Wh/kg
Gas-fired domestic hobs	February 2015	$EE_{gas\ hob}$>53 %
	February 2017	$EE_{gas\ hob}$>54 %
	February 2019	$EE_{gas\ hob}$>55 %
Domestic range hoods	February 2015	EEI_{hood}<120 FDE_{hood} >3
	February 2017	EEI_{hood}<110 FDE_{hood} >5
	February 2019	EEI_{hood}<100 FDE_{hood} >8
	February 2015	Air flow ≤ 650m3/h
	February 2015	E_{middle} > 40 lux

The above requirements are subject to revision in this preparatory study: in Annex II of Directive 2009/2015 on ecodesign requirements for energy related products, it is stated that:

> *"Concrete measures must be taken with a view to minimising the product's environmental impact. Concerning energy consumption in use, the level of energy efficiency must be set aiming the the life cycle cost minimum to end-users"*

Regulation (EC) No 66/2014 prescribes formulas for the calculation of EEI, EC, EE or FDE and the respective energy consumption, theoretic minimum required energy or annual energy consumption. These equations are taken over in the Energy Label Regulation (EC) No 65/2014, when appropriate.

In addition, the Ecodesing regulation sets minimum requirements for the low power modes of range hoods. From September 2017 the following requirements applied:

- the power consumption of any off mode condition shall not exceed 0.50W
- the power consumption in any condition providing only a reactivation function, or providing only a reactivation function and information or status display shall not exceed 1.00W
- when domestic range hoods are not providing the main functions or when other energy-using product(s) are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for off more and/or standby mode when the equipment is connected to the mains power source

The power management function shall be activated before delivery.

For range hoods with automatically functioning mode during the cooking period and fully automatic range hoods, the delay time after which the product switches automatically into the modes and conditions as referred to in the previous point shall be one minute after the motor and lighting have both been switched off either automatically or manually.

Additionally for the verification process tolerances for all measures values are given, as well as reference values of the most efficient appliances (electric and gas fed) available on the market at that time.

- **<u>Ecodesign regulation (EC) No 1275/2008 for standby and off mode</u>**

Regulation (EC) No 1275/2008 is implementing the Directive 2005/32/EC with regard to Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (European Commission 2008). According to Annex I of Regulation, electric ovens, electric hot plates and other appliances for cooking are covered by this Regulation. Range hoods are not included in the list of products within Annex I of this regulation, and in this case, stand-by and off mode requirements are set by the Ecodesing regulation, as explained above.

Currently, stage 2 is applicable for products placed on the market from 7 January 2013, with the following requirements regarding power consumption of standby- and off-mode, as well as power management or similar functions.

- power consumption in standby modes

    - the power consumption of equipment in any condition providing only a reactivation function, or providing only a reactivation function and a mere indication of enabled reactivation function, shall not exceed 0.50 W

    - the power consumption of equipment in any condition providing only information or status display, or providing only a combination of reaction function and information status display shall not exceed 1.00 W

- power consumption in off-mode: power consumption of equipment in any off-mode conditions shall not exceed 0.5 W

- availability of off mode and/or standby mode: equipment shall, except where this is inappropriate for the intended use, provide off mode and/or standby mode, and/or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source

- power management: when equipment is not providing the main function, or when other energy-using product(s) are not dependent on its functions, equipment shall, unless inappropriate for the intended use, offer a power management function, or a similar function, that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into:

  - standby mode, or off mode, or another condition which does not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source. The power management function shall be activated before delivery

- **Ecodesign Regulation (EC) No 801/2013 on networked standby**

Regulation (EC) No 801/2013 (European Commission 2013b) is an amendment to regulation (EC) No 1275/2008 for standby and off mode, expanding this by Ecodesign requirements related to networked standby electric power consumption for the placing on the market of electrical and electronic household and office equipment.

In this context, "networked standby" means a condition in which the equipment is able to resume function throughout a remotely initiated trigger from a network connection, i.e. a signal that comes from outside the equipment via a network. Thus, the Regulation applies to all domestic ovens, hobs and range hoods that can be connected to a network. In the networked standby, the equipment is inactive (not performing a main function but in a condition allowing it to be reactivated via an external network signal).

While Ecodesign Regulation (EC) No 1275/2008 for standby and off mode requires power management for all equipment other than networked equipment put on the market since 2013, as of 1 January 2015 the following requirements apply to networked equipment:

- possibility of deactivating wireless network connection(s): any networked equipment that can be connected to a wireless network shall offer the user the possibility to deactivate the wireless network connection(s). This requirement does not apply to products which rely on a single wireless network connection for intended use and have no wired network connection

- power management for networked equipment: equipment shall, unless unappropriated of the intended use, offer a power management function or a similar function. When the equipment is not providing a main function, and other energy-using product(s) are not dependent on its functions, the power management function shall switch equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into a conditions having networked standby. In a condition providing networked standby, the power management function may switch equipment automatically into standby mode or off mode or another condition which does not exceed the applicable power consumption requirements for standby and/or off mode as specified in Regulation (EC) No 1275/2088. The power management function, or a similar function, shall be available for all network ports of the networked equipment. The power management function, or a similar function, shall be activated, unless all network ports are deactivated. In that latter case the power management function, or a similar function, shall be activated if any of the network ports is activated. The default period of time after which the power management function, or a similar function, switches the equipment automatically into a condition providing networked standby shall not exceed 20 minutes.

- networked equipment that has one or more standby modes shall comply with the requirements for these standby mode(s)

  - when all network ports are deactivated (since 1 January 2015)
  - when all wired network ports are disconnected and when all wireless network ports are deactivated (1 January 2017)

- networked equipment other than HiNA equipment (high network availability equipment) shall comply with the provisions of “power management for all equipment other than networked equipment”

- when all network ports are deactivated (since 1 January 2015)
- when all wired network ports are disconnected and when all wireless network ports are deactivated (1 January 2017)

- the power consumption of “other” network equipment (i.e. not HiNA equipment or equipment with HiNA functionality) in a condition providing networked standby into which the equipment is switched by the power management function, or similar function:

- shall not exceed 6.00 W (since 1 January 2015)
- shall not exceed 3.00 W (since 1 January 2017)
- shall not exceed 2.00 W (since 1 January 2019

- **Ecodesign Regulation (EC) No 327/2011 on fans driven by motors with an electric input power between 125 W and 500 kW**

Regulation (EC) No 327/2011 covers fans that are integrated in other products without being separately placed on the market or put into service as long as they are between 125 W and 500kW.

This regulation however does not apply to the fan integrated into kitchen hoods < 280W total maximum electrical input attributable to the fan(s). A specific case can be found where the total maximum electrical power attributable to the fan is above 280 W but the input power in the optimum efficiency point is below. In this case, as the exclusion is made based on total maximum electrical input power, the fan must comply with the Regulation.

Most of the domestic range hoods will then be excluded from this eco-design regulation as most of them have a maximum electrical input lower than 280W.

If any of them are above this limit, as commented in the example before, then the definition applied in this regulation is that, a *fan is defined as a rotatory bladed machine that is used to maintain a continuous flow of gas, typically air, passing through it and whose work per unit mass does not exceed 25kJ/kg and which:*

1 is designed for use with or equipped with an electrical motor with an electric input power between 125W and 500kW (≥125W and ≤500kW) to drive the impeller at tis optimum energy efficiency point
2 is an axial fan, cross flow or mixed flowed fan
3 may or may not be equipped with a motor when placed on the market or put into service.

The requirements of this regulation refer to minimum energy efficiency requirements and information requirements In addition, the regulation requires the provision of information related to the technical characteristics of the fan in the free access websites of the manufacturers of fans, related to the year of manufacture and details of the manufacturers. In addition, the regulation requires information relevant for facilitating disassembly, recycling or disposal at the end-of-life, to minimise impact on the environment and ensure optimal life expectancy as regards installation, use and maintenance of the fan and description of additional items used when determining the fan energy efficiency, such as ducts, that are not described in the measurement category and not supplied with the fan. Finally, manufacturers should provide information in the manual of instructions on specific precautions to be taken when fans are assembled, installed or maintained as well as the details of the characteristics of the variable speed drive (VSD) that must be installed with the fan, if needed, to ensure optimal use after assembly.

- **Ecodesign Regulation (EC) No 2019/1781 for electric motors**

Electric motors are subject to EU Ecodesign requirements that establish minimum requirements for the products within its scope. The Regulation covers electric single speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motors that:

- *have 2 to 6 poles;*
- *have a rated voltage up to 1 000 V;*

- *have a rated power output between 0.75 kW and 375 kW;*
- *are rated on the basis of continuous duty operation.*
- *smaller motors between 120W and 750W*
- *larger motors between 375kW and 1000kW*
- *60Hz motors, 8 poles motors and single phase motors (the latter only as of July 2023)*

The Regulation does not cover motors completely integrated into a product (for example into a gear, pump, fan or compressor) and whose energy performance cannot be tested independently from the product. Therefore, motors used in ovens or range hoods are not included in the scope of this regulation.

- **<u>Ecodesign regulation 1253/2014 on ecodesign requirements for ventilation</u>**

Regulation (EC) No 1253/2014 set ecodesign requirements for ventilation units for their placing on the market or putting into service.

This regulation establishes requirements in terms of Specific Energy Consumption (SEC), noise, multi-speed/variable speed drives, thermal by-pass facilities and filters (among other parameters).

1.3.1.2 Energy efficiency regulations relevant for domestic cooking appliances

- **<u>Energy Label Regulation (EC) No 65/2014 on energy label requirements for domestic ovens and range hoods</u>**

Based on Directive 2010/30/EU with regard to labelling of energy related products, the Regulation (EC) No 65/2014 with regard to energy label of domestic ovens and range hoods came into force in January 2015. It describes the uniform design and content of the new energy label that shall be used for the declaration of performance characteristics.

Current energy label has a multilingual design, displays energy efficiency from classes A+++ to D. In the case of the domestic ovens, further information display on the label refers to the capacity and the energy consumption for the heating function conventional and if available the forced air convection. In the case of range hoods, information refers to energy consumption, fluid dynamic efficiency, lighting efficiency, grease filtering efficiency and noise.

Sizes and colours for all elements and declarations are prescribed in detail, as well as formulas to calculate annual consumptions, efficiency indices and tables that indicate minimum and maximum values for energy efficiency classes.

<u>Domestic ovens</u>

The energy efficiency classes of domestic ovens shall be determined separately for each cavity in accordance with values as set out in Table 9.

Table 9. Energy efficiency classes and energy efficiency index in ovens

Energy efficiency class	Energy efficiency index (EEI_{cavity})
A+++ (most efficient)	$EEI_{cavity} < 45$
A++	$45 \leq EEI_{cavity} < 62$
A+	$62 \leq EEI_{cavity} < 82$
A	$82 \leq EEI_{cavity} < 107$
B	$107 \leq EEI_{cavity} < 132$
C	$132 \leq EEI_{cavity} < 159$
D (least efficient)	$EEI_{cavity} < 159$

EEI is calculated according to following equations:

- for domestic electric ovens:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}}\ x\ 100$$

$$SEC_{electric\ cavity} = 0.0042\ x\ V + 0.55\ (in\ kWh)$$

- for domestic gas ovens:

$$EEI_{cavity} = \frac{EC_{gas\ cavity}}{SEC_{gas\ cavity}}\ x\ 100$$

$$SEC_{gas\ cavity} = 0.044\ x\ V + 3.53\ (in\ MJ)$$

Where:

EEI_{cavity} is the energy efficiency index for each cavity of a domestic oven, in % rounded to the first decimal place

$SEC_{electric\ cavity}$ is standard energy consumption (electricity) required to heat a standardized load in a cavity of an electric heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

$SEC_{gas\ cavity}$ is standard energy consumption (electricity) required to heat a standardized load in a cavity of a gas heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

$EC_{electric\ cavity}$ is energy consumption required to heat a standardized load in a cavity of an electric heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

$EC_{gas\ cavity}$ is energy consumption required to heat a standardized load in a cavity of a gas heated domestic oven during a cycle, expressed in kWh, rounded to the second decimal place

In current regulation, SEC was defined as a linear regression relating energy consumption and cavity volume, based on the market situation at that time. The definition of SEC is subject to revision in this preparatory study. The relation between energy consumption and cavity volume will be considered in section 4.1.4.3. Policy recommendations on this topic will be made in sections 7.3.4.1 and 7.3.4.4.

Domestic range hoods

The energy efficiency classes for domestic range hoods shall be determined in accordance with values as set out in Table 10.

Table 10. Energy efficiency classes and energy efficiency index in range hoods

Energy efficiency class	Energy efficiency index (EEI_{hood})			
	Label 1	**Label 2**	**Label 3**	**Label 4**
A^{+++} (most efficient)				$EEI_{hood} < 30$
A^{++}			$EEI_{hood} < 37$	$30 \leq EEI_{hood} < 37$
A^{+}		$EEI_{hood} < 45$	$37 \leq EEI_{hood} < 45$	$37 \leq EEI_{hood} < 45$
A	$EEI_{hood} < 55$	$45 \leq EEI_{hood} < 55$	$45 \leq EEI_{hood} < 55$	$45 \leq EEI_{hood} < 55$
B	$55 \leq EEI_{hood} < 70$	$55 \leq EEI_{hood} < 70$	$55 \leq EEI_{hood} < 70$	$55 \leq EEI_{hood} < 70$
C	$70 \leq EEI_{hood} < 85$	$70 \leq EEI_{hood} < 85$	$70 \leq EEI_{hood} < 85$	$70 \leq EEI_{hood} < 85$
D	$85 \leq EEI_{hood} < 100$	$85 \leq EEI_{hood} < 100$	$85 \leq EEI_{hood} < 100$	$EEI_{hood} \geq 85$
E	$100 \leq EEI_{hood} < 110$	$100 \leq EEI_{hood} < 110$	$EEI_{hood} \geq 100$	
F	$110 \leq EEI_{hood} < 120$	$EEI_{hood} \geq 110$		
G (Least efficient)	$EEI_{hood} \geq 120$			

EEI is calculated according to following equations:

$$EEI_{hood} = \frac{AEC_{hood}}{SAEC_{hood}} \; x \; 100$$

$$SAEC_{hood} = 0.55 \; x \; (W_{BEP} + W_L) + 15.3$$

Where:

EEI_{hood} is the energy efficiency index for a hood, rounded to the first decimal place

$SAEC_{hood}$ is standard annual energy consumption of the domestic range hood in kWh/a, rounded to the first decimal place

AEC_{hood} is the annual energy consumption of the domestic range hood in kWh/a, rounded to the second decimal place

W_{BEP} is the electric power input of the domestic range hood at the best efficiency point in Watt, rounded to the first decimal place

W_L is the nominal electric power input of the lighting system of the domestic range hood on the cooking surface in Watt, rounded to the first decimal place

The AEC_{hood} of a domestic range hood is calculated as:

i) for the fully automatic domestic range hoods

$$AEC_{hood} = \left[\frac{(W_{BEP} \; x \; t_H \; x \; f) + (W_L \; x \; t_L)}{60 + 1000} + \frac{P_0 \; x \; (1440 - t_H \; x \; f)}{2 \; x \; 60 \; x \; 1000} + \frac{P_S \; x \; (1440 - t_H \; x \; f)}{2 \; x \; 60 \; x \; 1000}\right] x \; 365$$

ii) for all other domestic range hoods:

$$AEC_{hood} = \left[\frac{(W_{BEP} \; x \; t_H \; x \; f) + (W_L \; x \; t_L)}{60 + 1000}\right] x \; 365$$

Where:

t_L is the average lighting time per day, in minutes (tL = 120)

t_H is the average running time per day for domestic range hoods, in minutes (tH = 60)

P_0 is the electric power input in off mode of the domestic range hood, in Watt and rounded to the second decimal place

P_s is the electric power input in standby mode of the domestic range hood, in Watt and rounded to the seond decimal place

f is the time increase factor, calculated and rounded to the first decimal place as

$$f = 2 - \frac{(FDE_{hood}\ x\ 3.6)}{100}$$

The FED_{hood} is the fluid dynamic efficiency and it is calculated at the best efficiency point by the following formula, and is rounded to the first decimal place

$$FDE_{hood} = \frac{Q_{BEP}\ x\ P_{BEP}}{3600\ x\ W_{BEP}}\ x\ 100$$

Where:

Q_{BEP} is the flow rate of the domestic range hood at best efficiency point, expressed in m3/h and rounded to the first decimal point

P_{BEP} is the static pressure difference of the domestic range hood at best efficiency point, expressed in Pa and rounded to the nearest integer

W_{BEP} is the electric power input of the domestic range hood at the best efficiency point, expressed in Watt and rounded to the first decimal place.

Further annexes prescribe obligatory information for product fiche, technical documentation, distribution and marketing.

All the values presented in Table 9 and Table 10 are subject to revision (rescaling) in this preparatory study. According to energy label regulation, “rescaling” means an exercise making the requirements for achieving the energy class on a label for a particular product group more stringent. REG 2017/1369 states that:

> The Commission shall review the label with a view to energy classes rescaling if it estimates that:
>
> (a) 30 % of the units of models belonging to a product group sold within the Union market fall into the top energy efficiency class A and further technological development can be expected; or
>
> (b) 50 % of the units of models belonging to a product group sold within the Union market fall into the top two energy efficiency classes A and B and further technological development can be expected.

Also on the matter of rescaling, REG 2017/1369 states that:

> For several labels established by delegated acts adopted pursuant to Directive 2010/30/EU, products are available only or mostly in the top classes. This reduces the effectiveness of the labels. The classes on existing labels, depending on the product group have varying scales, where the top class can be anything between classes A to A+++. As a result, when customers compare labels across different product groups, they could be led to believe that better energy classes exist for a particular label than those that are displayed. To avoid such potential confusion, it is

appropriate to carry out, as a first step, an initial rescaling of existing labels, in order to ensure a homogeneous A to G scale.

A newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised. In exceptional cases, where technology is expected to develop more rapidly, no products should fall within the top two classes at the moment of introduction of the newly rescaled label.

1.3.1.3 Potential issues of current Ecodesign and Energy labelling regulations on domestic cooking appliances

Ovens: Including energy consumption of pre-heating phase in product information requirements

According to stakeholders, the inclusion of the preheating phase in the energy consumption declaration should be explored, as it is the way consumers use their oven (in France people that always preheat their oven are 29%, and most of the time are 40%). Policy recommendations on this topic will be made in section 7.3.4.9.

Ovens: Including energy consumption of self-cleaning systems in product information requirements

The inclusion of information on the energy consumption of the cleaning function should be explored. A French ECUEL study (1995) showed that 44% of the people use the pyrolytic function. On the whole sample, pyrolytic cycles correspond to 10.8% of the total oven consumption. When people use it, pyrolytic function covers 25% of the total energy consumption. Policy recommendations on this topic will be made in section 7.3.4.8.

Hobs: Intermediate rounding in energy efficiency of gas hobs

Regarding gas hobs, the intermediate rounding to the 1st decimal, requested in Reg. 66/2014 (Annex II, clause 2.2) and in EN 30-2-1:2015 (clause 5.2.1) for $E_{theoric}$ and E_{gas} of the burner should be re-evaluated or removed. Otherwise, a small difference in the input data gives a big difference in the final result. Previous versions of EN 30-2-1 did not include that rounding.

Range hoods: Real-life representativeness

According to stakeholders, current indexes may not be reflecting real life usage in the case of range hoods, since the energy efficiency rating is based on a measurement at the best efficiency point (BEP). The BEP is defined by the highest value of flow rate times pressure divided by power input. The BEP is usually at pressures that are much higher than pressures in real applications. The change in efficiency from high to low pressures can differ between models. Therefore, the energy efficiency rating should be based on measurements at lower pressures which resemble an average scenario in households. This is supported by several stakeholders, who also indicated that the actual Energy Label and Ecodesign Regulation pushed manufacturers to increase more and more the energy efficiency of the product with the focus on maximum available speed (even in boosted mode) because the measurement of Annual Energy Consumption (AEC) and EEI take into consideration just this setting; the result is that the energy efficiency of the other available speeds is rather low. Market analysis, on the contrary, shows that the product is used at all available speeds and in particular at minimum and maximum not boosted speeds, and that the boost setting is activated few times, just in situations with high level of fumes and vapour, because of the noise generated by the hood itself that increase with the speed. For this reasons, they suggest to review the method for the calculation of AEC and EEI in the direction to be more and more consistent with user behaviours and so taking into consideration all the speeds declared in the actual product fiche and not just the maximum even in boosted (if any).

Stakeholders recommend to change the measurement of efficiency from best efficiency point to typical uses, with a typical pressure drop over the exhaust piping. In the current standard the fluid dynamic efficiency (FDE) is determined in the best efficiency point, defined as the point where FDE is the highest. However, in practice, the range hood is seldom operating in the best efficiency point, thus the FDE results in an efficiency which is different from a normal working point of the appliance. Therefore, to allow the evaluation of efficiency of range hoods in typical working conditions, it is proposed to develop a pressure – airflow curve and the corresponding electric power curve for the minimum and maximum continuous modes and for the boost mode, and to include these in the test reports together with the efficiencies calculated based on the measurements. Then, it will be possible to base ecodesign regulation and energy labelling on energy efficiency requirements at a typical working point for the fume extractors.

With the aim of solving some of these issues, CENELEC WG 8 is currently working in an update of the FDE measuring method, to take into account a profile of use which is more representative of the real life usage of consumers. This new method is commonly known in the industry as the 9 point method. This method is described in more detail in Section 4.3.3.2 of this report.

Range hoods: Capture efficiency

In a study from the Swedish Energy Agency (Blomqvist et al, 2019) the authors provide recommendations for a modification in the ecodesign and energy labelling regulations for range hoods. The rationale behind these modifications is based on the fact that current regulation is based only on energy efficiency in relation to airflow and pressure, but not on the primary function of a range hood, which is capture efficiency.

In their view, a range hood with a higher airflow could have the same labelling as a hood with a significantly lower airflow, whereas the ideal case would be to promote low airflow hoods (low energy consumption hoods) with high odour removal efficiencies. Therefore, current ecodesign and energy labelling regulations for range hoods do not reward high efficiency and does not drive manufacturers towards more energy efficient products, guiding the end-users to purchase not optimal products.

The authors recommend that regulations should be based on a calculation which considers the aspects below:

- efficiency of capture cooking odour
- energy consumption of heating or cooling of replaced air
- energy consumption of range hood

The study that supports this proposal shows the results of the methodology applied to several hoods including those without motor installed in central ventilation systems. The results prove that the central ventilation configuration would result in annual energy consumptions one order the magnitude lower than range hoods equipped with an electric motor. The effect of the energy consumption of heating or cooling of replaced air does not compensate the pressure losses due to the charcoal filter in recirculating hoods, which result in annual energy consumptions one order of magnitude higher.

In the study, the authors provide a method in which the Energy Efficiency Index (EEI) could be improved in order to capture all those aspects.

Other stakeholders expressed their disagreement with this proposal, arguing that the energy efficiency of a product should not depend on external factors, such as heating or cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers. Besides, moisture, grease and pollutants from cooking need to be eliminated and, in many cases, the most efficient way is expelling the fumes out of the building.

Range hoods: EEI and lighting efficiency

With regards to lighting efficiency in range hoods, a stakeholder argues that the technology driven efficiency of the lighting system has come to a maximum, so that the light itself is no longer a quantitative aspect of the overall efficiency/main label aspect. In parallel, the fluid dynamic efficiency is measured only in one point of the highest level at the best efficiency point. This FDE runs into a factor "f" which is considered within the EEI. The EEI can be "optimized" by reducing the lights brightness to simply reduce the power consumption. This has no negative effect on the sub-label of light since there, only Lux per Watt is relevant. As mentioned before, in the main part of the label - the scale - a bright appliance with a good lighting system will be punished in future. The sub label of light (icon below the energy efficiency scale on the label), based on Lux per Watt, will be not affected and could be preserved. Due to the limit of LED technology, Lux per Watt becomes a constant value. If you want to have a brighter light you need to linearly increase your power consumption. This is a tolerated mechanism in other devices, but not in the main- and sublabel. For appliances which are integrated into furniture, there is room for different interpretations regarding light and noise labelling. A recommendation from APPLiA is eliminating the Light efficiency calculation from EEI formula, considering that there is only Light Emission Diode (LED) now in the new generation range hoods and LED are separately regulated by Lighting ED regulation. However, other stakeholders, such BAM, do not agree with this proposal, and only recommend to eliminate the icon from the label.

Also related to the time increase factor "f", another stakeholder points out that this factor is rounded to the first decimal place in current standards calculations. However, this may have a strong influence on FDE and EEI. For instance with W_{BEP} = 100W and WL = 10W:

f = 0,752 is rounded to 0.8; EEI = 43.4 = A+

f = 0.748 is rounded to 0.7; EEI = 48.2 = A

Their suggestion is to round f to the second decimal place.

<u>Range hoods: Verification tolerances</u>

In terms of verification tolerances in range hoods, several comments have been made by stakeholders. One of them indicates that Q_{BEP}, P_{BEP} and W_{BEP} have a verification tolerance of 5 %. However, the best efficiency point is the maximum of a curve that can have a small slope (long horizontal line) around the maximum. For such a curve the values of the determined Q_{BEP}, P_{BEP} and W_{BEP} vary greatly with just small disturbing factors in the measurement. Furthermore, the test standard does not restrict the air density in the test room. A change in air density causes a change in two or sometimes all three parameters. Laboratories at different altitudes will test in different air densities. A round robin test in five laboratories on two range hoods conducted by the Federal Institute for Materials Research and Testing in Germany gave relative standard deviations of: 8.2 % for Q_{BEP}, 6.0 % for P_{BEP} and 6.1 % for W_{BEP}. Deviations between parameters partially compensated when calculating the fluid dynamic efficiency (FDE) which had a relative standard deviation of 5.0 %. For example, when a laboratory had the same Q_{BEP} but a higher P_{BEP} then it also measured a higher W_{BEP}. Therefore, it is suggested that the verification tolerance is set for the FDE instead of Q_{BEP}, P_{BEP} and W_{BEP}.

The same stakeholder adds that in the round robin test the grease filtering efficiency had a relative standard deviation of 5.2 %. Thus, a verification tolerance of 5 % is too restrictive. Small improvements are possible by a more thorough description in the standardization. However, no major leaps in an improved reproducibility are expected. A verification tolerance of 8 % might be justified.

Finally, they argue that lighting with LEDs demands low power inputs. A tested range hood on the market had a declared value of WL = 3.3 W. For this case the verification tolerance of 5 % relates to an absolute tolerance of 0.165 W. This accuracy is difficult to achieve for interlaboratory comparisons. A minimum absolute tolerance of 0.3 W could be added to the relative tolerance of 5 %.

Another stakeholder recommends not to define verification tolerances on Q_{BEP}, P_{BEP} and W_{BEP}, but to define a verification tolerance on FDE (e.g. 8%), which is the consumer relevant parameter. FDE is also less sensitive to measurement uncertainties.

They add that currently the verification tolerance on sound power level (LwA) is 0%. As a consequence, reported sound levels are higher than actual sound levels. Use an absolute verification tolerance of 2dB (A). Differences below 3dB (A) can hardly be heard by non-professionals.

1.3.2 EU safety legislation

- **<u>Low voltage Directive (LVD) 2014/35/EU</u>**

The purpose of the LVD Directive (European Parliament 2014) is to ensure that electrical equipment on the market fulfils the requirements providing a high level of protection of health and safety of persons and of domestic animals and property, while guaranteeing the functioning of the internal market. The directive applies to electrical equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current and between 75 and 1500 V for direct current, which is new to the union market when it is placed on the market (for example, a new electrical equipment made by a manufacturer established in EU-27 or new or second-hand imported from a third country).

Manufacturers of electrical equipment covered by Directive are obliged to carry out the conformity assessment procedure. The Conformité Européene (CE) marking, indicating the conformity of electrical equipment, is the visible consequence of a whole process comprising the conformity assessment.

- **<u>Electromagnetic compatibility Directive (ECD) 2014/30/EU</u>**

ECD 2014/30/EU (European Parliament 2014) aims to ensure the functioning of the internal market by requiring equipment to comply with an adequate level of electromagnetic compatibility, i.e. the ability of equipment function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment.

Equipment shall be so designed and manufactured, having regard to the state of art, as to ensure that:

- the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;
- it has a level of immunity to the electromagnetic disturbance to be expected in this intended use which allows it to operate without unacceptable degradation of its intended use

Manufacturers of equipment covered by this Directive are obliged to carry out the conformity assessment procedure. The CE marking, indicating the conformity of apparatus, is the visible consequence of a whole process comprising conformity assessment. Equipment shall be accompanied by information on any specific precautions that must be taken when the apparatus is assembled, installed, maintained or used, in order to ensure that, when put into service, the apparatus is in conformity with the essential requirements set out in the directive.

1.3.3 EU legislation on substances, material and resource efficiency and end-of-life

In Annex I, part 1.3 the Ecodesign Directive 2009/125/EC defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to the Directive 2009/125/EC (European Parliament 2009a), this includes

- *Ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, complexity of tools necessary for disassembly, use of component and material coding standards for the identification of components and materials suitable for reuse and recycling (including making of plastic parts in accordance with ISO standards), use of easily recyclable materials, easy access to valuable and other recyclable components and materials; easy access to components and materials containing hazardous substances*
- *Incorporating of used components;*
- *Avoidance of technical solutions detrimental to reuse and recycling of components and whole appliances*

This section identifies and provides an overview of legislation in the EU for the products in scope with focus on resources use and material efficiency.

- **EU RoHS Directive 2011/65/EU**

The Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (commonly referred to as RoHS 2) restricts the use of certain hazardous substances in electrical and electronic equipment to be sold in the EU and repeals Directive 2002/95/EC from 3rd of January 2013 (European Parliament 2011)

The RoHS-Directive restricts the presence of the substances listed in Annex II of the Directive, currently including the following substances: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PDBE).

The RoHS-Directive limits the presence of these substances in electrical and electronic equipment to be placed on the EU market, to concentrations not exceeding 0.1% by weight of homogenous material. For cadmium the threshold level is at 0.01%.

Exemptions from these provisions are only possible, provided that the availability of an exemption does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006, and that at least one of the following conditions is fulfilled:

- Substitution is not possible from a scientific and technical point of view;
- The reliability of substitutes is not ensured;
- The negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the benefits;

Decisions on exemptions and on their duration may also take into consideration the following aspects, though it is understood that these do not suffice on their own to justify an exemption:

- The availability of substitutes;
- Socio-economic impacts of substitution;
- Impacts on innovation; and
- Life-cycle thinking on the overall impact of an exemption;

Applications for granting, renewing or revoking exemptions have to be submitted to the European Commission in accordance with Annex V of the Directive, and are required to include among others a justification including comprehensive information on the substance-application and possible substitutes. All applications undergo a technical analysis as well as a stakeholder consultation.

In general, applications exempted from the restriction are listed in Annex III of the RoHS Directive. As most of the exemptions are very specific, it is not possible to generalise certain topics for household appliances. Possible exemptions might be for example lead in various alloys (steal, copper, aluminium) probably being relevant for housings, though depending on the applied housing materials, as well as other components for which such alloys are in use. Theoretically, another example of exemptions might be Compact Fluorescent Light (CFL) backlight systems if still being used in displays, although it is assumed that most displays have been shifted to LED backlight systems.

- **EU WEEE Directive 2012/19/EU**

The Directive 2012/19/EU (European Parliament 2012a) on waste electrical and electronic equipment (commonly referred to as WEEE-Directive) regulates the separate collection, treatment and recycling of end-of-life electrical and electronic equipment. Directive 2012/19/EU requires Member States to achieve quantitative collection targets (e.g. 65% of the average weight of EEE placed on the market in the three preceding years). It also requires Member States to ensure that producers provide for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE (Article 12).

The WEEE-Directive classifies EEE in various categories. From 15 August 2018 the domestic ovens, hobs and range hoods might not be classified in one single category, as before into the "large household appliances", but instead they fall under the following new categories:

- Category 1: Temperature exchange equipment; in the case of domestic ovens;
- Category 2: Screens, monitors, and equipment containing screens having a surface greater than 100 cm^2; this category might apply to domestic ovens in case of having a large control panel.

– Category 4: Large equipment (any external dimension more than 50 cm); this category will mainly apply to household ovens

Annex V of the Directive also contains minimum targets for recovery and recycling. For the initial category 1 equipment (large household appliances), these targets are 85% for recovery and 80% for re-use and recycling. Furthermore, Annex VII of the Directive specifies substances, mixtures and components that have to be removed from any collected WEEE for selective treatment. However, different interpretations by recyclers can be found: removal before or after shredding.

- **EU REACH Regulation 1907/2006/EC**

The Registration, Evaluation, Authorisation and Restriction of Chemicals regulation (also known as REACH Regulation (European Parliament 2006b)) entered into force 1 June 2007. Under the REACH Regulation, certain substances that may have serious and often irreversible effects on human health and the environment can be identified as Substances of Very High Concern (SVHCs). If identified, the substance is added to the Candidate List, which includes candidate substances for possible inclusion in the Authorisation List (Annex XIV). Those SVHC which are included in Annex XIV become finally subject to authorisation. By this procedure REACH aims at ensuring that the risks resulting from the use of SVHCs are controlled and that the substances are replaced where possible.

In this regard, REACH also introduced new obligations concerning general information requirements on substances in articles. Producers and importers of articles that contain SVHC included in the candidate list, will be required to notify these to the European Chemicals Agency (ECHA) if both of the following conditions are met:

– The substance is present in those articles in quantities totalling over 1 t/y per producer or importer;

– The substance is present in those articles above a concentration of 0.1% weight by weight (w/w).

Notification will not be required in case the SVHC has already been registered for this use by any other registrant (Article 7(6)), or exposure to humans or environment can be excluded (Article 7(3)).

In addition, Article 33(1) requires producers and importers of articles containing more than 0.1% w/w of an SVHC included in the candidate list, to provide sufficient information to allow safe handling and use of the article to its recipients. As a minimum, the name of the substance is to be communicated.

The provisions of Article 33(1) apply regardless of the total amount of the SVHC used by that actor (no tonnage threshold) and regardless of a registration of that use. Furthermore, this information has to be communicated to consumers, on request, free of charge and within 45 days (Article 33(2)).

The above mentioned Candidate list is updated regularly (two to three times a year). At July 2019, 201 substances are on the list. Several of these substances can be present in ovens, hobs or range hoods, e.g. plasticisers in seals.

- **EU CLP Regulation 1272/2008/EC**

The Classification, Labelling and Packaging regulation (also known as CLP Regulation (European Parliament 2008)) entered into force 20 January 2009. The purpose of the CLP Regulation is to identify hazardous chemicals and to inform their users about particular threats with the help of standard symbols and phrases on the packaging labels and through safety data sheets. The purpose of the globally harmonised system (UN-GHS) is to make the level of protection of human health and the environment more uniform, transparent and comparable as well as to simplify free movement of chemical substances, mixtures and certain specific articles within the EU.

Substances had to be classified until 1 December 2010 pursuant to Directive 67/548/EEC and mixtures until 1 June 2015 pursuant to Directive 1999/45/EC. Differing from this provision, the classification, labelling and packaging of substances and preparation may already be used before 1 December 2010 and 1 June 2015 in accordance with the provisions of the CLP/GHS-Regulation. After these dates the provisions of the CLP-Regulation are mandatory. The REACH-Regulation is complemented by the CLP Regulation.

1.3.4 Third country regulation

USA

The National appliance energy conservation act of 1978, amended the Energy Policy and Conservation Act (EPCA) to establish prescriptive standards for gas cooking products requiring gas ranges and ovens with an electrical supply cord that are manufactured on or after January 1990 not to be equipped with a constant burning pilot light.

DOE undertook a study and concluded in 1998 that no standards were justified for conventional electric cooking products at that time. In addition, partially due to the difficulty of conclusively demonstrating that elimination of standing pilots for conventional gas cooking products without an electrical supply cord was economically justified, DOE did not include amended standards for conventional gas cooking products in the final rule.

In 2009 DOE published a rule amending the energy conservation standard for conventional cooking products to prohibit constant burning pilots for all gas cooking products (i.e. gas cooking products either with or without an electrical supply cord) manufactured on or after April 2012. DOE decided to not adopt energy conservation standards pertaining to the cooking efficiency of conventional electric cooking products because it determined that such standards would not be technologically feasible and economically justified at that time. This rule was requested to be revised not later than 6 years after its issuance.

ENERGY STAR, the voluntary labelling program managed by the U.S. Environmental Protection Agency (EPA), sets compliance thresholds of energy efficiency for the certification of professional kitchen appliances. It is based on the ASTM standards and their parameters, which are described in section 1.2.2.

Brazil

Domestic gas ovens

In Brazil, energy labelling is already implemented in a voluntary or mandatory mode for gas cooking appliances. The oven gas consumption index is calculated as follows:

$$I_c\ (\%) = 100\ \frac{(measured\ gas\ consumption\ for\ oven\ 210C\ temp\ maintenance)}{(max\ admissible\ gas\ consumption\ for\ oven\ temp\ maintenance\ calculated\ by\ the\ standard)}$$

In the particular case of natural gas ovens, the gas consumption is the following:

$$I_c\ (\%) = 100\ \frac{\left(\frac{C}{0.0903}\right)}{(0.93 + 0.035 * V)}$$

Where C is the gas consumption in kg/h and V the volume in litres

Domestic gas hobs

In Brazil, energy label is implemented for gas hobs appliances. The cooking table burner individual energy efficiency is defined as the ratio between the measured heat absorbed by the water in a standard pan and the thermal energy theoretically available to be transferred to water on the gas fuel burn due to its calorific power. The cooking table efficiency index is defined by dividing the sum of the individual efficiencies by the number of burners.

Canada

All residential cooking appliances are subject to Canada's *Energy Efficiency Regulations*, which set a performance standard for their energy consumption. This helps keep the least efficient products off the Canadian market. In addition, they must have an EnerGuide label that informs how much energy a model uses (except from the gas ranges).

The Canadian regulation does not include an energy label or an energy star specification to qualify the cooking appliances because the energy consumption between different models is small. The minimum energy performance standards applied to household ranges that are:

- Free-standing appliances equipped with one or more surface elements and one or more ovens
- Built-in appliances equipped with one or more surface elements and one or more ovens
- Built-in appliances equipped with one or more ovens and no surface elements
- Wall-mounted appliances equipped with one or more ovens and no surface elements
- Counter-mounted appliances equipped with one or more surface elements and no ovens

The Canadian MEPS do not cover the following

- Appliances designed for an electrical supply of 120 volts
- Household appliances with one or more tungsten-halogen heating elements.

The EnerGuide (Figure 11) informs about the energy consumption of an appliance and allows comparison between the model and the rest of the models on the market. The EnerGuide label is a mandatory for all cooking appliances except gas ranges. It must be easy to see on the outside or inside the product. The label shows the product type, the model number and average energy consumption in kWh/year. A scale shows how the model performs in comparison with other models: the lower the number, the more energy efficient the product.

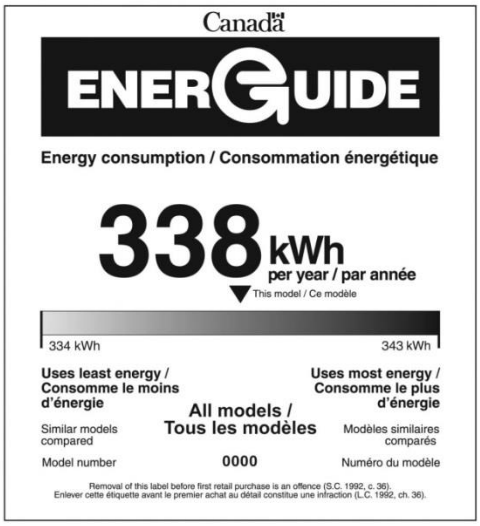


Figure 11. EnerGuide for cooking appliances in Canada

Regarding the energy efficiency regulation in Canada, there are two regulations that apply to gas range and electric range respectively.

A) Gas range

A gas range, according to the regulation, is a household propane or natural gas range that has an electrical power source, and is used for food preparation and provides one of the following functions: surface cooking, oven cooking, or broiling. This applies to appliance manufacturer on or after February 1995. There is no a testing standard associated with this regulation.

The energy efficiency requirement sets up that it must not have a continuously burning pilot light.

In addition to the minimum energy efficiency requirements, the regulation indicates that the following energy efficiency report requirements should be delivered;

- Name of the product
- Brand name
- Model number
- Manufacturer
- Volume of usable oven space in liters
- Whether the range is built-in or free standing
- Whether the broilers are open or closed
- Whether a mathematical model as defined in the regulations was used to generate any of the information provided.

<u>*B) Electric range*</u>

Electric range, is defined in this regulation as, *a household electric range. It does not include a portable range that is designed for an electrical supply of 120 V or a microwave oven.* The regulation is in force since 2013 and refers to the testing standard CAN/CSA-C358-03.

The minimum energy efficiency performance (in kWh/year) depends on the type of product (range, cooktop or oven) and is related to cavity volume in the case of ranges and ovens.

China

China set minimum allowable values of energy efficiency and energy efficiency grades for household induction hobs. This mandatory programme specifies the minimum allowable values of energy efficiency, evaluating values of energy conservation, energy efficiency grades, test methods and inspection rules of household induction hobs. It applies to household induction hobs with one or multiple heating units and the rating power of one heating unit is from 700 to 2800W. Commercial induction hobs, power frequency induction hobs and concave induction hobs are not included in the scope of this standard.

Japan

“Top Runner” is a Japanese programme in which energy consumption of domestic gas cooking appliances is tacked. Top Runner is mandatory but is not a MEPS. Manufacturers and importers are under the obligation to comply with the standards by Energy conservation law. Enforcement within the Top Runner Programme relies on ‘blame and shame’ that works well in Japan. The following information shall appear on the label:

- Fiscal year of the label
- Manufacturer and model
- Expected annual electricity bill with the concerned device
- Rating system

In case of non-compliance, the name of the company and fine are made publicly available.

Russia

The Gosurdarstvennyy Standart (GOST) R 51388-99 lays down the rules for delivering the information about energy performance of domestic electric appliances to consumers. The standard determines the general requirements, the rules and the amount of information to be given to consumers as well as energy performance classes, indices of saved energy costs, and other parameters of appliances.

Electric cooking ranges and ovens are in the list of domestic electric appliances which require a labelling scheme. Information about efficiency performance is delivered by providing an energy performance label, which contains indicators of energy efficiency and data on compliance of these indicators with requirements of respective standards. Energy labels are assigned to the appliances for a period of three years at most. The indicators of energy performance of appliances are described in GOST R 51541-99. GOST 14919-83 sets energy performance requirements of domestic electric cooking ranges, cooking plates and cooking ovens. An average consumed power can be calculated according to the formula that includes the size, the number of cycles and the time.

Costa Rica

Costa Rica has a programme of labels that must be placed on products prior to leaving the factory or customs. Non-compliance results in a fine of 25% of the product sale price. The label displays the products energy consumption and the required MEPS level for that compliance.

1.4 Recommendations

1.4.1 Preliminary product scope

In Section 1.1 of Task 1, a review has been completed on domestic cooking appliances regarding definitions and scope. Preliminary recommendations on these two aspects are summarized below.

Definitions

The definitions of domestic cooking appliances making use of data from Eurostat (NACE Rev2 database) is not straightforward. First, there are several product codes which could be interpreted as falling within the scope of this study, as presented in Table 4. Although there is a high level of granularity in the data available in NACE Rev2 database for domestic cooking appliances, the definitions of ovens and hobs are not obvious, since there are overlaps between these two product types. As it can be seen in Section 1.1.2.2 of this report, certain product categories refer to only one of those type of appliances (such as 27.51.28.70: *"Domestic electric ovens for building-in"*), whereas other categories refer to appliances which include both (27.51.28.10: *"Domestic electric cookers with at least an oven and a hob"*).. For this reason, in Task 2 of this Review Study, a differentiation will be made between "standalone ovens", "standalone hobs" and "ovens with hobs" (also known as cookers or ranges). On the contrary, the definition of domestic range hoods is simple in NACE Rev2 database, making the analysis of data for this appliance easier and straightforward.

In the case of commercial and professional appliances, Eurostat does not provide a high level of granularity, as only three categories are available: bakery/biscuit ovens, infra-red radiation ovens and equipment for cooking/heating food. Using this product classification, there is no clear differentiation between ovens, hobs and range hoods. No detailed data is provided either regarding energy source of commercial and professional cooking appliances.

Product definitions are clearer in Regulation (EU) No 65/2014 on Energy labelling and Regulation (EU) No 66/2014 on Ecodesign. Ovens, hobs and range hoods are clearly distinguished and further product category definitions are provided for each of them (for instance, definitions are provided for *small*, *portable* and *microwave* ovens). In addition to that, regulation defines its scope as "*domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes*". Therefore, current legislation seems to acknowledge the possibility of using these appliances outside the household sphere.

Some modifications were suggested by stakeholders that are taken into account in this preliminary scope proposal. Based on the information available, the following changes on the definitions of domestic cooking appliances covered by current legislation are recommended:

- In order to align to terms of the standard, use the term “cooking fume extractors” instead of range hoods.
- In order to include the filtration function and recirculation systems: in the definition of range hoods and to align the definitions with the IEC 61591
    - *Cooking fume extractor: appliance with a fan and filter intended to collect and treat cooking fumes, which can be operated in recirculation mode or extraction mode.*
    - *Range hood: cooking fume extractor installed over a cooking appliance.*

  - *Recirculation mode: mode of a cooking fume extractor that discahges the air back into the room, which includes an odour-reduction filter.*
  - *Extraction mode: mode of a cooking fume extractor that discahges the air to the outside of the building by means of ducting.*

- In order to better reflect induction technologies in the definition of electric hobs:

  Electric hob means an appliance or part of an appliance which incorporates one or more cooking zones and/or cooking areas including a control unit and which is ~~heated~~ supplied with electricity"

Other definitions suggested by stakeholders are aimed to improve the performance tests and limit the leeway allowed to manufacturers to choose the settings. In particular, the following definitions were proposed for ovens:

The standardised cycle to be tested is the most basic mode that allows baking or roasting all kind of foods on one or more oven levels at the same time with or without fan.

Ecomode is the mode that allows save energy compared to the standardised cycle. It should be defined in the user manual what it allows to cook, what are its limits.

In the current regulation, the definition of microwave heating is the following: "Microwave heating means heating of food using electromagnetic energy." It is proposed to be by "…heating of food by exposing it to electromagnetic radiation in the microwave frequency range."

Scope

Domestic appliances such as ovens or hobs using energy sources beyond electricity or gas, microwaves, portable ovens, small ovens, outdoor cooking appliances, among others, are not included within the scope of the current regulations. There are divergent views among stakeholders about their inclusion in the scope of this review. There is broad agreement regarding some specific products, which should be covered by the scope according to stakeholders:

- Combi steam oven. They are within the scope of current ecodesign and energy labelling regulation, due to their market relevance. In current and future versions of EN-60350 they are only tested in their conventional or convection modes. There is certain debate around the need of developing tests for each function (including steam function).
- Gas-cooking appliances designed for use only with LPG.
- Range hoods without lights

There is no similar agreement regarding the exclusion of the following products proposed by some stakeholders:

- Solo microwave ovens. Considering the size and market growth of microwave ovens, it might be necessary to reconsider their inclusion in ecodesign/energy labelling regulation. For products with lower savings potential as these, the starting point could be an energy label, as well as information requirements to foster innovation and differentiation.
- Ovens including a combined-microwave functionality, which represent a trend in the market, might be covered by ecodesign and energy labelling regulation, but only for their conventional and/or fan-forced modes. This could close a potential loophole for products with microwave function. Another possibility would be to develop a test method to quantify the effect of the microwave function in a heating cycle, to show consumers the advantages of a combined microwave oven mode.
- Steam ovens. Solo steam ovens are out of the scope of current ecodesign and energy labelling regulation, due to their low market share (5% of EU stock in 2020). Most of stakeholders support this exclusion today.
- Grills and grill ovens
- Only recirculation cooking fume extractors
- Cooking fume extractors without integrated fan for use with a central fan.

The latter appliances are proposed to be incorporated in this preliminary scope in order to evaluate along the review process whether their current exclusion is still valid. For example, the exclusion of *ovens which offer 'microwave heating'* function needs to be reviewed since this microwave heating function may be becoming a standard feature. In any case, the reasons provided from stakeholders for their exclusion (i.e. low frequency of use, small market share, lack of performance test method) will be part of this review process.

Appropriateness of including professional cooking appliances within the project scope

A relevant topic at this point is the potential inclusion of professional cooking appliances under the project scope. In Article 7, ecodesign regulation 66/2014 indicates that:

> *The review of the regulation shall assess, amongst others, the inclusion of professional and commercial appliances.*

First of the aspects to consider is whether commercial and/or professional cooking appliances should have ecodesign and energy labelling regulation. Consulted on this aspect, stakeholders have mixed opinions.

Against the development of regulation, three main arguments are provided.

- Users of commercial and professional cooking appliances have very different needs to the users of domestic appliances. This leads to significantly different intensity of use, cooking options, temperature settings as well as performance and durability requirements.
- Commercial and professional products have a much wider variability than domestic products, making it more difficult to standardize requirements
- Commercial and professional products are often conceived as part of a system, with modular designed in combination with other appliances in the kitchen

In favour of developing regulation two main arguments are provided:

- The commercial and professional sector is potentially a high impact sector from the energy consumption point of view (initial exploratory calculations indicate it might be around half the energy consumption of the domestic market, with a significantly lower market share).
- Having ecodesign regulation could be a relevant driver to energy efficiency in the commercial/professional sector.

If regulation is developed for commercial and professional cooking appliances, stakeholders also have mixed opinions whether they should be covered under the same regulation as domestic appliances, or whether they should have their own specific regulation.

In favour of having the same regulation for domestic and commercial/professional cooking appliances, two main arguments are provided:

- The function of domestic and commercial/professional cooking appliances is essentially the same (cooking food), therefore they should be covered under the same ecodesign/energy labelling regulation.

- Separating the review of domestic cooking appliances regulation from the development of new regulation for commercial/professional appliances would delay the adoption of measures in this sector

In favour of having two different regulations (one for domestic and a new one for commercial/professional), two main arguments are provided:

- Different user needs and significant product variability would make it particularly difficult to establish requirements which are satisfactory for all product types. Incompatibilities of definitions, formulas and energy categories are expected if domestic and commercial/professional are included under the same regulation

– The lack of harmonized European standards for commercial/professional products complicates the fair comparison between products and the definition of minimum requirements and energy categories (availability of standards will be covered in detail in Section 1.2 of this report)

Considering the reasoning above provided by relevant stakeholders, it has been concluded that regulation for commercial/professional cooking appliances is necessary, since it is potentially a high impact energy consumption sector with possibilities for improvement. Regulation in the commercial/professional sector could boost innovation and be a driver for efficiency.

In order to provide appropriate ecodesign requirements, the regulation for commercial/professional cooking appliances is proposed to be specific and separated from the domestic cooking appliances regulation. This will ensure that every requirement and energy labelling category defined are suitable and meaningful, considering sector-specific user needs.

1.4.2 Standard methods and regulation

Ovens

- In current version of the regulation, manufacturers declare energy consumption based on their best performing heating mode. Manufacturers may use so called energy saving modes (eco-modes) for energy consumption declaration, modes which might differ greatly between similar products in terms of temperature profiles and that might not be able to cook appropriately some recipes. Several stakeholders indicate that it is important to clarify which heating mode should be used to declare energy consumption and to determine energy class.
- Another debate triggered by the use of the energy saving modes is whether it is capable to reach a sufficient cooking quality. Some stakeholders suggest that in some occasions, these modes lead to under or over cooking. In this regard, CENELEC is working to develop a test for measuring the cooking quality (so called Energy cake test). However, there are several issues to resolve to come up with a robust and reliable test, mainly related to the standardisation of ingredients and recipe and the reproducibility of the test.
- In current version of the regulation, energy consumption declaration is based on the energy consumption observed using different heating functions and temperature settings. However, if the highest of these temperatures cannot be reached by the oven, the standard requires using the maximum reachable value by the appliance. Although this has been highlighted as a potential issue by some stakeholders, the current testing method already takes care of this, as the final result in terms of energy consumption is based on an interpolation of the different temperatures considered. The interpolation temperature is the same for every oven.
- The volume of the oven cavity is used to calculate the Energy Efficiency Index. Due to the way that EN-60350 is written, manufacturers have an incentive to declare the biggest possible volume cavity when testing an oven. The text in the standard could be revised as it may lead to higher declared volumes and thus better EEI compared to real life usage.
- Pre-heating the oven is a widespread practice among consumers with a potentially significant energy impact. However, this practice is only required for a limited amount of recipes and is not considered an energy efficient user behaviour. Declaring energy consumption of the pre-heating phase could send a misleading message regarding the appropriateness of this activity. If results from the user behaviour study indicate that overall energy consumption of pre-heating is significant, different options to address this issue may be evaluated in this preparatory study.
- Self-cleaning systems such as pyrolysis are widespread feature in current domestic ovens that incur in large energy consumptions due to high temperatures required. Declaring energy consumption of self-cleaning systems is however difficult since currently there is no standard method to evaluate level of cleanliness of ovens, making the comparison of the performance of this feature not feasible.

Gas hobs

- Small (auxiliary) burners with a nominal heat input under 1,16 kW are not covered by the current standard, since the test procedure is not optimal for them (they are not normally used for boiling big amounts of water). If small burners are to be included in the scope of Ecodesign, a test should be developed
- The intermediate rounding of the energy efficiency of gas hobs should be removed to enable the repeatability of results.

Range hoods

- Real-life representativeness

The best efficiency point (BEP) defined by the highest value of flow rate times pressure divided by power input. The BEP is not the usual mode that range hoods operate in real life. Therefore, the energy efficiency rating should be based on measurements at lower pressures which resemble an average scenario in households.

It is recommended to follow the suggestions from stakeholders, and shifting the measurement of efficiency from best efficiency point to typical uses, with a typical pressure drop over the exhaust piping. To allow for this, stakeholders proposed to develop a pressure – airflow curve and the corresponding electric power curve for the minimum and maximum continuous modes and for the boost mode, and to include these in the test reports together with the efficiencies calculated based on the measurements. Then, it will be possible to base ecodesign regulation and energy labelling on energy efficiency requirements at a typical working point for the fume extractors.

- Odour reduction efficiency

There is a debate about whether the regulation should be based on the primary function of a range hood, instead of energy efficiency in relation to airflow and pressure. Those in favour of including the primary function performance in terms of capture efficiency argue that current ecodesign and energy labelling regulations push manufacturers towards high air flow products, instead of optimal products.

Following this reasoning, some stakeholders recommend that regulations should be based on a calculation which considers the aspects below:

- odour reduction efficiency
- energy consumption of heating or cooling of replaced air
- energy consumption of range hood

According to this proposal, the central ventilation configuration would be the most efficient, resulting in annual energy consumptions one order the magnitude lower than range hoods equipped with an electric motor.

Stakeholders against this proposal argue that the energy efficiency of a product should not depend on external factors, such as heating or cooling systems or ventilation systems, since it would discourage any technological progress within the reach of manufacturers and product designers. Besides, moisture, grease and pollutants from cooking need to be eliminated and, in many cases, the most efficient way is ducting the fumes out of the building.

In this regard, EN 61591 contains a test method for the odour reduction with the substance MEK. There are several issues around this test method, mainly that it is just appropriate to measure the odour reduction efficiency of recirculation hoods. This is due to the fact that but as the test is performed for a short distance between hob and hood, the odour reduction efficiency of ducted range hoods is always 100%, as it just depends on the capture efficiency, i.e. the airflow. Apart from that, the odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. However, this test method can be considered a good starting point with sufficient margin for improvement.

2 Task 2: Markets

The purpose of this task is to present the economic and market analysis related to the domestic and commercial ovens, hobs and cooking fume extractors within the scope of the revision regulations on Ecodesign and Energy Label. The aim of this section is, firstly, to place these product groups within the context of EU industry and trade policy.

Secondly, this section provides market and cost inputs for the assessment of EU-wide environmental impacts of the product group.

Thirdly, it aims at providing insights into the latest market trends in order to identify market structures and ongoing trends in product design. This market data will serve as an input for subsequent tasks such as the base-case analysis and improvement potential (task 5 and task 7 respectively).

Finally, the data on consumer prices and rates is to be used later in the study of the life-cycle-costs (LCC) calculations.

2.1 Generic economic data: analysis of Eurostat data

This section presents an economic analysis based on official European statistics provided by Eurostat[8] concerning production and trade data. For this section, the PRODCOM Annual Data on manufactured goods were extracted for the years 2008 – 2018. The PRODCOM statistics have the advantage of being the official EU-source that is also used and referenced in other EU policy documents regarding trade and economic policy, thus guaranteeing EU consistency.

PRODCOM data is based on products whose definitions are standardised across the European Member States and thus allow comparability between the Member State data. However, as mentioned in Task 1 under product definition, PRODCOM classification is not detailed enough to cover all the products identified in task 1 as there is no specific category for cooking appliances specifically in the PRODCOM database. However, there are several product categories that can be considered (Table 11).

Table 11. PRODCOM product categories related to cooking appliances

Product category	Description
27511580	Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side = 120 cm
27521115	Iron or steel gas domestic cooking appliances and plate warmers
27521190	Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric
27512833	Domestic electric hobs for building-in
27512835	Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)
27512870	Domestic electric ovens for building-in
27512890	Domestic electric ovens (excluding those for building-in, microwave ovens)
27521113	Iron or steel gas domestic cooking appliances and plate warmers, with an oven
27512810	Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)
28211330	Electric bakery and biscuit ovens
28211357	Electric infra-red radiation ovens
28931580	Non-domestic equipment for cooking or heating food

[8] https://ec.europa.eu/eurostat/web/prodcom/data/database

The above product categories have been divided in the first place between Domestic Appliances and Commercial Appliances. This document covers the analysis only for Domestic Appliances. Data will be presented graphically to establish differences between specific appliances, as explained below.

Cooking fume extractors are a relatively independent category from the rest and needs no aggregation with other categories:

- Appliances under PRODCOM category 27511580 *"Ventilating or recycling hoods incorporating a fan, with a maximum horizontal side = 120 cm*2" will be considered a "**cooking fume extractor**"

In the case of hobs (hobs which are sold isolated, without an oven), the below PRODCOM categories have been aggregated:

- Appliances under PRODCOM category 27521115 *"Iron or steel gas domestic cooking appliances and plate warmers"* will be considered a "**gas hob**"
- Appliances under PRODCOM category 27512833 *"Domestic electric hobs for building-in''* and every appliance under PRODCOM category '27512835 *"Domestic electric cooking plates, boiling rings & hobs (excluding hobs for building-in)"*, will be both considered as "**electric hobs**"
- Appliances under PRODCOM category 27521190 *"Other domestic cooking appliances and plate warmers, of iron or steel or of copper, non-electric",* will be considered a "**non-electric hob**"

Under domestic ovens, a distinction has been made between ovens and cookers (ovens with hobs together). In the case of **ovens**, PRODCOM database only contains electric ovens:

- Appliances under PRODCOM category 27512870 *"Domestic electric ovens for building-in*" and 27512890 *"Domestic electric ovens (excluding those for building-in, microwave ovens)*" will be considered an "**electric oven**". The first of those categories refers to what is also known in the industry as a 'wall oven', or an oven which is installed directly on a wall. The second of these categories refers to what is also known in the industry as a 'slide-in' oven or 'drop-in' oven. As it is not explicitly stated in the dataset titled, it is assumed that ovens under 27512890 do not include a hob on top of them. Unfortunately, the definition of these categories does not specify whether portable ovens are included.

In the case of **cookers**, PRODCOM database contains gas and electric ovens:

- Appliances under PRODCOM category 27521113 *"Iron or steel gas domestic cooking appliances and plate warmers, with an oven"* will be considered a "**gas cooker**".
- Appliances under PRODCOM category 27512810 *"Domestic electric cookers with at least an oven and a hob (including combined gas-electric appliances)*" will be considered a "**electric cooker**".

2.1.1 Domestic Cooking Appliances EU28 Production

As it can be observed in Table 12, more than 21.5 million units of cooking appliances were produced in the EU in 2018. The countries with the largest production volume in that year were Italy, Poland (both with more than 7 million units each) and Germany (3 million units). Other significant producers were Spain, France, Portugal and Romania, all of them with over half a million units produced in 2018.

Table 12. Domestic Cooking Appliances – EU28 Production

	Production (Units)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
EU28	36,211,659	37,495,114	28,386,050	22,937,009	23,568,566	23,279,865	23,012,964	25,110,192	25,923,847	21,590,706
Austria	0	0	3,964	0	0	0	0	0	0	0
Belgium	0	68,205	67,942	0	0	0	79,123	73,472	66,209	0
Bulgaria	29,791	29,153	22,291	23,714	128,608	33,784	230,084	327,527	219,606	25,887
Croatia	62,282	70,913	58,242	49,869	32,847	22,689	24,036	23,916	24,957	20,306
Cyprus	0	0	0	0	0	0	0	0	0	0
Czech Republic	0	0	0	0	1,250	0	148,276	0	0	0
Denmark	401	986	301	0	0	0	0	1,045	1,642	450
Estonia	104,936	134,103	115,953	107,316	123,722	131,265	113,302	99,189	124,158	151,977
Finland	65,749	84,240	87,781	32,013	15,794	15,580	16,967	17,626	17,383	13,877
France	1,311,238	1,537,643	946,062	832,346	404,640	245,572	271,494	637,048	685,056	531,308
Germany	5,628,908	6,178,750	2,423,548	2,276,133	2,169,888	3,543,068	3,604,799	3,894,092	2,085,104	3,093,057
Greece	86,518	299,786	148,309	56,001	50,058	664	171,758	139,523	3,086	2,479
Hungary	0	0	0	0	0	0	154,840	177,390	9,588	9,065
Ireland	0	0	0	0	0	0	0	0	0	0
Italy	20,688,931	19,952,378	17,071,434	12,206,058	12,530,833	11,025,180	9,650,898	9,617,671	12,240,142	7,788,821
Latvia	0	0	0	0	0	0	0	0	0	0
Lithuania	451	5,068	5,291	4,850	4,328	3,294	2,850	2,482	2,412	2,100
Luxemburg	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0
Netherlands	6,763	7,013	0	0	0	0	0	0	0	0
Poland	4,297,596	5,725,437	5,888,203	6,144,129	6,016,750	6,611,936	6,703,084	7,206,468	7,554,915	7,402,950
Portugal	164,200	169,144	157,987	193,599	496,737	580,569	599,189	506,087	569,910	603,935
Romania	588,457	1,972	8,880	5,037	5,759	558,097	568,407	281,270	563,417	518,145
Slovakia	110,301	149,915	112,975	97,415	81,735	76,179	153,239	358,720	366,237	361,528
Slovenia	0	0	0	0	0	0	28,265	0	0	0
Spain	2,642,891	2,607,929	857,781	647,609	1,147,958	431,988	484,802	1,051,111	983,381	923,547
Sweden	0	0	0	93,058	192,892	0	0	0	0	0
United Kingdom	422,246	472,479	409,106	167,862	164,767	0	7,551	695,555	406,644	141,274

Figure 12 shows the evolution of production volume between 2009 and 2018, by country. It can be seen that total volume in EU28 has decreased from over 35 million units in 2010 to 21.5 million in 2018. The largest decrease is observed in Italy, where 20 million units were produced in 2009, going down to 7.8 million in 2018. Production has also decreased significantly in Spain (from 2.6 million in 2009 up to 0.9 in 2018) and in Germany (from 5.6 to 3.1 million). On the contrary, production has grown in Poland over the period 2009-2018: from 4.3 to 7.4 million. It is difficult to determine whether this overall decrease is real or it is more related to issues with data quality, since there are significant data gaps in the PRODCOM database. For instance, there is no data available on electric hobs (PRODCOM categories 27512833 and 27512835) after 2011 for any of the EU28 countries. It seems likely that the decrease in production observed from 2012 onwards is related to this lack of data on electric hobs.

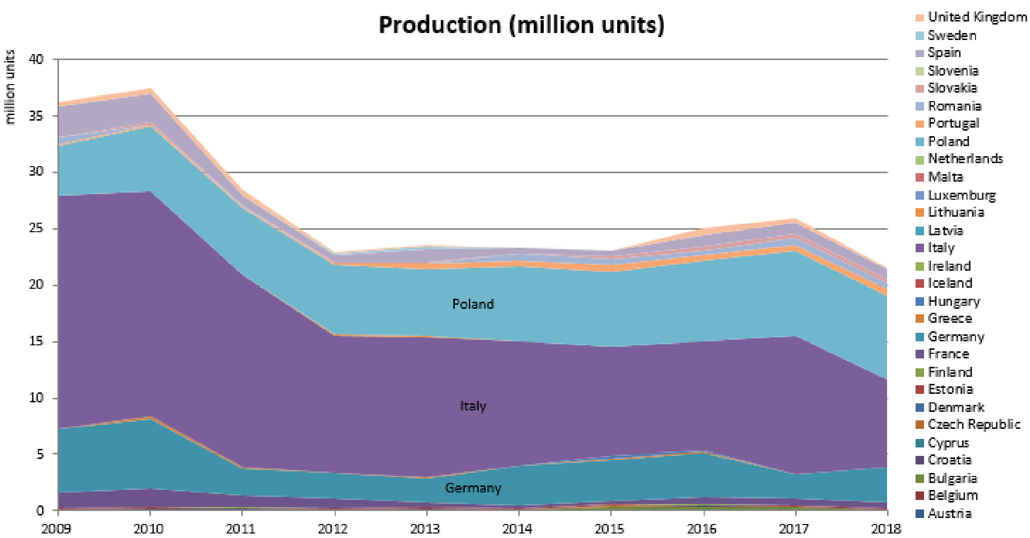


Figure 12. Production volume in units 2009-2018, per country

Figure 13 provides a breakdown of production per type of appliance. As it can be seen, more than 40% of units produced in 2018 were cooking fume extractors, followed by electric ovens (29%). This proportion has remained stable in EU28 for the past 6-7 years, being significantly different at the beginning of the period studied, when 25% of units produced were hobs and 13% ovens (cooking fume extractors and cookers remained similar as today). As it can be observed, production of electric hobs seems to fall considerably in 2011, although this drop might be related to the lack of data on production of electric hobs after that year.

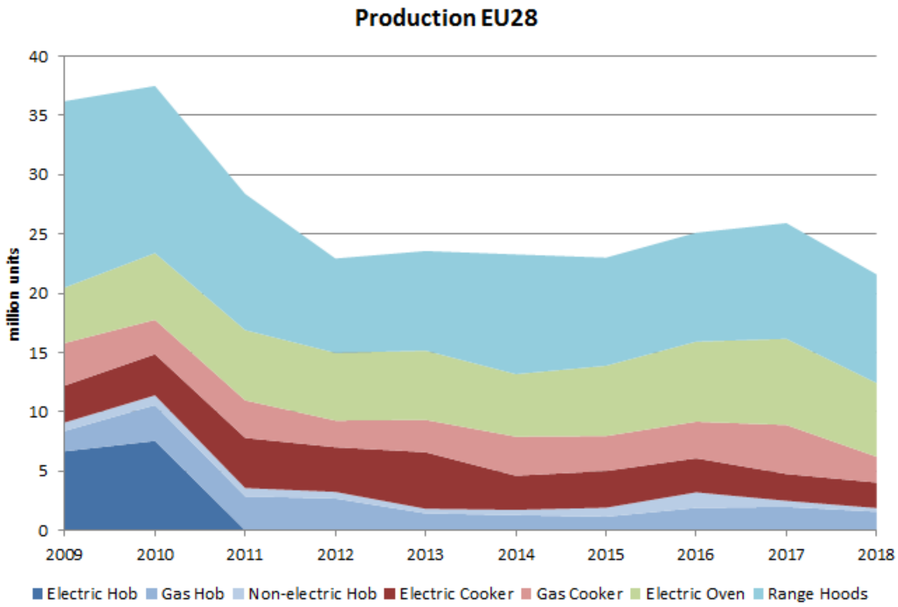


Figure 13. Production volume in units 2009-2018, per type of appliance

In order to evaluate which is the most common **energy source** of the appliances produced in EU28, an in-depth analysis has been carried out in Figure 14 (cookers data for 2009-2018). Over the past 10 years, production numbers have been oscillating without significant differences between them. In 2018, the share of electric and gas was equal. From this data, it appears that for cookers consumers seem to prefer equally electricity and gas. Consistent data from EUROSTAT was not available for hobs.

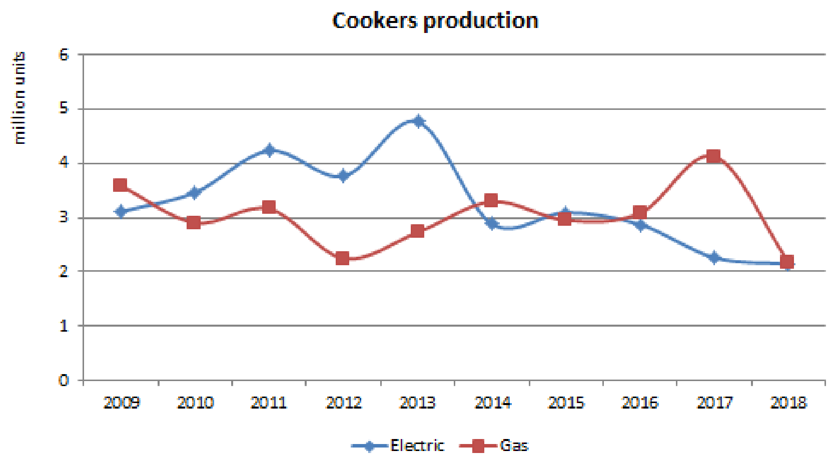


Figure 14. Cookers - Production

In terms of value, domestic cooking appliances market represented a total of 3,659 million Euros in the EU28. This is a 24% decrease when compared to 2009, where the value of this sector was 4,837 million Euros (Table 13).

Table 13. Domestic Cooking Appliances – EU28 Production

	Production (Million Euros)									
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
EU28	4,837.36	5,270.35	4,310.39	3,573.39	3,559.78	3,514.64	3,669.85	3,913.16	4,263.70	3,659.51
Austria	0.00	0.00	6.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belgium	0.00	36.39	37.77	0.00	0.00	0.00	44.04	43.92	41.79	0.00
Bulgaria	2.97	2.83	3.14	3.29	3.88	4.84	5.89	6.33	6.99	5.97
Croatia	10.47	12.09	11.14	10.89	7.56	5.38	5.90	5.76	6.02	5.62
Cyprus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Czech Republic	1.89	0.00	0.00	0.00	0.00	0.00	17.03	0.00	0.00	0.00
Denmark	0.68	1.66	0.45	0.00	0.00	0.00	0.00	0.02	0.01	0.44
Estonia	1.44	1.85	1.82	1.69	1.84	2.35	2.71	2.22	2.32	2.66
Finland	20.77	29.67	27.56	11.50	5.12	4.58	4.76	4.85	4.66	4.24
France	357.17	371.86	271.76	250.57	173.31	62.68	90.72	164.82	164.80	172.90
Germany	1,646.86	1,715.80	1,154.76	1,063.38	1,082.68	1,124.31	1,173.10	1,394.70	1,290.13	1,172.14
Greece	4.90	10.67	4.51	1.00	1.61	0.19	30.44	27.26	1.72	1.61
Hungary	0.00	0.00	0.00	0.00	0.00	0.00	1.80	1.90	0.08	0.07
Ireland	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Italy	1,463.25	1,616.59	1,685.99	1,334.28	1,234.66	1,364.73	1,299.99	1,272.54	1,553.27	1,262.98
Latvia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	0.10	1.90	2.17	1.98	2.24	1.36	1.19	1.13	1.02	0.94
Luxemburg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poland	530.84	658.53	673.98	703.88	694.69	696.90	743.56	690.58	804.33	735.33
Portugal	25.82	28.93	27.54	33.17	49.23	55.29	55.13	41.46	45.93	47.87
Romania	64.30	0.14	0.83	0.62	0.68	65.72	67.66	27.57	62.23	62.36
Slovakia	16.27	17.88	16.48	15.08	13.95	13.61	12.46	0.00	0.00	0.00
Slovenia	0.00	0.00	0.00	0.00	0.00	0.00	1.48	0.00	0.00	0.00
Spain	393.50	401.28	77.88	48.74	177.02	42.78	47.22	112.48	115.83	107.55
Sweden	0.00	0.00	0.00	20.33	35.47	0.00	0.00	0.00	0.00	0.00
United Kingdom	296.13	362.27	306.22	72.99	75.86	69.92	64.77	115.62	162.57	76.82

As it happens in volume production in units, the countries with the largest production value are Italy, Germany and Poland (Figure 15). In a similar way, the most significant decreases in the 2009-2018 period have been observed in Germany (29%) and Italy (14%). Poland has increased the value of their production in 39% in the same period (from 531 to 735 million Euro).

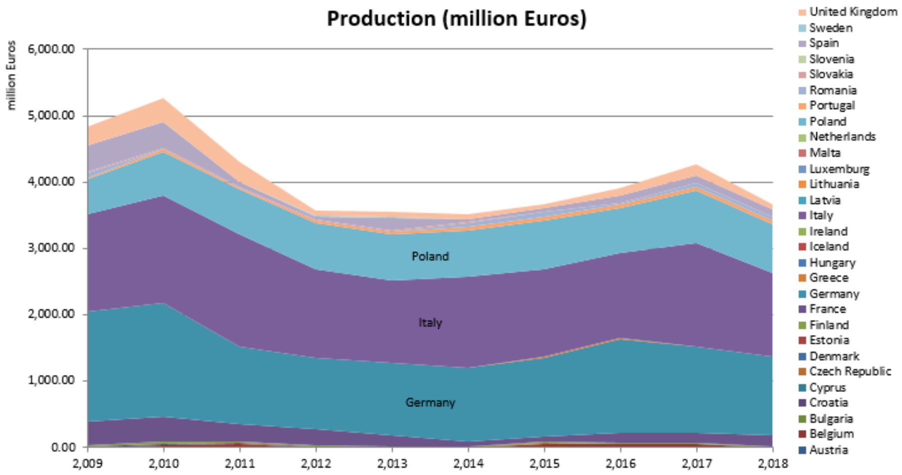


Figure 15. Production value, per country

Analysing value per type of appliance (Figure 16), most of the value in 2018 comes from electric ovens with almost 1,500 million Euro (41% of total), followed by cooking fume extractors (28%).

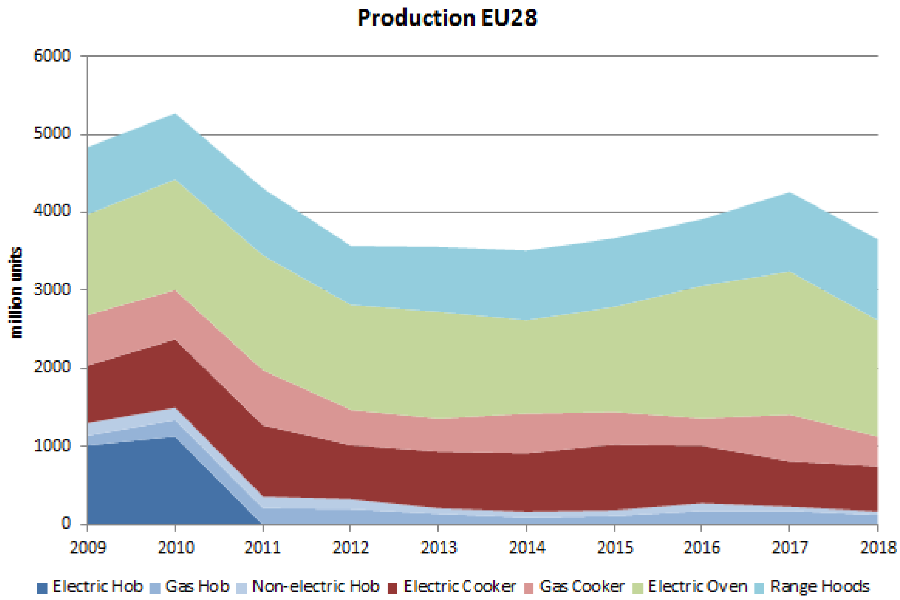


Figure 16. Production value, per type of appliance

Focusing on energy source, in Figure 17 the analysis is conducted on production value in Euros of cookers. The total value oscillates between 2009-2018, generally with considerable higher value of electric ones. Consistent data from EUROSTAT was not available for hobs.

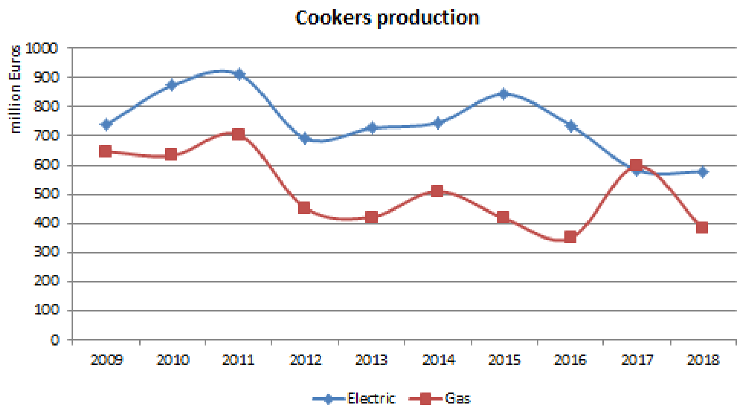


Figure 17. Cookers – Production value

2.1.2 Domestic Cooking Appliances EU28 Import-Export

Table 14 contains data regarding imports and exports in the EU28 for the year 2018, in units and in million Euros. In terms of units, the EU28 is a net importer of cooking appliances: 38 million difference, which is more than double imports than exports. In terms of value, the EU28 appears as a net importer, although the difference is much smaller in this case (4% bigger).

Table 14. Domestic Cooking Appliances – EU28 Import-Export (Units/Million Euros)

	2018 Units		2018 Million Euros	
	Imports	Exports	Imports	Exports
EU28	72,954,454	34,512,531	5,091.87	4,879.79
Austria	1,017,633	520,411	140.15	67.39
Belgium	2,362,485	1,538,027	195.68	90.12
Bulgaria	641,978	47,342	39.91	6.44
Croatia	353,644	61,612	32.49	10.85
Cyprus	88,004	203	8.70	0.19
Czech Republic	16,256,575	1,106,738	102.54	96.08
Denmark	915,319	285,677	154.45	65.82
Estonia	114,375	18,212	15.15	4.41
Finland	409,155	68,974	62.46	5.58
France	8,058,286	1,356,312	652.87	141.58
Germany	7,953,664	4,584,380	912.10	1,279.96
Greece	837,321	299,173	70.19	33.52
Hungary	793,864	97,217	59.28	7.20
Ireland	743,552	51,769	67.05	8.95
Italy	3,874,440	7,323,330	253.72	1,122.12
Latvia	111,027	23,865	11.26	4.35
Lithuania	306,287	113,014	27.70	12.62
Luxemburg	62,585	9,120	17.17	3.56
Malta	50,853	699	6.23	0.96
Netherlands	4,393,885	2,628,905	422.36	247.04
Poland	2,867,573	7,858,365	232.00	851.28
Portugal	747,100	637,973	70.01	47.77
Romania	1,666,554	655,017	112.34	64.84
Slovakia	1,007,804	409,258	64.62	34.11
Slovenia	532,521	922,516	41.76	142.44
Spain	4,974,821	2,201,287	274.04	256.87
Sweden	1,424,249	596,303	231.94	142.41
United Kingdom	10,388,900	1,096,832	813.69	131.35

The largest number of imports in 2018 appear to be in the Czech Republic. However, this number needs to be taken with caution, since it seems too big considering their population (16 million imports for less than 11 million people in that year) and number of imports in previous years in that country (just over 1 million in 2016 and 2017). Countries with a large number of imports are United Kingdom, France, Germany, Spain and Italy. Considering balance import-export, most of EU28 countries are net importers of cooking appliances, with the exception of Poland, Italy and Slovenia.

Focusing on energy source, a clear trend is observed in terms when looking at cookers. Both import and export numbers show a clear preference for electric cookers during the period 2009-2018. Consistent data from EUROSTAT was not available for hobs.

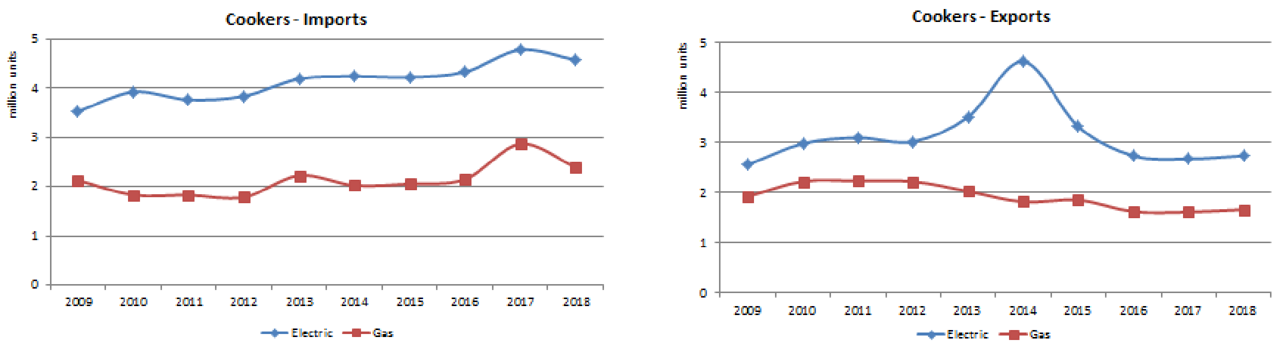


Figure 18. Cookers - Imports/Exports

2.1.3 Average value of Domestic Cooking Appliances

Table 15 provides information regarding the average value per unit of cooking appliances in the EU28. The numbers have been obtained dividing the value of total production in Euros by the number of total units produced, for each year.

Table 15. Domestic Cooking Appliances Average Value (Euro/Unit)

	Average Production (Euro/Unit)									
Product	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Cooking fume extractors	55	60	75	95	99	88	96	93	104	113
Hobs - Electric	153	150	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hob - Gas	72	69	74	75	99	74	98	94	91	81
Oven - Electric - building-in	281	253	249	235	235	227	229	253	253	240
Oven - Electric - non-building-in	132	206	193	249	218	285	n/a	107	118	n/a
Cooker - Electric	237	252	215	183	152	258	272	256	257	269
Cooker - Gas	180	217	223	201	155	155	141	113	144	175

As it can be seen in Figure 19, the average production value of Electric Ovens for building-in (in blue) has remained relatively constant between 275 and 240 Euros between 2009-2018. Electric cookers (in green) has changed significantly between that period, with a lowest average value of 150 Euros in 2013 and a highest of 265 in 2018. Data gaps prevent from providing values for certain years in the case of Electric ovens for non-building-in (120 Euros in 2017). Finally, Gas cookers have average production values that range between 225 Euros in 2011 to 115 Euros in 2016.

In the case of hobs (Figure 20), data gaps prevent from making a full comparison between gas and electric. The production value seems to be considerably higher in the case of electric hobs in 2009 and

2010 (years when there is data available for both energy sources), with values of 150 Euros for electricity and 70 Euros for gas. Cooking fume extractors appear to be increasing their production value in the analysed period, with 55 Euros per unit on 2009, up to 115 Euros per unit in 2018.

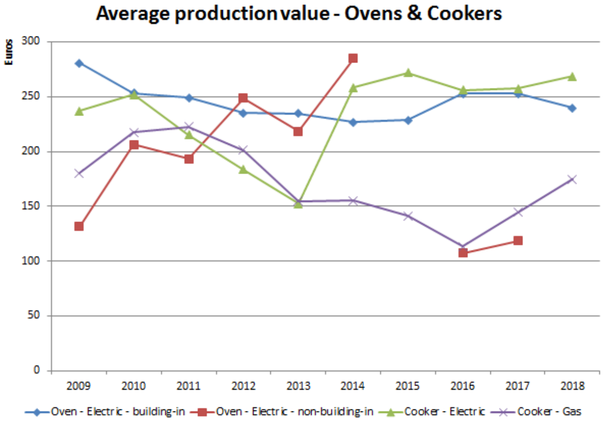


Figure 19. Ovens – Average production value

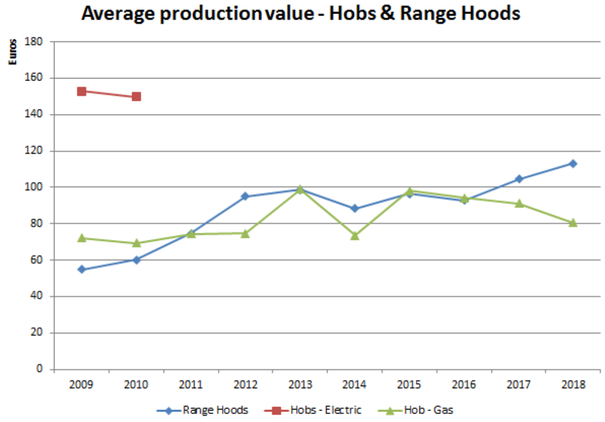


Figure 20. Hobs and cooking fume extractors – Average production value

2.1.4 Domestic Cooking Appliances EU28 Apparent Consumption

Apparent consumption is calculated as follows:

Apparent consumption= Production + Imports - Exports

Table 16 shows Apparent consumption for EU28. As it can be observed, most of the values in Table 6 are not available (n/a). This is related to both data gaps and inconsistencies in the PRODCOM database. Most of the data gaps are in Production numbers, since for many member states the databases are incomplete or empty (the clearest example of data inconsistencies found is production numbers which are lower than export numbers).

When such inconsistencies are detected, it is considered that data is either not available or not correct, and then presented as n/a in Table 6. Having data gaps and inconsistencies in mind, the largest apparent consumption in 2018 is observed in Italy (3.4 million), Poland (2 million), Germany (1.9 million) and France (1.7 million).

Table 16. Domestic Cooking Appliances – EU28 Apparent Consumption

	Apparent Consumption (Units)									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU28	28,178,600	26,989,477	19,436,810	13,791,221	14,620,713	13,567,822	12,445,173	14,050,307	16,610,576	11,385,502
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Belgium	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Bulgaria	138,010	137,866	88,142	88,744	87,118	109,533	98,727	104,765	102,165	103,565
Croatia	69,777	85,038	44,941	33,036	27,340	30,525	35,135	38,997	40,882	n/a
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	n/a	n/a	n/a	n/a	n/a	n/a	188,397	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Estonia	110,765	142,743	121,259	113,683	132,840	139,823	123,423	109,222	134,758	163,370
Finland	95,725	175,479	211,917	49,227	n/a	n/a	n/a	n/a	n/a	n/a
France	4,288,037	4,577,002	3,825,056	3,364,045	2,779,312	n/a	n/a	1,716,860	3,344,613	1,745,760
Germany	4,341,0	4,596,1	2,102,5	2,163,3	1,201,6	3,075,9	2,999,3	2,337,7	n/a	n/a

	10	31	28	40	76	09	08	26		
Greece	385,969	801,795	207,210	132,330	211,133	n/a	72,320	n/a	n/a	n/a
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	12,314,850	11,201,852	10,081,036	5,510,996	7,272,428	6,338,180	4,936,129	5,476,890	7,968,893	3,442,724
Latvia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Luxemburg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Poland	2,237,386	1,726,734	1,859,280	1,692,256	1,418,051	1,769,750	1,848,946	2,448,254	2,781,206	1,952,010
Portugal	214,316	171,457	140,154	164,131	380,537	543,923	493,341	502,719	263,935	392,404
Romania	549,041	n/a	n/a	n/a	n/a	680,082	686,674	434,739	721,725	679,934
Slovakia	n/a	n/a	n/a	n/a	n/a	n/a	148,693	375,781	417,857	398,524
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	2,639,331	2,611,436	n/a	n/a	321,026	880,097	814,080	n/a	n/a	n/a
Sweden	n/a	n/a	n/a	n/a	284,655	n/a	n/a	n/a	n/a	n/a
United Kingdom	794,383	761,944	755,287	479,433	504,597	n/a	n/a	504,354	834,542	599,885

Table 17 provides value of Apparent Consumption of Domestic Cooking Appliances in the EU28, in million Euros. With the same caution in the analysis as for production units, the largest apparent consumption in 2018 was in Germany (552 million), followed by France (535 million) and Italy (454 million). Significant apparent consumption is also observed in Spain (110 million) and UK (108 million).

Table 17. Domestic Cooking Appliances – EU28 Apparent Consumption

	Apparent Consumption (Million Euros)									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU28	3,380.7	3,684.4	3,090.8	2,192.3	2,149.3	2,015.7	1,923.9	2,385.4	2,609.1	2,004.5
Austria	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Belgium	n/a	49.3	49.6	n/a	n/a	n/a	53.3	52.2	47.5	n/a
Bulgaria	14.3	11.7	10.6	10.6	10.8	14.3	15.0	17.2	17.3	16.7
Croatia	12.8	14.7	12.1	10.3	9.2	10.4	10.3	11.6	10.3	4.2
Cyprus	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Czech Republic	3.7	n/a	n/a	n/a	n/a	n/a	10.5	n/a	n/a	n/a
Denmark	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Estonia	1.8	2.2	2.0	1.9	2.1	2.5	3.0	2.6	2.9	3.3
Finland	21.4	62.4	63.6	32.6	9.8	4.1	5.8	10.6	4.4	4.3
France	709.2	749.1	620.2	586.2	507.1	184.8	114.0	399.8	472.6	535.3
Germany	1,079.0	1,171.9	733.0	717.0	728.0	769.8	683.3	875.3	641.5	552.2
Greece	12.1	15.2	10.6	n/a	n/a	n/a	13.0	5.5	6.4	6.3
Hungary	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ireland	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Italy	426.2	471.7	736.0	405.2	401.3	493.7	442.5	425.4	729.6	454.9
Latvia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Lithuania	n/a	1.4	1.5	0.8	n/a	n/a	n/a	n/a	n/a	n/a
Luxemburg	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Malta	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Netherlands	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Poland	154.4	218.0	198.4	162.8	144.3	145.3	155.0	218.4	277.2	82.6
Portugal	38.2	21.2	17.4	32.7	43.6	29.7	43.4	50.3	36.6	43.6
Romania	62.7	3.0	3.6	2.8	2.4	71.2	78.4	46.6	80.4	81.8
Slovakia	15.0	8.5	16.7	15.1	14.3	14.7	14.6	n/a	n/a	n/a
Slovenia	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Spain	377.9	354.6	84.8	77.4	129.6	79.4	83.9	80.1	85.5	110.5
Sweden	n/a	n/a	n/a	27.6	37.7	n/a	n/a	n/a	n/a	n/a
United Kingdom	451.9	529.6	530.8	109.2	109.3	195.9	197.7	189.8	196.8	108.9

For the reasons explained above, it is considered that data quality regarding apparent consumption is not enough to provide meaningful graphical results. Therefore, no further analysis will be provided for apparent consumption.

2.1.5 Extra-EU-28 trade

Table 18 gathers the figures of extra-EU-28 trade with selected countries which represent more than 75% of extra-EU-28 exports and more than 95% of extra-EU-28 imports.

The product groups correspond to the following codes:

- 851660: Electric ovens, cookers, cooking plates and boiling rings, electric grillers and roasters, for domestic use (excl. Space-heating stoves and microwave ovens)
- 732111: Appliances for baking, frying, grilling and cooking and plate warmers, for domestic use, of iron or steel, for gas fuel or for both gas and other fuels (excl. Large cooking appliances)

In the case of electric appliances, China and Turkey are by far the largest exporters to the EU-28 (49% and 40% of extra-EU-28 imports respectively). On the other hand, the main destinations of European exports are Russia, Australia, China and the United States.

Table 18. Value of extra-EU-28 trade of electric appliances with some countries in 2018 (Eurostat)

Country	Imports	Exports
China	634 245 921	100 612 573
Turkey	528 046 707	27 319 133
Malaysia	86 811 178	3 732 298
United States	12 234 335	94 270 879
Hong Kong	5 709 010	15 202 327
Serbia	2 011 992	14 867 477
Taiwan	1 988 155	6 373 825
South Korea	1 820 304	27 570 792
Singapore	1 704 045	8 361 531
Ukraine	1 404 234	34 610 528
Thailand	1 270 861	9 206 151
Norway	1 083 978	121 453 708
Indonesia	625 169	1 547 069
Japan	624 994	3 929 680
Canada	240 717	19 073 013
Australia	193 683	125 150 724
Vietnam	74 864	21 355 794
Russian Federation (Russia)	69 092	230 004 617
United Arab Emirates	47 331	12 310 116
Israel	33 537	43 618 547
New Zealand	20 339	20 508 739
South Africa	15 841	19 478 573
Saudi Arabia	1 127	17 168 763

Note: the countries are order from the largest to the smallest value of imports to EU.

In the case of non-electric appliances, China is by far the largest exporter to the EU-28 (68% extra-EU-28 imports), followed by Turkey (20% extra-EU-28 imports). On the other hand, the main destinations of European exports are United States, Australia, Russia and Saudi Arabia.

Table 19. Value of extra-EU-28 trade of non-electric appliances with some countries in 2018 (Eurostat)

Country	**Imports**	**Exports**
China	375 092 998	12 600 823
Turkey	116 123 262	8 182 856
United States	29 894 370	55 343 557
Canada	14 169 773	6 686 856
Ukraine	3 979 038	10 061 102
Hong Kong	2 956 594	4 083 356
Taiwan	2 382 764	835 605
Vietnam	1 369 793	531 532
South Korea	939 235	154 542
Thailand	819 822	661 570
Indonesia	765 870	1 815 000
India	360 229	2 228 625
Japan	339 541	491 556
South Africa	318 414	5 314 808
Serbia	192 561	370 685
Iran, Islamic Republic Of	142 961	1 557 326
Norway	139 960	9 230 970
United Arab Emirates	122 227	13 001 264
Australia	118 927	53 997 405
Egypt	71 381	10 247 344
Singapore	30 616	1 978 795
Israel	21 009	13 550 473
Brazil	18 343	2 735 220
Russian Federation (Russia)	15 899	35 122 692
Lebanon	6 181	8 307 626
Saudi Arabia	4 290	28 409 321
New Zealand	0	3 783 106

Note: the countries are order from the largest to the smallest value of imports to EU.

2.1.6 Conclusions from analysis of Eurostat data

EUROSTAT data represents the official EU source and provides valuable qualitative information about the roles played by each country in this sector. However, as it has already been pointed out in this section, the data needs to be interpreted with caution as there are significant gaps for some countries which prevent from completing a robust analysis.

Moreover, the level of detail provided by EUROSTAT data is not sufficient to conduct a relevant environmental and economic impact analysis. For instance, it does not provide information regarding sales of appliances with different energy efficiency categories, which is essential to understand the benefits provided by ecodesign regulation. Also, the product classification does not differentiate clearly between relevant technologies in each product type (gas, radiant and induction hobs, for instance).

In order to estimate the total energy consumption of the product groups under study, it is necessary to calculate the total stocks of each of them in the EU. An essential piece of information to calculate the stocks are the annual sales, data which is also not available within EUROSTAT database.

Because of these reasons, the subsequent modelling tasks of the preparatory study will not be based on EUROSTAT data. In order to overcome this, relevant data will be obtained from trusted sources with significant expertise in the market of the different product groups. This data will be presented in section 2.2.

2.2 Market, stocks and trends of domestic cooking appliances

2.2.1 Data sources for environmental and economic impact modelling

Alternative data sources to EUROSTAT will be used in subsequent sections of this preparatory study. These data sources are:

- Previous Preparatory study for Ecodesign requirements for domestic cooking appliances (Mudgal et al, 2011)
- EUROMONITOR data for market high level analysis
- GfK data for market in-detail analysis: disaggregated data for five EU countries that represent 58% of EU27 population and are representative in terms of socioeconomic and cultural characteristics.

2.2.2 Ecodesign Impact Accounting

The European commission has identified a need to systematically monitor and report on the impact of Ecodesign, energy label and tyre labelling measures, including potentially new forthcoming actions, with a view to improve its understanding of the impacts over time as well as forecasting and reporting capacity.

With contract No. ENER/C3/412-2010/FV575-012/12/SI2.657835, DG Energy contracted Van Holstteijn en Kemna B.V. (VHK) to undertake this exercise. The accounting method developed in this study provides a practical tool to achieve those goals. The accounting covers projections for the period 2010-2050, with inputs going as far back as 1990 and earlier. Studies of 33 product groups (including lots 22 and 23 on domestic and commercial ovens and domestic and commercial hobs and cooking fume extractors) with over 180 base case products were harmonized and completed to fit the methodology.

Projections use two scenarios 'business as usual' (BAU) scenario, which represents what was perceived to be the baseline without measures at the moment of decision making and an ECO scenario that is derived from the policy scenario in the studies which come closest to the measure taken. Data used and results obtained in this study regarding domestic cooking appliances are presented in this section.

In terms of sales, gas hobs and ovens were expected to decrease their sales between the period 1990-2050. On the other hand, electric ovens and hobs, as well as cooking fume extractors, were expected to grow sales in the same period (Figure 21).

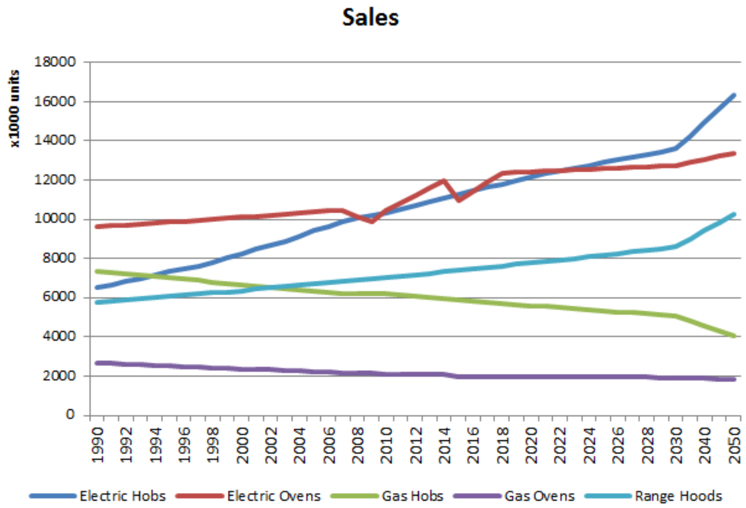


Figure 21. Sales of domestic cooking appliances (VHK, 2014)

Based on yearly sales and on fixed lifetime values for each type of appliance, stock of domestic cooking appliances was also estimated (Figure 22). A significant increase in the stock of electric hobs and ovens was expected for the analysed period, along with cooking fume extractors. The total number of gas ovens and hobs present in EU28 households was expected to decrease.

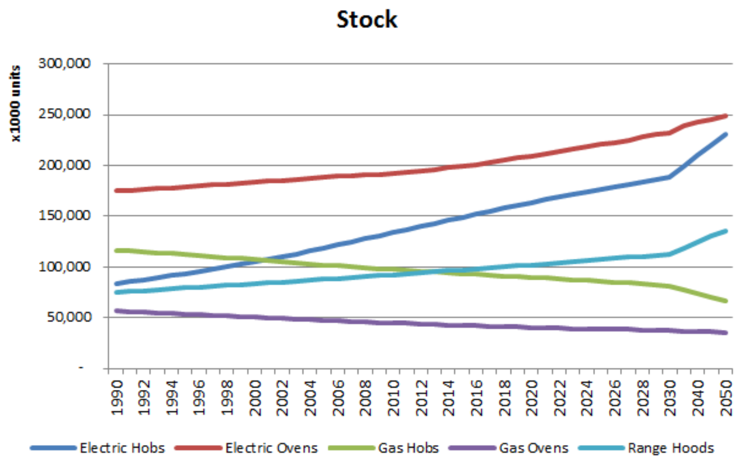


Figure 22. Stock of domestic cooking appliances (VHK, 2014)

Considering technology developments in each product type, energy consumption improvements were estimated for electric hobs, gas hobs, electric ovens, gas ovens and cooking fume extractors. These energy consumption improvements were considered in the ECO scenario. Finally, taking into account all the data presented below (sales, stocks, potential improvements), total primary energy consumption was estimated to BAU and ECO scenarios (Figure 23). A detailed description of the assumptions made for the ECO scenario can be seen in VHK (2014).

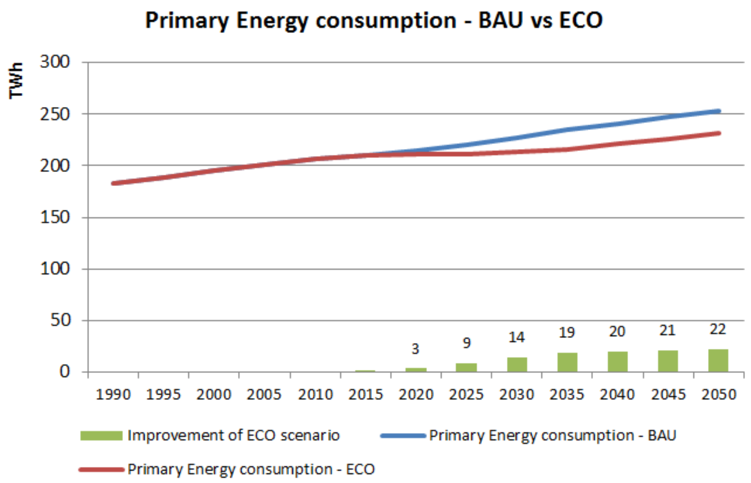


Figure 23. Improvement potential of ECO scenario vs BAU (VHK, 2014)

As it can be seen, technology improvements in domestic cooking appliances start providing a reduction of 3 TWh of primary energy consumption in 2020. By the year 2050, the expected energy consumption reduction of the ECO scenario is of approximately 22 TWh.

2.2.3 Sales of domestic cooking appliances

In this section, data regarding sales of the different product groups is presented. Sources of information are Euromonitor (2019) and GfK (2019).

2.2.3.1 Ovens

Over the period 2015-2018, oven sales have been growing steadily, from nearly 5.5 million units sold in 2015 to slightly over 6 million units in 2018 (Figure 24). The vast majority of ovens sold over that period were electrically heated (sales of gas ovens are so small that they are not visible in the graph).

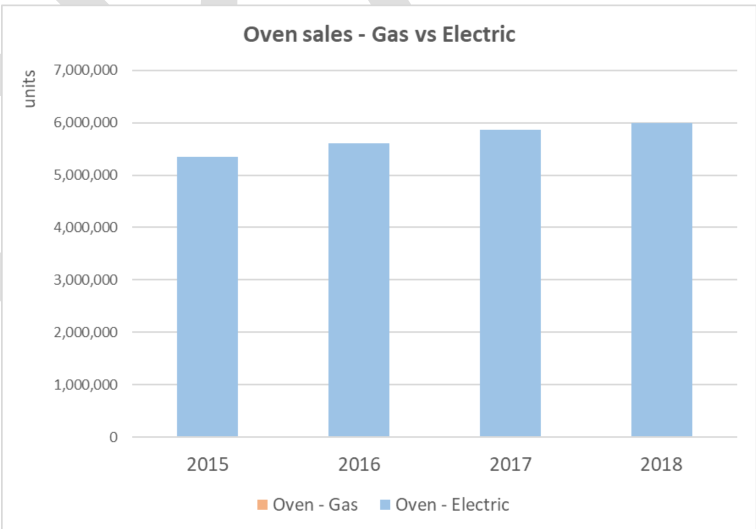


Figure 24. Oven sales 2015-2018 EU27 (Euromonitor, 2019)

Ovens in the market are currently being offered with a wide variety of modes, including steam-assisted and microwave-assisted heating functions. In Figure 25, data is shown regarding five representative EU countries. As can be seen, steam-assisted ovens tend to be growing over the past years, reaching 200,000 units in these five countries in 2018, with microwave-assisted ovens relatively stable at around 30,000 units. If these numbers are compared with the total market of ovens in those countries, it can be observed that these functions still represent a very low percentage of the market.

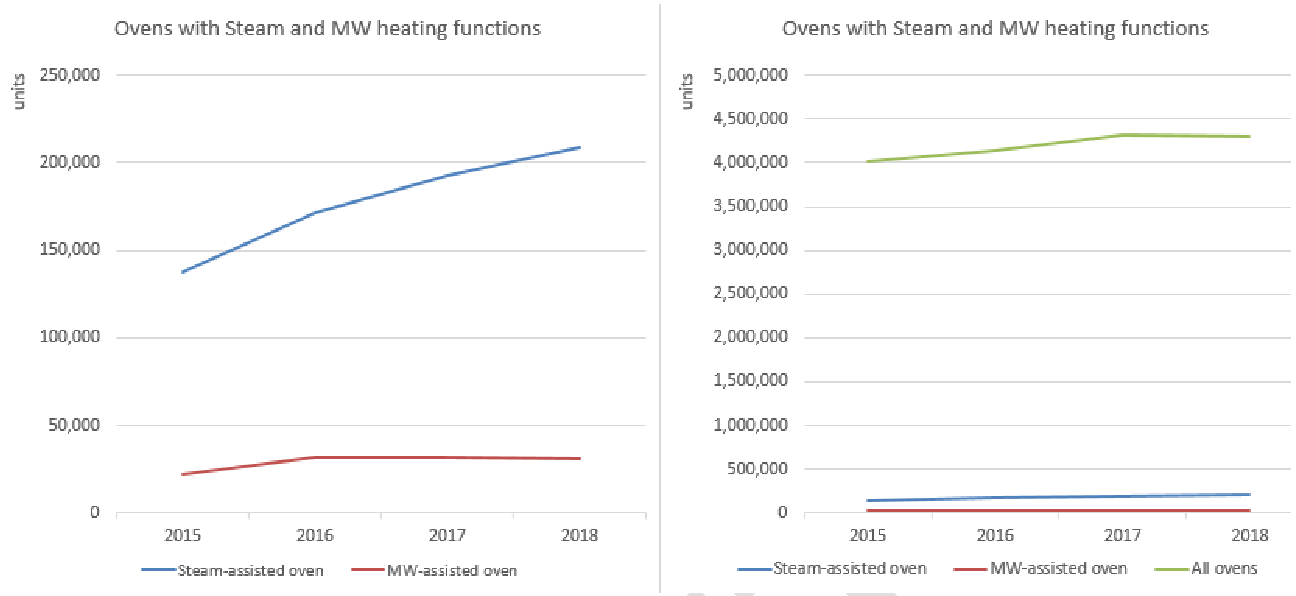


Figure 25. Ovens with steam and MW heating functions for 5 representative EU countries (GfK, 2019)

In terms of cavity volume, there is a growing trend for larger cavity ovens (Figure 26). In 2015, the most popular choice were 55-60 l. ovens, whereas in 2018, the cavity volume with the highest sales was 70-75 l.

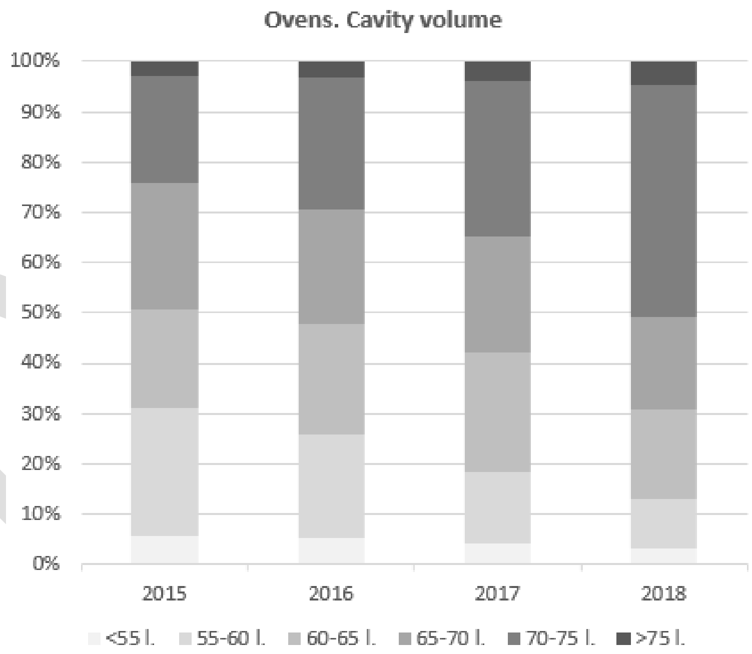


Figure 26. Oven sales - Cavity volume

Cooking appliances are increasingly equipped with connectivity features. In the recent years, consumers have shown an interest in connected ovens (Figure 27).

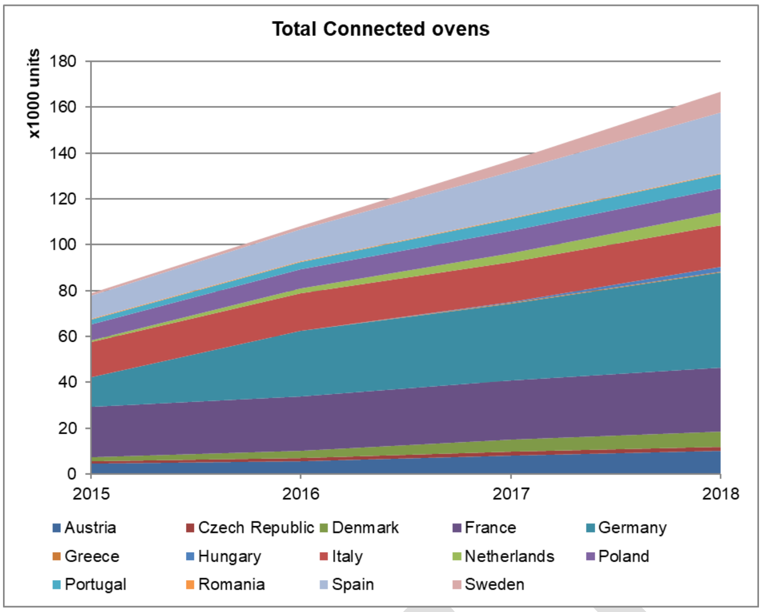


Figure 27. Connected ovens sold in 14 EU countries (Euromonitor International, Consumer Appliances, 2019)

As it can be observed, the amount of connected ovens sold in EU28 in 2018 was four times higher than in 2014. The countries where the most units were sold are Spain, Italy, Germany and France. However, it must be taken into account that in terms of proportion, only 3% of ovens sold in 2018 had connectivity features.

2.2.3.2 Cookers

In terms of cookers, sales decreased slightly over the period 2015-2018, with approximately 1.8 million units sold in 2018 (Figure 28). In contrast with ovens, the proportion of gas heated cookers is 21%, with electricity still being the most popular choice.

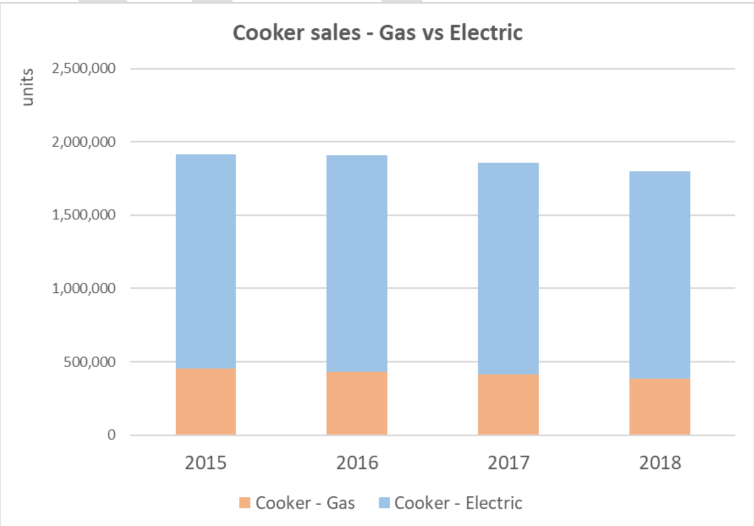


Figure 28. Cooker sales in EU27 2015-2018

2.2.3.3 Hobs

In terms of hobs, sales have been growing slowly over the period 2015-2018, from 5.8 million to 6.1 million in 2018. The technology that has been growing the most has been induction: 41% of units sold in 2018 were induction.

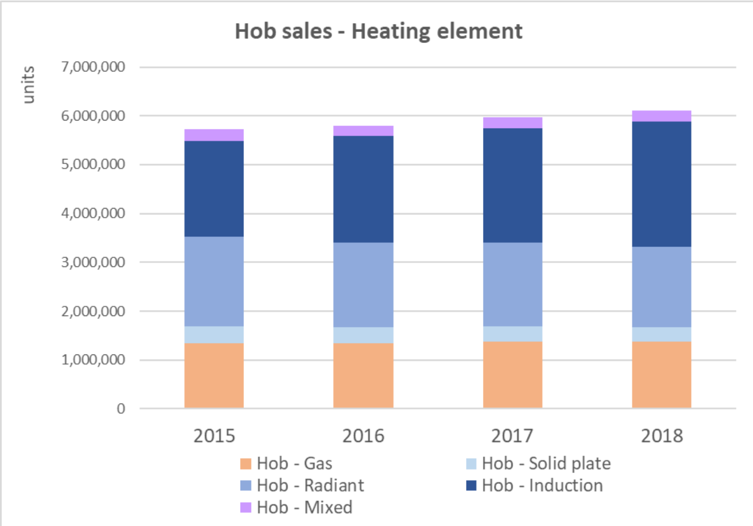


Figure 29. Hob sales in EU 27 2015-2018

However, significant differences can be observed between different countries and regions (Figure 30).

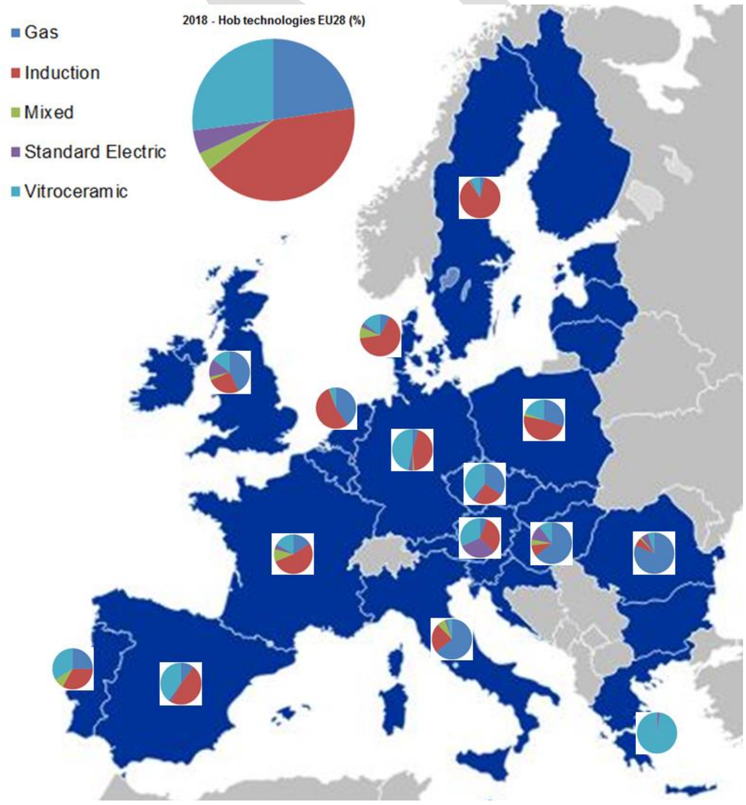


Figure 30. Share of hob technologies in 2018 in 14 EU countries and UK (Euromonitor International, Consumer Appliances, 2019)

In Sweden and Denmark, a remarkable dominance in sales was observed in the case of induction hobs (87% and 65%, respectively). This technology was the choice for most of the consumers as well in Poland, Netherlands, France and Spain. On the opposite side, most of the consumers in Hungary, Italy and

Romania preferred a gas hob in 2018. Finally, the only countries where the most sold hob technology was radiant were Austria, Germany and Czech Republic.

2.2.3.4 Cooking fume extractors

Finally, in terms of cooking fume extractors, sales have grown from 5.8 million in 2015 to nearly 6.1 million units in 2018 (Figure 31), following a similar pattern to hobs.

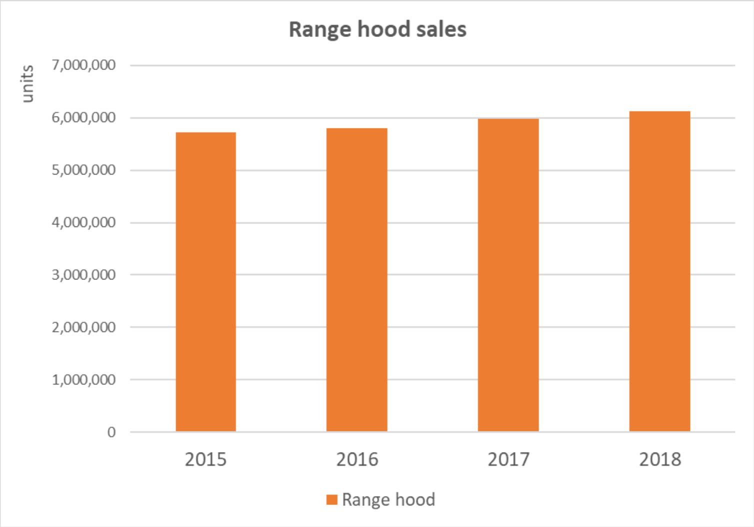


Figure 31. Cooking fume extractor sales EU27 2015-2018

2.2.4 Energy efficiency classes of domestic cooking appliances

In this section, an analysis is conducted on the distribution of energy classes for the different product groups applicable (ovens, cookers and cooking fume extractors). Source is GFK market data for five representative European countries, which account for 58 % of the EU27 population. Every graph in this section represents percentages of units sold.

2.2.4.1 Ovens

Figure 32 shows the distribution of energy classes for domestic ovens sold over the period 2015-2018.

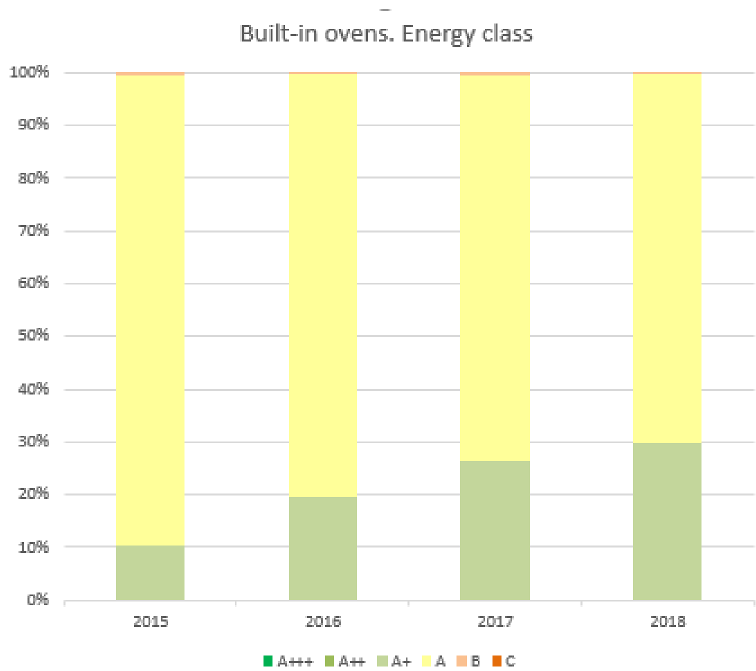


Figure 32. Built-in ovens. Energy class

The most significant points that can be extracted are summarized below:

- There are no A+++ ovens and only 0.06% are A++ (top energy classes)
- A+ category has been growing up to a 29% in 2018
- The vast majority of ovens are either A or A+
- Nearly 70% of ovens in 2018 are A (minimum possible class after 2020)
- 0.24% of ovens in 2018 are either B or C (banned after 2020)
- There are no ovens in the lowest energy class (D)

From that information, it can be interpreted that industry has found it difficult to reach the top energy classes (A++ or A+++). Less than a third of the ovens in the sample are A+.

An oven characteristic that might have an effect on energy efficiency class is cavity volume. As already seen in Figure 26, consumers are moving from smaller to higher cavity volumes: in 2015, the most popular choice was 55-65 litres, whereas in 2018, the most common was 70-75 litres. To understand whether this shift in cavity volume is having an effect on overall energy consumption, an analysis is conducted on Figure 33, to see whether there is a relationship between cavity volumes and energy efficiency class.

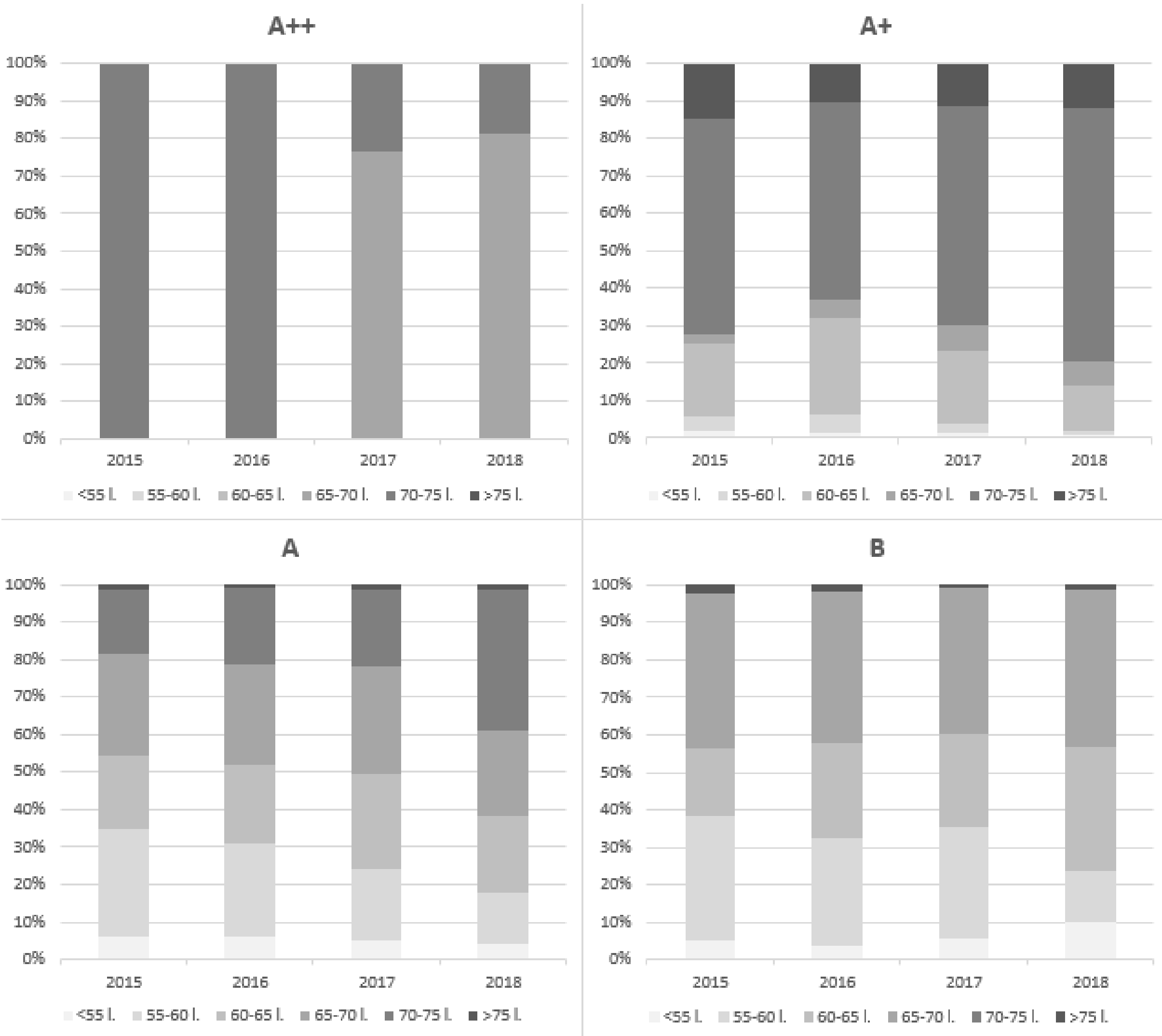


Figure 33. Built-in ovens. The effect of cavity volume on Energy class

A slight trend can be observed from the interpretation of Figure 33. It appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B). There is no clear explanation for this trend at this point. Either it is technically more difficult to achieve higher energy classes with small cavity volumes, or either bigger cavity volumes are considered "high-end" and therefore are equipped with better insulation and energy conservation features which allow them to achieve A+ and A++ classes.

This trend is confirmed when comparing the largest and smallest cavity volumes available in the data sample (Figure 34). Most of the ovens with cavity volume smaller than 55 litres are A, whereas most of the ovens with a cavity volume larger than 75 litres are A+.

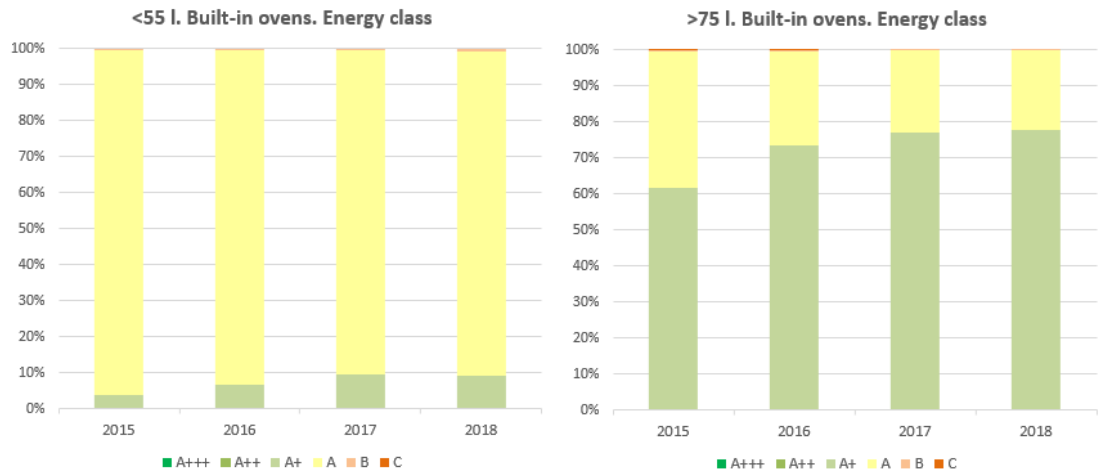


Figure 34. Built-in ovens. Small and big cavity volumes. Energy class

Another oven characteristic that might have an effect on energy efficiency class is the presence of a steam heating function supporting the convective heating process. An analysis is conducted in Figure 35.

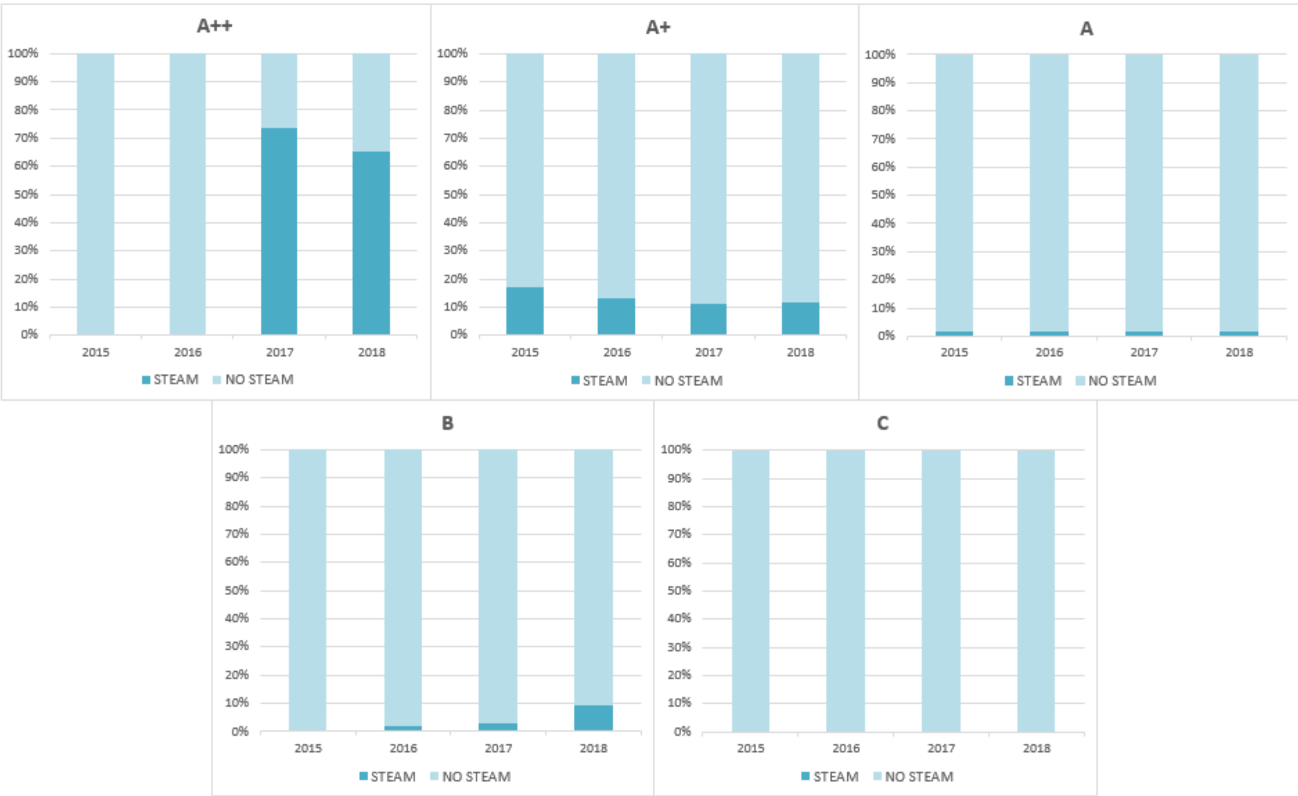


Figure 35. Built-in ovens. The effect of steam heating function

From the interpretation of Figure 35, it can be seen that nearly 70% of A++ ovens in 2018 had a steam heating function. On the contrary, none of the ovens in C class had this feature. However, the proportion of B ovens with steam heating function is approximately as high as that of class A+ ovens and much higher than that of class A ovens. From this graph, it could be inferred that it seems easier to reach highest energy class (A++) when the oven has a steam heating function. However, feedback from industry points out that the support of steam does not necessarily lead to lower energy consumption. This topic will be developed in Task 4.

2.2.4.2 Cookers

A similar analysis to the one conducted for ovens is presented for cookers in this section. Figure 36 shows the distribution of energy classes for domestic cookers sold over the period 2015-2018.

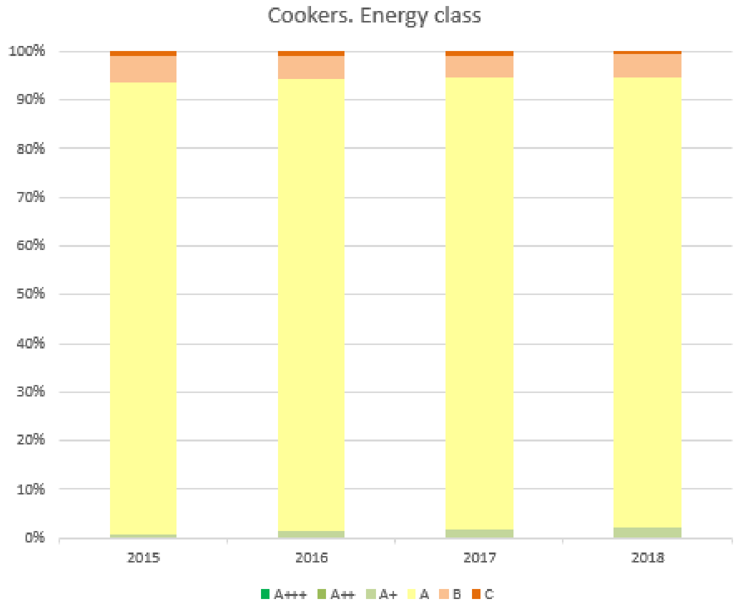


Figure 36. Cookers. Energy class

The most significant points that can be extracted are summarized below:

- There are no A+++ or A++ cookers (top energy classes)
- A+ category has been growing very slowly up to a 2% in 2018
- The vast majority (79%) of cookers are A (minimum energy class after 2020)
- 4.5% of cookers in 2018 are either B or C (banned after 2020)
- There are no cookers in the lowest energy class (D)

From that information, it can be interpreted that industry has found it difficult to achieve top energy classes in cookers. Only a residual percentage of these appliances (2%) has reached the A+ class. It could be interpreted that cookers are 2-in-1 appliances (oven + hob) with lower energy efficiency than their individual counterparts.

As in the case of ovens, in Figure 37, the distribution of cavity volumes sold in the five representative European countries are presented. For easier interpretation, darker colours represent larger cavity volumes.

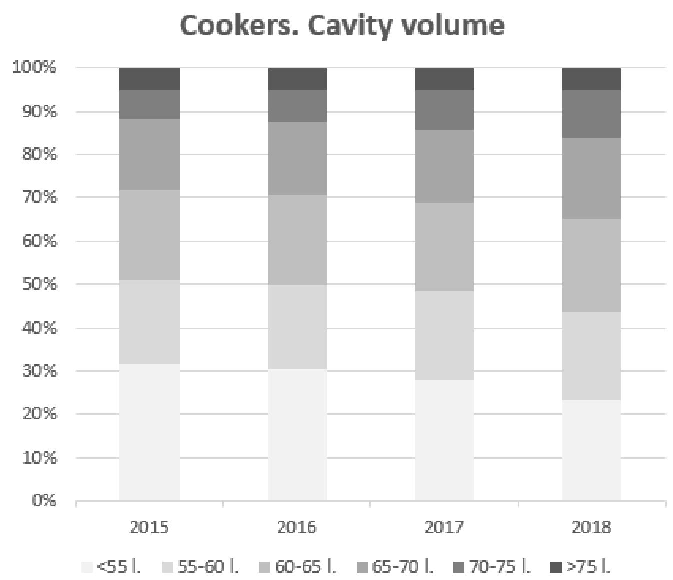


Figure 37. Cookers. Cavity volumes

In contrast to ovens, cavity volumes of cookers appear to be more stable over the period 2015-2018. In fact, in 2018, sales were almost equally distributed between <55 litres, 55-60 litres and 60-65 litres. The most popular choice for ovens (70-75 litres) is less common in cookers. To understand if cooker cavity volume has an influence on the energy class of the appliance, an analysis is conducted in Figure 38.

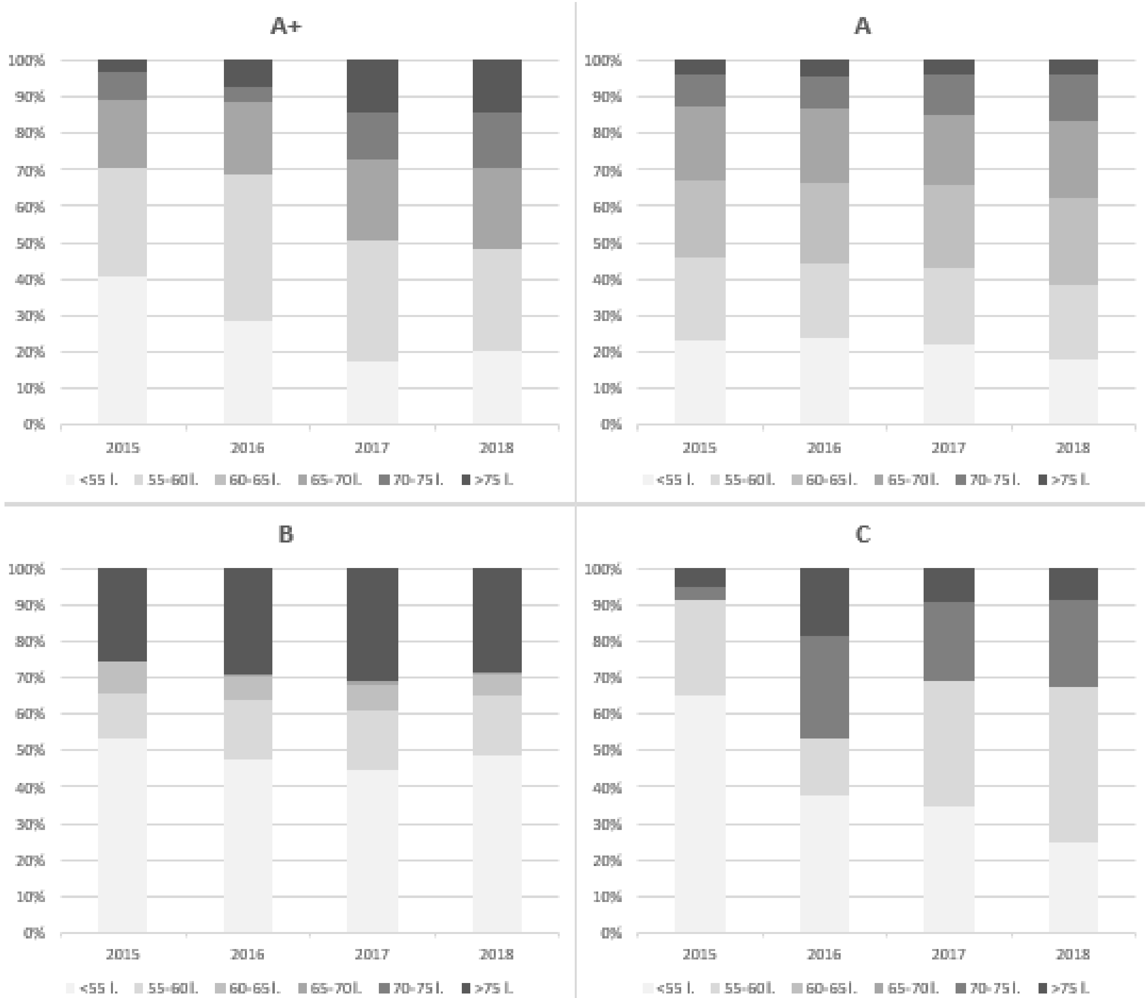


Figure 38. Cookers. The effect of cavity volumes on Energy class

The trend observed in the case of ovens is less apparent in cookers. However, looking at 2018, it can be seen that nearly 70% of cookers in the lowest class C have small cavities (less than 60 litres), whereas only 40% of the cookers in the highest class A+ have them. Again, it appears to be more difficult to reach top energy classes with a small cavity.

This trend can be confirmed with the analysis of Figure 39, when comparing the smallest and biggest cavities available in the data sample. It can be seen that only 2% of the small cookers reach A+ class, whereas up to 5% of the largest ovens reach it.

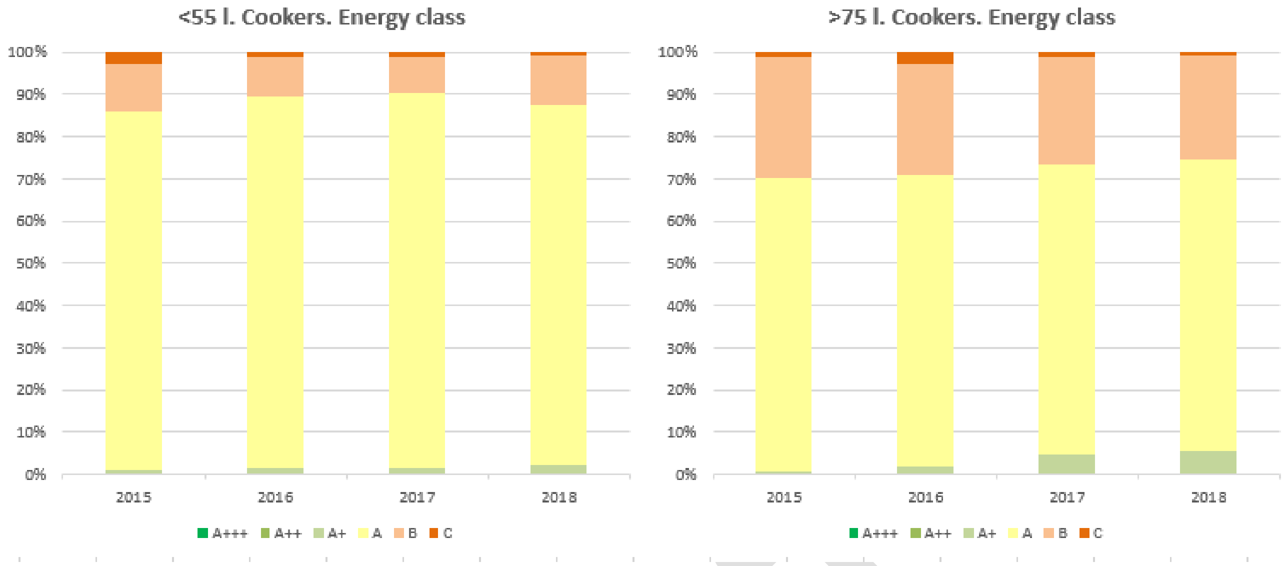


Figure 39. Cookers. Small and big cavity volumes. Energy class

2.2.4.3 Cooking fume extractors

Figure 40 shows the distribution of energy classes for domestic cooking fume extractors sold over the period 2015-2018.

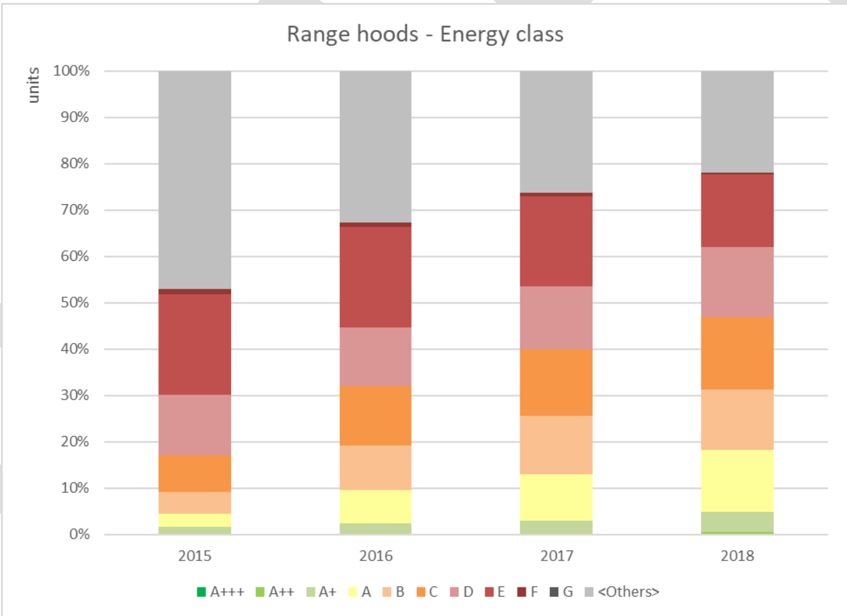


Figure 40. Evolution of cooking fume extractors sales in five EU countries per energy classes

As can be observed, the energy classes of cooking fume extractors have improved along the period, leading to a quite even composition among energy classes A to E. The penetration of A+ has increased significantly from 2015 to 2018, mainly due to the sales of ceiling hoods and worktop vent hoods, as it is shown in Figure 41:

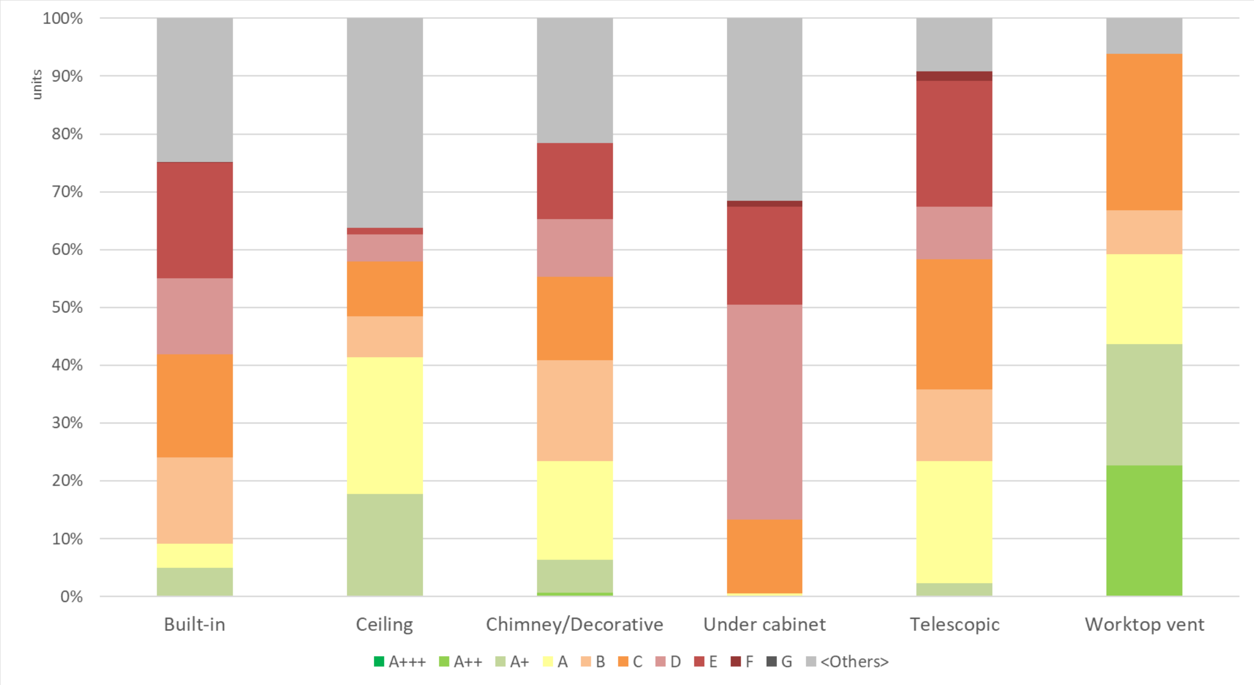


Figure 41. Composition of types of cooking fume extractor in terms of energy classes in 2018 in five EU countries

In particular, worktop vent cooking fume extractors have reached A++ energy class, though their market share is still very low. However, it must be taken into account that these cooking fume extractors have high airflows and relatively low capture rates. This can be seen as an example of the appropriateness of defining an energy efficiency calculation method which is not to closely linked with high airflow rates. This has already been mentioned in Task 1 of this report and will be addressed again in more detail in Task 4.

More common types of cooking fume extractors, such as under cabinet, have stagnated in C class and lower classes, which may be related to their typical sizes and flows. Figure 42 offers a better insight on this matter, showing the distribution of sales by energy classes and airflows. The area of the bubble represents the sales in units, differentiated by energy class (colour) and airflow in m^3 per hour (vertical axe, i.e. the higher the bubble is located the bigger its flow is).

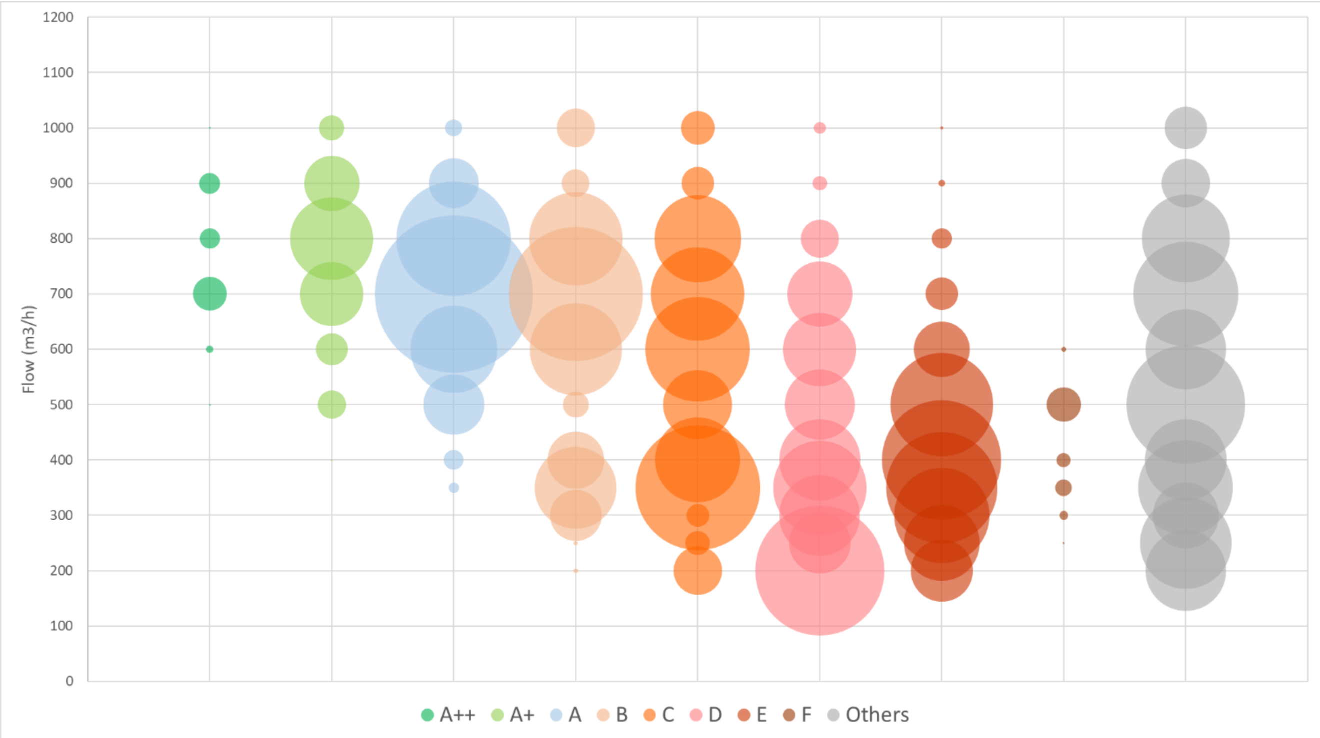


Figure 42. Unit sales (bubble area) per energy class and airflow in five EU countries (2018)

As can be observed, the largest sales of energy classes A or better are more apparent in cooking fume extractors of airflow above 600 m^3/h. On the other side, the sales of energy classes C or worse are larger in cooking fume extractors below 400 m^3/h.

The volumes of the cooking fume extractor sold vary significantly among countries, since it is limited by the kitchen furniture and the space available in the kitchen. This variation can be observed in Figure 43 and Figure 44:

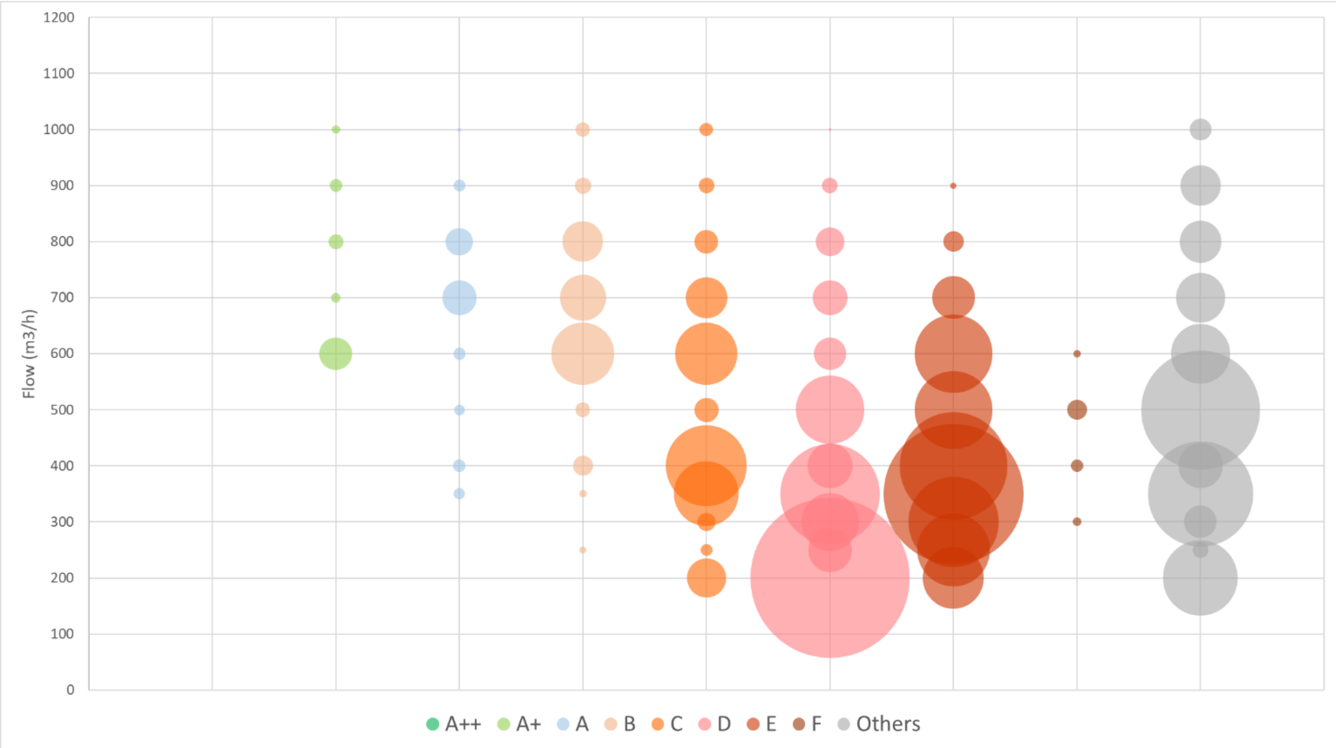


Figure 43. Unit sales (bubble area) per energy class and airflow in Poland (2018)

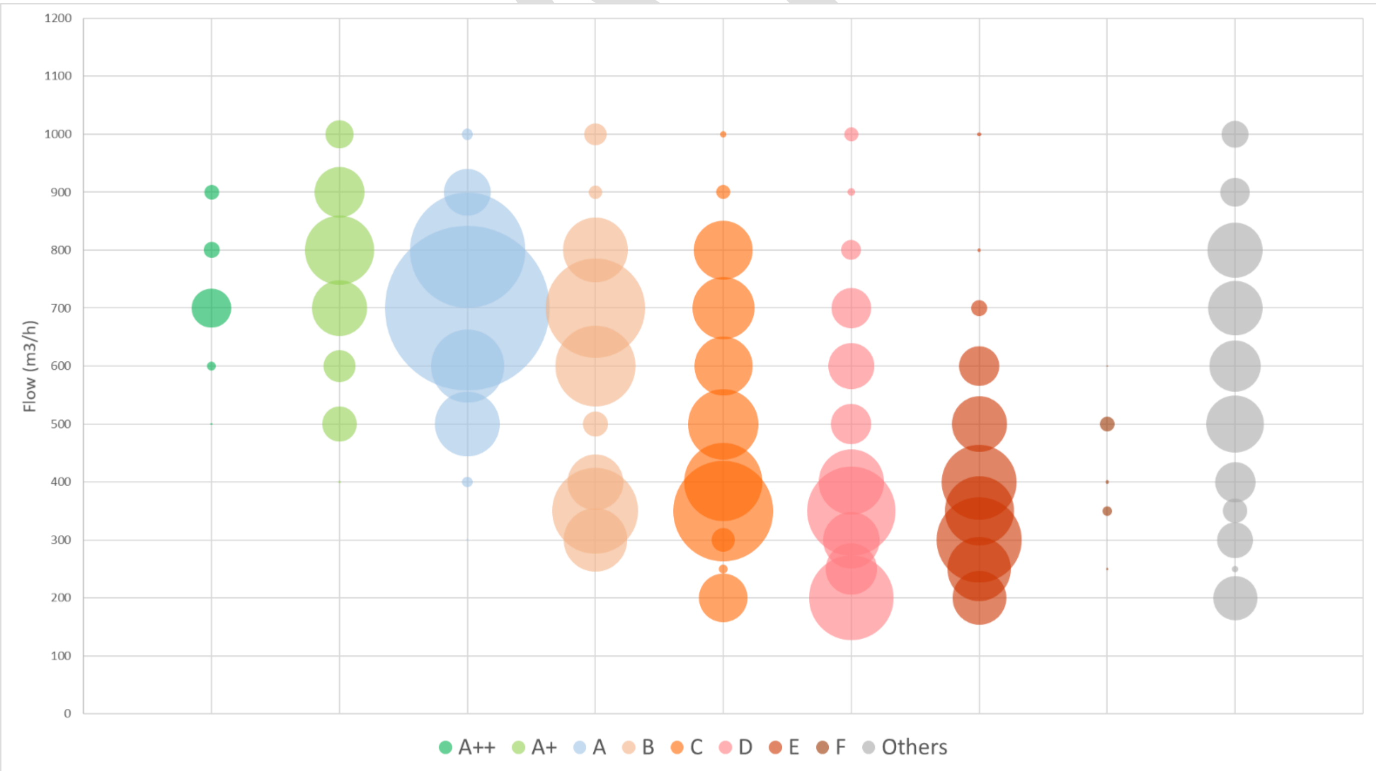


Figure 44. Unit sales (bubble area) per energy class and airflow in Germany (2018)

Poland and Germany clearly differ on the airflow of cooking fume extractors typically sold in their national markets. In Poland, lower airflow cooking fume extractors are more common, and as can be observed, the energy classes are concentrated in D and E. The contrary occurs in Germany, where the cooking fume extractors sold are typically larger airflow and also reach better energy classes. As indicated before, there seems to be a relation between airflow and energy class.

2.2.5 Trends of domestic cooking appliances

In this section, trends on domestic cooking appliances in terms of growth are presented. Figure 45 shows annual growth forecast for ovens over the period 2018-2023. Most of the countries in the EU will see a growth in oven sales over that period, with maximum growth expected in Austria at nearly 6%. On the other side, Belgium, Denmark, Finland, Germany, Netherlands and Portugal will observe slow decreases in sales over that period.

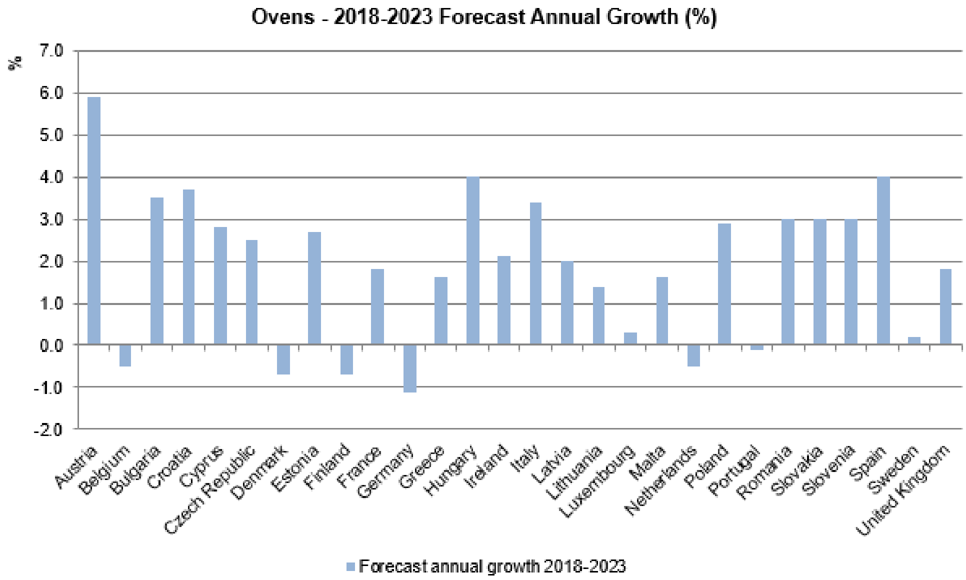


Figure 45. Ovens sales. Annual growth forecast (Euromonitor International, Consumer Appliances, 2019)

Figure 46 shows annual growth forecast for hobs over the period 2018-2023. Again, most of the countries in the EU will see a growth in hob sales over that period, with maximum growth expected in Austria at nearly 7%. On the other side, only Denmark will observe a decrease in sales over that period.

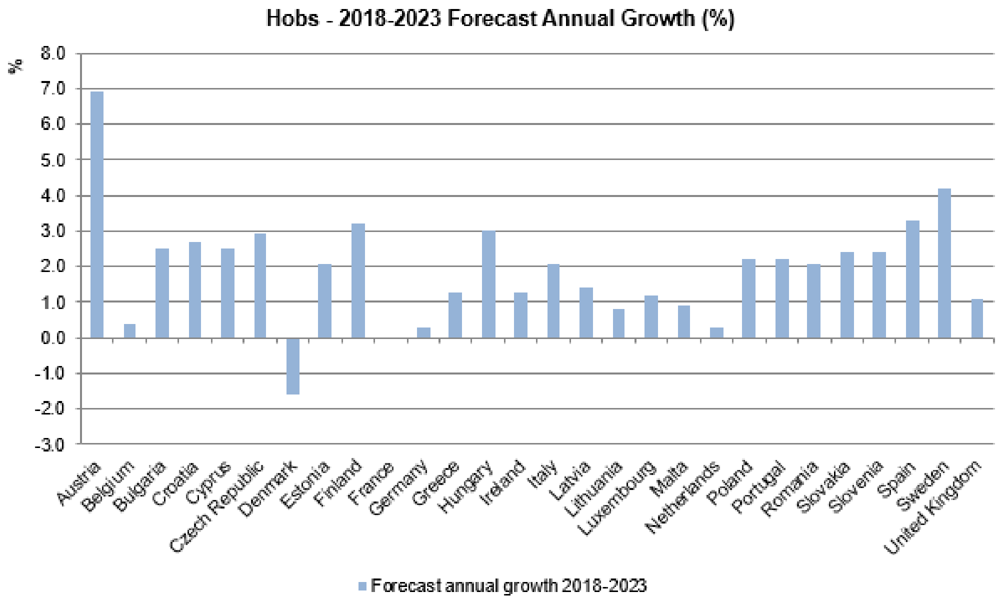


Figure 46. Hobs sales. Annual growth forecast (Euromonitor International, Consumer Appliances, 2019)

Figure 47 shows annual growth forecast for cooking fume extractors over the period 2018-2023. Again, most of the countries in the EU will see a growth in cooking fume extractor sales over that period, with maximum growth expected in Hungary at 3%. On the other side, only Denmark and Germany will observe a decrease in sales over that period.

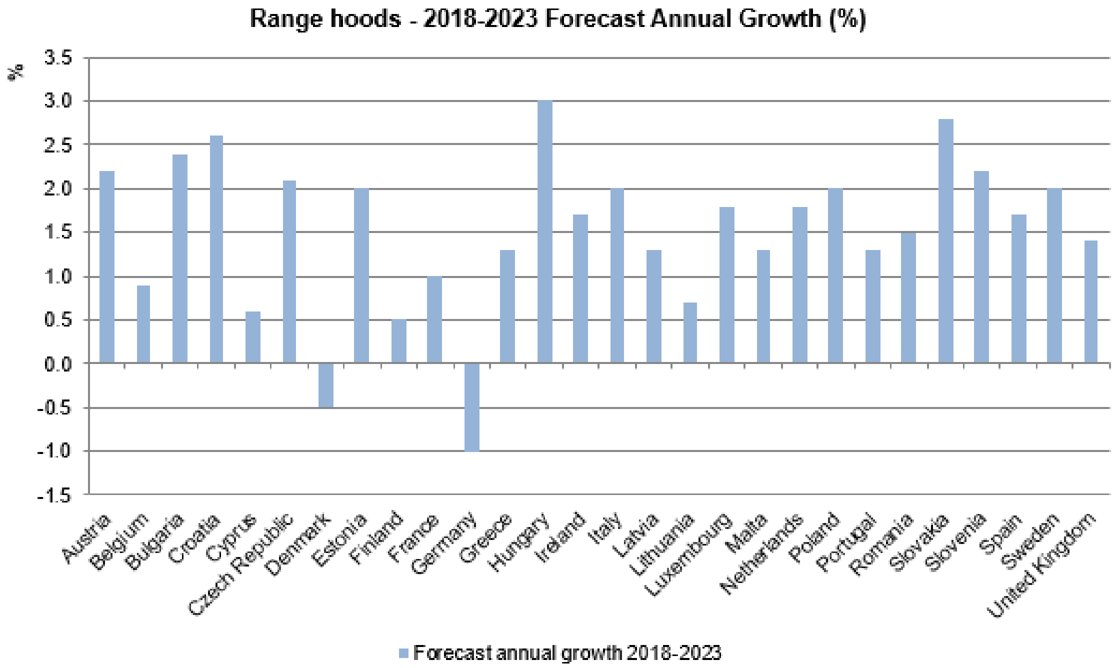


Figure 47. Cooking fume extractors sales. Annual growth forecast (Euromonitor International, Consumer Appliances, 2019)

Based on the above annual growth forecast, it is possible to estimate sales for the period 2018-2023 for the different product groups. As it can be seen in Figure 48, oven sales may grow up to 6.5 million units in 2023, with the vast majority of products being electrically heated.

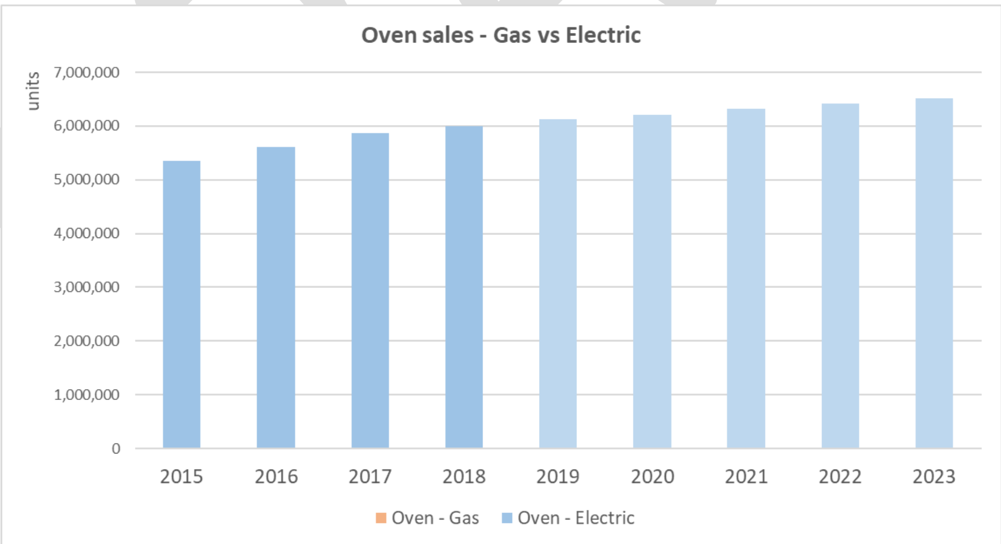


Figure 48. Oven sales trends

Cooker sales may see a slow decrease over the period 2018-2023, reaching slightly above 1.7 million units in 2023 (Figure 49). In this product group, less than half a million correspond to gas heated appliances.

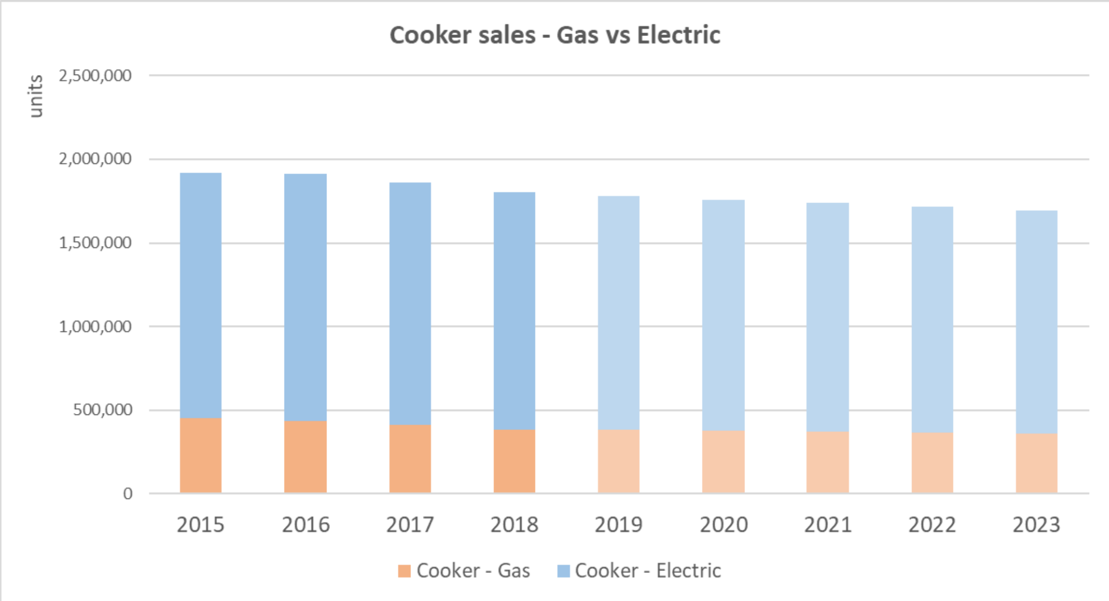


Figure 49. Cooker sales trends

In terms of hobs, sales are expected to grow up to nearly 6.4 million units in 2023, with most of the sales being on that year of induction appliances (Figure 50).

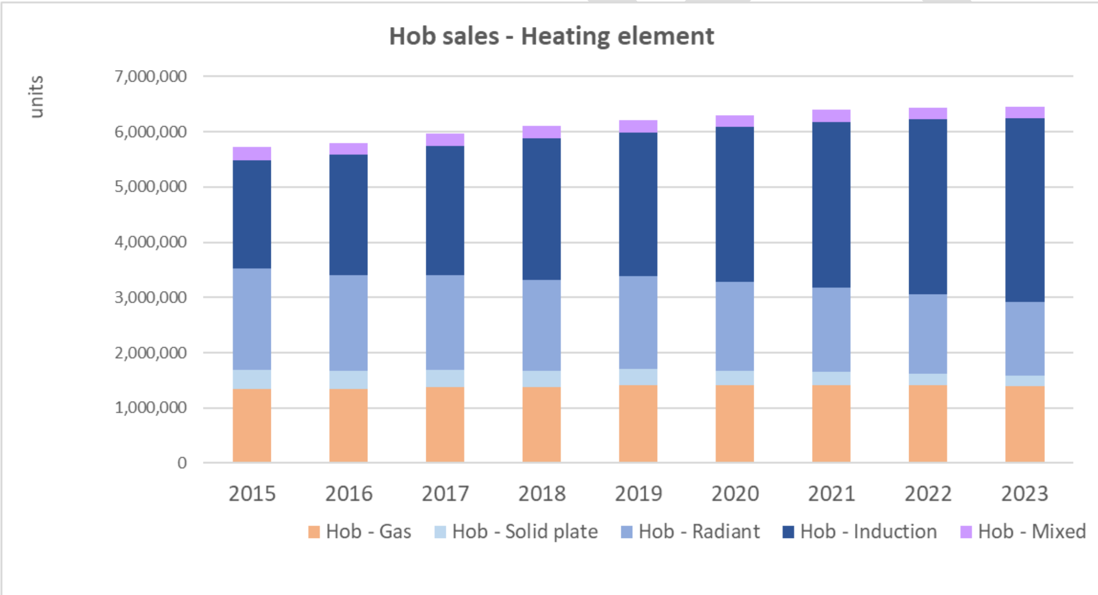


Figure 50. Hob sales trends

Finally, cooking fume extractors are expected to grow over the same period, reaching slightly over 6.5 million units sold in 2023 (Figure 51).

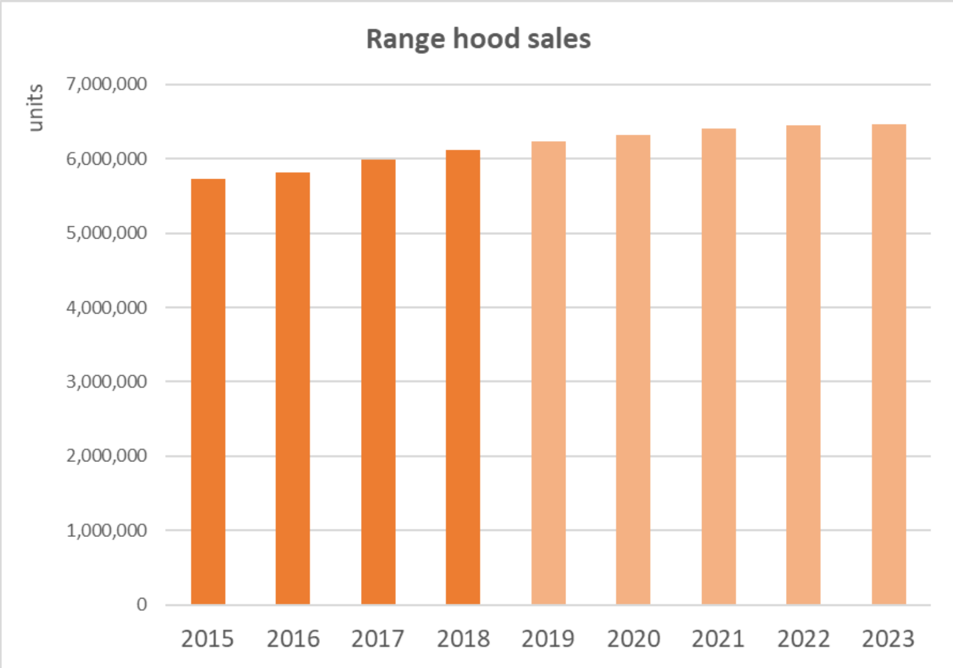


Figure 51. Cooking fume extractors sales trends

Looking specifically at technology trends for the different product groups (Figure 52), it can be seen in the first instance that electric ovens are expected to keep on dominating the market over the next years (sales of gas ovens are so small that the red line appears almost flat in the graph)

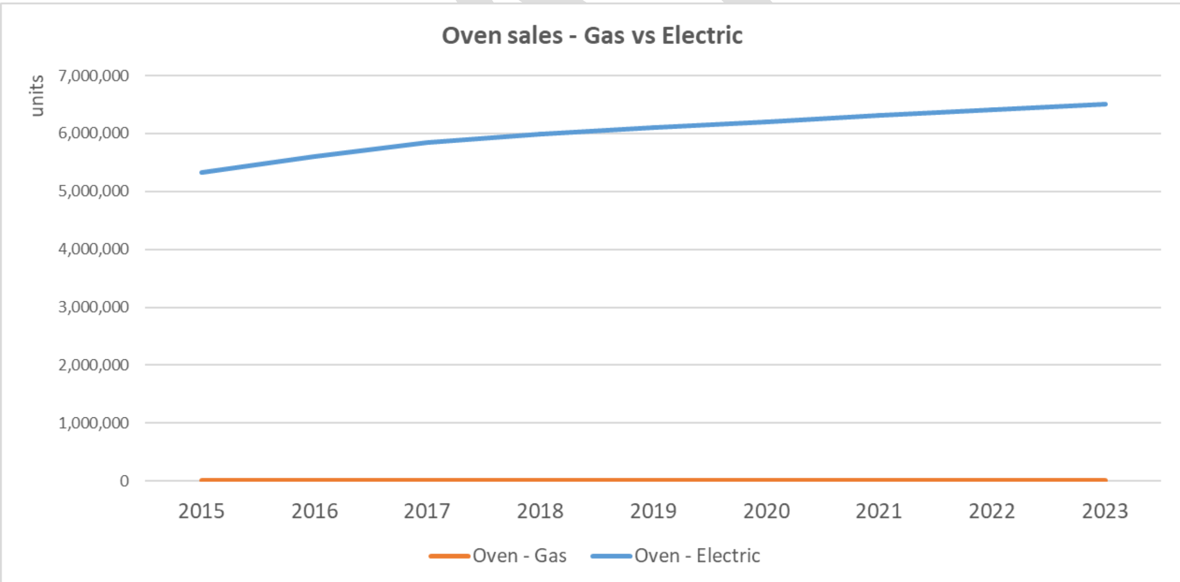


Figure 52. Oven heat source trends

In terms of cookers (Figure 53), energy sources are distributed differently, with approximately 25% of the sales being gas and 75% electric. In both cases, sales are expected to slowly decrease over the period 2018-2023.

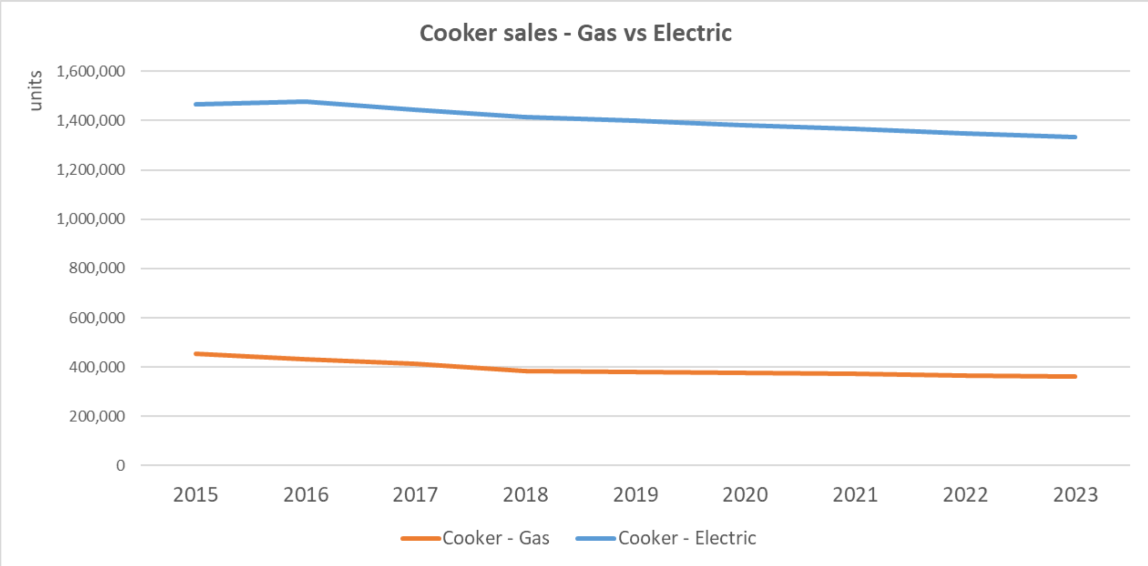


Figure 53. Cooker heat source trends

In terms of hobs (Figure 54), induction technologies are expected to see a significant growth over the next years. Gas hob sales are expected to grow at a very slow rate, with radiant and solid plates technologies decreasing gradually.

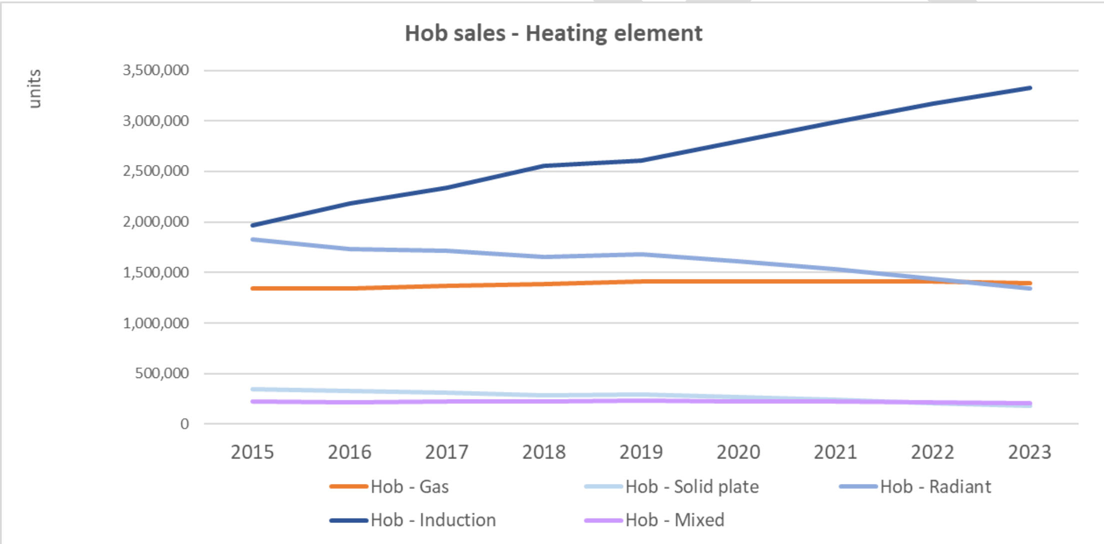


Figure 54. Hobs heat source trends

According to the market data of five EU countries, the sales of cooking fume extractors have slightly decreased between 2017 and 2018. As can be observed in Figure 55, under cabinet cooking fume extractors have declined at a constant pace seemingly in benefit of built-in hoods. Chimney hoods are by far the dominant type of cooking fume extractor among sales.

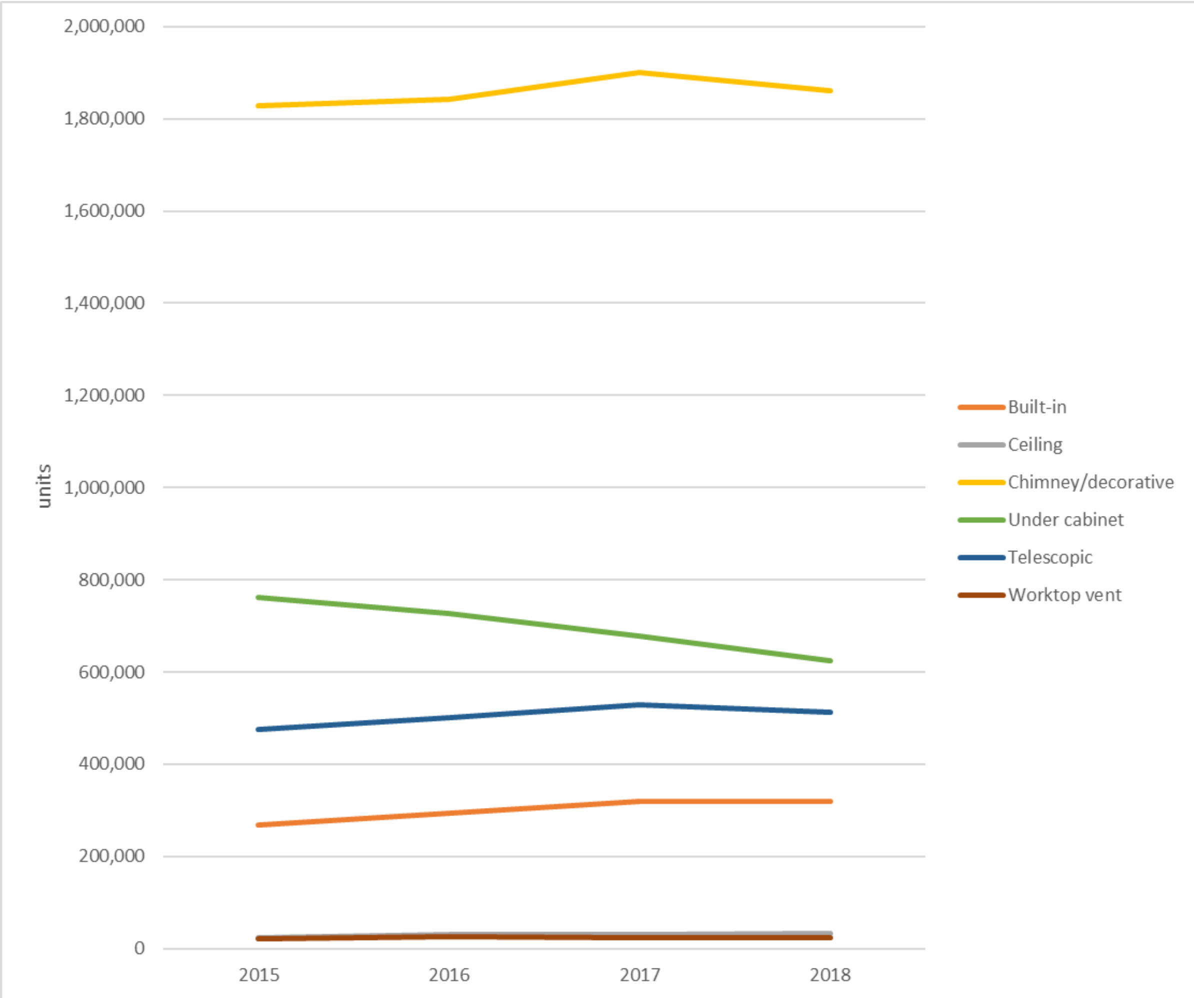


Figure 55. Evolution of sales of different types of cooking fume extractor in five EU countries

In the case of the market distribution in terms of flow, no significant trend is apparent, as Figure 56 shows. The different flow ranges are quite evenly distributed, since it is related to the different types and sizes of the kitchen furniture and the space available.

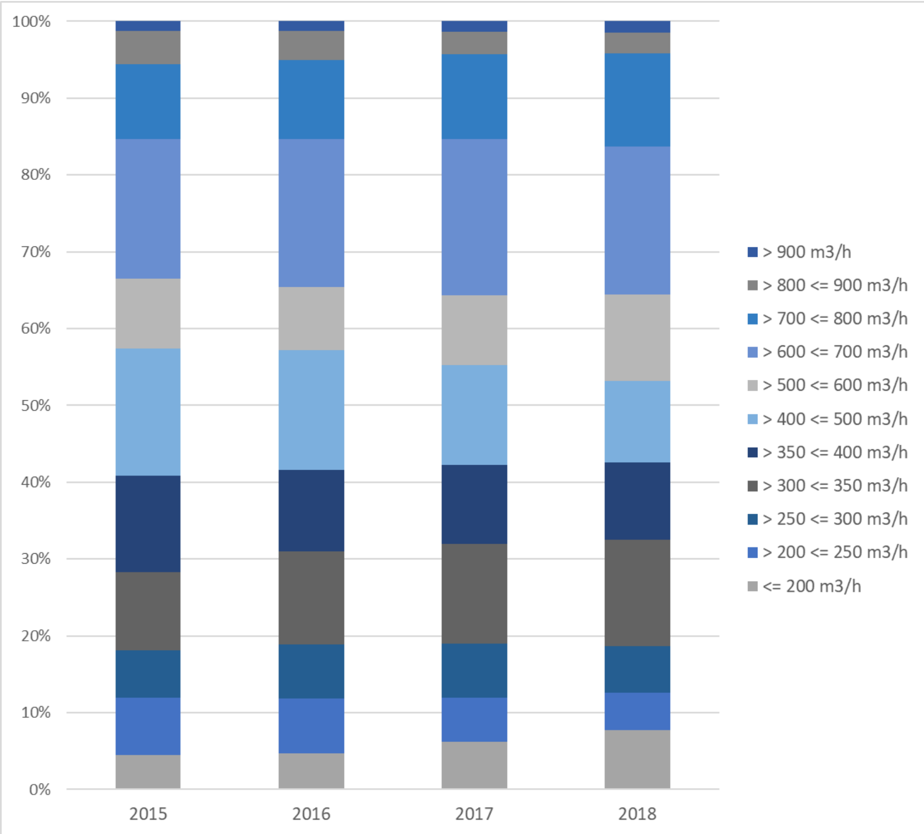


Figure 56. Evolution of sales of different cooking fume extractors in terms of flow in five EU countries

2.2.6 Stock of domestic cooking appliances

In this section, the stock of appliances will be estimated for:

a) Ovens
b) Cookers
c) Hobs
d) Cooking fume extractors

In this report, the estimation of stocks has been made based on the penetrations rates published in Mugdal et al (2011) and the results of the user behaviour study (Task 3). These sources show that the market of ovens and hobs is saturated (penetration > 90%) while the penetration of cooking fume extractors is lower, 45% in 2012 and 70% in 2020, and according to the annual sales is not expected to go beyond 75% of market penetration.

The changes in the stock each year are determined by the sales of appliances (entry of appliances in the stock) and the probabilities of obsolescence, which represent the number of appliances that have reached their lifetime and are hence leaving the system as waste flow. The relation of these elements is presented in the following formula.

Stock on year (X) = Stock on year (X-1) + Sales over year (X) – Obsolete products over year (X)

In order to conduct stock estimations, data regarding annual sales of ovens, cookers, hobs and cooking fume extractors is needed for a considerable number of years in order to produce reliable prospects. However, annual sales data for appliances is very valuable and therefore scarce. In this study, sales data is available for 2015-2018, with growth estimations for 2019-2023. Therefore, certain assumptions and estimations need to be made. Data sources and assumptions made are detailed below:

- Annual sales data for the period 2015 – 2018 comes from GfK and Euromonitor
- Annual sales data trends for the period 2019 – 2023 comes from Euromonitor
- For data not available from GfK or Euromonitor, annual growth trends from Mugdal et al (2011) have been used
- Annual sales data for the periods 2000-2014 and 2024-2040 have been estimated based on best-fit trends for each product group

As it can be seen in Figure 57, the total stock of ovens (both built-in and cookers) is estimated to grow between 2019-2040 up to almost 200 million units in 2040. The evolution of gas ovens is slightly downward which is consistent with the expected growth in sales for the period 2015-2018 seen in Section 2.2.3.

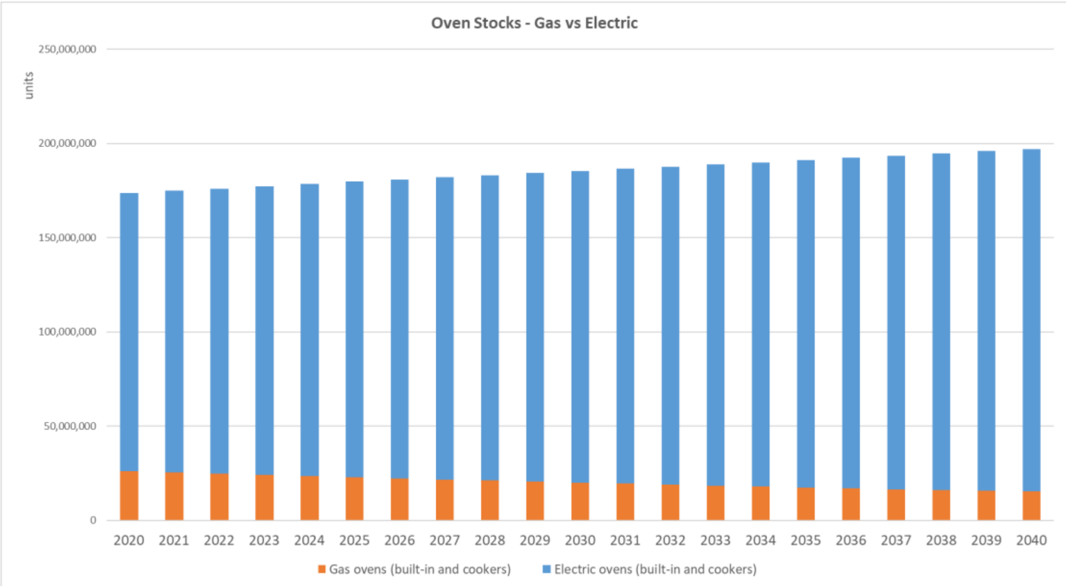


Figure 57. Estimated oven stocks 2020-2040

In the same way, as it can be seen in Figure 58, the total stock of hobs shows a similar pattern.

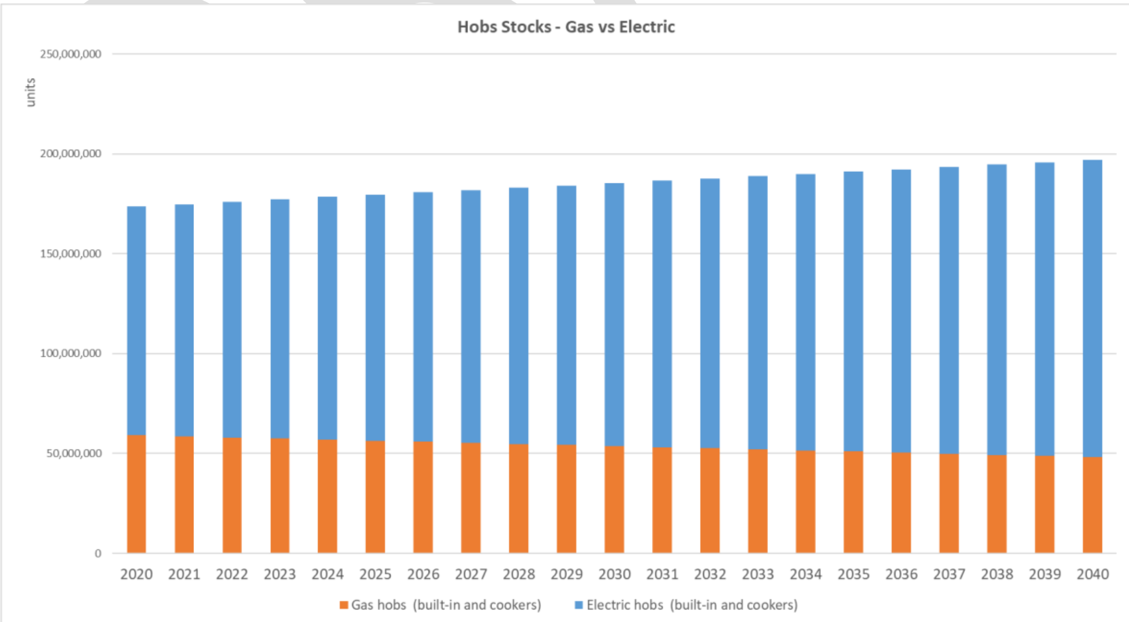


Figure 58. Estimated hob stock 2020-2040

According to the sales data, induction will grow significantly, becoming the most common technology is the coming years. (Figure 59).

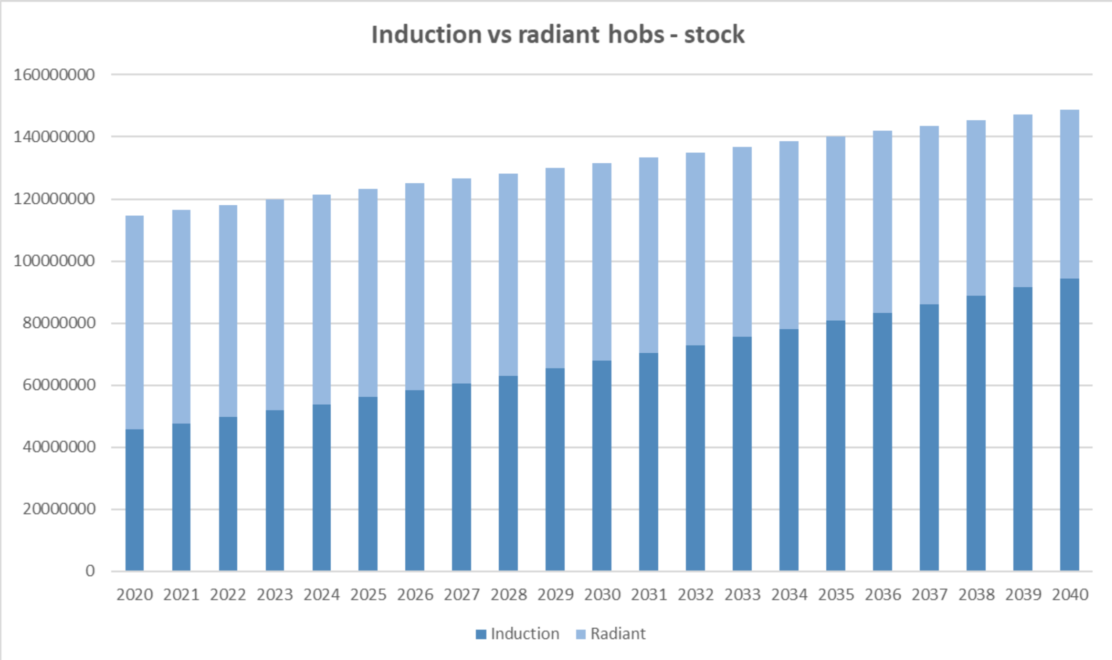


Figure 59 Estimated induction / radiant hob stock 2020-2040

As it can be seen in Figure 60, the total stocks of cooking fume extractors is estimated to grow between 2019-2040 up to 160 million units in 2040. This growth is consistent with the expected growth in sales for the period 2015-2018 seen in Section 2.2.3.

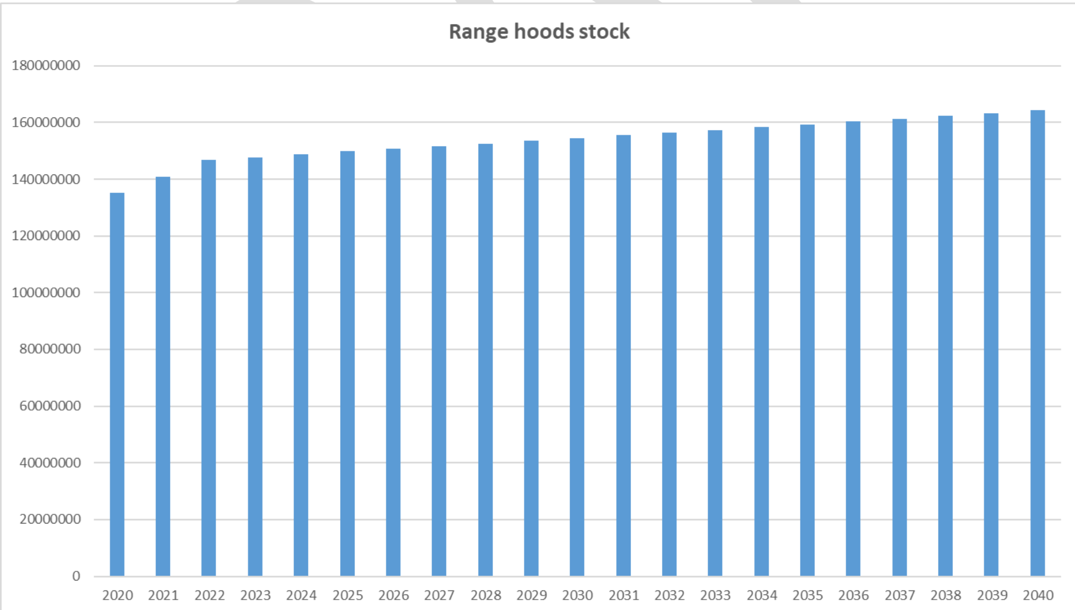


Figure 60. Estimated cooking fume extractors stock 2020-2040

2.2.7 Stock of microwave ovens

At the time of development of this report, data of sales of microwave ovens was not available, therefore the estimation of stocks could not be made following the same method as for the rest of products groups. However, for the development of Task 3, a survey was launched to understand the user behaviour of European consumers with regards to cooking appliances. In that study, it was estimated that the penetration rate of microwave ovens was 75.3% in 2020, or a total of 145 million appliances.

2.2.8 Market structure of the European domestic cooking appliances industry

According to Mudgal et al (2011), the domestic oven market appears to be highly concentrated. In 1999, the three leading manufacturers were covering between 40 to 80% of the market (e.g. General domestic appliances and Electrolux in UK and BSH in Germany). The situation was considered to be similar in 2008, even though the number of brands increased due to more competition, especially from Asian manufacturers.

The relevance of original equipment manufacturers (OEM) in the domestic cooking appliance sector is quite significant. OEMs are producers of appliances for other brands, which generally operate as small and medium enterprises (SMEs). According to Mudgal et al (2011), they manufactured approximately 25% of the appliances in 1999. In that year, most of the factories were located in Italy, Germany and UK. Some manufacturers also own factories outside the EU (in Eastern Europe or Turkey). The size of the factories is variable, from 50 to more than 3000 employees. The production of these factories is also very variable, potentially ranging from 30.000 to 300.000 units. APPLIA provides an indication on the location of large home appliances manufacturing sites in Europe in 2018 (Figure 61).

Figure 61. Large home appliances manufacturing sites in Europe in 2018 (APPLIA, 2019)

As it can be seen in Figure 61, the countries with the highest number of manufacturers are Germany and Italy, followed by France, Poland and Turkey. Spain, UK and Romania also have a significant number of manufacturing sites.

Since the publication of Mudgal et al (2011), not much data has been made publicly available regarding cooking appliances specifically. Most of the data in this section will therefore refer to household appliances in general: it will include cooking appliances in particular but also fridges, washing machines, dishwashers, etc.

Euromonitor International (2010) published data regarding home appliance manufacturers in general. The top five companies on that year were Whirlpool, Electrolux, Haier, BSH and LG (Figure 62).

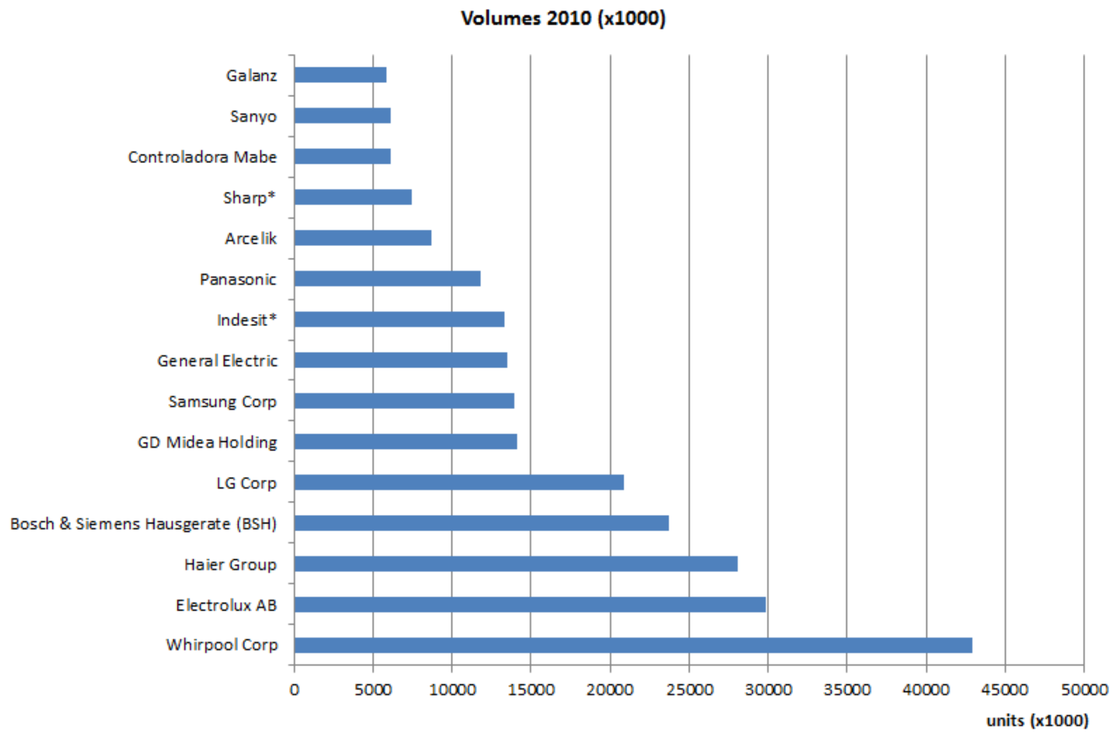


Figure 62. Top 15 home appliances manufacturers in 2010 (Euromonitor International)

It is worth noting that some of the information seen in Figure 62 may be out of date by 2019, since some of the smaller brands may have been acquired by bigger corporations. These acquisitions may have modified the current picture of global home appliances market share.

In terms of specialization, some of the companies in Figure 62 are focused in home appliances (such as Whirlpool), whereas other have much bigger markets in completely different sectors (such as LG or Panasonic). Another relevant point is that many of the corporations in Figure 62 are companies which own and distribute a wide variety of home appliances brands (this is the case of Whirlpool, Electrolux, Haier, BSH and others), whereas others such as LG, Samsung or Panasonic operate under a single brand.

In terms of value, the global household appliances market was valued at $501,532 million in 2017 and is projected to reach $763,451 million by 2025, growing at a CAGR of 5.4% from 2018 to 2025 (AMR, 2019). Some of the key factors affecting this growth are:

- Technological advancements
- Shift towards more energy efficient appliances
- Rapid urbanization
- Growth in housing sector
- Rise in per capita income
- Improved living standards
- Surge in need for comfort in household chores
- Change in consumer lifestyle
- Escalating number of smaller households

Considering distribution channels, AMR indicates that most of household appliances are purchased through specialty stores, followed by supermarkets/hypermarkets, online commerce and others. This trend is expected to continue towards 2025. The biggest growth is expected to happen in the e-commerce segment, due to high penetration of internet connection and smartphones.

A brief analysis by region shows that the European market experiences growth owing to low interest rates and a good economic situation. The market is witnessing an increase in demand for premium built-in or integrated appliances such as ovens, with integrated steam function, flexible induction hobs and integrated hob extractors,. Destination of EU exports can be seen in Figure 63.

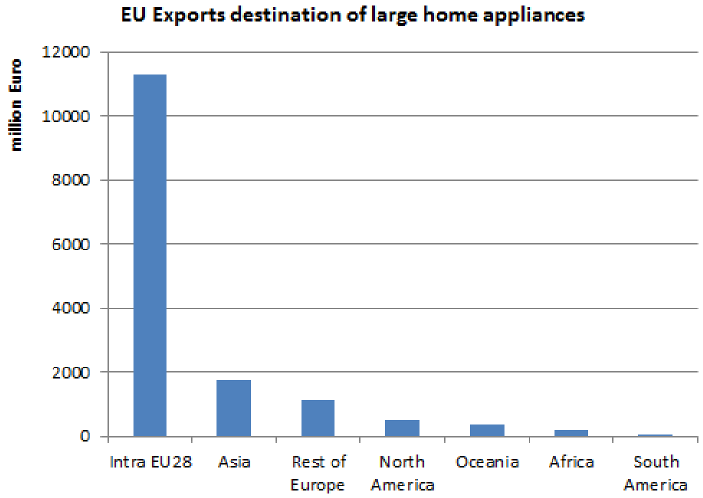


Figure 63. EU export destinations of large home appliances 2017 (APPLIA, 2019)

Still focusing on the EU market, the top five exports destinations outside of EU were Russia, USA, Norway, Switzerland and Australia. In contrast, the top five countries of origin of large home appliances from outside of EU were China, Turkey, South Korea, Malaysia and Russia.

North America is a matured and homogenous market for household appliances with high product penetration. The demand for household appliances is dominated by product replacement. The Asia-Pacific household appliances market is anticipated to witness strong growth owing to increase in household income, rapid urbanization, rise in the middle-class population, easy access to goods through development of retail channels, easy access to consumer finance, and change in lifestyles of the population.

2.3 Consumer expenditure base data

This section presents purchase prices, installation, repair and maintenance costs as well as applicable rates for running costs (e.g. electricity, natural gas) and other financial parameters (e.g. taxes, rates of interest, inflation rates). This data will be input for later tasks where Life Cycle Costing (LCC) for new products will be calculated.

The average consumer prices and costs experienced by the end user throughout the product lifetime are determined by unit prices in the following categories:

- average price per unit for each category;
- consumer prices of electricity and fuel;
- inflation and discount rate;
- installation costs;
- repair and maintenance costs;
- disposal tariffs and end-of-life cost.

2.3.1 Average unit values of domestic cooking appliances

2.3.1.1 Average unit value of ovens

In Figure 64, a comparison is conducted between the two most common energy classes for ovens (A+ and A) for five different countries in terms of price. As it can be seen, there is a significant difference between the price of A+ and A ovens. Both energy classes have seen a decrease in price between 2015-2018.

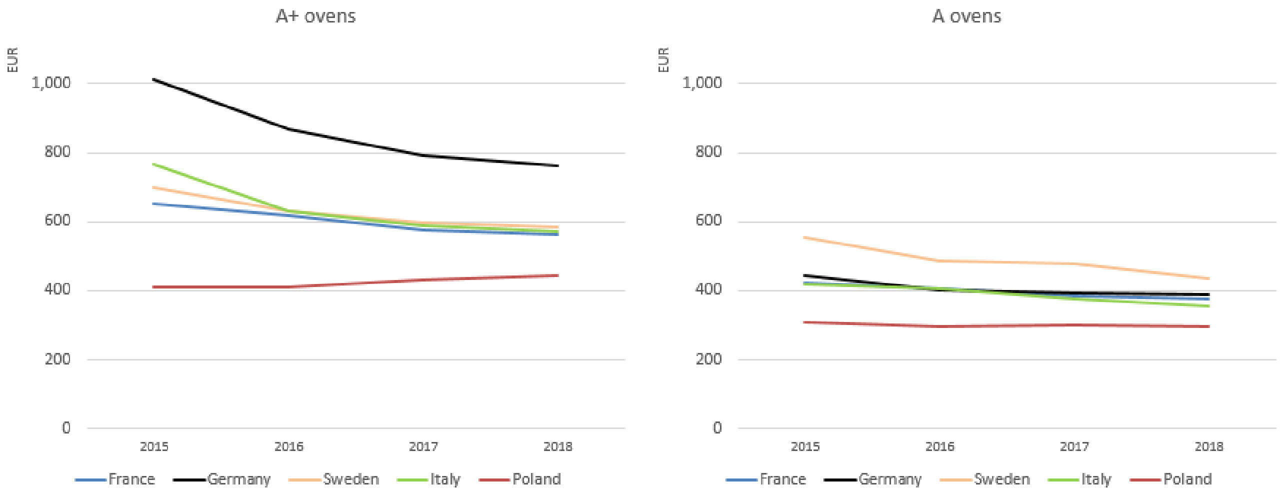


Figure 64. Price of ovens by energy class

In Figure 65, a comparison is conducted between two different functions offered by ovens (steam and microwave functions) for five different countries in terms of price. As it can be inferred from the graph, both functions tend to be found in high-end products. A wider range of prices can be seen in steam-assisted ovens, whereas prices of microwave-assisted ovens tend to be consistently higher. Prices of both types of functions are stable over the period 2015-2018.

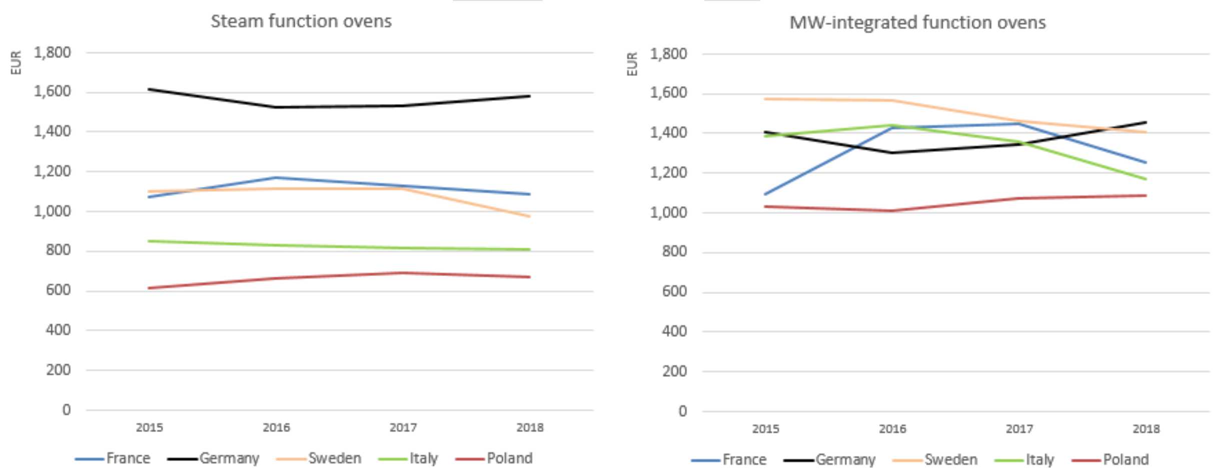


Figure 65. Price of ovens by function

2.3.1.2 Average unit value of hobs

In Figure 66, a comparison is conducted between three different heating elements for hobs (gas, induction and radiant) for five different countries in terms of price. As it can be seen, the most expensive technology is currently induction. Gas and radiant hobs tend to have similar prices, with a wider range for gas appliances. Prices of the three types of technologies are stable over the period 2015-2018.

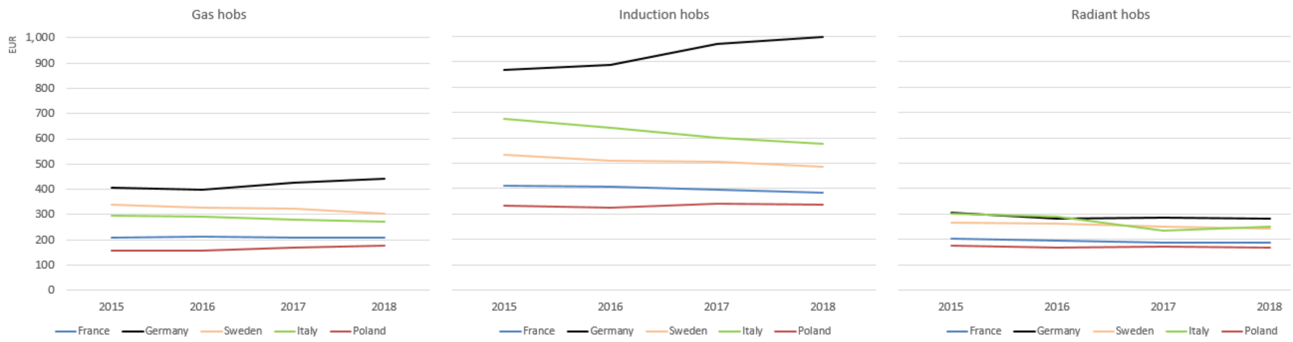


Figure 66. Price of hobs by heating element

2.3.1.3 Average unit value of cooking fume extractors

In Figure 67, a comparison is conducted between three different energy classes in cooking fume extractors (A+, C and F) for five different countries in terms of price. As it can be seen, there is a clear relationship between energy class and price in the case of cooking fume extractors. Top categories (A+) have significantly higher prices that middle and low categories (C and F).

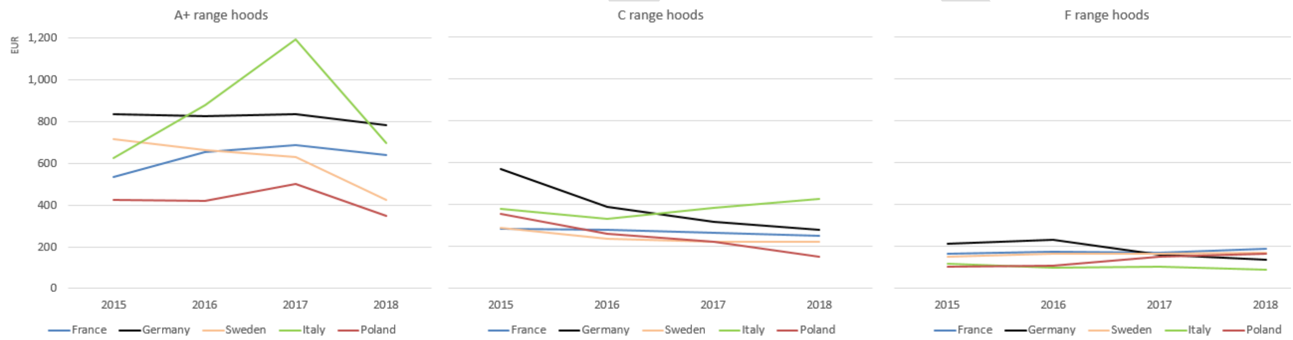


Figure 67. Price of cooking fume extractors by energy class

In Figure 68, a comparison is conducted between two different mounting configurations in cooking fume extractors (standard and ceiling) for five different countries in terms of price. Standard cooking fume extractors tend to have the lowest energy classes and ceiling cooking fume extractors tend to be in the top energy classes, as seen in Figure 41. Price is consistent with what was already observed previously: standard cooking fume extractors are in the lower spectrum of prices (the most expensive is less than 250 Euro), whereas ceiling cooking fume extractors are in the highest spectrum (with cooking fume extractors up to 2500 Euro).

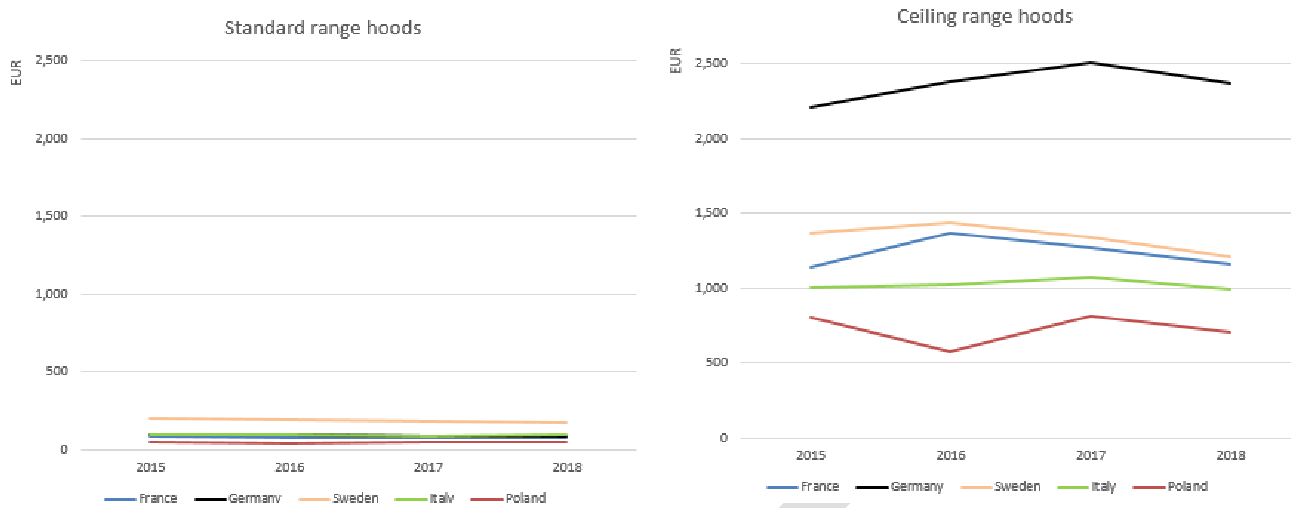


Figure 68. Price of cooking fume extractors by configuration

2.3.2 Consumer prices of electricity/fuel

The annual energy prices are taken from the PRIMES Model[9], which provides the prices referred to the year 2013 (Table 20). The reference year prices will be calculated using the inflation rates from Eurostat.

Table 20. Annual prices of energy products

	2013 END USER PRICE (in EUR cents/kWh)					
Electricity	2005	2010	2015	2020	2025	2030
Average price	**11.7**	**13.6**	**14.4**	**15.3**	**15.7**	**16.1**
Industry	8.4	9.7	9.7	9.8	9.9	10.0
Households	15.6	17.2	19.0	20.3	20.9	21.2
Services	12.7	14.8	15.7	17.1	17.6	17.9
Natural gas						
Industry	3.0	3.8	3.8	4.3	4.5	4.8
Households	4.6	6.1	7.1	7.5	7.9	8.4
Services	3.9	5.0	5.7	6.1	6.5	6.9
LPG						
Industry	7.4	7.8	5.6	8.3	9.0	9.5
Households	7.7	8.6	6.7	9.5	10.2	10.8
Services	6.6	7.1	5.5	7.6	8.1	8.7

2.3.3 Installation, repair and maintenance costs

If the installation, repair or maintenance requires a professional service, the average EU labour cost in the category "Industry, construction and services (except public administration, defence, compulsory social security)" is to be used, as shown in Table 21[10].

9 https://ec.europa.eu/clima/policies/strategies/analysis/models_en

10 http://ec.europa.eu/eurostat/cache/metadata/en/lc_lci_lev_esms.htm#unit_measure1475137997963

Table 21. Average total labour costs for repair services

Year	2000	2004	2008	2012	2013	2014	2015	2016	2017	2018
EU-28 countries, (EUR/h)	16.7	19.8	21.5	23.9	24.2	24.5	25.0	26.0	26.7	27.4

2.3.4 Disposal tariffs/ taxes

Since domestic cooking appliacnes are covered by the WEEE Directive and producers are responsible for paying a WEEE tax or in some other way financing the EOL treatment, it is assumed that end users will not experience any further EOL costs. The WEEE tax paid by manufacturers is assumed to be reflected in the sales prices of cooking appliances to end users. In the end user life cycle cost calculations, the EOL cost is therefore set to zero.

2.4 Conclusions

Ovens and cookers conclusions

In terms of sales and technology trends:

- Total oven sales are growing steadily. Vast majority of consumers today purchase electric ovens.
- Steam assisted oven sales are growing rapidly, although still a very small part of the market.
- MW-combi oven sales are stable and are a very small part of the market.
- Larger cavity volume oven sales are growing and currently are the main preference for consumers
- Connected oven sales are growing rapidly, although still a very small part of the market
- Total cooker sales are decreasing. Majority of consumers prefer electric cookers.

In terms of energy classes (ovens):

- There are no A+++ ovens and only 0.06% are A++ (top energy classes)
- A+ category has been growing up to a 29% in 2018
- The vast majority of ovens are either A or A+ (mid energy classes)
- Nearly 70% of ovens in 2018 are A (minimum possible class after 2020)
- 0.24% of ovens in 2018 are either B or C (banned after 2020)
- There are no ovens in the lowest energy class (D)
- It appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B)
- It seems easier to reach top energy classes when the oven has a steam heating function supporting the convective function. However, these appliances have improved sealing with reduced vapour outlet, which leads to better results in the standard test, although the vapour function may not be active.

In terms of energy classes (cookers):

- There are no A+++ or A++ cookers (top energy classes)
- A+ category has been growing very slowly up to a 2% in 2018
- The vast majority (79%) of cookers are A (minimum energy class after 2020)
- 4.5% of cookers in 2018 are either B or C (banned after 2020)

- There are no cookers in the lowest energy class (D)

Hobs conclusions

- Induction technologies are expected to see a significant growth over the next years. Gas hob sales are expected to grow at a very slow rate, with radiant and solid plates technologies decreasing gradually.

Cooking fume extractors conclusions

- The energy classes of the sales have improved along the last years, and worktop vent hoods have reached A++. However, the market share of this type of hood is very low (<1%). Under cabinet hoods perform the worst energy classes (C to E), though their sales show a downward trend.
- There seem to be a relation between energy class and flow, since the data available show a concentration of the best energy classes in the larger flow ranges and of the worst energy classes in the smaller flow ranges. However, there is not a significant trend towards a specific range of flow, probably because the flow and the size of the hood are dependent to the kitchen furniture and space available, which significantly vary across EU households.

3 Task 3. Analysis of user behaviour and system aspects

User behaviour has a significant effect on the environmental impacts of domestic cooking appliances during all phases of their life-cycle: firstly through the selection of the appliance type, secondly through the actual use of the appliance over the life time and finally on the end-of-life. To some extent, product-design can also influence consumer's behaviour and consequently the environmental impacts and the energy efficiency associated with the product use.

The aim of this section is to investigate the influence of consumer behaviour on the energy and environmental performance of cooking appliances, as well as best-practices in sustainable product use.

- In Section 3.1, the relevance of energy consumption of domestic cooking activities will be put in perspective within the European context.
- In Section 3.2, system aspects affecting energy consumption such as frequency of use and duration of cycles will be presented. This section will include currently available published data and will be used for reference.
- In Section 3.3 other aspects affecting total energy consumption such as purchase decision and cooking habits will be presented.
- In Section 3.4, aspects related to user behaviour cooking habits
- In Section 3.5, aspects related to the information offered to consumers
- In Section 3.6, aspects related to user behaviour and end of life –such as reusability, repairability and disposal channels- will be presented.
- In Section 3.7, aspects related to local infrastructure will be addressed. For domestic cooking appliances, these will be mainly related to the effects of product installation and maintenance on performance and durability
- Section 3.8 includes the results of a complete user behaviour study, with information on frequency of use, duration of cycles and preferred programmes and modes.

3.1 The relevance of domestic cooking activities in the EU context

In 2017, households energy consumption represented 27% of total final energy in the European Union (Eurostat, 2017), being the second consuming sector after transport (33%). The peak of energy used in residential sector was observed in 2010 with 3,721 MWh, with a slight decrease of 9% since then (European Commission, 2018). Total energy consumption in EU households may be reduced with the help of energy efficiency initiatives. It has been estimated that European households could save roughly 27-30% of their energy usage by correcting inefficiencies (PENNY, 2019).

Energy is used for various purposes within households: space and water heating, space cooling, cooking, lighting and other electrical appliances and other end-uses. Most of that energy is spent in space heating (64%). Cooking activities represent 5.6% of household electricity consumption (**Figure 69**).

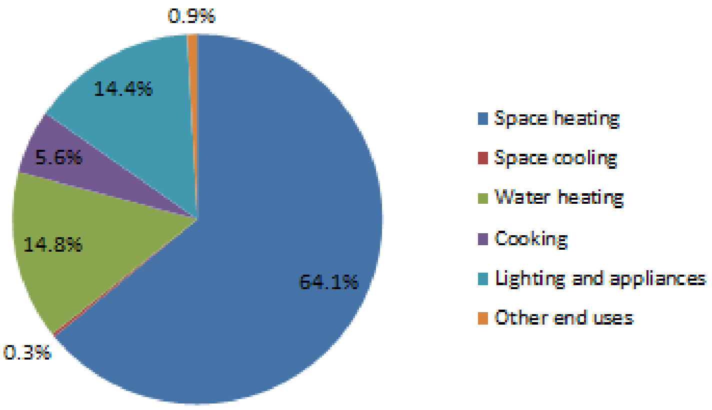


Figure 69. Final energy consumption in the residential sector of the EU28 (Eurostat, 2017)

Average annual energy consumption for cooking has been estimated in 460 kWh per year (Zimmermann et al, 2012). Energy spent also differs significantly depending on the type of household and on level of occupancy. The highest energy consumption has been reported in household with single inhabitants non-pensioners, with 505 kWh/year and person; whereas the lowest average is in households with multiple people with children: 422 kWh/year and person (Zimmermann et al, 2012).

The share of final energy consumption dedicated to cooking activities within the household varies considerably when analysing member states individually, ranging from 1% up to 39%. Several factors can affect that wide variability. First, in certain countries, most of energy may be spent in other areas, such as space heating (as it happens in Finland with 66%), reducing proportionally the share dedicated to cooking. In fact, it is observed that most of the countries with the highest proportion of energy dedicated to cooking are in the South/Mediterranean area (Portugal, 39%; Malta, 12%; Spain, 8%), whereas those with lowest proportion tend to be in the north (Finland, 1%; Sweden, 2%; Denmark, 2%; UK, 3%). Differences in terms of food culture and diet may have an influence on the energy spent on cooking.

3.2 Reference values of frequency of use and energy consumption

In current version of the energy label, energy consumption of domestic cooking appliances is measured as in **Table 22**:

Table 22. Ways of measuring energy consumption for domestic cooking appliances

Appliance	Energy efficiency in product declaration	Unit
Ovens	Energy per cycle	Electric (kWh/cycle) Gas (MJ/cycle)
Hobs	Energy per amount of standard load	Electric (kWh/kg water) EE [1] (%)
Cooking fume extractors	Energy per year	kWh/year

1-EE is expressed as % in gas hobs but is also related to energy required to heat a standard amount of water (see Task 1 for details)

A key parameter in the analysis of user behaviour for cooking appliances is the frequency of use (generally expressed as cycles/year). A secondary but also relevant parameter will be the duration of each cycle (generally expressed as minutes/cycle). Data published so far on those two parameters is presented in Section 3.2.1. Based on frequency of use, typical energy consumption values is presented in Section 3.2.2.

3.2.1 Frequency of use of domestic cooking appliances

European citizens invest a considerable amount of time in cooking at home, both in weekdays and in weekends. As it was analysed in Foteinaki et al. (2019) for the case of Denmark, at certain times of the day, nearly 30% of the population may be doing cooking/eating related activities (Figure 70).

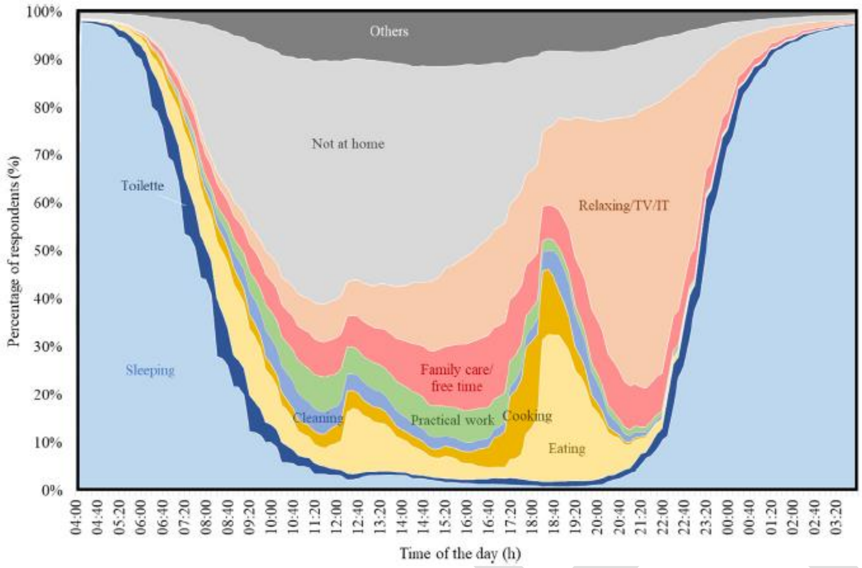


Figure 70. Daily activity profiles in Denmark

Similar patterns, with slight differences are observed in other European countries such as Spain (**Figure 71**). As indicated in Santiago et al (2014), food preparation shows a small peak in the morning, another much larger peak at noon (with 20% of households involved in this activity on weekdays and more than 30% on weekends), and another peak corresponding to the evening.

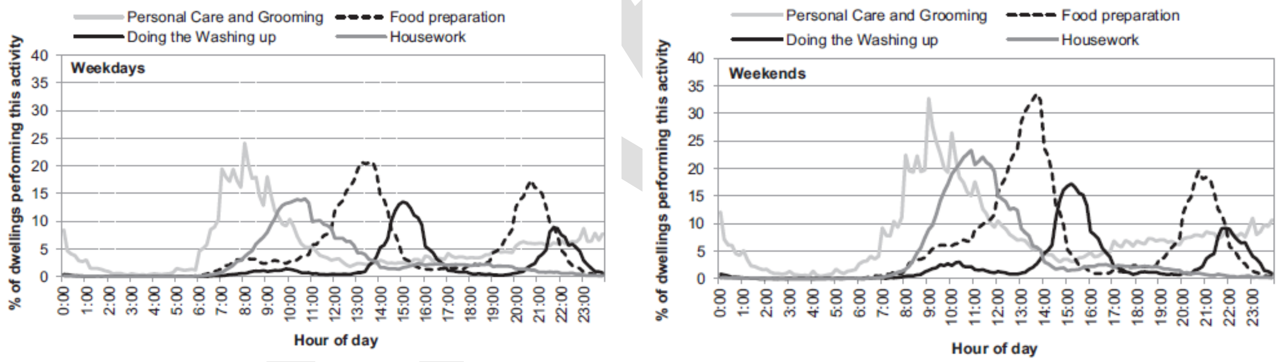


Figure 71. Daily activity profiles in Spain

Figure 70 and Figure 71 show that there are differences in the schedules and habits among the different European countries, reflecting different lifestyles and routines, closely linked to the customs, practices and climate of each zone. Another relevant comment pointed out by the authors is that energy consumption related to cooking activities coincides with household active occupancy peaks and with the greatest electricity demand in the residential sector. This is a time interval which is difficult to modify, as it is closely linked to habits and working schedules and therefore occupants must necessarily be in the home.

In general, cooking activities last between 36-43 min/day, with slightly longer duration for weekends and colder seasons (Barthelmes et al, 2018). Lower energy consumption for cooking activities in summer is also observed, mainly because of the type of meals prepared and the time spent on cooking (Zimmermann et al, 2012). In Wood et al (2003) it is also observed that energy consumption in cooking of the average Sunday is twice as big as the energy consumption on the average weekday. Santiago et al (2014) also indicate that size of municipality has certain influence on amount of energy spent on cooking activities. In small municipalities, there are more homes dedicated to cooking than in the cities during the day. At the noon peak, for instance, there are 8% more households engaged in this activity than in the big cities.

Ovens

In previous Preparatory Study for Domestic Cooking Appliances on average a household uses the oven 110 times per year (**Table 23**). The average duration of cycles was estimated at 55 minutes both for electric and gas ovens.

Table 23. Frequency of use and cycle duration for ovens (Mugdal et al, 2011)

	Electric oven	Gas oven
Frequency of use (cycles / year)	110	110
Average duration of cycle (min)	55	55
Standby mode (hours/year)	8595	8595

Hobs

In previous Preparatory Study for Domestic Cooking Appliances the frequency of use for domestic hobs is 424 cycles per year (**Table 24**).

Table 24. Frequency of use and cycle duration for hobs (Mugdal et al, 2011)

	Gas	Solid plate	Glass ceramic	Induction
Frequency of use (cycles / year)	424	424	424	424
Average duration of cycle (min)	n/a	26	45	58

According to Mudgal et al (2011a), induction hobs are used an average time of 58 minutes per cycle, whereas for the ceramic and solid plates it is 45 and 26 minutes respectively (**Table 24**). The differences in times are not explained in the report, even though induction hobs heat food more quickly with lower heat losses and therefore shorten the cooking time and consume less electricity annually than other types of hobs. An explanation could be related to different usage patterns.

Cooking fume extractors

In previous Preparatory Study for Domestic Cooking Appliances no data is provided on cooking fume extractors in terms of frequency of use or duration of cycles. According to a stakeholder, a cooking fume extractor operates for approximately **300 hours/year**. Other stakeholders indicate that, according to internal company studies, all speeds of cooking fume extractors (min, medium, max) are used equally, whereas boost mode is rarely activated and it is used only during specific cooking types. The frequency of use is from **1h-3h/day**.

3.2.2 Typical energy consumption of domestic cooking appliances

In this section, typical energy consumption values (primary energy) are presented, based on available bibliography.

Ovens

In terms of ovens, Mudgal et al (2011a) gathered data on user behaviour, specifically on typical dishes, number of times they were prepared and the temperature used was collected for several countries. The study concluded that it was not possible to identify major differences in oven use practices. Information was collected for six different types of uses of meal cooking: meat, home-made meals, cakes/bread, snacks, ready meals, and reheating.

It was also reported a decrease in the consumption per use by 25% from 1980 to 2008 possibly due to the fact the market share of most energy efficienct ovens and cookers has increased although the energy consumption in additional functions (such as standby power) also increased, shrinking households and the shift to other appliances (e.g. microwave ovens). Values of Energy consumption, frequency and duration used in the previous Preparatory Study for Ecodesign Requirements for Cooking Appliances are presented in **Table 25**.

Table 25. Electricity consumption electric and gas ovens (Mudgal et al, 2011a)

	Electric oven	Gas oven
Energy consumption	1.1 kWh/cycle	1.67 kWh/cycle
Annual Electricity consumption (kWh/year)	164	184

Lot 22, Task 3, p16

Hobs

Energy consumption values used for scenario modelling and analysis in the previous Preparatory Study for Ecodesign Requirements for Cooking Appliances are reported in **Table 26**. The figures below do not include standy consumption.

Table 26. Hobs annual energy consumption (Mudgal et al, 2011a)

	Gas	Solid plate	Glass ceramic	Induction
Energy consumption (kWh/cycle)	0.78	0.58	0.57	0.45
Annual energy consumption (kWh/year)	334	250	240	190

Lot 23, Task 3, p12 & p15

Regarding gas hobs, Mudgal et al (2011b) suggested that the evolution of the gas hobs energy consumption was approximately constant for 20 years (1980-2008), as the main parameters remained constant: the consumption per use and the number of uses per year. The reason for the slight increase in the evolution is the standby power demand that has increased in the last years.

According to a stakeholder, energy consumption of current hobs is around **0.55 kWh/cycle for radiant vitroceramic** and around **0.75 kWh/cycle for gas**. These figures are in the same order of magnitude than in the previous preparatory study.

Cooking fume extractors

In previous Preparatory Study for Domestic Cooking Appliances no data is provided on cooking fume extractors in terms of energy consumption.

According to a stakeholder, energy consumption of domestic cooking fume extractors is **between 36.5 and 72.1 kWh/year**, depending on different performance factors such as airflow, lighting power or grease filtering efficiency.

3.3 Purchase of domestic cooking appliances

Most of the households in the EU28 have some type of oven, hob and hood. In a study focused on Denmark (Foteinaki et al, 2019), it is stated that these appliances can be found in 90% of households. Separate hobs or ovens are present in 14% and 12% of households respectively (EIA, 2019).

Similar to the topic, some authors (Baldini et al, 2018) have focused their analysis in analysing which are the socioeconomic characteristics which can predict better the choice of purchasing energy efficient appliances in general (not focused on cooking appliances). Variables used in this study were the number of inhabitants in the household, the type, age and size of house, the age of respondents, their job, their income and their environmental awareness. Some of the findings from this study are summarized below:

- The higher the income, the higher the probability to choose more energy efficient appliances
- It is more probable to choose more energy efficient appliances in farmhouses and single houses than in townhouses and apartments
- The higher the number of people living in the dwelling, the greater the propensity to choose an energy efficient appliance
- The higher the environmental previous awareness and behaviour, the higher the chance of selecting a more energy efficient appliance
- Older respondents have a higher propensity to choose energy efficient appliances

Since there is no specific research on purchase behaviour for cooking appliances, it is only possible to extrapolate conclusions from previous studies applied in different products. Some of the potential aspects influencing purchase behaviour for ovens, hobs and hoods are commented in this section.

Price and **cost of use** are obvious factors that may affect purchase decisions of cooking appliances. At equal level of performance in terms of functionalities or energy consumptions, consumers will likely prefer appliances that allow them to save money across their lifetime. Aspects which may have influence consumers in acquiring a more expensive product –of similar performance- are brand reputation or aesthetics. It has been demonstrated that consumer age is a factor that correlates with the amount of money spent on home appliances (Hennies et al, 2016). In general, younger people buy significantly more low-cost appliances such as washing machines and TVs. It has also been observed that the price paid for these appliances correlates significantly with the lifespan of the appliance.

Related to price and cost of use, **durability** is a relevant factor as well that may affect purchase decisions. In the case of cooking appliances, consumers tend to prefer ovens, hobs and hoods that guarantee longer periods without maintenance needs or critical failures. Durable products avoid –or delay significantly- the need of acquiring new appliances to substitute old ones. Consumers have shown a clear preference for durable products: in Perez-Belis et al (2017), it was concluded that 79% of consumers find very relevant to include durability requirements in product design.

Nevertheless, an although it may be correct to assume that consumers do prefer purchasing durable products, this statement can be debated with the current trend of rapid substitution of appliances, driven by the constant availability of new technologies and products, which make older products quickly obsolete. The topic of **obsolescence** is addressed by Hennies et al (2016). In their study, the authors differentiate between:

- Quality obsolescence, when the product does not work anymore.
- Functional obsolescence, when the product does not satisfy completely the expectations of consumer
- Psychological obsolescence, induced purely by the desire of acquiring new products.

The most problematic of the types of obsolescence defined would be the psychological, since the decision of discarding the product in those cases is neither related to failure or to lack of required functionalities. However, the authors point out that psychological obsolescence tends to be low in 'workhorse' appliances such as washing machines (1%) and slightly higher in 'up-to-date' appliances such as TVs (14%). In terms of socioeconomic characteristics related to obsolescence, Dindarian et al (2012) indicate that high income and low educational achievement are both correlated with early replacement of durable products. End of life aspects are discussed in more detail in Section 3.4 of this report.

In terms of **second hand market**, there is not much data publicly available for ovens, hobs and cooking fume extractors. With regards to other home appliances such as small devices, it has been estimated that only 12% of population actually purchase second hand products (Bovea et al, 2018), and that when they do, it is mainly due to economic reasons (environmental aspects are generally ignored). This figure is even lower in Perez-Belis et al (2017), where only 0.75% of respondents to a survey admitted having bought second hand small home appliances. When they actually did, they did not invest more than 20 EUR in them.

In terms of the barriers for this low preference of second hand products from the consumers' side, the most common are the association with potential premature failure of second hand products, health, safety and hygiene concerns, perception of inferior quality, perception of little difference in price between new and second hand products, lack of repair guarantees and general desire to acquire new products. In addition to those, second hand product sellers also argue that barriers for this market to grow are the unpredictability of supply and demand, the lack of legal incentives to promote repair and the perception that, on occasions, consumers may feel ashamed of purchasing second hand products (Bovea et al, 2017).

Other authors suggest that the **reputation** of the seller of the second hand product is important. Reputation mechanisms such as the ones in online second hand selling sites can provide signals about product or service quality and help mitigate uncertainties faced by potential buyers of remanufactured products. It has also been observed that consumers pay relatively higher prices (8%) for products remanufactured by OEMs or their authorized factories than those remanufactured by third parties (Subramanian et al, 2012).

Another important purchase decision regarding cooking appliances may be **energy source**. Considering that, it is relevant to point out that most ovens and hobs in the EU28 are electrically heated. The market share of electrical appliances is growing even bigger, with gas appliances still in a significant 16% for ovens and 36% of for hobs (European Commission, 2012). Type and size of household tend to determine the choice of energy source for appliance. For instance, it has been observed that the use of gas appliances is greater as household size and income increase (Hager, 2013).

Another factor that can influence the selection of gas or electric appliances is the **local infrastructure**. For example, many rural locations throughout the EU are not connected to natural gas distribution networks and so if gas cooking is preferred, users need to use bottled gases which are far more expensive than natural gas. This cost difference encourages the selection of electric cooking appliances instead of gas. On the other hand, there are also kitchens which are equipped with a gas connection and not with a 3-phase electrical outlet. In this case, the consumer will purchase a gas appliance instead of an electric appliance.

An important aspect influencing purchase decision is the amount and type of **information provided** to the consumer. According to the results presented in PENNY (2019), providing tailored information about the potential of monetary savings from adopting new energy efficient durables induces households to purchase home appliances that consume on average 18% less electricity compared to those purchased by households that did not receive such information. In the same study, it is also highlighted that what matters is not only the content of the information provided, but also the way in which this information is presented. For instance, if information of energy usage cost for a specific product is presented –instead of monetary savings-, consumers tend to shift towards less efficient products. The format of the information presented is therefore a strong moderator of the effectiveness of information policies on investments.

Another important factor is **literacy** regarding energy consumption and related environmental impact of appliances. It has been observed that households with a low degree of energy literacy tend to underestimate the benefits of purchasing efficient appliances. Therefore, educational campaigns could increase the level of energy literacy and promote investments into energy-efficient appliances. Still on the matter of information provided, in Baldini et al (2018), it is concluded that information campaigns such as labelling have not had significant effects in promoting energy efficiency improvements. The authors recommend that the focus for future policies is to consider not only what metric is shown in the label, but also what this metric actually means to the customer in the moment of purchase.

In terms of appliance choice, it is also worth mentioning that in certain contexts, consumers cannot affect energy efficiency of cooking activities through the purchase of appliances, such as tenants in already furnished houses or students in residences, where energy efficient devices are often not the option. In other occasions, people may be economically constrained when trying to incorporate energy efficient behaviours, not being able to replace old inefficient appliances even if they are willing to do so. In these situations, the only way consumers can affect energy consumption will be through the actual use they make of those appliances.

Oven capacity (cavity volume) is a factor for consumers when purchasing a new oven. Even when the dishes cooked more often might not be large in size, they might opt for ovens with more capacity to cover the rare occasions when they cook large meals. On this topic, one stakeholder indicated that for built-in ovens the maximum capacity is limited due to the typical furniture in European kitchens. Also, the used capacity varies strongly during the year. For a given consumer, even if only once per year a large meal (such as a goose) is prepared, this consumer will never decide on a smaller capacity. Usually, the oven provides more levels for inserting the food to optimize the application for the different modes and dishes. In order to ensure the very high range of applications (grilling, pizza, roasting a turkey, baking cookies on several levels, baking bread) the concept of more levels in a certain volume is needed. Another stakeholder adds that optimal capacity of the oven depends also on the family composition and status.

The purchase decision of a cooking fume extractor is usually made together with the **kitchen design and installation**, and it is usually limited by the space available. The size of the cooking fume extractor has a significant impact on its components and its energy efficiency. This is further explained in Task 4 Analysis of technologies.

3.4 User cooking habits

It has been estimated that 26-36% of the total in-home energy use is directly related to residents' behaviour (Wood et al, 2003). Specifically related to cooking, energy use has decreased 50% since the 1970s, but these gains have not come from changes in cooking methods but from the use of more energy efficient cooking devices (such as microwaves), through the expansion of ready-made meals and takeaways and from eating out habits. In fact, the connections between cookery practices and environmental impacts is often ignored by consumers, industry and government policy, when these practise may be up to 50% of energy use when analysing a food product's life cycle (Reynolds, 2017).

There are numerous energy saving behaviours that can be performed during cooking. Even when cooking simple meals, energy efficient techniques can help to reduce energy consumed by a third (Oliveira et al, 2012). Changing energy-using behaviour during cooking has therefore a significant potential for energy conservation.

An appropriate **cooking temperature** is a very relevant factor concerning energy consumption of appliances, especially in the case of ovens. Using higher temperatures than needed will mean a significant waste of heat –and the possibility of spoiling the meal-. However, it is also worth taking into account that according to Reynolds (2017), cooking at lower temperatures in the oven than indicated in the recipe actually increases energy use since it also increases the amount of time the meal needs to be in the appliance. The right balance in terms of temperature settings is essential.

Switching to **smart** or more **energy efficient appliances** has the potential of reducing significantly energy use while cooking. In the case of cooking fume extractors, it has been demonstrated that the use of smart devices, which are able to automatically adapt its performance and optimize its operation, depending on the type of system used (Castorani et al, 2018). However, it is important to note that using energy efficient products does not necessarily mean that people automatically use less energy, as the overuse or incorrect use of the appliance can drastically increase final energy consumption.

Clear **indications** and **energy consumption feedback** in cooking appliances has significant improvement potential. Indications of cooking appliances being on/off are important for reduced energy consumption. In Oliveira et al. (2012), it is demonstrated how a confusing display on a hob can lead to significant energy wasted when cooking a simple meal. Generally, when having controls on the same disposition as the burners, subjects tend to incur in less errors in identifying which one is working. It is also worth mentioning the reduction potential of information feedback to consumer. It has been demonstrated that a significant proportion of households are able to reduce electricity expenditures while cooking if they are given feedback on their energy related behaviours, especially if it is immediate and in electronic format (Wood et al, 2003).

Accurate **cooking times** can be a relevant factor that influences energy consumption. Turning hobs off when water is already boiling or switching ovens off for the last minutes of cooking has been highlighted as technique that has a big energy saving potential (Oliveira et al, 2012).

Reading carefully **cooking instructions** can have a significant energy saving potential, as it can lead to reduce errors in temperature settings, cooking times, quantities, as well as to the use of other simple tips such as the use of lids or not opening the oven door to check is food is already cooked.

The **choice of cookware** has an important effect on the final consumption per use. Although there is no information on different types of cookware tested in various appliances (e.g. electrical, induction or gas hobs) to enable comparison between them, a test conducted on an electric hob of two different types of pans demonstrated the significance of this factor. Other relevant aspects related to cookware are the intelligent use of the residual heat, selecting the right size pan, using lids, etc.

As already mentioned in section 3.3, product **durability** can affect purchase decisions. At the same time, consumer behaviour is also decisive on product durability. They way in which the product is used and maintained can compromise the limit of their lifetime.

In O'Leary et al (2019), it is estimated that the existing domestic kitchen ventilation strategies and airflow rates are inadequate in over 88% of houses when the cooking fume extractor is used only during the cooking operation. However, if the **cooking fume extractor is used for a period of time after cooking**, it can reduce the daily mean of PM2.5 concentration significantly. Daily average concentration can be reduced 58% if cooking fume extractor operates for 10 extra minutes after cooking. Dobbin et al (2018) also found benefits in operating the hood for longer time after cooking, although in their experiment it had a relatively small effect compared to the effects of fan flow rate and the specific fan used during cooking. For PM2.5, the effect of running an exhaust fan for 15 minutes after cooking was similar in magnitude to the impact of a 168 m3/h increase in the flow rate used during cooking. This suggests that one can partially compensate for low flow rate exhaust fan by continuing to run the fan after cooking. It must also be taken into account that running the hood for some time after cooking would be detrimental for the total energy consumption of the appliance, so a clear trade-off arises here between capture and energy efficiency of cooking fume extractors.

3.5 Information to consumers

Information provided to consumers (both in terms of energy efficiency and on end of life) is a very relevant topic.

One stakeholder argues that consumer studies have shown (https://www.verbraucherzentrale-rlp.de/sites/default/files/migration_files/media231718A.pdf) that the energy efficiency classes are better understood than the information on the total consumption. Thus, there is certainly room to explain this aspect better to consumers.

Some stakeholders provided feedback on potential additional information requirements which could be included in future regulation for domestic cooking appliances:

- Overall, they recommend to follow the example set by the recently adopted ecodesign and energy labelling regulations in which improved information requirements (also on resource efficiency aspects) have been set.

- Include information on how to carry out maintenance and repair, as well as information on end-of-life treatment.
- Explore the icons on the Energy Label that could help consumers buy more durable, reparable products, such as the free warranty period offered by the manufacturer or spare parts availability. DG Justice's behavioural study on consumer engagement in the circular economy describes how effective this could be in shifting purchasing decisions towards products with greater durability and reparability.
- Ovens: indicate on the energy label both, the energy consumption in standard mode, and optionally in the ecomode.
- Cooking fume extractors: Table 6 Annex I "information on domestic cooking fume extractors" contains a list of information, symbols, values and units but not on the type of cooking fume extractors which is important.
- Provide consumers with information on the performance of the appliances by introducing an energy label for hobs, and for the commercial appliances.

Other stakeholder adds that information about the used energy after a heating process, not in terms of absolute values, but in terms of steps or ranges (low-mid-high energy consumption) could guide users to save energy. Absolute values should be avoided, because the product is not mentioned as a measurement system and the tolerances of the power installation would require an advanced measurement system, which would make costs higher without a significant user advantage. Now, the users have no possibility to evaluate and improve their usage behaviour.

3.6 User behaviour aspects related to material efficiency and end of life

Domestic ovens, hobs and cooking fume extractors are appliances that are present in the majority of households of the EU. Domestic cooking appliances are heavy, bulky items with abundant different materials, including ferrous and non-ferrous metals, plastics and several types of electronics. This abundancy of materials –very valuable, but also energy-intensive and rich in rare resources- makes their proper management at end of life a very relevant aspect of their life cycle. Ovens, hobs and cooking fume extractors –among other large household appliances- are under the scope of the Directive 2012/19/EU on waste electrical and electronic equipment (WEEE Directive).

The habits of consumers in relation to end of life strategies concerning electrical and electronic equipment have not been widely analysed so far. However, it is necessary to know whether consumer behaviour is aligned with the objectives promoted by policies such as the WEEE Directive and also with the principles of the Circular Economy. This is fundamental to determine whether more awareness-raising actions are required to guide consumers towards priority strategies in the waste hierarchy, such as reuse and repair.

To date there is not much literature available on reuse and repair practices for domestic cooking devices specifically. In this section, information is provided on consumer behaviour at end of life regarding small electrical and electronic equipment and large home appliances in general. Although crucial aspects such as lifetime expectancies, usability patterns and technology evolution may be significantly different between those and domestic cooking appliances, some interesting conclusions can still be made based on the data available.

3.6.1 Maintenance of domestic cooking appliances

Maintenance is a very relevant factor concerning domestic cooking appliances related to their end of life. According to a stakeholder, for a proper performance and durability of appliances, they should be appropriately cleaned and maintained. For instance:

- The cavity of the oven and the door sealing need to be regularly cleaned, in order to avoid excessive grease and soil deposition, which can burn irreversibly into the enamel and which can disturb the good functioning of the heating elements.
- In gas hobs, burners should be periodially cleaned
- Grease filters of hoods have to be regularly replaced or cleaned. Active charcoal filters of recirculation hoods also have to be cleaned or replaced according the manufactures' instructions.

With a proper maintenance, the performance is ensured and the risk of repairs can be significantly reduced.

3.6.2 Reusing and repairing domestic cooking appliances

In the past years, it has been observed that electrical and electronic appliances are replaced earlier than they actually need to. In Bovea et al (2018), the authors conducted an analysis on the habits of consumers regarding the substitution, repair or second hand purchase of most frequent information and communication technology (ICT) devices in Spain (mobile phones, e-book readers and tablets). Some of their findings were that only 13% of the population stopped using the devices because they were broken. In terms of functionality or safety, there was not a real need to dispose of or substitute the device, but the consumer still decided to change it. This is in line with the findings of Dindarian et al (2012) regarding microwave ovens: half of the units studied required only minor repairs; some of them only minor cosmetic or cleaning operations. This short substitution cycle leads to an accelerate growth of the amount of waste, and is mainly caused by rapid technology evolution, particularly in the ICT sector.

Domestic cooking appliances are significantly different to ICT devices. They have different usage patterns, they are not so related to trends, and they generally do not generate an emotional attachment to consumers. Their lifetime, which will be discussed in further detail in subsequent sections of this report, is generally expected to be longer than ICT devices. However, this trend of substituting appliances even if they are still functioning –or if they can be easily repaired- may also be happening at a slower pace in the large appliances sector. More research should be carried in this field to confirm this aspect.

In terms of potential **reusability** of appliances, in Bovea et al (2016) a methodology was defined to classify small WEEE according to its potential reuse. The methodology was then applied to a sample of small devices. From the analysis it was concluded that 30% of the sample had to be diverted to recycling due to functional or safety requirements not met; 2% of the sample could be directly reused after minor cleaning operations; and 68% of the sample required posterior evaluation of its potential repair. Adding up the last two, it may be concluded that the total potential for reuse of small electrical and electronic appliances is of 70%. As said earlier, this cannot be directly extrapolated to the domestic cooking appliances sector due to the obvious differences between product types. However, it does provide an indication of the potential reusability and reparability of appliances in general.

In terms of **reparability** of domestic cooking appliances, from consumers' perspective, the barriers to repairing used appliances are related to the fact that most of them (79%) do not consider it worthwhile given the price of purchasing new equipment. Moreover, Dindarian et al (2012) also point out that refurbishing and remanufacturing costs are for some products only a fraction of manufacturing costs of a new product. Other barriers are not knowing where to take the appliance in order to be repaired and the inconvenience of bringing the equipment to the repair centre. From the repairers' perspective, the unpredictability of supply and demand and the difficulty of obtaining cheap spare parts are highlighted as the main barriers for this end of life alternative.

3.6.3 Disposal channels for domestic cooking appliances

Although reuse and repair are the preferable end of life alternatives, the average consumer is generally not aware of options beyond recycling or landfilling. According to Dindarian et al (2012), 67% of consumers bringing microwave ovens to collection points are not aware of other end of life options for this appliance. Reuse and repair do not seem like options that consumers are considering widely. When home appliances are not reused or repaired, consumers still need to dispose of them in an appropriate manner. Different disposal alternatives for consumers regarding waste of electric and electronic equipment (WEEE) are:

- Municipal collection points
- Retailers
- Door-to-door collection
- Charity initiatives

Related to the disposal channels above, in Magalani et al (2012) an analysis was conducted on the main disposal channels for large household appliances. The two main disposal paths in Italy are through municipal collection points and retailers. Regarding retailers, large household appliances are mostly picked up at consumers' homes 75-95% of the time, often in conjunction with the delivery of new equipment (Table 27).

Table 27. Disposal channels for large household appliances in Italy (Magalani et al 2012)

Disposal channel	Average*
Municipal collection points	39.1%
Retailers	37.1%
Reuse (sold or given away)	8.0%
Bad habits (e.g. waste bin, plastic waste, other wrong streams)	5.8%
Life extension (old house....)	5.3%
Do not know, do not remember	4.1%
Warranty replacement	0.6%

*Values correspond to large home appliances: dishwashers, washing machines, wash dryers and centrifuges, furnaces and ovens and microwave ovens.

Most of the materials recovered from the collection of large home appliances are ferrous metals, followed by plastics and non-ferrous metals in smaller proportion. Nowadays, the majority of these products are recycled at the end-of-life (Magalini et al, 2017).

3.6.4 Stakeholder feedback on material efficiency and end of life behaviour

Regarding end of life, one stakeholder considers that appliances that are placed on the market today, do not pose any recycling problems, as they have to respect applicable substance regulation. For older appliances, there is a potential risk. Information about that potential can be found on the Information for Recyclers online platform: https://i4r-platform.eu/.

In terms of **reusing and remanufacturing** products, relevant stakeholders state they cannot provide any information on the market for re-used products as no conclusive data about that market –which is mostly informal– is available. They add that the market for remanufactured cooking appliances is rather limited. Most likely due to accumulated dirt and grease residues in the products after several years of use. Preparation for re-use organisations mostly focus on washing machines, tumble dryers, dishwashers and cooling and freezing appliances. The same is true for components.

According to another stakeholder, the market of reused and remanufactured cooking products is very limited (for instance, charity organisations). The remanufacturing of an appliance could heavily affect safety, EMC, performance and energy consumption of the product itself. For this reason, this operation should be done just by the original manufacturer that is the only player with the proper knowledge and capability for retesting and reverification of repaired products. Remanufacturing by other operators that are not the original manufacturers, should be made clear to the users and it must not, for any reason, affect the original manufacturer and nor the status of the original placement of the product in the market.

Another stakeholder reminds that Circular Economy, resource savings and savings on embedded energy and CO_2 are clear priorities for the EU. They have been assessed necessary to reach our climate goals as set in the EU Long-term Decarbonisation Strategy for 2050. They believe that ambitious action should be taken in this regard through the ecodesign policy. Several studies show that the lifetime for large household appliances has declined and such a decline in a product's service time needs to be reversed. A way to improve the lifetime of household appliances is to design products that are easier and less costly to repair so that it is more affordable for consumers to repair appliances than to replace them. Furthermore, they recommend to explore guidance for easy maintenance and proper cleaning of the cooking appliances.

3.7 Local infrastructure

3.7.1 Installation of domestic cooking appliances

One of the aspects that should be taken into account when installing a domestic cooking appliance is its most appropriate location within the kitchen. For instance, studies suggest that the location of the cooking appliances can have a significant effect on total energy consumed in the household. For instance, it is recommended that an oven is not placed adjacent to a fridge (Wood et al, 2003). A stakeholder indicates that this is more relevant for free-standing appliances than for built-in. For the latter, there is enough distance between them, and due to the low usage of the cooking appliance compared to the fridge, the impact will be quite low.

Product installation may have a significant influence on product durability and maintenance. On this topic, a relevant stakeholder indicates that ovens and hobs are appliances which need ventilation for cooling of the electronics, furniture, etc. Proper circulation of air should be assured by following the installation instruction manuals. However, experience shows that this is often not the case. For instance:

- Wrong electrical connection on 400 V instead of 230 V can cause defects to the appliance.
- Constraints of power quality can cause defects and may influence lifetime of products.
- Wrong installation leads to complaints from users. The cooking fume extractor is identified as the cause, where in fact it is the installation.

In the case of cooking fume extractors, the type of installation has a significant impact on the configuration and performance of the hood. Hood performance is related to its design, both in terms of inherent **aerodynamic properties** and in terms of **mounting configuration**, since they all have different capture areas and are mounted at different heights relative to the cooking equipment. Island mounted hoods, for instance, require greater exhaust airflow rate than wall mounted hoods. They are also more sensitive to makeup air supply and cross drafts than wall mounted (Fisher et al, 2015).

Exhaust **duct arrangement** of the hood also has an influence on the hood capture efficiency. For optimal performance, duct runs must be short with minimal amount of bends and corners.

The type of ventilation and the availability of exhaust duct also affects the installation and operation. Three different configurations can be distinguished:

1) **Recirculation Hoods:** a grease filter and a charcoal filter clean the air collected, than is recirculated into the ambient air.
2) **Extraction Hoods:** the air collected is filtered by grease filter, and then evacuated outside.

3) **Extraction Hoods connected to a Central Ventilation System:** the air collected is filtered by a grease filter and then is evacuated outside. There is no motor and the hood does not control the motor speed but it can open or close a damper.

According to the industry, cooking fume extractors working only in recirculation version represent a niche market, and almost 100% of the products can work in both conditions, recirculation and extraction mode.

In terms of **size and position**, minimizing the vertical distance from appliance to the lower edge of the hood can reduce the required exhaust airflow rate and therefore improve performance. The higher the distance between hood and cooktop, the higher the opportunities for leakage, as cooking oil mists thermal plume expands with vertical distance from generation source. It has been demonstrated that increasing the installation height of the hood by 30 cm requires 14% increase in airflow (Swierczyna et al, 2006). However, low installations may affect cooking operations and are more likely to cause fires. Also, concentration of particles in the breathing zone of the cook is higher when the distance of hood and cooktop is lower (Sjaastad et al, 2010). Other authors indicate that for optimal performance, it should be 50-60 cm above an electric cooktop and 60-70 cm above a gas cooktop (Lowes, 2019).

Relevant parameters in cooking fume extractor performance are also the **front overhang** and the **rear gap** (**Figure 72**).

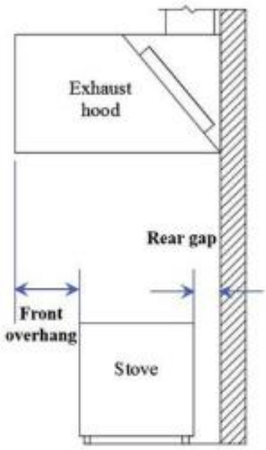


Figure 72. Front overhand and rear gap (Han, 2019)

For same sized-hoods, increasing the front overhang significantly improves the hood's ability to capture and contain cooking pollutants. A similar thing happens with the rear gap. In Swierczyna et al, 2006, it was demonstrated that for the same front overhang, a deeper hood required less airflow to operate, since rear gap becomes smaller. This is also the reason why inserting a rear seal behind the appliance to fill in the rear gap can improve hood performance, as some of the replacement air which would have otherwise been drawn up from behind the appliance, is instead drawn in along the perimeter of the hood, helping guide the plume into the hood. Other authors point out that for optimal performance, hood must be preferably around 8 cm longer than the cooktop on each side (Lowes, 2019). Related to overhand and rear gap is the **position of the burners**, which may also have an effect on hood capture efficiency. In Rim et al (2012), it is suggested that at the same hood flow rate, using the back burners is more effective in reducing particles than the front burner.

Disturbing airflows from cooking behaviour, movement of people, open windows or doors, etc., are unavoidable. These airflows have a detrimental effect on hood performance. The presence of a person in front of the cooktop, for instance, creates a wake which can potentially transport the pollutants out of the hood. In general, an island cooking fume extractor is more affected by disturbing airflows than a wall mounted hood. A potential solution to mitigate the negative effects of these airflows is the use of side panels next to the cooktop, which permit the use of a reduced exhaust rate in the cooking fume extractor (CEC, 2012). However, they are not very popular in domestic kitchens for aesthetic reasons.

Another relevant aspect in capture efficiency is the effect of **make-up air**. A cooking fume extractor extracts air from the kitchen area. This air removed from the kitchen must be replaced with an equal volume of air through a different pathway. This equal volume of air is known as the make-up air. The strategy used to introduce make-up air can significantly impact hood performance. Make-up air introduced close to the hood's capture zone may create local air velocities and turbulence that result in failures in thermal plume capture and containment. A series of design recommendations regarding make-up air installation is provided in CEC, 2012

3.7.2 Energy: Reliability, availability and nature

Electricity

The power sector is in a state of transition, moving from fossil fuels to renewable energy. The origin of the electricity is a very important factor to consider regarding both the environmental impact of using electrical cooking appliances and how it may affect consumer behaviour. A binding renewable energy target of at least 32% of final energy consumption for the EU was agreed in 2018 for 2030. The final energy consumption is the total energy consumed directly by end users, such as households, industry and agriculture. It is the energy which reaches the final consumer's door and excludes that which is used by the energy sector itself.

The reliability of the electricity grid could, to some degree, be affected by the transition to a renewable energy system. With more renewable energy in the system new challenges occur, e.g. with excess production of wind energy and the two-directional transfer of energy (e.g. electric cars that can supply electricity to the grid when they are not in use). Renewable energy production can vary greatly from hour to hour and day to day.

Due to technological developments, the reliability of the electricity supply in many EU countries is ensured via the expansion of the electricity grid to distribute renewable energy. The quality of the electricity grid in Europe is considered to be high and among the best in the world.

Natural gas

According to EU Reference Scenario 2016 (European Commission, 2016), natural gas consumption in the residential sector is projected to keep constant. The main consumers of natural gas are water and space heating appliances, while the share of cooking appliance in natural gas consumption is much lower.

The composition of the natural gas affects the safety, performance and the environmental impact of gas cooking appliances. Therefore, each manufacturer must test the oven or hob using the natural gas that is typical of the country where the appliance is to be sold.

GHG emissions of the combustion of natural gas can be drastically reduced by the injection of biomethane (upgraded biogas) in the natural gas grids. The terms "upgraded biogas" or "biomethane" are used to refer to the biogas that has undergone the upgrading process to remove impurities and achieve the standard requirements for grid injection purposes. Biogas is mainly produced from agriculture: energy crops, agricultural residues and manure. Other sources are sewage sludge and landfill, though more than 70% come from agriculture (European Biogas Association, 2014). Biomethane production has increased from 752 GWh in 2011 to 17 264 GWh in 2016 (European Biogas Association, 2017). This represents less than 2% of the total natural gas consumption in the residential sector. The increment between 2015 and 2016 was 40%, being Germany, France and Sweden the top countries in production increase (European Biogas Association, 2017). However, the injection of biomethane in the grids is far from being a common practice in EU. According to Scarlat et al (2018), in 2015 most of the biomethane injected into the gas grid was in Netherlands and marginal volumes in other countries.

Natural gas can be also blended with hydrogen, which would also reduce the GHG emissions from its combustion. The permitted concentration of hydrogen in the gas grid varies across EU countries ranging from 0.1 Vol. % to 14 Vol.%, and it can also vary within each country (e.g. Germany) (**Figure 73**).

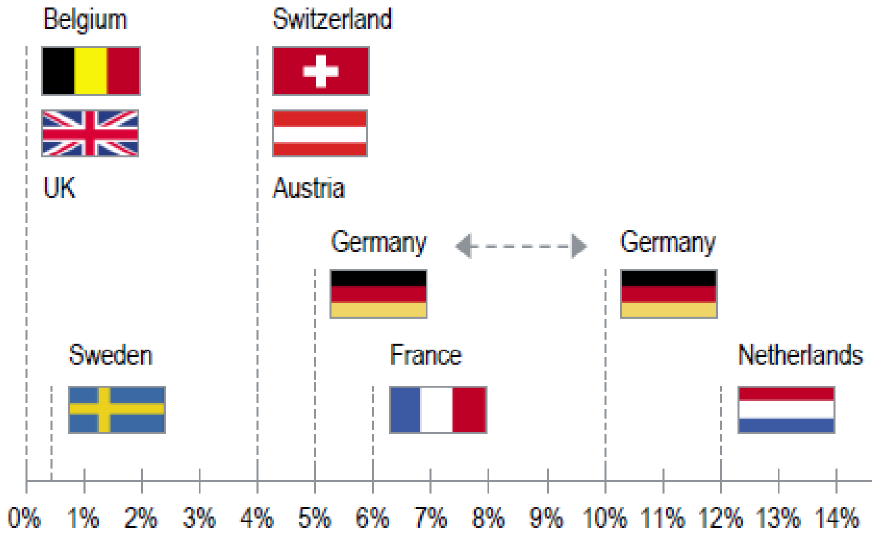


Figure 73. Injection percentage in EU countries in % vol. (FCH and Roland Berger, 2017)

Injections above 15% would require investments to adapt the infrastructure, including monitoring and maintenance measures, and upgrading due to the lower durability of the materials when exposed to hydrogen. Hydrogen injection is not allowed in a large number of EU countries (Hydrogen Europe 2019, FCH and Roland Berger, 2017).

There are no standards setting a common admissible concentration of hydrogen in the natural gas network. The European Committee for Standardisation (CEN) standard EN 16726: 2015 recommends a case by case analysis since the variety within the EU gas infrastructure prevents a general valid solution (Hydrogen Europe, 2019)

Concerning hydrogen production, the most common method in industry to produce hydrogen is Steam Methane Reforming (SMR), a chemical synthesis process which generates syngas (hydrogen and carbon monoxide) from hydrocarbons and natural gas. This process is conducted in a reformer which reacts steam at high temperature and pressure with methane in the presence of a nickel catalyst. SMR has been deemed by some authors (Schmidt-Rivera et al, 2018) as unsustainable for two reasons: as it requires natural gas it means a depletion of fossil fuel resources; moreover, the actual process of conversion generates significant greenhouse gas emissions. To avoid these emissions, CO2 could be captured and then sequestered underground, as suggested in Frazer-Nash (2018). The resulting hydrogen would then be transferred in the national grid pipeline to provide a zero-carbon heat at the point of end use.

Alternatively to SMR, excess energy from renewable sources such as photovoltaic (PV) panels could be used to produce hydrogen from the electrolysis of water. Hydrogen would then be blended with natural gas in the pipeline infrastructure, by compressed gas canisters or in low-pressure metal hydride tanks. This is a solution proposed by certain authors (Tropiska, 2016) for developing countries, where fuels such as charcoal, firewood or animal dung are primarily used for cooking. The use of these fuels causes significant air pollution and safety issues, so generating hydrogen from a renewable energy source may have the potential of solving several issues at a time.

An environmental analysis of that kind was completed in Schmidt-Rivera et al (2018). The authors evaluated different scenarios of substitution of solid fuels and liquefied petroleum gas (LPG) by hydrogen generated from renewable sources (solar PV). Results from the analysis indicated that, when compared to charcoal and firewood, hydrogen is the best option for fossil fuel depletion, climate change (2,5 to 14,1 times lower), ozone depletion and summer smog. However, hydrogen was worse when considering depletion of minerals, freshwater eutrophication and freshwater/marine ecotoxicity. They also pointed out that for most of impacts analysed, LPG is still a better option than hydrogen.

3.8 Study on consumer behaviour and domestic cooking appliances

3.8.1 Methodology

A semi-representative online survey was conducted in April 2020. The aim of the survey was to assess the behaviour of 5,100 households in 11 countries (Czech Republic, Finland, France, Germany, Hungary, Italy, Poland, Romania, Spain, Sweden and Ireland) representing 70% of all households in EU-27. A questionnaire was developed by the authors based on their professional (home economics) product know-how and with support from the JRC and other stakeholders. Registered consumers were included in the survey considering the required quotas (age between 20 and 80 years, corresponding to statistical data regarding household size and age; more than 50% female) for each country. The panellists included have to answer positively to the question if they are 'mostly/all the time involved in preparing the meals for your household'. Thus, the survey delivers a representative sample of the relevant population of most EU countries. Although, participants were asked to report about their 'normal' behaviour in using their oven, hob and cooking fume extractor, an influence because of the COVID-19 lockdown and other measures cannot be excluded.

The participants were asked about the type of cooking devices they have at home and details of their usage. Demographic data was recorded additionally. Before starting the analyses, the validity of each dataset was checked with the aid of two predefined consistency check criteria (number of meals prepared and number of ovens used per week). Datasets are excluded from the following evaluation in the case of inconsistent answers. The survey consists of a total of 4,922 valid answers. Thus, the statistical uncertainty level of the overall sample (given as $\sqrt{n}/n$) is 1.4%.

Results from the online questionnaire were analysed using SPSS (by IBM) and presented in a descriptive and analytic format. Furthermore, weighting according to the number of households of each country compared to the sum of all countries investigated is implemented for calculating the result given as "all hh weighted" (Table 28).

Table 28 Overview of the panels and databases for analysis

Country		Panel target	Panel after consistency check	Private Households (in millions)	Contribution to total result in %
	Abbreviation				
Czech Rep.	CZ	350	340	4,759,800	3
Finland	FI	350	340	2,677,100	2
France	FR	600	592	29,802,900	19
Germany	DE	600	584	40,806,600	26
Hungary	HU	350	339	4,124,800	3
Italy	IT	600	577	25,925,800	17
Poland	PL	600	566	14,608,900	9
Romania	RO	350	332	7,494,300	5
Spain	ES	600	577	18,580,600	12
Sweden	SE	350	340	5,239,500	3
Ireland	IE	350	335	1,842,000	1
All households in the EU sample	'all hh weighted'	5,100	4,922	155,862,300	100
Total number of households in the EU				222,839,600	70

3.8.2 Demographics

Following the predefined quotas, the age and household size distribution of the participants represents the national distribution per country (Figure 74 and Figure 75). Nevertheless, it is worth keeping in mind when analysing the results of the survey and comparing the answers for different countries that there are relevant differences in the composition of the age and household sizes between countries.

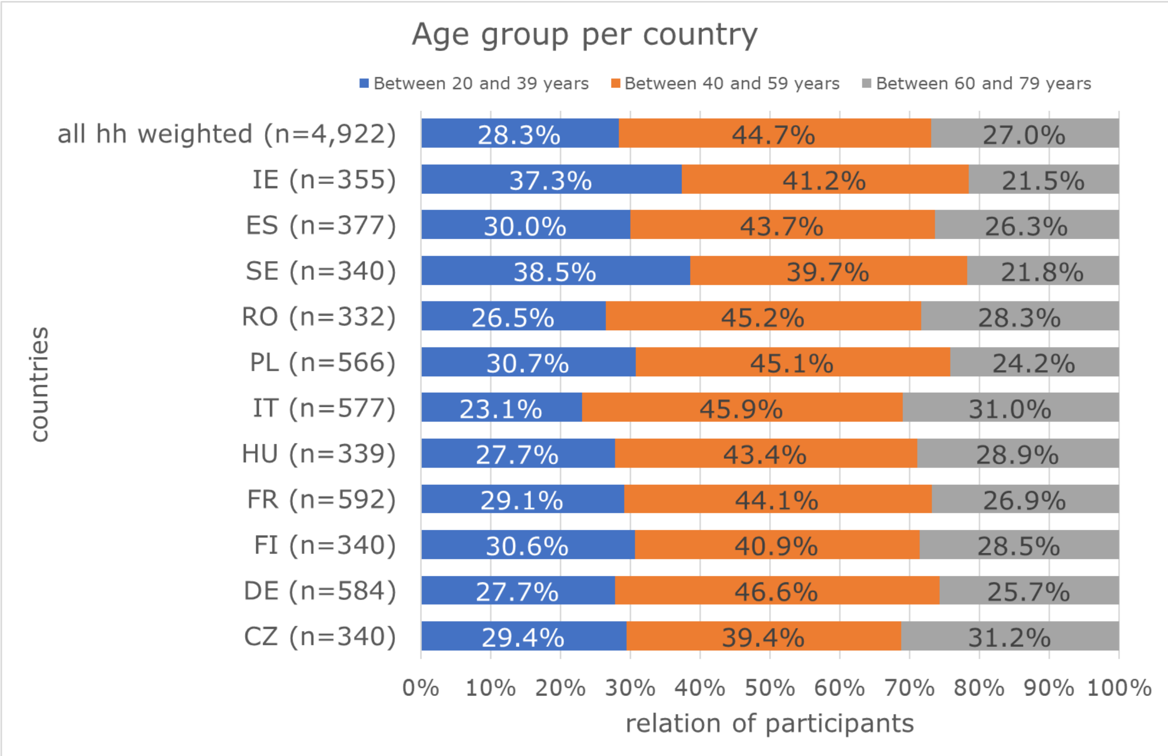


Figure 74 Age group distribution of the panel

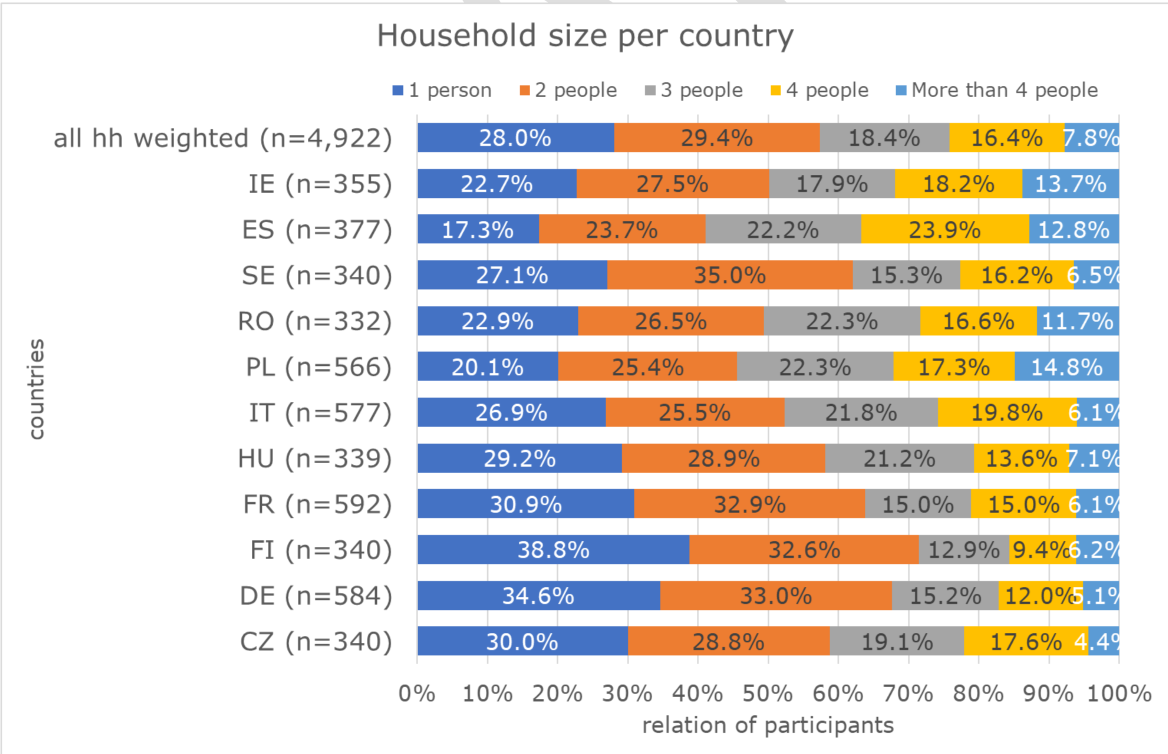


Figure 75 Household size distribution of the panel

Differences between the 'official' demographic household size distribution and the distribution of the panel (Figure 76) are explained by the exclusion of very young and very old households in the panel. Thus, the sample is representative of consumers who are mostly or all the time involved in preparing the meals for their household regarding gender, age and household size distribution of the individual 11 countries which cover about 70% of the population of EU-27.

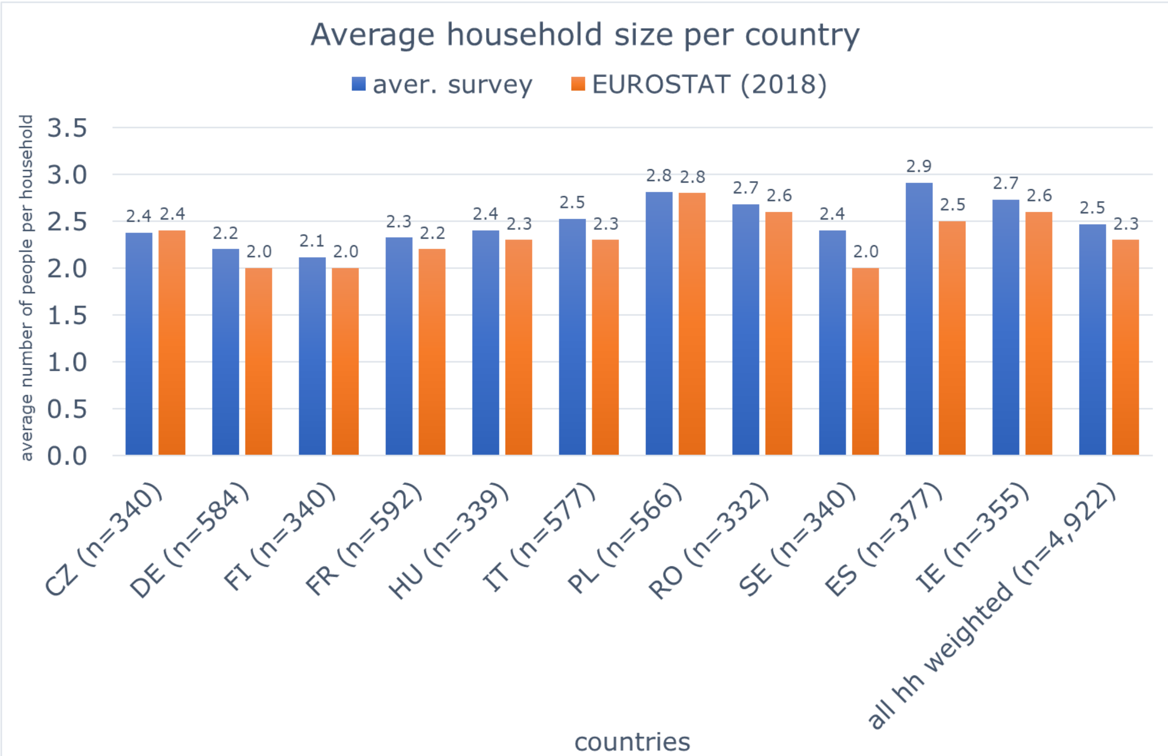


Figure 76 Comparison of the average household size of the panel to the household size given by EUROSTAT

The distribution of the gender in the panel was approximately 50:50.

As the panellists had to be 'mostly/all the time involved in preparing the meals for your household', the answers to the question "How many cooked meals do you prepare at home for yourself and any other members of the household?" somehow reflect the minimum of the cooking activities of the household.

A cooked meal is prepared seven times per week in most households (Figure 77), followed by 14 meals per week. Averaging all the answers shows that cooked meals are prepared between 5.2 and 11.6 times per week (Figure 78) per country per household. An average of 8.9 cooked meals are prepared in the household of the respondents per week (4.8 per person).

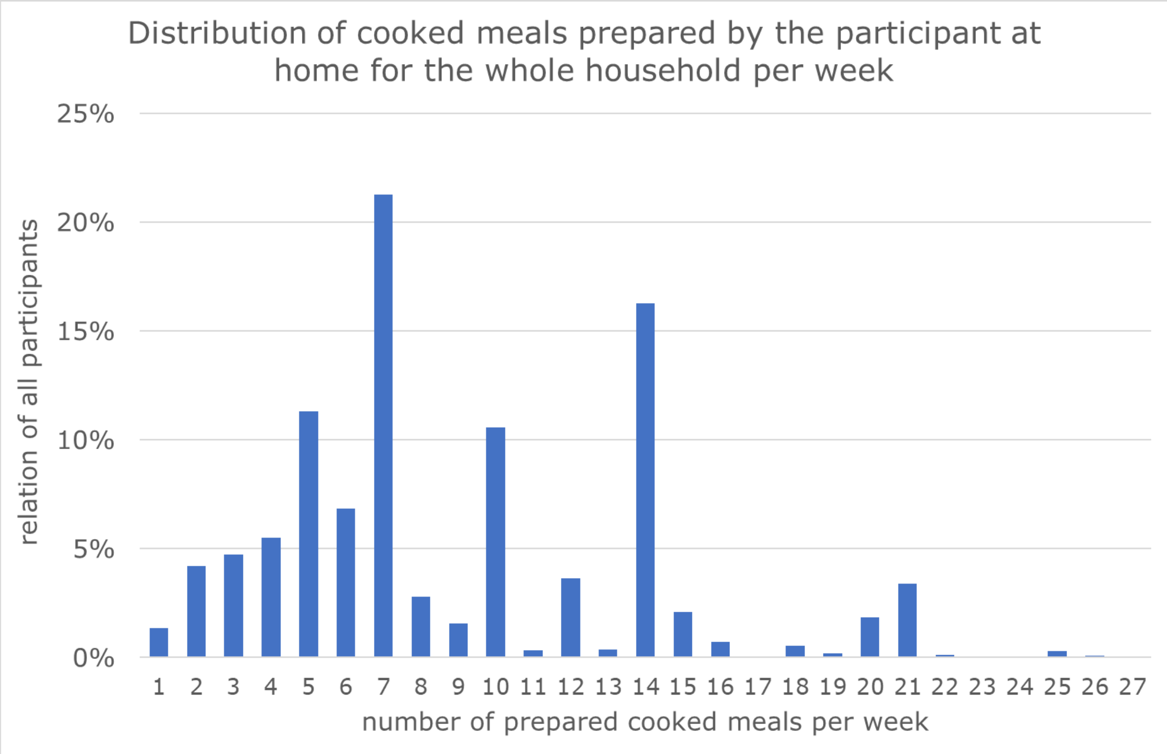


Figure 77 Number of meals prepared at home per week

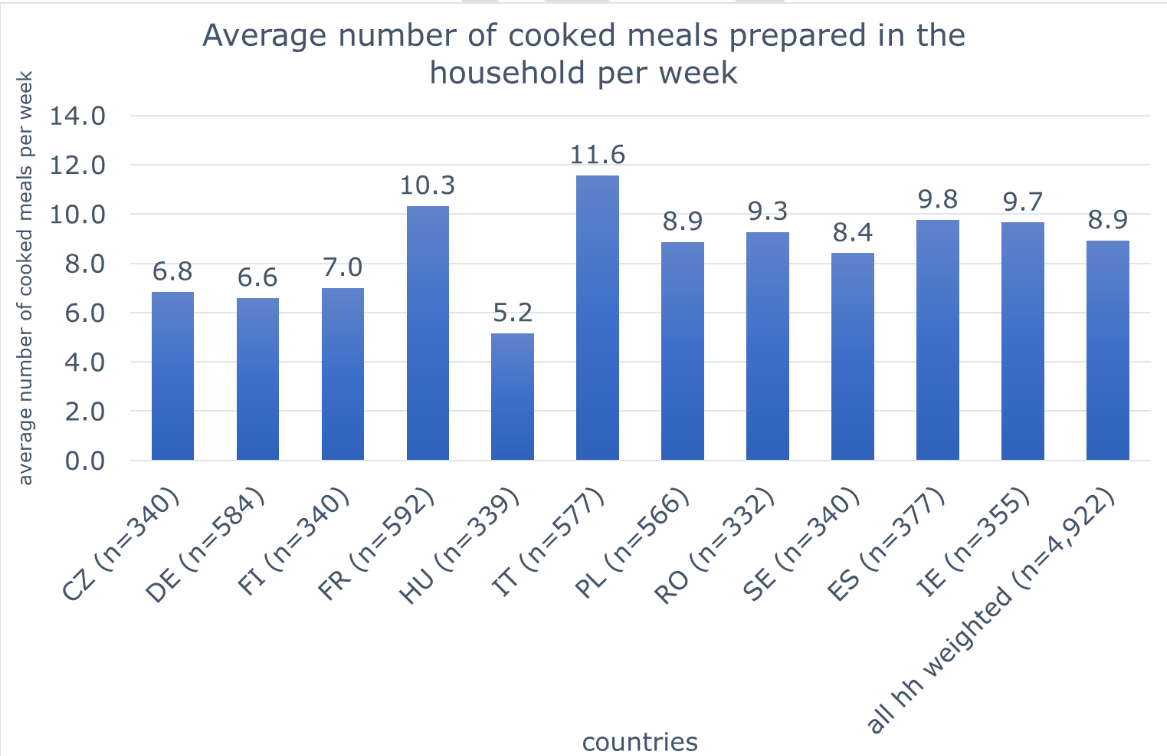


Figure 78 Average number of cooked meals per household per week

As household sizes are different between countries, it may be interesting to normalise those answers by the number of people living in each household: this distribution shows that most households prepare a cooked meal between 1.0 and 7.0 times per person per week (Figure 79) with extreme averages for Hungary (2.8 cooked meals per person and household per week) and Italy (6.2) (Figure 80).

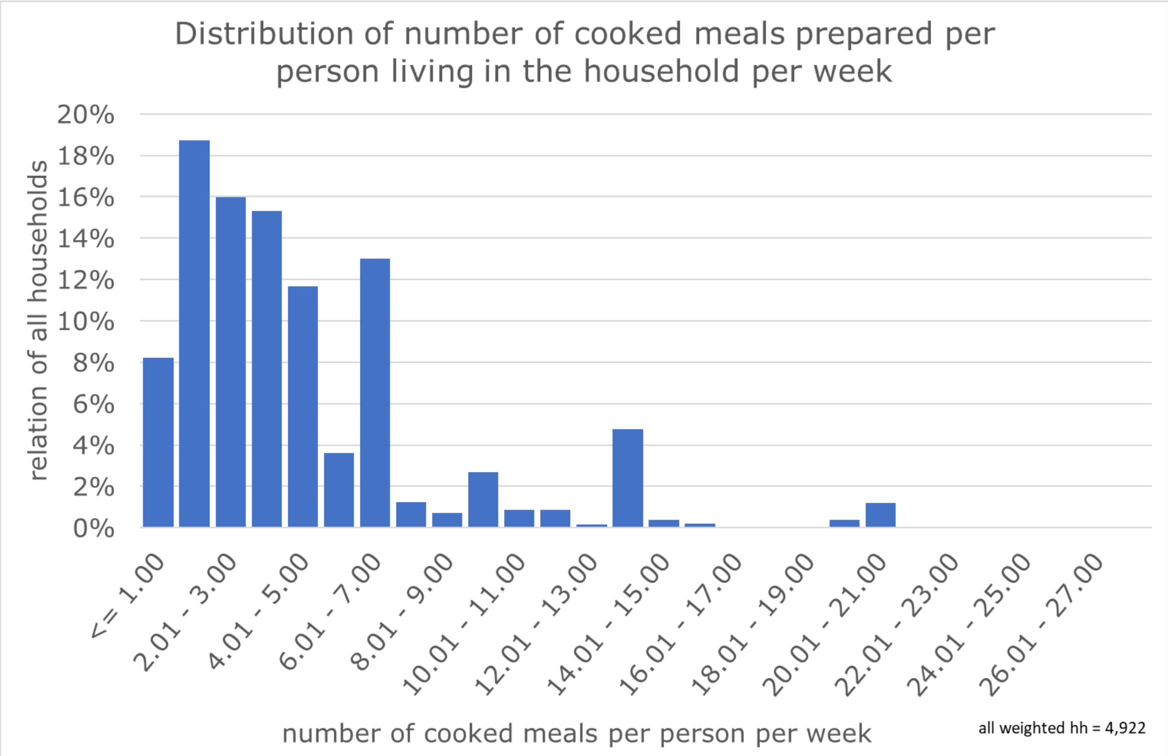


Figure 79 Number of cooked meals at home per person in the household per week

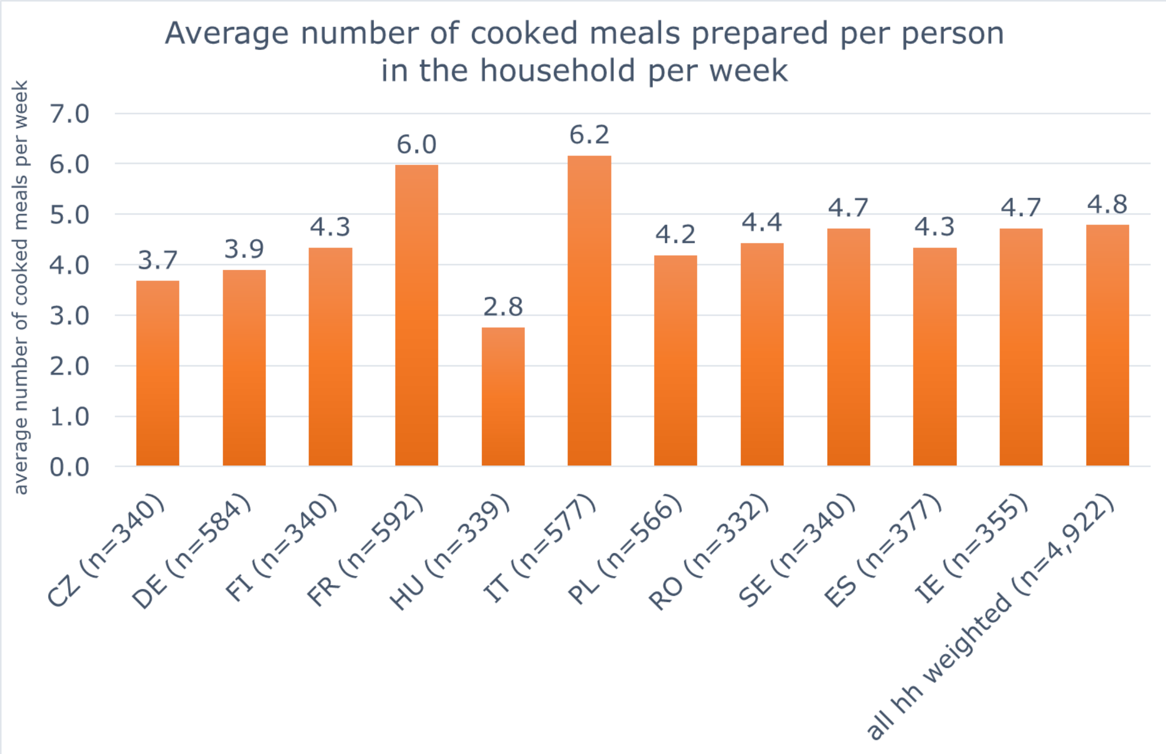


Figure 80 Average number of cooked meals per person per week

3.8.3 Cooking appliances in homes

Going more deeply into the stock of appliances, a predefined list of kitchen appliances was given to the participants with the request to indicate all they have in their household. Overall, almost nine out of ten households indicate that they have a conventional oven (Figure 81) and about three out of four indicate that they to have a solo microwave, a cooking fume extractor and a fixed hob. Portable appliances for cooking are available only to a minority of households and a pure steam oven is a rarity, as it is available in only about 5% of households.

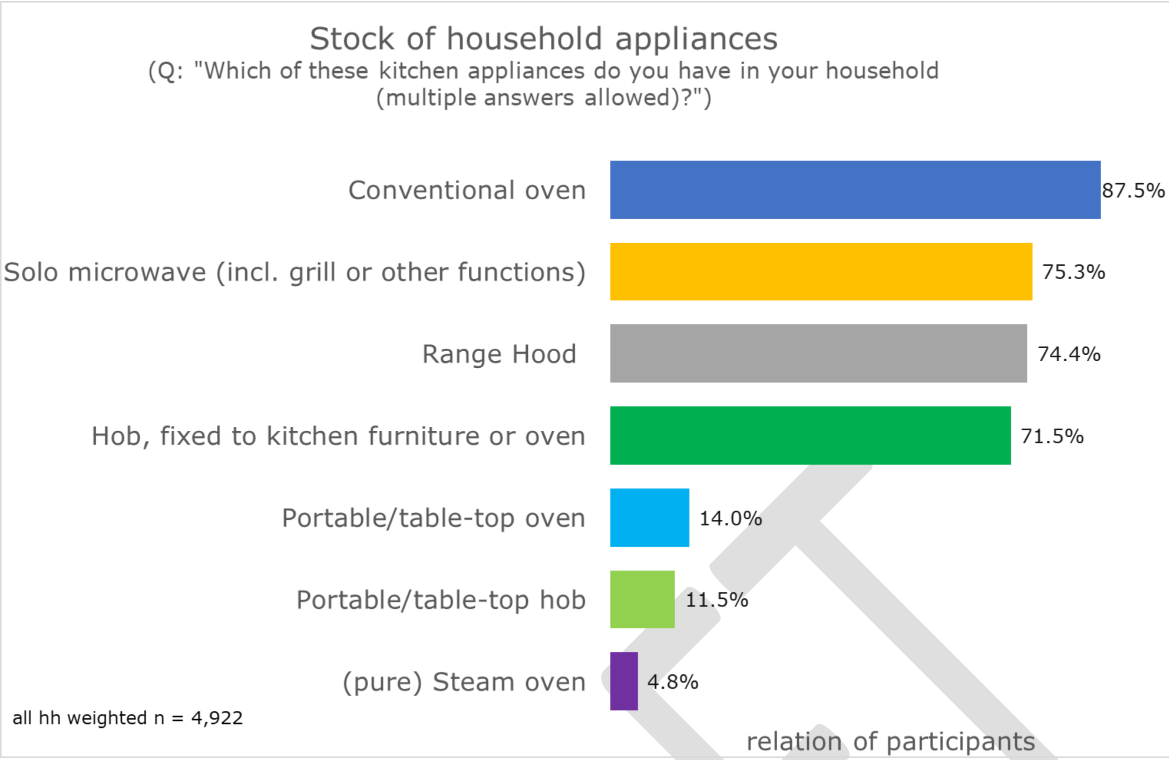


Figure 81 Stock of cooking appliances

However, there are significant differences between the stock of cooking appliances in various countries (Figure 82). Exemplarily, less than 50% of the households own a conventional oven in the Czech Republic and cooking fume extractors are owned by in a few more than just one out of four households in Ireland. However, there are generally between three and 3.5 cooking appliances in the stock of households in all countries. Surprisingly, this is also the range of the stock of cooking appliances for one to multiple person households (Figure 83).

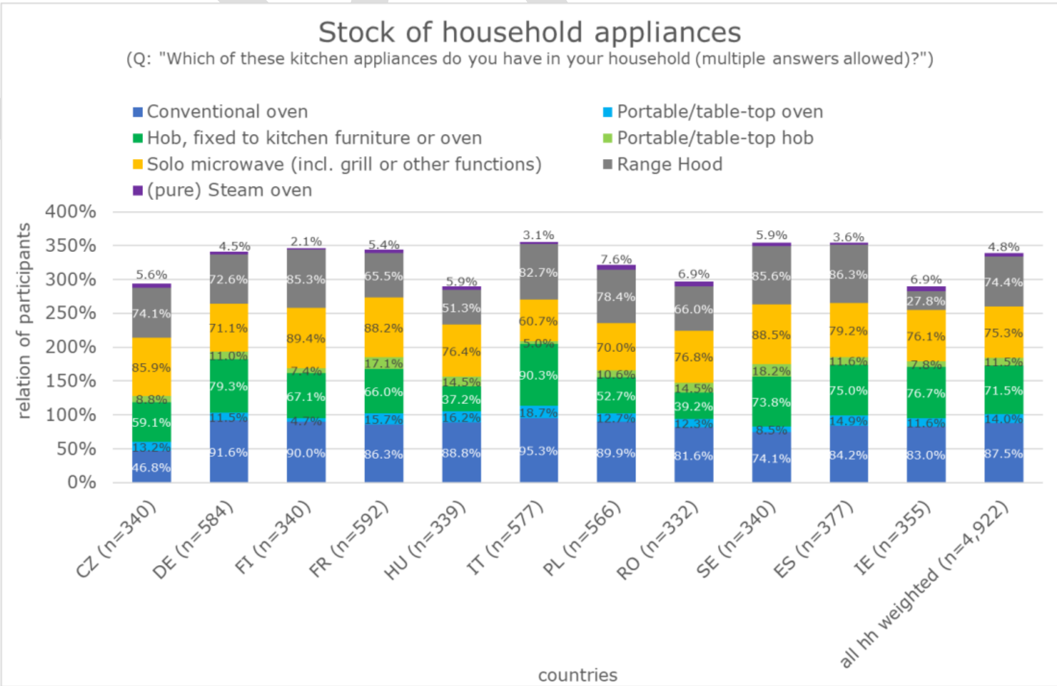


Figure 82 Stock of cooking appliances per country

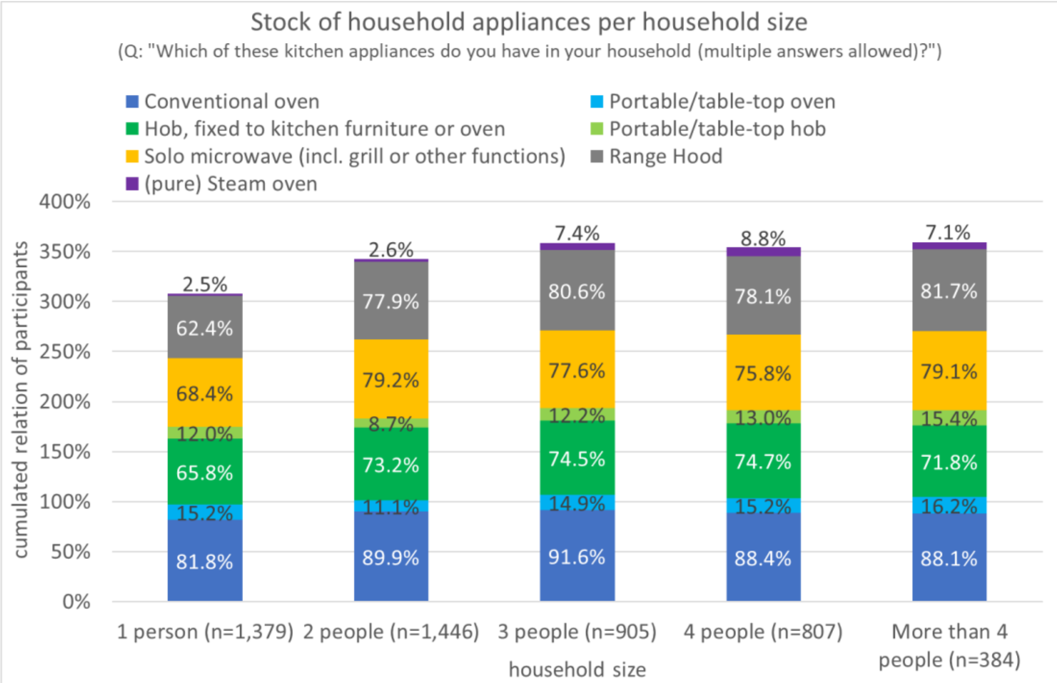


Figure 83 Stock of cooking appliances per household size

3.8.4 Oven

3.8.4.1 Type of ovens

Asking in detail what kind of oven – conventional or portable/table-top – the participants have revealed that 85% own a conventional oven. Only about 4% own a portable/table-top oven and about 11% own both types of ovens (Figure 84). However, there are relatively large differences between countries: almost 23% of households in the Czech Republic, for example, own a portable/table-top oven and for most of them, this is the only oven they have (Figure 85).

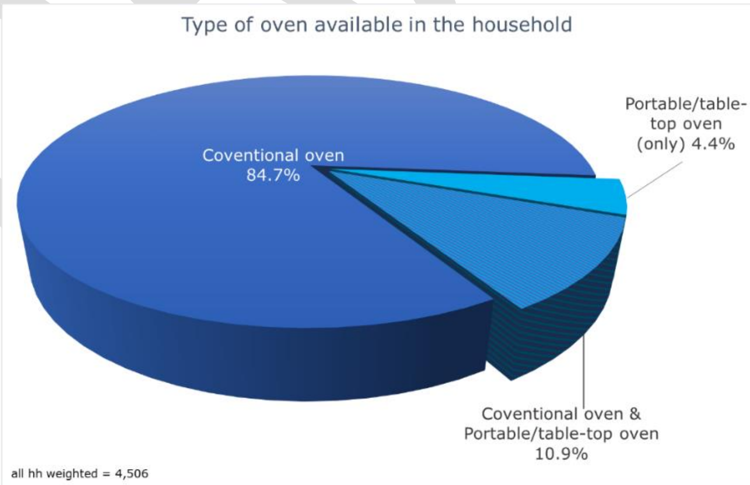


Figure 84 Type of ovens

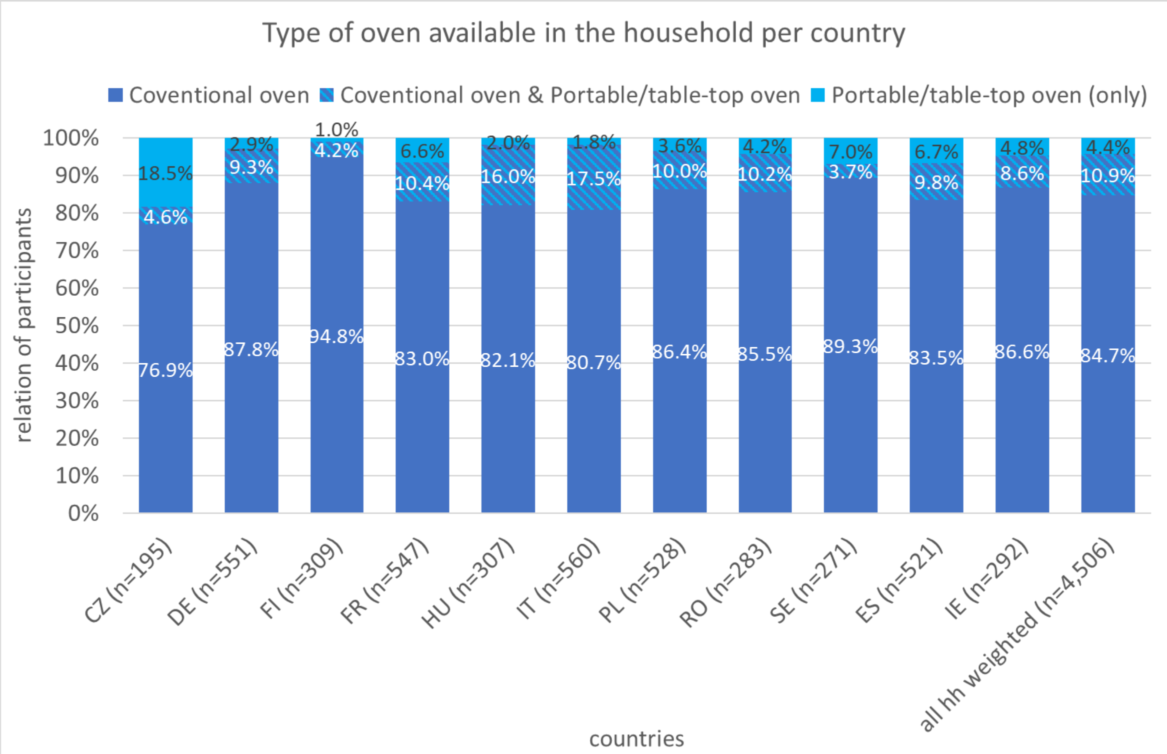


Figure 85 Type of oven per country

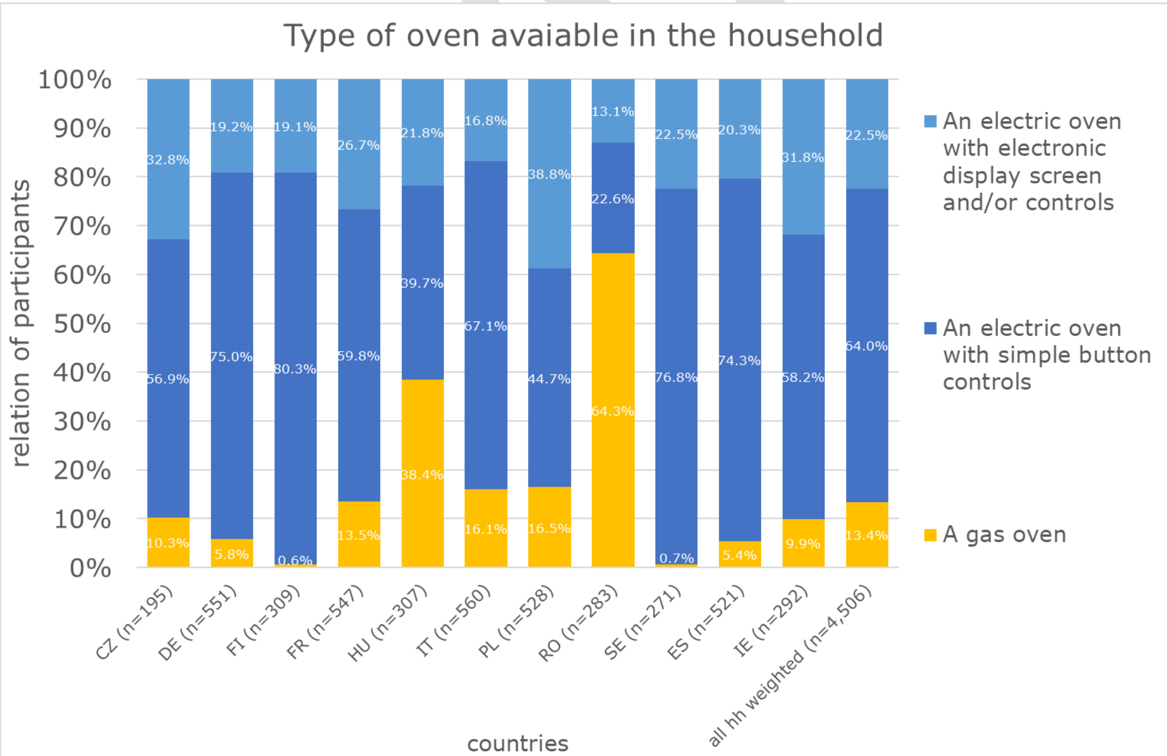


Figure 86 Energy source of oven available per country

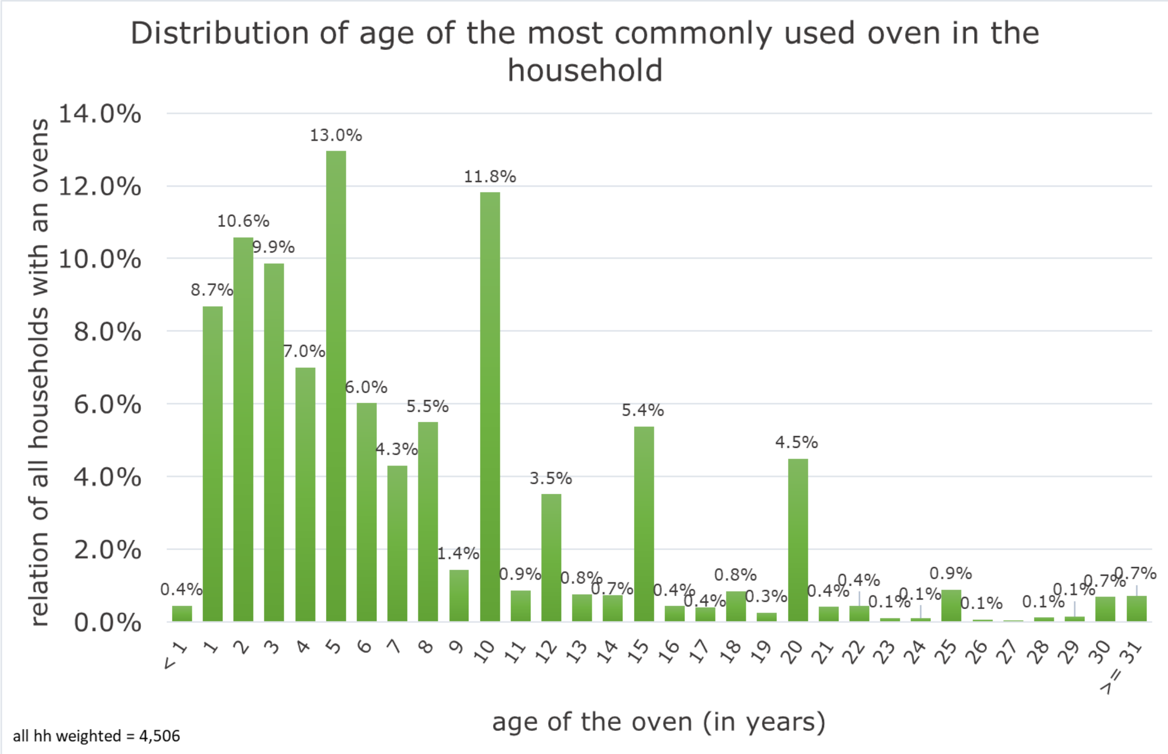


Figure 87 Age distribution of the oven

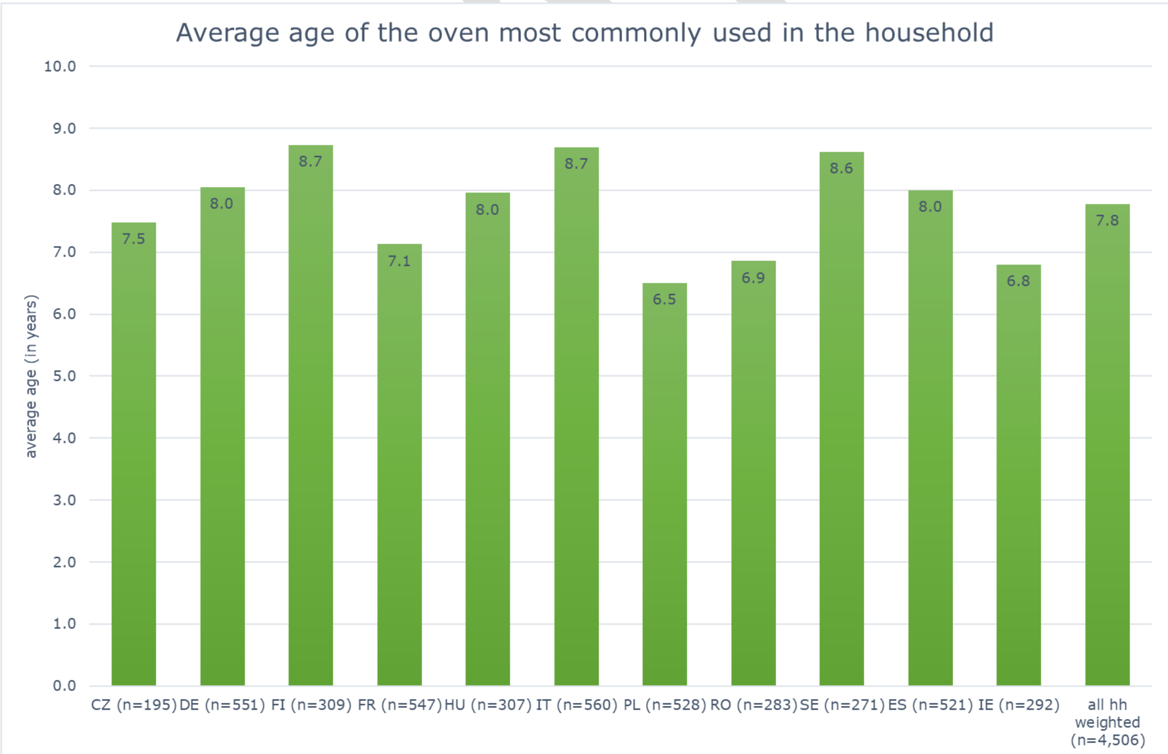


Figure 88 Average age of the oven per country

Participants were also asked about the age of the oven most commonly used in their household. The answers given show a large distribution of ages (Figure 87), with some spikes at 5, 10, 15 and 20 years of age. The average age was found to be 7.8 years, with some differences between countries (Figure 88).

3.8.4.2 Frequency of use of the oven

In this section, the respondents were asked about how frequently they use their ovens each week. The usage frequency of the oven was investigated twice in different parts of the questionnaire. This was done to check the consistent answering behaviour of the participants. The answers were given as nominal indications (Figure 89) and show some country-specific differences.

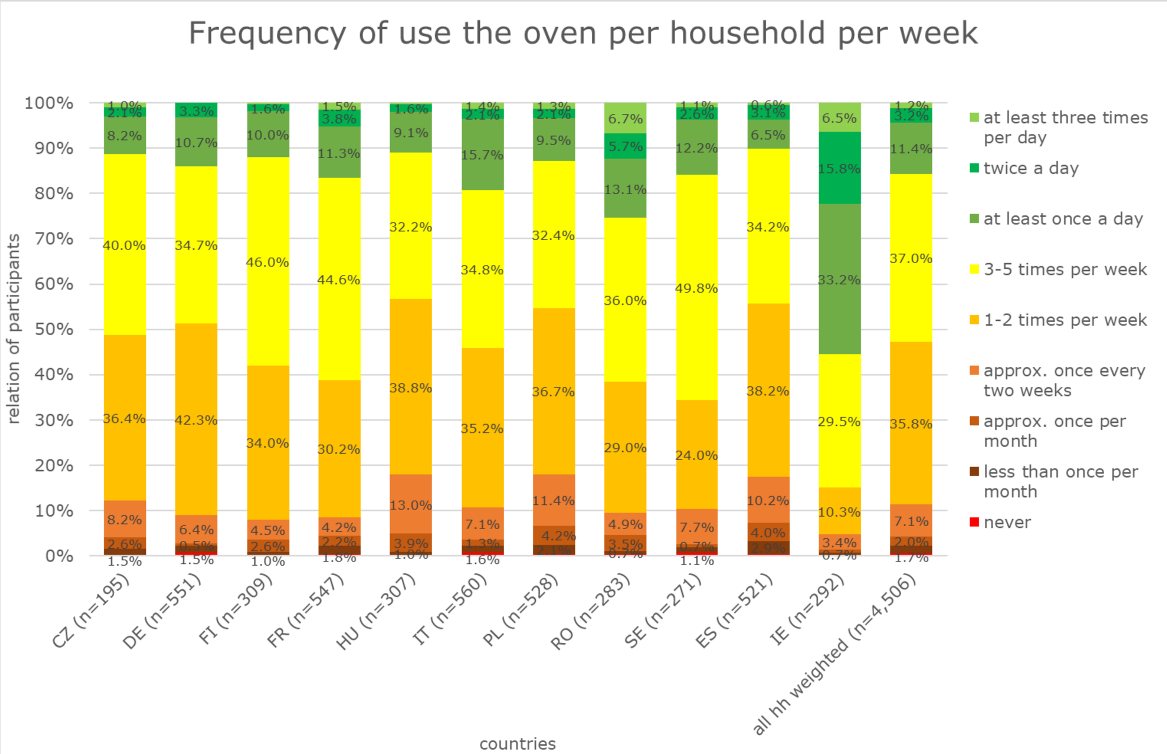


Figure 89 Average usage of the oven per week per country

Household size is one of the most important variables defining the number of oven usages (Figure 90).

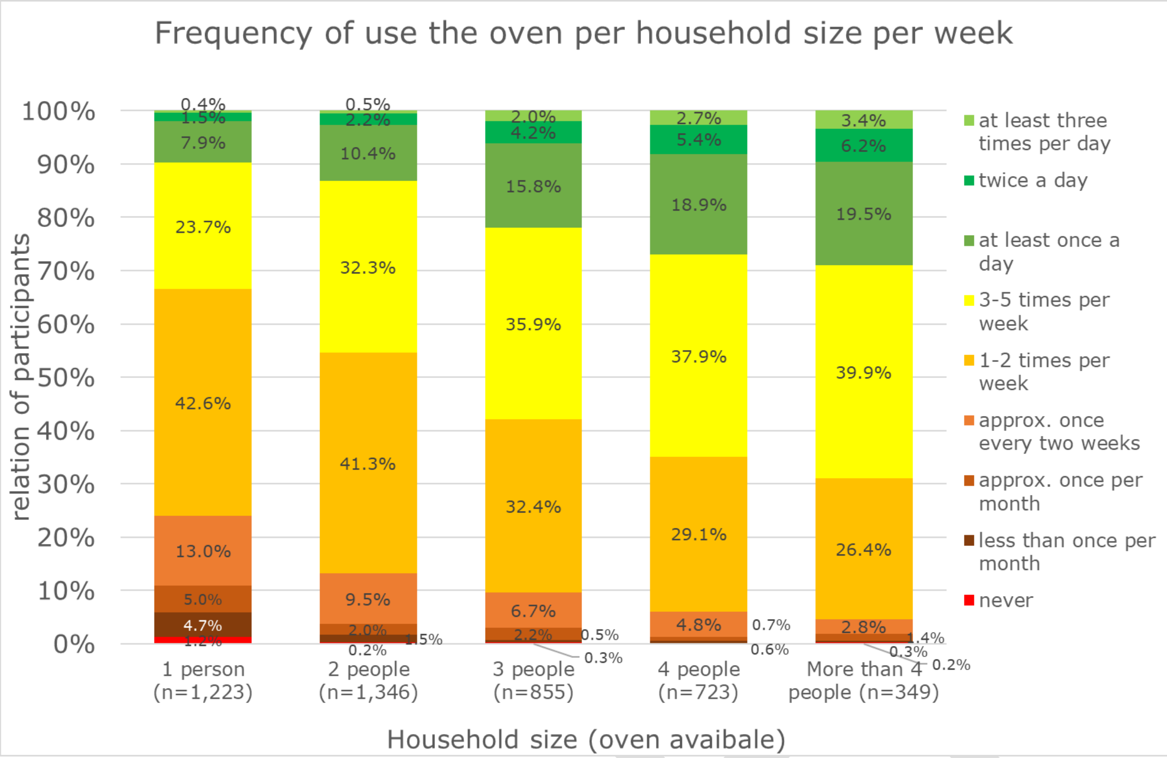


Figure 90 Average usage of the oven per week per household size

It is easier to compare different behaviours if the nominal answers are decoded into numerical values. Results of this decoding now show the differences between countries very clearly (Figure 91), with a high peak of 7.3 usages of the oven per week in Ireland for the first time the question was asked.

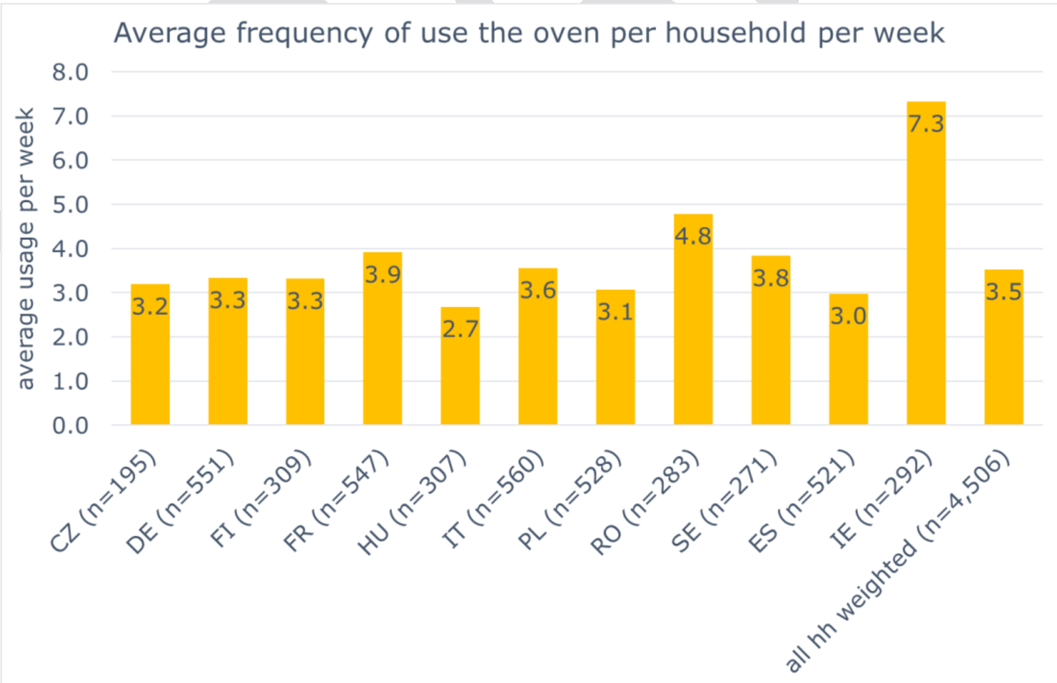


Figure 91 Average usage of the oven per week

This also allows us to quantify the dependency of the oven use with household size as a clear trend in all countries (Figure 92). The overall average frequency of use is 3.5 times per household per week.

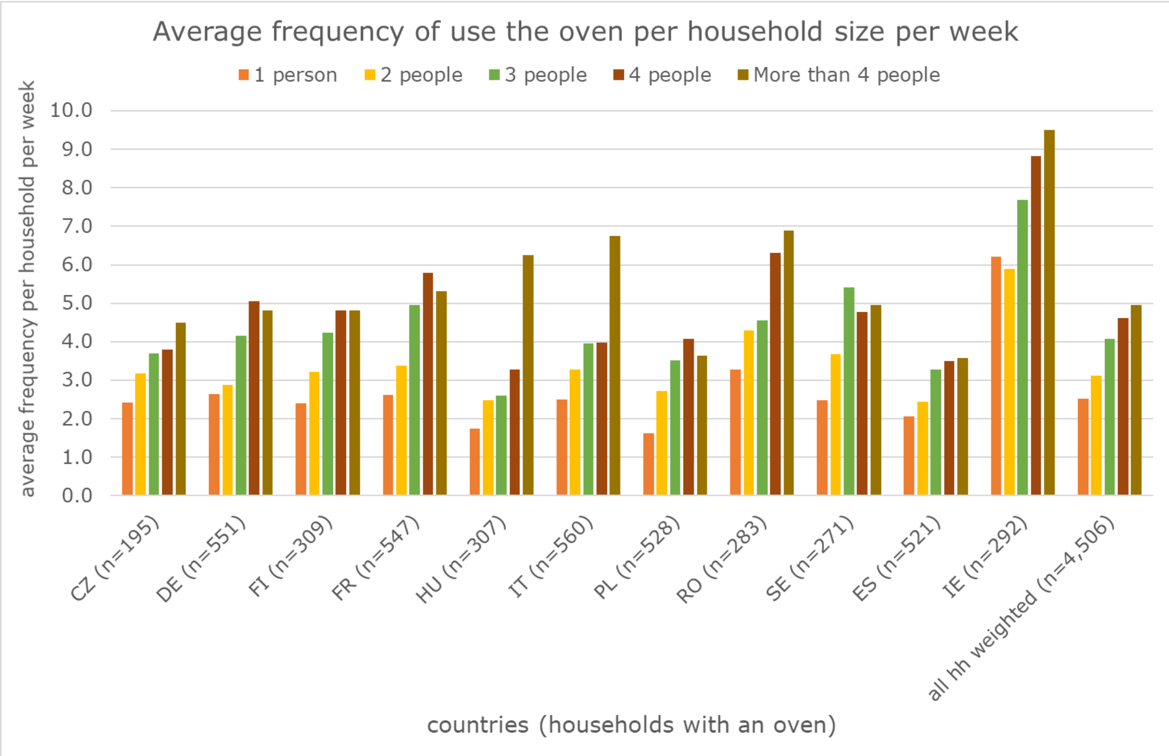


Figure 92 Average use of the oven per household size per country

3.8.4.3 Frequency and duration of use of oven heating modes

A more detailed list of questions was requested to be answered by the participants regarding their currently available oven. At first, the heating modes available were investigated. As the relevant European regulation was introduced only in 2014, a split of the analysis was done regarding the age of the oven (50% of the ovens are equal or less than five years of age) and between gas and electric ovens. The heating modes 'top and bottom heat', 'grill' and 'convection/hot air' and combinations thereof are available in almost all ovens which fall under this regulation as they were younger or equal to five years old (Figure 93, Figure 95). A separate 'Energy-saving mode/Eco mode' is available (and can be identified by the respondent) in about two-thirds of the ovens. This is in clear contrast to the older ovens, where this mode is only identified by about one-third of the respondents (Figure 94, Figure 96). Besides the 'Energy-saving mode/Eco mode' it is interesting to note that younger ovens do have a lot of additional features available compared to the older ovens and are combining the oven function with additional heating and cooking functions (like combi-microwave and combi-steam function) for gas and electric ovens.

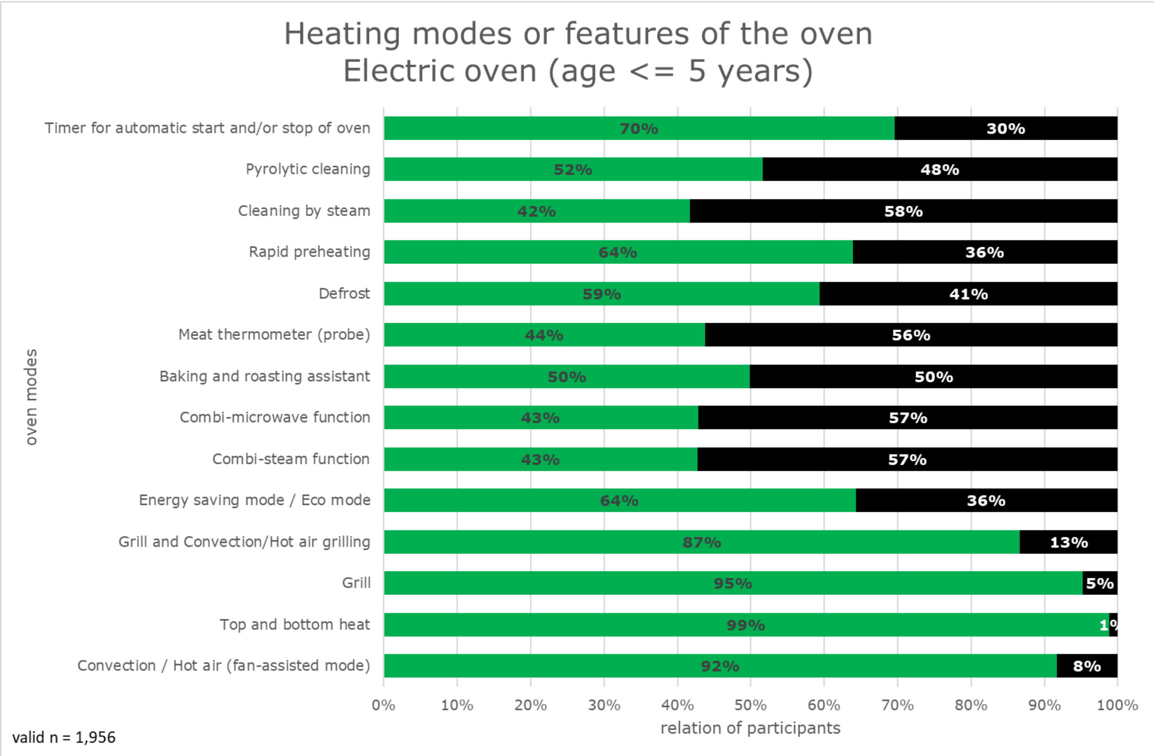


Figure 93 Heating modes available in electric ovens < 5 years

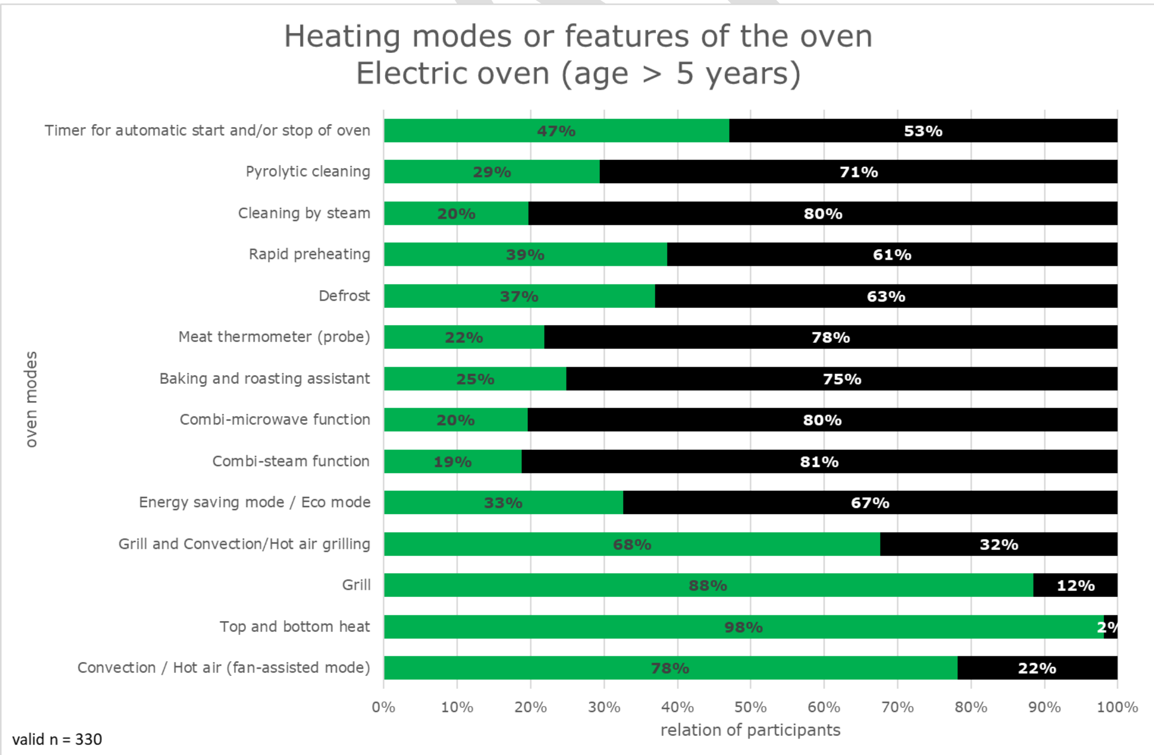


Figure 94 Heating modes available in electric ovens > 5 years

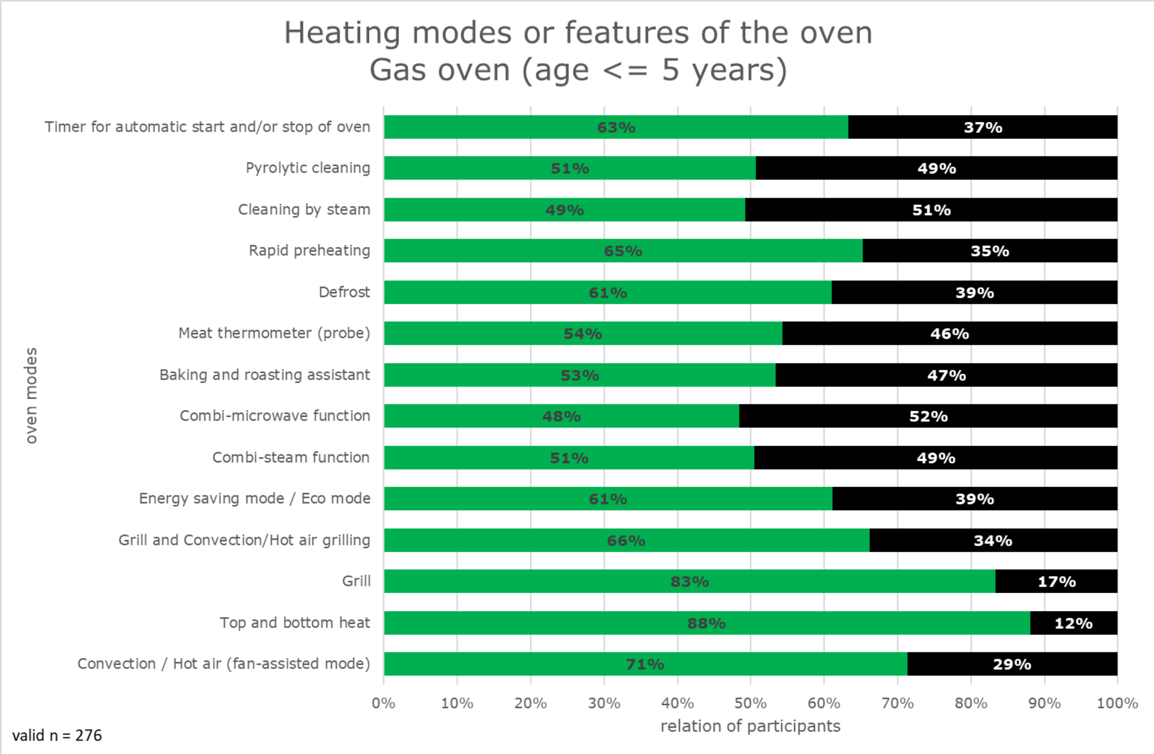


Figure 95 Heating modes available in gas ovens < 5 years

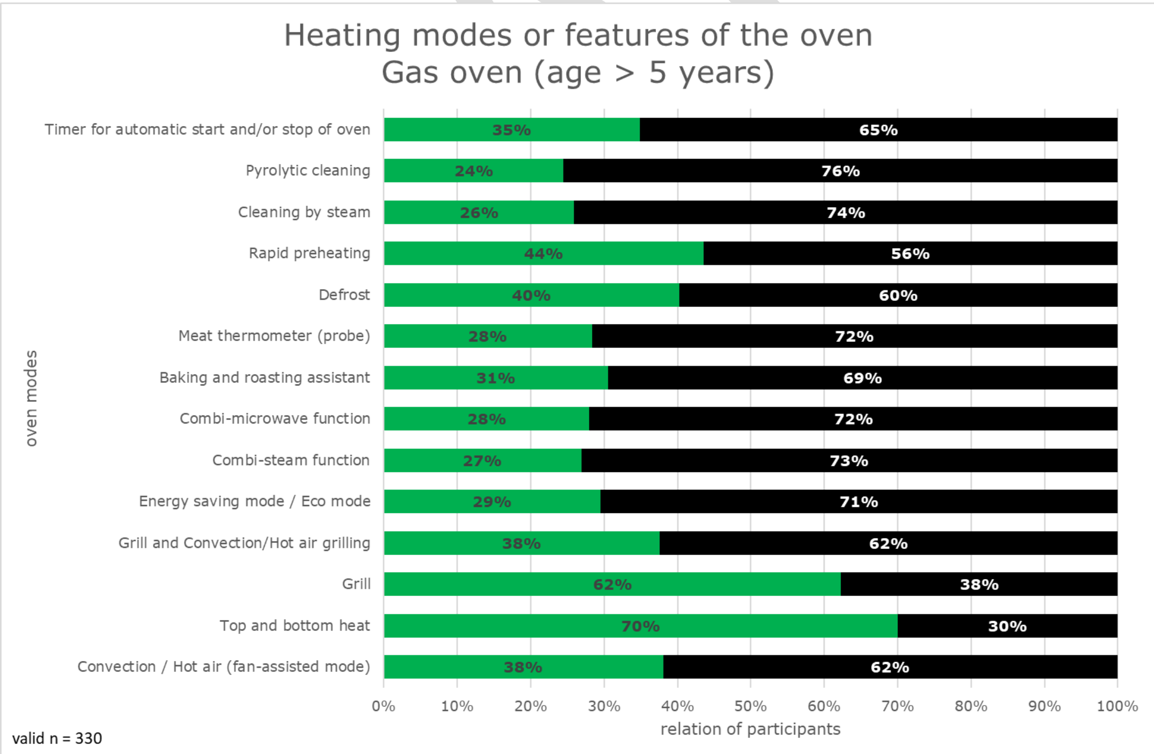


Figure 96 Heating modes available in gas ovens > 5 years

However, this difference in available operation modes of the oven depending on their age does not show up in a corresponding difference in the usage of these modes. Comparing the result of the second question regarding the usage frequency of those modes which are available in the oven (gas and electric combined) of the respondent for all respondents (

Figure 97) and for these with a younger (Figure 98) and older oven (Figure 99) reveals only minor differences. Generally, the 'traditional' modes of 'top and bottom heat' and 'convection/hot air' are more used in older appliances.

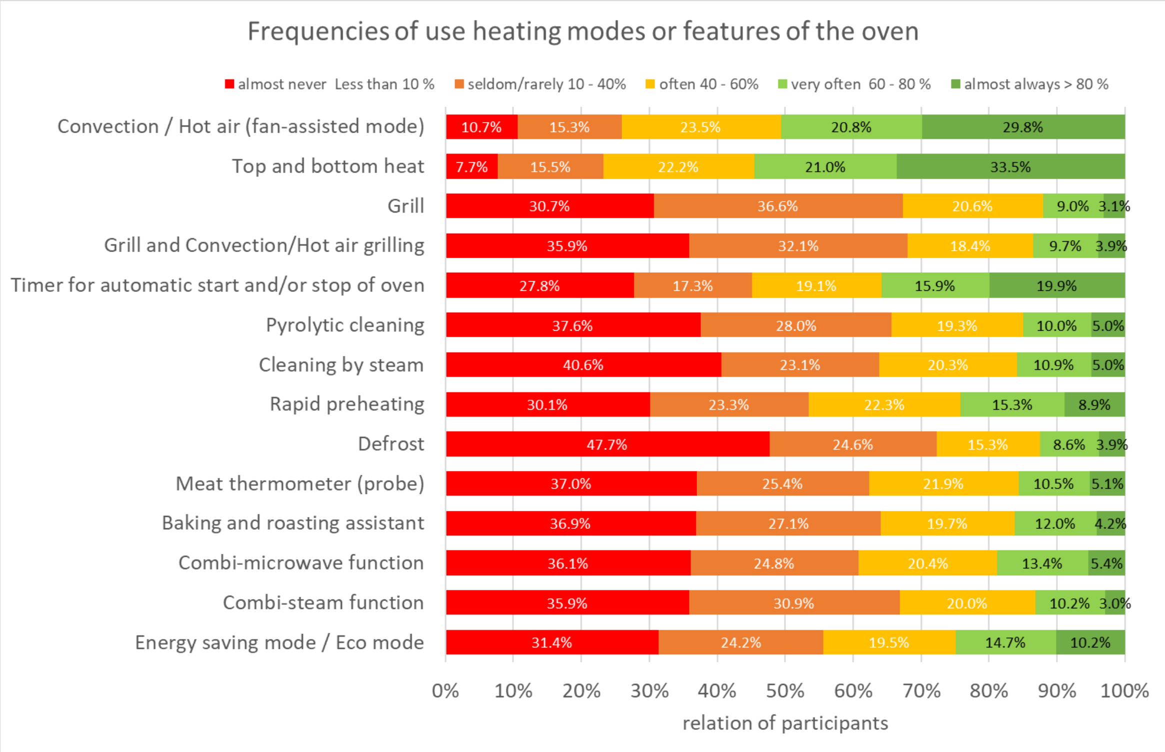


Figure 97 Frequency of use of heating modes of all ovens

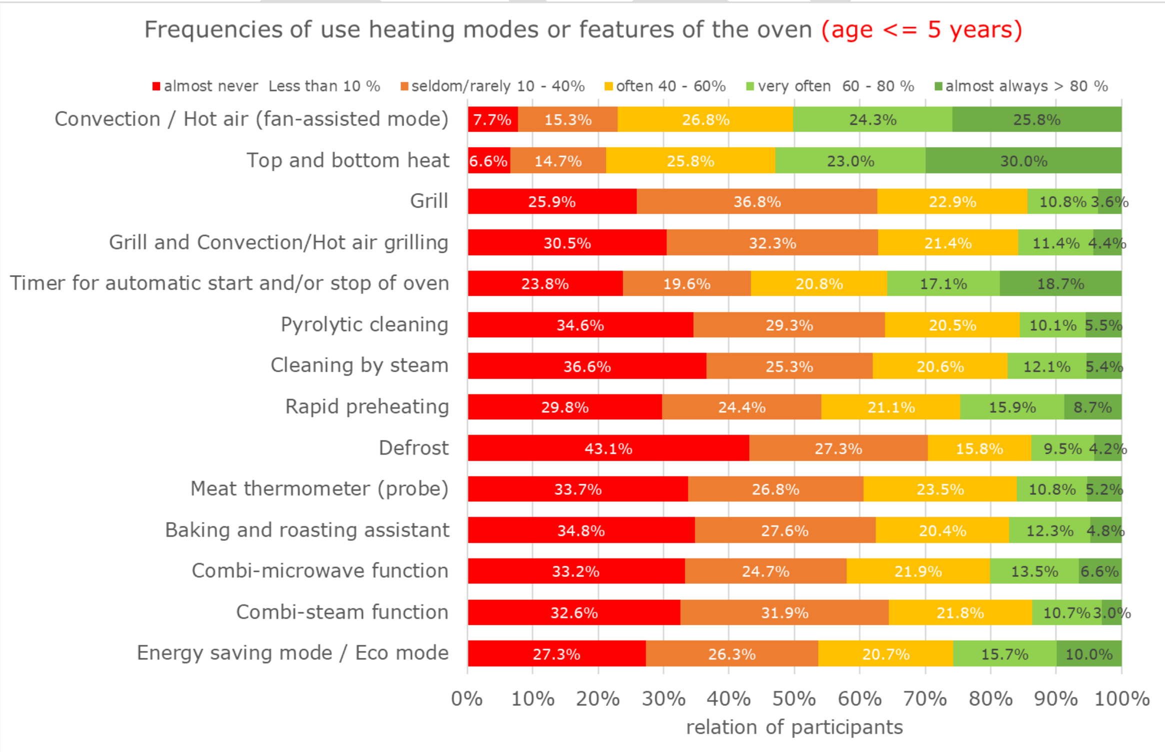


Figure 98 Frequency of use of heating modes of all ovens < 5 years

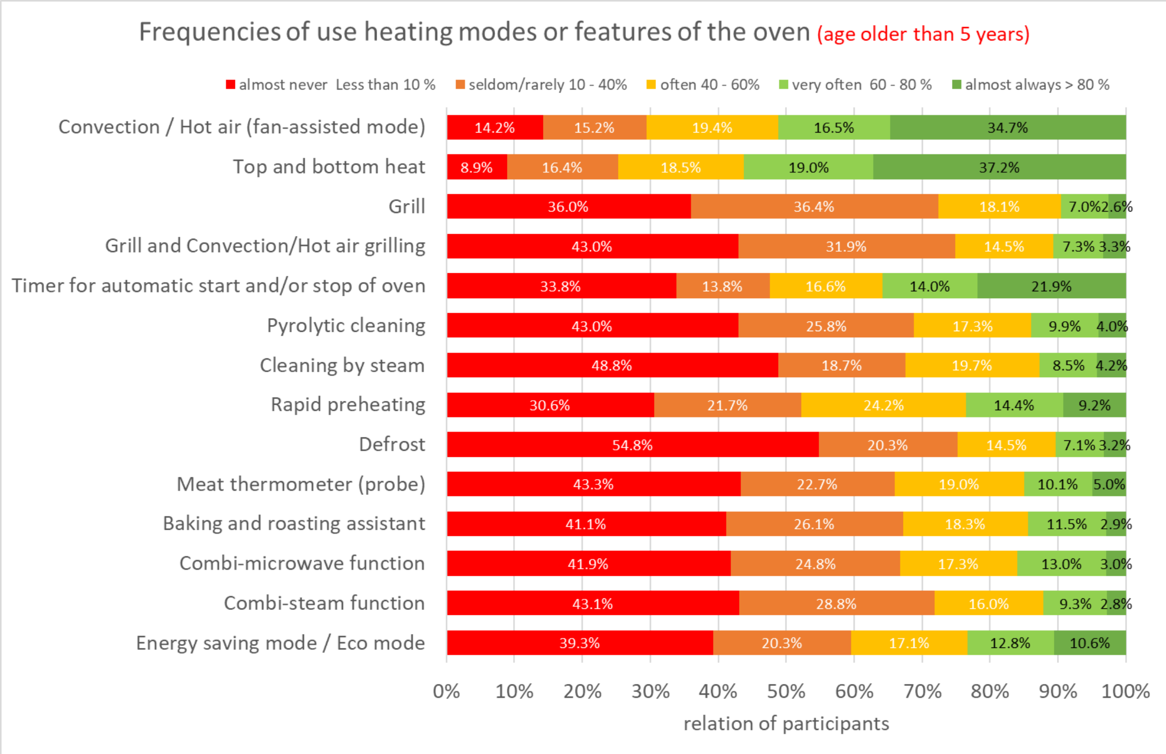


Figure 99 Frequency of use of heating modes of all ovens > 5 years

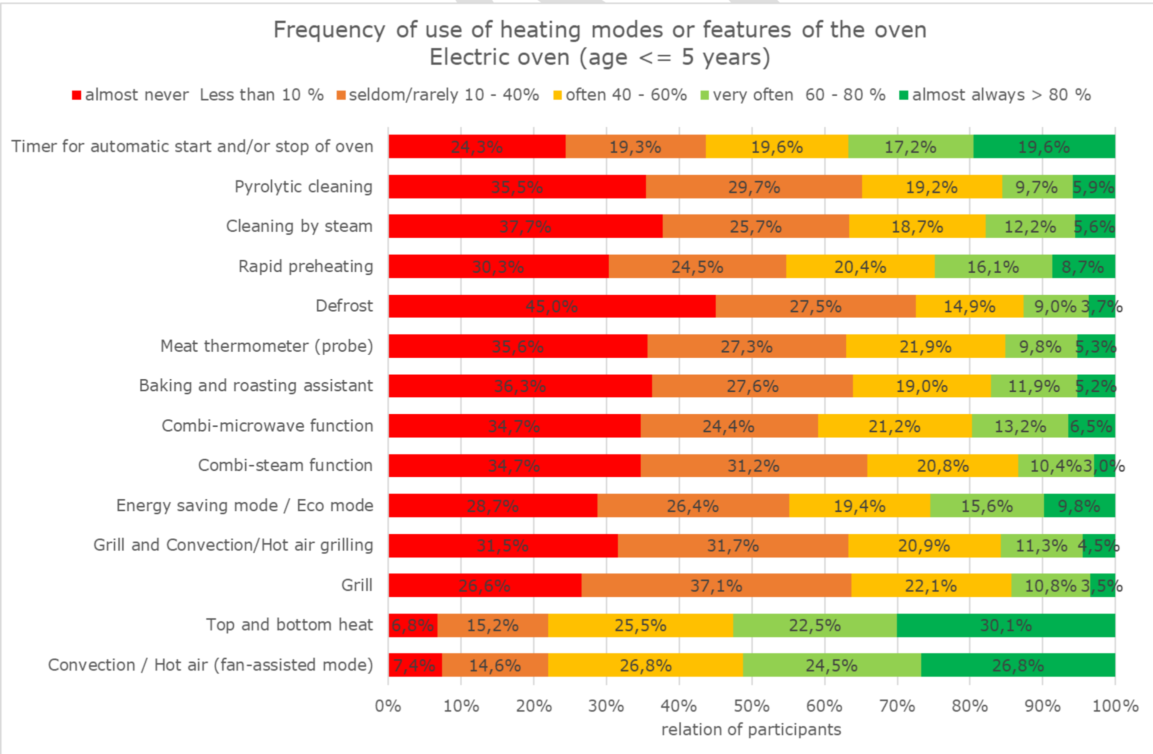


Figure 100 Frequency of use of heating modes of electric ovens < 5 years

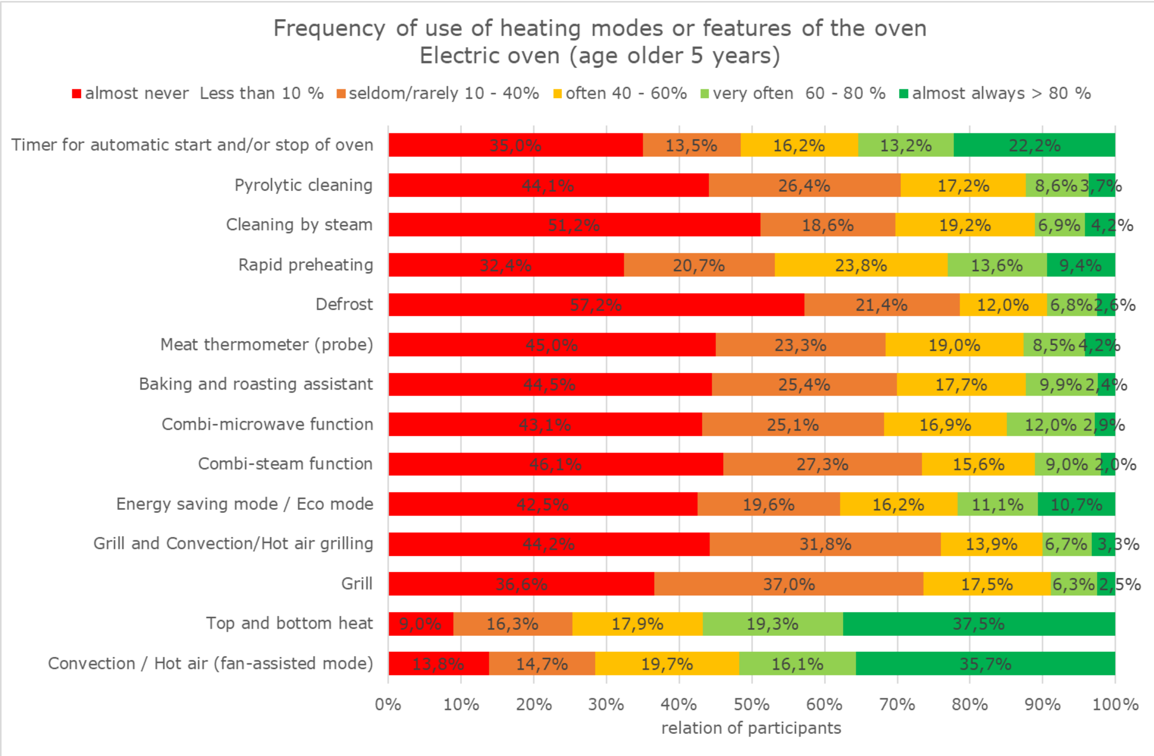


Figure 101 Frequency of use of heating modes of electric ovens > 5 years

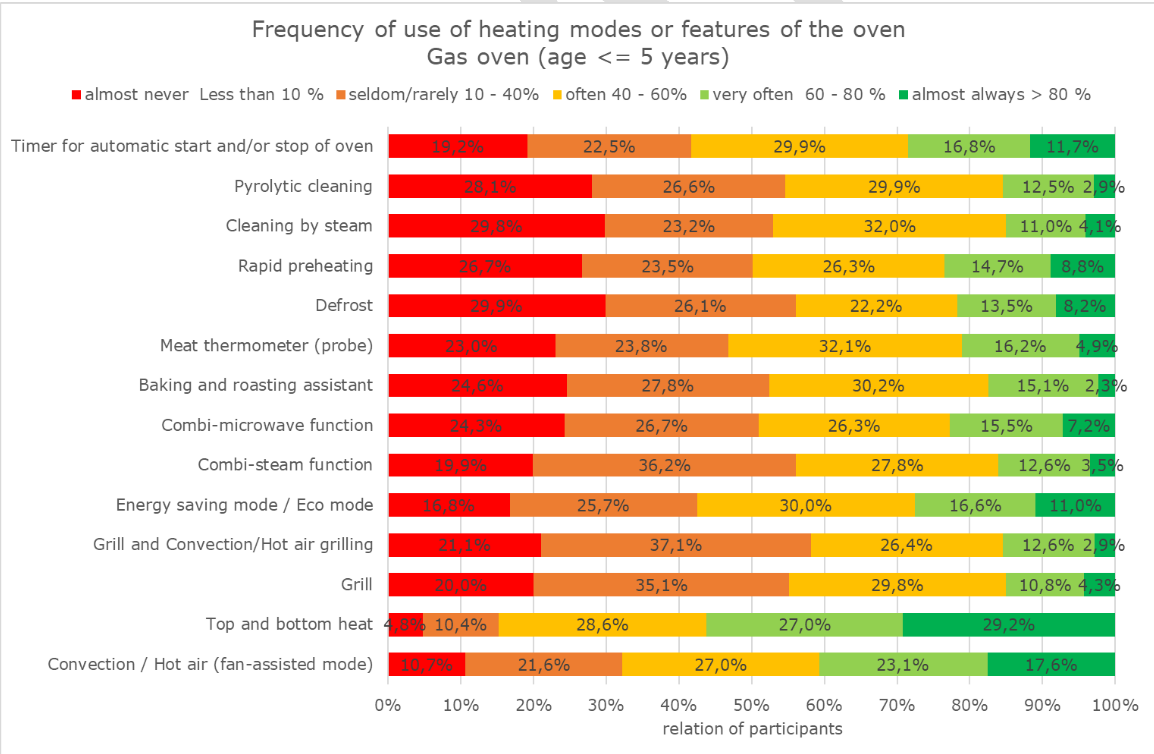


Figure 102 Frequency of use of heating modes of gas ovens < 5 years

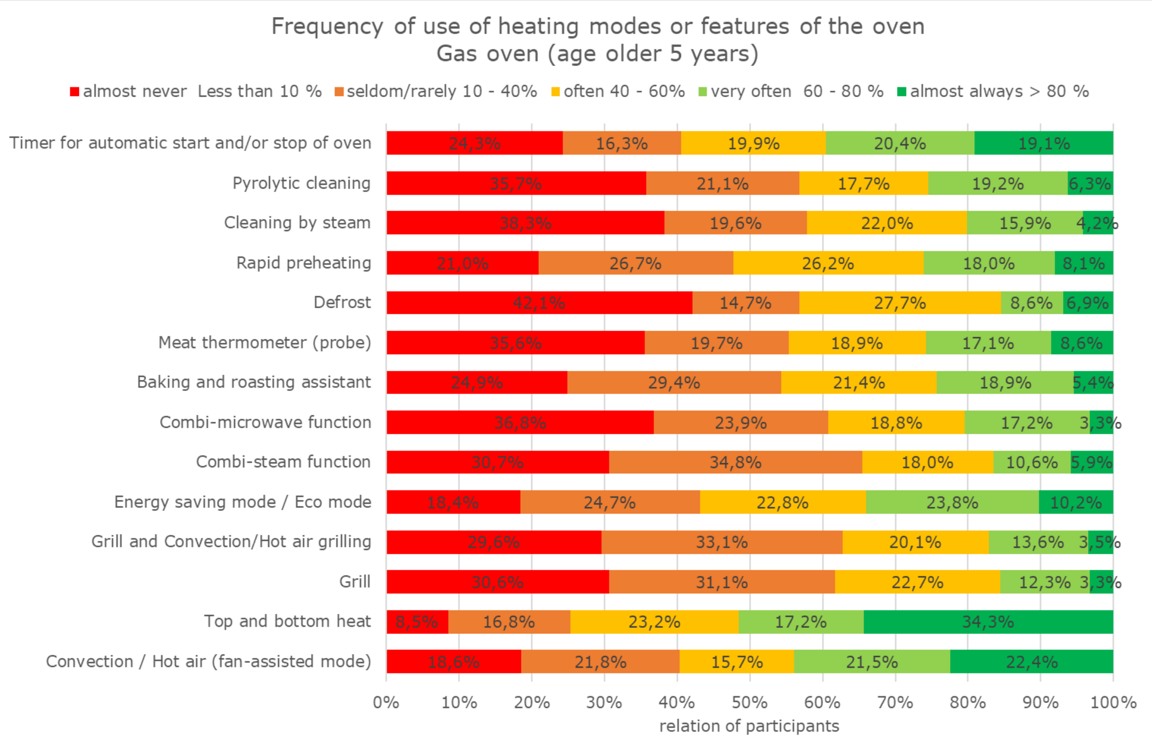


Figure 103 Frequency of use of heating modes of gas ovens > 5 years

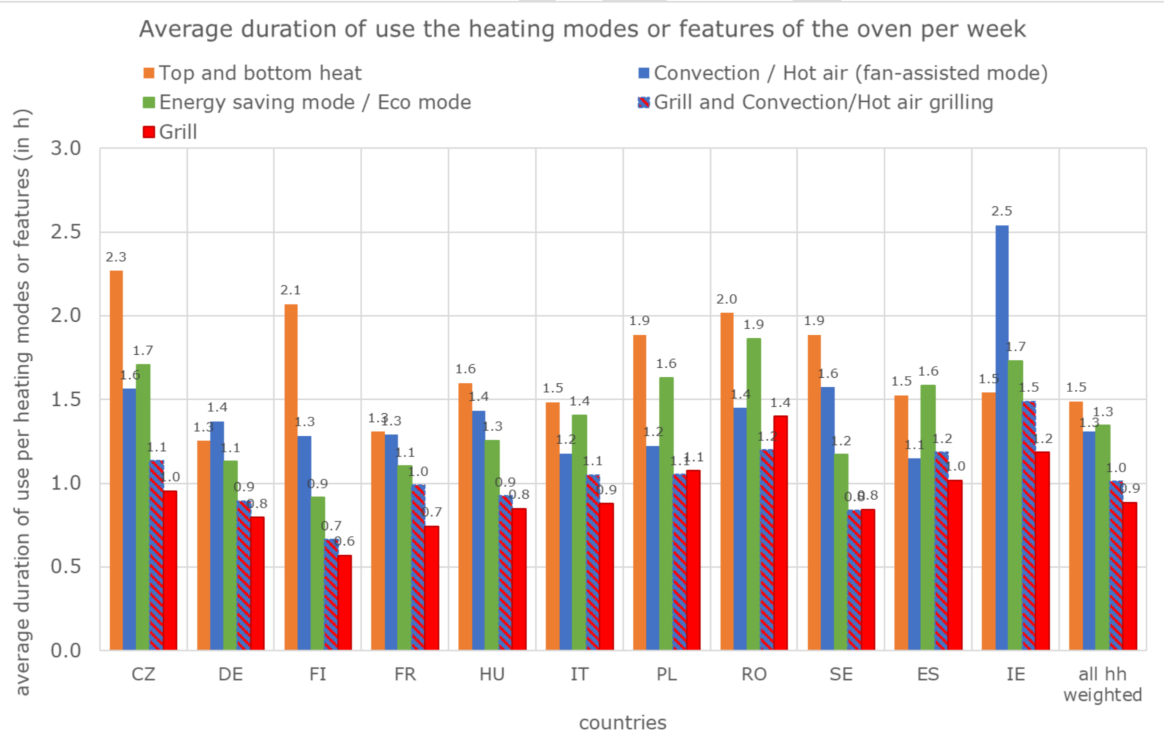


Figure 104 Duration of using heating modes of all the ovens

3.8.4.4 Oven cooking habits

The Preparatory Studies for Ecodesign Requirements for Ovens (BIO, 2010) has already shown that there are wide differences in oven electricity consumption, which can be explained by differences in cooking preferences and oven usage among the EU Member States. Participants were asked about their cooking habits when using the oven to shed some light on those differences. Five recommendations for an energy-efficient use of the oven (gas and electric combined) were presented to the participant and they were asked how much they practice this habit. Letting frozen or chilled food approach ambient temperature before placing in the oven is very often or almost always done by more than 50% of the respondents (Figure 105). Reducing the heat several minutes before the cooking time is completed is followed by less than 40% very often or almost always on average (Figure 105). An average of more than 70% of the consumers responded (Figure 105) that they very often or almost always remove unused trays from the oven before use. In contrast to this, no preheating of the oven before inserting food is followed by less than 25% of the participants very often or almost always (Figure 105). An average of almost 60% follow the advice to check the dish during cooking via the window only, instead of opening the door very often or almost always (Figure 105).

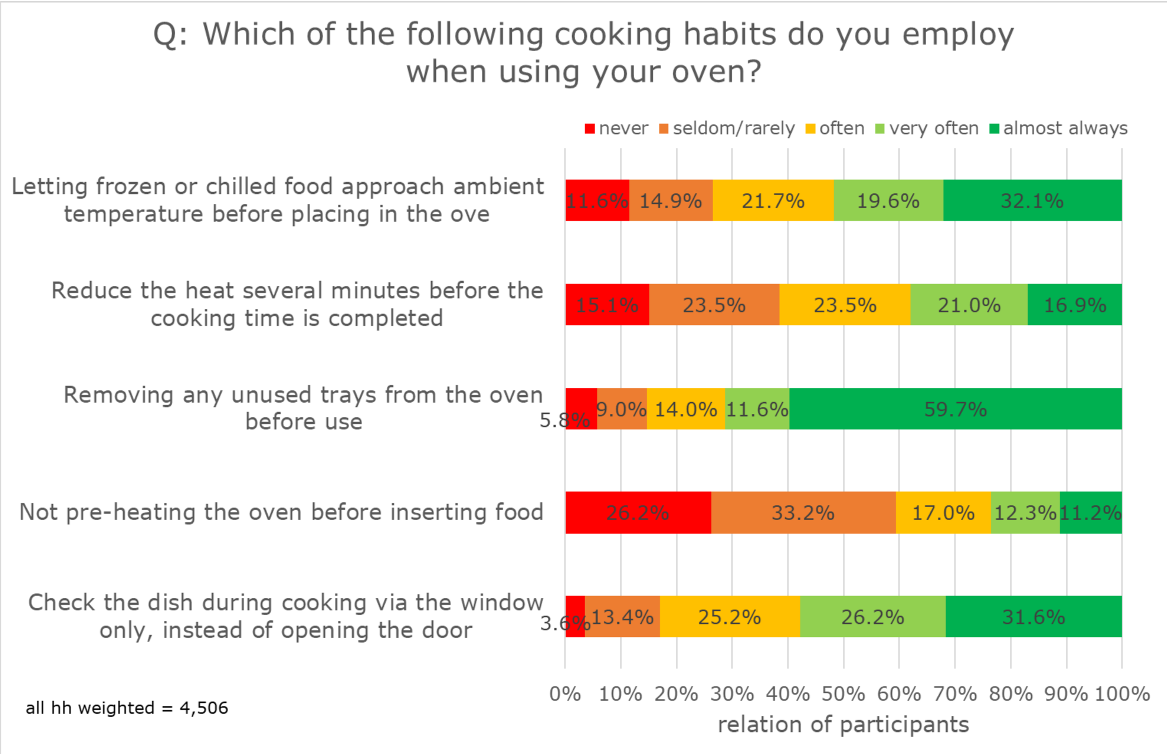


Figure 105 Cooking habits when using the oven

3.8.4.5 Frequency of preparation of dishes with the oven

The usage behaviour differences regarding the oven may be influenced by the type of dishes prepared. A list of selected dishes was presented in an arbitrary order to the participants and they were asked how often those dishes were prepared in the oven. When looking at the answers overall, they do not show a lot of differences between the different dishes (Figure 106).

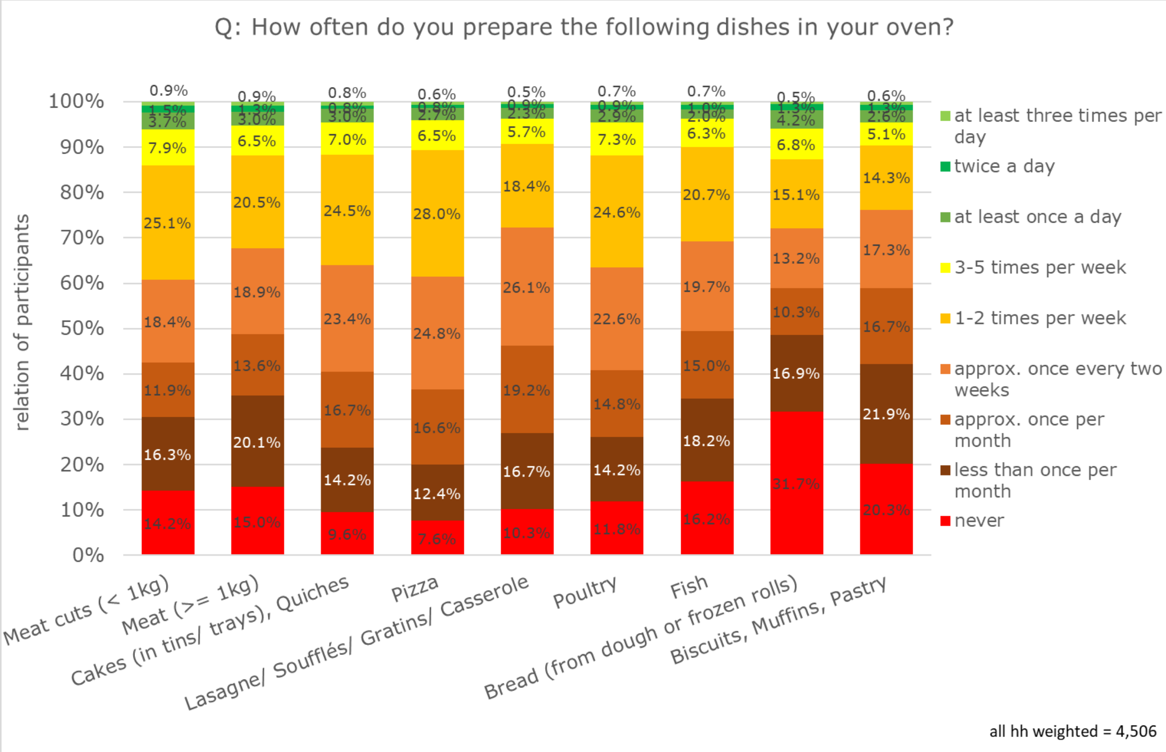


Figure 106 Frequency of preparing dishes

However, more differences can be observed regarding the use of the oven looking at the individual dishes by country. Decoding the nominal answers into numerical values depicts the differences between the countries in a simpler way (Table 29). The frequency of preparation of all those dishes over all households varies just between 1.1 and 1.5 time per week. It is not justified to sum up the usage frequencies as some of the dishes can be prepared in parallel in the oven.

Table 29 Average frequency of preparing dishes per week

	countries											
	CZ (n=195)	DE (n=551)	FI (n=309)	FR (n=547)	HU (n=307)	IT (n=560)	PL (n=528)	RO (n=283)	SE (n=271)	ES (n=521)	IE (n=292)	all hh weighted (n=4,506)
	aver. freq. per week											
Meat cuts (< 1kg)	1.8	1.3	1.3	1.6	1.5	1.3	1.9	2.6	1.1	1.3	2.9	1.5
Meat (>= 1kg)	1.5	1.2	0.5	1.3	1.4	1.1	1.8	2.1	1.1	1.2	2.4	1.3
Cakes (in tins/ trays), Quiches	0.8	1.1	0.5	1.6	0.9	1.5	1.5	1.6	0.7	1.2	1.2	1.3
Pizza	1.0	1.2	0.9	1.3	0.9	1.5	1.3	1.5	0.7	1.6	1.6	1.3
Lasagne/ Soufflés/ Gratins/ Casserole	0.7	1.0	0.8	1.2	0.8	1.1	1.1	1.3	0.8	1.2	1.2	1.1
Poultry	1.6	1.1	0.9	1.2	1.5	1.3	1.8	2.4	1.2	1.3	2.1	1.3
Fish	0.8	0.9	0.7	1.2	0.7	1.3	1.4	1.7	1.0	1.5	1.5	1.2
Bread (from dough or frozen rolls)	0.9	1.4	0.7	1.1	0.6	1.2	1.1	1.6	0.9	1.2	1.2	1.2
Biscuits, Muffins, Pastry	1.0	0.9	0.5	1.2	0.6	1.2	1.4	1.3	0.7	1.0	0.9	1.1

3.8.4.6 Satisfaction with different aspects when using the oven

The satisfaction with different aspects of using the oven (gas and electric combined) is generally quite high, between about 75 and 85% (Figure 107).

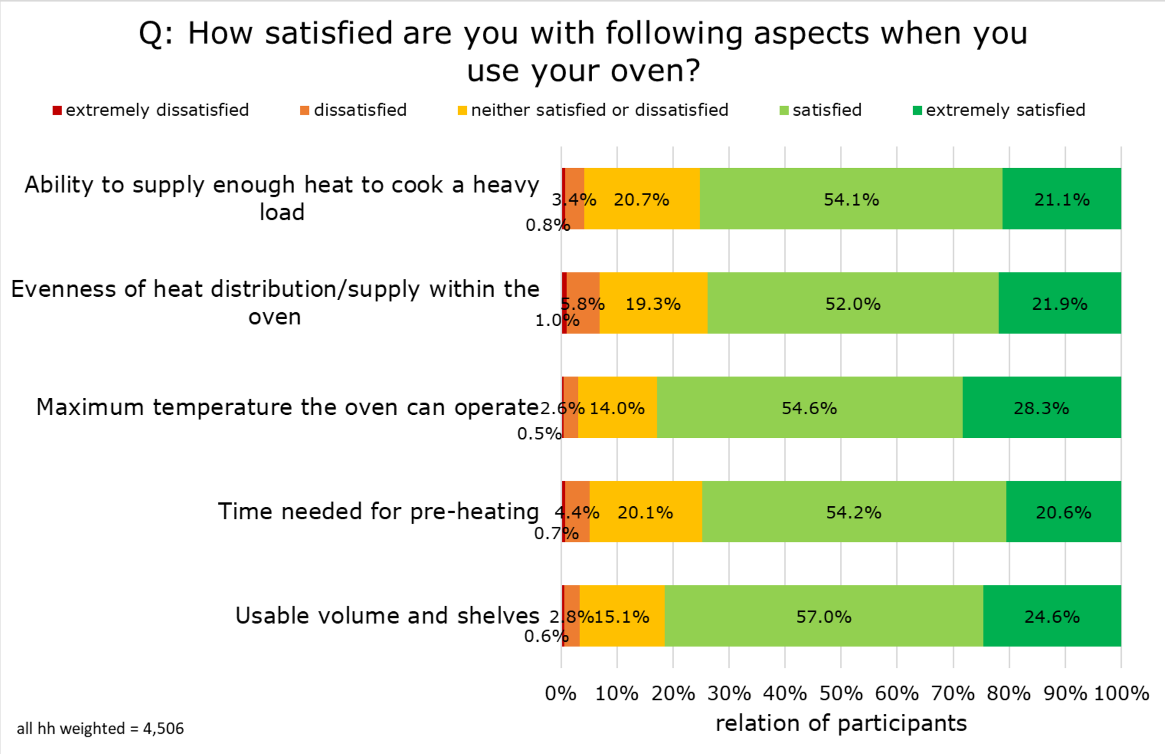


Figure 107 Satisfaction with aspects when using the oven

3.8.5 Hob

3.8.5.1 Type of hob available

Asking in detail what kind of hob – fixed to kitchen/oven or portable/table-top – the participants have reveals that 85% own a hob fixed to the kitchen or oven. About 7% own only a portable/table-top hob and about 8% own both types of hobs (Figure 108). However, there are relatively large differences between countries: in Hungary and Romania, for example, more than 30% own a portable/table-top oven and for 18% this is the only hob they have (Figure 109).

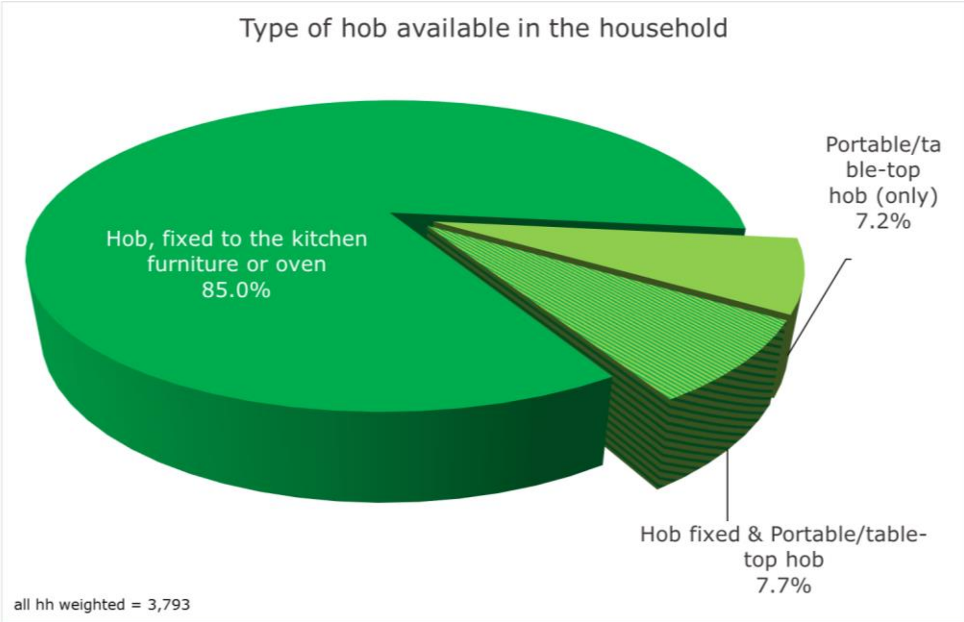


Figure 108 Type of hob available

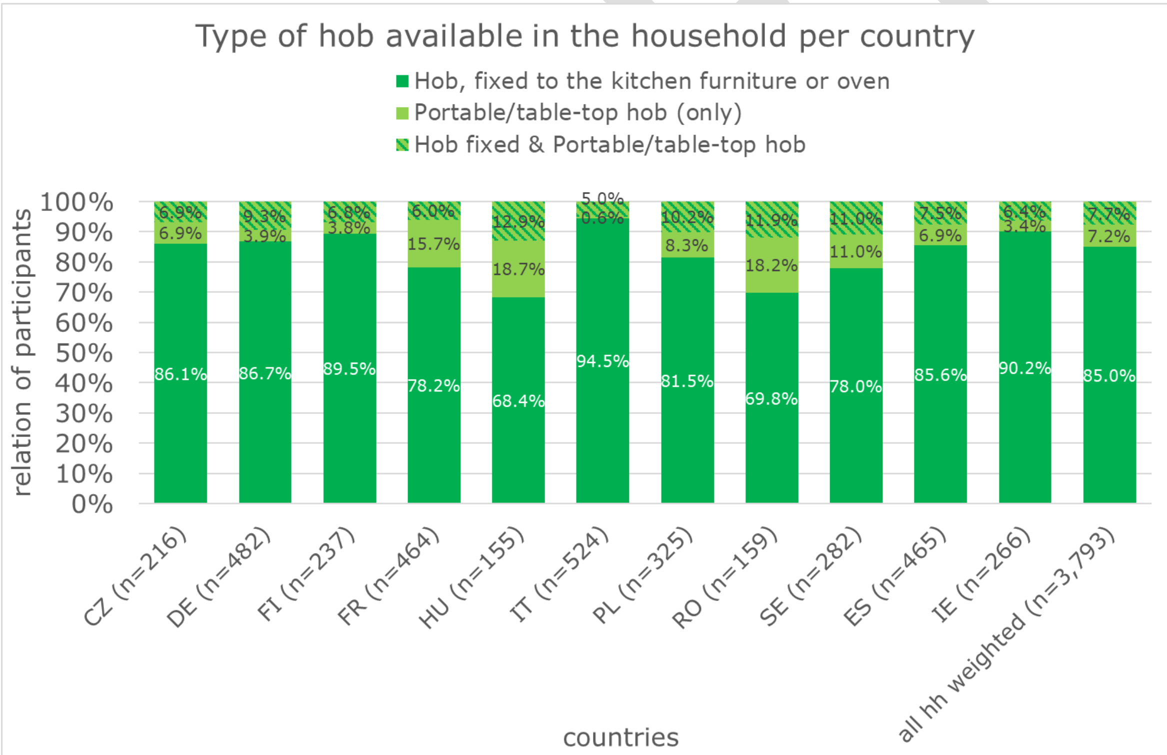


Figure 109 Type of hob available per country

3.8.5.2 Type of hob and energy sources

In a more in-depth investigation, the participating consumers are asked about the energy source of the hob they have and the number of cooking zones or burners their hob has. The answers reveal (Table 30) that 63% of consumers use electricity to run their hob and 31% use gas. Only 6% use both kinds of energy source. This split is almost independent of the kind of hob used in the households.

Table 30 Type/kind of hob and energy sources

		Which of these appliances do you have in your household?			
		Hob, fixed to the kitchen furniture or oven	Portable/table-top hob	Hob fixed & Portable/table-top hob	all hh weighted (valid n) 3,700)
Which type/kind of hob do you have and how many cooking zones or burners are available?	Gas & Electric hob	4%	1%	1%	6%
	Gas hob	28%	2%	2%	31%
	Electric hob	54%	5%	5%	63%
	all hh weighted (valid n = 3,700)	86%	7%	7%	100%

Going into more detail about the number of cooking zones and burners their hob has, most electric hobs have four cooking zones (Table 31, Figure 110). Gas hobs also mostly have four single flame burners – but only one double-flame burner (Figure 111). The situation is very fragmented for hobs using a combination of gas and electricity (Figure 112).

Table 31 Average number of cooking zones/burners

	Which type/kind of hob do you have and how many cooking zones or burners are available?		
	Gas & Electric hob	Gas hob	Electric hob
	Aver.	Aver.	Aver.
Metallic surface with single-flame burners	3.0	3.7	
and double-flame burners	2.2	1.9	
Glass surface with single-flame burners	2.4	3.4	
and double-flame burners	2.1	2.1	
Solid iron plate with cooking zone(s)	1.9		3.0
Radiant glass ceramic with cooking zone(s)	2.0		3.6
Induction with cooking zone(s)	2.1		3.3

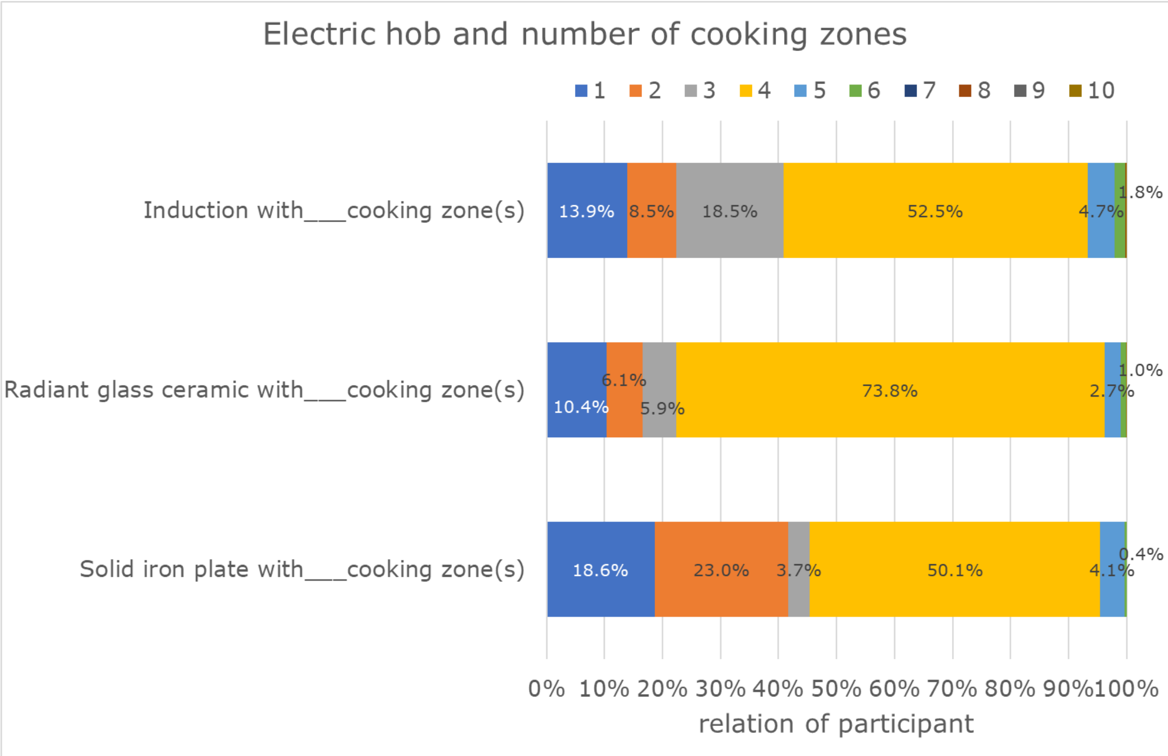


Figure 110 Electric hob and number of cooking zones

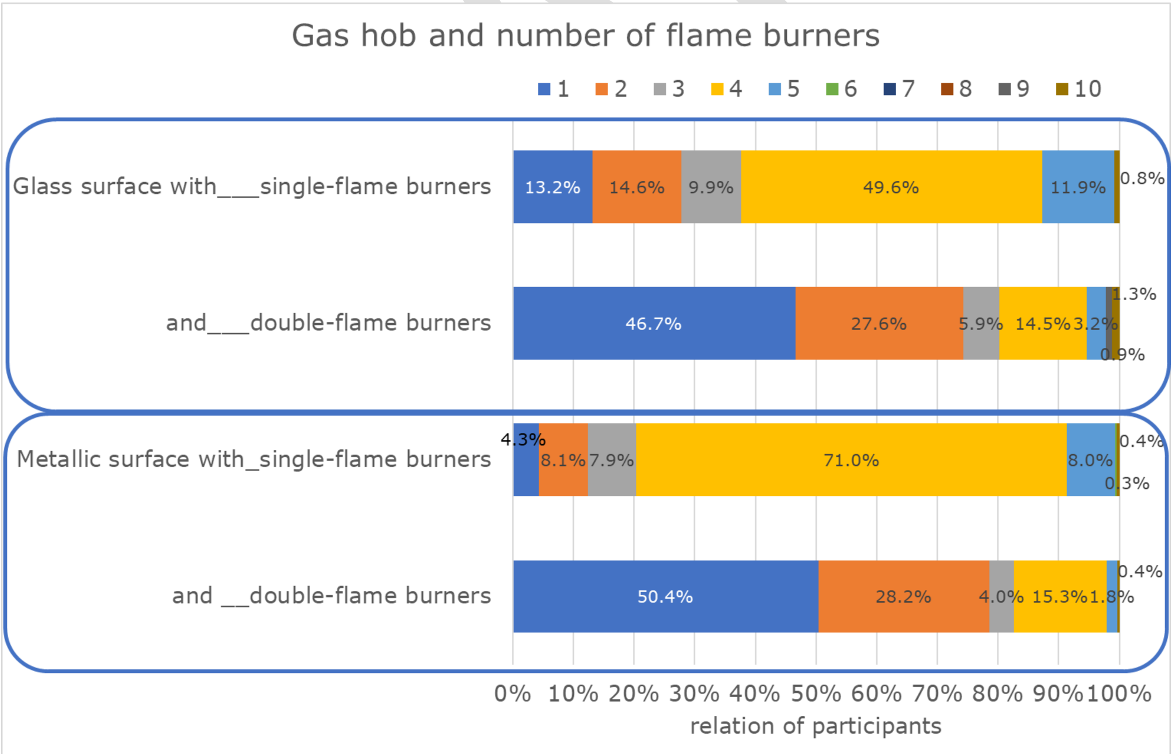


Figure 111 Gas hob and number of flame burners

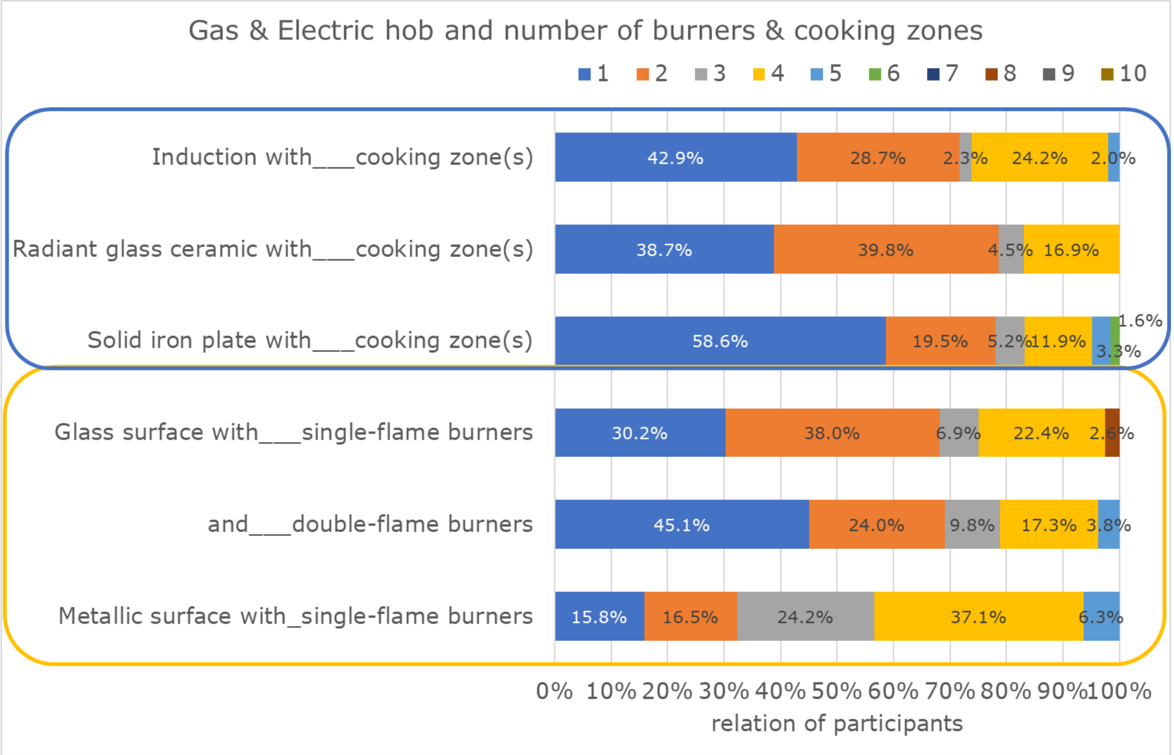


Figure 112 Electric hob and gas hob and number of cooking zones/flame burners

Answers to this question also allow one to deduct what kind of cooking surfaces are in use in the households. Gas hobs have a metallic surface for almost 90% of the consumers (Figure 113), while glass ceramic surfaces are most common for electric hobs in 84% of the households (assuming all which do not have an iron solid plate surface = 16.2%). A combination of surfaces also exists for combined gas and electric hobs as multiple answers were given (Figure 114).

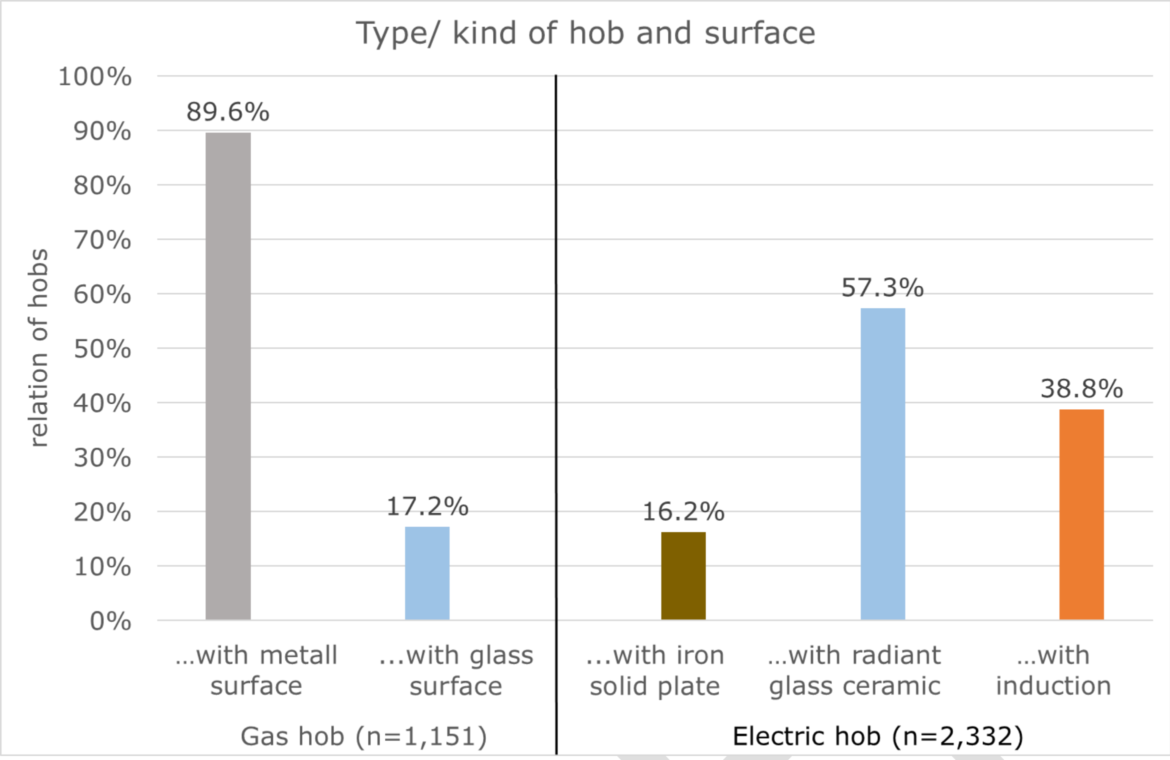


Figure 113 Gas and electric hob and surface

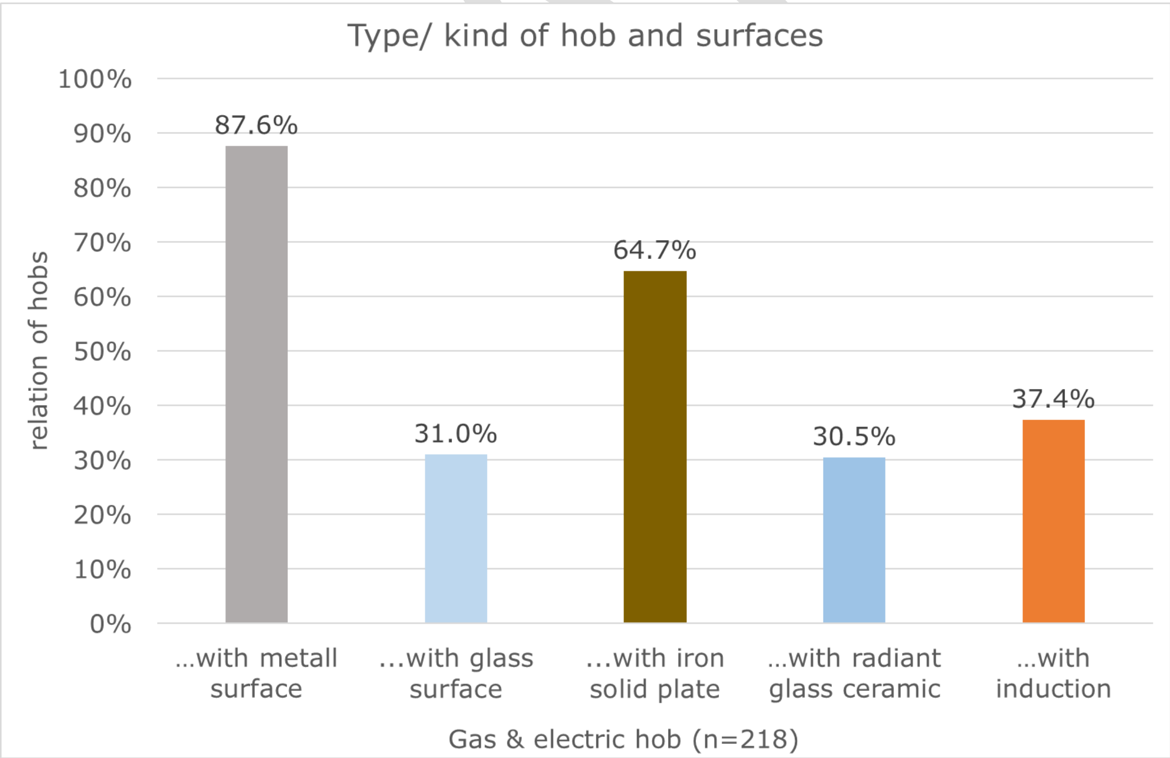


Figure 114 Combination gas and electric hob and surfaces

Investigating the age of the hob (Figure 115) shows that the average age is highest for combined gas and electric hobs (9.4 years) followed by gas hobs (8.6 years) and electric hobs (7.1 years).

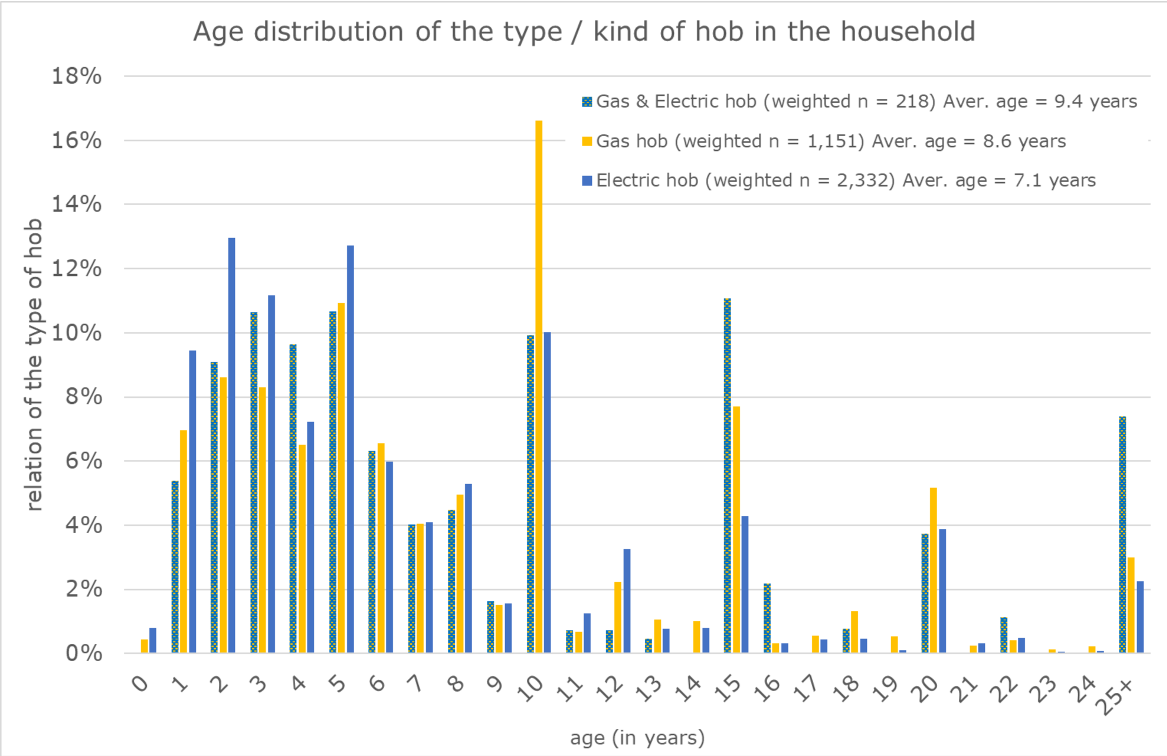


Figure 115 Age distribution of different types of hobs

Country-specific averages (Figure 116) show some differences between an average of hobs in Romania (4.6 years) and Italy (9.4 years).

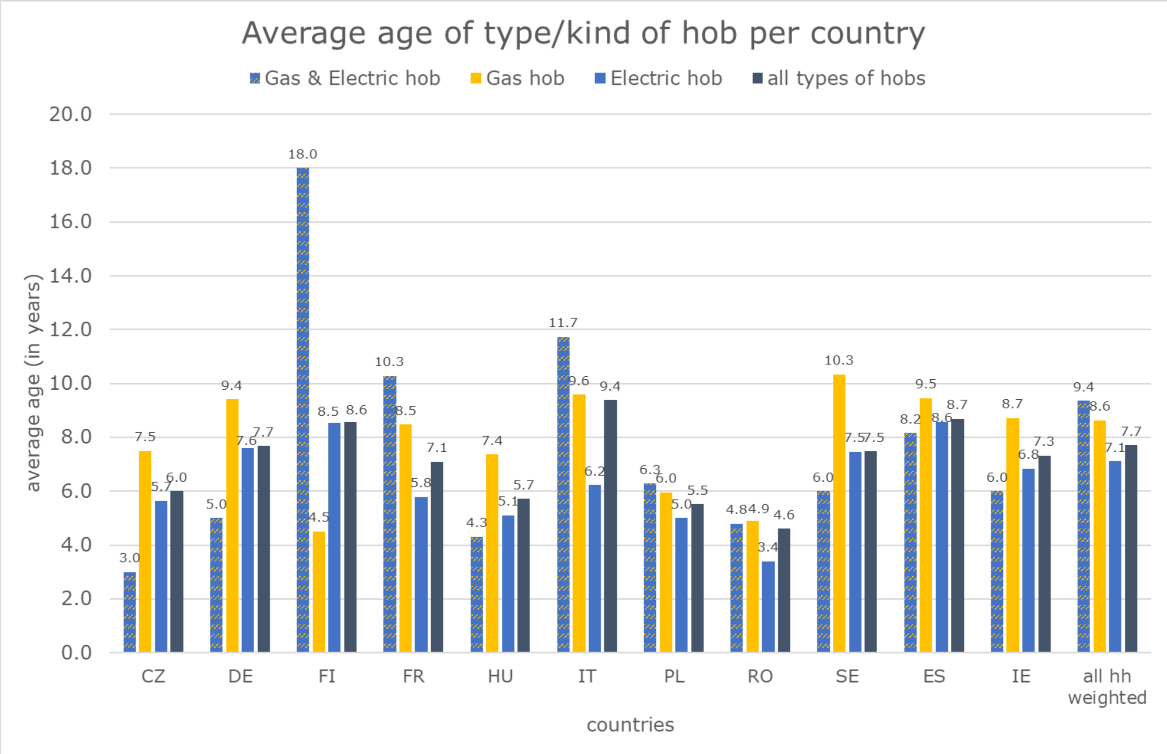
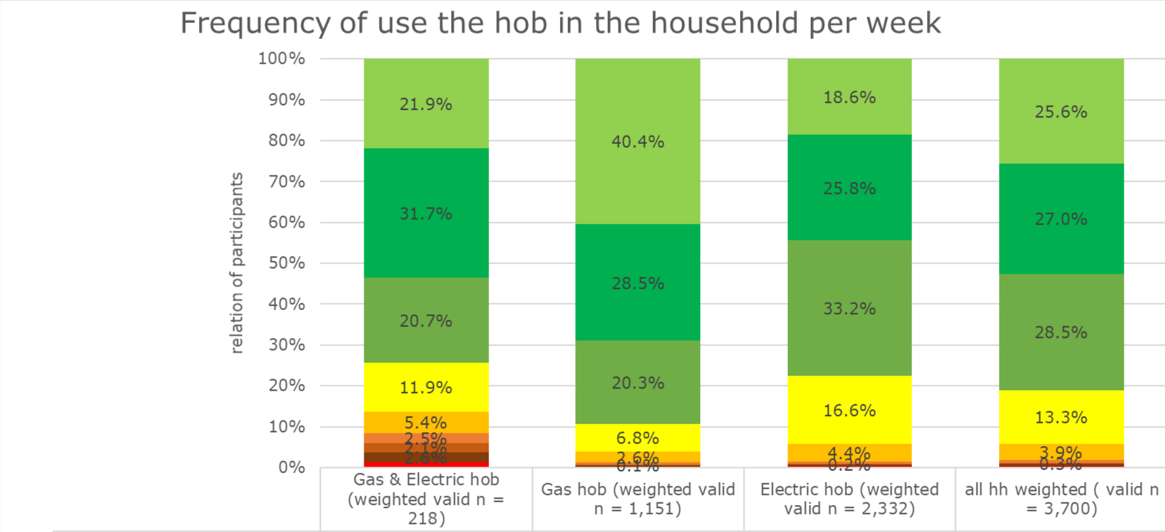


Figure 116 Average age of different types of hobs

3.8.5.3 Frequency and duration of the use of the hob

The frequency of using the hob was gathered again by some semi-nominal variables the participants could select. The answers (Figure 117) show that hobs are generally used by about 80% of the consumers at least once per day. Gas-operated hobs are used even more frequently. Decoding the answers into numerical values (Figure 118) shows even more clearly that gas-operated hobs are used more frequently (14.2 times per week), especially compared to electric hobs (10.6 times per week). The hob is used an average of 11.7 times per week. However, the usage averages are very different from country to country (Figure 118). Household size is just one variable to explain those differences, as there is a clear tendency for a more frequent use with an increasing number of members of the household asked (Figure 119).



	Gas & Electric hob (weighted valid n = 218)	Gas hob (weighted valid n = 1,151)	Electric hob (weighted valid n = 2,332)	all hh weighted (valid n = 3,700)
at least three times per day	21.9%	40.4%	18.6%	25.6%
twice a day	31.7%	28.5%	25.8%	27.0%
at least once a day	20.7%	20.3%	33.2%	28.5%
3-5 times per week	11.9%	6.8%	16.6%	13.3%
1-2 times per week	5.4%	2.6%	4.4%	3.9%
approx. once every two weeks	2.5%	0.6%	0.5%	0.7%
approx. once per month	2.1%	0.1%	0.2%	0.3%
less than once per month	2.6%	0.4%	0.3%	0.5%
never	1.2%	0.2%	0.3%	0.3%

Figure 117 Frequency of using the hob per week and household

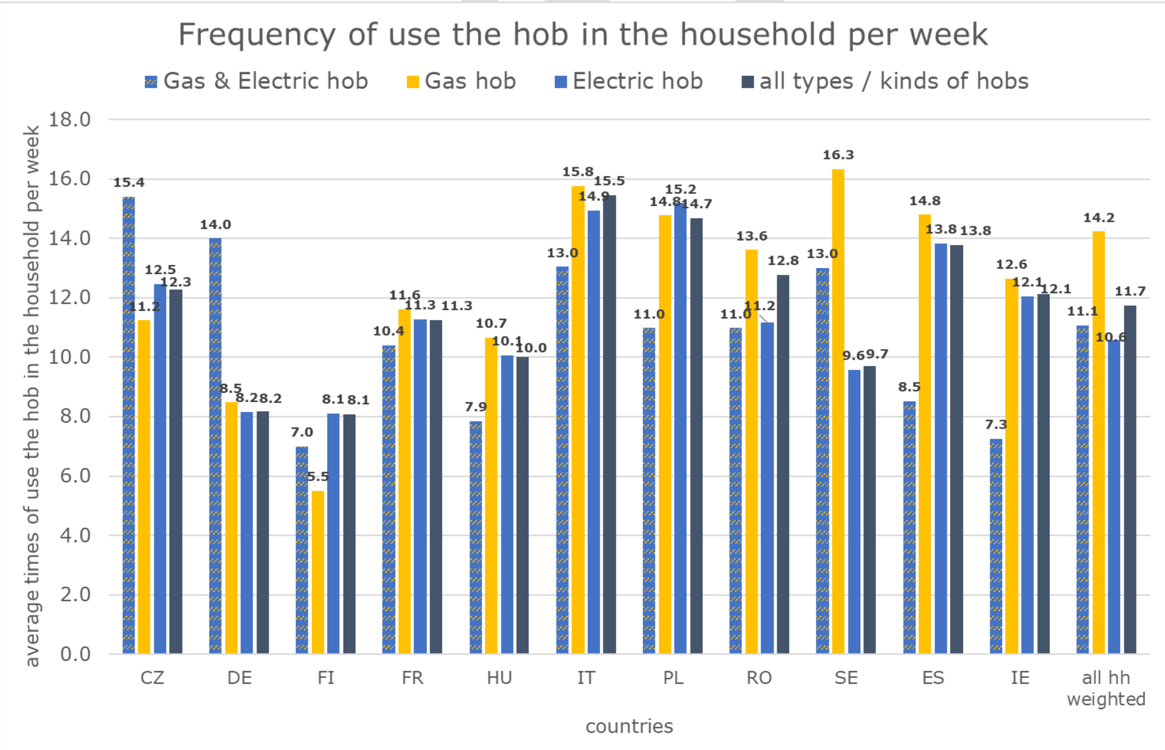


Figure 118 Average frequency of use per different types of hobs

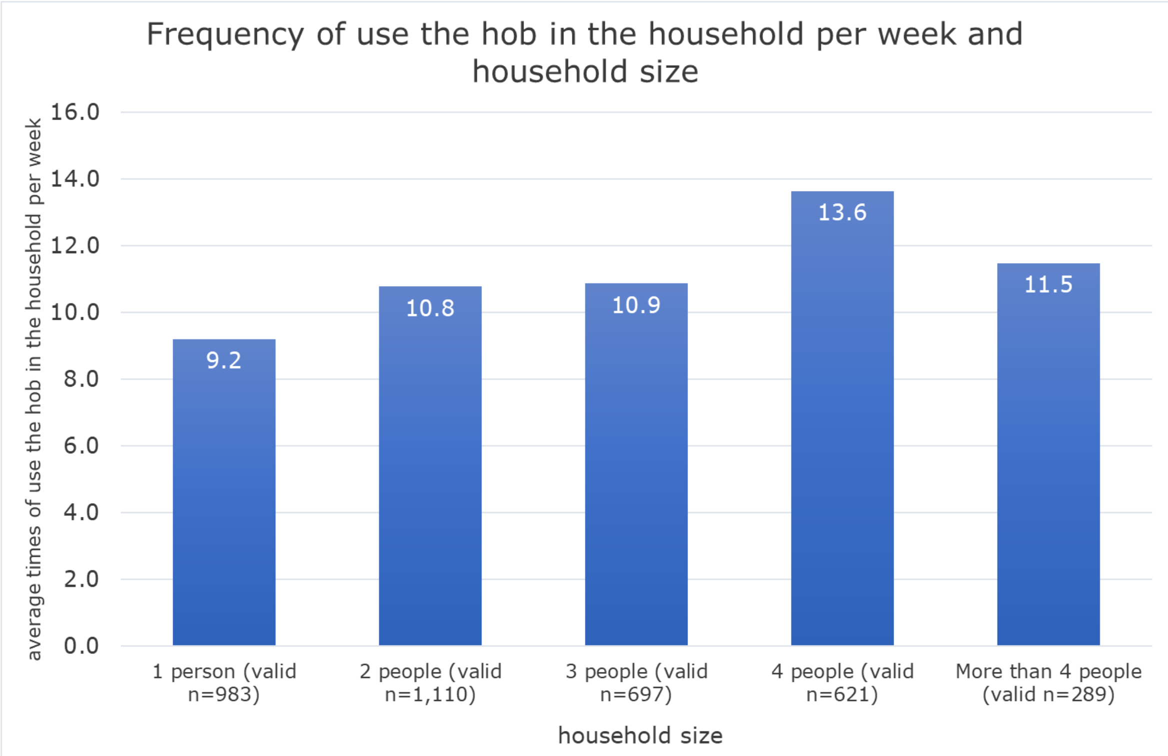


Figure 119 Average frequency of using the hob per week and household size

Regarding the energy consumption, it is more important to know how long the hob is used. This was queried in another question where the participants were asked to select the average use of the hob per week. The results show (Figure 120) an almost equal distribution of the answers given between longer than 30 minutes and more than 8 hours. However, looking at the data on a country level reveals relevant differences between countries (Figure 121).

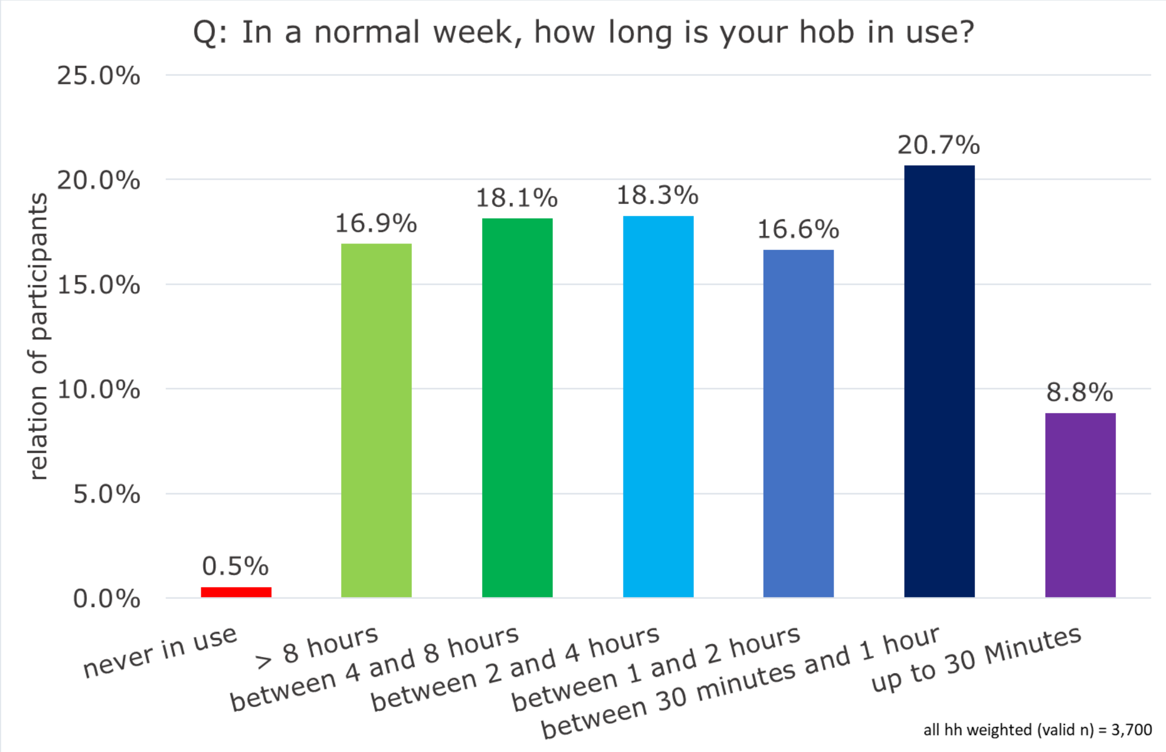


Figure 120 Distribution of duration of use

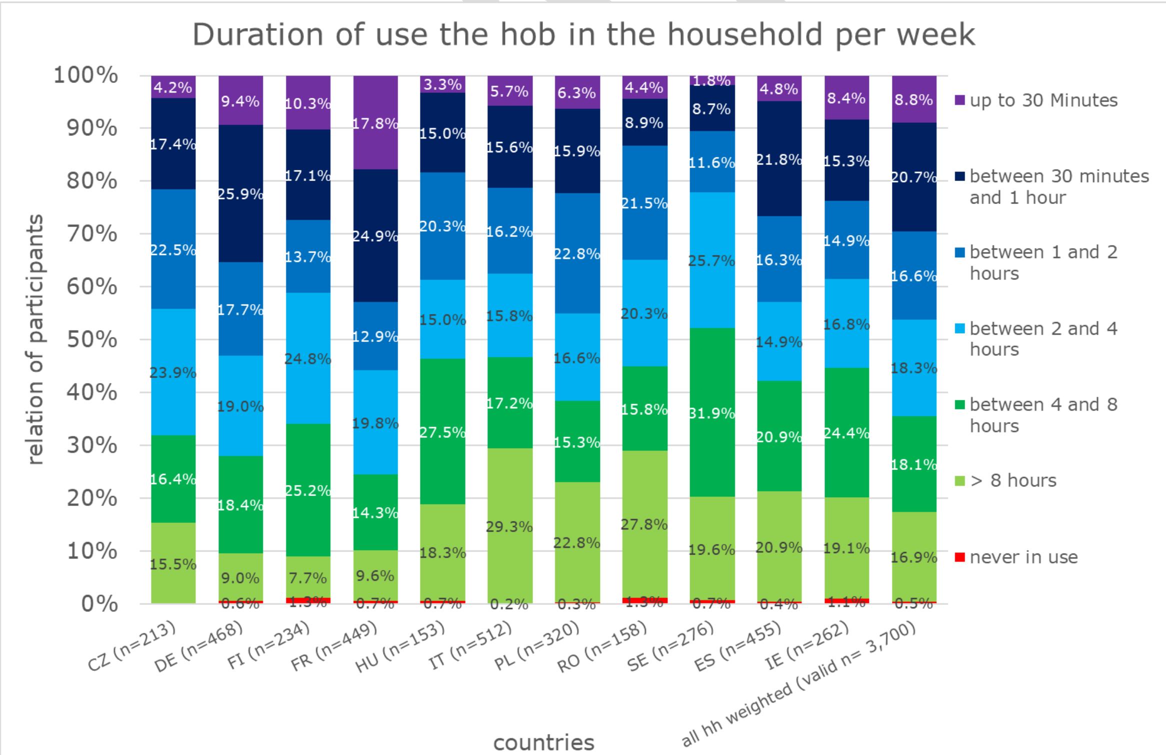


Figure 121 Distribution of duration of use per country

Again, decoding the nominal selection of the respondents into numerical values shows that the hob is in use between 2.9 hours (France) and 4.9 hours (Sweden) per week (Figure 122). The overall average use is for 3.8 hours per week.

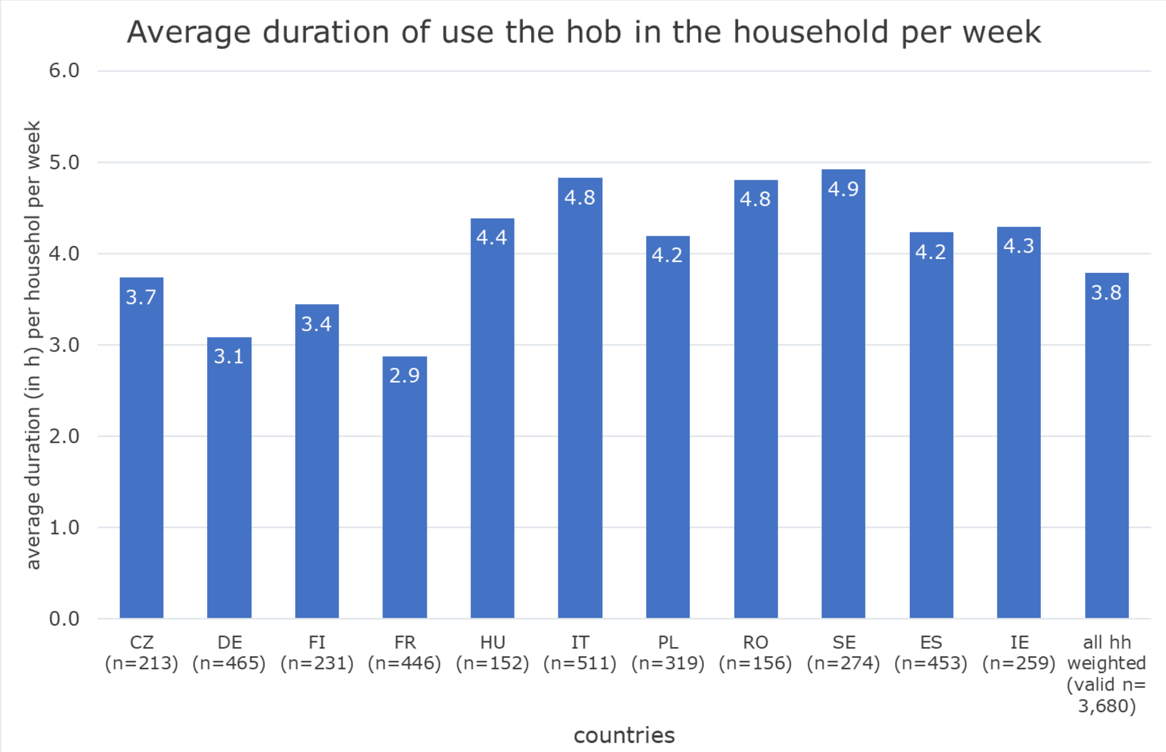


Figure 122 Average duration of use per week

Asking about the features the hob has shows that those features are not so common, as about one-third of the participants do not have any features at all (Figure 123). The most common feature is to keep dishes warm, but the feature most used is the power boost or rapid cooking.

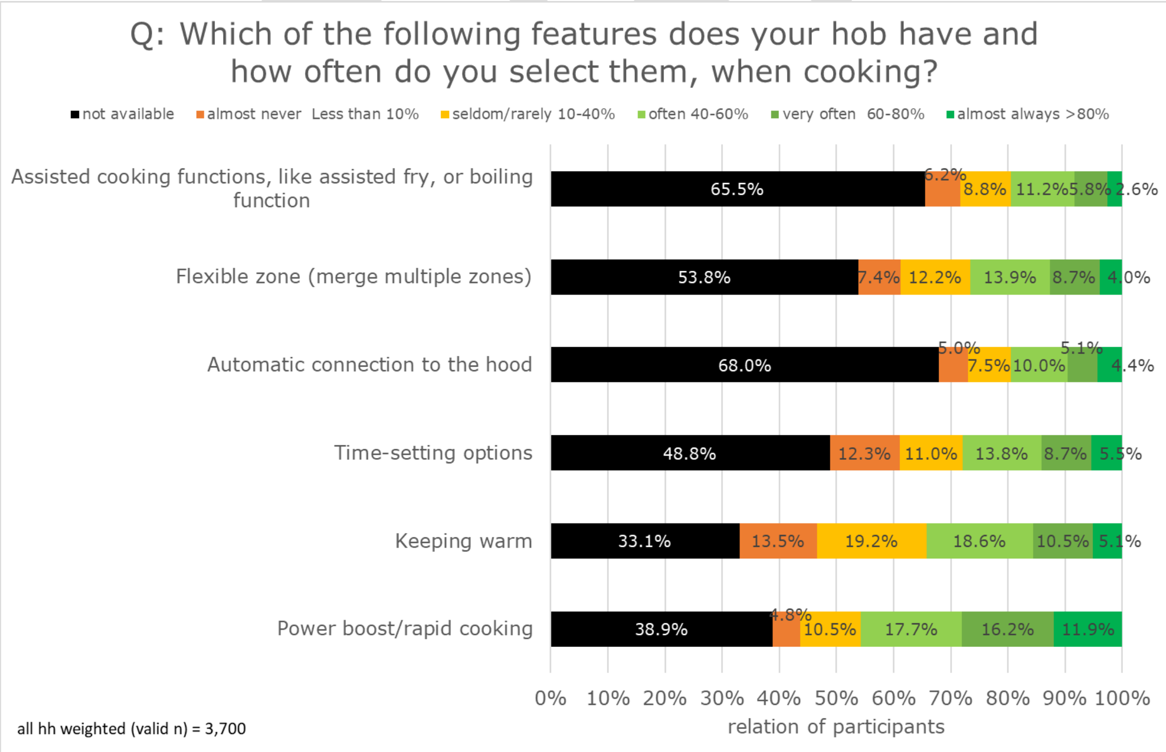


Figure 123 Availability and frequency of use of features of the hob

The purpose of using the hob was asked in another question and a range of options were given to the participants as possible answers. The purpose of use most answered was generally cooking pasta followed by cooking rice or boiling or steaming vegetables (Figure 124).

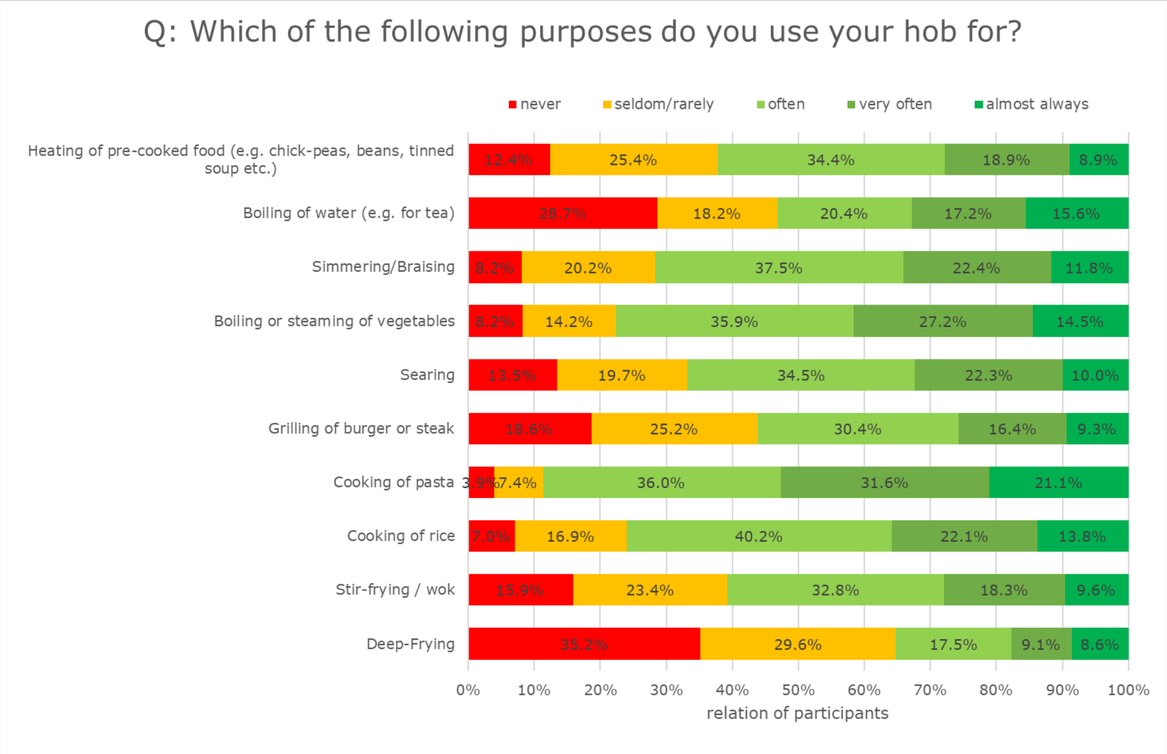


Figure 124 Purposes of using the hob

3.8.5.4 Hob cooking habits

Best practice and energy-saving cooking habits when using the hob are followed often, very often or always by an average of at least 80% of the participants, following their self-declaration when asked (Figure 125).

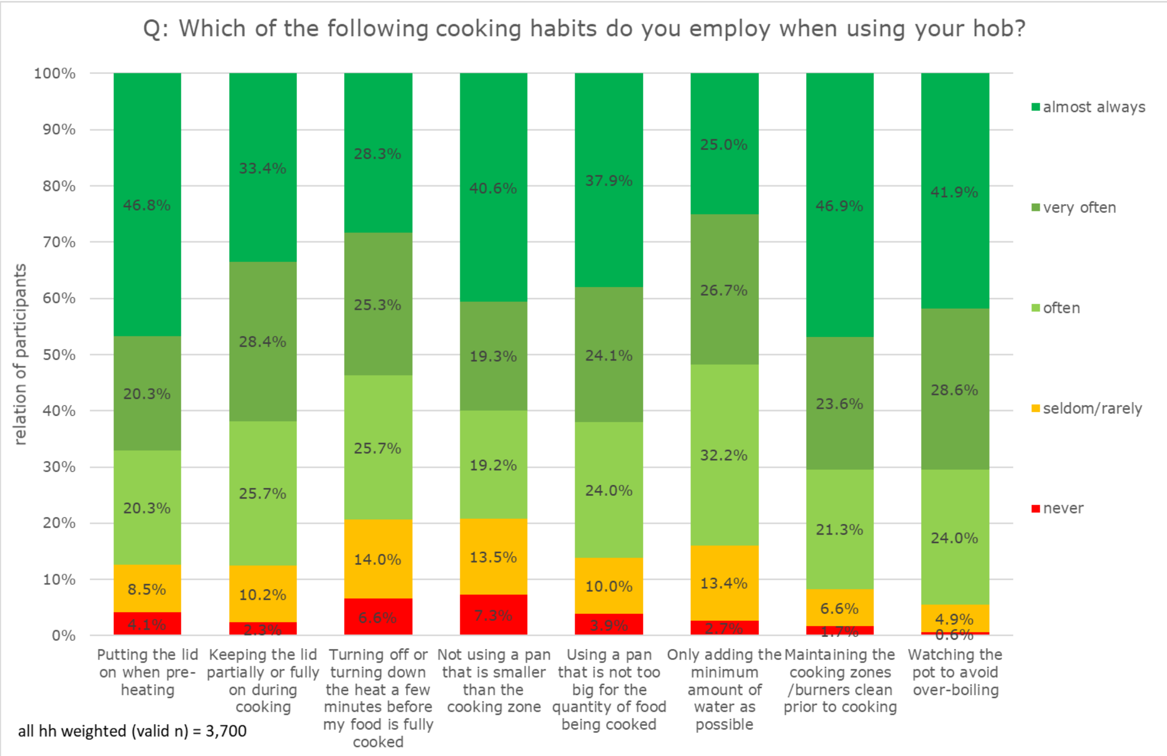


Figure 125 Cooking habits when using the hob

3.8.6 Cooking fume extractor

3.8.6.1 Types of cooking fume extractors in European households

There are various kinds of cooking fume extractors installed in kitchens in Europe (Figure 126). Overall, close to 40% of respondents own a cooking fume extractor built into kitchen furniture and about one-third have a standalone, wall-mounted cooking fume extractor. One can find a ceiling-mounted cooking fume extractor less frequently. The latest innovation of a down-draft cooking fume extractor mounted at the height level of the hob is found in about 8% of the kitchens. However, there are high variations between the countries in our survey.

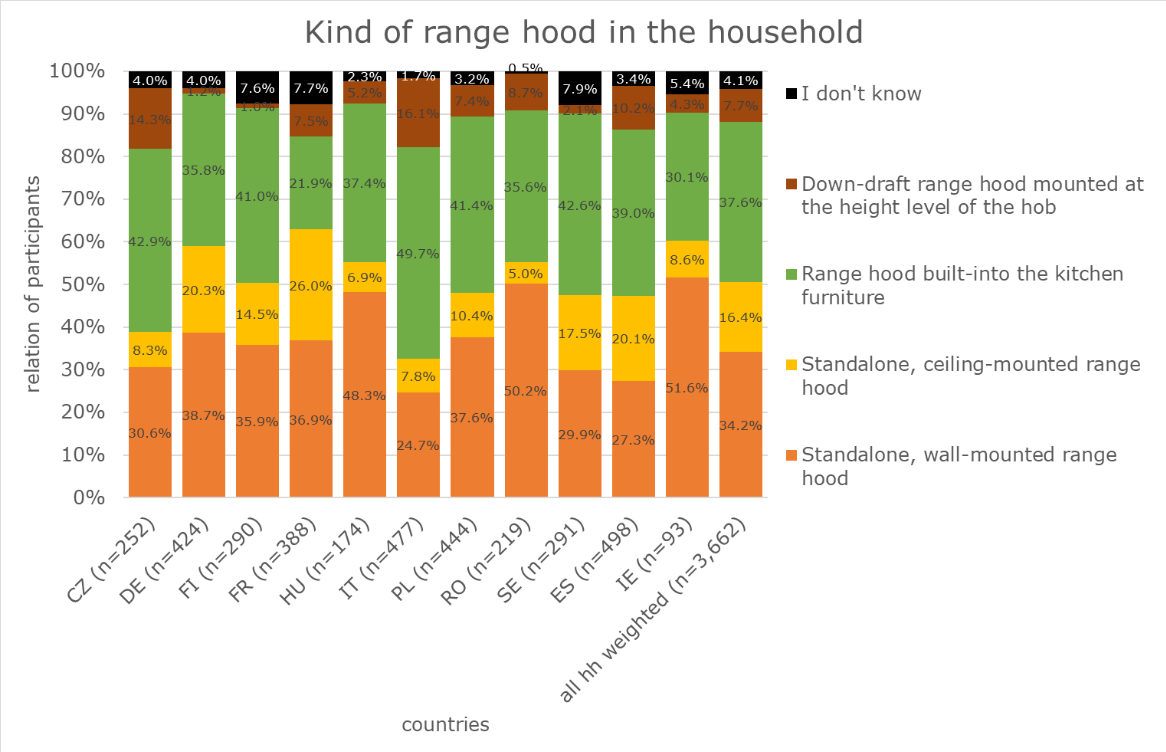


Figure 126 Type of cooking fume extractor used in the household per country

3.8.6.2 Use of cooking fume extractor

About 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor (Figure 127). The differences in usage between countries are not high, but the usage in Sweden and Finland, for example, is highest for both functions (Figure 128, Figure 129). About 14% of the respondents claim to use the cooking fume extractor also when not cooking (Figure 130). Using the cooking fume extractor light as a substitute for the kitchen light is the most important use of the cooking fume extractor when not cooking (Figure 131). Other purposes, such as getting rid of residual food odours and humidity after cooking, when someone is or has been smoking in the kitchen or when cleaning with chemicals in the kitchen, are less often named.

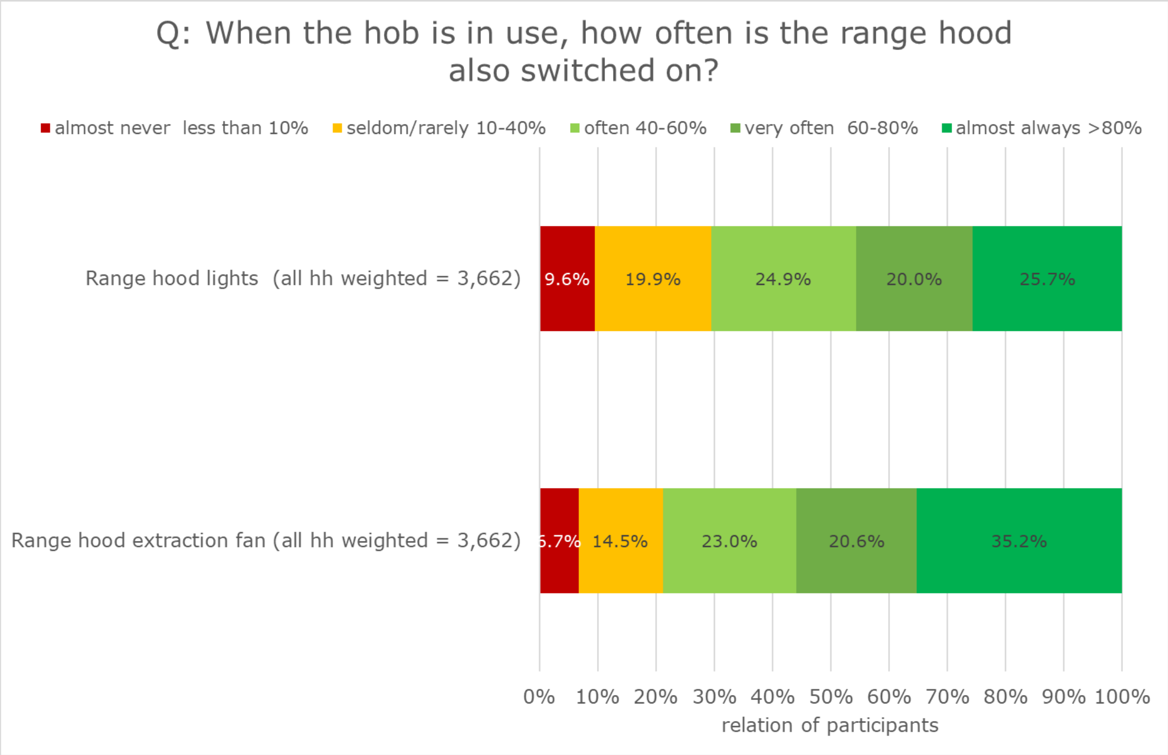


Figure 127 Frequency of switching on the cooking fume extractor when the hob is used

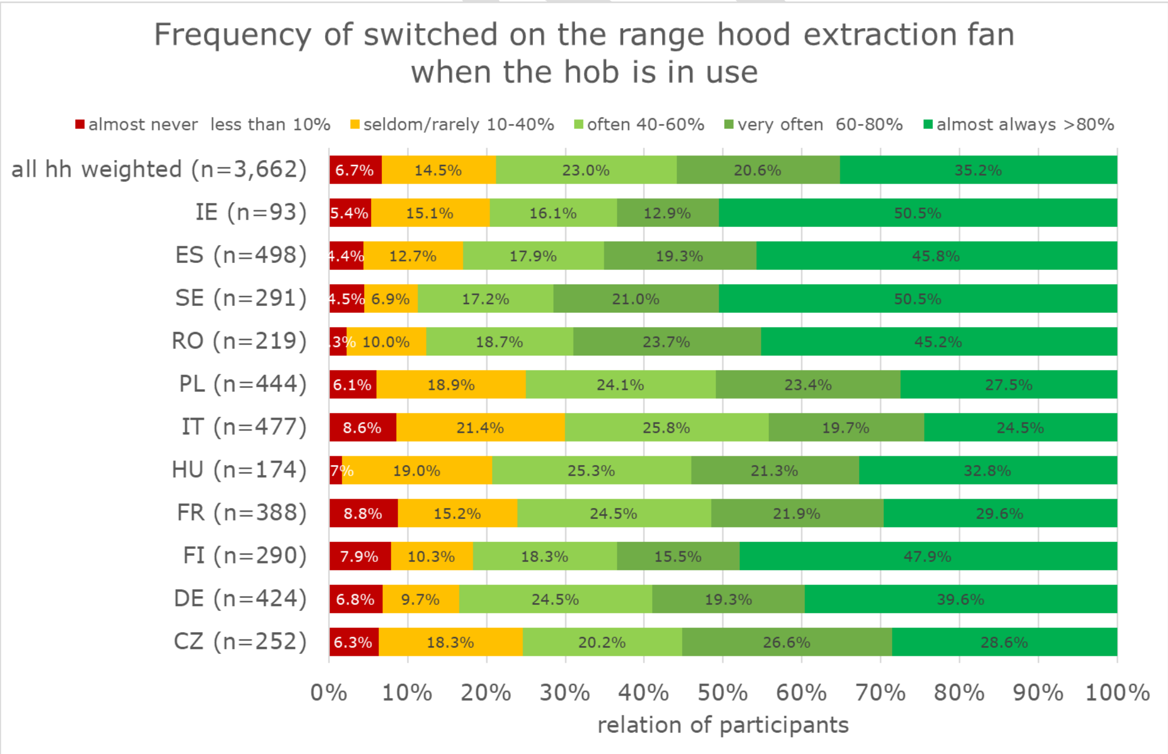


Figure 128 Frequency of switching on the cooking fume extractor extraction fan when the hob is used

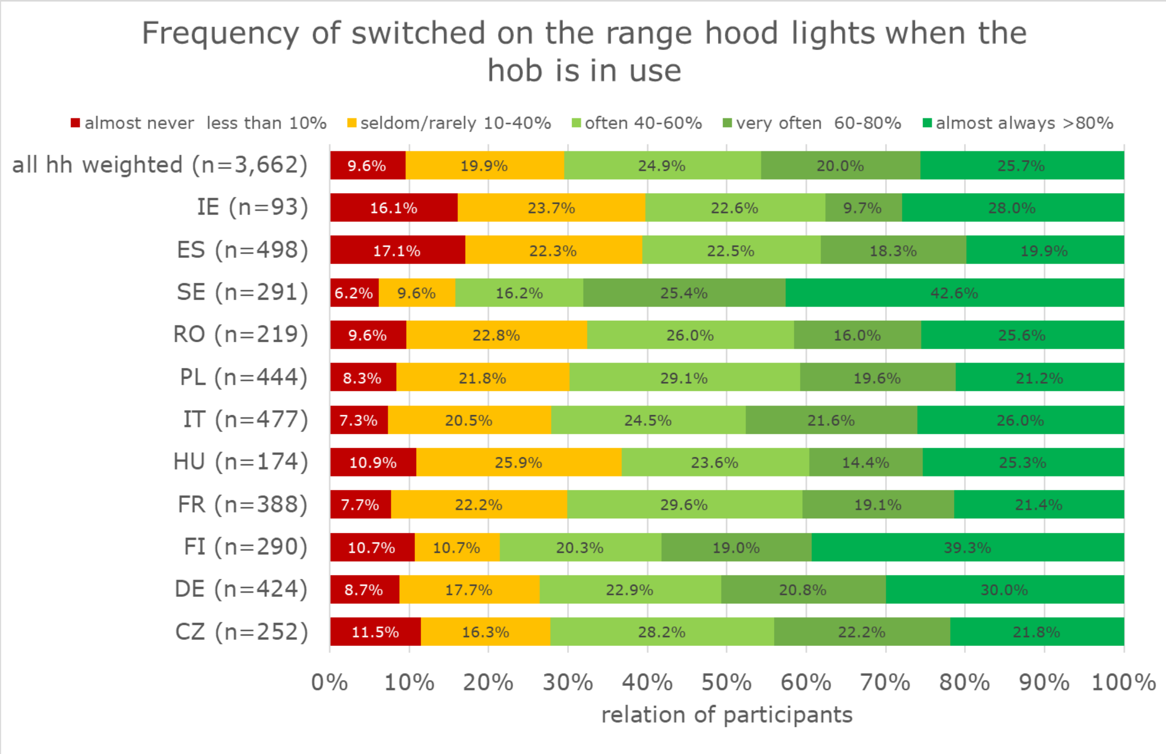


Figure 129 Frequency of switching on the cooking fume extractor lights when the hob is used

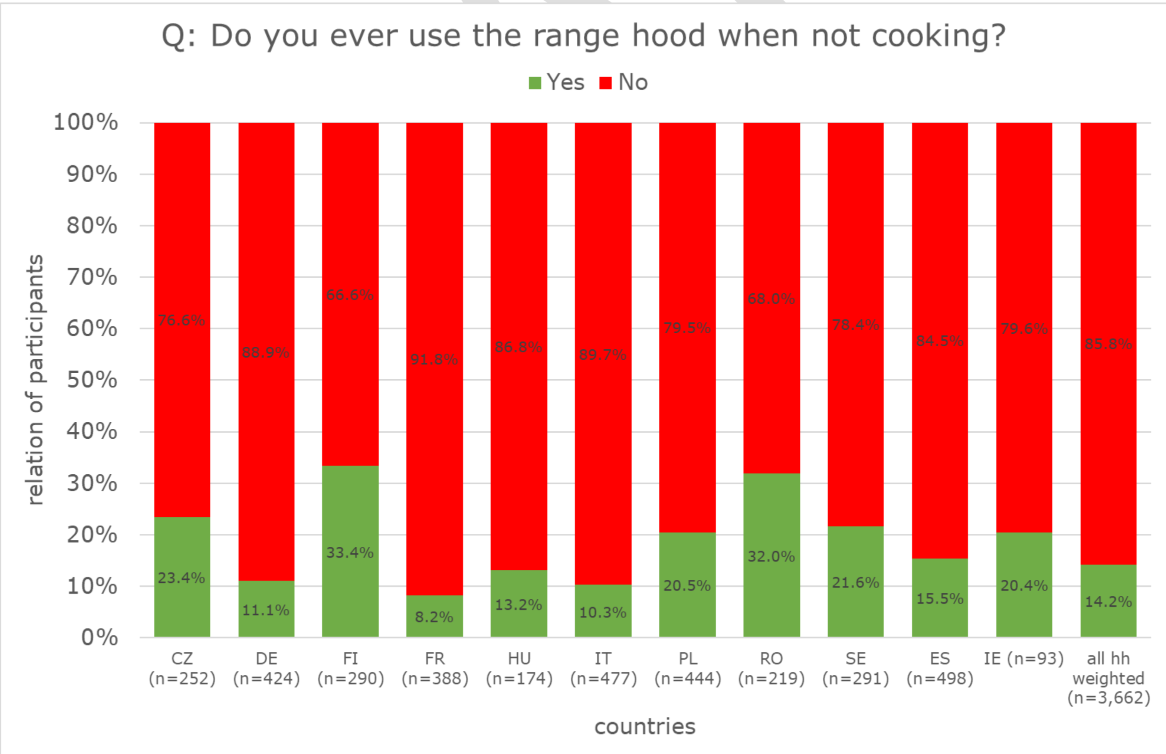


Figure 130 Usage of the cooking fume extractor when not cooking

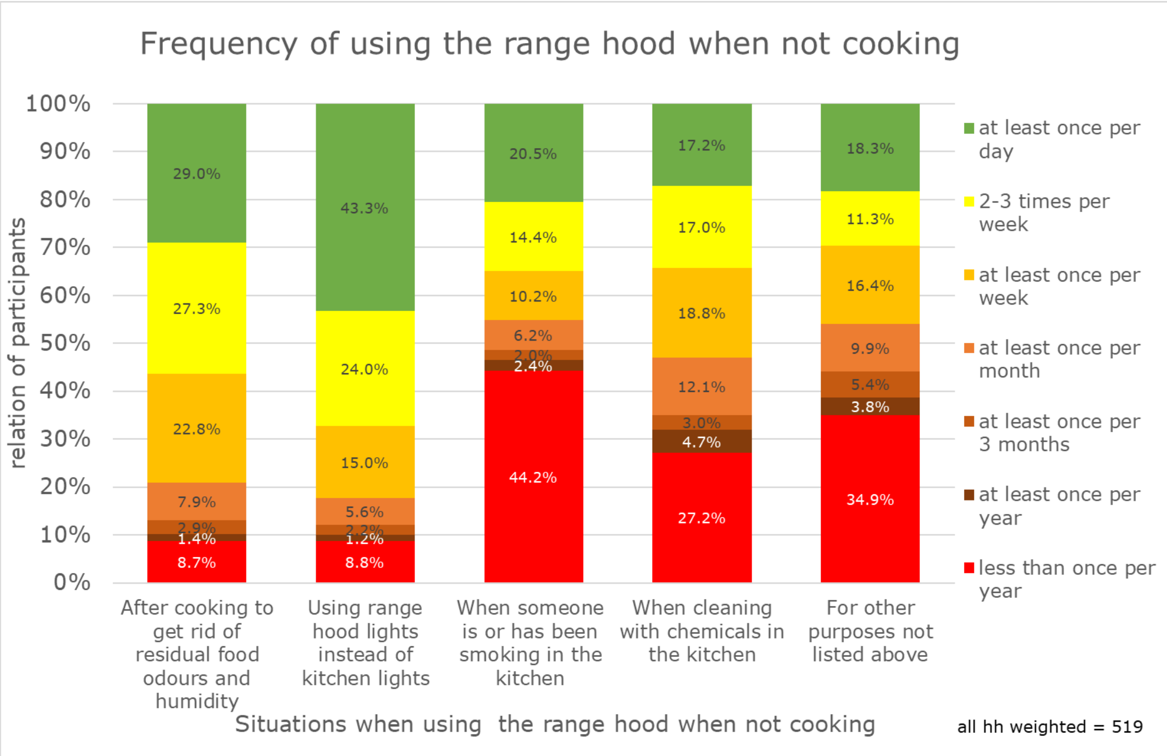


Figure 131 Frequency of using the cooking fume extractor when not cooking

Decoding the nominal answers into numerical values determines the frequency of using the cooking fume extractor for other purposes on average per country (Table 32).

Table 32 Average frequency of using the cooking fume extractor for other purposes per week

	After cooking to get rid of residual food odours and humidity	Using cooking fume extractor lights instead of kitchen lights	When someone is or has been smoking in the kitchen	When cleaning with chemicals in the kitchen	For other purposes not listed above
	aver. freq. per week				
CZ (n = 59)	2.5	3.4	1.3	1.3	0.7
DE (n = 47)	1.8	4.5	1.5	0.8	0.9
FI (n = 97)	2.5	3.2	0.8	1.3	2.0
FR (n = 32)	2.3	3.2	1.9	1.8	1.5
HU (n = 23)	3.0	3.7	1.1	1.1	0.9
IT (n = 49)	2.8	3.4	1.9	2.6	2.0
PL (n = 91)	4.2	4.3	2.3	2.5	2.8
RO (n = 70)	3.9	3.2	3.3	2.5	1.8
SE (n = 63)	3.4	4.0	1.2	1.0	1.7
ES (n = 77)	3.4	3.8	2.3	2.3	2.2
IE (n = 19)	2.6	2.4	1.1	1.5	0.9
all hh weighted (n = 519)	3.0	3.8	1.9	1.9	1.8

Variable fan speeds are available in at least 80% of all cooking fume extractors (Figure 132). A boost speed function is available for about 40% of the participants. An intermediate speed function is used most in all countries (Figure 133).

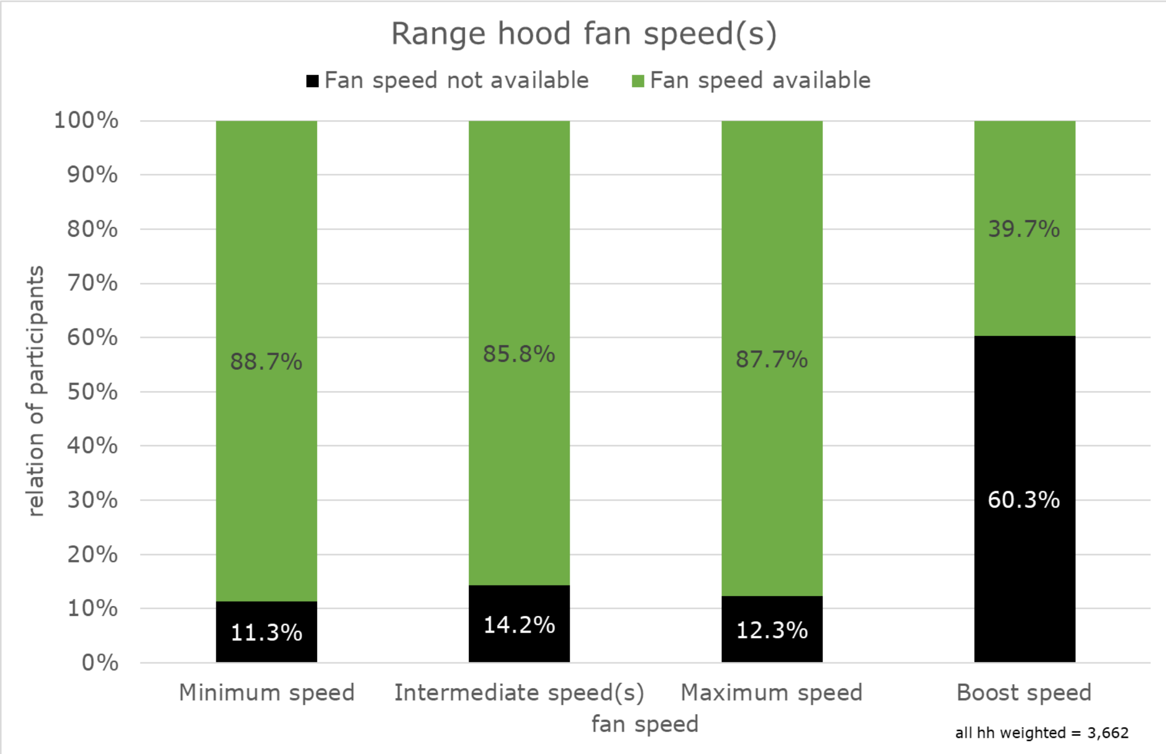


Figure 132 Availability of 'speeds' of the cooking fume extractor

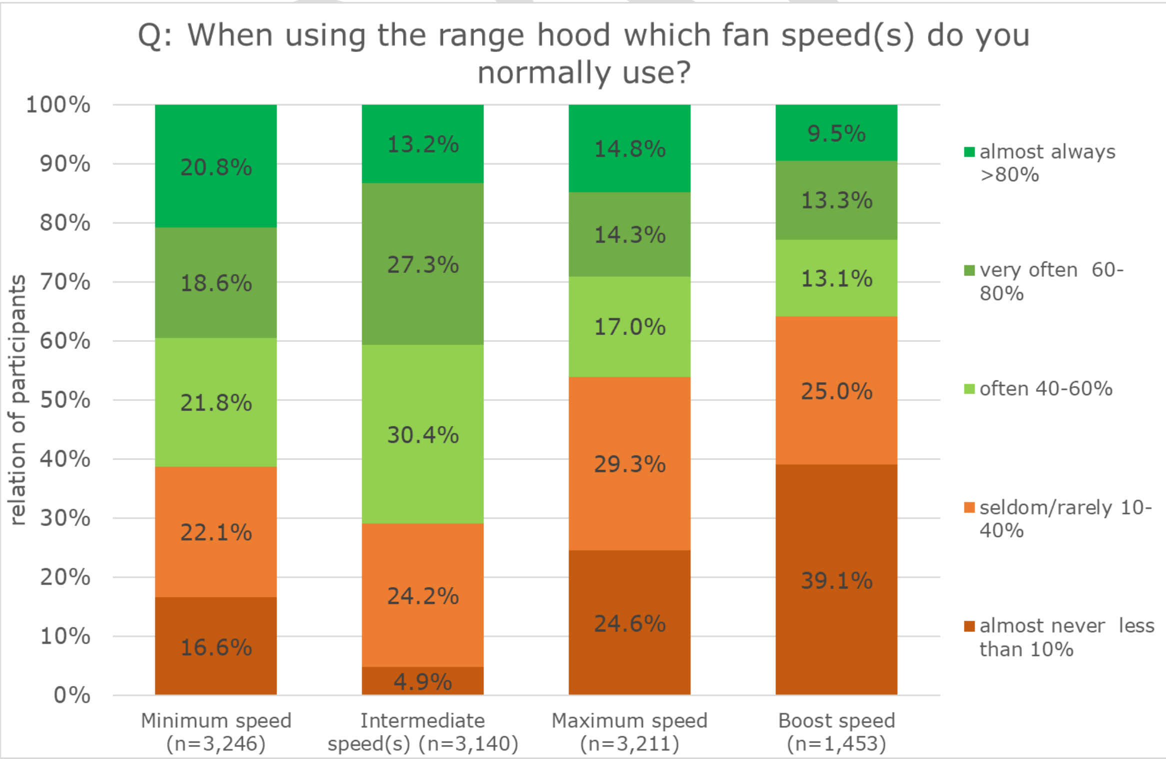


Figure 133 Usage of fan speeds of the cooking fume extractor

About 45% of the participants claim that their cooking fume extractor is equipped with a metal mesh filter and roughly 20% each claim to have a paper or fabric-based filter and a charcoal cartridge filter (Figure 134). However, 15% do not know which filter their cooking fume extractor has. The latter are probably those who claim not to know or never to clean the filter of the cooking fume extractor (Figure 135). About 50% of the respondents claim to clean the filter at least once per three months.

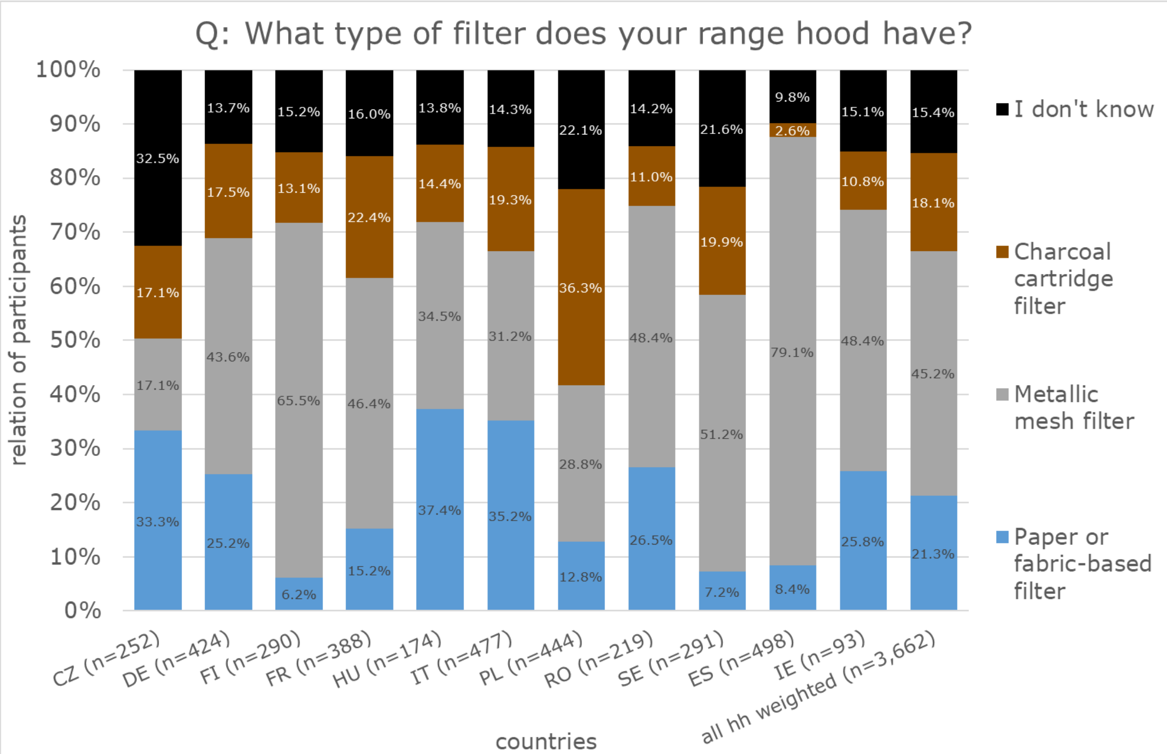


Figure 134 Type of filter of the cooking fume extractor

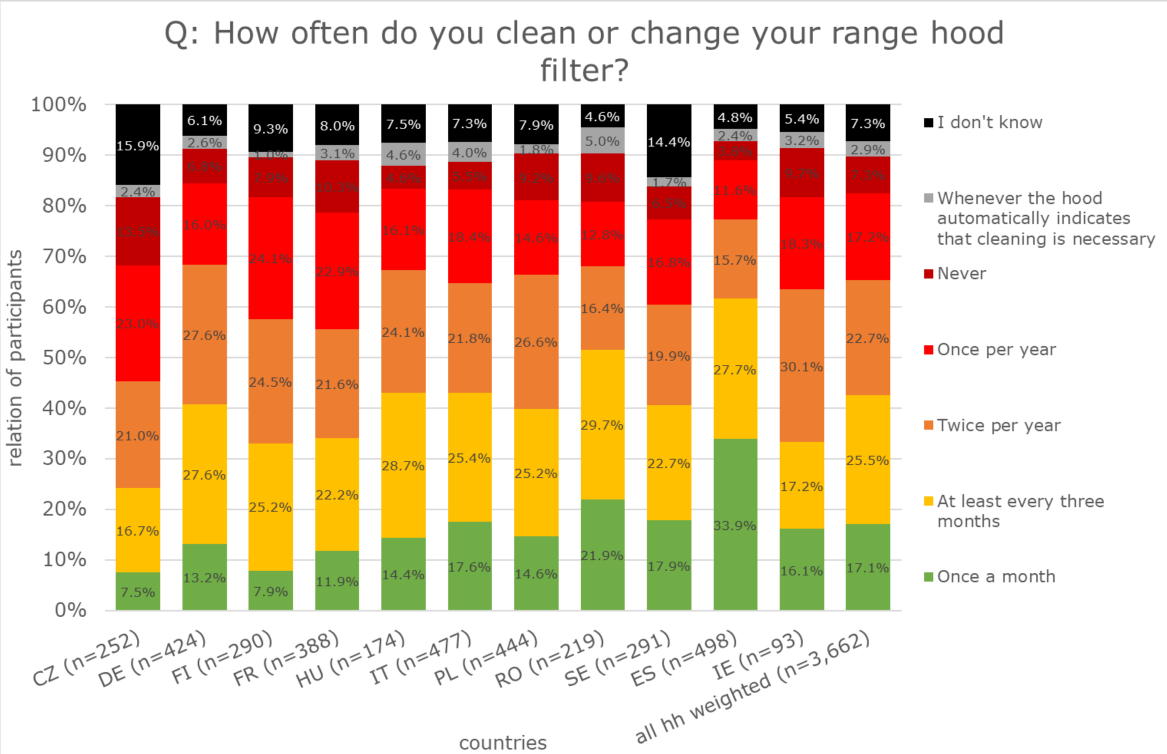


Figure 135 Frequency of changing the filter of a cooking fume extractor

3.8.7 Solo microwave ovens

Regarding microwave ovens, a predefined list of six applications was provided and the participants were asked about the frequency of use. Almost all participants use this appliance to warm up precooked food (Figure 136). Many participants use it to defrost and to warm up beverages. Only seven out of ten use it to cook fresh food and even fewer own and use the grill and hot air function at all.

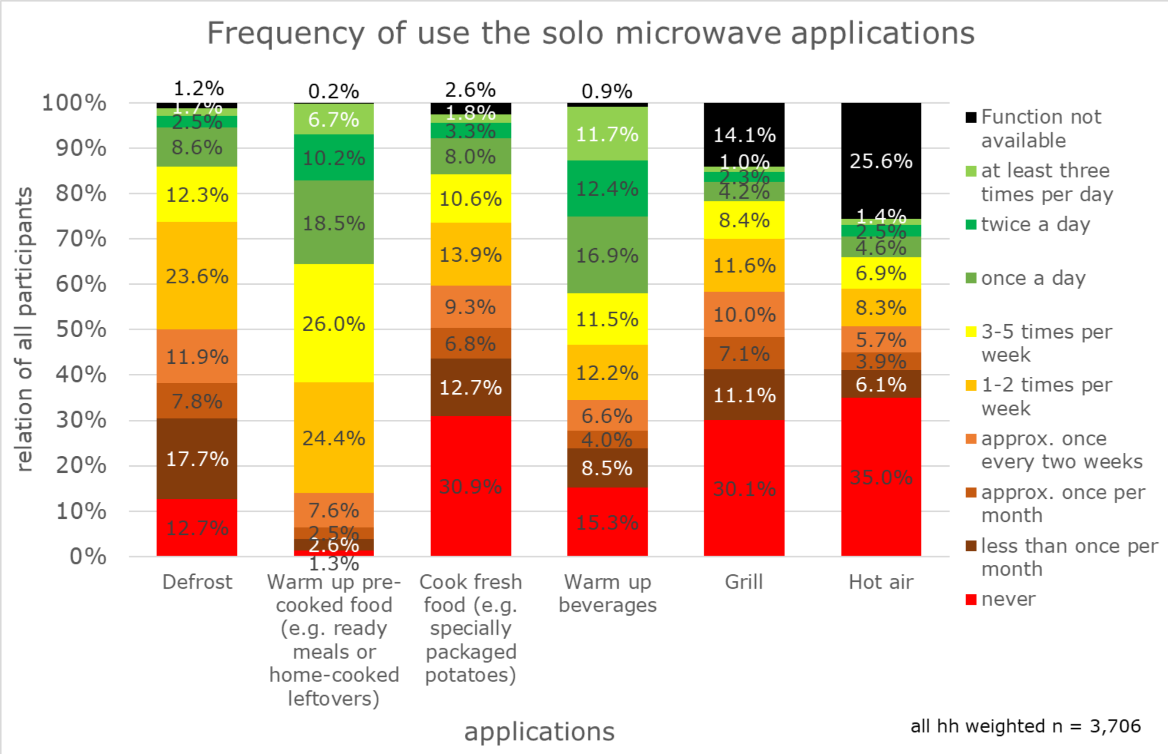


Figure 136 Frequency of using microwave applications for all participants

The nominal answers given by the participants were decoded into a numerical figure of how often the application was used per week to ease the interpretation. Owners of a solo microwave function generally use the 'warm up beverages' function 6.1 times per week and 'warm up precooked food' function 5.6 times per week when this function is available in their microwave oven. The other applications are used, when available, much less often. High variations can be observed when the European countries are compared regarding their use of a microwave oven, for example, the high use of the 'warm up precooked food' function in the Czech Republic and Finland, and the contrasting dominant use of the 'heat up beverages' function in Spain (Figure 138). The solo microwave – when available in the household – is generally used 18.9 times per week as a European average, with high variations between countries (Figure 139).

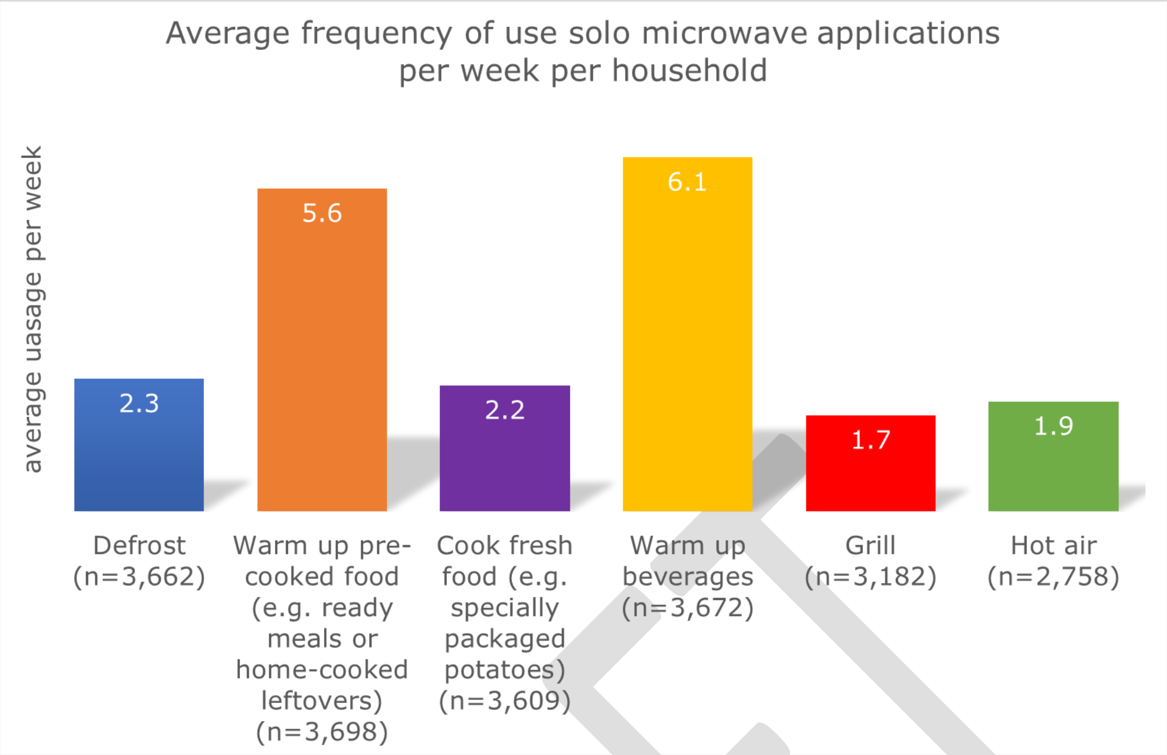


Figure 137 Average frequency of use of various microwave applications

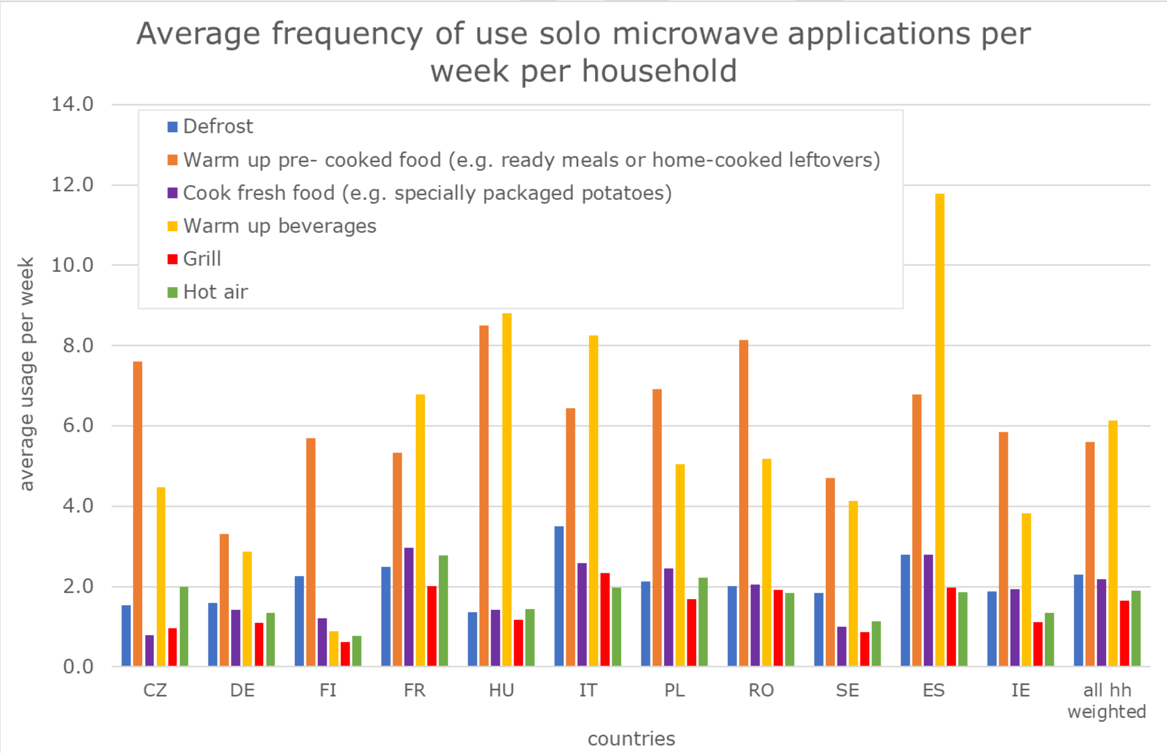


Figure 138 Average frequency of use of various microwave applications

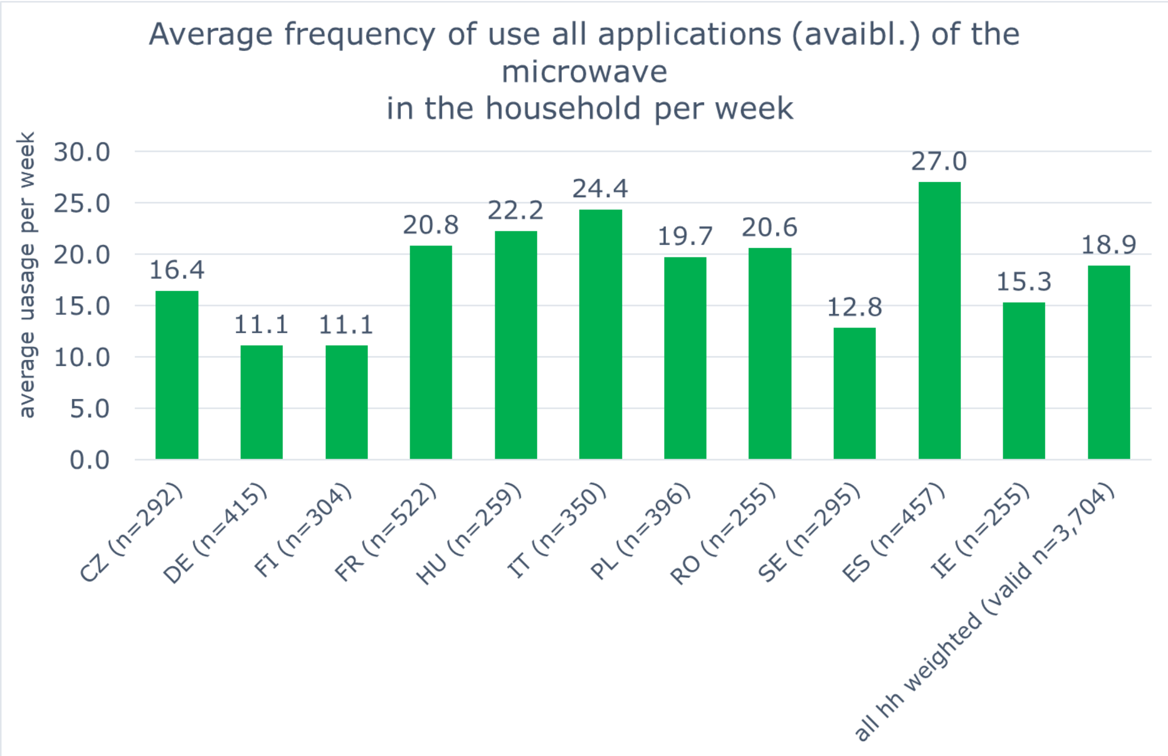


Figure 139 Average frequency of use of microwave ovens independent of the application

3.8.8 Pure steam oven

A pure steam oven is only available to 4.8% of European households (Figure 81). However, when available, it is used by about one-third of the participants at least once per day and another 40% use it at least once per week as a European average, with some variation between countries (Figure 140).

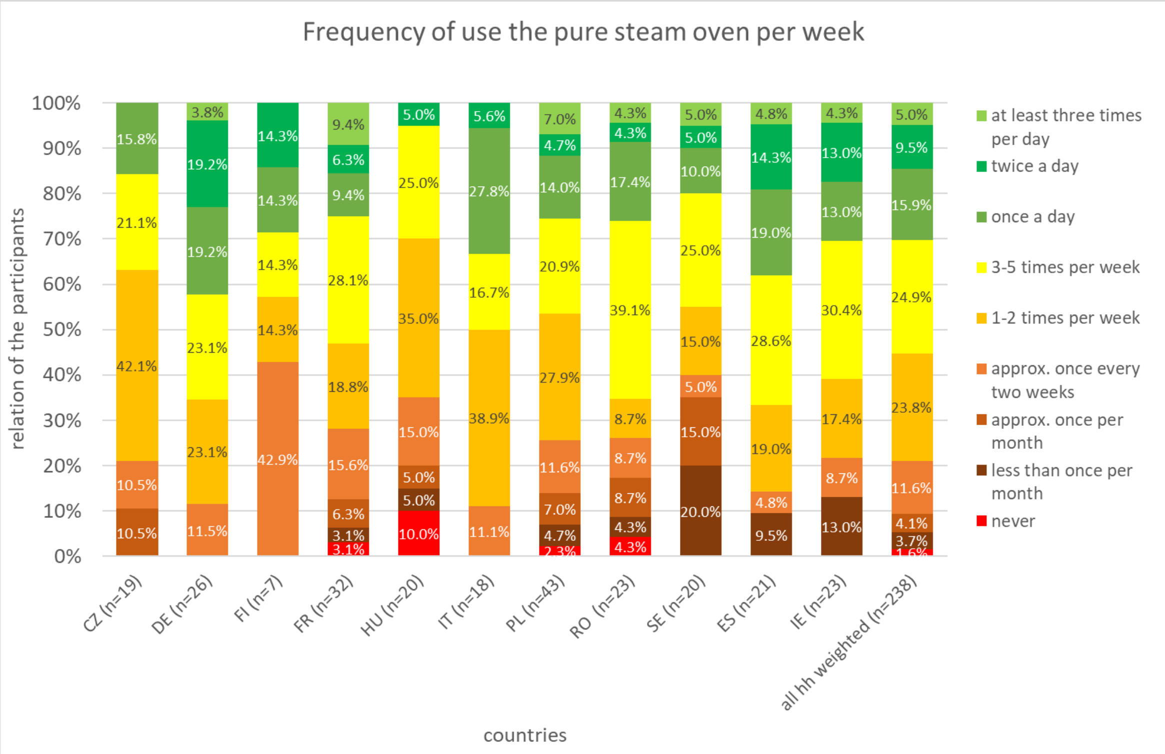


Figure 140 Frequency of using the pure steam oven

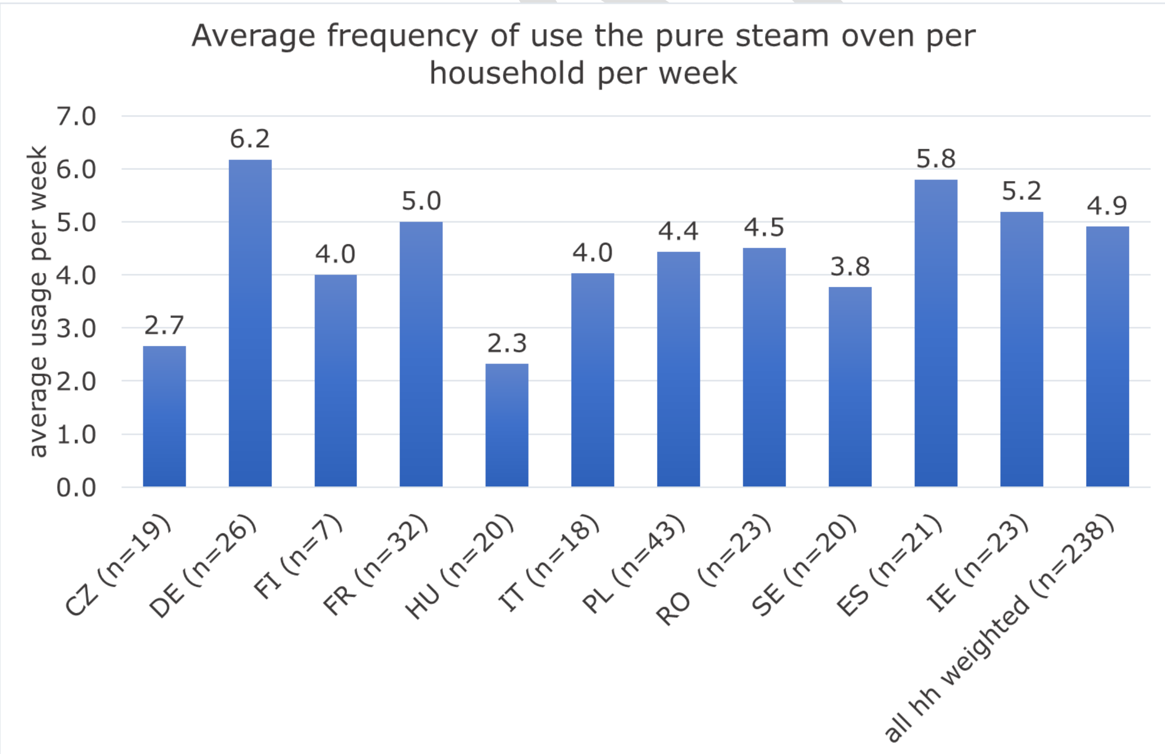


Figure 141 Average frequency of using the pure steam oven

Again, decoding the nominal answers to numeric frequencies of usage per week gives a European average of almost 5 (4.9) usages of the pure steam oven per week.

3.8.9 Energy Label Relevance

Respondents were asked for the six most important arguments when buying a new oven, hob and/or cooking fume extractor from a list of 16 randomly presented arguments. They were asked to rank them based on priority from 1 (first priority) to 6 (last priority) (Figure 142). The analysis of the priority position results in a median of 2 (Table 33) for the feature 'Energy efficiency and label class'. Features such as the 'Purchase price', 'Capacity', 'Energy source', 'Convenience of use' and 'Durability' have a median of 3. The other features reached a median of 4.

A ranking of importance can be shown by a calculation of points. The priority levels one to six were scored with points and these were summed up subsequently (Figure 143). After this allocation of points, the analysis shows that the most important feature seems to be a 'Purchase price', closely followed by an 'Energy efficiency and label class'. Five other criteria are listed with some gap in priorities: 'Convenience of use', 'Durability', 'Energy source', 'Ease of cleaning and maintenance' and 'Capacity'. Features such as 'Smart functionality/networked control' are among the least important features.

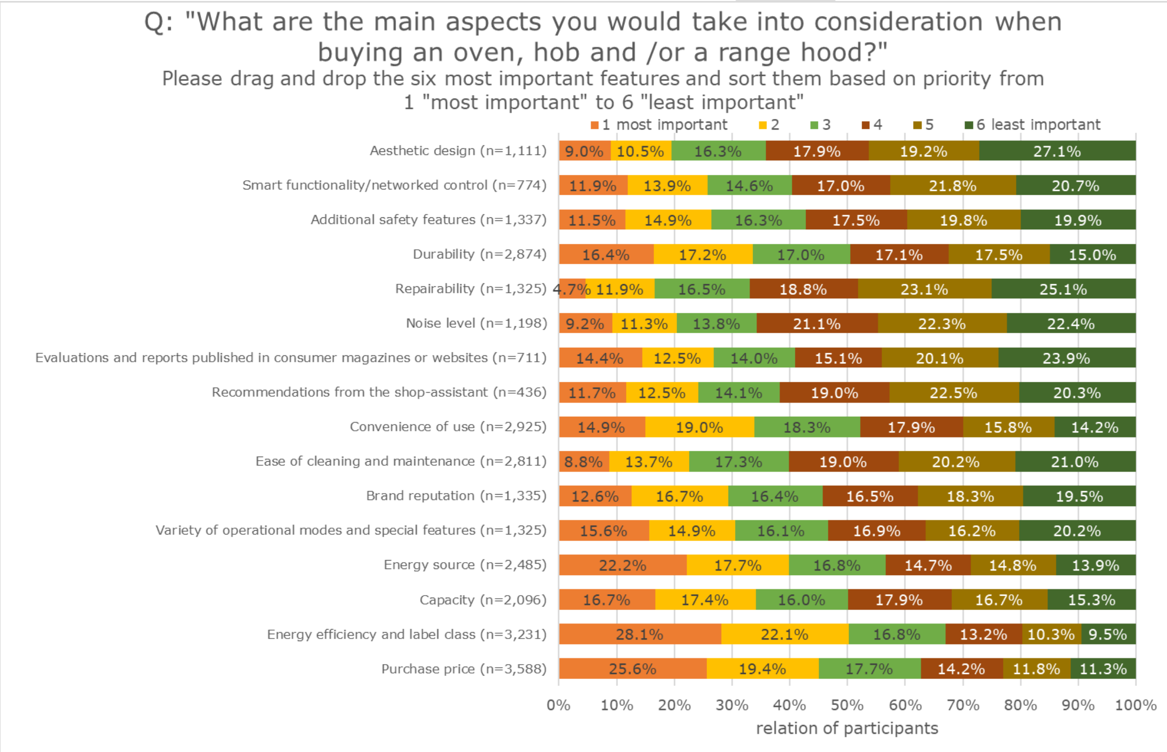


Figure 142 Main aspects considered when buying a new oven, hob and/or cooking fume extractor

Table 33 Ranking of most important aspects when buying a new oven, hob and/or cooking fume extractor

Q: "What are the main aspects you would take into consideration when buying an oven, hob and /or a cooking fume extractor?"	aver.	median	mode
Purchase price (n = 3,588)	3.0	3	1
Energy efficiency and label class (n = 3,231)	2.8	2	1
Capacity (n = 2,096)	3.5	3	4
Energy source (n = 2,485)	3.2	3	1
Variety of operational modes and special features (n = 1,325)	3.6	4	6
Brand reputation (n = 1,335)	3.7	4	6
Ease of cleaning and maintenance (n = 2,811)	3.9	4	6
Convenience of use (n = 2,925)	3.4	3	2

Recommendations from the shop-assistant (n = 436)	3.9	4	5
Evaluations and reports published in consumer magazines or websites (n = 711)	3.9	4	6
Noise level (n = 1,198)	4.0	4	6
Repairability (n = 1,325)	4.2	4	6
Durability (n = 2,874)	3.5	3	5
Additional safety features (n = 1,337)	3.8	4	6
Smart functionality/networked control (n = 774)	3.9	4	5
Aesthetic design (n = 1,111)	4.1	4	6

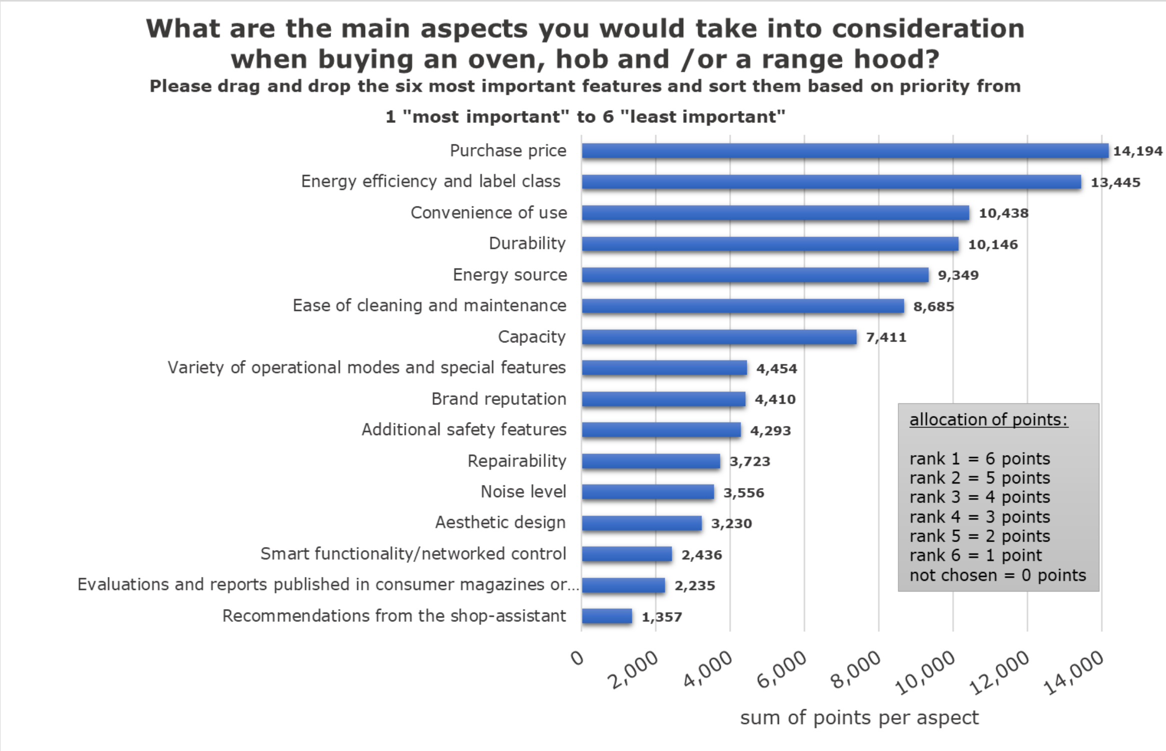


Figure 143 Main aspects considered when buying a new oven, hob and/or cooking fume extractor

Participants were asked about the importance of an hypothetical energy label for those appliances independent of whether an energy label for one of the cooking appliances in the focus of this investigation exists today. Overall, 80% of the participants rate it as very or extremely important for ovens and about 75% for hobs. A few less (almost 70%) consider it as very or extremely important for microwave ovens, more than 60% for cooking fume extractors and about 55% for pure steam ovens (Figure 144).

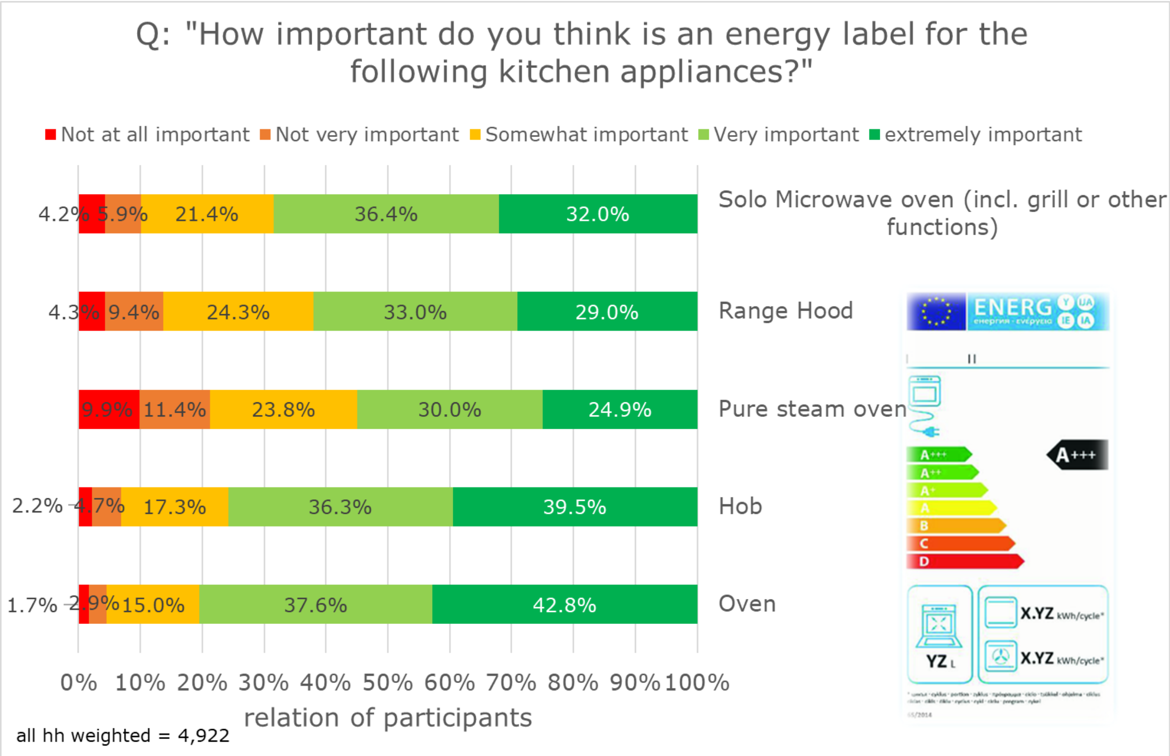


Figure 144 Importance of a hypothetical energy label for cooking appliances

Asking in detail which items of lists of pieces of information given for a potential future energy label for ovens, hobs and cooking fume extractors are important and asking the participants to sort those pieces of information into an order from most to least important reveals that the top priority for ovens is the energy efficiency class followed by the kind of energy source (Figure 146). Additional energy information (... for standard programme, annual energy consumption, cycle energy consumption given) follows, only broken by the information about the expected lifetime of the product. Repairability (ease of access to repair parts) and smart functionality/networked control are the least importantly rated. The picture for hobs looks fairly similar, except that the number of cooking zones/burners is rated as the third priority (Figure 148). The picture for cooking fume extractors is different, as here, just after the energy efficiency class, performance values such as noise emission, odour removal performance, grease filtering efficiency and fan power are rated as next important (Figure 149, Figure 150).

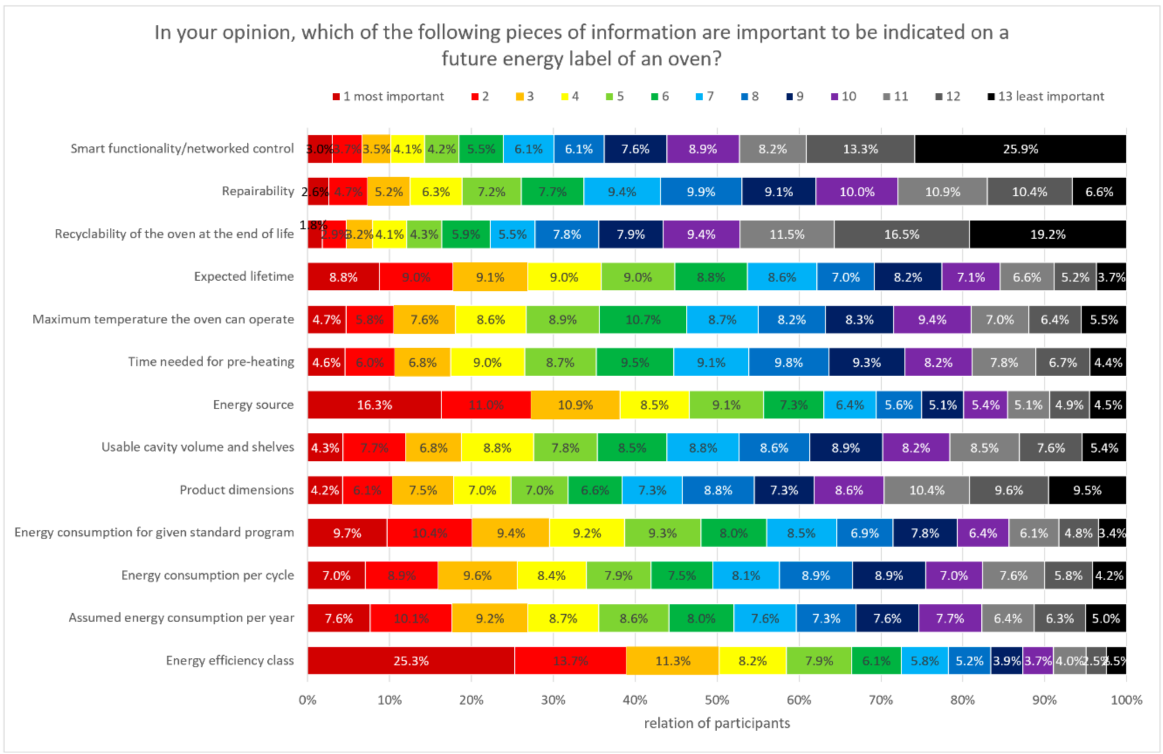


Figure 145 Importance of information indicated on a future energy label of an oven

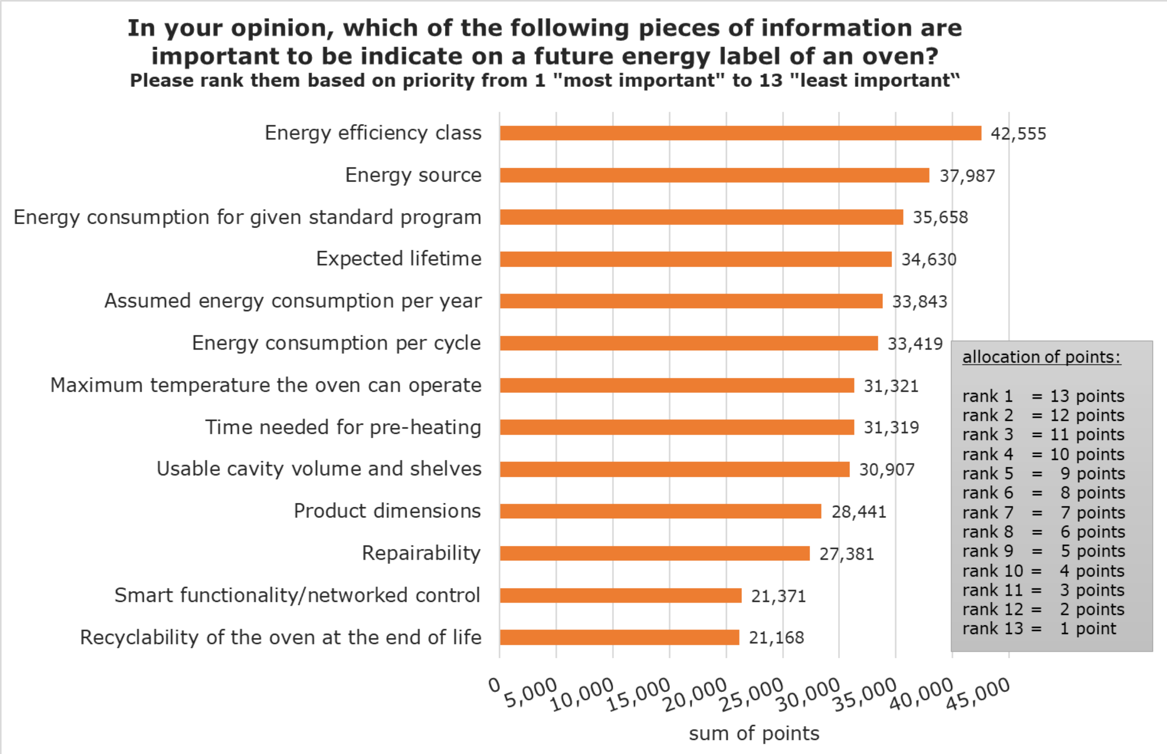


Figure 146 Importance of information indicated on a future energy label of an oven

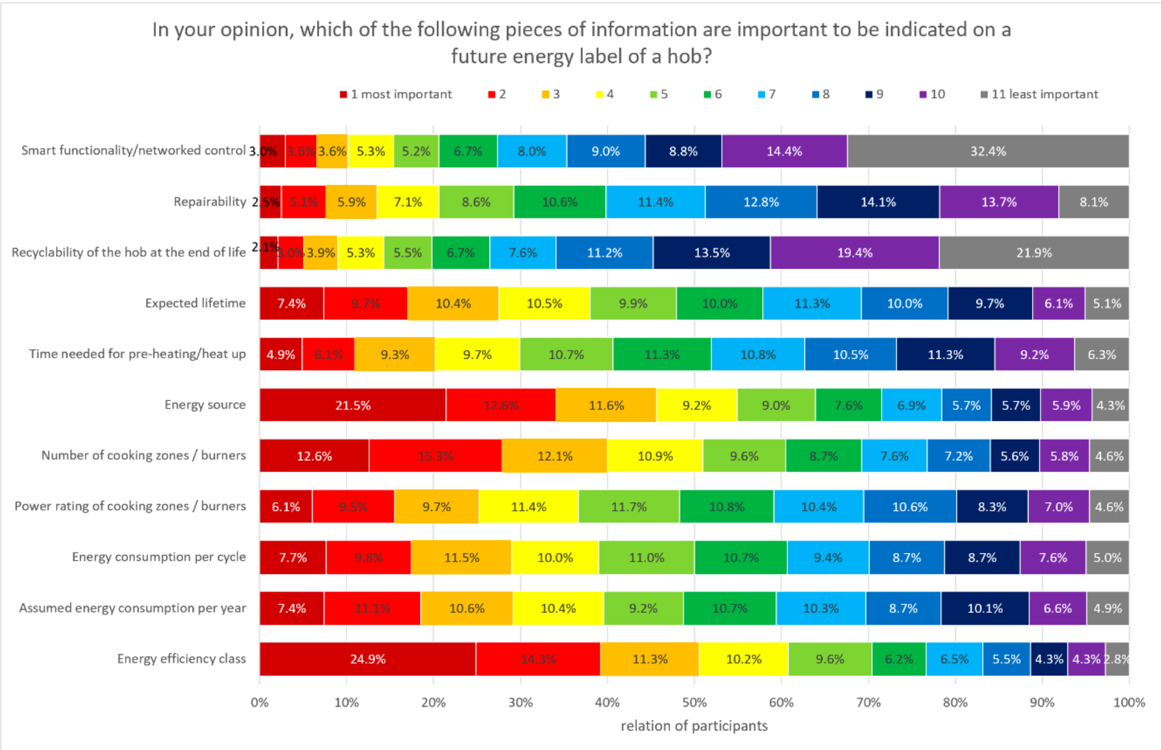


Figure 147 Importance of information indicated on a future energy label of a hob

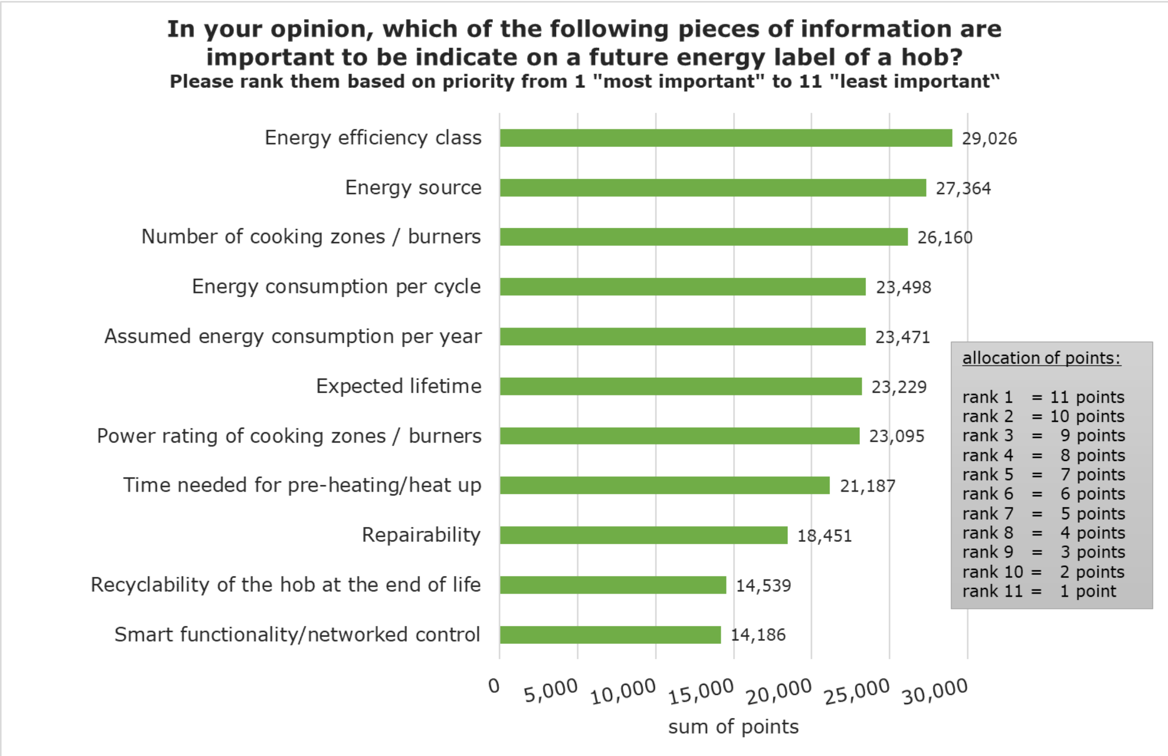


Figure 148 Importance of information indicated on a future energy label of a hob

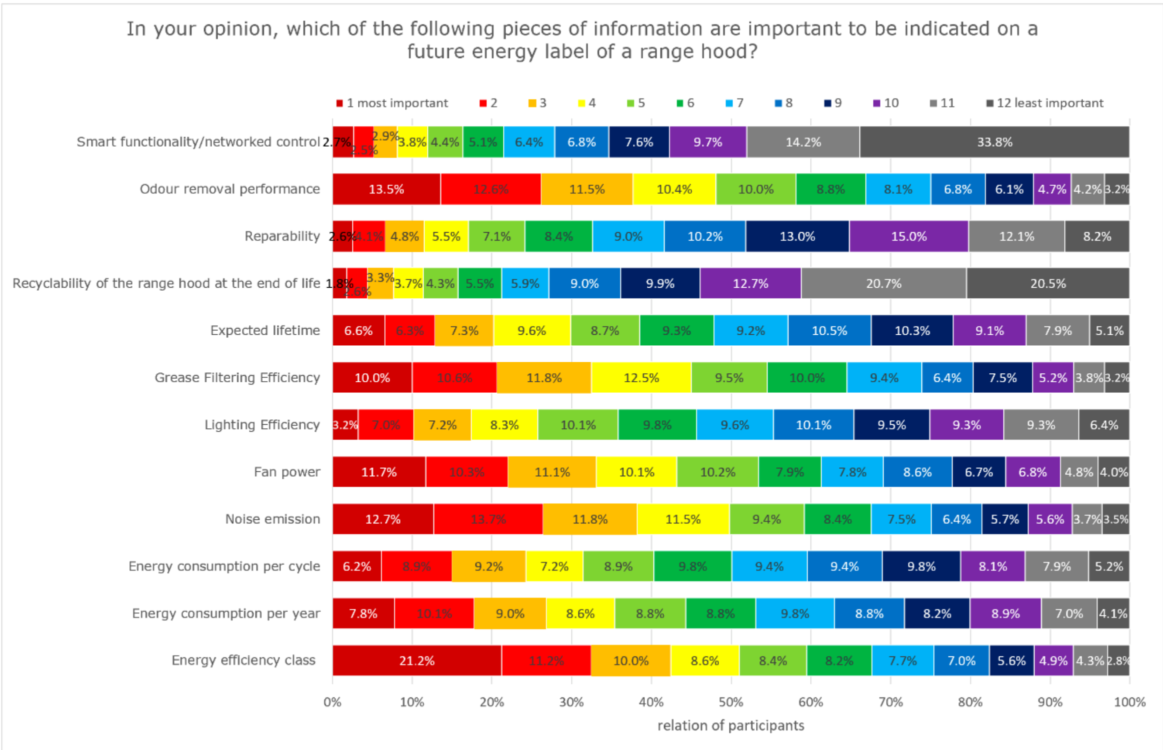


Figure 149 Importance of information indicated on a future energy label of a cooking fume extractor

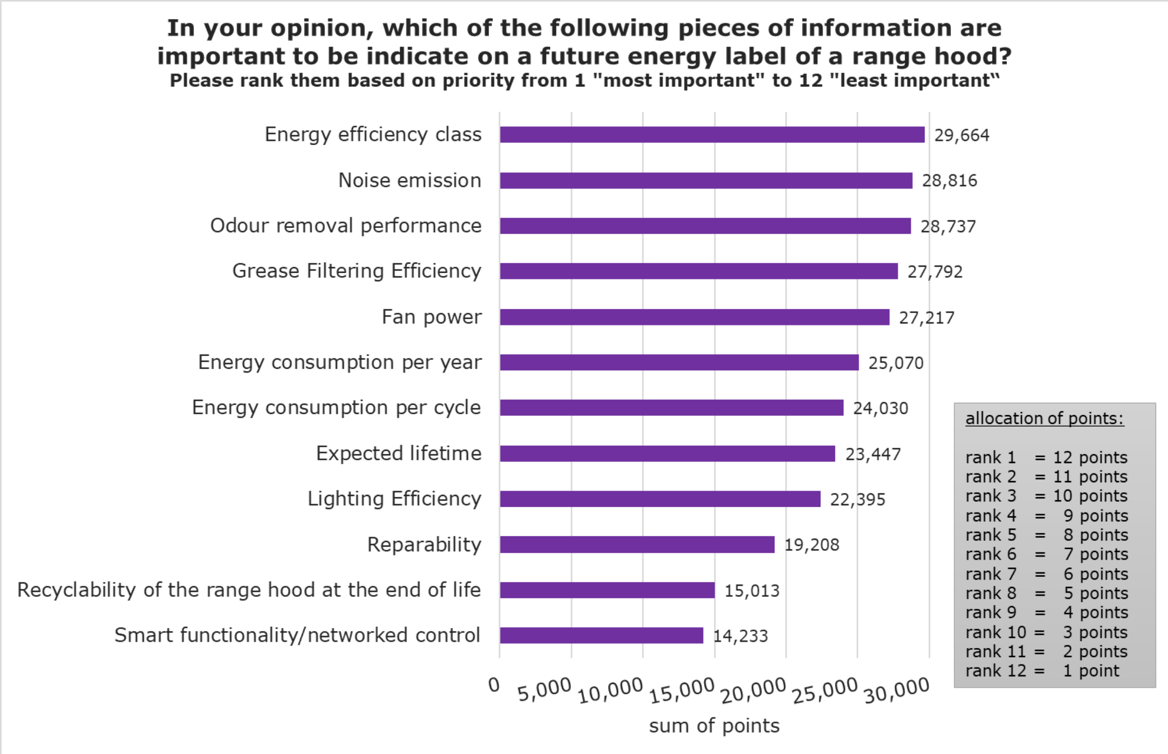


Figure 150 Importance of information indicated on a future energy label of a cooking fume extractor

3.8.10 Conclusions

- According to the results of the user behaviour study conducted, 87.5% of European households have a conventional oven; 75.3% have a microwave oven, 74.9% have a cooking fume extractor, 71.5% have a hob and 4.8% have a steam oven.

- The average frequency of use of domestic ovens is 3.5 times/week.

- According to the results of the user behaviour study conducted, considering all ovens combined, the most frequently used heating modes and features are, in decreasing order: top/bottom (conventional), fan-forced, timer for automatic start, rapid pre-heating, ecomode and grill. In contrast, the heating modes used for a longer time are, in decreasing order: top/bottom, ecomode, fan-forced, grill + convection and grill.

- The most frequently used cooking habits when using the oven are, in decreasing order: removing unused trays before cooking; not opening the door; letting frozen food approach ambient temperature before cooking and making use of residual heat.

- Regarding hobs, 63% of consumers use electricity to run their hob and 31% use gas. Only 6% use both kinds of energy source. Most electric and gas hobs have four cooking zones.

- The hob is used an average of 11.7 times per week. The overall average use is for 3.8 hours per week.

- The most frequently used cooking habits when using the hob are, in decreasing order: watching the pot to avoid over-boiling; maintaining cooking zones clean; using the lid when pre-heating and using the right size of pan for the amount of food.

- About 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor. About 14% of the respondents claim to use the cooking fume extractor also when not cooking. Using the cooking fume extractor light as a substitute for the kitchen light is the most important use of the cooking fume extractor when not cooking.

- The most frequently used cooking fume extractor fan speeds are, in decreasing order: intermediate, minimum, maximum and boost speed.

- Solo microwave ovens are used 18.9 times per week as a European average, with high variations between countries.

- A pure steam oven is only available to 4.8% of European households (Figure 81). However, when available, it is used by about one-third of the participants at least once per day and another 40% use it at least once per week as a European average, with some variation between countries. The frequencies of usage per week gives a European average of almost 5 (4.9) usages of the pure steam oven per week

- According to the responses from consumers, the most important pieces of information to include on a future energy label of an oven are, in decreasing order: energy efficiency class; energy source; energy consumption for given standard program; expected lifetime and assumed energy consumption per year.

- According to the responses from consumers, the most important pieces of information to include on an hypothetical energy label of a hob are, in decreasing order: energy efficiency class; energy source; number of cooking zones; energy consumption per cycle and assumed energy consumption per year.

- According to the responses from consumers, the most important pieces of information to include on a future energy label of a cooking fume extractor are, in decreasing order: energy efficiency class; energy source; noise emissions; odour removal performance, grease filtering efficiency and fan power.

4 Task 4: Analysis of technologies

Cooking is the transfer of heat into food items to make them more palatable and easier to digest. In order to cook food, heat must be transferred from a heat source to and through the food. When a substance gets hot, it means that the molecules have absorbed energy, which causes the molecules to vibrate rapidly. The molecules start to expand and bounce off one another. As the molecules move, they collide with nearby molecules, causing a transfer of heat energy. Heat can be transferred to food in different ways:

- **Conduction**. This is one of the most basic principles of cooking. It consists in the transfer of heat through direct contact. This is the type of heat transfer that happens when using a hob and a frying pan: the flame or the electrically heated surface of cooking zone from the hob touches the bottom of the pan, heat is conducted to the pan and finally transferred to the food.
- **Convection**. This is the transfer of heat through a fluid, which may be in a liquid or gas state. There are two types of convection: natural and mechanical.
    - **Natural convection** causes a natural circulation of heat because warm fluids (liquid or gas) have a tendency to rise while cooler fluids fall. This is the type of heat transfer that happens in a conventional oven.
    - **Mechanical convection** makes heat circulate more evenly and quickly through mechanical elements such as fans. This is the type of heat transfer that happens in a convection oven.
- **Radiation**. This is the transfer of heat by waves of heat or light striking the food. There are two types of radiation in the cooking context:
    - **Infrared radiation**, where an electric or ceramic element is heated to such a high temperature that gives off waves of radiant heat. This is the type of heat transfer that happens in toasters and broilers.
    - **Microwave radiation**, where food is cooked by exposing it to electromagnetic radiation in the microwave frequency range. This induces polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating.
- **Induction**, where food is cooked by means of a magnetic field generated by electric current flowing through a coil, heating the bottom of a ferromagnetic pot placed above a hob.

The act of cooking is conducted with the help of cooking appliances, mostly ovens and hobs for the actual heating of food, often using as well cooking fume extractors to collect and remove odours and volatile substances. Cooking appliances designs have evolved quickly over the past years. Starting from a traditional, purely-functional design and size, there is a current trend to offer ovens, hobs and cooking fume extractors that are a merge between a cooking appliance and a piece of furniture.

In this section of the report, the main technologies related to domestic ovens, hobs and cooking fume extractors are described with more detail. The intention is not to cover every single technological aspect related to these appliances, but only that ones that have the potential of influencing in some way the environmental impact across their life cycles. Each of the three appliance group will be covered in an individual sub-section. Within each of them, technical descriptions and basic product types will be provided. Moreover, a brief description of relevant technological aspects and potential best available technologies will be discussed.

4.1 Domestic ovens

4.1.1 Technical product description: domestic ovens

An oven is an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared (Regulation 65/2014). In a general way, the main components of domestic ovens are described below. An exploded view of a typical electric oven can be seen in Figure 151.

- Cavity, where the food is located for cooking.
- Chassis, the structure that supports the cavity and the rest of the oven assemblies
- Door, which enables access to the cavity
- Heating elements, which will differ depending on heat source
- Fans, used to distribute heat evenly in convection oven
- Cables/pipes, which transfer energy from heat source to electrical resistance or burner
- Thermostat, to keep control of the temperature
- Insulation, to restrict loss of heat

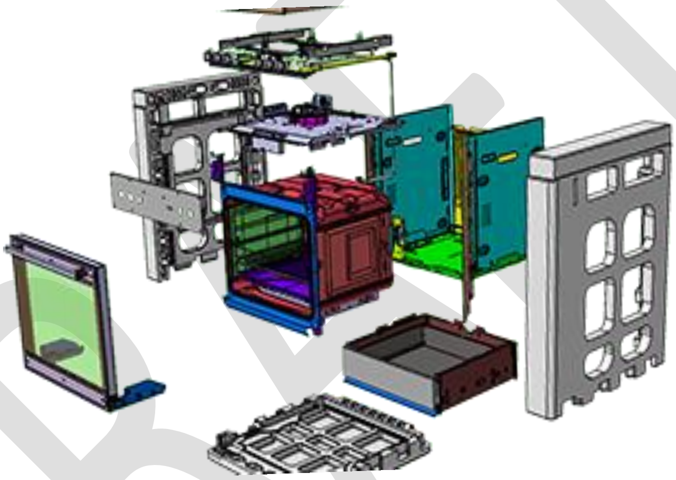


Figure 151. Exploded view of a domestic oven

4.1.2 Basic product types

Depending on the characteristics of the main components, domestic ovens can be classified in multiple ways. In Table 34, a classification is provided considering four different criteria: heat source, cooking mode, number of cavities and mounting.

Table 34. Types of ovens

Heat Source	Cooking mode	Number of cavities	Mounting
Gas	Conventional	Single	Free-standing
Electricity	Convection	Multiple	Built-in
	Steam		Portable
	Microwave		

Considering **heat source,** domestic ovens can be powered either by gas or electricity. In principle, the main components of a gas or an electric oven (cavity, chassis, door, fans) are the same. The differences between them are in the way the heat is generated and the fuel transported through the appliance. Gas ovens generate heat via gas-fuelled burners, and therefore will need special pipes to transport it, outlets for expulsion of fumes and gas-related control/safety systems. Electric ovens generate heat by using an electric resistance, so they will need cables to transport electricity. Generally, gas ovens tend to require a higher amount of assemblies and materials, and their energy consumption is higher under equivalent use conditions (Landi, 2019). Due to the nature of the sources of energy, gas ovens tend to offer only conventional heating modes, whereas electric ovens have a wider variety of cooking modes and features.

Considering **cooking modes**, domestic ovens can be classified as conventional, fan-forced, steam, or microwave. Other cooking modes offered in domestic ovens are grill and roasting. Some ovens offer a combination of these cooking modes. In conventional cooking mode, a stationary heat source radiates heat in the oven and therefore uses only natural convection for the circulation of heated air inside the cavity. In fan-forced cooking mode, a built-in fan circulates heated air inside the cabin, distributing it evenly throughout the cavity. Ovens with fan-forced mode can run at lower temperatures than conventional because heat movement increases inside the oven cavity. These ovens will need a motor to operate the fan, increasing slightly the complexity of the appliance. A steam oven operates by leading steam, which is produced by injecting water in a steam generator, into the cavity, or directly generating steam inside the cooking cavity by evaporating water by means of one or more heating elements.

A **microwave oven** is an oven that heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range, inducing polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating.

The cavity of the ovens is the enclosed compartment in which the temperature can be controlled for preparation of food. In terms of **number of cavities**, the most common configuration is single-cavity oven (Figure 152), although multiple-cavity ovens (those with two or more cavities) can also be found easily (Figure 153).

Figure 152. Single cavity oven (APPLIA)

Figure 153. Double cavity oven (APPLIA)

Considering **mounting** configuration, ovens can be classified as built-in or free-standing (

Figure 154). **Free-standing** ovens can be either installed separated from cabinets or by sliding them into an open space into the kitchen cabinetry. These appliances can also be known as **cookers**, since they include both an oven and a hob.

Built-in ovens are installed at a comfortable height in the wall, embedded between other kitchen cabinets or appliances and also right under a hob.

Finally, in Regulation 65/2014 ovens are also classified in terms of their portability: a portable oven is one with a product mass of less than 18 kilograms (although these are out of the scope in the mentioned regulation).

Free-standing (electric) **Free-standing (gas)** **Built-in** **Portable**

Figure 154. Types of ovens based on mounting (APPLIA)

According to stakeholders feedback, the most common ovens that could be considered base cases have the features shown in Table 35:

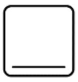
Table 35. Typical features of most common ovens

	Base Case 1 (BC1) Electric oven	**Base Case 2 (BC2) Gas cooker**
Energy Class	A	A
Energy source	Electric	Gas
Self-cleaning cycle	Pyrolytic	None
Capacity (litres)	70	65
Number of cavities	1	1
Mounting configuration	Built-in	Free standing
Opening system	Drop down	Drop down
Interior lighting	halogen/inca Special purpose	halogen/inca Special purpose
Smart features	n/a	n/a
Volume of product (m3)	0.6x0.6x0.55m = 0.198 m3	0.85x0.6x0.6m = 0.306 m3
Volume of packaged product (m3)	0.265 m3	0.396 m3
Packaging materials	EPS, carton board and foil and in some cases also wood	EPS, carton board and foil and in some cases also wood
Mass (kg)	40	45
Energy consumption Natural convection/Top Bottom	0.89 kWh/cycle	5.6 MJ/cycle
Energy consumption Convection/Fan-forced	0.79 kWh/cycle	n/a

4.1.3 Heating modes

Ovens usually offer a wide variety of **heating modes** or **settings** in which they can be operated. Some of these settings are common to the majority of ovens in the market today, whereas others are more specialized and can only be found on a few models. The names of these settings are usually marketing driven and may not necessarily be common around the industry –potentially causing confusion to consumers-. Although not universal, symbols used to represent each of those settings tend to be similar and recognisable. The most common oven settings, their symbols and a brief description can be seen in Table 36.

Table 36. Oven heating modes

Symbol	**Mode**	**Description**
	Conventional – bottom heating only	Heat will come solely from the heating element at the bottom of the oven. The fan won't be used to circulate the heat.
	Conventional – Top and bottom heating	Heat will be generated by elements in the top and bottom of the oven. Heat spreads through the oven by natural convection.
	Fan-forced heating	Heat comes from a circular element surrounding the fan at the back of the oven and the fan then circulates this heat around.
	Fan-forced with lower heating	Heat produced at the base and will be wafted around by the fan. In some occasions, heat can also be produced from the top (in that case, the symbol would include an additional horizontal line on top)
	Full grill	Heat is produced by the whole grill element.
	Part grill	Only one section of the grill element gets hot
	Grill and fan	Grill and fan are alternating. The fan spreads the grill's heat
	Defrost	Fan is on but no heat is produced, so no cooking takes place. The moving air defrosts food much more quickly than simply leaving it on the kitchen table
	Plate warming	Plate-warming function. This gently warms plates or other dishes to prevent food from cooling too quickly when served.
	Pyrolytic cleaning	This program heats up the oven to around 500°C, which has the effect of incinerating burnt-on cooking grime
	Eco	This is generally understood as the most energy-efficient mode of the oven. They are also commonly known as energy saving modes and generally use residual heat. In some occasions, it is a function

		for cooking small quantities of food, activating only a limited amount of the heating elements.
	Pizza	This is a heating mode of the oven specifically designed to cook pizza
	Microwave	A heating mode where microwaves are used in the cooking cycle in order to speed-up the process and save energy
	Steam-assisted	A heating mode where steam is added to the cooking cycle in order to add specific characteristics to the food related to steam-cooking
	Automatic functions	Some appliances have pre-programmed setting values that the consumer can use, in order to use the most appropriate temperature and time, according to the type of food being cooked.

4.1.4 Technology areas of domestic ovens

4.1.4.1 Technology area 1: Electricity versus gas as heat sources for ovens

Domestic ovens can be powered either by electricity or by gas. The main elements of electric and gas ovens will be similar or equal, the only differences being in the heating system. Different energy consumptions and environmental impacts are observed as well when comparing equivalent performance electric and gas ovens. A brief summary of these aspects is presented in this section.

In an electric oven, electric current is passed through a wire within the heating element and encounters electrical resistance that heats the wire and surround bulk of the element (Figure 155).

Figure 155. Heating elements in electric oven (APPLIA)

Heating elements for electric domestic ovens typically use Nichrome wire (80% nickel, 20% chromium), ribbon or strip, a material with relatively high resistance which forms an adherent layer of chromium oxide when it is heated for the first time. The wire is generally wound into a coil that is surrounded by densely packed magnesium oxide powder and then encased in a protective sheath. This material provides excellent thermal conductivity and dielectric strength. Ceramic or mica insulators ensure the electrical insulation of the terminal stud from the sheath. Due to the nature of the energy source and the possibilities it allows in terms of modulating temperature, a wide variety of heating modes are usually available in an electric oven (see Table 36).

In contrast, the heating element in a gas oven is a gas burner located at the rear of the oven base, which burns a stream of gas in air, generating stable and controllable arrays of small flames, modulating the desired cavity temperatures (Figure 156). Additionally in some cases, a grill burner is located at the top of the cavity (Figure 157)

Figure 156. Gas burner (APPLIA)

Figure 157. Grill burner (APPLIA)

Gas ovens can work with different kind of gases:

- Manufactured gases (also known as town gas) of variable composition (hydrogen, nitrogen, methane), with nominal pressure of 8 mbars.
- Natural gas (mainly methane) with nominal pressures of 20-25 mbars.
- Liquefied petroleum gas (mainly propane or butane), with nominal pressures of 28-30, 37-50 mbars.

In gas ovens, the gas burner is located outside the food compartment and hot air is allowed to enter via ports to produce a more even spread of heat temperature throughout the oven, often with additional fans for improved efficiency. Due to the relatively slow circulatory motion, temperature zones develop within gas oven cavities, the hottest regions being at the top. The volume of gas entering the burner is managed through a thermostatic gas valve (Figure 158). Hot gases are eventually discharged from the rear of the oven by means of a flue. Ventilation of gas ovens is more important than electric ones, since toxic gases such as carbon monoxide (CO) may be produced.

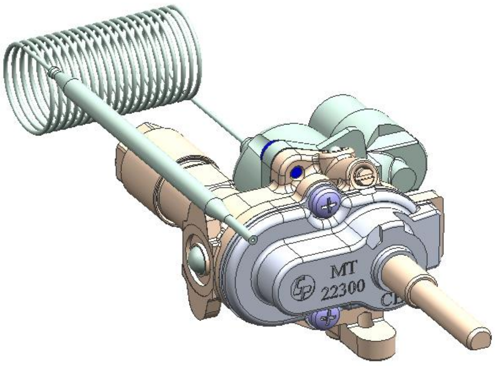


Figure 158. Thermostatic gas valve (APPLIA)

In a gas oven, a few cooking modes are normally available, since typically they have a burner at the bottom and a grill burner at the top. The burner at the bottom is mostly used for baking or preparing pizza, while the grill can be used for roasting or grilling meat and fish. Their settings are therefore much simpler than those of an electric oven, consisting mainly in a temperature setting and a grill settings (if available). Gas ovens do not offer automatic cleaning functions such as pyrolytic systems either.

Although in current regulation energy consumption of electric and gas ovens is measured differently (in kWh and MJ, respectively), recent research has been conducted to make a direct comparison of electric and gas ovens in kWh over lifetime of the appliance. This research indicates that lifetime energy consumption tends to be higher in gas ovens, both in intensive and non-intensive uses (Figure 159).

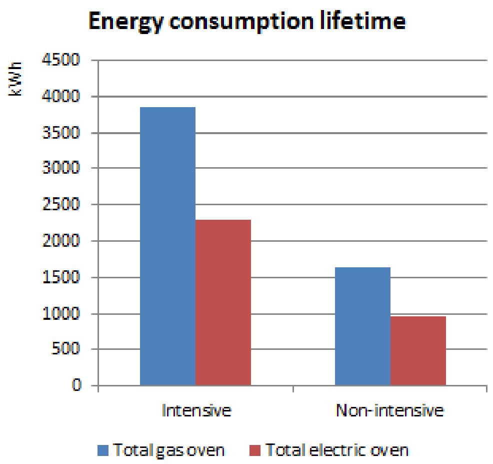


Figure 159. Energy consumption in gas and electric ovens over lifetime (Landi, 2019)

However, it must be taken into account that electricity and gas are energy sources of different nature. Gas is a raw material, whereas electricity is an energy carrier obtained from other sources. Therefore, the comparison between gas and electric appliances in terms of energy efficiency must be made with caution.

As already seen in Task 1, current ecodesign and energy labelling regulation allows the comparison of electric ovens between them and gas ovens between them, but direct comparison between electric-gas appliances are not possible, since the formulas to calculate EEI are different. To overcome this, some stakeholders support a comprehensive and comparable labelling for all appliances based on primary energy, therefore not differentiating between gas and electricity. Since the objective of this regulation is to reduce overall energy consumption, all technology options and decisions need to be assessed by a comparable parameter: primary energy. According to them, when gas and electricity are compared, a 2.1 conversion factor should be used to convert electricity to primary energy, allowing the comparison between electric and gas appliances.

4.1.4.2 Technology area 2: Cavity materials

In domestic ovens, the cavity and casing are generally made of pressed mild steel, a material that fulfils the requirements of functional strength and ease of manufacture, being suitable for bending and piercing, offering a durable surface with scratch and corrosion resistance. The selection and use of these materials have a high influence on the energy consumption of the oven. In fact, the energy fraction actually absorbed by the food during cooking is low because a large portion of energy goes into the structure (walls, door, insulation), and is lost in the surrounding environment. High emissivity linings absorb the thermal radiation energy from the cavity which then is lost through conductive bridges and convective leaks. In addition to that, a lot of energy is lost through the venting of the evaporated moisture form the cavity (Burlon, 2015).

The mass of materials inside the oven cavity –casing, racks, internal parts- is proportional to the energy consumed when bringing the oven up to its operating temperature. Therefore, in order to reduce energy consumption, manufacturers are continuously working in reducing the mass of metal used in the cavity and casing. In Burlon (2015), it is reported that reducing the mass of the oven structure has energy savings potential between 10-18%. Modern ovens use steel sheet of about 1 mm thickness.

Enamel-coated steels are commonly utilised in the oven cavity. Conventional porcelain enamels for low carbon steel substrates are generally based on alkali borosilicate glasses which are fired at 750-850C on a continuous fast belt furnace. Most abundant materials in a standard enamel are Al_2O_3 (37%), S (16%), Fe_2O_3 (13%). A complete breakdown of enamel materials is presented in Palmisano et al (2011).

Regarding oven interior walls, there has been debate over the years around emissivity and energy consumption. Certain studies point out that low emissivity ovens use around 35% less energy than standard ovens (Shaughnessy, 2000), whereas others indicate that wall emissivity should be high, as dark surfaces adsorb energy but are also efficient energy radiators. The project named Highly Efficient Oven (Santacatterina et al, 2016) is a demonstrative project involving four European partners, co-financed by LIFE Environmental Programe. Its main objective is to showcase a mix of environmentally friendly technologies for manufacturing domestic electric ovens when compared with current state of the art ovens, in order to:

- Use less energy in the production process
- Avoid the use of toxic substances
- Improve efficiency during use

To achieve that, specific aspects of the electric oven that were investigated are:

- Substitution of the steel enamel cavity with a stainless steel cavity with increased reflectivity
- Use of a new sol-gel coating applied to avoid deterioration of oven's metal cavities
- Upgrade of the oven heating system to increase the amount of energy transferred directly to food

The rationale of this project is based on the fact that traditional ovens use convection as the main vector of heat transfer to food. Radiation does not provide a significant contribution to this transfer, since the cavity is usually made of a dark enamelled material. In this project, it was identified that using a reflecting cavity wall (Figure 160) was a good solution to increase radiation heat transfer mechanism, allowing to reduce energy consumption during use.

Figure 160. Dark enamelled cavity vs Reflective stainless steel cavity

As part of the experiment, different ferritic stainless steels were compared to identify the best substrate for the oven cavity based on the worst case working conditions (highest temperature). Several transparent coatings (instead of dark enamel) were evaluated: a sol-gel coating was selected, since it was the only transparent coating which was able to withstand temperatures without degrading and due to its extremely high chemical resistance. The selection of this material for the cavity allowed reducing energy use during cavity manufacture by 50% (when compared to typical dark enamel oven). Moreover, a set of tests on prototypes were carried out to evaluate performance. When following the 'brick test method', there was an energy efficiency improvement of 30% in comparison to a conventional oven (black enamelled cavity).

Related to this project is also the work from Isik (2017), where a novel combination of surface properties was developed, based on “hybrid emissivity” materials (essentially, the top and bottom walls of the cavity were dyed with a black paint). They obtained energy savings of 4%.

However, it must be noted that the use of stainless steel in oven cavities comes with certain disadvantages, mainly related to the cleaning process. Feedback from industry points out that they generally do not admit pyrolytic process, since high temperatures degrade stainless steel surfaces. Also, the emissivity of heat from the bottom part of the cavity is worse when using stainless steel. For these reasons, most modern ovens use dark high emissivity surfaces. Highly reflective surfaces are normally used for solo and combi microwave ovens and for steam ovens, to avoid corrosion issues.

Also regarding materials used in the cavity, one stakeholder highlights the potential issues with the use of refractory ceramic fibres in domestic cooking appliances. According to them, ideally the use of these fibres should be prohibited. If not completely prohibited, at least they should be marked clearly (marking minimum 5 cm big, in clear colour).

4.1.4.3 Technology area 3: Cavity volume

In terms of cavity volume (generally measured in litres), a wide variety is available in the market today (Figure 161).

Figure 161. Different cavity volumes in the market

Cavity volume has a relevant role in energy consumption declaration of ovens. In principle, the bigger the cavity volume, the larger will be the mass of the oven and therefore the higher will be the energy consumption of the oven. To avoid that only small cavity ovens aspire to high energy classes, in current regulation this is taken into account in the Energy Efficiency Index (EEI) formulas:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}} \times 100$$

$$SEC_{electric\ cavity} = 0{,}0042 \times V + 0{,}55 \text{ (in kWh)}$$

Based on those formulas, Figure 162 shows the thresholds of the different energy, based on the energy consumption of the test cycle (EC, vertical axes) and on the cavity volume (horizontal axes).

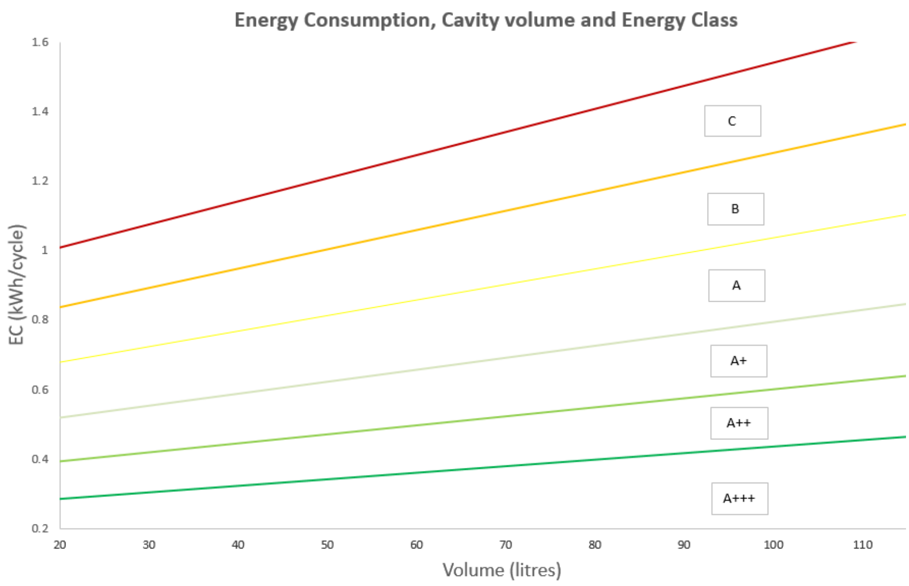


Figure 162. Energy consumption, cavity volume and energy class

For larger cavity volumes, higher energy consumption values are allowed to heat the standard load. However, as already seen in Task 2, a market trend has been observed towards larger cavity ovens in the past few years. If a consumer compares a 45 litre "A" oven with a 71 litre "A+" oven, they might perceive that the latter has lower energy consumption (as it holds a better energy class). Based on this, it appears reasonable to question whether current formulas to calculate EEI are somehow driving consumers to buy larger ovens than they actually need. It might be worth exploring a slightly different way to calculate EEI, in order to make a less linear correlation between energy efficiency and cavity volume. Several consumer organisations support this approach since there could be a potential reduction in total energy consumption by promoting the purchase of "the right-size" of ovens.

In response to this, organization of manufacturers indicate that consumers will buy only products that can fit the largest dish they want to prepare, even if it is only a few times over the year. Consumers only buy products which are adapted to their expectations, therefore they are not over-dimensioned. The right size of an oven depends on the need of the consumer and to installation, therefore furniture manufacturers also play a role.

Another aspect related to cavity volume (already addressed in Section 1.2.1.2) is related to the fact that, **due to the way that the EN-60350 is written, manufacturers have an incentive to declare the biggest possible volume cavity when testing an oven** ("*Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out*"). According to different stakeholders, this sentence should be revised as it may lead to higher declared volumes and thus better EEI compared to real life usage. Other organisations disagree with this position indicating that there are very few removable items inside the cavity oven, therefore this is not an important issue.

Domestic oven cavities are rectangular to facilitate usability. Regarding cavity shape, it is worth mentioning the patent by Nuñez (2009), an oven with a cylindrical cavity. According to the authors of this patent, a cylindrical cavity facilitates the movement of hot air. This allows to reach all the points inside the oven, helping the heat accumulated on the walls to be reflected by radiation in a uniform manner. In the experimental tests they observed that energy consumption efficiency is 29% compared to ovens with a square section. The main disadvantage regarding a cylindrical cavity is related to usability. The authors of the patent indicate that a circular oven's useful volume is 10% less than the standard shape. However, due to the cylindrical shape, only one tray could be used at a time.

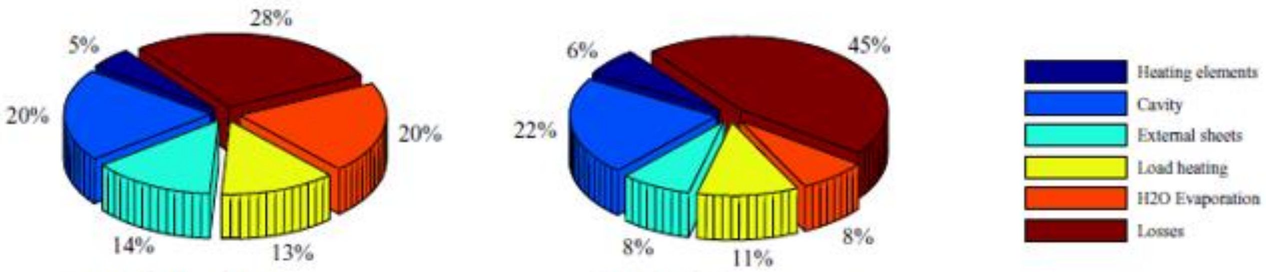
4.1.4.4 Technology area 4: Conventional, fan-forced and energy saving modes

As stated earlier, in a domestic oven, the food is cooked by transferring heat by means of radiation, convection or conduction. A typical measure of performance for a domestic oven is the heat transfer coefficient, which gives an indication of the heat flux between the appliance and the product being cooked. An oven has heat transfer coefficients referred to radiation (Hr) and to convection (Hc). Some authors also use the combined heat transfer coefficient, which takes into account both radiation and convection (Sakin, 2009).

In conventional cooking mode, food is only cooked by radiation and natural convection, meaning that the convection is not forced by any external element. In these ovens, heat transfer between the appliance and the food happens typically 70% by radiation and 30% by convection.

In fan-forced cooking mode, heat transfer is artificially forced by the use of a fan. The use of this fan helps to distribute the hot air evenly throughout the oven, reaching food which is located anywhere inside the cavity, achieving even temperatures and evaporation rates. Operating under a forced-air convection mode, values of convection heat transfer coefficient (Hc) roughly double. This allows to reduce cooking times and to operate at slightly lower temperatures since the heating element does not need to be as hot to heat up the cavity. In contrast to conventional ovens, in convection ovens, the ratio of heat transfer due to convection can be of up to 60% (Cernela, 2014). However, it must be kept in mind that increasing the level of convective heat transfer leads to an increase of product drying rate (evaporation rate is higher in the convective process), resulting in product surface desiccation and overheating. The appropriate balance between convection and radiation heat transfer needs to be achieved, depending on the dish being cooked.

In Ramirez-Laboreo et al (2016), an analysis is conducted on how much energy is transferred to a standard load and lost in different cooking modes on a domestic oven, comparing heat transfer in convective and radiative processes (Figure 163). As it can be seen, more energy has been transferred to the load (the food) in a convective process than in a purely radiative process (13% to 11%).



(a) Convective process. (b) Radiative process.

Figure 163. Distribution of energy supplied by the oven in convective and radiative cooking (Ramirez-Laboreo et al, 2016)

Energy losses in the radiative process tend to be higher, mainly because fan operation during convective cooking causes the heat generated in the ring heating element to flow into the cavity, losing less energy through the rear side. However, although energy losses are higher in a purely radiative process, this does not mean convection should be the only cooking function to use, as this will depend on the type of food to be cooked. In bread baking, for instance, an even heat distribution and considerable water evaporation is needed, therefore a convective process is more appropriate. However, for meat or fish roasting, water evaporation has to be minimal to keep food juicy and succulent, therefore a radiative process is the most appropriate option (Ramirez-Laboreo et al, 2016).

In a typical oven with fan-forced cooking mode, a centrifugal fan is mounted on the back wall. The fan shrouding tends to be minimal and it can expel air on all points around its circumference. An appropriate design of the fan and its surrounding elements has a significant effect on temperature distribution and energy consumption of the oven. The fan is generally separated from the oven cavity by a baffling plate, which allows circulation of air circulates through holes, which may have a variety of geometries.

Energy saving modes

A particular variant of fan-forced modes are energy saving modes. Although there is no specific definition in current legislation or in the standards, they are generally known within the industry as “eco-modes” and are an energy saving alternative to the convection modes. These energy savings can be achieved in different ways, generally by using residual heat.

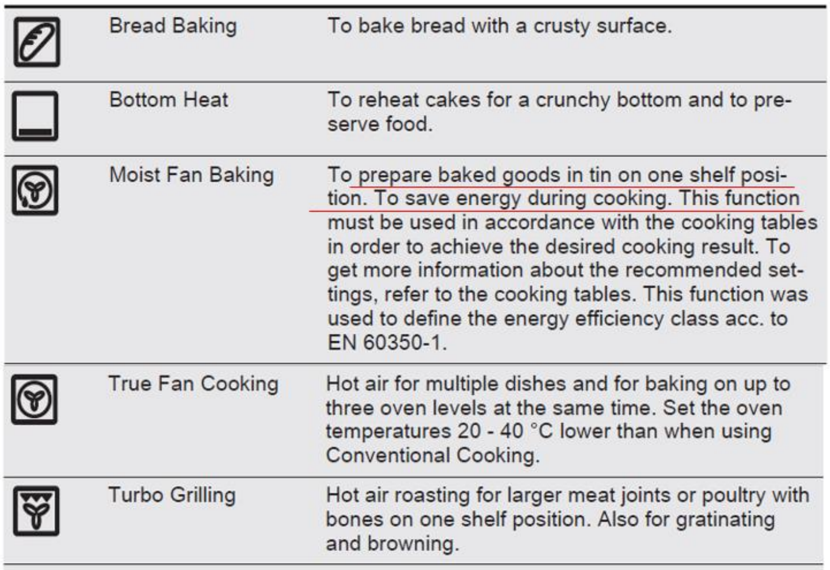
This lack of definition for energy saving modes is an aspect to improve from current regulation and standards. It is not possible to evaluate the appropriateness of using these heating modes for energy declaration is there is no agreed defintions for such modes. To tackle this issue, in recent publications from WG17 in CENELEC, an attempt to provide a definition for energy saving modes has been made. The proposal is to define “eco functions” in the new standard method (Brickmethod 2.0) as:

Heat transmission by natural air circulation and/or forced air circulation and/or radiation for certain applications using efficient technical solutions. Examples of these technical solutions are residual heat usage, low power heating or a combination of both.

According to feedback from manufacturers, current ovens are close to optimal condition in terms of energy efficiency. There is not much room for improvement. In fact, the biggest opportunity for improvement in terms of energy efficiency is related to the development of energy saving modes. They are currently seen as an incentive for innovation. Manufacturers are nowadays free to choose the heating mode to use for energy declaration and to determine the energy class. Most of manufacturers are already using these modes for energy declaration as can be seen in examples of Figure 164 and Figure 165.

Types of heating		Temperature	Use
	4D hot air	30-275 °C	For baking and roasting on one or more levels. The fan distributes the heat from the ring heating element in the back panel evenly around the cooking compartment.
	Top/bottom heating	30-300 °C	For traditional baking and roasting on one level. Especially suitable for cakes with moist toppings. Heat is emitted evenly from above and below.
	Hot air eco	30-275 °C	For gently cooking selected types of food on one level without preheating. The fan distributes the heat from the ring-shaped heating element in the back panel around the cooking compartment. This heating function is most effective between 125 and 275 °C. This heating function is used to measure both the energy consumption in air recircula-tion mode and the energy efficiency class.
	Top/bottom heating eco	30-300 °C	For gently cooking selected types of food on one level. Heat is emitted from above and below. This heating function is most effective between 150 and 250 °C. This heating function is used to measure the energy consumption in the conventional mode.
	Hot air grilling	30-300 °C	For roasting poultry, whole fish and larger pieces of meat. The grill heating element and the fan switch on and off alternately. The fan circulates the hot air around the food.

Figure 164. Example of oven manual with eco-mode (provided by ECOS)



	Bread Baking	To bake bread with a crusty surface.
	Bottom Heat	To reheat cakes for a crunchy bottom and to preserve food.
	Moist Fan Baking	To prepare baked goods in tin on one shelf position. To save energy during cooking. This function must be used in accordance with the cooking tables in order to achieve the desired cooking result. To get more information about the recommended settings, refer to the cooking tables. This function was used to define the energy efficiency class acc. to EN 60350-1.
	True Fan Cooking	Hot air for multiple dishes and for baking on up to three oven levels at the same time. Set the oven temperatures 20 - 40 °C lower than when using Conventional Cooking.
	Turbo Grilling	Hot air roasting for larger meat joints or poultry with bones on one shelf position. Also for gratinating and browning.

Figure 165. Example of oven manual with eco-mode (provided by ECOS)

Energy saving modes allow to reduce energy consumption of ovens, but they have two fundamental issues, as highlighted by some stakeholders. First, energy saving modes can produce unsatisfactory cooking results in the form of undoneness or burning. Second, they are not the most frequently used heating modes, as confirmed by the user behaviour results.

The fundamental question related to energy saving modes is whether to allow their use for energy declaration and to determine the energy class of ovens. Some stakeholders are in favour of allowing their use; some others are against their use; and some stakeholders recommend some sort of commitment between energy saving modes and conventional modes for energy declaration. There are benefits and drawbacks related to each option (allowing or banning their use). The topic of allowing or banning energy saving modes for energy declaration and to determine energy class will be addressed in more detail in Task 7 of this preparatory study.

4.1.4.5 Technology area 5: Thermal insulation and door glazing

Domestic ovens have a layer of insulation to restrict loss of heat. The performance of the thermal insulation depends on the thickness, density and thermal conductivity. Generally, mass of insulation material is proportional to the heat energy used by the oven. Air trapped between fibres or particles act as a good insulator, although this air must not be allowed to move, since flow of hot air from interior to exterior surfaces may cause heat losses. Ideal insulating materials have microporous characteristics, with trapped porosity which prevents air flow and low density. However, these materials tend to be less flexible, a preferable condition in ovens because of large expansion and contraction that occurs during heat-up and cool-down (as much as 1 cm in pyrolytic ovens during cleaning cycles). If insulation is damaged, heat losses will occur through gaps in the material.

In domestic ovens, insulation is based on flexible rolls or rigid slabs made of glass-fibre. For non-pyrolytic ovens, typically 25 mm thickness is used. Pyrolytic ovens require superior insulation systems to maintain external surface temperatures below safe limits and to comply with applicable standards, therefore slightly thicker and denser layers are used, with additional layers of aluminium foil acting as reflector of heat radiation. According to feedback from industry, increasing insulation level from 25mm to 40mm can reduce energy consumption by 12% when following the brick method test.

Regarding insulation, a patent has been identified that might be of interest. The patent by Bareyt (2016) is related to a new insulation material for ovens. This material is formed of at least two layers. A first layer, placed towards the heating element to be isolated, formed of wool and/or mineral fiber, and a second layer, further away, formed of airgel or of amorphous silica or insulators under vacuum. The use of the insulating, composite and multilayer product according to the patent makes it possible to improve the performance in terms of energy consumption of ovens (10-20% according to experimental results). These results might suggest that there is still certain room for improvement in terms of insulation.

In terms of glazing, historically ovens did not have glazed doors. This element of the door is actually a significant source of heat loss. Certain studies indicate that an oven with an unglazed door has a very significant potential to reduce energy consumption (Burlon, 2015). However, if an oven door does not allow seeing the interior of the cavity, it will be opened more frequently by the user, causing even more significant heat losses. Since the widespread introduction of this feature, unglazed doors have become an unacceptable product feature in domestic ovens. The combination of a glass door and oven cavity light reduces the number of times that the oven door must be opened to check the progress of the cooking, limiting the amount of heat lost each time the door is opened.

Oven doors are opened during cooking processes mainly to examine and to turn and manipulate food. In some occasions, ovens doors may also be opened to allow humidity to escape. When they are opened, most of the hot air from inside the cavity escapes. The relation between opening frequency, window size and heat loss is complex and no data is available. However, it is assumed that window size potentially has an influence opening frequency: a bigger window may reduce number of opening times as it allows a proper examination of food. Nevertheless, certain conflicting effects need to be considered:

- More heat is lost by conduction through windows than through insulated metal panels, so ovens with no window –or small window- lose less heat. This is counterbalanced by the heat lost every time the door is opened.
- The outer layer of the glass needs to be air cooled to limit the outer surface temperature to safe limits (this is not necessary for insulated metal panels).
- Heat consumption is proportional to the mass of materials: the higher the mass, the larger the energy consumed by the oven. More layers of glass provide a higher level of insulation but also induce higher energy consumption. Depending on cooking times, more layers of glass will be beneficial or detrimental. As a general rule, for shorter cooking times, less layers of glass are better, whereas for larger cooking times, the insulating effect of additional layers compensates the increase of energy consumption.

Two types of glass window configurations are used. In one, the glass window is inserted into an opening in the metal door using heat resistant adhesives. In the other, the door itself is made of a sandwich of two or more sheets of glass so that there is no need to seal the glass to a metal door. The outer sheet is usually made of clear float glass, tinted glass, coated –mirror effect- or white glass. For the middle and inner glass, heat transfer is limited by the use of low emissivity glasses. The inner panel of most new domestic oven includes as well an infrared reflective coating.

4.1.4.6 Technology area 6: Ovens with steam functions

Depending on the way in which the steam is used in the oven cavity, different options are available in the market (Table 37) in terms of steam ovens.

Table 37. Types of steam ovens

Type of steam oven	Ecodesign / Energy label regulation	Heating functions
a) Solo-steam oven	Out of scope	- Steam cooking
b) combi-steam oven	Within scope	- Steam cooking - Steam cooking with fan-forced convection - Fan-forced convection
c) Steam-assisted oven	Within scope	- Steam cooking with fan-forced convection - Fan-forced convection

a) Solo steam ovens

A steam oven (also known as solo steam oven) uses hot steam rather than hot air to cook food. They work by siphoning water from a small tank into a built-in boiler, heating it to 100C, and releasing the steam into the cavity. Steam ovens are generally considered to be healthier than standard ovens, since steam helps lock moisture into the food being cooked, eliminating the need for extra oils and fats to keep food moist. The main downside of solo steam ovens is that they do not allow cooking foods that require temperatures above 100C, since this is the boiling temperature for water. They are only able to conduct "wet" cooking. Also, they are not able to roast or brown food, limiting their cooking possibilities. Unlike in conventional ovens, steam prohibits the formation of a crust on the surface of the food.

As already discussed in Task 1, solo steam ovens are out of the scope of current ecodesign and energy labelling regulation. The reasons argued for this exclusion are related to the fact that solo steam ovens have a low market share and are therefore less relevant than other cooking appliances in terms of total energy consumption. Most of stakeholders support this exclusion today and data presented in Task 2 points in the same direction (they are in 5% of European households in 2020).

b) Combi steam ovens

Convection steam ovens -or combi-steam ovens- can cook using three different functions: with steam only, with steam and fan-forced convection, and with fan-forced convection only. Convection steam ovens combine both wet and dry cooking, with the advantages of evenly distributed heat. In a convection-steam oven, while the movement of hot air ensures consistent heating and browning, steam adds moisture at the right times in the right amounts (Papageorge, 2013). In Burlon (2015), an analysis is conducted on how much energy is transferred to a standard load and lost in different mechanisms within a convection steam oven. Around 79% of the energy goes to the load in the centre of the oven, whereas the rest is lost in walls (6%), vapours (11%), door (3%) and liquids (1%). These figures contrast with the ones presented in Ramirez-Laboreo et al (2016) and already cited in Section 4.1.4.4 of this report (where the amount of energy transferred to the load with a convection oven was much lower). To understand the significant differences would require a detailed analysis of the experiments conducted on those studies, but it is likely related to methodological differences in the experiments conducted and the load used for the analysis. Also, the experiment conducted in Burlon (2015) is with a commercial steam oven.

As already discussed in Task 1, combi-steam ovens are within the scope of current ecodesign and energy labelling regulation. The main reason for their inclusion is their market relevance. There is a general consensus among stakeholders that they should be included. However, there is certain debate around which heating functions should be tested for energy declaration in combi-steam ovens. In current and future versions of EN-60350 (Brickmethod 1.0 and 2.0, respectively), they are only tested in their conventional or convection modes (heating function with steam only is not tested), since they are the modes more commonly used. According to a stakeholder, tests should be developed for each function (including steam function). In their view, it is necessary to be sure that the use of steam mode is common among consumers, to decide if it should be allowed during the test for energy declaration.

c) Steam-assisted ovens

A steam-assisted oven is a similar appliance to a convection steam oven. In this case, however, the oven can work in two modes only: either fan-forced convection or fan-forced convection with addition of steam. This appliances does not offer the option of working with solo-steam function. Steam function in these types of ovens is essentially used to add moisture to the food. These appliances are within the scope of current ecodesign and energy labelling regulation. In current version of EN-60350, they are tested for the three modes, but in the new version of that test (Brickmethod 2.0), the intention is to leave steam heating function out.

An interesting aspect of steam-assisted ovens is that they perform well in terms of EEI, often achieving high energy classes (as already seen in Task 2). In TopTen database (which provides data on a different range of products) ovens are classified in three categories: ovens, steamers and stoves. There is no explicit definition of these categories in their website, although from the analysis of the models, it appears that they can be understood as:

- Ovens: built-in ovens, without additional steam function and without a hob.
- Steamers: built-in ovens, with additional steam function and without a hob
- Stoves: without additional steam function, with a hob (cookers)

All ovens currently listed within this database are either in energy classes A+ or A++. The energy efficiency classes and EEI of the 46 models listed in TopTen are displayed in Figure 167. Indicative benchmark as in Ecodesign regulation 66/2014 is also shown in the graph in orange dotted line.

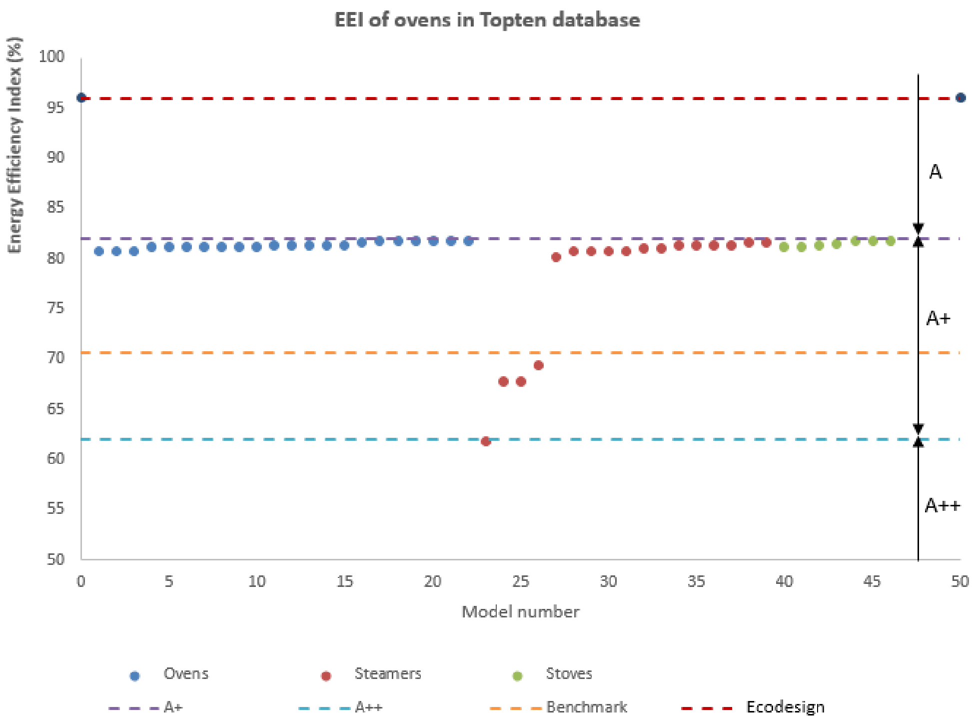


Figure 166. EEI and Energy classes of ovens in Topten database

As it can be observed, most of the products in the database have very similar EEI, with very small variation between them (80.2 - 81.7), with no significant difference between ovens, steamers or stoves.

The most relevant conclusion from this analysis is that there are four products with significantly better EEI than the rest and all of them are steamers (ovens with additional steam function).

- The four of those steamers are below the indicative benchmark for electric ovens (70.7%).
- Only one of those steamers is within A++ energy class.

From this analysis, one might conclude that steam-assisted function is relevant to obtain better EEI results and therefore relevant to achieve better energy classes. However, certain aspects must be taken into account:

- Ecodesign and Energy labelling regulation say that EEI calculations shall be made with the energy consumption of the best performing mode of the oven, following a test standard procedure. However, this does not mean that the mode used for the calculations is the steam-assisted mode (the best performing may have been another mode).
- Feedback from industry points out that ovens with steam-assisted function have better sealing and isolation characteristics with reduced vapour outlet, when compared to conventional ovens. This better sealing leads to better results in the energy consumption test (although the steam function may not have been active during the test). Manufacturers highlight that the support of steam does not necessarily lead to lower energy consumption.

Considering the points above, there is certain debate around the possibility of improving energy efficiency of ovens by enhancing their sealing conditions. Some stakeholders suggest that a promising way of improving energy efficiency of ovens in general is in the development of ovens with the sealing characteristics of steam-assisted ovens, modifying "air tightness" during the cooking cycle in order to reduce heat loss (as suggested in Pensek et al, 2005). However, manufacturers do not agree with this suggestion either, since there are some recipes which do not work with such highly-sealed conditions and require some air leakage.

4.1.4.7 Technology area 7: Microwave ovens

Microwave ovens are appliances where food is exposed to microwave radiation at a frequency of 2.45 GHz, with a power usually ranging from 500 to 1100 W. Microwaves are produced by an electronic tube called a magnetron. Once the oven is switched on, the microwaves are dispersed in the oven cavity and reflected by a stirrer fan so the microwaves are propagated in all directions. They are reflected by the metal sides of the oven cavity and absorbed by the food. Uniformity of heating in the food is usually assisted by having the food on a rotating turntable in the oven. Water molecules vibrate when they absorb microwave energy, and the friction between the molecules results in heating which cooks the food. Unlike conventional ovens, microwaves are absorbed only in the food and not in the surrounding oven cavity. In comparison to heating in conventional ovens, the main differences of microwave heating are as follows (Datta et al, 2013):

- It is a quicker process. The rates of heating are much higher than in conventional heating
- It is a more non-uniform process.
- It is a selective process. Moist areas heat more than dry areas of food.
- It has significant internal evaporation, enhancing moisture loss during heating.
- It can be turned on or off instantly

The main components of a microwave oven are:

- Enclosure, usually made of steel
- Door, usually made of glass with a metallic mesh which provides a barrier to radiation with enough visibility of the interior
- Magnetron, which generates the microwave radiation. This is a device made mainly from copper with an electrode inside a specially shaped cavity.

- Circuitry, in charge of converting mains input into microwave frequency for operating the magnetron.
- Fans, which cool the magnetron and circuitry
- Turntables, which allow food to rotate while cooking, ensuring an even distribution of microwave radiation

To prevent microwave radiation from escaping, the interior of the oven comprises a metallic mesh structure that prevents microwave radiation from passing through. This is used on the glass door and has gaps that are large enough for visible light to pass.

In terms of energy consumption, microwave cooking can offer substantial energy savings over alternative cooking methods. Industry estimates that typically up to 40% of the input energy is transferred to the food when using microwave ovens, although this figure depends on many variables, particularly the size of the load and whether it is being heated to raise its temperature or extended cooking is being carried out. Estimates of energy savings obtained with microwave ovens in comparison to alternative methods were published in Market Transformation Programme (2007).

Table 38. Energy savings when cooking with microwave oven. Adapted from MTP (2007)

Food	Energy saving (%)	Alternative method
Potatoes	70-75	Pan on hob
Fresh salmon fillet	63-78	Pan on hob
Frozen ready meal	55-73	Electric oven
Lasagne	40-81	Electric oven
Milk	25-50	Saucepan on hob
Frozen vegetables	65	Pan on hob

In global terms, the numbers above suggest that an increased use of microwave ovens in substitution of other ovens or hobs -when the recipe allows it- would reduce total energy consumption. However, since there is no method to measure energy consumption in microwave ovens comparable to the method used in conventional ovens –the brick method-, direct energy efficiency comparisons between conventional and microwave ovens are currently not possible.

As already indicated in Task 1, microwaves ovens are out of the scope of current ecodesign and energy labelling regulation. Some of the reasons argued for not being included in current regulation are listed below:

- There is a wide variety of different products with microwave function, which makes comparisons challenging. Consumers can find ovens with microwave function only, but also appliances that combine conventional heating and microwave (see Section 4.1.4.8).
- Microwave ovens tend to be used for short cooking periods (1-2 minutes) with maximum powers of 1000W, making their total energy consumption significantly lower than other cooking appliances.
- The use of turntables makes the testing method used for conventional ovens (the brick method test) not feasible for microwave ovens.
- The use of thermocouples to check temperature of the standard load inside the oven is also not possible in microwave ovens.
- Potential of improvement in terms of energy efficiency has been considered as low.

The latter bullet point (potential improvement of microwave ovens) appears a topic under debate. On one hand, in a report published in 2005 by the Energy Conservation Center of Japan (ECCJ, 2005), it was stated that in the previous years, engineering developments had been carried out mainly with the objective of improving taste of food cooked with microwave technology. In addition, although engineering developments had also been taking place for improving energy consumption efficiency –such as reduction of standby power consumption- it was concluded that there was still some room for improvement in efficiency of microwave ovens, possibly by improving the radiation method and thermal insulation performance. Efficiency of the magnetron, which comprises a large percentage of power consumption, appeared to be saturated. On the other hand, in the previous Preparatory study for Ecodesign requirements for domestic and commercial ovens (Mudgal, 2011), it was published that in the view of manufacturers members of the European Committee of Domestic Equipment Manufacturers (CECED), modern microwave oven designs are close to the maximum energy efficiency. Cavity size has no effect on it whereas internal coatings could only improve it by 1-2%.

The second bullet point has also created debate among stakeholders. Some of them argue that, considering the size and market growth of microwave ovens, it is necessary to reconsider their inclusion in ecodesign/energy labelling regulation. For products with lower savings potential as these, the starting point could be an energy label, as well as information requirements to foster innovation and differentiation. The same stakeholder supported this reasoning with the results from monitoring campaigns conducted in France (ADEME, 2016), where it was estimated that the energy consumption of microwave ovens is around 45 kWh/year (higher than the energy consumption of cooking fume extractors).

4.1.4.8 Technology area 8: Microwave combination heating

Some manufacturers offer ovens with combined function of forced-air convection and microwave. These appliances integrate the advantages of microwave energy to overcome the shortcomings of other food processing technologies. Adding microwaves to convective heating, for instance, generates heat inside food in a short time due to heightened penetration depth and rapid heating.

In general, the main reasons to introduce microwave energy within conventional domestic ovens is to reduce cooking times, improve quality in certain recipes and to obtain a higher degree of automation (Datta et al, 2013). A clear advantage of these appliances is that they allow the faster heating of the microwave ovens with the surface browning ability of hot air or grills.

Microwave energy can be introduced in many different ways when cooking a specific dish in an oven, in terms of power level, duration, sequence, etc. Therefore, there is enormous variation between manufacturers of similar ovens in terms of how to combine these modes. Due to this high variation in terms of options, microwave combined heating is generally used in an automated mode, for specific processes or recipes. In a typical microwave combined oven, the user can select the power levels used for each individual heating mode (hot air and microwave) as well as the sequence of the combination (for instance, microwave first followed by forced-air convection). According to Datta et al (2013), microwave combination heating appliances can be grouped into:

- Microwave with infra-red. A source of infrared heat is provided inside the oven, using halogen lamps or heated rods (grill).
- Microwave with hot air. Typically forced hot air is provided to emulate simultaneous hot air heating. This is the most common microwave combination mode in the domestic market.
- Microwave with steam. This is a relatively recent feature. Steam is generated and fed to the oven cavity. Generally steam appears to be used not simultaneously with microwaves, although it should be possible to design combinations that sequence microwave and steam.
- Microwave with induction. A shielding plate is mounted on the bottom surface and an induction coil is provided below it to selectively choose between microwave and/or induction cooking. Currently there is no known commercially available unit with this technology.

Benefits and drawbacks of the above microwave-assisted food processing technologies and others (such as ultrasound, ohmic heating, vacuum, etc.) are listed in Chizoba et al (2017).

The main differences between a conventional oven and a microwave combined oven are the presence of all the required components for the generation of the actual microwaves (essentially the magnetron and rest of componentry listed in Section 4.1.4.7). With microwave combined ovens there are a number of compromises that need to be made in design. For example, enameled surfaces are better for conventional oven modes but stainless is better for microwave modes. Enamelled surfaces are required if pyrolytic cleaning is an option. A microwave combined oven also require a different level of insulation to avoid potential leakage of microwaves.

As indicated in previous section, an appliance that offers a microwave heating function is currently out of the scope of ecodesign and energy labelling regulation. One of the main reasons for this exclusion is that any oven with microwave functionality and a turntable cannot be tested by the brick method, according to feedback from industry. Ovens with microwave function but no turntable can be tested by the conventional brick method, but the microwave function would need to be decoupled first because some manufacturers may “hide” microwave operation within conventional operating modes. Besides, door seals for ovens with microwave function are tighter and make it more complicated to run a thermocouple wire through the door. Any hidden microwave activity would be potentially dangerous for the convention test set-up. Additionally to those reasons, there are so many different combinations of convection heat and microwave possible that it would make comparisons between products unfeasible (unless a standard combined cycle was defined).

Feedback from industry highlights the energy and time saving potential of these microwave combi-modes, observed in tests with real food. Depending on the type of dish being prepared, when compared to convective heating:

- Time savings: 40% - 55%
- Energy savings: 5% - 20%

However, despite this energy saving potential of microwave combined ovens, since currently there is no standard test to evaluate these savings in comparison to conventional ovens, this potential is currently not perceived by consumers.

Some stakeholders suggest that ovens including microwave functionality should be covered by ecodesign and energy labelling regulation, but only for their conventional and/or fan-forced modes. This could close a potential loophole for products with microwave function.

Other stakeholders also raise their concerns about the risks of not including ovens with microwave function, which seem to represent a trend in the market. Their recommendation is to include them within the scope and to develop a test method to quantify the effect of the microwave function in a heating cycle. Another stakeholder agrees with this position, adding that a measurement method showing the advantages of a combined microwave oven mode would lead to a better understanding of the consumer to save energy.

4.1.4.9 Technology area 9: Self-cleaning systems

Ovens are appliances which need periodical cleaning. Most of the modern appliances already incorporate some sort of self-cleaning system, but before that, the only way to clean a domestic oven was manually, often using toxic products. Three different cleaning methods are available in the market (Schmidt, 2019).

- Pyrolytic cleaning. This is currently the main commercial solution in the market, a self-cleaning process where the oven is heated in a special heating cycle up to 500C for long periods of time (1-3 hours). This causes fat deposits to pyrolyse, mainly to gaseous by-products. Organic residues are incinerated, then easily removed as dust. In comparison to a standard oven, the composition of the enamel is significantly different, in order to withstand the higher temperatures. The most abundant materials in the enamel in this case are SiO_2 (29%), ZrO_2 (19%) and CeO_2 (11%). A complete breakdown of materials for a pyrolytic enamel is presented in Palmisano et al (2011). The pyrolytic cleaning cycle has high energy consumption, which could be larger than the energy saved by the improved insulation needed for these types of oven. Total annual energy consumption will depend on how frequent this system is used.

- Catalytic cleaning. This is a modern version of the self-cleaning oven, where the cleaning cycle is conducted at a lower temperature than the pyrolytic (around 350C). These are ovens which can be recognised by their porous interior walls which are rough to touch. This type of wall absorbs the cooking grease. The catalysis destroys splashes of fat by oxidation when cooking dishes at more than 200C. It has been reported that catalytic cleaning is less effective than pyrolytic cleaning, since the catalytic liners cannot be cleaned, and there are certain gaps within the cavity which may need to be cleaned manually using chemicals. Catalytic liners require additional parts to be installed, adding about 1 kg of mass. This additional mass will absorb heat, increasing oven energy consumption. However, published research points out that there is still room for improvement, mainly around the properties of the oven wall coating.

- Hydrolytic cleaning. This is a cleaning process which involves the use of steam, combining evaporation and condensation. The dirt in the oven turns soft and detaches easily, making it easier to clean the oven. The system is simple and economical, as it just needs a small amount of water and washing up liquid. This is also the least energy consuming self-cleaning process.

Considering the results from Task 3 regarding the use of the pyrolytic function and the high temperatures required during that cycle, the total energy consumption of this function could be quite significant. Stakeholders suggest that pyrolytic function represents around 25% of the lifetime energy consumption of the oven. Other stakeholders indicate that it is important that consumers have access to information about the huge energy consumption of pyrolytic cleaning and that it should be declared. Their proposal is to include information on energy consumption of self-cleaning systems in the user manual. However, they acknowledge the difficulty in including such information. In fact, this is the position of the manufacturers, which point out that self-cleaning systems should not be included in ecodesign/energy labelling regulation, as it would be very challenging to evaluate different levels of cleanliness and to compare self-cleaning programmes with manual cleaning.

In terms of innovative solutions for self-cleaning ovens, in Palmisano et al (2011), a series of tests were conducted to analyse the ability of cerium oxide (CeO_2) as a main component in the enamel of catalytic self-cleaning ovens. Four different synthesis techniques were studied for CeO_2 deposition over an enamelled oven tray. In terms of temperatures required, it was observed that for 4 different solid residues, when using the CeO_2-based enamel, the temperatures needed to remove 90% of that residue were between 8%-49% lower than with a standard enamel. Moreover, when comparing the CeO_2 catalytic enamel with an equivalent pyrolytic enamel, it was observed that similar results in terms of residue elimination can be obtained at temperatures around 150C lower. These results indicate that room for improvement may be available in energy consumption of self-cleaning systems.

4.1.4.10 Technology area 10: Smart and connected ovens

Modern cooking appliances are increasingly equipped with automatic and connectivity features. A smart cooking appliance is essentially a Wi-Fi enabled appliance which allows its connection to the Internet as well as the use of automatic cooking programs that reduce the influence of the user during the cooking process.

As it was mentioned in Task 2 of this report, the influence of the user is one of the aspects that affects the energy consumption of the oven, with inefficient cooking habits such as pre-heating with the empty oven or opening the door to check the state of the food. Ovens that incorporate automatic cooking functions can help to mitigate these inefficiencies. With the help of sensors, the oven can detect the status of the dish being prepared and adjusts temperature and heating functions accordingly, without the intervention of the user. If the oven is connected to the Internet, it may have access to database of recipes. The user selects a recipe from the database and loads it onto the device, which automatically sets the right temperature and timing for the selected dish. As highlighted in Favi et al (2020), smart software can help to modulate the power depending on the recipe being cooked, without affecting product manufacturing or materials.

According to feedback from manufacturers, the use of automatic programs can reduce the energy consumption of the oven by approximately 15% per cycle. However, the savings of the automatic functions cannot be easily shown with the current measurement methods (brickmethod 1.0 or brickmethod 2.0).

Being connected to the Internet provides a series of benefits to its users (altghoug not particularly related to energy consumption savings). A connected oven, for instance, may become the hub or the centre of connection and dialogue for the management of all kitchen appliances: induction hob, cooking fume extractor, refrigerator, dishwasher and washer dryer. A connected oven can also be manipulated remotely by the user via smartphone or tablet. A connected oven can also provide information regarding the remaining cooking time or send a notification to the user when a program has ended.

4.1.5 Best Available Technologies in ovens (BAT)

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic ovens are investigated. Data for this investigation will be taken again from TopTen database (as in Section 4.1.4.6). All ovens currently listed within this database are either in energy classes A+ or A++. The energy efficiency classes and EEI of the 46 models listed in TopTen are displayed in Figure 167. Indicative benchmark as in Ecodesign regulation 66/2014 is also shown in the graph in orange dotted line.

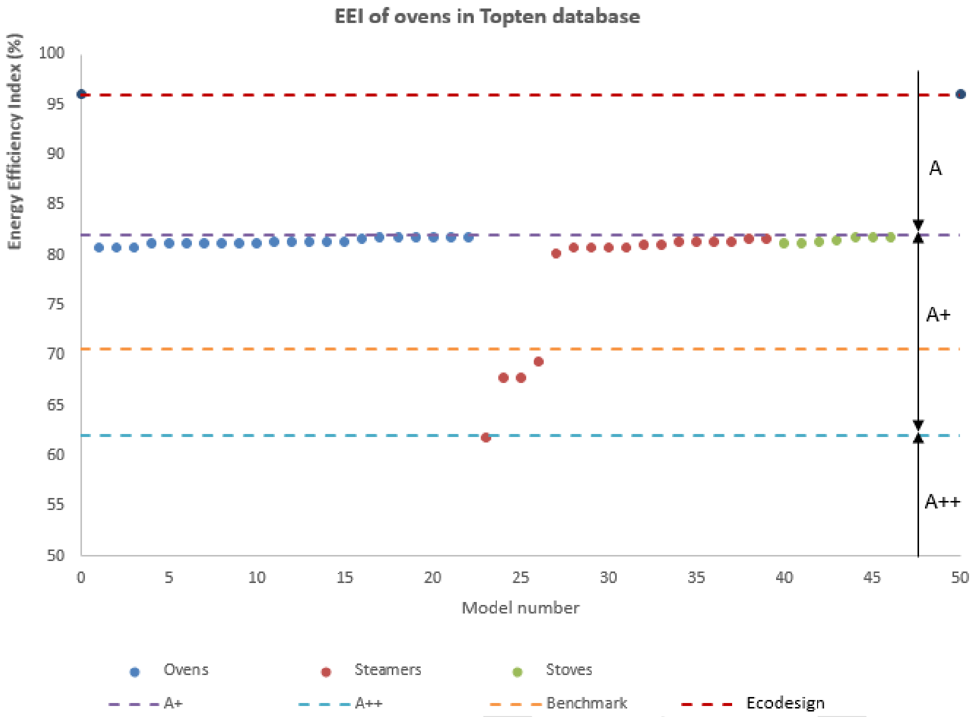


Figure 167. EEI and Energy classes of ovens in Topten database

As it can be observed, most of the products in the database have very similar EEI, with very small variation between them (80.2 - 81.7), with no significant difference between ovens, steamers or stoves.

- All the products in the database are comfortably below the EEI ecodesign limit for 2019 (96%)
- There are 4 products with significantly better EEI than the rest and all of them are steamers (ovens with additional steam function).
    - The four of those steamers are below the indicative benchmark for electric ovens (70.7%).
    - Only one of those steamers is within A++ energy class.
- Ovens and stoves show similar EEI values.
    - All of the ovens and stoves are right below the value to be within A+ energy class (82%)

An additional analysis is conducted to investigate whether there is a relationship between EEI and cavity volume (Figure 168).

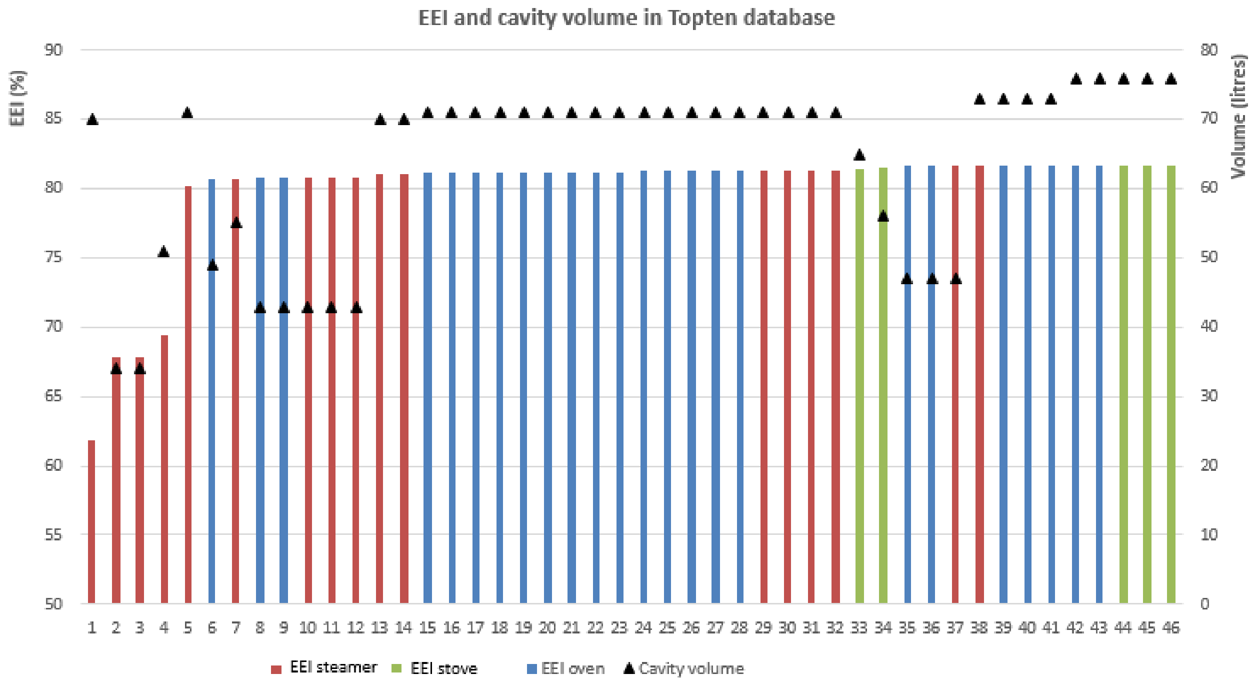


Figure 168. EEI and cavity volume of ovens and stoves in Topten database

As can be seen in Figure 168, not very obvious trends can be observed regarding EEI and cavity volume:

- The best performing product is model number 1 in this figure (EEI=61.9%) and has a big cavity (70 litres).
- On the contrary, the next two models in terms of EEI (67.8%) have smaller cavities (34 litres).
- The nine products (models 36-45) with the highest EEI values (81.7%) also have the highest cavity volumes (73-76 litres).

A very slight trend can be observed regarding EEI and cavity volume: bigger cavities lead to slightly higher EEI values. However, this needs to be taken with caution, since the sample is small (46 models) and the differences in EEI among most of the models are marginal (most of them between 80.2%-81.7%).

<u>BAT 1: Oven with heating mode that uses residual heat</u>

Based on feedback from manufacturers, the biggest opportunity of improving energy efficiency in current ovens is through the development of heating modes that use residual heat to reduce energy consumption, also known as energy saving modes, or ecomodes. The use of this heating modes for energy declaration and to determine energy class is nowadays being questioned by some stakeholders, as already explained in Section 4.1.4.4.

<u>BAT 2: Oven with steam-assisted function</u>

From the analysis of Figure 167 and Figure 168, it could be concluded that Best Available Technology (BAT) regarding energy efficiency is an oven with an additional steam function, since the 5 most energy efficient products in the database are within this category. However, as mentioned earlier in this report, feedback from industry points out that the support of steam does not necessarily lead to lower energy consumption. Ovens with additional steam function have improved sealing with reduced vapour outlet, which is essential for steam functions. This leads to better results in the test, but the steam function may not be active during the test. An alternative to BAT could be to consider that the best performing oven in terms of energy efficiency is an oven with works in convection mode, but with the improved sealing characteristics of a steam-assisted oven, which would reduce heat loss. However, manufacturers do not agree with this suggestion either, since there are some recipes which do not work with such highly-sealed conditions and require some air leakage.

BAT 3: Oven with microwave combined function

Another alternative to BAT 1 and BAT 2 would be to take into account the promising results in terms of energy savings observed by industry (seen in Section 4.1.4.8) and consider that the best performing oven in terms of energy efficiency is an oven with microwave combined function. However, the lack of a method to measure energy consumption of such a mode makes it currently not possible to determine how much better these ovens are in terms of energy efficiency. A potential middle-term solution for this would be to launch a standardisation request to define a method to measure energy consumption of these functions.

BAT 4: Oven with automatic functionality

According to feedback from manufacturers, an oven with automatic functionality may provide energy savings. There is currently no data to support this potential improvement, but their feedback indicates that they could reduce energy consumption per cycle by 10%.

4.1.6 Best Not Available Technologies in ovens (BNAT)

In this section, the Best Not Available Technologies (BNAT) in terms of energy efficiency for domestic ovens are investigated. Data for this investigation will be obtained from scientific literature and feedback from industry and stakeholders.

From the analysis of scientific literature, there is no obvious technology for domestic ovens, currently not available in the market, which could improve drastically energy efficiency in the near future. Feedback from manufacturers also points at the fact that there are no significant technology developments expected in terms of energy efficiency for the upcoming years. In their view, the biggest potential for energy efficiency improvement is more related to user behaviour than to the actual appliances. Best practices for energy savings when cooking with an oven have been mentioned in Task 3 of this report.

A new technology mentioned in specialized magazines is solid-state semiconductor materials. As explained in Section 4.1.4.7, microwave ovens are based on the use of magnetrons, devices capable of creating microwaves, a form of electromagnetic radiation with waves shorter than radio waves but longer than anything human eye can see. When electricity runs through a metal filament, negatively charged electrons rush to the positive end. Magnetrons keep these electrons going in a loop created by a magnet, creating electromagnetic waves that radiate outward. These waves affect the water molecules in the food, which start wiggling around rapidly. Metal mesh lining in microwave ovens reflect these waves, bouncing them around the cavity about 2.5 billion times per second. The friction created by this movement of water molecules heats food from within (Foley, 2017). One of the main disadvantages of microwave ovens is related to the uncontrolled bouncing of the electromagnetic waves within the cavity, affecting the food from different angles. The turntable is in charge of balancing this but the cooking results are often not repeatable even using the same power amount.

In Werner (2015), a potential solution is presented to overcome this issue, based on the use of a solid-state semiconductor, paired with signal amplifiers and receivers. Semiconductors are made out of ceramics like silicon, which typically block the flow of electrons, but have chemical impurities that help electrons move only in one direction. Semiconductors slow down electricity coursing through a system. The amplifier and receiver create a power feedback loop that allows the semiconductor to adjust and produce the right amount of microwaves, at the right power level, and for the correct length of time, to heat food evenly. Unlike conventional microwave technology, this one may allow for much higher precision cooking because the signals generated provide a feedback loop to help the oven understand and target specific zones within the cooking cavity. A few examples of companies working on ovens with this technology is compiled in Wolf (2017). Another potential advantage of semiconductor-based microwave ovens is their portability. Substituting magnetrons (which are bulky, heavy components) by lighter and compact semiconductor materials could open the possibility to the manufacturing of portable microwave cookers (Hambling, 2016).

Currently, there is no scientific evidence published regarding any potential improvements in terms of energy efficiency regarding this technology. Feedback from industry indicates that whereas the efficiency of generating microwaves with a magnetron is around 70%, that of generating them by semiconductors is only of 35%. Semiconductors offer the theoretical advantage of variable wavelength. However, this brings also disadvantages as the ovens need to be dimensioned for a specific frequency to assure an efficient use and especially to avoid microwave leakage. On top of that, the costs of this technology are still far away from being applicable for the domestic sector.

A different technology is presented as part of the Green Kitchen Project (2014). In this project, the main goal was to develop and share knowledge in future home appliances for improving energy efficiency. This project led to the development of a prototype for gathering and storing thermal energy making use of Phase Change Materials (substances which absorb or release large amounts of so-called 'latent' heat when they go through a change in their physical state). This resulted in an oven design that, according to the authors, can reduce electric power consumption up to 20%.

On top of those, the MAESDOSO project (2017) aims to develop electrochromic devices for use in domestic ovens, mainly in glass doors. Electrochromic devices generate reversible color changes responding to electricity. They are promising candidates in the applications of display, smart window, and military camouflage. In the MAESDOSO project, the reduction of heat losses in the glass will be achieved by reflection of infrared radiation using low emissivity coatings on transparent conducting oxide. Unfortunately, no savings are mentioned in their report.

4.2 Domestic hobs

4.2.1 Technical product description: hobs

A hob is a domestic appliance used for heating food. It generally works as a primary heat source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heating source, transferring heat to the food within it. In the definitions section of Regulation 65/2014, European Commission differentiates between electric hobs, gas hobs and mixed hobs.

- **Electric hob**. Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity
- **Gas hob**. Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners of a minimum power of 1.16 kW.
- **Mixed hob**. Appliance with one or more electrically heated cooking zones/areas and one or more cooking zones heated by gas burners.

4.2.2 Basic product types

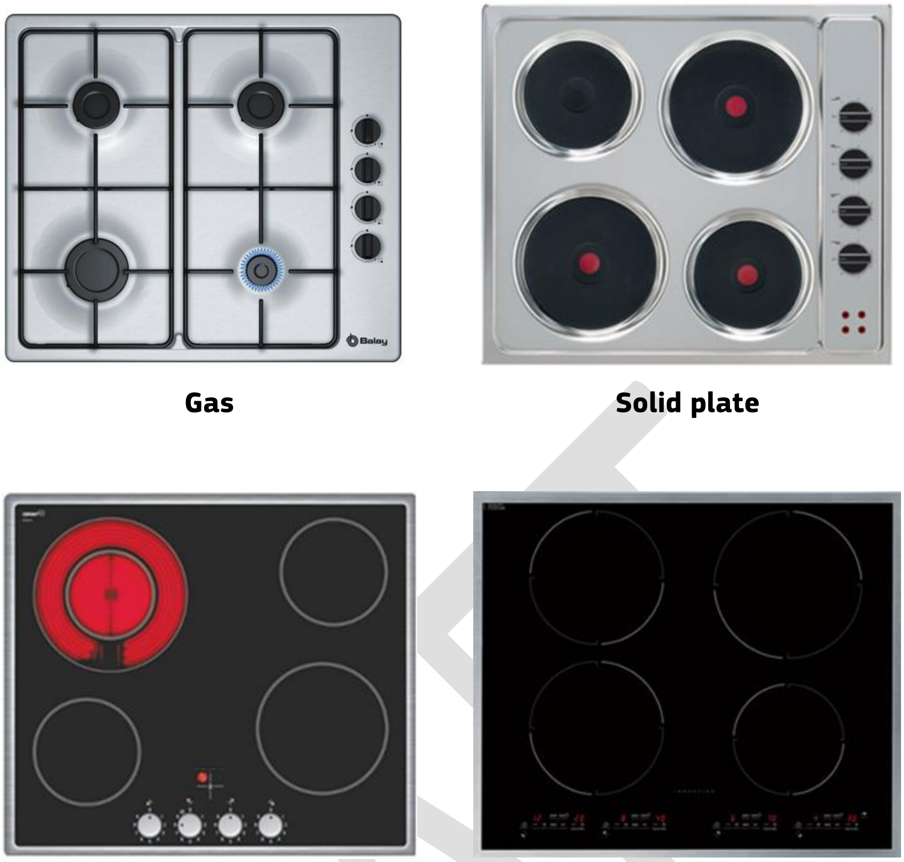
Depending on the characteristics of the main components, domestic hobs can be classified in different ways. In Table 39, a classification is provided considering three criteria: heat source, heating element, and mounting.

Table 39. Types of hobs

Heat Source	Heating element	Mounting
Gas	Burners (gas)	Built-in
Electricity	Solid plate (electric)	Integrated in a cooker
	Radiant (electric)	Portable or table top
	Induction (electric)	

Considering heat source, domestic hobs can be powered either by gas or electricity. Gas hobs imply the use of burners that, after being ignited, maintain a flame that transfer heat to a cooking vessel. Although they can differ in size, configuration and ignition type, gas burners are relatively similar between them. On the other hand, there are more differences between electric powered hobs, depending on the heating element they use. In terms of heating element, electric hobs can be classified in different types (Figure 169):

- **Solid plate** hobs contain a sealed electric resistance, through which circulates electrical current, transferring heat to the cooking vessel on top of it.
- **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by infrared radiation via a glass-ceramic surface
- **Induction hobs** are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food.



Gas | Solid plate

Radiant | Induction

Figure 169. Different types of hobs according their heating element (APPLIA)

An important usability factor when comparing domestic hobs is the ability to **control temperature**, as this is a key aspect of the cooking process. In general, it is considered that gas hobs offer a basic level of control, whereas radiant ones allow the user to be slightly more accurate thanks to different levels offered in this kind of cooktops.

Time response is another factor valued by consumers. Induction hobs have the quickest response to temperature changes. As an average, the time needed to boil 2 litres of water with an induction hob is 5 minutes. This is mainly due to the fact that the electromagnetic fields created in these hobs do not heat the cooking surface, but rather directly the cooking vessel. Moreover, the flat surface prevents heat to be lost (highest energy efficiency among hobs).

In terms of **durability**, gas hobs have been widely used over time and their durability has been long proven. 19 years is a widespread figure used for gas hobs lifetime (ETSAP, 2012). On contrast, glass-ceramic is more prone to scratching and breaking. If a pot is accidentally dropped over the cooktop it may damage the surface, affecting its performance. Induction and radiant hobs may have a slightly lower average lifetime because of that (a range between 15 and 19 years is provided in ETSAP, 2012). Moreover, the significant amount of electronic components present in induction hobs may reduce lifetime of these appliances. As reported in Favi et al, (2018), lifetime bottleneck is usually represented by electronic components, which tend to have the shortest lifetime among all components of a product. It is suggested that lifetime may be lower than gas or radiant cooktops, more similar to other consumer electrical products (10-15 years).

4.2.3 Safety in domestic hobs

In terms of safety, it is worth noting that generally every product placed on the market has put in place every measured required to make them safe enough for the consumer. However, this does not mean that the user will never make any mistake when using the appliance, such as forgetting to turn it off after cooking or touching the cooking surface accidentally.

Considering accidental touches, there is an obvious risk in touching a gas hob when it is working, as the flame can cause instant burns to the user. Nevertheless, it seems unlikely that this sort of accident may happen. On the contrary, this is a situation that seems slightly more likely in the case of electric radiant hobs. The flat surface is often used to cook and chop food, particularly in small kitchens where cooking space is limited. Radiant hobs have a glowing red colour when turned on, but go almost instantly black after use. Although there is generally a small pilot light indicating the surface is still hot, the user may rush to use it for preparing food, increasing the risk of accidental burns. Some manufacturers offer electric hobs with LED lights which simulate the appearance of the flame and light up or down according to the temperature. Finally, induction hobs are the safest from this point of view. While cooking, the surface will only get slightly warm, due to the heat transmitted from the pan to the actual surface.

Forgetting to turn off the hob after cooking is a common mistake made by users. Generally, gas hobs do not come with any automatic turn off device, so if the user forgets to turn it off after cooking, it will keep on burning gas indefinitely, posing an obvious fire risk. According to certain studies, 62% of home fires start because of the hob (Rance, 2019). Just a limited number of gas hobs are equipped with independent timers for programming the cooking times and switching off each burner after certain time. Others also include a sound alarm that alerts if the hob remains active beyond certain threshold (Preda, 2018). There is certain risk as well in forgetting to turn off an electric radiant hob. In this case, the highest risk is again related to burns by accidental touch. Induction hobs will be again the safest ones: if the user forgets to turn off the device after cooking, the pan will get hot, but it is unlikely that a fire will start because of a hot pan, or that any other user would touch the interior of the pan. If the user forgets to turn off an induction hob, but removes the pan from the surface, nothing will happen, as induction needs a ferromagnetic material to be located on top of the surface to start working.

4.2.4 Technology areas: hobs

4.2.4.1 Technology area 1: Gas hobs

Gas hobs are usually made of a metal plate that functions as a frame; upon which several cooking spots or burners are mounted (a typical configuration is 4 burners). Generally, hobs are made with burners of two or more different sizes and maximum energy output, in order to accommodate different size cooking vessels. Each cooking zone includes a metallic grid, or pan support, where the vessel is placed for cooking. The main components of gas hobs are:

- Burners
- Igniters
- Gas flow controllers

Most burners are round with an array of small gas flames around the periphery. Typical domestic hob burners have a maximum power output of approximately 3.7 kW, although some burners with up to 6 kW can also be found. In the traditional gas hob, each burner is centrally located below a pan support and surrounded by a dish shaped depression to avoid spillages from the cooking vessels extinguishing the flame. Control of the power to the burner is typically only by the control of the gas supply, although some manufactures market dual burners consisting in inner and outer circular burners, intended to provide more even heat distribution.

Size and power of burners is a relevant aspect in ecodesign regulation. Small burners (below 1,16 kW) are currently out of scope. Some of the reasons argued to leave small burners out of scope was that they are mostly used for simmering and not cooking; and that due to their low power and the nature of the standard test (the temperature rise is not adequate to measure their performance), they may cause reproducibility issues during testing. However, some stakeholders consider that, unless substantiated by data, **smaller hobs should also be included into the scope**. To overcome reproducibility issues, stakeholders recommend **to develop a simmering test for small burners**, to collect data on a wide amount of them and set efficiency minimum requirements. Manufacturers highlight that, although a test could be developed for small burners, **a minimum power threshold to be into the scope of ecodesign regulation should still be in place**.

In gas hobs, gas is premixed with some air before it reaches the burner, so that a smoke-free blue flame is produced. Combustion also requires secondary air from around the flame to burn all the hydrocarbon gases. To avoid CO formation, it is essential that some excess air is mixed in the flame. The amount needs to be limited, as too much cold air cools the flame and reduces heat transfer efficiency.

High voltage spark igniters are the most common type in the case of domestic hobs, since they provide near-instantaneous ignition of the gas. The spark electrode surfaces are affected by contamination and moisture, causing gradual loss of energy efficiency. However, their useful life is long and they usually do not need to be replaced across the hob lifetime. Hot surface igniters use electrically heated ceramic surfaces that are sufficiently hot to ignite the gas. Originally, these took as long as 30 seconds before ignition, but some recent designs operate much quicker. One potential problem is that, being made of ceramic, the igniters could be physically damaged from thermal shock. This technology is rare in the EU and more common in the US. Hot wire igniters use a proprietary alloy resistance wire that heats up to over 1000C in order to ignite the gas. Ignition takes less than 3 seconds. The wire is not affected by contamination and there are no electromagnetic compatibility issues. This type of igniter is also rare in the EU.

In terms of type of gases being covered by ecodesign regulation of cooking appliances, it is worth reminding at this point that current regulation leaves out of the scope (among others), those appliances designed for use only with gases of the 3rd family (butane and propane). However, according to manufacturers this exception has no big sense nowadays, so **appliances which work with gases of the 3rd family should be included in the scope**.

Gas flow control elements (valves) are made from either brass or aluminium. Valves restrict the flow of gas in order to control the heat output. Electronic gas control valves have recently been introduced, providing a variety of functions, including:

- Automatic burner ignition (reignites gas if the flame goes out)
- Electronic gas flow control (more accurate control of gas flow)
- Safety switch that turns gas off after certain time
- Timers to turn gas off after pre-set time
- Touch control systems
- Flame supervision device: safety device designed to stop flammable gas going to the burner of a gas appliance if the flame is extinguished

The main materials used to manufacture gas hobs are aluminium alloy, carbon steel, copper, brass and synthetic rubber. A detailed Bill of Materials of a gas hob system is presented in Favi et al (2018).

In terms of energy efficiency, it is generally considered that gas technology is largely accepted and well known in the global market. Therefore, less research and development actions are currently being undertaken to improve its efficiency (in comparison to other hob technology such as induction). Current innovation in gas hobs are related to aspects listed below:

- The design of gas hobs which reduce the distance between the pot and the flame, which may greater speed in cooking and lower energy consumption (Corti, 2019b). However, this may jeopardise the safety of the hob, thus any improvement in this area is limited by safety requirements that must be fulfilled above any other requirement. Also, although efficiency can be improved by making the flame closer to the pot, it can also increase pollutant emissions of the burner as chemical reaction occurring during combustion could be stopped when the flame impinges the pot. Therefore, **reducing the distance between pot and burner is an area which is not recommended to explore as a way to improve energy efficiency**.

- A more precise flame control that makes the gas hob more efficient and performant. Manufacturers are offering gas hobs where the flame increases or decreases according to several power levels, with a similar precision to that of induction (Preda, 2018).

4.2.4.2 Technology area 2: solid plates

Solid plates consist of a resistance wire of Nichrome, either as a spiral ring or within a solid plate. Heat transfer is primarily by conduction, so it only occurs efficiently where the cooking vessel and the ring are actually in contact. Hobs are usually sold with a range of ring sizes to accommodate cookware of different dimensions. The main elements of solid plates are shown in Figure 170:

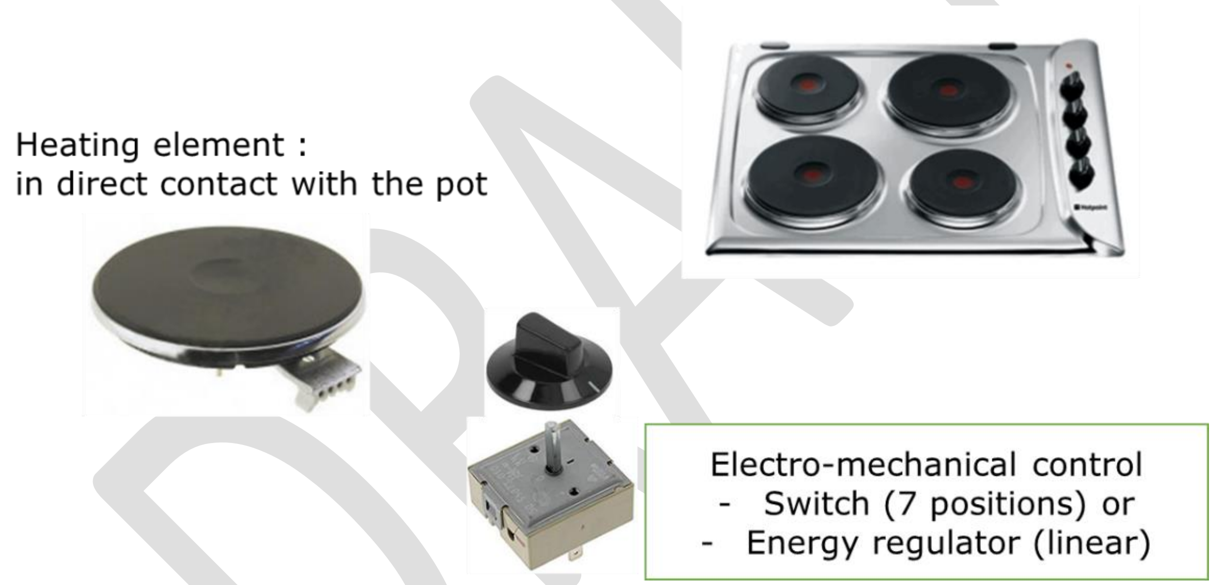


Figure 170. Components of solid plates (APPLIA)

The main advantages of these hobs are the low price and robustness. However, cooking temperature control is difficult as they are relatively slow to respond to changes in the controls due to their high thermal mass (inertia of the plate).

According to feedback from manufacturers, **the potential of improving energy efficiency in solid plate hobs is almost exhausted at this point**, since today's solid plates are already equipped mainly with energy regulators (no longer 7-steps switches), due to the current requirements of ecodesign regulation.

4.2.4.3 Technology area 3: Radiant hobs

Electric radiant hobs consist of a glass-ceramic surface, beneath which electrical current flows through a unique metal coil. Electrical resistance heats to generate a hot glowing metal coil that transfers its heat through the glass-ceramic via radiant energy and to the glass-ceramic via convective heat. (Joachim, 2019). The main components of radiant hobs are shown in Figure 171:

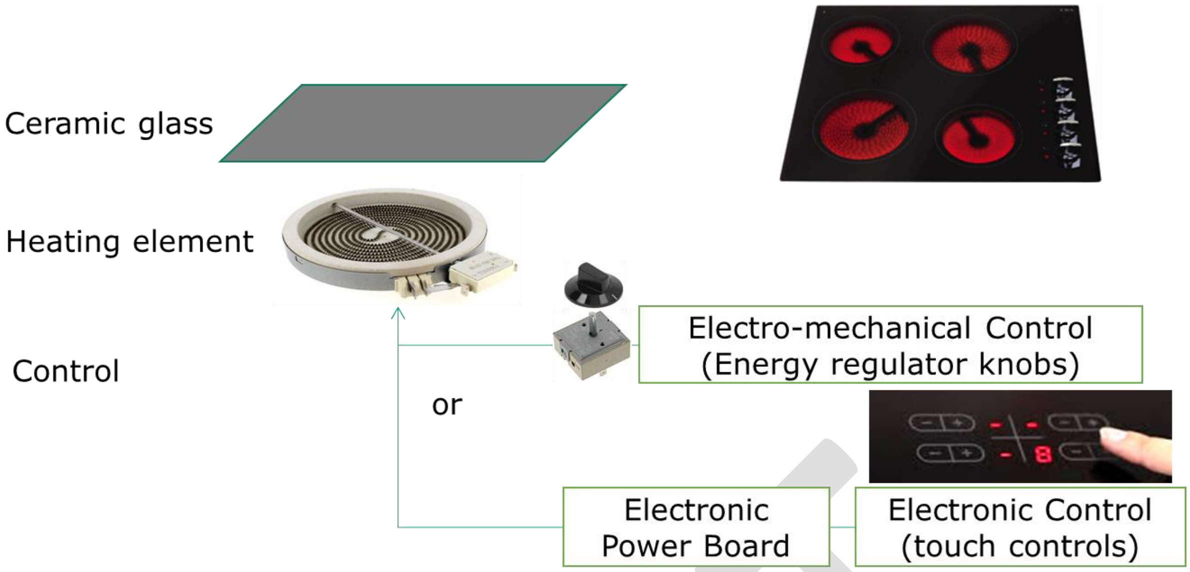


Figure 171. Components of a radiant hob (APPLIA)

Food is cooked by the transfer of heat from the electric coil to the ceramic-glass surface and finally to the cookware. At the same time, the surrounding surface of the glass-ceramic remains relatively cool. The glass-ceramic continues to emit heat after electricity stops flowing, so this residual heat can be used to continue cooking or to keep food warm (Wegert, 2015). As the thermal mass of the heating elements is relatively low, they cool rapidly when the current is reduced, giving much better temperature control than solid plate hobs. The response time is not as fast as in induction hobs, as some heat is retained by the glass ceramic.

Because of the glass-ceramic's low thermal expansion and infrared transmission and emission characteristics, the pot or pan on the cooking zone is warmed evenly by the energy transmitted through the glass-ceramic to the cookware. They also have less thermal inertia and a faster response than solid plates.

4.2.4.4 Technology area 4: Electric induction hobs

In induction hobs, below a glass-ceramic cooktop, there is an electronically controlled coil of copper. When power is on, constantly changing electric current flows through that coil, generating a magnetic field that terminates at the bottom of the ferromagnetic pot placed above the hob. This fluctuant magnetic field indirectly produces heat by inducing an electrical current flow in the pot: an eddy current (Favi et al, 2018). A diagram explaining the basic functioning of an induction hob can be seen in Figure 172 (Hager et al, 2013).

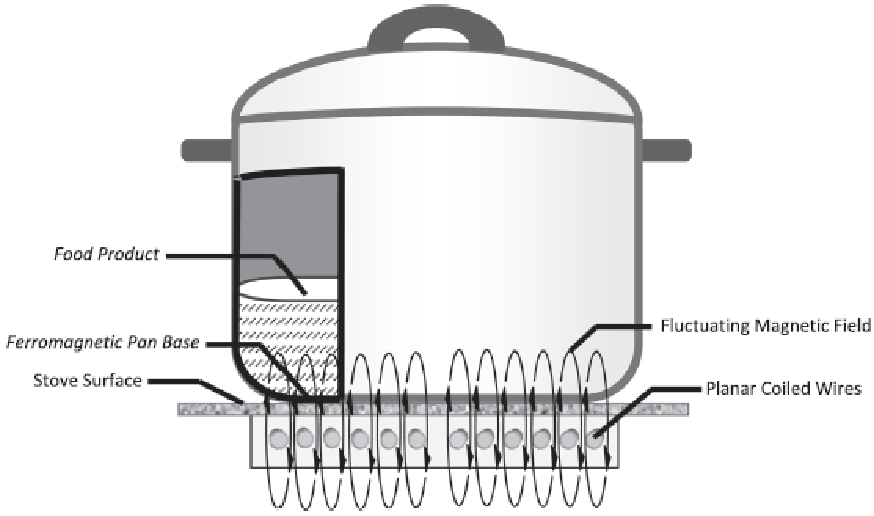


Figure 172. Diagram demonstrating basic functioning of induction hob

The electromagnetic induction generates Eddy currents within the metal and its resistance leads to Joule heating and also generates losses due to the hysteresis of the magnetic material in the pan. An induction cooker consists of a copper coil (generally), through which a high-frequency alternating current (AC) is passed. The frequency of the AC used is based on the maximum switching frequency of the switch of the power converter. The main components of an induction hob are shown in Figure 173:

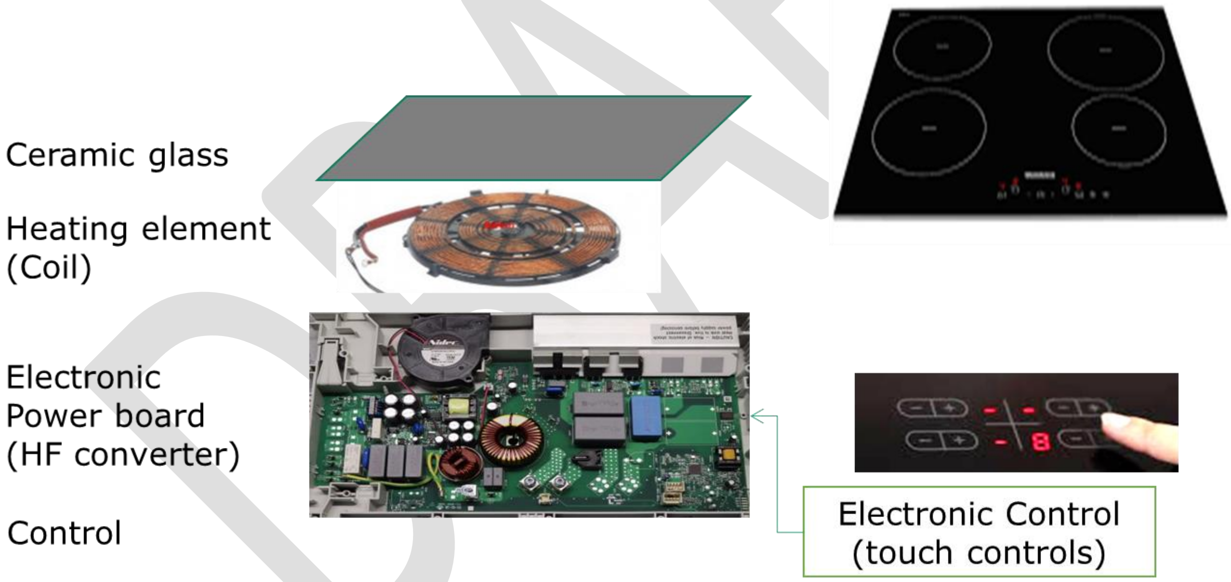


Figure 173. Components of induction hobs (APPLIA)

The most common topologies for induction heating are the Half-Bridge series-resonant converter and the Single switch Quasi-Resonant. The Resonant Half-Bridge is the most employed topology in induction cookers for multiple burner, high-power systems due to its simplicity, its cost-effectiveness, and the electrical requirements of its components. Quasi-Resonant converters require only one switch, and only one resonant capacitor. Quasi-resonant converters might be considered as a good compromise between cost and energy conversion efficiency (Semiconductor Components Industries, LLC, 2014)

In terms of required cookware, any ferromagnetic steel flat-bottomed pot is suitable. However, especially design cookware is also used. These have ferromagnetic metallic bases that couple efficiency to the alternate current signal. Cooking area size is much less important in these hobs, as induction only heats the actual size of the pan being used. Heat losses are therefore reduced significantly with these appliances. The medium frequency coil needs to be located at a certain distance from the pan base for optimum coupling efficiency. The heat energy generated in the pan is inversely proportional to the square of the coupling distance. Therefore, the hob needs to be designed with the correct distance between the coil and the pan.

The main materials used in an induction hob are glass-ceramic, stainless steel, carbon steel, aluminium alloy, polypropylene and a considerable amount of copper –for induction coils and power cables- and electronics. A detailed Bill of Materials of an induction hob system is shown in (Favi et al, 2018). Focusing on electronics, they fundamentally are resistors, inductances, capacitors, transistors and microcontrollers, attached on top of printed circuit boards (PCBs). A detailed inventory of the materials used in such PCBs can be seen in Elduque et al (2014).

In terms of energy efficiency, induction hobs tend to have very fast response and better performance than the rest of technologies, particularly during heat up, as the pan is heated directly and energy is not wasted heating the cooker itself. During subsequent cooking, the difference in energy consumption is slightly lower, as the hob does warm up a little due to heat losses from the induction electronics and conduction of heat away from the pot to the hob surface. Certain energy losses happen as well from the induction electrical control circuitry that generates the medium frequency current applied to the coil. These occur during heat up at full power and during simmering. Furthermore, as technological development advances, overall efficiency of induction hobs keeps improving.

However, it needs to be taken into consideration that induction hobs are more complex, in terms of number of parts and technology, than conventional electrical or gas hobs. This may lead to shorter lifetimes than other hob technologies (more similar to other consumer electrical products). Another drawback is that the performance is affected by the material of the pot, which needs to be compatible with the induction technology.

4.2.4.5 Technology area 5: Smart and connected hobs

A smart hob is broadly understood as a cooktop with a built-in Wi-Fi module that can be synchronised with an application managed from a portable device such as a smartphone or tablet. The benefits of a smart hob are very similar to those of a smart oven and can be summarised as it follows:

- A connected hob may have access to an extensive database of recipes. The user may select a recipe from the database and load it onto the device, which automatically sets the right temperature and timing for the selected dish.
- A connected hob can be manipulated from an application on a smartphone or tablet, making it easier for the user to access the functions and basic settings. It is worth noting that, unlike ovens, cooktops are not designed to be left unattended and the cooking process must be monitored at all times. The goal of a connected hob is not to be managed remotely.
- A connected hob may be also operated via voice control devices. While the user is preparing other food in the kitchen, the hob may be turned-off via voice command, without the need of approaching the cooktop or touching the controls. This may help reduce cooking time and also avoid leaving fingerprints on the surface.
- A connected hob with a failure may send a notification to the user when it detects something is not working properly, and can also be diagnosed remotely. With remote diagnosis, customer service can obtain online access to the device, identifying the cause of any problems and giving advice on what needs to be done.

4.2.5 Best Available Technologies in domestic hobs

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic hobs are investigated. Data for this investigation will be taken from TopTen database.

In terms of domestic hobs, Topten provides data only regarding induction hobs, so no comparison can be made with other electric or gas hobs. The list of most efficient induction hobs is provided in terms of energy consumption per kg of water, according to a criteria set that is regularly updated. The energy consumption of the 37 models listed in TopTen database are displayed in Figure 174.

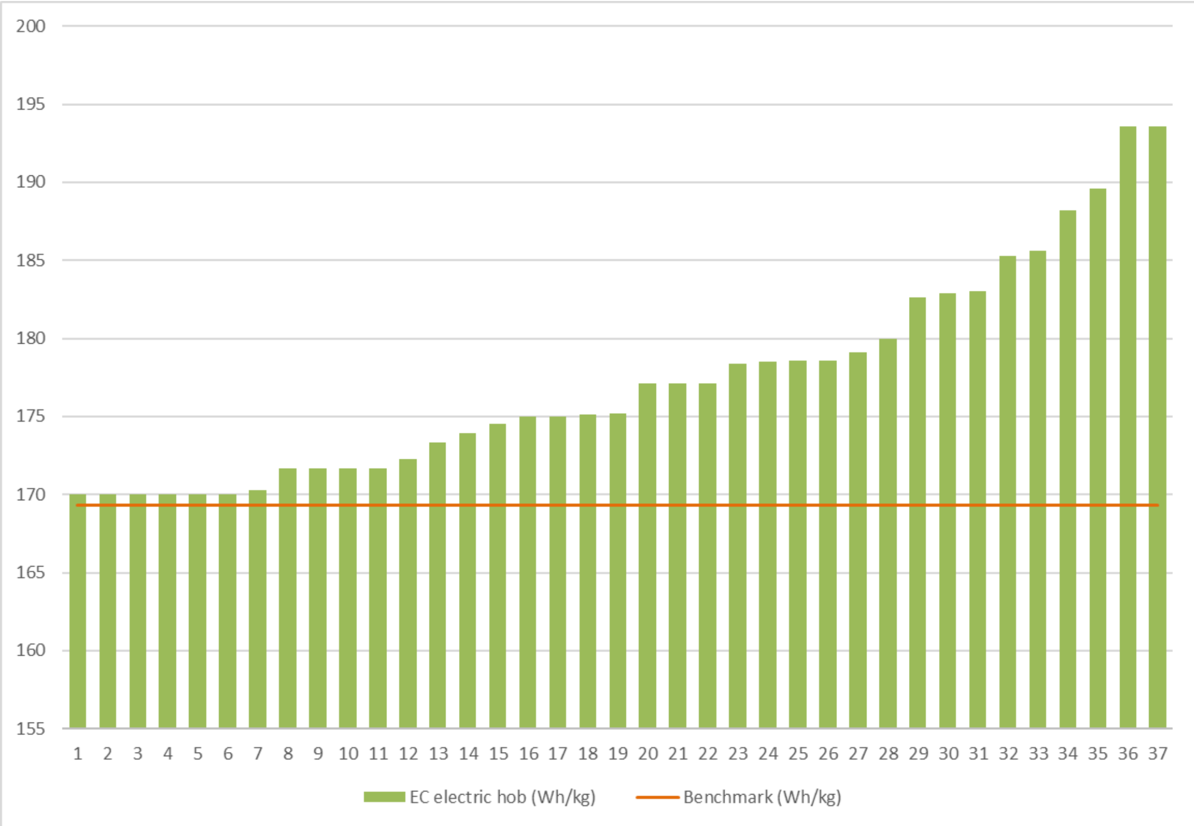


Figure 174. Energy consumption of induction hob models presented on www.topten.eu in January 2020

As it can be observed, only six models are close to the benchmark set by Regulation 66/2014 (169.3 Wh/kg). There is only a 14% difference in terms of energy consumption between the worst and the best performing models of the database (193.6 versus 170 Wh/kg).

Apart from the data provided by TopTen, manufacturers shared the range of energy consumption that the three types of electric hobs (solid plate, radiant heater and induction) typically perform (Figure 175). In a red line, the ecodesign limit for energy consumption after 2019 is displayed (195 Wh/kg).

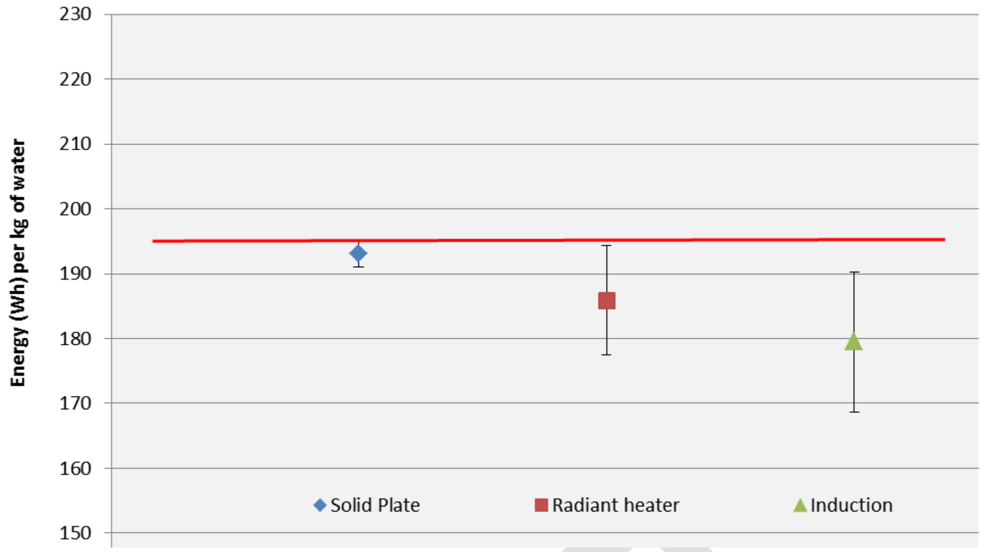


Figure 175. Energy consumption ranges of electric hobs (APPLIA)

From the analysis of Figure 175, it can be concluded that **Best Available Technology (BAT) for domestic hobs is induction**. It can also be seen that the range of energy consumptions that solid plates can provide are very close to the minimum requirements of ecodesign regulation.

As it can be seen in Figure 175, there is a small difference between the energy consumption of the three technologies under comparison. This is one of the main reasons for not having an Energy label on domestic hobs.

4.2.6 Best Not Available Technologies in domestic hobs

In this section, the Best Not Available Technologies (BNAT) in terms of energy efficiency for domestic hobs are investigated. Data for this investigation will be obtained from scientific literature and feedback from industry and stakeholders.

From the analysis of scientific literature, there is no obvious technology for domestic hobs, currently not available in the market, which could improve drastically energy efficiency in the near future. Feedback from manufacturers also points at the fact that there are no significant technology developments expected in terms of energy efficiency for the upcoming years. In their view, as it happens for ovens, the biggest potential for energy efficiency improvement is more related to user behaviour than to the actual appliances. Best practices for energy savings when cooking with hobs have been mentioned in Task 3 of this report.

Also according to stakeholders, cookware used has a very significant influence on the energy efficiency of the appliance. A very energy efficient appliance can deliver a very poor performance in terms of energy consumption if an inappropriate or low quality cookware is used.

The most significant technology development in the near future regarding hobs may be related to changes in terms of uses of gas. This is explained in more detail in the next sub-section.

4.2.6.1 Hydrogen as an energy source for domestic appliances

Currently, there is a growing interest in understanding how hydrogen-based technologies could contribute in the decarbonisation of heat supply sector for households (either for cooking or warming). A manufacturer highlights that the replacement of the current gases of fossil origin (like natural gas or butane) by “green gases” (like biomethane or hydrogen), will be a trend in the future. Consequently, appliances such as gas hobs and ovens will have to adapt to these new gas mixtures, keeping a high level of safety, reliability and performance.

Domestic cooking appliances industry seems to be in an immature state on the adaptation to the use of hydrogen as an energy source**.** Some research indicates that hydrogen technologies for these purposes might be economically and technically feasible (H21, 2019).

For the coming years, according to Frazer-Nash (2018) there are three options for the adoption of hydrogen as an energy source:

a) Developing new appliances from scratch, which would use only hydrogen as a fuel. This offers the freedom of designing and optimising a new solution, with the associated challenges of rolling out a completely new product.

b) Adapting existing appliances, currently running with natural gas, to run on hydrogen. This option could soften the challenges of a completely new roll-out, but would also come with technical and operational issues.

c) Developing dual fuel appliances, capable of operating on natural gas and hydrogen.

c1) in one case, it would mean appliances being able to use both fuels for their whole life cycle

c2) in a second case, it would mean appliances designed to be used first with natural gas, and then with hydrogen when surrounding infrastructure is ready. In this case, it would require certain components to be changed at the point of switchover from natural gas to hydrogen.

Manufacturers associations disagree with some of the statements presented in Frazer-Nash (2018). For instance, they highlight that **one gas appliance will never be able to switch from natural gas to pure hydrogen without any adaptation**. Gas controls or burners designed to work with natural gas cannot work directly with hydrogen. Switching from natural gas to hydrogen would mean challenges in several areas of the cooking appliances sector, mainly around combustion, heat transfer, controls, piping, seals and casings.

According to a stakeholder, the characteristics of biomethane are similar to natural gas, so burners would not require severe adaptations for that energy source. However, the situation is more complex in the case of hydrogen-natural gas blends, since they would have significant effects on the characteristics of the combustion (such as flame velocity or Wobbe index). Gas appliances may then require design adaptations and other control strategy operations, depending on the percentage of hydrogen in the blend.

Preliminary work on the impact of hydrogen on appliances is unfinished and works on the integration of H2 in gas standards has just begun: currently, the Sector Forum Gas Utilisation ad hoc group on H_2 is just beginning to list gas standards that will be impacted by hydrogen. No standard for domestic gas appliances has been updated to take into account an excess of hydrogen in the natural gas. Even the TC238, in charge of defining test gases has not been able to define new test gases because no maximum percentage of hydrogen in the distributed gas has been decided. On the pure hydrogen side, the BSI has not finished working on the pre-standard PAS 4444.

A recommendation from this stakeholder is to work on a progressive and voluntary approach (instead of a compulsory requirement) concerning the ability of gas burners to operate with blends gases. The favoured option would be **the use of a specific pictogram on the equipment (and its energy label) illustrating its possible operation with a minimum rate of X% of hydrogen in natural gas**. They also recommend an objective of 20% of H2 in 2030. Furthermore, the same principle could be implemented for pure hydrogen, with a voluntary specific pictogram such as "100% H2 ready".

Other stakeholders recommend consider that, although hydrogen quickly rose on the political agenda as an easy way to decarbonise energy systems, it is rather far from being a clean solution. Hydrogen has potential only if it is produced from the excess renewable electricity that would otherwise be curtailed, and if it is then used in sectors where direct renewable electrification is not possible. In their view, **hydrogen should not be considered as an energy source in sectors other than heavy industry and transport**.

As a summary from this section, it can be concluded that although hydrogen is a promising technology for domestic gas cooking appliances, technologies in this sector are currently not mature for operation with neither hydrogen blends or pure hydrogen. Further research is required to ensure that appliances using hydrogen perform at the same level of their natural gas counterparts, both in terms of performance and safety. In addition to that, standards need to be updated and developed. All these tasks are out of the time frame of this preparatory study.

4.3 Domestic cooking fume extractors

4.3.1 Technical product description: cooking fume extractors

Cooking is a significant source of indoor pollutants. Fumes generated during cooking processes usually comprise sub-micrometer-sized particles, such as oil droplets, combustion products, steam and condensed organic pollutants (Abdullahi et al, 2013). Exposure to cooking fumes has been recognized to cause adverse health effects. As an example of, the World Health Organization (WHO) recommends that mean PM2.5 concentrations in ambient air (including indoor environment) are less than 10 µg/m3 per year and 25 µg/m3 per day. Minimizing the presence of those pollutants in kitchens is the fundamental reason to use cooking fume extractors.

A cooking fume extractor can be defined as an appliance hanging above the cooktop in the kitchen which uses a blower to collect steam, smoke, fumes and other airborne particles that may be generated while cooking. Its main purpose is therefore to control smoke and odours that are associated with cooking at the stove.

Using a cooking fume extractor is not the only strategy that can be used to remove pollutants from cooking. Natural ventilation –also known as infiltration- can help to reduce those pollutants in households. However, it has been estimated that 98% of houses (in England) are too airtight to provide sufficient infiltration to dilute PM2.5 emissions from cooking to be below the WHO guidelines. It is not desirable to increase infiltration because it is positively correlated with heating energy demand, and current policies seek to improve energy performance of housing stocks. Therefore, controlled ventilation is required in kitchens to mitigate against negative impacts on occupant health from cooking (O'Leary et al, 2019).

The extraction system of a cooking fume extractor consists of a centrifugal blower composed on an conveyor, a fan and an electric motor, both housed inside a scroll (Figure 176). The energy is provided to the exhausts to expel the fumes.

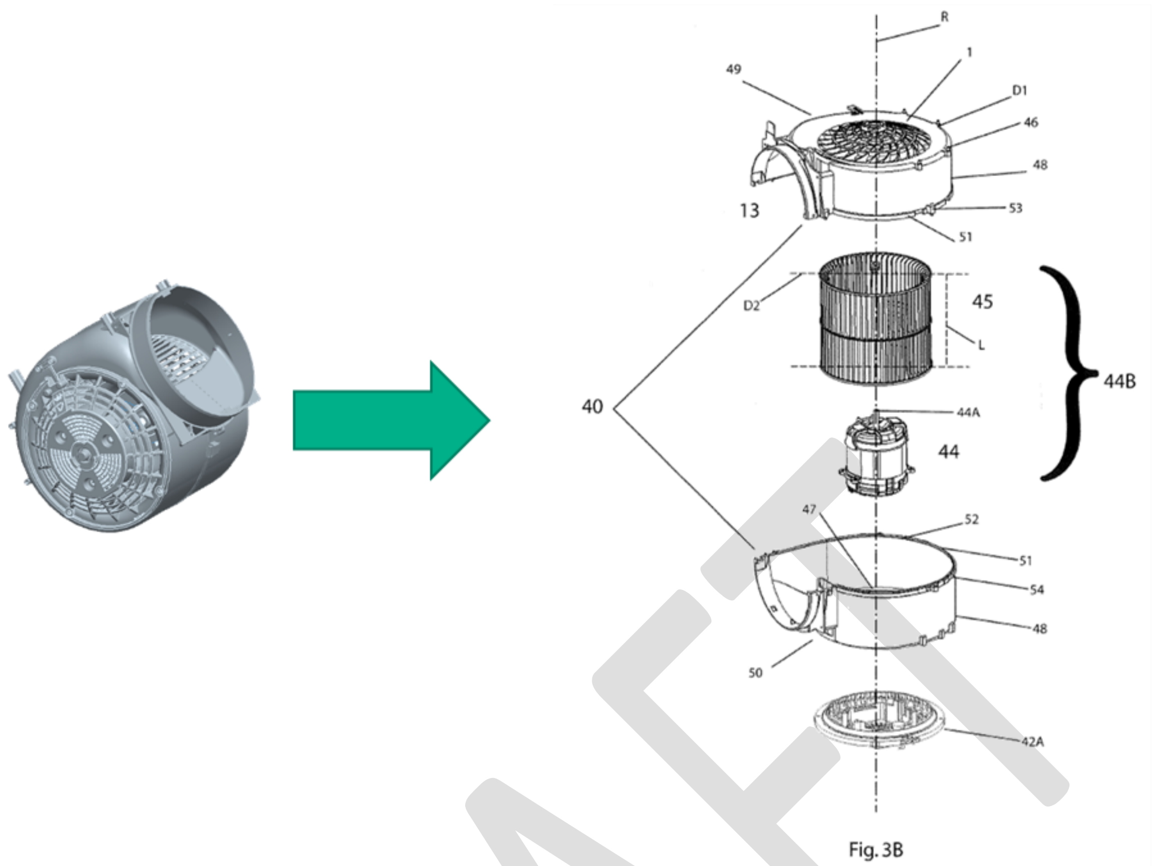


Figure 176. Illustration of a blower and its three components (APPLIA)

The system can work in multiple conditions of airflow rate, velocity and pressure (Bevilacqua, 2010). Generally, cooking fume extractors are manufactured with a combination of stainless steel, copper, bronze, nickel, zinc, tempered glass, aluminium, brass and heat resistant plastics. The main components of a cooking fume extractor are:

- Filters, which are the elements of the cooking fume extractor that capture the impurities when the cooking appliance is in operation
- Fans, which provide an active pressure gradient for ventilation
- Lighting, which provide a illumination onto the cooking area

Due to their predominantly visible location in kitchens, cooking fume extractors are increasingly seen not only as an appliance, but more as a piece of furniture. This is the main reason why a market for decorative hoods has been growing in the past years. Some hoods are also being offered with the ability to hold tools and objects, distributed on different levels. They may include hooks, shelves and even electrical outlets and USB ports capable of charging electronic devices (Di Meo, 2018).

4.3.2 Basic product types

Depending on the characteristics of the main components, domestic cooking fume extractors can be classified in different ways. Considering their ventilation system, cooking fume extractors can be either ducted or ductless. In ducted systems (also known as air-extraction cooking fume extractors), the output collar of the extractor hood's blower motor is attached to a ducting system which terminates outside of the building. The cooking fumes are pushed through the duct-work to the exterior of the building and vented outside (Dooley, 2019). This is the most common configuration in European kitchens, as they tend to be more efficient in the removal of airborne contamination and they eliminate the need for regular replacement of filters. However, ducted systems require a more complex installation as they need more ducting and venting elements. This limits the areas where such a configuration can be installed, which could be impractical if lack of space in the kitchen is an issue (Gannaway, 2015).

On the other side, ductless cooking fume extractors (also known as recirculating cooking fume extractors) make use of a strong air filtration system and then pump out the air back into the room. The fumes are therefore pushed through filters that remove odour and smoke particles from the air before venting it back into the kitchen. In this configuration, the use and periodical replacement of filters is essential. Recirculating heat and moisture into the kitchen might cause increasing the levels of humidity in the kitchen fairly quickly. It is worth taking into account that filtering might not be 100% effective, so odours might not be completely removed in ductless hoods. Moreover, ductless hoods tend to be noisier, as they often require more fan power, due to the fact the air stream is introduced in the internal ambient. However, ductless systems have the advantage of versatility: since they need fewer amounts of ducting and venting elements, they require a simpler installation and can be placed in more locations within the kitchen.

As already mentioned in Task 1 of this report, recirculating cooking fume extractors are currently out of the scope of ecodesign and energy labelling regulation, mostly due to their low market share and the lack of a standard to compare their performance to extraction cooking fume extractors. However, some stakeholders disagree with this reasoning and **support the inclusion of recirculating cooking fume extractors into the scope of new regulation**. To overcome the lack of standard, they also recommend the **development of a test that enables their rating and the comparison to models that operate in extraction mode, and even with models that are part of a central ventilation system**. The comparison should include the evaluation of energy consumption for additional air tempering when cooking fume extractors operate in extraction mode (this topic will be developed further in Section 4.3.3.3).

In terms of installation method (Figure 177), cooking fume extractors can be defined as:

- Built-in: hoods are built into or concealed within a cupboard or fitted kitchen so they are less noticeable to the eye.
    - Under cabinet, when it is mounted underneath of the cabinets which are positioned above the stove. This is one of the most common and compact options: the design of the venting system is simple; it is versatile enough with almost any kitchen style and tends to save some wall space.
    - Built-in means an under cabinet hood fully integrated in the kitchen cabinet.
    - Telescopic means an under cabinet hood fully integrated in the kitchen cabinet and one of the grease filters slides out of the cabinet. .
    - T-shape hood and chimney hood, when it is attached to the wall above the cooktop. In this case, the cooking fume extractor is installed instead of a cabinet in the space over the stove. They often come with a chimney that helps with ventilation, typically venting out through an exterior wall behind them. This configuration can serve as a design element in the kitchen.
    - Vertical hood, when the hood is installed vertically almost in parallel to the wall.
    - Island mounted or suspended, for kitchens where the cooktop is located on an island or not against a wall. This is the configuration generally used for larger, professional style cooktops, in order to handle the extra output.
    - Downdraft, when the cooking fume extractor is kept inside the cook space, integrated into the worktop and hidden away until it is used. According to manufacturers, their

main advantage is that they eliminate steam and odour right at the source. This is a less common configuration, a good solution for kitchens with limited space and when maintaining a clear sightline is a priority.

- Downdraft integrated, as already described in previous section regarding air venting hobs. This is an appliance that combines cooking fume extractor and hob –usually induction- in just one. The working principles are similar to a downdraft hood.

- Ceiling mounted, when the hood is installed directly into the ceiling. The configuration is similar of that of an island mounted hood, but in this case the result is a completely smooth surface rather than a hanging appliance in the centre of the kitchen.

Figure 177. Types of cooking fume extractors in terms of installation (pictures provided by APPLIA)

Cooking fume extractor are equipped of two types of filters, depending on the installation:

- The grease filter protects the hood by retaining grease particles. It is present in all cooking fume extractors regardless their installation.
- The activated charcoal filter which is used in recirculating hoods only, captures and retains air odorous particles.

There are different grease filters, such as aluminium filters (the most common ones), stainless steel filters, steel filters and paper filters. Paper filters need to be replaced once a month while metal filters must be cleaned once a month using mild detergents, either hand-washed or in the dishwasher at low temperatures and short cycle. This cleaning may fade the metal grease filter though the filtering performance is not affected.

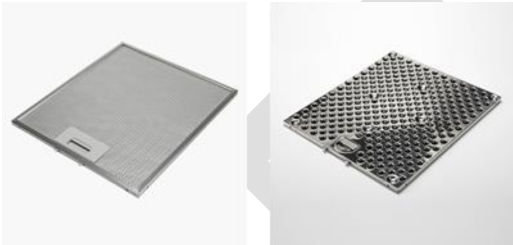


Figure 178. Grease filters (APPLIA)

Charcoal filters contain a fine powdered activated charcoal material, mounted in a honeycomb structure. Activated charcoal is a carbon-based compound that has been treated with oxygen to make it very porous. Impurities that are attracted to carbon become absorbed through the pores of the mineral and are kept trapped inside. These filters are used in ductless configuration for filtration of odours. They cannot be cleaned, so need to be replaced approximately every 3 or 4 months. If the charcoal filter is not regularly changed, a significant decrease of indoor air quality can be expected.

Figure 179. Charcoal filters (APPLIA)

According to stakeholders feedback, the most common cooking fume extractors that could be considered base cases have the features shown in Table 40:

Table 40. Typical features of most common cooking fume extractors

Ventilation (ducted/ductless)	ducted
Airflow rate MAX (m3/min)	700 - 800
Airflow rate MIN (m3/min)	260 - 300
Noise at Airflow rate MAX (dB(A))	66 - 73
Noise at Airflow rate MIN (dB(A))	40 - 60
Installation (under cabinet/wall/island/downdraft/ceiling/integrated with hob)	cabinet / wall
Type of filter (mesh/baffle/charcoal/none)	mesh
Lighting (LED/other/none)	halogen / LED
Lighting power (W)	3 - 40
Grease Filtering Efficiency (%)	70 - 90
Smart features (remote control & diagnosis/voice activation)	remote control and diagnosis
Packaging materials (list of materials)	Cardboard, wood, EPS, foil
Mass (kg)	8.3 -21
Annual energy consumption (kWh/year)	36 - 68

4.3.3 Energy Efficiency in cooking fume extractors

4.3.3.1 Current approach

Current approach of measuring Energy Efficiency Index and Fluid Dynamic Efficiency of cooking fume extractors is based on the Best Efficiency Point (BEP) of the appliance. BEP of cooking fume extractors is generally found at maximum operating speeds, therefore the standard requires to test at the highest speed available in the appliance. FDE curve in Figure 180 (extracted from EN 61591) represents fluid dynamic efficiency when the cooking fume extractor works with its maximum speed.

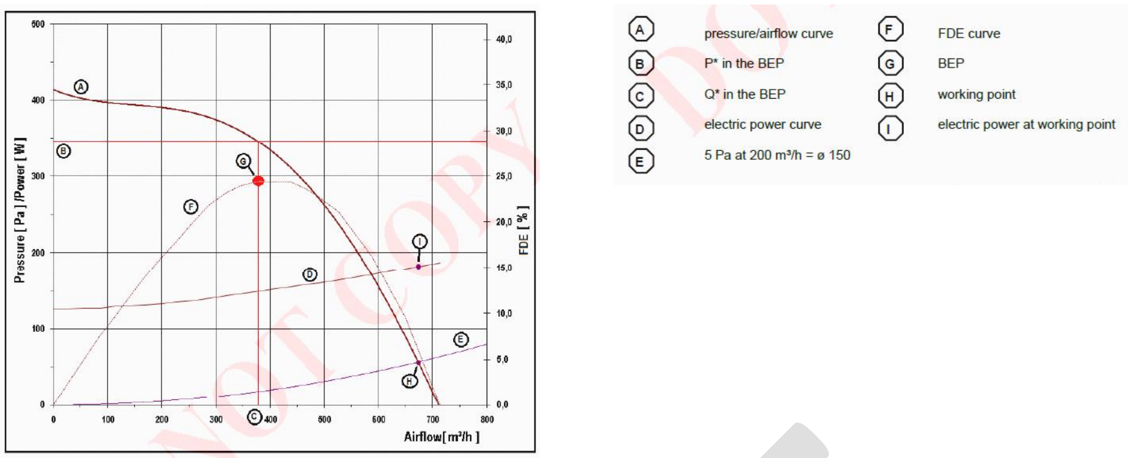


Figure 180. FDE measurement at Best Efficiency Point (EN 61591)

The FDE curve is obtained by changing the pressure drop in the installation, providing different airflow (Q) and power (W) values (minimum 20 points to represent the curve). At each of those points, FDE is calculated as:

$$FDE = \frac{Q \ x \ P}{3600 \ x \ W} x100 \ (\%)$$

Then, the maximum value (point G) is identified in the curve (FDE_{BEP}), and similarly the values for Q_{BEP}, P_{BEP} and W_{BEP} are obtained. With this method, FDE_{BEP} is calculated with the same formula, at just one operating point of the appliance (point H in Figure 180).

As already detailed in Task 1 of this report, there is a real-life representativeness issue with the current method of calculating EEI and FDE. According to several stakeholders, current indexes are not reflecting real life usage, since they are based on measurements at the best efficiency point (BEP). Current method pushes manufacturers to increase energy efficiency of products, focusing on highest speeds of operation only. The result is that **the energy efficiency of the lower speeds is rather low and that cooking fume extractors with higher airflow rates tend to obtain better energy classes** (also observed in Task 2 of this report).

Moreover, market analysis shows that cooking fume extractors are used at all available speeds and not only at maximum speeds. In fact, most common uses are intermediate and slow speeds. Therefore, with current approach, cooking fume extractors are being awarded their energy class based on an airflow rate (or working speed) that does not correspond to their most common use. Stakeholders suggest **to review the method for the calculation of EEI to be more consistent with typical user behaviors** and so taking into consideration all the speeds declared in the product fiche.

In response to this real life representativeness issue, a new method to calculate FDE is currently under development by CENELEC (commonly used as the 9-point method), described in more detail in next section.

4.3.3.2 The 9-point method

A new method to calculate FDE has been proposed, based on an average of 9 points: 3 different pressures at 3 different settings, rather than using the Best Efficiency Point (Figure 181). The test settings are identical, but in this case more measurements are taken into account.

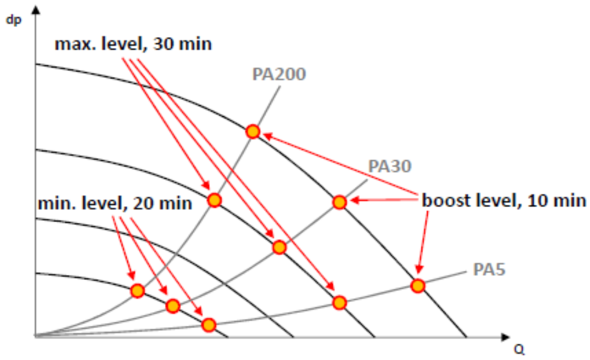


Figure 181. Graphic description of 9 point method

The main differences of the new method are that:

- Instead of setting the cooking fume extractor only at its maximum speed, it is now set at 3 different speeds.
- Instead of setting the cooking fume extractor only at 1 pressure value, it is now set at 3 different pressures
- Therefore, a total of 9 working points of the appliance are considered.
- Instead of calculating only 1 value of FDE (FDE_{BEP}), 3 different FDE's are calculated (one for each speed).
- FDE of the appliance ($FDE_{cooking\ fume\ extractor}$) is calculated by weighing the 3 different speeds according to how often those speeds are used.

The main benefits of this method is that FDE is calculated at different blower levels and at user relevant operating points, therefore it prevents the optimization at a non-relevant point. Moreover, the differences between the blower technologies (see Section 4.3.5.2) become more visible.

Based on feedback received from different stakeholders, **there is a general consensus that moving from the current method to the 9 point method will be a positive aspect**.

4.3.3.3 The inclusion of energy consumption of heating/cooling replacement air

Another issue brought up by some stakeholders regarding current methods for measuring EEI is the fact that it only takes the direct energy consumption of the cooking fume extractor into account. When a hood is operated, it removes air from the kitchen that needs to be replaced with air from the exterior (replacement air). This air will need to be either cooled or heated by the heating system of the household. The energy consumption of the heating system is a direct consequence of the cooking fume extractor usage, therefore some stakeholders consider should be reflected on the energy label.

Their recommendation is that, beyond Annual Energy Consumption, **the EEI should also take into consideration the indirect Annual Heating/Cooling Consumption**. The weighing between those two elements should be determined carefully, as well as the way of taking into account the different climate zones. This proposal has been explained in detail in the document "Standards for testing cooking fume extractors based on odour reduction" (DTI, 2019). According to them, the inclusion of energy required for tempering replacement air would make cooking fume extractors more comparable in terms of their installation characteristics: extraction, recirculation and connected to central ventilation systems (Figure 182).

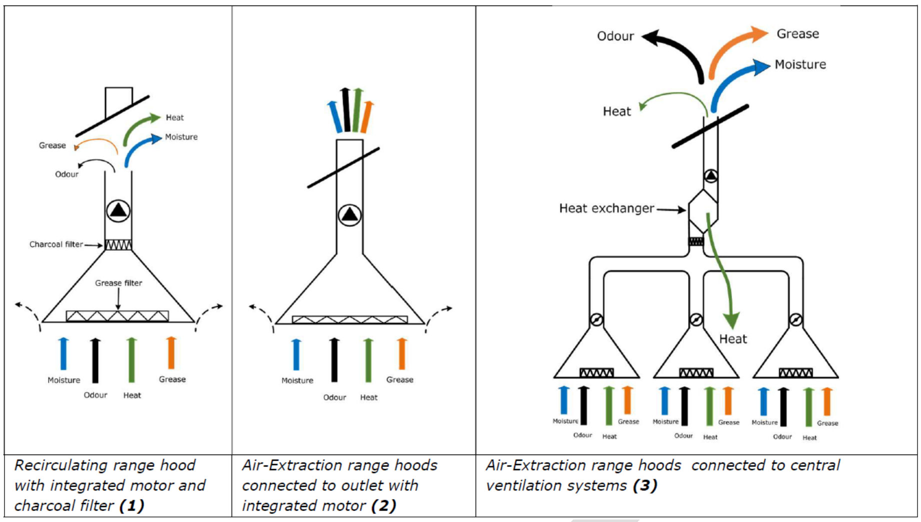


Figure 182. Types of cooking fume extractor installations (Blomqvist, 2019)

Manufacturers generally disagree with this proposal, arguing that **energy efficiency of a product should not depend on external factors, such as heating/cooling systems or ventilations systems**, since it would discourage any technological progress within the reach of manufacturers and product designers.

4.3.4 Capture efficiency in cooking fume extractors

Several stakeholders indicate that the current approach for measuring energy efficiency of cooking fume extractors (based on annual energy consumption and fluid dynamic efficiency) is not sufficient and that **capture efficiency should be taken into account in some manner**. Capture efficiency can be defined as the ability of a cooking fume extractor in collecting products of cooking activities (CEC, 2012). It quantifies the fraction of generated pollutants removed either directly or over the duration of exhaust fan operation. As a general rule, it can be calculated as:

$$Capture\ efficiency = \frac{Contaminant\ produced\ at\ source - Contaminant\ escaping\ from\ hood}{Contaminant\ produced\ at\ source}$$

Capture efficiency is a function of different parameters such as airflow rate, installation height, hood capture volume and fraction of cooktop covered by the hood, among others (O'Leary et al, 2019). As it depends on a wide variety of factors and there is no harmonised standard to calculate it, current capture efficiency of cooking fume extractors is unknown. According to Dobbin et al (2018), it can vary between 12% and 98%.

There are different ways in which capture efficiency could be evaluated for cooking fume extractors. One of the most commonly supported by different stakeholders is related to the capacity of removing odour.

4.3.4.1 Odour reduction factor

Odour reduction factor is considered as a good approximation of cooking fume extractor capture efficiency for some stakeholders. According to them, current regulation focuses exclusively on the hydraulic power of the hood but not on the primary function: the odour reduction. Therefore, the cooking fume extractor is only described as a fan and not as a tool for capturing cooking odour from the kitchen, as the requirements only focus on how much electrical energy is used to move the air. In data provided by Danish Energy Agency (Figure 183) it can be seen that increases in airflow rates often lead to marginal increases in the function of the cooking fume extractor: odour reduction. As it can be seen, odour reduction increases minimally for airflow rates above 500 m3/h, which could present an issue of excessive energy consumption without improvement in functionality.

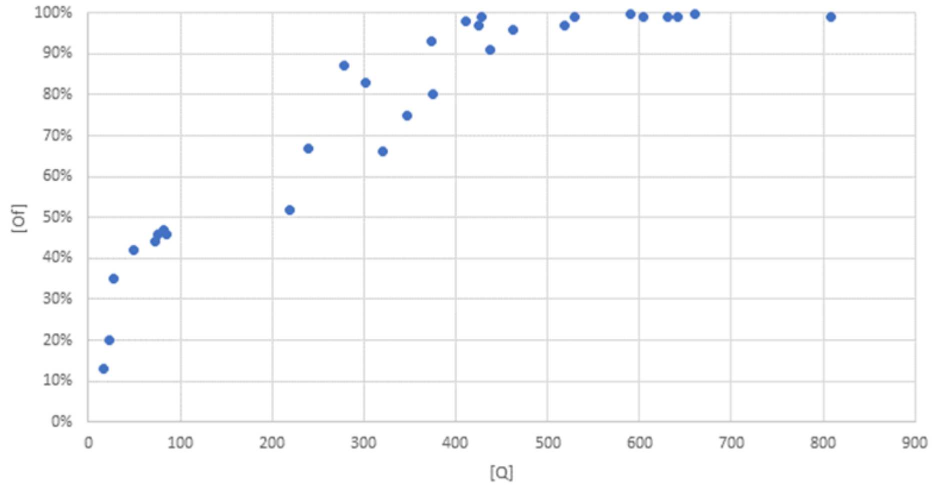


Figure 183. Odour reduction factor versus airflow rate (provided by DEA)

One of the main reasons argued not to consider odour removal efficiency in current regulation is that available standards were not sufficiently robust. To overcome this, DTI (2019) have developed **a** proposal to incorporate the odour reduction factor (Of) into the Annual Energy Consumption formula, so that both energy consumption and odour removal are considered when measuring EEI. EN-61591 indicates how odour reduction factor of a cooking fume extractor can be measured. As already explained in Task 1 of this report, it is based on the usage of the substance MEK. In their study, DTI suggest a slight modification to the way Of is calculated in the standard.

Another reason provided by manufacturers not to include odour removal in energy labelling for cooking fume extractors is the fact that this parameter is directly related to the filter installed in the appliance. Normally, filters are not included when the cooking fume extractor is purchased by the consumer, but at the moment of installation. Also, when filters are replaced, consumer may purchase a filter which is not from the same manufacturer as the actual cooking fume extractor.

4.3.4.2 Particle removal

Related to capture efficiency, other stakeholders propose a different approach. EN-61591 defines an odour reduction efficiency, but since the test is performed at short distance between the hob and the hood, the capture efficiency is almost 100%, and thus the capture efficiency effect is not taken into account. That is the reason why they are **in favour of performing a real capture efficiency test and a separate odour filter test**. In the capture efficiency test, the distance between the hob and the hood would be dependent on the type of hood and the air would be extracted to the outside of the test room, also for recirculation hoods.

4.3.5 Technology areas: cooking fume extractors

4.3.5.1 Technology area 1: Fans

Blowers are typically equipped by one of these two types of fans (Figure 184), depending on the dimension and installation of the hood:

- Tangential fan with **two air inlets**. This type of fan can have different dimensions, and thus the hood can reach higher efficiencies, since the efficiency increases with its overall dimension.
- Radial fan with **one air inlet**. Due to the space limitation, under cabinet cooking fume extractors or cooking fume extractors with small dimensions are usually equipped with this type of fans. For this reason, efficiencies are usually lower.

- Tangential fan

- Radial fan

Figure 184. Illustration of types of fans (APPLIA)

4.3.5.2 Technology area 2: Electric motors

The key component that influences the energy efficiency and the price of the hood is the electric motor. Cooking fume extractors are equipped with one of these three types of electric motors: brushless, asynchronous capacitors and asynchronous shaded poles. The main features of these motors are described below:

- **Brushless motors**: they are components of high-end models that can reach energy classes between A+ and A+++. They perform high motor efficiencies, within the range of 70 and 85%. They are smaller and lighter than capacitor or shaded poles motors.
- **Asynchronous capacitor motors**: they are components of middle and high-end models that can reach energy classes between D and A+. They perform lower motor efficiencies than brushless motors, within the range of 55 and 70%.
- **Asynchronous shaded poles motors:** they are components of low-end models whose energy classes are between D and C. They perform the lowest efficiencies, within the range of 20 and 30%, and they are the most economical ones.

4.3.5.3 Technology area 3: Filters

Odour filters

Charcoal filters are usually disposable devices, however there are long life filters with a duration of 3 years. The charcoal filter is able to be regenerated by a cleaning and drying cycle every 2 or 3 months. The cleaning is done in the dishwasher at 65 ° or by hand with hot water and a neutral detergent. Then it is dried in the oven at 100 ° for 10 minutes.

A specific type of long life filter is the ceramic filter. In this case, the charcoal filter is mounted in a ceramic frame and can be thermally regenerated every 2 or 3 months in the oven at 200° for 45 minutes, reaching a maximum of 5 years of lifetime.

Plasma filters are an alternative to charcoal filters in recirculating cooking fume extractors. As explained earlier, active carbon filters retain cooking fumes particles and need to be replaced when they become saturated. According to manufacturers, plasma filters aim at removing all foreign particles from air by eliminating and not storing them in a filter (which eventually would need to be replaced). This technology, also known as non-thermal plasma (NTP) is a flexible electrical technique for exhaust air treatment. Typical features of an NTP are the acceleration of free electrons in an external electrical field, the formation of activated chemical species by collisions between electrons and gas molecules and chemical reactions of these species with other gas constituents, such as the cooking pollutants.

In a laboratory study, Holzer et al (2018) showed that the model substances as representatives for odorous organic compounds being produced in cuisine processes like roasting, baking and cooking can be completely eliminated by a homogeneous gas phase plasma. However, the relative large contents of CO and O_3 are not acceptable and require further treatment steps. Also, energy efficiency in the laboratory experiments is still too low for practical use, especially when running the system in a continuous mode. These limitations require further investigations.

According to some stakeholders, plasma filters might be in disadvantage when compared to other filtering technologies if the standard odour removal test EN 61591 is followed. As indicated in Task 1 of this report, this test is to determine how efficiently the carbon filter stores MEK molecules. This test is not intended for recirculation filters based on plasma and ionization. Also according to stakeholders, plasma filters have been used in certain applications of commercial products, where the extraction always is towards the exterior of the building. These filters are not appropriate for domestic environment as issues with Ozone generation may arise.

Grease filters

The basic principle of **centrifugal filters** is the use of centrifugal force for air cleaning. In these cooking fume extractors, cooking vapours are sucked through a narrow gap into extractor hood. Once inside, the vapours are accelerated and the flow is diverted in two bends which create centrifugal force. This force hurls fats and oils out of air. A subsequent integrated residue separator removes the finest particles of fat and traps them, allowing the air to escape clean at the end. According to stakeholder feedback, this technology is not common in the Europe and is mostly used in markets with significantly different cooking styles. They also have considerably lower efficiencies than conventional cooking fume extractors with filters.

4.3.5.4 Technology area 4: Downdraft cooking fume extractor

A downdraft cooking fume extractor is a ceramic or induction hob with an integrated extractor fan in the centre of the hob. They are designed to remove cooking vapours and lingering odours as soon as they appear, by drawing the air directly from the cooking vessel. Instead of sucking air up, downdraft cooking fume extractors have a cross flow which is greater than the rising speed of the cooking vapour, therefore they capture them before escaping around the kitchen area, creating a transversal flow (Corti, 2019). Downdraft cooking fume extractors are relatively new in the cooking appliances market, offering an alternative option to the traditional extraction methods. They are generally commercialized with high-end products such as induction cooktops.

There are downdraft cooking fume extractors with manual settings and others that tend to correct fan settings automatically without user input, regulating it continuously during the cooking process. There are models with the aspirator positioned in the centre of the cooktop (with a circular or rectangular grid) or versions which the extraction takes place through lateral slits (Figure 185).

Figure 185. Downdraft cooking fume extractor (Bora; Siemens)

Downdraft cooking fume extractors are complex appliances as they combine cooktops and extraction systems in one. This generally has an impact on price. Also, having the extraction system in the centre of the cooktop reduces the surface available for cooking. Additional space is also required below the cooktop, in order to locate the extraction and ventilation unit (Figure 186).

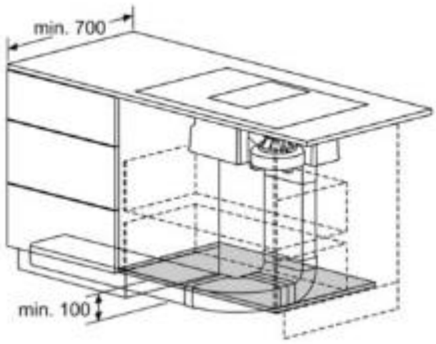


Figure 186. Downdraft cooking fume extractor installation diagram (NEFF)

The most direct advantage of a downdraft cooking fume extractor is that it combines two appliances in one: cooktop and cooking fume extractor. It makes a good use of space in the kitchen and has aesthetical benefits, particularly when the cooktop is placed on an 'island' in the middle of the kitchen, where placing a traditional cooking fume extractor would be difficult. However, this type of cooking fume extractor needs more suction power for the same ventilation results, as the fumes naturally tend to go up, and this could require more energy for the same results. They could be also noisier than typical hoods due to this increase in power demand.

4.3.5.5 Technology area 5: Smart and connected cooking fume extractors

A smart cooking fume extractor is broadly understood as a hood with a built-in Wi-Fi module that can be synchronised with an application managed from a portable device such as a smartphone or tablet. The benefits of a smart cooking fume extractor are similar to those of a smart oven or hob, and can be summarised as it follows:

- A connected cooking fume extractor may be connected to other cooking appliances such as the hob. When the system detects that food is being cooked, it automatically connects at the required airflow, depending on temperature and other factors. When cooking activity ends, the cooking fume extractor automatically switches off or remains in idle state.
- A connected cooking fume extractor can be manipulated from an application on a smartphone or tablet, making it easier for the user to access the functions and basic settings.
- A connected cooking fume extractor may let the user know when the grease or activated charcoal filter needs cleaning, changing or regenerating, providing tips and instructions on how to change it.
- A connected cooking fume extractor may send a notification to the user when it detects something is not working properly, and can also be diagnosed remotely.

4.3.6 Best Available Technologies

In this section, the Best Available Technologies (BAT) in terms of energy efficiency for domestic cooking fume extractors are investigated. Data for this investigation will be taken from TopTen database. Topten shows the availability of efficient cooking fume extractors, according to a criteria set that is regularly updated.

In terms of the different parameters shown in the energy label for cooking fume extractors, the appliances currently listed in the database are:

- Energy Efficiency: A, A+ and A++
- Fluid Dynamic Efficiency: A
- Lighting Efficiency: A

- Grease Filtering Efficiency: A, B and C

The energy efficiency classes (coloured dots, left axis) and grease filtering efficiencies classes (grey bars, right axis) of the 137 models listed in TopTen are shown in Figure 187.

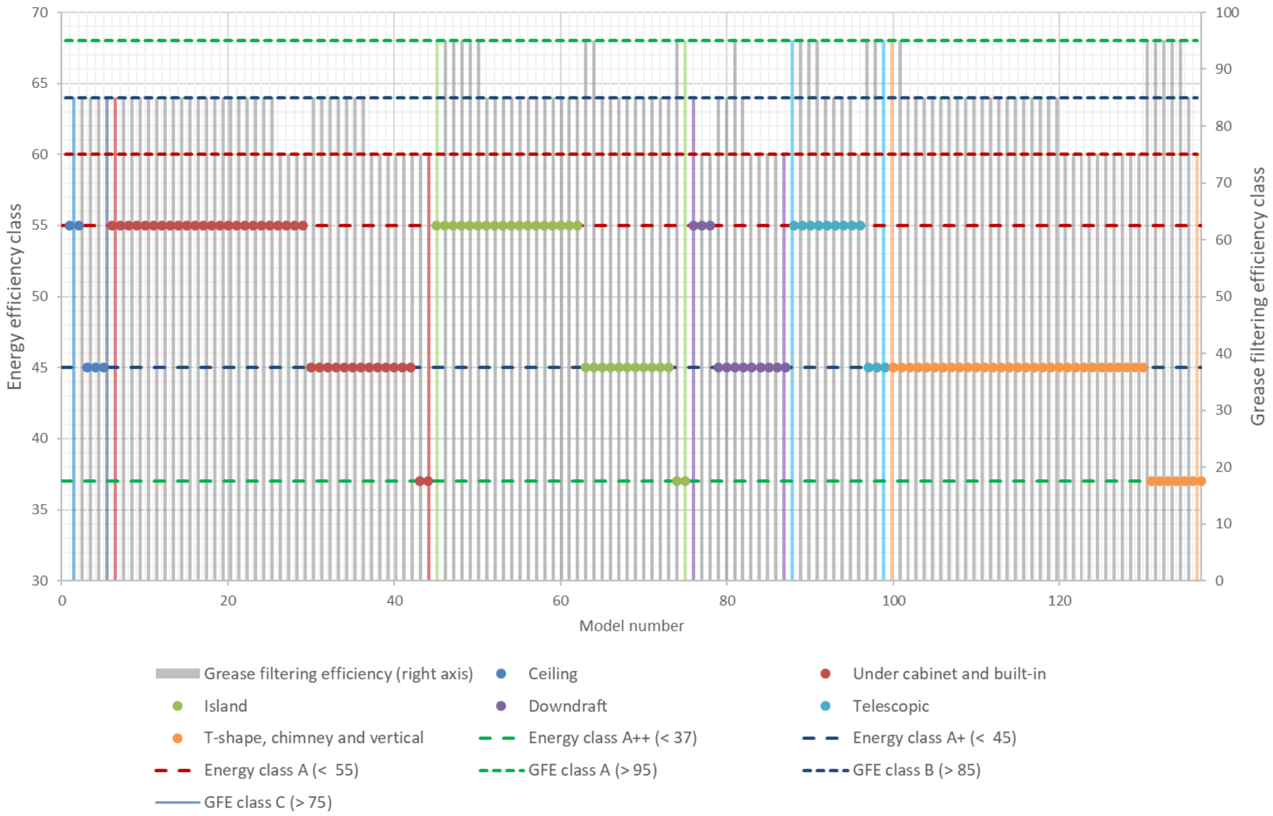


Figure 187. EEI and GFE of cooking fume extractors in Topten

The main findings from this analysis are:

- 11 models reach the Energy Efficiency Class A++
  - 2 are under cabinet
  - 2 are island mounted
  - 7 are chimney (wall mounted)
  - 0 are downdraft*

  *This contradicts the findings from Task 2, where best performing hoods were worktop vent (downdraft), while under cabinet did not reach good energy classes.

- From the 7 chimney A++ models:
  - 5 reach Grease Filtering Efficiency Class A

- From the 2 island mounted A++ models
  - Both of them reach Grease Filtering Efficiency Class A

- From the 2 under cabinet A++ models
  - Both of them reach Grease Filtering Efficiency Class C

In terms of mounting and Energy Efficiency, it could be concluded that it is easier to reach the top energy classes for wall mounted hoods. This could be related to the typically bigger size of wall mounted hoods compared to the other ones. A bigger cooking fume extractor can have a bigger and therefore more powerful electric motor, capable of reaching higher airflow rates, which is the significant factor to achieve higher energy classes.

In terms of Grease Filtering Efficiency, it could only be concluded that under cabinet cooking fume extractors reach lower energy classes than the other models, although the sample is too small to reach any significant conclusion.

As already explained in Section 4.3.5.2 of this report, the key component that influences energy efficiency and the price of a cooking fume extractor is the electric motor:

- Brushless motors: able to reach Energy Efficiency classes between A+ and A+++
- Asynchronous capacitor motors: able to reach Energy Efficiency classes between D and A+
- Asynchronous shaded poles motors: able to reach Energy Efficiency classes between D and C

From the analysis conducted on this section, it could be concluded that the Best Available Technology in terms of Energy Efficiency is a wall mounted cooking fume extractor equipped with a brushless motor.

4.4 Production, distribution and end-of-life of domestic appliances

Domestic cooking appliances under the scope of this study are products with high energy consumption in comparison to other home appliances. For that reason, from a life cycle assessment perspective, in the previous sections more focus has been put on the analysis of the use stage, which is where energy consumption contributes the most. The significant contribution of the use stage in the life cycle impact is confirmed in scientific literature in the case of ovens (Landi et al, 2018), gas hobs (Favi et al, 2018), induction hobs (Elduque et al, 2014) and cooking fume extractors (Bevilacqua et al, 2010).

Despite this preponderance of the use stage, other life cycle stages such as production, distribution and end of life also have their relevance, such as metal depletion potential or marine eutrophication potential (Landi et al, 2018). The relevance of end of life stage is even higher if Circular Economy principles want to be incorporated into future product design.

In this section, aspects affecting production, distribution and end of life are presented. Some of these aspects are product weight and materials, primary scrap production, packaging materials and volumes, means of transport and shipment, product lifetimes and waste material flows.

4.4.1 Aspects affecting production of domestic cooking appliances

4.4.1.1 Product weight and materials

When considering the impact of production and manufacturing, a product Bill of Materials is a key piece of information required to conduct a robust environmental and economic assessment. However, without access to data from manufacturers, it is usually difficult to find data available regarding mass and material breakdown of specific products. Even in LCA or LCC scientific literature, BoMs are usually published partially, providing only breakdown of materials in percentage, number of components, etc. For instance, in Magalini et al. (2017), an average material composition of kitchen appliances is published (Table 41), but it is not clearly specified whether it refers to a cooktop, an oven or an average of those and more kitchen appliances. In some other cases, only a list of materials (without masses or percentages) is provided.

Table 41. Average material composition of cooking appliances (Magalini et al, 2017)

Material	%
Aluminium	1.8
Copper	1.9
Copper + Aluminium	0.01
Electronics	0.51
Glass	14.4
Polyvinyl Chloride	0.19
Stainless Steel	19.5
Steel	54.3
Other plastics	1.7
Other	5.6

In this section, it is presented a summary of data available published in scientific papers regarding material breakdown of cooking appliances (ovens, hobs and cooking fume extractors).

A detailed BoM for domestic gas and electric ovens is presented in this section in Table 42 (gas) and in Table 43 (electric). Source of data is Landi et al (2019).

Table 42. Bill of Materials of gas oven (Landi et al, 2019)

kg of material	Cavity	Chassis	Door	Front panel	Hot air fan	Tangen tial fan	Packagi ng	Cables	Total
Galvanized steel	1.71	5.58	0.48	0.54	1.16	1.72	0.00	0.01	**11.20**
Enamelled steel	7.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**7.91**
Stainless steel	0.22	0.00	0.17	0.01	0.00	0.00	0.00	0.00	**0.40**
Nickel/Chrome alloy	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.02**
Ferrite	0.00	0.00	0.00	0.00	0.14	0.06	0.00	0.00	**0.21**
Aluminium	0.12	0.00	0.23	0.00	0.00	0.07	0.00	0.00	**0.43**
Glass	0.03	0.00	4.53	0.00	0.00	0.00	0.00	0.00	**4.56**
Glass fibre	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.40**
Rock wool	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.63**
Brass	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
Copper	0.02	0.00	0.00	0.01	0.12	0.08	0.00	0.05	**0.28**
Nylon	0.00	0.00	0.00	0.04	0.02	0.17	0.00	0.00	**0.22**

Polypropylene	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.02	**0.05**
Ethylene vinyl acetate	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	**0.02**
Magnesium	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.09**
Ceramic	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.03**
Glass fibre polyamide	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00	**0.39**
Polystyrene foam	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	**0.88**
Polyethylene low density	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	**0.29**
Other plastics	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.11	**0.16**
Total	**12.19**	**5.59**	**5.85**	**0.60**	**1.46**	**2.11**	**1.17**	**0.18**	**29.17**

Table 43. Bill of Materials of electric oven (Landi et al, 2019)

kg of material	Cavity	Chassis	Door	Front panel	Hot air fan	Tangen tial fan	Packagi ng	Cables	Total
Galvanized steel	0.97	5.63	0.48	0.26	1.02	1.72	0.00	0.01	**10.10**
Enamelled steel	8.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**8.82**
Stainless steel	0.41	0.00	0.17	0.45	0.00	0.00	0.00	0.00	**1.03**
Nickel/Chrome alloy	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.05**
Ferrite	0.00	0.00	0.00	0.00	0.13	0.06	0.00	0.00	**0.19**
Aluminium	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	**0.23**
Glass	0.03	0.00	4.53	0.00	0.00	0.00	0.00	0.00	**4.56**
Glass fibre	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.40**
Rock wool	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.63**
Brass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Copper	0.00	0.00	0.00	0.01	0.10	0.08	0.00	0.00	**0.19**
Nylon	0.00	0.00	0.00	0.05	0.01	0.17	0.00	0.00	**0.23**
Polypropylene	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	**0.02**
Ethylene vinyl acetate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Magnesium	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.20**
Ceramic	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.00	**0.05**
Glass fibre polyamide	0.00	0.00	0.39	0.04	0.00	0.00	0.00	0.00	**0.43**
Polystyrene foam	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Polyethylene low density	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	**0.29**

Other plastics	0.00	0.00	0.06	0.03	0.00	0.00	0.84	0.11	**1.04**
Total	**12.55**	**5.63**	**5.85**	**0.87**	**1.26**	**2.03**	**1.13**	**0.12**	**29.44**

In Favi et al (2018), a BoM is provided for gas and induction hobs. A list of assemblies, components, quantities and materials is provided for both types of hobs. No mass data is presented. Table 44 contains data on gas hobs and Table 45 on induction hobs.

Table 44. Bill of Materials of gas hob (Favi et al, 2018)

Assembly name	Component name	Quantity	Material
Hob grill	Grills	2	Carbon Steel
	Rubber feet	8	Synthetic rubber (EVA)
Flame spreaders	Ausiliario	1	Aluminium alloy
	Semirapido	2	Aluminium alloy
	Rapido	1	Aluminium alloy
Caps	Ausiliario	1	Carbon Steel
	Semirapido	2	Carbon Steel
	Rapido	1	Carbon Steel
Main bodies	Ausiliario	1	Aluminium alloy
	Semirapido	2	Aluminium alloy
	Rapido	1	Aluminium alloy
Gas taps	Main body	4	Aluminium alloy
	Valve body	4	Copper
	Nut	4	Brass
	Bottom brackets	4	Aluminium alloy
	Screw TORX M4x8	16	Carbon Steel
	Cable clips	4	PA (Nylon)
	Tap brackers	4	Carbon Steel
Thermocouples	Probe	4	Chrome (90%Ni - 10%Cr)
	Body	4	Copper
	Cables	4	Wire (Copper). Insulation/Jacket (PVC)
Spark plugs	Spark plug	4	Ceramic

	Cables	4	Wire (Copper). Insulation/Jacket (PVC)
	Spring	4	Carbon Steel
Metal plate	Plate	1	Stainless Steel
	Screw TORX M4x8	8	Carbon Steel
	Caps	6	PA (Nylon)
	Plate protection	1	Carbon Steel
	Brackets	4	Carbon Steel
	Screw M2.9 x 16	8	Stainless Steel
Knobs	Knobs	4	Acrylonitrilebutadiene-styrene (ABS)
	Reinforcement	4	Carbon Steel
	Metal inserts	4	Aluminium alloy
	Rubber feet	4	Synthetic rubber (EVA)
Piping	Main hose	1	Carbon Steel
	Screw TORX M4x8	3	Carbon Steel
	Rapido hose	1	Aluminium alloy
	Semirapido hose	2	Aluminium alloy
	Ausiliario hose	1	Aluminium alloy
Electric cables	Electric cable	1	Wire (Copper). Insulation/Jacket (PVC)
	Bands	1	PA (Nylon)
	Transformer cable	2	Wire (Copper). Insulation/Jacket (PVC)
	Transformer	1	Different materials

Table 45. Bill of materials of induction hob (Favi et al, 2018)

Assembly name	Component name	Quantity	Material
Glass-ceramic top	n/a	1	Glass-ceramic
Support brackets	n/a	7	Stainless Steel
Bottom plane	n/a	1	Carbon Steel
Electronic board housing	n/a	1	Polypropylene (PP)
Touch screen housing	n/a	1	Polypropylene (PP)
Cable connection	n/a	1	Polypropylene (PP)

Cooling fan	n/a	2	Various materials
Main coil (210 mm)	Electrical insulator top sheet	1	Potassium Aluminium Silicate (Mica)
	Springs	2	Aluminium Alloy
	Sensor	1	Aluminium Alloy
	Diode	1	Diode
	Coil	1	Copper
	Cables	2	Wire (Copper). Insulation/Jacket (PVC)
	Plastic support	1	Low density polyethylene (LDPE)
	Ferrite elements	8	Ferrite
	Electrical insulator bottom sheet	1	Potassium Aluminium Silicate (Mica)
	Bottom cover	1	Aluminium Alloy
Medium coils (180 mm)	Electrical insulator top sheet	1	Potassium Aluminium Silicate (Mica)
	Springs	4	Aluminium Alloy
	Sensor	2	Aluminium Alloy
	Diode	2	Diode
	Coil	2	Copper
	Cables	4	Wire (Copper). Insulation/Jacket (PVC)
	Plastic support	2	Low density polyethylene (LDPE)
	Ferrite elements	16	Ferrite
	Electrical insulator bottom sheet	1	Potassium Aluminium Silicate (Mica)
	Bottom cover	2	Aluminium Alloy
Small coil (140 mm)	Electrical insulator top sheet	1	Potassium Aluminium Silicate (Mica)
	Springs	1	Ceramic fibres
	Sensor	2	Aluminium Alloy
	Diode	1	Aluminium Alloy
	Coil	1	Copper
	Cables	1	Wire (Copper). Insulation/Jacket (PVC)
	Plastic support	1	Low density polyethylene (LDPE)
	Ferrite elements	6	Ferrite
	Electrical insulator bottom sheet	1	Potassium Aluminium Silicate (Mica)

	Bottom cover	1	Aluminium Alloy

In Elduque et al (2014), a detailed BoM of the electronic components of an induction hob is provided. Table 46 contains data on the electronic induction printed circuit board assembly located on the left (ELIN LPCBA) and on the right (ELIN RPCBA) of the appliance. Table 47 contains data on the touch control printed circuit board assembly (TC PCBA).

Table 46. BoM of left and right PCBAs (Elduque et al, 2014)

	ELIN LPCBA		ELIN RPCBA	
Component	**Units**	**Total mass (g)**	**Units**	**Total mass (g)**
Electrolyte capacitor	9	18.36	6	5.43
Film capacitor	28	126.37	26	134.40
0402 capacitor	50	0.06	48	0.05
Diode	8	32.36	5	31.23
Inductor ring core	4	188.90	3	179.32
Relay	3	34.35	2	22.84
Transformer	3	25.05	2	12.25
0402 Resistor	60	0.03	73	0.04
Total		425.48		385.56

Table 47. BoM of touch control PCBA (Elduque et al, 2014)

Component	Units	Total mass (g)
SMD resistor 0603	79	0.15
SMD capacitor 0603	52	0.28
SMD transistor	28	0.24
8 segment display	6	4.50
IC logic	5	0.51
IC memory	2	0.11
Total		5.79

Up to date, no Bill of Materials has been found in scientific bibliography regarding cooking fume extractors. The closest data to a BoM is published in Bevilacqua et al (2010), where a list of materials present in a domestic cooking fume extractor is shown (Table 48). No mass data is provided.

Table 48. List of materials in domestic cooking fume extractor (Bevilacqua et al, 2010)

Materials in domestic cooking fume extractor
Steel
ABS-PP
EPS
Cardboard
Electronic board
Glass
Aluminium

4.4.2 Aspects affecting transport of domestic cooking appliances

As already seen in previous sections, the main environmental impact of cooking products is during the use phase. In comparison, transport and packaging tend to have a low environmental impact in these products. For information on transport activities, manufacturers tend to provide information in their annual sustainability reports.

4.4.2.1 Packaging materials

Typical packaging materials in the domestic cooking appliances industry are cardboard, wood, EPS, foil and paper. According to a stakeholder, for 3 different ovens, volume of packaged products are as in Table 49.

Table 49. Volume of packaged oven

	Oven 1	Oven 2	Oven 3
Capacity of oven (litres)	70	50	70
Volume of oven (m3)	0.22	0.16	0.31
Volume of oven with packaging (m3)	0.34	0.27	0.47

In terms of built-in hobs, the volume of packaged products are as in Table 50.

Table 50. Volume of packaged built-in hob

	Hob 1
Number of cooking areas	4
Volume of hob (m3)	0.02
Volume of hob with packaging (m3)	0.05

In terms of wall cooking fume extractors, the volume of packaged products are as in Table 51.

Table 51. Volume of packaged cooking fume extractor

	Cooking fume extractor 1	**Cooking fume extractor 2**
Volume of cooking fume extractor (m3)	0.21	0.31
Volume of cooking fume extractor with packaging (m3)	0.32	0.49

4.4.3 Aspects affecting end of life of domestic cooking appliances

4.4.3.1 Critical parts and failures in domestic cooking appliances

The study conducted by Evans et al (2015) for the European Commission had as a purpose to identify priority products and develop a method to measure their durability; and to estimate the benefits and costs of more durable products. A remarkable list of definitions of the concept of durability is provided in this study.

In European product policy, durability is usually addressed by the provision of spare parts for around 10 years after then end of production of an appliance to enable appropriate repair. When addressing durability –or lifetime- of products in product policy, it is essential to have data on which are the key critical components in terms of failures.

Domestic ovens are appliances which make use of critical components to deliver their main function, which will be subject to abrupt temperature variations. It has been proved difficult to find reliable figures regarding the reasons that domestic ovens fail or need repairing. In Evans et al (2015), an analysis of the critical components failing in an oven is conducted for domestic ovens. Data provided by Which and UK Whitegoods -consumer organisations in United Kingdom- and UK retailer repair records, there are little differences between built-in and free-standing cookers/ovens. These are appliances generally reliable and not prone to breaking down or developing faults. The most common problems in domestic ovens are in:

- Failure of fan. These components are prone to failure since they are subject to stress of quick heating and cooling.
- Failure of thermostat, the most probable cause being oven overheating.
- Light not working
- Dials or controls not working, potentially due to faulty thermostat or thermal fuse
- Door not closing properly, potentially due to failure in sealing, rollers or hinge runners. This may cause uneven cooking, higher energy use and damage to adjacent units.
- Oven cutting out after being ON for a while
- Noise, potentially due to moving parts being misaligned or due to bearing failures

- Glass door breaking, potentially due to overheating or the presence of temperature differentials
- Handles breaking

In the mentioned report, some data is provided regarding frequency of failure and main components requiring attention. However, this data needs to be taken with caution as figures do not seem consistent between them.

Table 52. Percentage of appliances recorded with each type of fault

(Which, published in Evans et al (2015)

Fault	Built in oven	Free standing oven
Light not working	32%	9%
Door not closing properly	8%	9%
Dials/controls broken	7%	12%

Table 53. Percentage of appliances recorded with each type of fault

(UK Whitegoods, published in Evans et al (2015)

Component	Percentage of appliances with fault in component
Thermocouples	8%
Knobs and controls	6%
Thermostats	3%
Door gaskets or seals	4%
Hotplates	4%
Heating elements	2-3%
Selection switches	2-3%
Glass lid assembly	2-3%
Hinges	2-3%

According to a manufacturer, they have no reliable data available about the most frequent occurring failures and defects, as they do not receive repair information over the entire usage lifetime of the appliances. Repair of appliances is performed by the manufacturer within the legal guarantee period. After that, repairs are mostly conducted by independent professional repairers.

The same manufacturer highlights it is part of their core business to extend lifetime of product as much as possible, also through repair. They develop appliances with the aim of longevity and durability. Cooking appliances are appliances which are typically used for a long time. These appliances are not fashion or trend related. In principle every failure/defect can be repaired. The decision for repair lays by with the end-user. In terms of the most common failures in components for ovens, hobs and cooking fume extractors, their feedback is:

Ovens: a very wide variety of technologies is used. From very basic models up to highly complex appliances with integrated microwave and/or steam function with TFT displays and Wifi connection (e.g.). Therefore, any general recommendation about most failing components cannot be made.

Hobs: as there are many hob technologies available (radiant, gas, induction) and different solutions are offered within one technology, a general answer about occurring failures/defects cannot be given.

Cooking fume extractors: the main recurrent complaints are “the appliance is too loud” and “does not evacuate well”. In most of the cases this is due to incorrect installation.

4.4.3.2 Product lifetime of domestic cooking appliances

Lifetime of a product ends when it is replaced by another product that takes over the original application. A concept directly related with this is durability, understood as the ability of a product to endure to its lifetime. Regarding lifetime of domestic cooking appliances, there is a significant lack of data available in the form of scientific research or national/regional statistics. There is consensus in the fact that life expectancy of typical appliance depends to a great extent on the use it receives. Also in the fact that nowadays appliances are often replaced long before they are worn, since changes in styling, technology and consumer preferences make newer products more desirable. According to a study conducted by Bank of America (2007), the average life expectancy for cooking appliances is:

- Electric Oven with hob: 13 years
- Gas Oven with hob: 15 years
- Cooking fume extractors: 14 years

More recent research conducted for the development of previous Ecodesign regulation on cooking appliances (Mudgal et al, 2011a; 2011b) provides data as well on expected lifespan of domestic cooking appliances (Table 54).

Table 54. Product lifetime for cooking appliances (Mugdal et al, 2011)

(Lot 23, Task 3, p21; Lot 22, Task 3, p30)

Appliance	Lifetime average (years)
Domestic electric hobs – solid plates	19
Domestic electric hobs - radiant	19
Domestic electric hobs – induction	15
Domestic gas hobs	19
Electric ovens	19
Gas ovens	19

In their Annual Energy Outlook, the EIA (2019) provide slightly different lifetime ranges (minimum and maximum) for different household appliances, including domestic ones (Table 55).

Table 55. Product lifetime for cooking appliances (EIA, 2019)

Appliance	Lifetime range (years)
Natural gas and propane cooking ranges, cooktops and ovens	9 – 15
Electric cooking ranges, cooktops and ovens	10- 20

According to a manufacturer, there is no reliable data available on product lifetime of domestic cooking appliances. Their internal testing shall ensure a minimum lifetime of 10 years, but there are appliances in households which are much older. The lifetime depends on the usage and maintenance of the appliances. It is their experience that maintenance is a bigger concern for cooking appliances than for dishwashers, for instance. Maintenance is a bigger concern for cooking fume extractors, especially related to filter cleaning and changing. A commonly accepted average lifetime they highlight is 19 years for ovens and hobs.

4.4.3.3 Trade-off between durability and efficiency in the use phase

There is a clear relationship between the durability of a product, the resources consumed and the emissions generated during its lifetime. In the specific case of electrical and electronic appliances, extending product life is considered an effective means to contribute to resource conservation: fundamentally materials and energy. In principle, with extended lifetimes of products, fewer appliances will have to be produced to cover consumer demand. However, there is a trade-off that needs to be taken into account, which is the potential savings achieved in the production/manufacturing stage versus energy consumed during the use phase (Truttman et al, 2006). According to several authors, extending lifetime – also referred to as 'reuse' end of life strategy in literature review, should not be an a-priori goal-oriented strategy, but analysed case by case. In this line, there are certain factors related to the practical limits on lifetimes that need to be taken into account:

- A very durable product may have cost implications in terms of changes to materials, components and manufacturing processes
- Innovation rates in certain markets may cause that extended lifetime products become quickly obsolete
- Consumer buying habits and expectations may divert them from very durable products
- Durable products may have a negative effect on the product's potential second life

The environmental performance of end of life strategies which consider extended lifetime of products has not been widely covered in scientific research. Studies addressing the potential benefits of reuse and remanufacturing of products has been limited to a small number of papers published over the past three decades, according to Zanghelini et al (2014). Some of this research is summarised in this section.

In Truttman et al (2006) the authors investigated the potential benefits of reusing –extending lifetime- of several home appliances (refrigerator, washing machine, dishwasher, microwave, PC, video, monitor and TV), taking into account use of materials and energy consumption. In terms of materials, it was observed that increasing product lifetime by a factor of 1.5 decreased all material flows in the system by the same factor. However, these factors were based on assumptions, and different values should be considered for different types of products and substances. Also regarding materials, the authors analysed the potential benefits of extending lifetime versus the benefits of improving recycling efficiency. They observed that material use is more sensitive due to changes in recycling efficiency. Even doubling product lifetimes could be offset by comparably small losses of 10% in the recycling efficiency. In terms of energy consumption, the authors observed that around 10% less energy is consumed in extended-life scenarios. However, the benefits in energy use were very different between appliances: higher benefits were obtained in PCs and washing machines and lower in videos and monitors.

Along similar lines, in Tasaki et al (2013) the authors refer to parameters which may have an influence on the potential benefit of extending lifetime of a product or replacing it by a more efficient one, such as size of the two products (the old one and the new one), their function, the patterns of use and the time of replacement. According to their findings, whether product replacement is preferable from the viewpoint of reducing energy consumption depends substantially on how often a consumer uses the product and the characteristics of the particular replacement product. As specific examples, they indicate that replacement of refrigerators after 8-10 years of use is preferable, even if the replacement product is larger. On the contrary, the replacement of TVs tends to be not preferable if it is not used often or if the consumer replaces it by a larger one (which tends to be the case).

Specifically on cooking appliances, in Iraldo et al (2017) an analysis was carried out to understand the potential benefits of durable ovens. Two scenarios were defined for that purpose: a scenario where a Product A was substituted by a more energy efficient Product B after a certain period of time; and a scenario where Product A was not substituted and was being used for an extended period of time, as described in **Figure 188**.

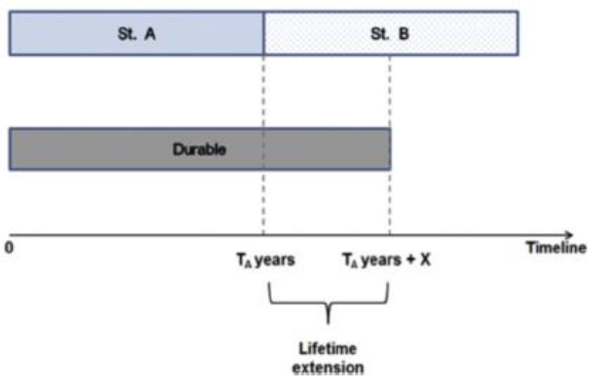


Figure 188. Product substitution versus product durability (Iraldo et al, 2017)

Results from this study –using data from available scientific literature- showed that the durable option had lower environmental impact in four impact categories. In the rest of impact categories analysed, if a certain energy efficiency improvement (energy efficiency threshold) is achieved in Product B, replacing the Product A by Product B is preferable than maintaining Product A by a longer period of time. In **Figure 189**, these energy efficiency improvement thresholds are presented.

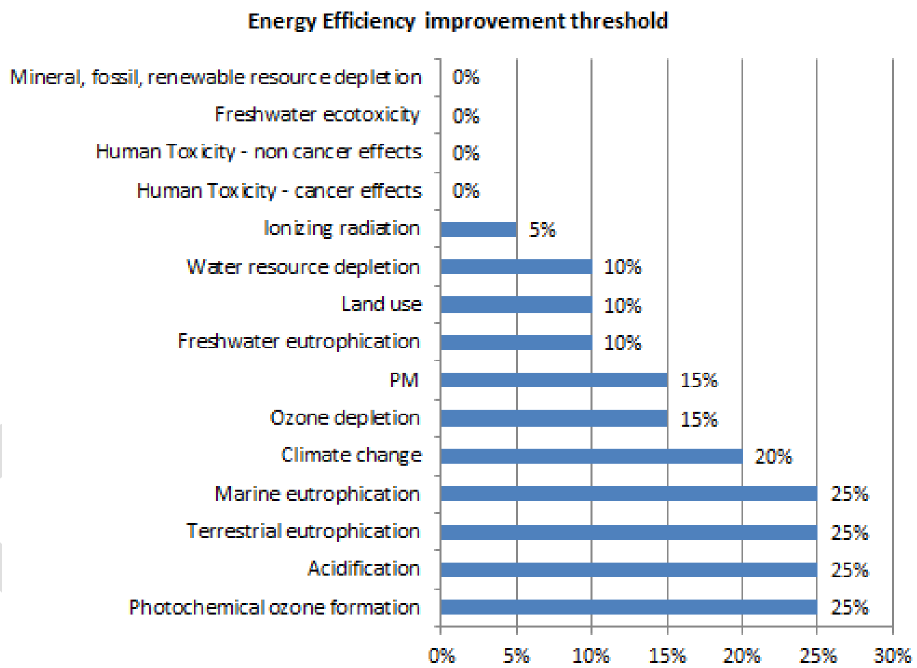


Figure 189. Energy Efficiency improvement threshold in domestic ovens (Iraldo et al, 2017)

Essentially, for the impact categories whose significant contribution comes from production and end of life, the durable option is always preferred, even with improvements in energy efficiency. However, for most of the impact categories, a small improvement in the energy efficiency of the replacement product is sufficient to deliver environmental benefits by substituting the product. For instance, in the case of climate change, if the new oven (Product B) is 20% more energy efficient than Product A, it is preferable to substitute it than to extend its lifetime.

4.4.3.4 Material efficiency aspects

In the past years, material efficiency aspects have been addressed by several authors from different perspectives. The most relevant studies on this matter are summarised in this section.

Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency by Bundgaard et al.

Bundgaard et al. (2015) reviewed in their study "Ecodesign Directive version 2.0 – from energy efficiency to resource efficiency" in total 23 currently adopted implementing measures and voluntary agreements under the Ecodesign Directive, criteria for resource efficiency in voluntary instruments such as ecolabels and Green Public Procurement as well as recent Commission projects with regard to implementation of resource efficiency aspects into the Ecodesign Directive.

In the study, Bundgaard et al. generally subsume under "resource efficiency" the following measures:

- Reducing materials and energy use in the entire life cycle of products (mining of materials, production / use / final disposal of the product)
- Improving possibilities for maintenance and repair (e.g. guidelines)
- Ensuring re-use or redistribution, i.e. multiple use cycles.
- Increasing the potential for remanufacturing or refurbishment of the product, i.e. multiple use cycles (e.g. improving reparability, access to spare parts)
- Improving recyclability of materials used in the product

The review of existing instruments revealed that resource efficiency is already widely applied in voluntary instruments covering energy related products. The instruments include following criteria which were also assessed by the study team with regard to their transferability to the Ecodesign Directive (Bundgaard et al. 2015):

Declaration and threshold of RRR ratio (reusability, recyclability and recoverability)

According to Bundgaard et al. (2015), transferring declaration and threshold requirements with regard to RRR ratio to the implementing measures and voluntary agreements of the Ecodesign Directive first needs a common methodology to be developed on how to calculate the RRR ratio for products and materials to verify the requirements based on technical information provided by the producers.

However, setting requirements for the RRR ratio of the material or the product only reflects the theoretical potential and will not ensure that the materials or products are in fact reused, recycled or recovered which depends on the infrastructure for collection and treatment and the technologies available.

In case of future requirements to RRR ratio it is recommended to make them according to the waste hierarchy, by prioritising reuse before recycling, and recycling before recovery.

Declaration and/or threshold of recycled content

According to Bundgaard et al. (2015), setting criteria for the threshold of recycled materials can help create a market for these materials. The environmental benefits of using recycled materials would depend on the type of material. However, before transferring these requirements to the Ecodesign Directive, it is important to assess if the manufacturers of recycled materials can handle the increase in demand that a requirement would create. A possibility could be to begin by setting declaration requirements and then tightening them continuously by setting threshold requirements.

Setting criteria for recycled materials, however, first needs reliable technologies for an analytical assessment of the recycled content in the products to enable verification and market surveillance.

Bill of materials (BOMs)

BOMs are an important source of information to conduct LCAs, assess the product's recyclability, recoverability and recycled content and identify priority resources in the product to ensure their reuse and recycling; all of these activities are the basis for other requirements to improve resource efficiency.

However, Bundgaard et al. (2015) conclude that due to the complexity of the supply chain of electronic and electrical equipment, a mandatory requirement on providing BOMs would be especially challenging to comply for small producers, as they might not have the ability to force these requirements on to their larger suppliers. Further, the implementation of such a requirement might first need the setup of a system that can ensure the companies' property rights, e.g. with regard to the use of rare metals.

Identification of plastic components

Marking of plastic components according to ISO 11469 shall help recyclers identifying different plastic types and parts to ensure correct handling during waste recovery or disposal, when the plastic parts are manually sorted. Also, the visual marking of plastics parts according to certain ISO standards might be quite easy to verify visually by market surveillance authorities when dismantling the product.

On the other hand, there are certain drawbacks shown by the literature research of Bundgaard et al. (2015): A certain percentage of the labels were found to be incorrect and, mainly, for automatic sorting (currently the large majority of treatment) systems the ISO labels had no effect as these systems sort according to the plastic's mechanical, optical and electrostatic properties.

Thus, Bundgaard et al. (2015) recommend that before setting criteria for visual marking of plastics in the Ecodesign Directive it should be further examined to what extent the waste is manually sorted for the product group in question, and how the future waste treatment of the product might look like. Furthermore, alternative marking methods should be examined (e.g. Radio Frequency ID), which could be applied for example in automatic sorting systems.

Contamination of materials / plastics

Requirements regarding contamination of materials are relevant for the recyclability, as the potential for recycling is reduced if incompatible materials are combined, e.g. painting, coating or metallizing large plastic parts making them not compatible with recycling. Depending on the specific requirement, it could be verified visually.

Mono-materials

Using compatible or a reduced number of plastics can improve the recyclability of e.g. thermoplastics, as a mixture of different polymers or a contamination of the plastic fractions can significantly decrease the plastics properties and thereby the use of the recycled materials.

Bundgaard et al. (2015) recommend that setting these types of requirements should be supplemented with a dialogue with the stakeholders from the recycling industry to ensure the effectiveness of these types of requirements which depends on the recycling system that the products enter into.

Durability requirements (incl. extended warranty, upgradability and repair, spare parts, modularity)

All criteria strive to extend the lifetime of the product thereby preventing electronic waste. Durability is also related to the previous category disassembly, where criteria targeting easy disassembly for repair and upgradability were included.

The length of the warranty should be product specific and it is also strongly related to the availability of spare parts, which is also an issue for reparability. Determining how long spare parts should be available taking into account both economic and resource efficiency aspects: On one hand components should be available to enable repair, but on the other hand the risk is that a too large inventory of components will be out-dated and never utilized. Modular design and easy disassembly enable upgrading and repair and are thus prerequisites for lifetime extension. Upgradability can potentially reduce the frequency of replacement against the background of rapid technological product developments.

Bundgaard et al. (2015) conclude that durability should be included as possible resource efficiency requirements in the Ecodesign Directive, also due to the requirements being possibly verifiable by market surveillance authorities. However, it is important to ensure that prolonging the lifetime of the product is the environmentally best solution in a life cycle perspective, e.g. that possible environmental benefits are not evened out by increased energy consumption of the older product compared to a new more energy efficient product.

Easy disassembly

Easy or manual disassembly can help improve reparability and upgradability of the product improving the durability of the product. Criteria might be detailed with regard to the components to be separated, the type of connections or the tools to be used.

Regarding end-of-life treatment, Bundgaard et al. (2015) conclude that it is not possible based on the finding of their study to assess whether or not requirements for manual disassembly will improve the recyclability and recoverability of electrical and electronic equipment in the future. This is due to the reason that manual disassembly in the waste treatment process of electrical and electronic equipment (EEE) is increasingly being replaced by automatic or destructive disassembly in many developed countries which questions if requirements for easy or manual disassembly will improve the recyclability and recoverability of EEE if they are fed into an automatic or destructive disassembly system. However, manual disassembly is still performed when economically feasible, e.g. components or materials containing valuable resources, or when Regulations such as the WEEE Directive require it, e.g. by removal for separate treatment of components containing hazardous substances. Bundgaard et al. (2015) propose requirements in addition to manual disassembly which might target automatic or destructive disassembly, however, without further specifying this proposal.

Waste from manufacturing

By including requirements to the manufacturing, the scope would be expanded from a product focus towards a production focus which is applicable to the Ecodesign Directive which mainly sets requirements to the design of the product, however targeting the environmental performance of the entire product life cycle. Therefore, design requirements to the product that might improve the manufacturing process would be highly relevant. However, as many electronic products are produced outside Europe, it might be difficult to enforce these criteria. (Bundgaard et al. 2015)

Further requirements

Further requirements on hazardous substances, take-back schemes and packaging identified in voluntary instruments such as ecolabels are not recommended to be transferred to the Ecodesign Directive as there are rather large overlaps with existing legislations such as REACH and RoHS, WEEE and the European Directive on packaging and packaging waste.

Information requirements related to resource efficiency

With regard to information and specific requirements targeting resource efficiency in Ecodesign, Bundgaard et al. (2015) recommend in their study the following:

- Information and specific requirements on durability (e.g. on lifetime of the product as for lamps, or for components, such as minimum loading cycles for batteries in computers)
  - Relevant for consumers to enable them selecting the most durable product.
- Information requirements with regard to resource consumption in the use phase
  - Relevant for consumers: e.g. to stipulate consumers choosing the most efficient programmes in terms of energy and water consumption and the best suitable detergents.
- Information requirements on hazardous substances, precious metals or rare earths
  - Relevant for recyclers to a) avoid contamination of the materials when they are recycled or b) ensure a more optimal recovery of precious materials.
- Information relevant for disassembly, recycling or disposal at end-of-life

- Relevant for end-users to know how to correctly dispose the product at its end-of-life.
- Relevant for recyclers to know how to disassemble and recycle the products in the best possible way, for example to ensure that hazardous substances are removed and treated correctly. As in case of the information on hazardous substances, precious metals and rare earths it is suggested that such information could be made more easily available, by embedding it in the product in e.g. a Radio Frequency Identification (RFID). This results in a higher benefit for the recyclers compared to information provided on webpages or in user instructions. Furthermore, it could be specified in the Directive which type of information the recyclers may need. This could be done in close collaboration with the recyclers to ensure that the information is indeed relevant for their processes.

- Information and specific requirements on easy disassembly:
  - Relevant for consumers / repair facilities to help improving maintenance and repairs. Generic information requirements for non-destructive disassembly for maintenance could be supplemented by requirements for the producers to make repair and service manuals public. It may also be relevant to set specific requirements for easy disassembly of the product for maintenance purposes.
  - Relevant for recyclers to help improving end-of-life treatment, for example the removal of certain components which have to be treated separately in accordance with the WEEE Directive (batteries, heat pumps etc.).

Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP)

BIO Intelligence Service (2013) conducted a study to clarify the implications of material efficiency from the pragmatic perspective of its practical application for Ecodesign purposes, and the elaboration of recommendations for the MEErP methodology (Part 1); and undertook an update of the MEErP methodology and its component EcoReport tool, to include the necessary means for better analysing material efficiency in MEErP (Part 2). Part 2 also contains a guidance document for analysing material efficiency in ErP; as well as an updated version of the EcoReport Tool and a report of the test of the updated methodology on two case studies.

The project identified from available evidence the most significant parameters regarding material efficiency that may be used in MEErP, in order to analyse the environmental impacts of ErP, and assessed their suitability and robustness for Ecodesign purposes, together with associated information parameters.

The parameters selected as most suitable were:

- Recyclability benefit ratio, describing the "potential output" for future recycling, based on a formula considering the recyclable mass per material and its recycling rate and a down-cycling index. It implies that it is possible to assess the potential benefits of recyclable plastic parts in a product. However, due to data constraints only data on recyclability benefit rate for bulk and technical plastic is included.
- Recycled content, describing the "input" of materials with origin on waste, based on new data sets for materials. The dataset makes it possible to model products with recycled material as input material. However, again due to data constraints, only data on paper, Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET) and High Density Polyethylene (HDPE) has been included in the EcoReport Tool.
- Lifetime, a mechanism to display impacts not only as a total over the whole lifespan, but also per year of use, allowing an easier comparison of products with different lifetimes or analysing the effect of lifetime extension. The product lifetime can refer to:

  - The technical lifetime is the time that a product is designed to last to fulfil its primary function (technical lifetime).
  - The actual time in service is the time the product is used by the consumer (service lifetime). The actual time in service is not a typical parameter in industry and depends more on the user than on the manufacturers of the product design.
- Critical raw materials, a tool to analyse products including critical raw materials to display differences between different product designs and improvement options.

A key end result of this project was that the new features within the MEErP, enabling further analyses of material efficiency aspects in products, are fully functional and ready to be used in future Ecodesign preparatory studies. However, Bundgaard et al. (2015) conclude in their study:

> *The MEErP methodology has not been changed significantly. The alterations made to the EcoReport Tool are minor and to some extent updates of existing elements. Hence, despite the good intentions to include material efficiency into MEErP, the current update and expansion of MEErP will properly not be enough to ensure a focus on material efficiency in future implementing measures and voluntary agreements.*

<u>The durability of products</u>

Ricardo-AEA, in collaboration with Sustainability Management at Scuola Superiore Sant'Anna di Pisa (SuM) and Intertek, has been commissioned by the European Commission – DG Environment to conduct a study on the durability of products. The purpose of the study is to identify two priority products and develop a methodology for measuring their durability. The study also aims to estimate the benefits and costs of more durable products. The outputs from this work can then be used in relevant product policies. (Ricardo-AEA 2015)

Within the durability study, the authors undertook a literature analysis to develop an appropriate definition of durability. For example, the Ecodesign Directive 2009/125/EC in Annex I, Part 1.3 defines parameters which must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects of products. According to European Parliament (2009a), this includes inter alia

> *"<u>Extension of lifetime</u> as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability."*

The following definition has been developed by Ricardo-AEA (2015) proposed to be potentially also applied to other policy interventions in Europe aimed at improved durability of products.

> *"<u>Durability</u> is the ability of a product to perform its function at the anticipated performance level over a given period (number of cycles – uses – hours in use), under the expected conditions of use and under foreseeable actions.*
>
> *Performing the recommended regular servicing, maintenance, and replacement activities as specified by the manufacturer will help to ensure that a product achieves its intended lifetime."*

The authors further discussed the possibility of creating an extended definition of durability that encompasses repair, design for repair and remanufacturing, and that such an extended definition of durability could be developed for inclusion within for example the EU Ecolabel and Green Public Procurement (GPP) criteria requirements.

> *"A product to maintain its functions over time and the degree to which it is repairable before it becomes obsolete."…. "In other words, a product should not cease to function after relatively little usage and <u>its reparability should not be hindered by its design</u>."*

It is thus worth considering that, within this context, extended durability is the aim to extend the life of a product past its first life by ensuring a product can be easily repaired, upgraded, remanufactured and, at end of life, dismantled and recycled.

Beyond the above definitions on durability, Ardente et al. (2012) concluded their literature review, cited in Ricardo-AEA (2015), the following definitions for a number of relevant terms:

- Design for durability: considering the product's longevity, reparability and maintainability; considering environmental improvements emerging from new technologies (ISO/TR 14062 2002).
- Operating time: average time frame during which the product is supposed to be used. Operating time can be derived from product statistics or from estimating models.
- Extension of operating time: estimated time frame extension of the operating time that can be achieved due to specific design and maintenance actions.

Within the study of Ricardo-AEA (2015), domestic refrigerators and freezers, and ovens were selected for further analysis. The selection is based on the assumption, that they might also be applicable to other products with similar components. The study results are expected to be transferable to a large extent as following components are similar: outer casing, pumps, filters, heating elements, mechanical elements such as hinges and catches and electronics, including controls and displays

Addressing resource efficiency through the Ecodesign Directive. Case study on electric motors

Dalhammar et al. (2014) conducted a case study in 2012 on the potential inclusion of permanent magnet (PM) motors in the Ecodesign requirements for electric motors. The objective was to see how the Ecodesign Directive could promote eco-innovation for resource use in PM motors, and to:

- Investigate what kind of requirements related to resource use of rare earth elements (REE) are of relevance for permanent magnet electric motors, and
- Obtain input from experts on the feasibility of outlined potential requirements, and the most important drivers for eco-innovations.

Against the background of increased demand for REE, combined with global supply imbalances and unavailable post-consumer recycling options for REE, their substitution in the magnets is currently being investigated in several pilot projects. Replacing REEs with other materials however can come with a performance loss in the PM motor (i.e. reduced energy efficiency due to a reduced energy density in the magnet and more material use). Therefore, increasing the recyclability of PMs is of interest, if technically and economically feasible at the point in time of interest, as it could provide a stable supply of REEs and thus, enhances their continued use to achieve more energy-efficient motors.

Based on interviews with material experts, Dalhammar et al. (2014) outline potential implementing measures facilitating recycling of REE.

- Generic requirements that producers should show how they take design for recycling into account in the design process.
- Design for dismantling, e.g. modularisation; or preventing that permanent magnets are for instance covered by plastic, which would ease recycling practices.
- BOMs providing information about key materials and their positions to promote future recycling (when new technologies may allow for profitable recycling if the motors are easy to disassemble).
- Additional information to recyclers that are relevant for allowing cost-effective recycling.
- Take-back obligation; it might provide incentives to design a motor from which materials can more easily be recycled.

Dalhammar et al. (2014) conclude that it appears as if a more developed set of requirements cannot be set under the Ecodesign Directive until pilot projects and ongoing research have provided more insights on the technical and economic viability of REE recycling. The long-time scales involved (i.e. time before the motors are at the EoL stage) however mean that future recycling options and associated costs and benefits are rather uncertain compared to products with shorter life spans, e.g. laptops or cell phones.

Resource efficiency requirements in Ecodesign: Review of practical and legal implications (VHK, 2014)

This study for the Dutch Ministry of Infraestructure and Environment explores the potential role of material resource efficiency, except energy efficiency during use, in the Ecodesign of ErP Directive. This study strengths the role of material efficiency in Ecodesign, beyond energy efficiency and concludes that Ecodesign measures regarding savings on non-energy resources consumption in the use-phase have proven to be enforceable, at least for directly consumed resources, legally and in practice. Methodology and measures regarding weight-saving measures in Ecodesing would need to be developed. Measures on product durability (lifetime extension) have proven to be enforceable when formulated in terms of minimum technical life of the product or components according to harmonised test and calculation procedures. Also minimum warranty times and the time period during which spare parts are available can be enforced.

Should Ecodesign preparatory studies be able to provide robust evidence that justifies introduction of specific RRR measures in legislation (a set of) specific or tailor-made requirements should be introduced in Ecodesing legislation that could meet legal and practical criteria enforceability. Amongst others this means that the requirements should be technically and economically feasible and preferably relate to parameters that can be assessed with an accurate, reliable and reproducible test and calculation methods at product-level. If they would depend on input from upstream actors (suppliers) or downstream (end-of-life) processes, the administrative burden would be considerable and still the accuracy and reproducibility of measurements would require robust test standards to be in place to guarantee a level playing field.

International trade agreements emphasize the relation between the proposed measure and its means of verification. Measures that can be verified on the product itself are considered to constitute less of a (potential) barrier to trade than measures that can only be verified indirectly as they relate to non-product related production and process methods.. There are however measures that may relate solely to the product, such as parameters dealing with durability, light-weighting, presence of substances (hazardous or critical raw materials, etc.)

4.4.3.5 Product design in relation to durability and reparability

In terms of reparability of domestic cooking appliances specifically, there is little data regarding the habits of consumers or on the number and success of repairs performed in this sector. There is also limited information regarding the disassembly and reassembly properties (key aspects in reparability) of home appliances in general. Related to this topic, Dindarian et al (2012) investigate quality and costs of remanufacturing microwaves and propose design changes based on that. Some of their recommendations, which may be applicable to domestic cooking appliances such as ovens, hobs and cooking fume extractors, are:

- Reduce the complexity of how printed circuit boards are assembled
- Facilitate the access to internal parts
- Redesign how key component are fitted to make them more accessible
- Change painting characteristics to make it more durable
- Change the design of mains cables and plugs to make them removable or interchangeable
- Reduce the number of different designs of mechanical parts to make them more interchangeable

Along the same lines, using a sample of 749 units of small household WEEE, an analysis of the current situation in terms of their disassembly properties and material characterisation was conducted in Bovea et al, 2016b. It was observed that the most problematic aspects regarding disassembly in small WEEE were easiness of material identification and easiness of separation of individual components. Some of the joints used needed to be broken in order to disassemble them; whereas others required two people to avoid having to break them. In order to improve the reparability of these appliances, the authors recommended reducing the number and variety of types of joints, along with the utilization of more intuitive snap-fits, clips or sliding connections. These recommendations are also applicable in the case of large domestic appliances such as ovens, hobs and cooking fume extractors.

When a consumer needs to repair their faulty appliance, one of the options is to get in touch with the manufacturer. According to data collected from members of APPLIA, 81% of the requests to manufacturers for a repair of a product resulted in an actual repair in 2016. The breakdown of costs of repair activities in large home appliances can be seen in **Figure 190**.

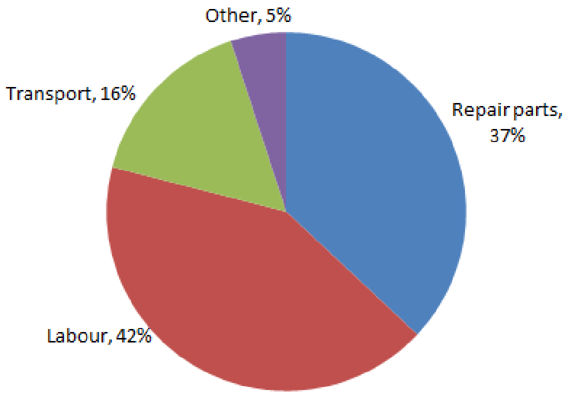


Figure 190. Cost breakdown for repair activites in large home appliances (APPLIA, 2019)

As it can be observed, the most significant contribution to the cost of repair is related to labour. However, it needs to be taken into account that depending on the country, there are different considerations from the consumers due to differences in labour cost. Labour cost needs to be factored in, in particular in countries where it is very high. For that, data from Eurostat regarding hourly labour costs will be used in the modelling section.

A product design with a view on reparability and disassembly has the potential of reducing significantly time and energy spent in repairing the appliance, as well as in the capacity of recovering valuable materials at end of life. Barriers for reusability and reparability of home appliances have already been addressed in Task 3 of this report.

In terms of the technical benefits of repairing domestic cooking appliances, no specific data has been found on the topic. On their analysis on home appliances, Hennies et al (2016) indicate that when a washing machine has taken place, its lifespan is significantly higher by 2 years. The authors also observed that the more expensive the washing machines, the more times they are repaired across their lifetimes, potentially because they last longer or because the cost of the repair relative to the cost of acquisition is lower. Repairs due to early failures in appliances under warranty period are very rare (5%). They also recommend that increasing the awareness of environmental factors could change the attitudes of consumers and push the market economy in a direction towards a more sustainable lifespan.

On reparability, a manufacturer indicated they can support the approach with respect to spare part availability for professional repairers and end-users, as for washing machines, washer-dryers, dishwashers and refrigerating appliances in their revised eco-design regulations. This can be implemented for domestic ovens, hobs and cooking fume extractors. The specific content of the requirements for these appliances should be discussed with industry.

4.4.3.6 Material flows and collection effort at end-of-life

In Magalini et al (2017), data is presented regarding home appliances waste in general. It is reported that home appliances waste is mostly made up of:

- Electrical and Electronic Waste (WEEE)
- Packaging Waste, mainly in distribution phase
- Batteries, particularly for small home appliances

Considering all size home appliances, it can be observed that WEEE flows are steadily increasing (Figure 191), for a total of 5 million tonnes in 2016 (30% increase in 9 years). It is estimated that nearly 50% of that mass corresponds to large home appliances (where ovens, hobs and cooking fume extractors are accounted).

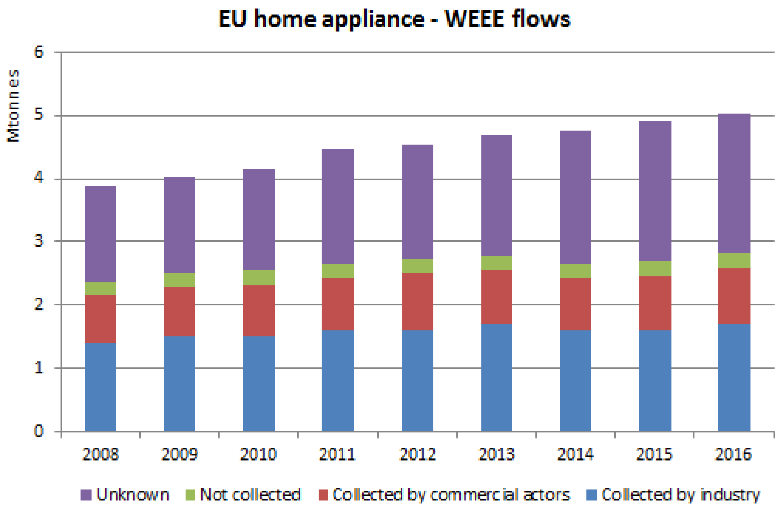


Figure 191. Home appliances WEEE flows

Four main streams are identified for home appliances waste:

- Collected by industry
- Collected by commercial actors
- Not collected
- Unknown

In 2016, only 34% of the total was actually collected by the home appliance industry. The reason for this low amount is related to the high metal content of this waste stream and the presence of a mature recycling industry even before WEEE Directive was implemented. Commodity prices play a fundamental role in how home appliances are collected and treated. This causes that a large share of this waste is handled by commercial actors, outside of the industry-driven recycling schemes. Appropriate tracking mechanisms are still not in place, as a significant 44% of the home appliances waste destination is currently unknown. The remaining 5% is not collected separately in any form, therefore can be considered as sent to landfill.

In terms of materials, steel is the material which is recovered the most for large, small and cooling/freezing appliances (Figure 192). Approximately 0.15 million tonnes of concrete are recovered from large home appliances, presumably from built-in devices. Plastics, copper, aluminium and glass are other materials with significant presence in this waste stream.

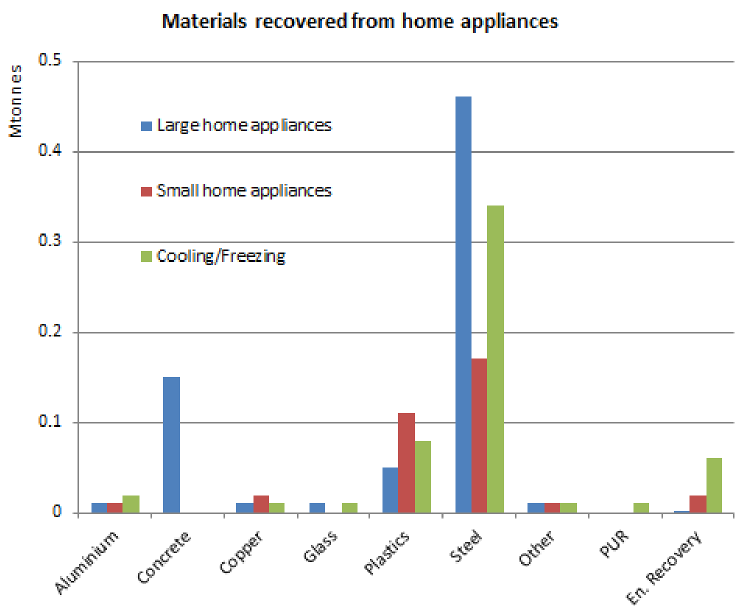


Figure 192. Materials recovered from home appliances waste

4.5 Conclusions

4.5.1 Ovens

- Some stakeholders support a comprehensive and comparable labelling for all appliances based on primary energy, therefore not differentiating between gas and electricity. For that, a conversion factor should be used to convert electricity to primary energy, allowing the comparison between electric and gas appliances.
- The use of stainless steel in oven cavities comes with certain disadvantages, mainly related to the cleaning process: high temperatures of pyrolytic process degrade stainless steel surfaces. Also, the emissivity of heat from the bottom part of the cavity is worse when using stainless steel.
- It might be worth exploring a way to calculate EEI, in order to make a less linear correlation between energy efficiency and cavity volume.
- Energy saving modes are the biggest opportunity of improvement in terms of energy efficiency of ovens and they are seen as an incentive for innovation. However, in some occasions they can produce unsatisfactory results in the form of undoneness or burning. Moreover, they are not the most frequently used heating modes. Some stakeholders are against their use in energy declaration and energy class determination. Nevertheless, banning their use could hinder innovation. Further analysis is needed to determine the benefits and drawback of allowing/banning their use for energy declaration.
- There is a limited improvement potential in conventional ovens with fan-forced functions. Steam-assisted ovens appear to obtain better EEI results and therefore achieve higher energy classes. However, the mode used for the energy declaration may have not been the steam-assisted mode (the best performing may have been conventional or fan-forced). Moreover, ovens with steam-assisted function have better sealing and isolation characteristics with reduced vapour outlet,

when compared to conventional ovens. In conclusion, the support of steam does not necessarily lead to lower energy consumption.

- There is certain debate around the possibility of improving energy efficiency of ovens by enhancing their sealing conditions. A way of improving energy efficiency of ovens in general is in the development of ovens with the sealing characteristics of steam-assisted ovens, modifying "air tightness" during the cooking cycle in order to reduce heat loss A potential issue with this reasoning is that there are some recipes which do not work with such highly-sealed conditions and require some air leakage.

- There is energy and time saving potential in microwave combi-modes, observed in tests with real food. Depending on the type of dish being prepared, when compared to convective heating, energy savings can vary between 5% - 20%. However, despite this energy saving potential, since currently there is no standard test to evaluate these savings, it is currently not perceived by consumers.

- According to feedback from manufacturers, the use of automatic programs can reduce the energy consumption of the oven by approximately 15% per cycle. However, the savings of the automatic functions cannot be easily shown with the current measurement methods

- The total energy consumption of pyrolytic function could be quite significant. It is important that consumers have access to information about the energy consumption of systems. There are proposals to include information on energy consumption of self-cleaning systems in the user manual. However, it would be very challenging to evaluate different levels of cleanliness and to compare self-cleaning programmes with manual cleaning.

4.5.2 Hobs

- There is still a limited differentiation in terms of energy efficiency which prevents the introduction of energy labelling measurers.

- The Best Available Technology in terms of Energy Efficiency is an induction hob

- Small burners (below 1,16 kW) are currently out of scope because they are mostly used for simmering and not cooking; and because the temperature rise in the test standard is not adequate to measure their performance. However, there are proposals to include them into the scope, after the development of a simmering test for small burners. A minimum power threshold to be into the scope of ecodesign regulation should still be in place.

- Current regulation leaves out of the scope appliances designed for use only with gases of the 3rd family (butane and propane). However, this exception has no big sense nowadays.

- The design of gas hobs which reduce the distance between the pot and the flame, which may greater speed in cooking and lower energy consumption. However, this may jeopardise the safety of the hob, thus any improvement in this area is limited by safety requirements. Moreover, it can also increase pollutant emissions of the burner. Therefore, this strategy is not recommended to improve energy efficiency.

- The potential of improving energy efficiency in solid plate hobs is almost exhausted at this point, since today's solid plates are already equipped mainly with energy regulators (no longer 7-steps switches), due to the current requirements of ecodesign regulation.

- In terms of using hydrogen as an energy source for cooking appliances, there are several areas where technology is currently not ready for its adoption. One current gas appliance could never switch from natural gas to pure hydrogen without any adaptation. Moreover, hydrogen appears to be far from being a clean solution: it has potential only if it is produced from the excess renewable electricity that would otherwise be curtailed, and if it is then used in sectors where direct renewable electrification is not posible. There are recommendations to work on a progressive and voluntary approach concerning the ability of gas burners to operate with blends gases (for instance, with a pictogram illustrating its possible operation with a minimum rate of X% of hydrogen in natural gas).

4.5.3 Cooking fume extractors

- There is a significant improvement potential related to the type of electric motors of the blower. Brushless motors are more efficient and are able to reach the highest efficiencies, however, they are the most expensive and therefore, they are currently only present in high-end models.

- The type of fan used in the blower plays a role in the energy efficiency of the cooking fume extractor, however, it is often limited by the space available to install the cooking fume extractor.

- The Best Available Technology in terms of Energy Efficiency is a wall mounted cooking fume extractor equipped with a brushless motor

- Recirculating cooking fume extractors are out of the scope of ecodesign and energy labelling regulation. There are recommendations to include them into the scope of new regulation to enable their rating and comparison to models that operate in extraction mode, and even with models that are part of a central ventilation system.

- Current EEI in cooking fume extractors are not reflecting real life usage, since they are based on measurements at the best efficiency point (BEP), usually found at pressures much higher than the ones in real applications. Manufacturers have an incentive to focus on high speeds of operation. The result is that the energy efficiency of the lower speeds is rather low and that cooking fume extractors with higher airflow rates tend to obtain better energy classes. There is a general consensus that moving from the current method to the 9 point method will be a positive aspect for energy efficiency rating of cooking fume extractors.

- Current method to measure EEI only takes the direct energy consumption of the cooking fume extractor into account. However, when a hood is operated, it removes air from the kitchen that needs to be replaced with air from the exterior (replacement air). This air will need to be either cooled or heated by the heating system of the household. There are recommendations to take also into consideration the indirect Annual Heating/Cooling Consumption when calculating EEI. However, doing that would cause that energy efficiency of a product depends on external factors, such as heating/cooling systems or ventilations systems.

- Some stakeholders consider that current approach for measuring energy efficiency of cooking fume extractors is not sufficient and that capture efficiency should be taken into account in some manner. Odour reduction factor is considered as a good approximation for that. There are proposals to incorporate the odour reduction factor (Of) into the Annual Energy Consumption formula, so that both energy consumption and odour removal are considered when measuring EEI.

5 Task 5: Environment and economics

The aim of this section is to assess environmental and economic impacts associated to different base cases of ovens, hobs and cooking fume extractors. The assessment is based on the updated version of the EcoReport Tool (version 3.06), as provided with the MEErP 2011 methodology (COWI and VHK 2011b).

According to MEErP methodology, Base Cases (BC) should reflect average EU products. Different products of similar functionalities, Bill of Materials (BoM), technologies and efficiency can be compiled into a single base case. Therefore, it may not represent a real product on the shelves. The base cases are used as reference for modelling the stock of products together with their environmental and economic impacts and the available improvement design options.

For the identification of the base cases for cooking appliances, the analyses presented in the previous Tasks 1 (Scope & definition), 2 (Markets), 3 (Users) and 4 (Technologies) have been considered.

5.1 Technical description of base cases

5.1.1 Ovens base cases

The aim in this section is to define three base cases: one for electric ovens, one for gas cookers and one for microwave ovens. Each of those base cases should represent, to the extent possible, the "typical" or "average" appliance. The following base cases have been identified and chosen to further assess the environmental and economic impacts over the life cycle of ovens:

- Base Case 1 (BC1): Electric built-in oven, 65-75 litres, "A" energy class
- Base Case 2 (BC2): Gas cooker, 55-65 litres, "A" energy class
- Base Case 3 (BC3): Free-standing microwave oven, 20 litres

The main characteristics of BC1, BC2 and BC3 are summarised in Table 56.

Table 56. Ovens summary of base cases

	BC1 **Electric oven**	**BC2** **Gas cooker**	**BC3** **Microwave oven (3)**
Energy Class	A	A	n/a
Energy source	Electric	Gas	Electric
Self-cleaning cycle	Pyrolytic	None	None
Capacity (litres)	70	65	n/a (4)
Number of cavities	1	1	1
Mounting configuration	Built-in	Free standing	Free-standing
Opening system	Drop down	Drop down	Side
Interior lighting	halogen/inca	halogen/inca	n/a
Smart features	n/a	n/a	n/a
Volume of product (m3)	0.6x0.6x0.55m = 0.198 m3	0.85x0.6x0.6m = 0.306 m3	n/a
Volume of packaged product (m3)	0.265 m3	0.396 m3	0.092 m3
Packaging materials	EPS, carton board and foil and in some	EPS, carton board and foil and in some	EPS, carton board and foil

	cases also wood	cases also wood	
Mass (kg)	40	45	13.5
Energy Consumption (1) (Natural convection / Top Bottom)	0.89 kWh/cycle	5.6 MJ/cycle 1.56 kWh/cycle	n/a
Energy Consumption (1) (Convection / Fan-forced)	0.79 kWh/cycle	n/a	n/a
Power Output (2) (Microwave)	n/a	n/a	700 W

(1) Energy consumption measured with standard test EN 60350-1 (Brickmethod 1.0)

(2) Efficiency of appliance assumed as 55% based on feedback from manufacturers

(3) Data for BC3 taken from product brochure

(4) Capacity of microwave ovens is not indicated since the measurement method is different to electric and gas ovens

5.1.1.1 Ovens Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including the following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

The Bill of Materials (BoM) of BC1, BC2 and BC3 have been selected based on input provided by stakeholders (Table 57). BC1, BC2 and BC3 have the same BoM as in in the previous preparatory study (Lot 22).

Table 57. Bill of materials of BC1, BC2 and BC3 for ovens

Material category	BC1 (electric oven)	BC2 (gas oven)	BC3 (MW oven)
	Mass (g)		
1-BlkPlastics	250.8	65.0	1077.4
2-TecPlastics	583.3	2172.2	41
3-Ferro	30105.6	34730.5	6977.8
4-Non-ferro	1859.6	2974.3	2339.6
5-Coating	0.0	0.0	216
6-Electronics	162.0	0.0	510
7-Misc.	7038.6	5058.1	2361.2

To compile the BoM considered for the oven base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. For certain other materials no correspondence is possible. In this case the missing materials' weight is reallocated in other material categories.

5.1.1.2 Ovens manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of sheetmetal scrap. The default value is 25%.

5.1.1.3 Ovens distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP Methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the volume of the final (packaged) product.

- 0.266 m^3 for Base Case 1
- 0.396 m^3 for Base Case 2
- 0.092 m^3 for Base Case 3

5.1.1.4 Ovens use phase

There are two relevant parameters in the use phase of an oven: pattern of use by consumers and energy consumption per cycle. In the previous Preparatory Study (Lot 23), it was considered for both electric and gas ovens a common pattern of use of **110 cycles/year** and **55 minutes/cycle**. For microwave ovens, the figures used were **1200 cycles/year** and **2.6 minutes/cycle** (with an average power of 500W). These numbers will be used in this report for Approach 1.

In this report, a user behaviour study has been conducted and presented in Task 3. In this study, respondents provided information regarding their frequency of use (in total and by heating mode) and duration of use per heating mode. Considering the frequency of times that the appliances is used (ignoring the duration of time that each cycle is used), results indicate that ovens are used **182 cycles/year**, a significant increase when compared to the previous preparatory study. For the calculation of annual energy consumption, energy consumption of Top & Bottom and Fan-forced heating modes will be used, with a weighted average of 50% each, resulting in an energy consumption per cycle of **0.84 kWh/cycle**.

Regarding microwave ovens, results from the user behaviour study indicate that microwave ovens are used **842 cycles/year**, a decrease from the previous preparatory study.

As a result of using the data presented in this section, annual energy consumption (including standby) is estimated for the different cases and presented in Table 58.

Table 58. Annual energy consumption of oven base cases

BC1: Electric oven	BC2: Gas oven	BC3: Microwave oven
156.6 kWh/year	1051 MJ/year	33.2 kWh/year

5.1.1.5 Ovens end-of-Life (EoL) phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the oven is purchased and discarded, 15 years have been assumed, the same as for the product service life, i.e. the period that the product is in use and operational.

As “unit sales L years ago”, it would correspond to the units sold in the year 2020 minus the product life, and the resulting unit sales figures would be:

BC1 = 5.4 million units

BC2 = 0.8 million units

BC3 = 7.3 million units

The current fraction of materials contained in appliances on the market is calculated by the EcoReport tool based on the material shares of the BoM and the calculated spare parts for maintenance and repair. This tool tool requires input on the destination of the EoL of the different fractions in terms of re-use, recycling, recovery, incineration and landfill/missing/fugitive. In lack of more specific data on the destination of the material fractions of ovens, the default values of the EcoReport tool have been used. For the calculation of base cases, an average recyclability of the fractions has been chosen. Table 59 gives a summary of the assumptions.

Table 59. End of life assumptions

	Bulk Plastics	TecPlastics	Ferro	Non-ferro	Coating	Electronics	Misc, excluding refrigant & Hg	refrigerant	Hg (mercury), in mg/unit	Extra	Auxiliaries
EoL mass fraction to re-use, in %	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	5%
EoL mass fraction to (materials) recycling, in %	29%	29%	94%	94%	94%	50%	64%	30%	39%	60%	30%
EoL mass fraction to (heat) recovery, in %	15%	15%	0%	0%	0%	0%	1%	0%	0%	0%	10%
EoL mass fraction to non-recov. incineration, in %	22%	22%	0%	0%	0%	30%	5%	5%	5%	10%	10%
EoL mass fraction to landfill/missing/fugitive, in %	33%	33%	5%	5%	5%	19%	29%	64%	55%	29%	45%

5.1.2 Hobs base cases

Task 2 shows that radiant hobs represent 35% of the current stock and induction hobs are 28%. According the historic sales series, this situation is expected to shift in the future, becoming induction hobs the dominant technology. There is still a small share of solid plates that is expected to be reduced along time, from current 14% to 3% in 2040. Gas hobs are expected to retain their share in the future, ranging from 20 to 30% of the stock.

The following base cases have thus been identified and chosen to further assess the environmental and economic impacts over the life cycle of hobs:

- Radiant technology, 4 cooking zones
- Induction technology, 4 cooking zones
- Gas technology, 4 cooking zones

Three base cases have been chosen to represent the types of hobs on the market, while solid plates are discarded as representative technology. However, solid plates will still be within the scope of regulations..

Table 60 summarises the detailed performance characteristics chosen for the hobs base cases including the respective underlying sources and assumptions.

Table 60: Characteristics of the chosen base cases 1 and 2 for hobs

	BC1 (radiant)	BC2 (induction)	BC3 (gas)	Sources
Cooking zones	4	4	4	From Task 3 and task 4
Power on-mode (kW)	7.4	7.4	9	BC1 and BC3 Lot 23, BC2
Power off-mode (W)	0.49	0.49	-	Technical specifications
Weight (kg)	8.3	11.2	7.8	From manufacturers
Energy efficiency as ED	190 Wh/kg water	185 Wh/kg water	56%	From manufacturers

Compared to the base cases used in the ecodesign preparatory study of 2011 ("Lot 23") by BIO (2011) the current base cases include explicitly induction technology, based on its current and future share in the market.

5.1.2.1 Hobs Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including the following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

The Bill of Materials (BoM) of the base case products have been selected based on input provided by stakeholders (mainly personal communication with manufacturers). In order to define the average model for each base case the data collected were analysed and aggregated or averaged regarding the type of material.

To compile the BoM considered for the oven base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. For certain other materials no correspondence is possible. In this case the missing materials' weight is reallocated in other material categories. The amount of materials that does not exactly correspond to the categories included in the ErP EcoReport data base is around 7% of the total mass.

Table 61: Aggregated BoM considered for hobs base cases

Component / Material	BC1 (radiant)	BC2 (induction)	BC 3 (gas)
	Weight (in g)	Weight (in g)	Weight (in g)
Product			
Bulk Plastics	253	253	107
TecPlastics	283	71	150.5
Ferro	1 951	1 791	5 467
Non-ferro		2 209	0
Electronics	266	3 203	0
Miscellaneous (glass)	5 002	3 060	0
Miscellaneous (others)	510	634	39

5.1.2.2 Hobs manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of sheetmetal scrap. The default value is 25%.

5.1.2.3 Hobs distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP Methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the volume of the final (packaged) product.

Regarding the average volume of the final packaged product the same values as in Lot 23 (BIOS 2011) are assumed:

- 0.061 m^3 for Base Case 1 and 2
- 0.057 m^3 for Base Case 3

5.1.2.4 Hobs use phase

The only input at the use phase is the energy consumption. The estimation of energy consumption requires the following parameters:

- Energy consumption per kg, for electric hobs, and energy efficiency, for gas hobs, is provided in the technical description of base cases.
- Frequency of use per week: according Task 3 User behaviour: 12 times per week, 624 times per year.
- For electric hobs: it is assumed that the simmering test method represents a cooking cycle and that 1 kg of water represent a normalised amount of food to be cooked.
- For gas hobs: it is assumed that the cooking cycle is represented by heating up an amount of water from 20 to 90C in an aluminium pan, according to EN 30-2-1. The normalised amount of water is 1.5 kg of water, which would account for the different cooking cycles of electric and gas hobs, e.g. the simmering phase in a gas hob would correspond to the shift of the pan to a smaller hob.

The results are shown in Table 62.

Table 62: Summary of cycles and energy consumption of hobs at the use phase

	Efficiency as ED regulation	**Energy consumed per cycle**	**Energy consumed per year in kWh**	**Energy consumed per year in kWh Lot 23 (for comparison)**
Radiant	190 Wh/kg water	190.0 Wh	118.6	240
Induction	185 Wh/kg water	185 Wh	115.4	-
Gas	56% (heat output/heat input)	825.4 kJ	515.0 MJ (143.1 kWh)	328.5

5.1.2.5 Hobs End-of-Life (EoL) phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the hob is purchased and discarded, 15 and 19 years have been assumed for electric and gas hobs, respectively. They are the same as for the product service life, i.e. the period that the product is in use and operational. This assumption is made because consumers do not keep the old hobs stocked after buying a new one.

As “unit sales L years ago”, it would correspond to the units sold in the year 2020 minus the product life, and the resulting unit sales figures would be:

- 6.93 million units, for radiant hobs, Base Case 1 in year 2005
- 1.22 million units, for induction hobs, Base Case 2 in year 2005
- 1.90 million units, for gas hobs, Base Case 2 in year 2001

EcoReport tool requires input on the destination of the EoL of 5 fractions in mass: re-use, recycling (material), recovery (heat), incineration and landfill/missing/fugitive. In lack of more specific data on the destination of the material fractions of hobs the default values of the EcoReport tool have not been changed.

The EcoReport tool requires to define qualitatively the ‘EoL recyclability'. This relates to the potential of the new products to change the course of the material flows, e.g. due to faster pre-disassembly or other ways to bring about less contamination of the mass to be recycled. In that case, it is likely that the recycled mass at the EoL will displace more virgin material in other applications. The recyclability does not influence the mass balance but it does give a reduction or increase up to 10% on all impacts of the recycled mass. For the calculation of base cases, an average recyclability of the fractions is chosen.

Table 63 gives a summary of the assumptions.

Table 63: End-of-life destination of material fractions

Per fraction (post-consumer)	Bulk Plastics	TecPlastics	Ferro	Non-ferro	Coating	Electronics	Misc. , excl. refrigerant	Refrigerant	Extra	Auxiliaries
EoL mass fraction to re-use, in %	*1*		*1*			*1*	*1*	*1*	*1*	*0*
EoL mass fraction to (materials) recycling, in %	*29*		*94*			*50*	*64*	*30*	*60*	*0*
EoL mass fraction to (heat) recovery, in %	*15*		*0*			*0*	*1*	*0*	*0*	*0*
EoL mass fraction to non-recov. incineration, in %	*22*		*0*			*30*	*5*	*5*	*10*	*0*
EoL mass fraction to landfill/ missing/ fugitive, in %	*33*		*5*			*19*	*29*	*64*	*29*	*100*
TOTAL, in %	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
EoL recyclability	avg	avg	avg	avg	avg	avg	avg	avg	avg	avg

5.1.3 Cooking fume extractors base cases

Section 2.2.3.4 reveals that chimney cooking fume extractors represent 55% of sales in 2016, 2017 and 2018, followed by under cabinet, telescopic and built-in (43%). These three types could be named under the descriptor cabinet cooking fume extractors. Ceiling and worktop vent cooking fume extractors represent 2% of sales.

The energy class profile of the different types of cooking fume extractors is shown in Figure 193:

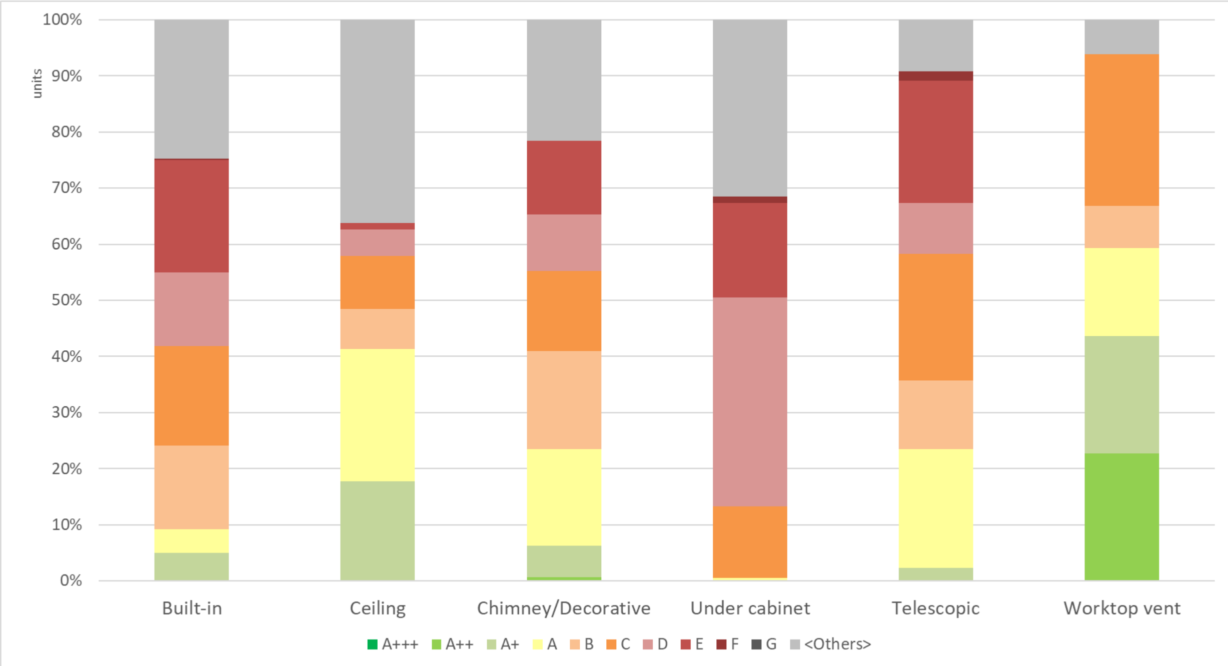


Figure 193: Distribution of energy classes of the different types of cooking fume extractors

Under cabinet hoods are typically less efficient, due to the space limitation, though there seems to a jump from C class to A, perhaps due to a change in the motor technology. The other two cabinet cooking fume extractors can achieve energy classes of B and better. For the purpose of base case definition, the typical energy class of a cabinet cooking fume extractors is set as C. Chimney cooking fume extractors show a wide range of energy classes, reaching A+. The energy class of the base case is set as B, as a middle point within this range of energy classes.

Therefore, the following base cases have thus been identified and chosen to further assess the environmental and economic impacts over the life cycle of cooking fume extractors:

- Chimney cooking fume extractor, energy class B
- Cabinet cooking fume extractor, energy class C.

While the market of cooking fume extractors are highly segmented, there is a robust information pointing at these two types of products as representative of the stock and of the overall energy performance of these products. They also represent the typical kitchens in EU, where there may be space limitations that only allow for the installation of small, integrated cooking fume extractors.

Table 64 summarises the detailed performance characteristics chosen for the cooking fume extractors base cases including the respective underlying sources and assumptions. The data has been provided by manufacturers.

Table 64. Characteristics of the chosen Base Cases 1 and 2 for cooking fume extractors

	Base case 1	**Base case 2**
Ventilation	ducted	ducted
Airflow rate MAX (m3/h)	387,4	707,2
Airflow rate MIN	255,8	278,3
Noise at Airflow rate MAX (dB)	67	73
Noise at Airflow rate MIN (dB)	60	52

Installation	cabinet	Chimney or wall
Type of filter	mesh	mesh
Lighting	halogen	LED
Lighting power (W)	43,5	3,5
Grease Filtering Efficiency (%)	86,6	91,1
Smart features	-	-
Volume of product (m3)	0,0378	0,04
Volume of packaged product (m3)	0,0704	0,233
Packaging materials	Cardboard, wood, EPS, foil	Cardboard, wood, EPS, foil
Mass (kg)	8,36	9.93
Electricity consumption (kWh/year)	68,30	63,00
Energy class	C	B
Retail price (EUR)	82.5	363.2 – 236.2

5.1.3.1 Cooking fume extractors Bill of Materials (BoM)

The manufacturing phase includes the extraction and production of the required materials including the following steps necessary to produce and assemble one product. The MEErP 2011 EcoReport tool contains a detailed list of materials and processes for which defined environmental indicators are provided as default values.

The Bill of Materials (BoM) of the base case products have been selected based on input provided by stakeholders (mainly personal communication with manufacturers). In order to define the average model for each base case the data collected were analysed and aggregated or averaged regarding the type of material.

To compile the BoM considered for the oven base cases, it is worth noting that in the data base available in the ErP EcoReport many materials are missing. The materials not mentioned in the data base have been reallocated to the existing material categories. For certain other materials no correspondence is possible. In this case the missing materials' weight is reallocated in other material categories.

The aggregated BoM for cooking fume extractors is shown in Table 65.

Table 65. Aggregated BoM of cooking fume extractor base cases and the base case used in Lot 10

Component / Material	BC 1 (under cabinet)	BC 2 (chimney)	Lot 10
	%	%	%
Bulk Plastics	5%	2%	10%
TecPlastics	5%	2%	9%
Ferro	86%	94%	80%
Non-ferro (Copper)	3%	1%	2%
Electronics	2%	1%	2%
Miscellaneous (glass)	0%	0%	0%

5.1.3.2 Cooking fume extractors manufacturing process

The manufacturing process is mainly fixed in the EcoReport tool. The only variable which can be edited is the percentage of sheetmetal scrap. The default value is 25%.

5.1.3.3 Cooking fume extractors distribution phase

This phase comprises the distribution of the packaged product. According to the MEErP Methodology report (COWI and VHK 2011b), the section on Final Assembly and Distribution covers all activities from OEM components to the final customer. The only design variable, however, is the volume of the final (packaged) product.

The values were reported by manufacturers by means of the questionnaire:

- 0,0704 m^3 for Base Case 1
- 0,233 m^3 for Base Case 2

5.1.3.4 Cooking fume extractors use phase

The energy consumed by the cooking fume extractor depends on the load, FDE and the time of use. According to the current methodology, the AEC is calculated assuming an average running time per day of 60 min and an average lighting time per day of 120 min.

The outcomes of the user behaviour study shows that about 80% of the respondents use the fan of the cooking fume extractor often or almost always when the hob is in use and about 60% use the light of the cooking fume extractor. This means that the average time of use of the cooking fume extractor is similar to the use of the hob. Assuming that 80% of the times of use of hob, the cooking fume extractor is also switched on, it would mean 3 hours per week (25 minutes per day). Most respondents also indicated that the use of the cooking fume extractor is linked to the use of hob (only 15% reported the use of the cooking fume extractor when not cooking). Using the cooking fume extractor light as a substitute for the kitchen light is the most important use of the cooking fume extractor when not cooking, with an average of 3.8 times per week. Assuming and average time of use of 30 minutes, the average times of use per day of the cooking fume extractor would be:

- average running time per day: 25 min
- average lighting time: 41 min

The result of the survey confirms that the average times of use in the current methodology may overestimate the annual consumption of the cooking fume extractor. However, manufacturers have consistently used this methodology for consumer information; therefore, the modelling will be based on the current methodology, unless better information is provided.

The annual energy consumption of a domestic cooking fume extractor (AEC_{hood}) is calculated as a function of the electric power input of the domestic cooking fume extractor at the best efficiency point. As explained in Task 1 and Task 3, the best efficiency point is usually the boost speed, and it is not representative of real use. According to Task 3, the typical load profile of a cooking fume extractor use cycle is the following:

- Time at minimum speed equal to 20 minutes.
- Time at maximum speed equal to 30 minutes.
- Time at boost equal to 10 min.

Manufacturers have developed a new method to take into account the different speeds in the AEC calculation. The so-called 9-points method is based on measurements at three different blower speed and three different operating points representing common hydraulic loads in a real kitchen. The average of the three blower speeds are based on the same time profile shown by the user behaviour study.

Manufacturers provided the data of different models, measured using the current method and the 9 points method. The data allowed the conversion of the AEC declared of the base cases into a 9 points method AEC. The conversion factors used are shown in Table 66.

Table 66: AEC of bases cases based on current methodology and 9-points method.

Base case	**Conversion factor**	**AEC current (kWh)**	**AEC 9-points (kWh)**
BC1 cabinet	0.69	68.3	47.1
BC2 chimney	0.68	63.0	42.8

5.1.3.5 Cooking fume extractors End-of-Life phase

Recycling of materials can avoid the extraction of raw materials and the production of virgin materials. This is modelled in the EcoReport tool as credits (avoided impacts), i.e. negative impacts.

For the product (stock) life, i.e. the period between when the cooking fume extractor is purchased and discarded, a lifetime of 15 years is assumed. It is the same as for the product service life, i.e. the period that the product is in use and operational. This assumption is made because consumers do not keep the old cooking fume extractor stocked after buying a new one.

As “unit sales L years ago”, it would correspond to the units sold in the year 2020 minus the product life, and the resulting unit sales figures would be:

- 4.2 million units, for cooking fume extractors in 2005, of which 45% would be cabinet cooking fume extractors and 55% chimney cooking fume extractors.

EcoReport tool requires input on the destination of the EoL of 5 fractions in mass: re-use, recycling (material), recovery (heat), incineration and landfill/missing/fugitive. In lack of more specific data on the destination of the material fractions of cooking fume extractors the default values of the EcoReport tool have not been changed.

The assumptions taken are equivalents to the shown in Table 59.

5.2 Life cycle cost input data

5.2.1 Common input data

In the EcoReport tool the Life Cycle Costs (LCC) are calculated according to the following formula:

$$LCC = PP + PWF * OE + EoL$$

With:

- LCC is the Life Cycle Costs to end-users in EUR
- PP is the purchase price (incl. installation costs) in EUR
- OE is the annual operating expense in EUR
- EoL is the end-of-life costs for end-users (i.e. costs for disposal)
- PWF is the (Present Worth Factor)

$$PWF = 1 - \left(\frac{1+e}{1+d}\right) \cdot \left[1 - \left(\frac{1+e}{1+d}\right)^N\right] \qquad (d \neq e)$$

Where

- e is the aggregated annual growth rate of the operating expense ('escalation rate')
- d is the discount rate in %
- N is the product life in years.

5.2.1.1 Discount and escalation rate

To calculate the PWF the discount rate (d) and the escalation rate (e) of the operating expenses has to be defined. For the discount rate (d = interest - inflation) (COWI and VHK 2011b) recommends to apply 4% (which is also the required discount rate of the impact assessment guidelines of the Commission).

The escalation rate (e = inflation corrected running cost price increase) shall be the weighted average of the different annual growth rates of the different elements of the operating expenses. (COWI and VHK 2011b) suggest a default value of 4%.

Additionally, end-users in Europe do not have separate costs for the disposal of household cooking appliances, so EoL is zero.

5.2.1.2 Energy prices

The annual energy prices are taken from the PRIMES Model[11], which provides the prices referred to the year 2013. The reference year prices is calculated using the inflation rates from Eurostat.

Table 67. Energy prices

	2013 END USER PRICE (in EUR cents/kWh)					
Electricity	2005	2010	2015	2020	2025	2030
Households	15.6	17.2	19.0	20.3	20.9	21.2
Natural gas						
Households	4.6	6.1	7.1	7.5	7.9	8.4
LPG						
Households	7.7	8.6	6.7	9.5	10.2	10.8
	2018 END USER PRICE (in EUR cents/kWh)					
Electricity	2005	2010	2015	2020	2025	2030
Households	16.2	17.9	19.8	21.1	21.8	22.1
Natural gas						
Households	4.8	6.4	7.4	7.8	8.2	8.7
LPG						
Households	8.0	9.0	7.0	9.9	10.6	11.2

[11] https://ec.europa.eu/clima/policies/strategies/analysis/models_en

5.2.2 Ovens life cycle cost inputs

5.2.2.1 Ovens stock and sales data

For the calculation of the EU totals, data on the annual sales and the stock from Task 2 are taken into account.

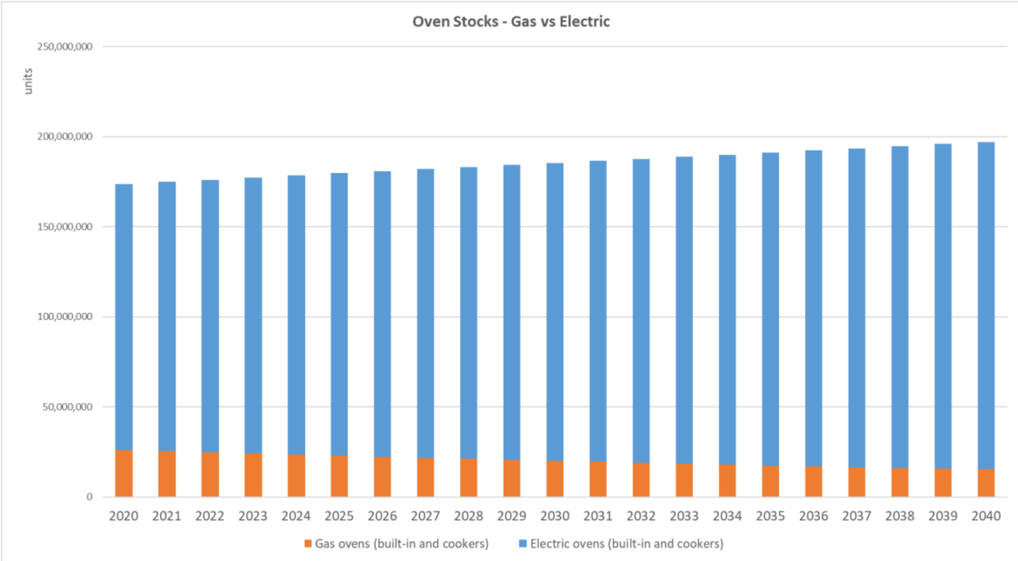


Figure 194. Stock of ovens

As seen in Figure 194, stock of electric ovens (BC1) in 2020 is 147.6 million units, whereas the stock of gas cookers (BC2) is 26.0 million units. Considering a penetration rate of 75.3%, the stock of microwave ovens (BC3) was estimated as 145.0 million units.

5.2.2.2 Ovens product prices

As shown in Task 2 of this report, the average unit prices of electric ovens and gas cookers over the years 2015-2018 can be seen in Figure 195.

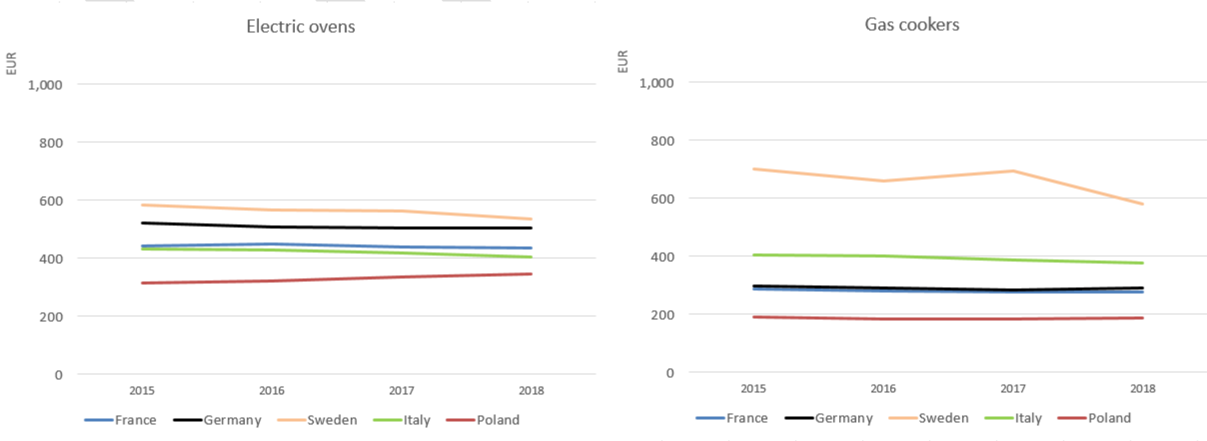


Figure 195. Ovens product prices

The average price for the EU27 of BC1 results in 446 Euro, whereas for BC2 it is 342 Euro. The average price of BC3 has been estimated as 60 Euro.

5.2.2.3 Ovens maintenance and repair costs

Maintenance and repair costs are estimated to for the three base cases according to their technical features and lifetime. The costs are based on the following parameters:

- The percentage that require repair once in their lifetime
- The cost of the spare parts used in the repair, assumed as 1/10 of the price of the product.
- The labour costs, taking into account the dedicated time and the cost per hour, according Task 2.

Installation costs are calculated based on the labour costs.

The results are shown in Table 68.

Table 68. Maintenance and repair costs of ovens

	% require repair	Cost of spare parts (Euro)	Labour costs(1) (Euro)	Maintenance and repair cost (Euro)	Installation cost (Euro)
BC1	15	44.6	82.2	19.02	82
BC2	15	34.2	82.2	17.46	82
BC3(2)	0	0	0	0	0

(1) Assuming 3 hours average

(2) Assumed that MW ovens are not repaired due to low cost of product and potential high cost of spare parts

5.2.2.4 Ovens ratio average new appliance vs. stock

Finally the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. For the average product installed, data provided by APPLIA on 2012 models has been used, with an average energy consumption of 0.82 kWh/cycle in their best performing mode. For the average new product, data from TopTen database in 2019 has been used, with an average energy consumption of 0.65 kWh/cycle in their best performing mode. With these numbers, the resulting ratio is 79%.

5.2.3 Hobs life cycle cost inputs

5.2.3.1 Hobs stock and sales

For the calculation of the EU totals, data on the annual sales and the stock from Task 2 are taken into account.

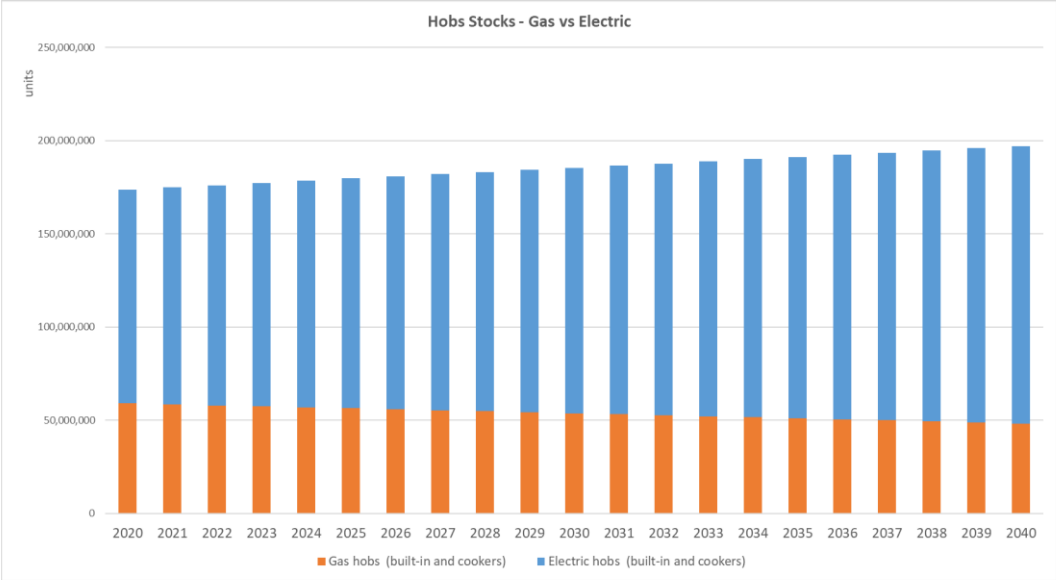


Figure 196. Stock of hobs

As seen in Figure 196, stock of electric hobs (BC1) in 2020 is 114.6 million units, whereas the stock of gas hobs (BC2) is 59.0 million units. The sales in 2020 of radiant and induction are estimated in 6.25 million units respectively Gas hobs sales are estimated in 1.81 million units.

5.2.3.2 Hobs product price

The retail prices of hobs are describe under Task 2, and as can be observed, there is a significant variation across EU countries, particularly for induction hobs (Figure 197)

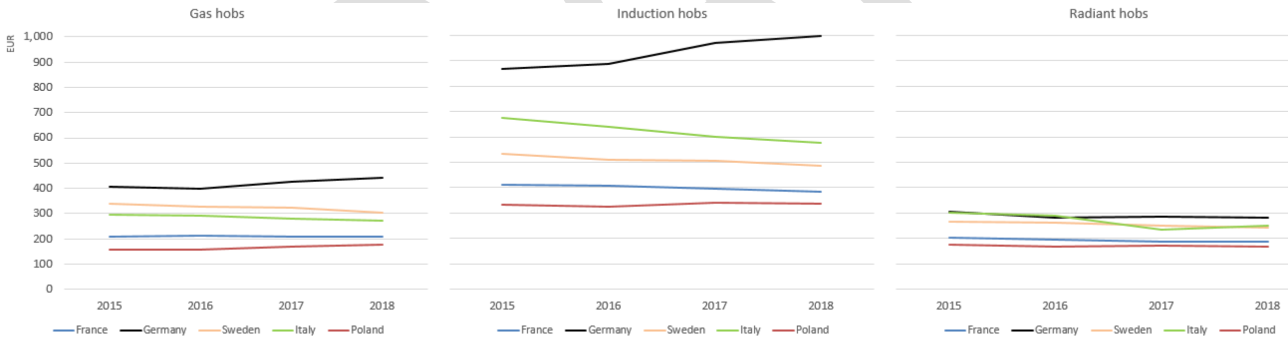


Figure 197. Price of hobs by heating element

An average value can be calculated, taking into account the units sold in each country, resulting the following values for the year 2018:

- BC1 radiant hob: EUR252.0
- BC2 induction hob: EUR535
- BC3 gas hob (without glass surface): EUR210.0

5.2.3.3 Hobs installation, maintenance and repair costs

Maintenance and repair costs are estimated to for the three base cases according to their technical features and lifetime. The costs are based on the following parameters:

- The percentage that require repair once in their lifetime
- The cost of the spare parts used in the repair, assumed as 1/10 of the price of the product.

- The labour costs, taking into account the dedicated time and the cost per hour, according Task 2.

Installation costs are calculated based on the labour costs.

The results are shown in Table 69

Table 69: Maintenance and repair costs and installation costs for the bases cases

	% require repair	Cost of spare parts	Labour costs (average 3 hours)	Maintenance and repair cost	Installation cost
Hobs BC1	15	23	82	15.8	82
Hobs BC2	20	56	82	27.6	82
Hobs BC3	10	28	82	11.0	82

These estimations heavily rely on assumptions that bring a wide range of uncertainty to the results. The impact of repairs has been analysed by means of a sensitivity analysis. In this study a higher and a lower repair rate is proposed as the effect would be similar to a higher or lower cost per repair respectively.

5.2.3.4 Hobs ratio average new appliance vs new stock

Finally the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. The average product installed approximately equals the average new product a number of years ago.

For electric hobs, the ratio is assumed to be 0.92, based on the typical range of energy consumption per kg of water provided by manufacturers. For gas hobs, a ratio of 90% can be derived from the mandatory thresholds of energy efficiency set by Ecodesign measures.

5.2.4 Cooking fume extractors life cycle cost inputs

5.2.4.1 Cooking fume extractors stock and sales data

For the calculation of the EU totals, data on the annual sales and the stock from Task 2 are taken into account.

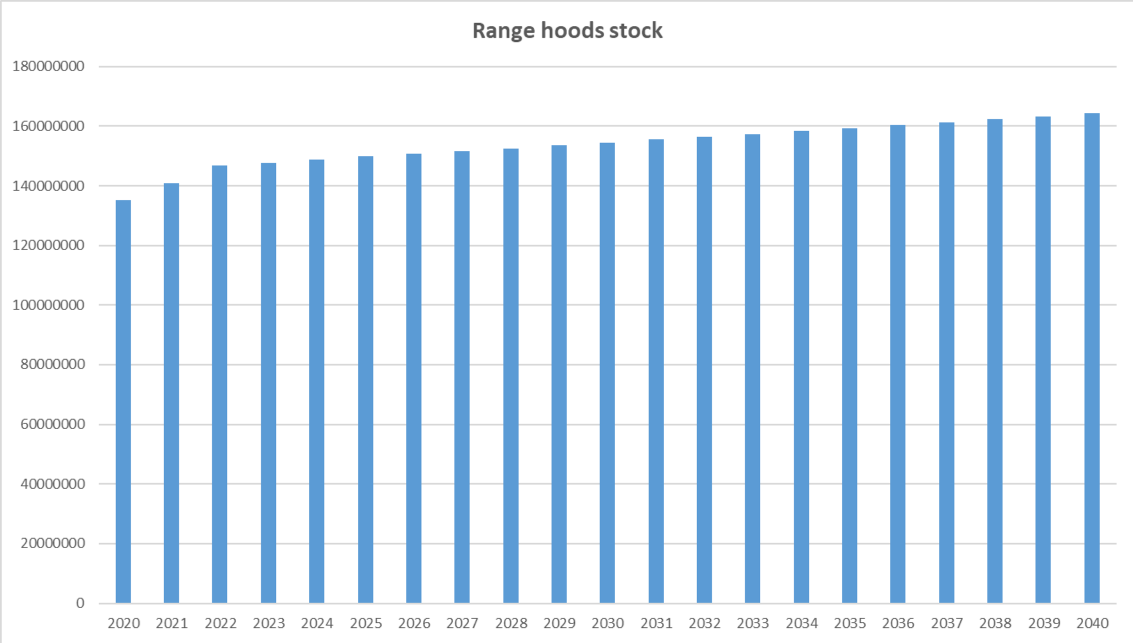


Figure 198. Stock of cooking fume extractors

As seen in Figure 198, stock of cooking fume extractors in 2020 is 164.3 million units. According to the results of the user behaviour study, close to 40% of EU stock can be considered cooking fume extractor built into kitchen furniture and about one-third have a standalone, wall-mounted cooking fume extractor. Ceiling-mounted cooking fume extractor is less frequent (16.4%). The latest innovation of a down-draft cooking fume extractor mounted at the height level of the hob is found in about 8% of the kitchens. Since the two base cases chosen represent the EU stock, it is assumed that ceiling cooking fume extractors are within the same group of chimney cooking fume extractors (stand-alone cooking fume extractors) while down-draft are meant to replace standard cabinet cooking fume extractors.

Table 70. Assumptions on stock of cooking fume extractors

	Assumption	Share of the stock	Stock (2020) (in million units)
BC1 Cabinet	Cabinet and down-draft	47.2%	77.6
BC2 Chimney	Wall-mounted and ceiling mounted	52.8%	86.7

For sales, projections have been developed based on GfK and Euromonitor data, which result in a figure of estimated sales of 6.32 million units cooking fume extractors. As explained in previous sections, the sales of chimney cooking fume extractors represent 55% of the market and the sales of cabinet cooking fume extractor 43%. It is assumed that 55% of sales are chimney cooking fume extractors and 45% cabinet cooking fume extractors.

5.2.4.2 Cooking fume extractors product prices

The retail prices of cooking fume extractors are describe under Task 2. An average value can be calculated, taking into account the units sold in each country, resulting the following values for the year 2018:

- BC1 cabinet: EUR189.4
- BC2 chimney: EUR334.4

5.2.4.3 Cooking fume extractors installation, maintenance and repair costs

Maintenance and repair costs are estimated to for the three base cases according to their technical features and lifetime. The costs are based on the following parameters:

- The percentage that require repair once in their lifetime
- The cost of the spare parts used in the repair, assumed as 1/10 of the price of the product.
- The labour costs, taking into account the dedicated time and the cost per hour, according Task 2.

Installation costs are calculated based on the labour costs.

The results are shown in Table 71.

Table 71: Maintenance and repair costs and installation costs for the bases cases

	% require repair	Cost of spare parts	Labour costs (average 3 hours)	Maintenance and repair cost	Installation cost
Cooking fume extractor BC1	15	18.9	82	15.1	82
Cooking fume extractor BC2	15	33.4	82	17.3	82

These estimations heavily rely on assumptions that bring a wide range of uncertainty to the results. The impact of repairs has been analysed by means of a sensitivity analysis. In this study a higher and a lower repair rate is proposed as the effect would be similar to a higher or lower cost per repair respectively.

5.2.4.4 Cooking fume extractors ration average new appliance vs stock

Finally the ratio between the energy consumption of the average new product and the energy consumption of the average product installed ('stock') has to be derived. The average product installed approximately equals the average new product a number of years ago.

For cooking fume extractors, it is assumed that this new product would be an energy class lower than the base case currently considered. The ratio would be 0.85 for base case 1 and 0.82 for base case 1.

For electric hobs, the ratio is assumed to be 0.92, based on the typical range of energy consumption per kg of water provided by manufacturers. For gas hobs, a ratio of 90% can be derived from the mandatory thresholds of energy efficiency set by Ecodesign measures.

5.3 Environmental Impact Assessment of base cases

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for

- Raw materials use and manufacturing,
- Distribution,
- Use phase, taking User behaviour approach 2, described above
- End-of-life phase.

5.3.1 Environmental impact assessment of ovens

5.3.1.1 Base Case 1: Electric built-in oven

Table 72 shows the material consumption of an electric oven over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair of the bill of materials. The material consumption during the End-of-Life phase is split in disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

Table 72. Material consumption of oven BC1

Resources Use		Production	Distribution	Use	End of Life-Disposal	End of Life-Recycling	End of Life-Stock
Bulk Plastics	[g]	250.8	0.0	2.5	98.8	80.8	73.7
TecPlastics	[g]	583.3	0.0	5.8	229.7	188.0	171.5
Ferro	[g]	30105.6	0.0	301.1	1077.9	20479.6	8849.2
Non-ferro	[g]	1859.6	0.0	18.6	66.6	1265.0	546.6
Coating	[g]	0.0	0.0	0.0	0.0	0.0	0.0
Electronics	[g]	162.0	0.0	1.6	56.9	59.2	47.6
Misc.	[g]	7038.6	0.0	70.4	1713.6	3326.5	2068.9
Extra	[g]	0.0	0.0	0.0	0.0	0.0	0.0
Auxiliaries	[g]	0.0	0.0	0.0	0.0	0.0	0.0
Refrigerant	[g]	0.0	0.0	0.0	0.0	0.0	0.0
Total weight	[g]	40000.0	0.0	400.0	3243.4	25399.0	11757.6

Table 73 shows the environmental impacts of an electric oven over the whole lifecycle of 15 years. The results are also shown in Figure 199 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 73. Environmental impact of oven BC1

Life Cycle Phase		Production			Distribution	Use	End-of-Life			Total
		Material	Manuf.	Total			Disposal	Recycling	Stock	
Resources & Waste										
Total Energy (GER)	[MJ]	2676.6	537.6	3214.2	429.6	18281.9	17.9	-658.1		21285.5
of which, electricity (in primary MJ)	[MJ]	663.0	307.7	970.7	0.8	21738.9	0.0	-133.7		22576.7
Water (process)	[ltr]	2245.6	4.1	2249.7	0.0	22.5	0.0	-589.5		1682.7
Water (cooling)	[ltr]	521.7	129.0	650.7	0.0	971.1	0.0	-96.6		1525.3
Waste, non-haz./ landfill	[g]	30656.9	2674.8	33331.7	265.6	11505.9	274.1	-8228.7		37148.6
Waste, hazardous/ incinerated	[g]	26.6	0.4	27.0	5.3	343.2	0.0	-3.7		371.7
Emissions (Air)										
Greenhouse Gases in	[kg CO_2	222.1	30.8	252.9	28.8	425.8	0.1	-56.8		650.7

GWP100	eq.]								
Acidification, emissions	[g SO_2 eq.]	2207.3	133.6	2340.9	87.1	4127.1	1.4	-573.3		5983.2
Volatile Organic Compounds (VOC)	[g]	4.8	0.6	5.5	5.6	485.4	0.0	-1.2		495.3
Persistent Organic Pollutants (POP)	[ng i-Teq]	261.8	74.8	336.5	1.5	53.3	0.1	-70.9		320.5
Heavy Metals	[mg Ni eq.]	4221.0	173.6	4394.5	13.5	261.9	3.4	-1138.9		3534.5
PAHs	[mg Ni eq.]	110.1	0.2	110.3	14.5	51.8	0.0	-28.9		147.7
Particulate Matter (PM, dust)	[g]	381.9	20.3	402.2	909.9	90.7	5.1	-85.8		1322.2
Emissions (Water)										
Heavy Metals	[mg Hg/20]	2569.9	5.6	2575.5	0.4	119.2	0.6	-689.2		2006.6
Eutrophication	[g PO4]	68.3	0.2	68.5	0.0	4.8	1.2	-18.0		56.6

From the analysis of emissions to air (Figure 199), it can be seen that the use of the oven is the most significant stage in three impact categories: Greenhouse gases (GHG), Acidification and Volatile Organic Compounds (VOC). This is related with product characteristics in terms of materials: predominance of ferromagnetic materials (75%) and glass (14%), and a low amount of plastics (1.5%) and electronics (0.4%).

On the other hand, for other impact categories such as Persistent Organic Pollutants (POP), Heavy metals (HM) and Polycyclic Aromatic Hydrocarbons (PAH), the most significant life cycle stage is production (including both the materials used and the manufacturing of the product). In contrast with all the above, product distribution is the most significant stage for impact category Particulate matter (PM).

Credits (negative impact) are obtained thanks to the recovery of materials at end of life (see assumptions made in Table 59). The impact categories most benefited from these credits are HM, POP and PAHs.

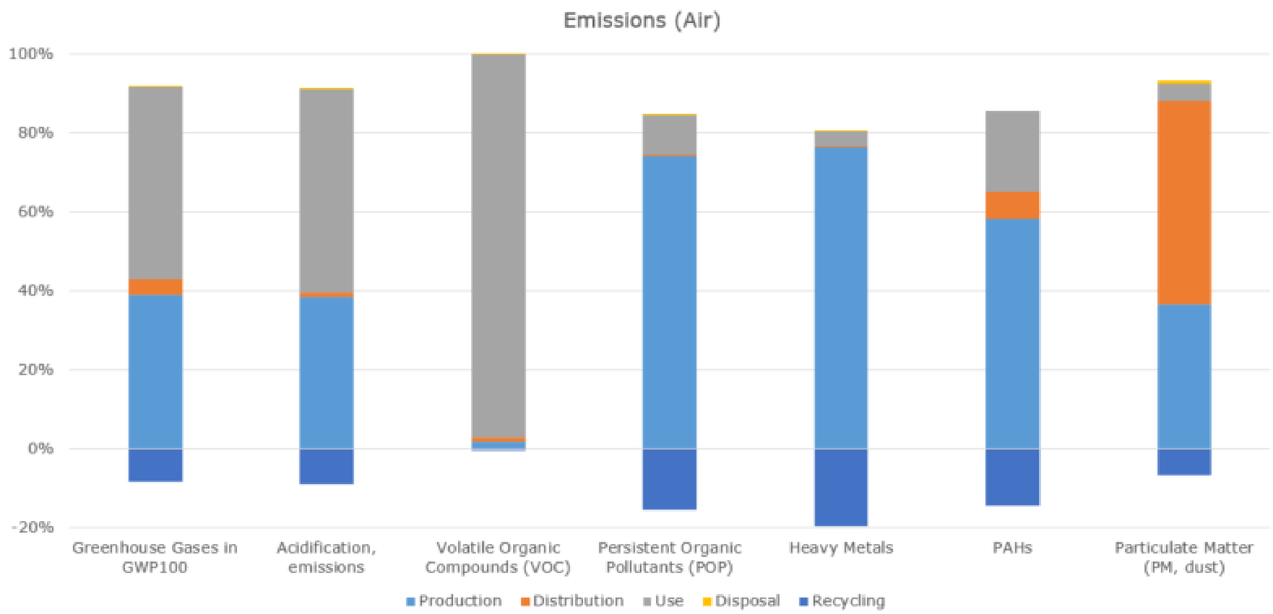


Figure 199. Impact of air emissions of ovens BC1

From the analysis of other resources and waste (Figure 200), it can be seen that the use stage is again the most significant phase for Energy, Water (cooling) and hazardous waste sent to incineration. It appears reasonable that the use stage is the most significant for the Energy category, since an electric oven is a product with a relatively simple manufacturing process but a significant energy consumption. On the contrary, for water related to the production process and non-hazardous waste, the most significant life cycle stage is production (including materials and manufacturing).

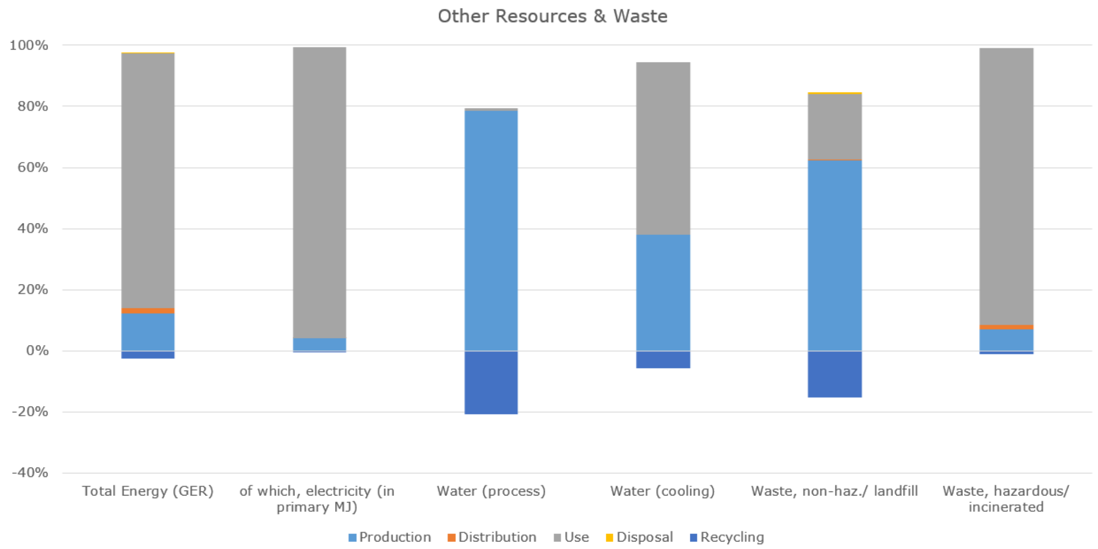


Figure 200. Impact of other resources & waste of ovens BC1

From the analysis of emissions to water (Figure 201), it can be seen that the most significant life cycle stage for both impact categories (Heavy Metals and Eutrophication) is production. Again, this is coherent with the product characteristics (an oven does not consume water during its use).

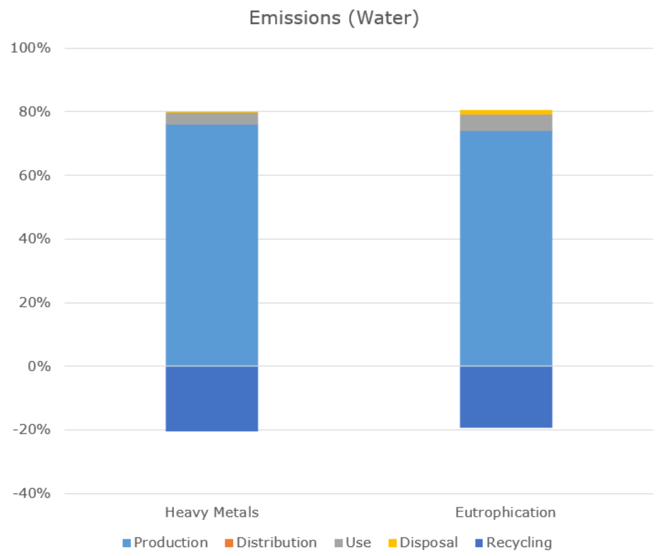


Figure 201. Impact of emissions to water of ovens BC1

5.3.1.2 Base Case 2: Gas free-standing cooker

Table 74 shows the material consumption of a gas free-standing gas cooker place over the whole life cycle of 15 years.

Table 74. Material consumption ovens BC2

Resources Use		Production	Distribution	Use	End of Life-Disposal	End of Life-Recycling	End of Life-Stock
Bulk Plastics	[g]	65.0		0.6	71.2	58.2	-63.8
TecPlastics	[g]	2172.2		21.7	2379.0	1946.5	-2131.6
Ferro	[g]	34730.5		347.3	3457.9	65700.6	-34080.7
Non-ferro	[g]	2974.3		29.7	296.1	5626.5	-2918.6
Coating	[g]	0.0		0.0	0.0	0.0	0.0
Electronics	[g]	0.0		0.0	0.0	0.0	0.0
Misc.	[g]	5058.1		50.6	3424.5	6647.6	-4963.4
Extra	[g]	0.0		0.0	0.0	0.0	0.0
Auxiliaries	[g]	0.0		0.0	0.0	0.0	0.0
Refrigerant	[g]	0.0		0.0	0.0	0.0	0.0
Total weight	[g]	45000.0		450.0	9628.8	79979.4	-44158.1

Table 75 shows the environmental impacts of a gas free-standing gas cooker place over the whole life cycle of 15 years. The results are also shown in Figure 202 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 75. Environmental impact ovens BC2

		Production			Distribution		End-of-Life			Total
		Material	Manuf.	Production		Use	End of Life - Disposal	End of Life - Recycling	Stock	
Other Resources & Waste										
Total Energy (GER)	[MJ]	2481.2	415.9	2897.1	429.6	20230.7	40.4	-1728.3		21869.6
of which, electricity (in primary MJ)	[MJ]	308.0	240.4	548.5	0.8	594.4	0.0	-199.7		943.8
Water (process)	[ltr]	1836.2	3.3	1839.5	0.0	18.4	0.0	-1311.7		546.2
Water (cooling)	[ltr]	1006.3	103.4	1109.7	0.0	36.3	0.0	-398.0		748.0
Waste, non-haz./ landfill	[g]	54263.3	1920.9	56184.2	265.6	847.3	1332.6	- 40609.1		18020.7
Waste, hazardous/ incinerated	[g]	29.9	0.3	30.2	5.3	9.6	0.0	-10.2		34.9
Emissions (Air)										
Greenhouse Gases in GWP100	[kg CO_2 eq.]	198.8	23.7	222.5	28.8	1098.0	0.2	-144.1		1205.3
Acidification, emissions	[g SO_2 eq.]	1436.0	102.6	1538.7	87.1	441.9	2.4	-1039.9		1030.1
Volatile Organic Compounds (VOC)	[g]	33.0	0.4	33.4	5.6	27.8	0.0	-18.6		48.2
Persistent Organic Pollutants (POP)	[ng i-Teq]	734.7	46.6	781.3	1.5	8.7	0.6	-555.5		236.7
Heavy Metals	[mg Ni eq.]	3053.6	108.3	3161.9	13.5	36.5	6.4	-2301.8		916.4
PAHs	[mg Ni eq.]	85.1	0.1	85.3	14.5	2.8	0.0	-63.6		39.0
Particulate Matter (PM, dust)	[g]	1135.2	15.7	1150.9	909.9	19.2	57.4	-640.8		1496.6
Emissions (Water)										
Heavy Metals	[mg Hg/20]	1802.9	3.5	1806.4	0.4	20.6	1.9	-1297.6		531.6
Eutrophication	[g PO4]	53.9	0.2	54.1	0.0	0.7	5.0	-36.4		23.4

From the analysis of emissions to air (Figure 202), it can be seen that the use of the gas cooker is the most significant stage in one impact category: Greenhouse gases (GHG). As in the case of electric oven, this is coherent with the product characteristics in terms of material: predominance of ferromagnetic materials (77%) and glass (11%), and a low amount of plastics (5%) and absence of electronics.

On the other hand, for the rest of impact categories (Acidification, Volatile Organic Compounds (VOC), Persistent Organic Pollutants (POP), Heavy metals (HM), PAH and Particulate Matter), the most significant life cycle stage is production (including both the materials used and the manufacturing of the product). In contrast with all the above, and as it happened in electric ovens, product distribution has a significant impact for the category Particulate matter (PM) in the case of gas cookers.

Credits (negative impact) are obtained thanks to the recovery of materials at end of life (see assumptions made in Table 59). The impact categories most benefited from these credits are ACD, HM, POP and PAHs.

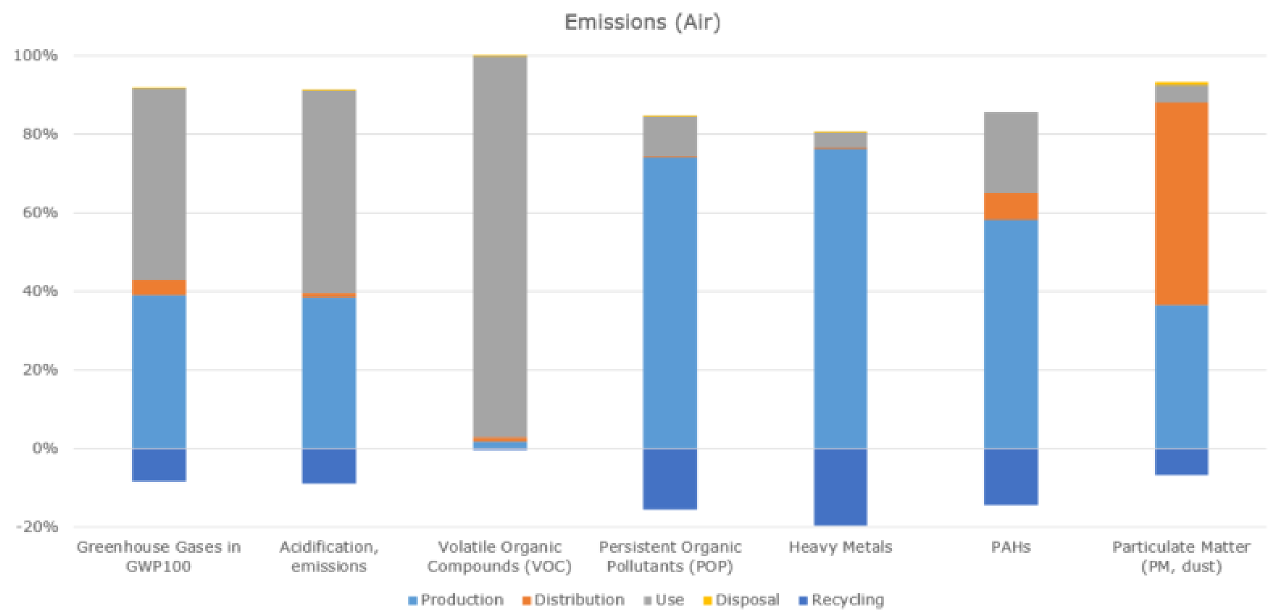


Figure 202. Impact of emissions to air of ovens BC2

From the analysis of other resources and waste (Figure 203), it can be seen that the use stage is again the most significant phase for Energy, again coherent with product characteristics, since a gas cooker is a product with a relatively simple manufacturing process but a significant energy consumption. On the contrary, for Water (both related to the production process and for cooling, and for Waste (hazardous and non-hazardous), the most significant life cycle stage is production (including materials and manufacturing).

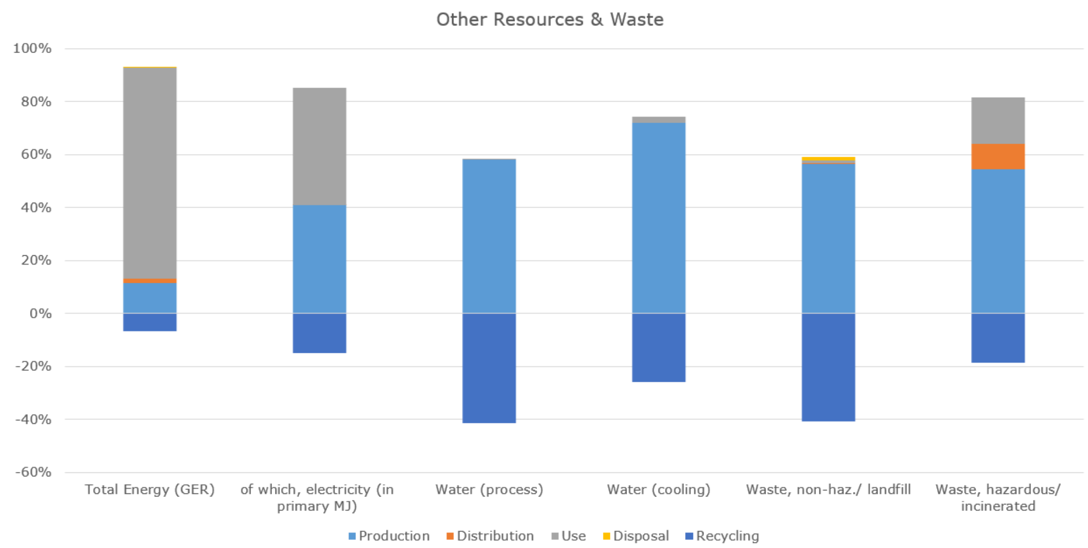


Figure 203. Impact of other resources & waste of ovens BC2

From the analysis of emissions to water (Figure 204), it can be seen that the most significant life cycle stage for both impact categories (Heavy Metals and Eutrophication) is production. Again, this is coherent with the product characteristics (a gas cooker does not consume water during its use).

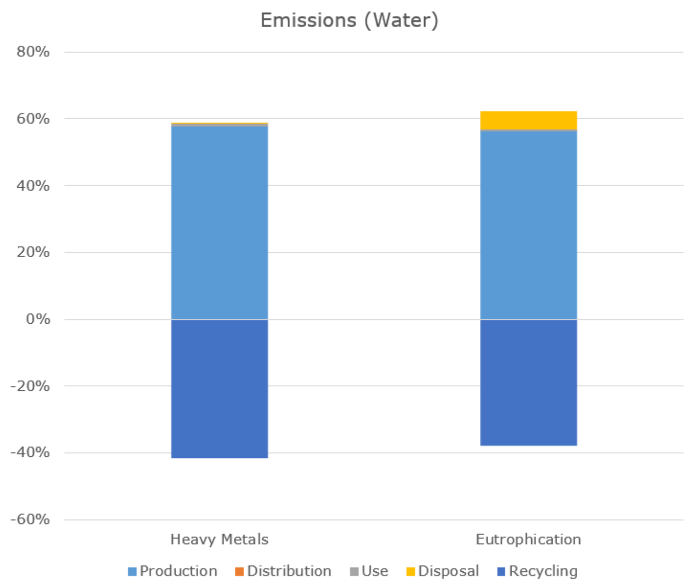


Figure 204. Impact of emissions to water of ovens BC2

5.3.1.3 Base Case 3: Microwave oven

Table 76 shows the material consumption of a microwave oven over the whole life cycle of 15 years.

Table 76. Material consumption ovens BC3

Resources Use		Production	Distribution	Use	End of Life-Disposal	End of Life-Recycling	End of Life-Stock
Bulk Plastics	[g]	1077.4		10.8	487.5	398.9	201.8
TecPlastics	[g]	41.0		0.4	18.6	15.2	7.7
Ferro	[g]	6977.8		69.8	287.0	5453.6	1307.0
Non-ferro	[g]	2339.6		23.4	96.2	1828.5	438.2
Coating	[g]	216.0		2.2	8.9	168.8	40.5
Electronics	[g]	510.0		5.1	205.6	214.0	95.5
Misc.	[g]	2361.2		23.6	660.5	1282.1	442.3
Extra	[g]	0.0		0.0	0.0	0.0	0.0
Auxiliaries	[g]	0.0		0.0	0.0	0.0	0.0
Refrigerant	[g]	0.0		0.0	0.0	0.0	0.0
Total weight	[g]	13523.0		135.2	1764.3	9361.0	2533.0

Table 77 shows the environmental impacts of a microwave oven over the whole life cycle of 15 years. The results are also shown in Figure 205 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 77. Environmental impact ovens BC3

		Production			Distribution		End-of-Life			Total
		Material	Manuf.	Production		Use	End of Life - Disposal	End of Life - Recycling	Stock	
Other Resources & Waste										
Total Energy (GER)	[MJ]	1678.0	192.9	1870.9	220.8	3071.8	28.7	-374.2		4818.0

of which, electricity (in primary MJ)	[MJ]	703.2	99.8	803.0	0.3	3062.1	0.0	-123.5		3741.9
Water (process)	[ltr]	277.7	3.4	281.1	0.0	2.8	0.0	-61.0		222.8
Water (cooling)	[ltr]	249.1	48.8	297.9	0.0	138.3	0.0	-39.2		397.0
Waste, non-haz./ landfill	[g]	15281.2	802.4	16083.6	161.3	1727.2	169.2	-4629.1		13512.2
Waste, hazardous/ incinerated	[g]	51.4	0.8	52.2	3.2	48.7	0.0	-8.9		95.2
Emissions (Air)										
Greenhouse Gases in GWP100	[kg CO_2 eq.]	96.7	11.3	108.0	15.5	60.5	0.1	-22.4		161.7
Acidification, emissions	[g SO_2 eq.]	1168.3	50.5	1218.8	46.4	588.7	1.9	-306.2		1549.6
Volatile Organic Compounds (VOC)	[g]	2.9	0.5	3.4	2.0	68.3	0.0	-0.7		73.0
Persistent Organic Pollutants (POP)	[ng i-Teq]	228.2	18.6	246.9	0.9	9.4	0.1	-70.7		186.6
Heavy Metals	[mg Ni eq.]	385.8	43.5	429.2	8.2	34.7	1.3	-98.8		374.7
PAHs	[mg Ni eq.]	86.3	0.6	86.8	6.8	8.0	0.0	-14.3		87.3
Particulate Matter (PM, dust)	[g]	323.3	9.0	332.2	315.1	15.5	10.2	-59.1		613.8
Emissions (Water)										
Heavy Metals	[mg Hg/20]	92.6	1.4	94.0	0.3	14.1	0.1	-21.4		87.0
Eutrophication	[g PO4]	4.7	0.2	4.9	0.0	0.6	0.3	-1.2		4.6

From the analysis of emissions to air (Figure 205), it can be seen that the use of the microwave is the most significant stage in two impact categories: Greenhouse gases (GHG), and Volatile Organic Compounds (VOC). As in the case of electric oven, this is coherent with the product characteristics in terms of materials: a relatively light product, with predominance of ferromagnetic materials (51%), copper (16%), glass and plastics (8% each), and a certain amount of electronics (4%).

On the other hand, for other impact categories such as Acidification, Persistent Organic Pollutants (POP), Heavy metals (HM) and PAH, the most significant life cycle stage is production (including both the materials used and the manufacturing of the product). Product distribution is a very significant stage for impact category Particulate matter (PM) in the case of microwave ovens, with a similar contribution to the production stage.

Credits (negative impact) are obtained thanks to the recovery of materials at end of life (see assumptions made in Table 59). The impact categories most benefited from these credits are POP, HMs, Acidification and PAHs.

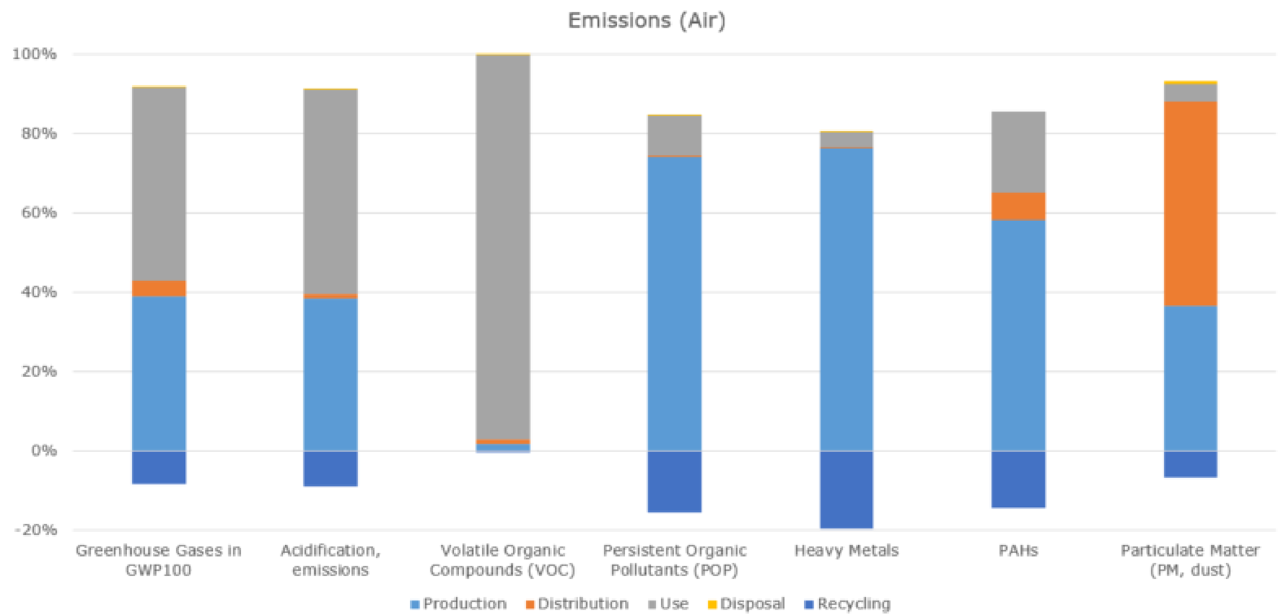


Figure 205. Impact of emissions to air of ovens BC3

From the analysis of other resources and waste (Figure 206), it can be seen that the use stage is again the most significant phase for Energy, again coherent with product characteristics, since a microwave oven is a product with a relatively simple manufacturing process but a significant energy consumption. On the contrary, for Water (both related to the production process and for cooling, and for Waste (hazardous and non-hazardous), the most significant life cycle stage is production (including materials and manufacturing).

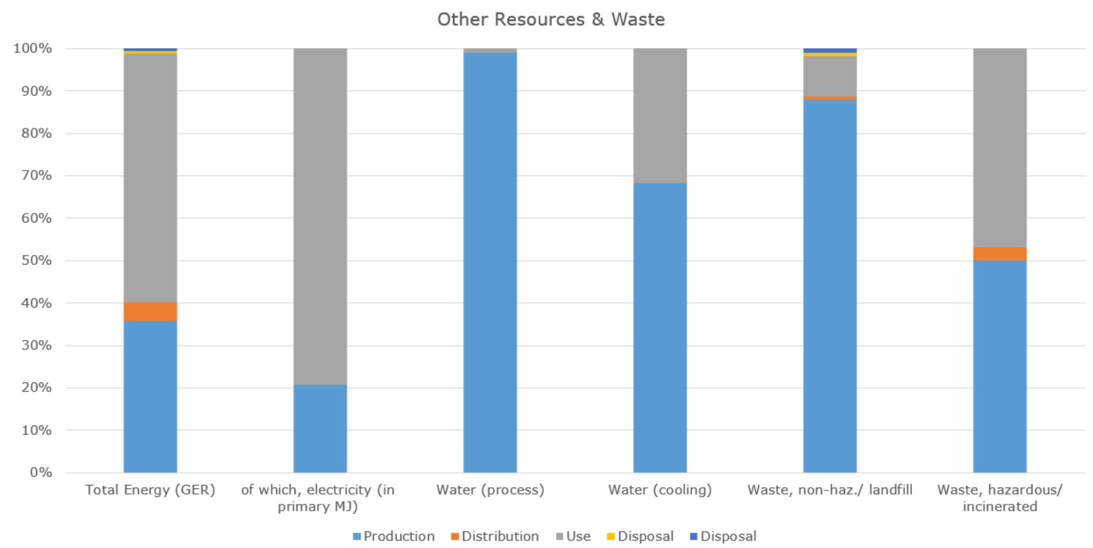


Figure 206. Impact of other resources & waste of ovens BC3

From the analysis of emissions to water (Figure 207), it can be seen that the most significant life cycle stage for both impact categories (Heavy Metals and Eutrophication) is production. Again, this is coherent with the product characteristics (a microwave oven does not consume water during its use).

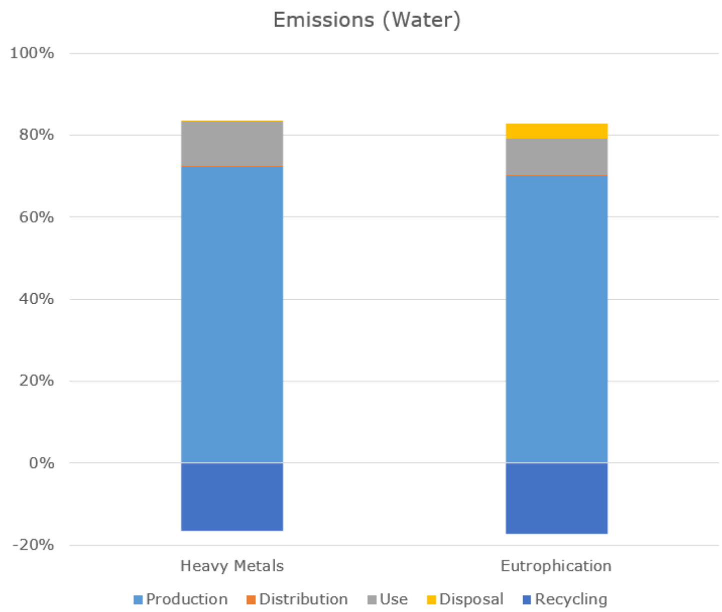


Figure 207. Impact of emissions to water of ovens BC3

5.3.1.4 Analysis of pyrolytic function

In this section, a brief analysis of the effect of the pyrolytic cleaning function will be conducted, to understand how significant is its contribution to impact categories such as Global Warming Potential (GWP) or Total Energy. It has been assumed that this function is only available on an electric oven.

According to the ECUEL Project (1999), pyrolytic cleaning has an average consumption of 3.49 kWh/cycle. The analysis of the responses of the user behaviour presented in Task 3 suggests that this function is operated an average of 0.12 times/week, or around 6 times/year. Based on this, it can be assumed that the total energy consumption of pyrolytic cleaning is 20.94 kWh/year.

Figure 208 shows the life cycle impact on GWP and Total Energy of an electric oven with and without use of pyrolytic function.

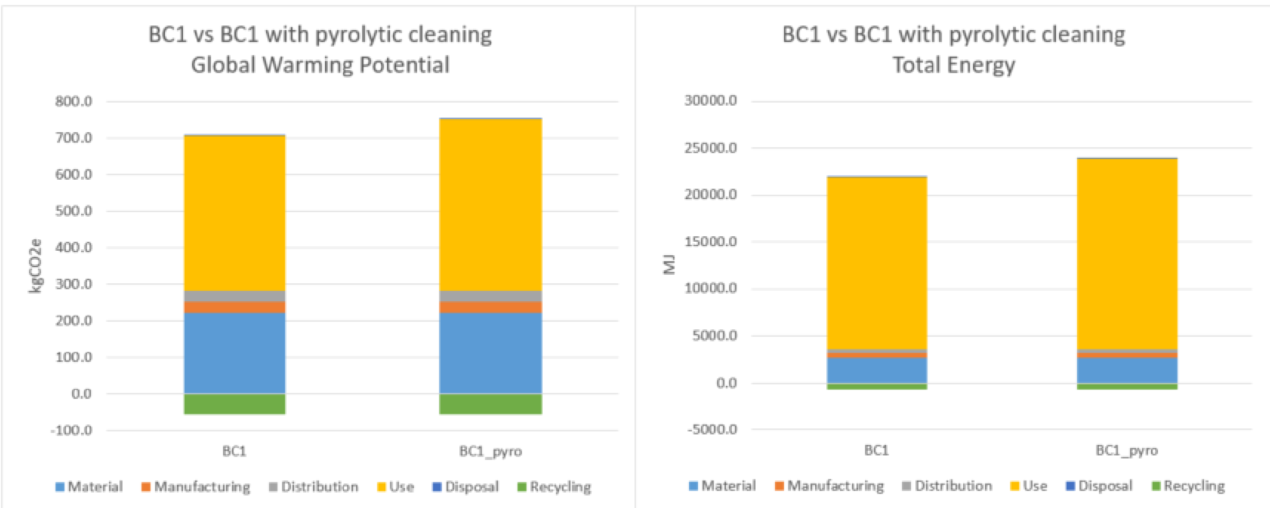


Figure 208. Analysis of the impact of the pyrolytic function

In both impact categories evaluated, the use stage is the one affected by the additional energy consumption of the pyrolytic function, with a growth of 11%. This represents a total growth of the life cycle impact of 9% attributable to the pyrolytic function.

5.3.1.5 Environmental impact assessment of EU totals for ovens

Table 78 shows the environmental impacts of all new electric ovens and gas cookers (sales) produced in 2020 over their lifetime, and the impact of the stock on that year.

Table 78. Environmental impact of ovens EU totals

	Sales 2020			Stock 2020		
	BC1	BC2	BC3	BC1	BC2	BC3
Greenhouse Gases in GWP100 [Mt CO_2 eq.]	4.9	0.5	1.2	96.1	31.4	23.9
Acidification, emissions [kt SO_2 eq.]	45.4	0.4	11.7	883.2	26.8	228.8
Volatile Organic Compounds (VOC) [kt]	3.8	0.0	0.6	73.1	1.3	10.8
Persistent Organic Pollutants (POP) [kg i-Teq]	2.4	0.1	1.4	47.3	6.2	27.5
Heavy Metals [t Ni eq.]	26.8	0.4	2.8	521.7	23.9	55.3
PAHs [t Ni eq.]	1.1	0.0	0.7	21.8	1.0	12.9
Particulate Matter (PM, dust) [kt]	10.0	0.6	4.7	195.2	39.0	90.6
Total Energy (GER) [PJ]	161.3	8.4	32.8	3142.1	567.0	639.1

5.3.2 Environmental impact assessment of hobs

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for

- Raw materials use and manufacturing,
- Distribution,
- Use phase
- End-of-life phase.

5.3.2.1 Base Case 1: radiant hob

Table 79 shows the material consumption of a radiant hob over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair that account for 1% of the bill of materials. The material consumption during the End-of-Life phase is split in disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

Table 79: Life cycle material consumption of a radiant hob

Life Cycle phases -->		Production	Distribution	Use phase	End-of-Life		
Material	Unit				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	253		3	361	295	-400
TecPlastics	g	283		3	403	330	-448
Ferro	g	1 951		20	253	4 805	-3 087
Non-ferro	g	0		0	0	0	0

Life Cycle phases -->		Production	Distribution	Use phase	End-of-Life		
Material	Unit				**Disposal**	**Recycling**	**Stock**
Coating	g	0		0	0	0	0
Electronics	g	266		3	338	352	-421
Misc.	g	5 512		55	11 145	3 144	-8 722
Extra	g	0		0	0	0	0
Auxiliaries	g	0		0	0	0	0
Refrigerant	g	0		0	0	0	0
Total weight	g	8 265		83	12 500	8 925	-13 078

Table 80 shows the environmental impacts of an electric hob over the whole lifecycle of 15 years under the conditions set explained in section 5.1.1.4.

The results are also shown in Figure 209, Figure 210 and Figure 211 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 80: Life cycle environmental impacts of a radiant hob

Life Cycle phases -->		Production			Distri butio n	Use phase	End-of-Life			Total (of absolute values of impacts)
	Unit	Materia l	Manufacturi ng	Total			Disposal	Recycl.	Total	
Resources & Waste										
Total Energy (GER)	MJ	810	54	864	184	13 457	70	-420		14 154
of which, electricity (in primary MJ)	MJ	559	31	590	0	13 455	0	-279		13 766
Water (process)	ltr	159	0	160	0	2	0	-72		90
Water (cooling)	ltr	115	14	129	0	713	0	-41		801
Waste, non-haz./ landfill	g	3 900	232	4 133	143	8 290	205	-3 482		9 289
Waste, hazardous/ incinerated	g	33	0	33	3	253	0	-17		272
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	46	3	49	13	312	0	-25		350
Acidification, emissions	g SO2 eq.	310	13	323	39	3 027	4	-164		3 230
Volatile Organic Compounds (VOC)	g	2	0	2	1	358	0	-1		360
Persistent Organic Pollutants (POP)	ng i-Teq	51	5	56	1	38	0	-49		46
Heavy Metals	mg Ni eq.	121	11	132	7	163	3	-67		238
PAHs	mg Ni eq.	29	0	29	5	38	0	-11		62
Particulate Matter (PM dust)	g	226	2	228	209	66	24	-122		405
Emissions (Water)										
Heavy Metals	mg Hg/20	49	0	49	0	69	0	-28		92
Eutrophication	g PO4	2	0	2	0	3	1	-1		5

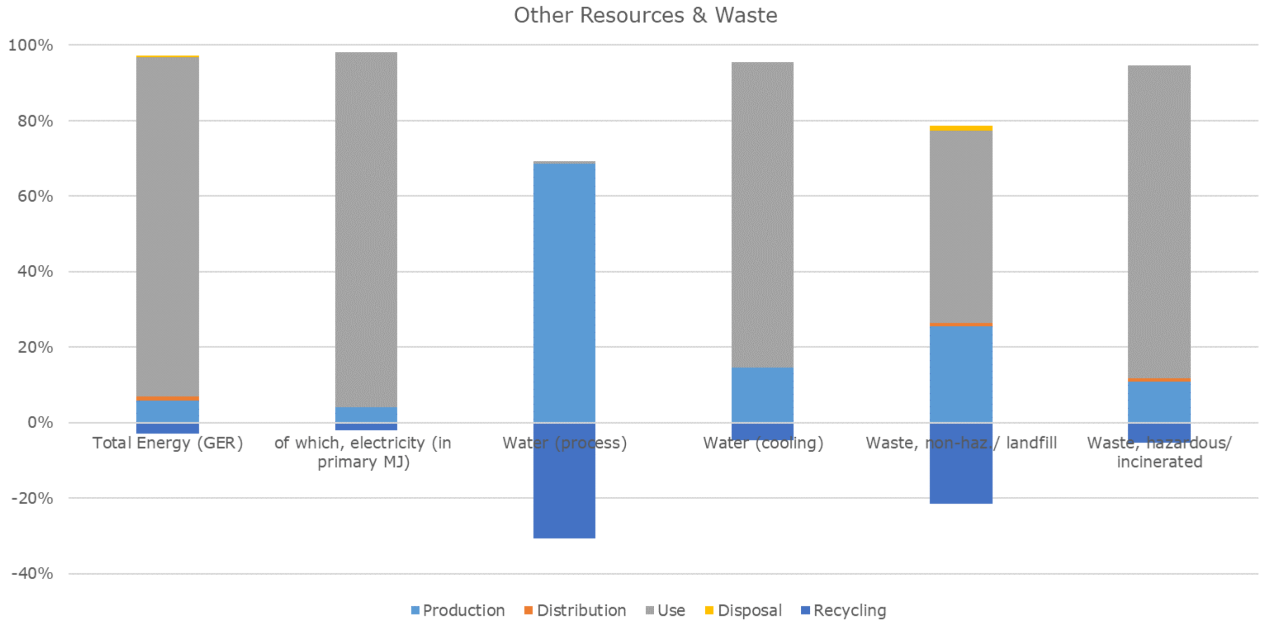


Figure 209: Contribution of each lifetime stage of a radiant hob to resources and waste

Figure 209 shows that the use phase clearly dominates the consumption of energy (90%) and water (80%) and the generation of hazardous/incinerated waste (80%) along the life cycle. Consumption of electricity is the main contribution to all the other indicators of these three macro categories.

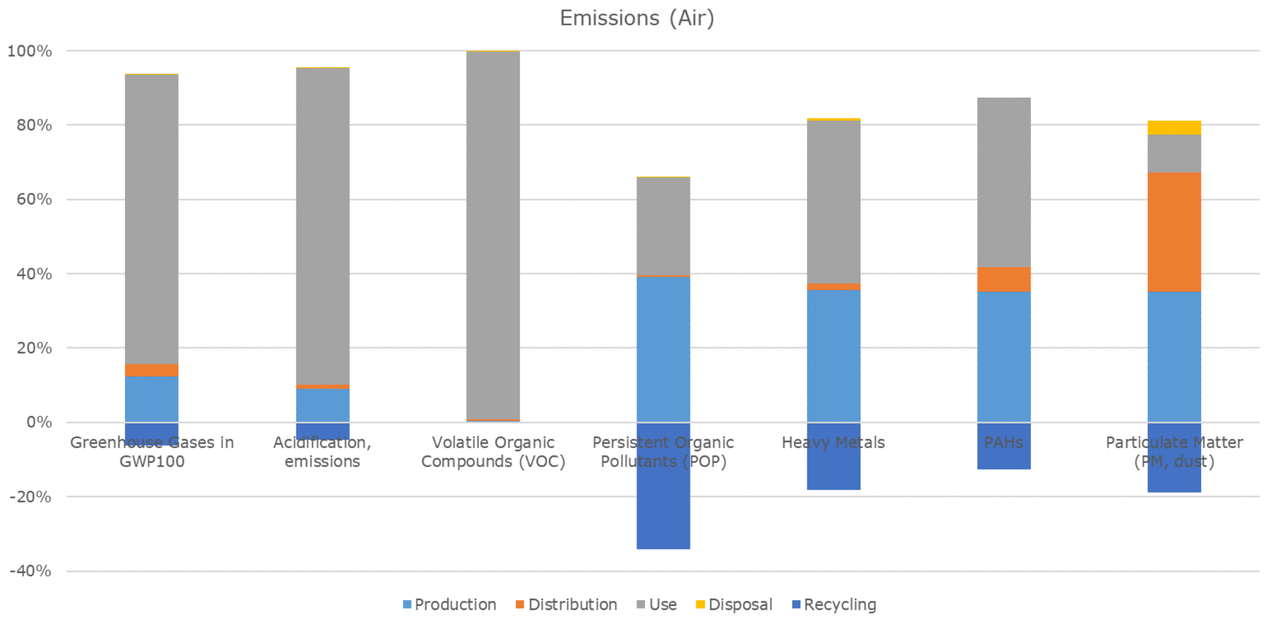


Figure 210: Contribution of each lifetime stage of a radiant hob to emissions to air

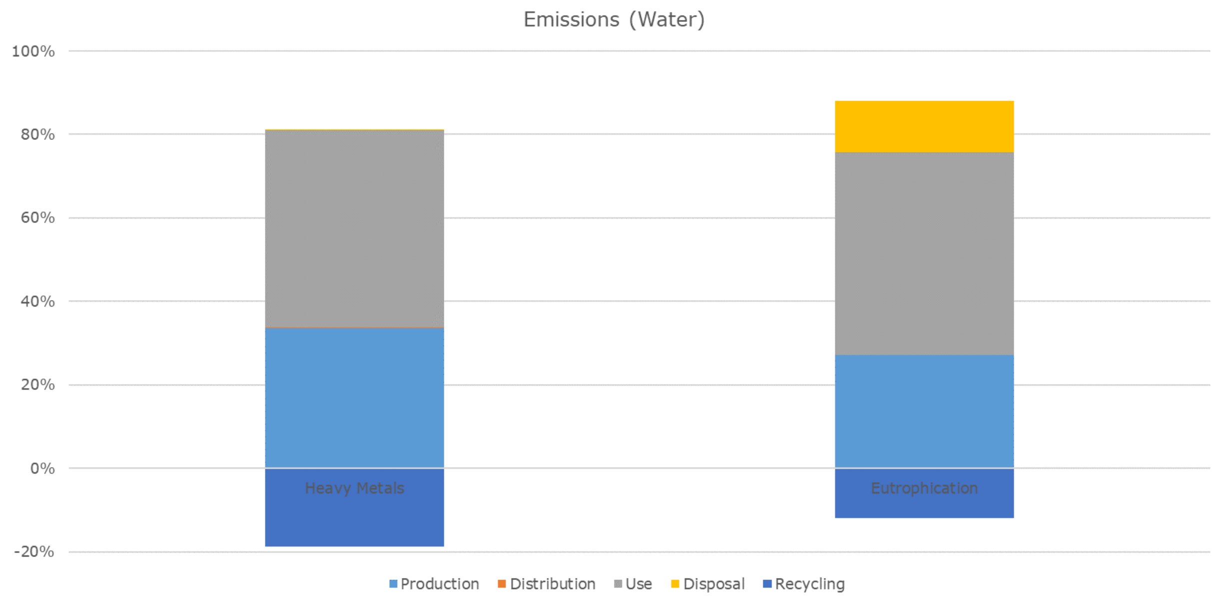


Figure 211: Contribution of each lifetime stage of a radiant hob to emissions to water

Regarding the emissions to air and water (Figure 210 and Figure 211), the use phase also dominates global warming potential (GWP100) (≈ 90%), acidification potential (AP) (≈ 85%), volatile organic compounds (VOC) (≈ 99%) and eutrophication (≈50%). For heavy metals to air (HM air), persistent organic pollutants (POP), polyaromatic hydrocarbons (PAH), particulate materials (PM dust) the use phase has a contribution ranging from 15% to close to over 30% from the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impacts categories: POP (≈ 50%), HM air (≈ 40%), PAH (40%) and PM (40%). This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation PM (≈30%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL POP is -35%. This high percentage is also influence by the replacement of radiant hobs by induction hobs, which the EcoReport tool interprets as an increase in the recycling share at the EoL.

5.3.2.2 Base Case 2: induction hob

Table 81 shows the material consumption of an induction hob over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair that account for 1% of the bill of materials. The material consumption during the End-of-Life phase is split in disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

Table 81: Life cycle material consumption of an induction hob

Life Cycle phases -->		Production	Distribution	Use phase	End-of-Life		
Material	Unit				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	253		3	49	40	167
TecPlastics	g	71		1	14	11	47
Ferro	g	1 791		18	31	594	1 184
Non-ferro	g	2 209		22	39	733	1 460
Coating	g	0		0	0	0	0
Electronics	g	3 203		32	548	570	2 117
Misc.	g	3 694		37	1 006	284	2 441
Extra	g	0		0	0	0	0
Auxiliaries	g	0		0	0	0	0
Refrigerant	g	0		0	0	0	0
Total weight	g	11 221		112	1 686	2 231	7 416

Table 82 shows the environmental impacts of an electric hob over the whole lifecycle of 15 years under the conditions set explained in section 5.1.1.4.

The results are also shown in Figure 212 in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 82: Life cycle environmental impacts of an induction hob (corrected)

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total (of absolute values of impacts)
	Unit	Material	Manufacturing	Total			Disposal	Recycl.	Total	
Resources & Waste										
Total Energy (GER)	MJ	7 753	85	7 837	184	13 164	84	-582		20 687
of which, electricity (in primary MJ)	MJ	5 858	49	5 907	0	13 145	0	-419		18 633
Water (process)	ltr	1 379	1	1 380	0	14	0	-98		1 296
Water (cooling)	ltr	169	21	190	0	694	0	-10		874
Waste, non-haz./ landfill	g	10 596	406	11 002	143	8 134	119	-989		18 408
Waste, hazardous/ incinerated	g	315	0	315	3	249	0	-23		544
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	434	5	439	13	308	0	-33		727
Acidification, emissions	g SO2 eq.	3 363	21	3 384	39	2 976	5	-250		6 155
Volatile Organic Compounds (VOC)	g	15	0	15	1	348	0	-1		364
Persistent Organic Pollutants (POP)	ng i-Teq	92	11	103	1	37	0	-10		131
Heavy Metals	mg Ni eq.	1 384	25	1 408	7	171	4	-100		1 491
PAHs	mg Ni eq.	393	0	393	5	40	0	-40		398
Particulate Matter (PM dust)	g	2 674	3	2 677	209	89	39	-194		2 820
Emissions (Water)										
Heavy Metals	mg Hg/20	428	1	429	0	71	0	-36		465
Eutrophication	g PO4	7	0	7	0	3	0	-1		10

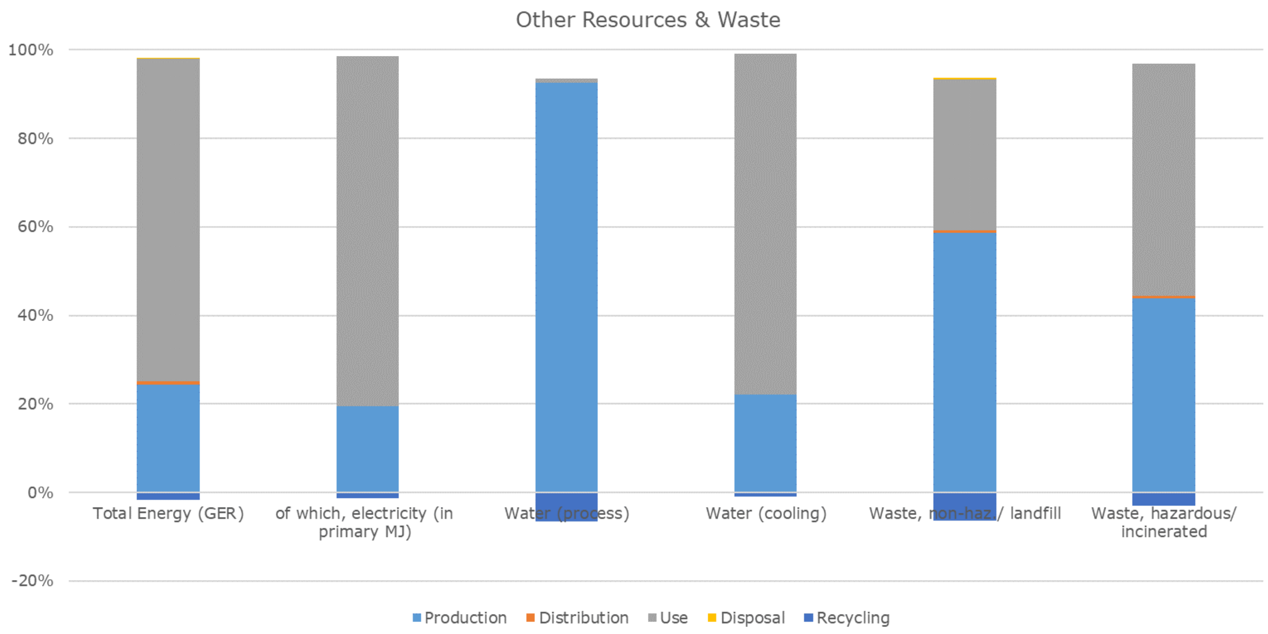


Figure 212: Contribution of each lifetime stage of an induction hob to resources and waste

Figure 212 shows that the use phase dominates the consumption of energy (75%) and water (80%). Consumption of electricity is the main contribution to all the other indicators of these macro categories.

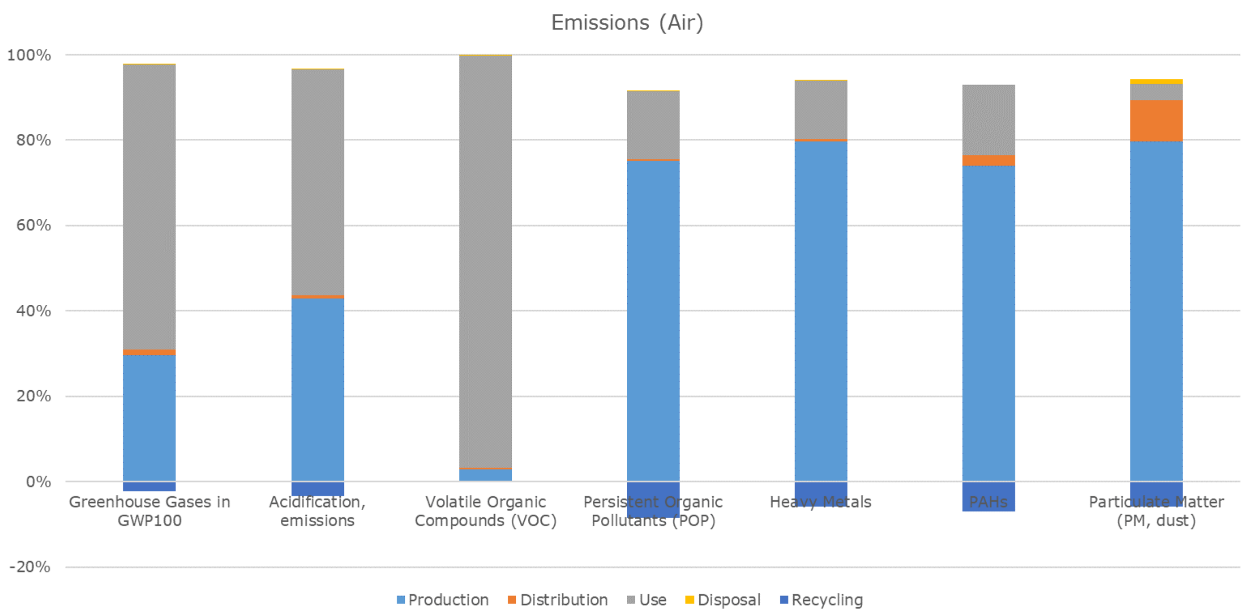


Figure 213: Contribution of each lifetime stage of an induction hob to emissions to air

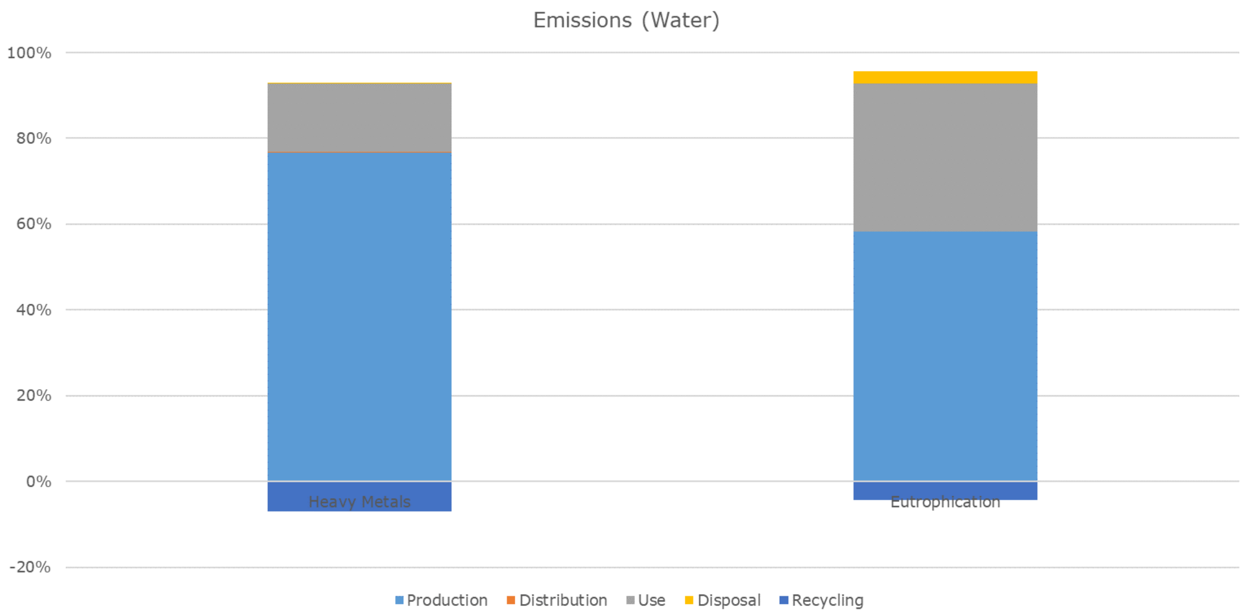


Figure 214: Contribution of each lifetime stage of an induction hob to emissions to water

Regarding the emissions to air and water (Figure 213 and Figure 214), the use phase also dominates global warming potential (GWP100) (≈ 65%), and volatile organic compounds (VOC) (≈ 99%). For acidification potential (AP), persistent organic pollutants (POP), heavy metals to air (HM air), polyaromatic hydrocarbons (PAH), particulate materials (PM dust) the use phase has a contribution ranging from 5% to close to over 20% from the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impacts categories: AP (40%), POP (≈ 75%), HM to air (80%), and PAH (70%), PM (75%), heavy metals to water (80%). This is mainly due to the extraction of raw materials such as minerals for the electronic components, and the further manufacturing to steel or processing of raw materials to get the different types of plastics and electronic components.

The distribution phase is relevant only for the generation PM (≈15%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL PAHs is -10%.

5.3.2.3 Base Case 3: gas hob

Table 83 shows the material consumption of gas hob over the whole life cycle of 19 years.

Table 83: Material consumption of gas hob

Life Cycle phases ->		Production	Distribution	Use phase	End-of-Life		
Material	**Unit**				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	107		1	62	51	-5
TecPlastics	g	151		2	88	72	-8
Ferro	g	5 467		55	290	5 506	-275
Non-ferro	g	2 031		20	108	2 045	-102
Coating	g	0		0	0	0	0
Electronics	g	0		0	0	0	0
Misc.	g	39		0	14	27	-2
Extra	g	0		0	0	0	0
Auxiliaries	g	0		0	0	0	0
Refrigerant	g	0		0	0	0	0
Total weight	g	7 794		78	562	7 702	-391

Table 84: Life cycle environmental impacts of a gas hob

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total (of absolute values of impacts)
	Unit	Material	Manufacturing	Total			Disposal	Recycl.	Total	
Resources & Waste										
Total Energy (GER)	MJ	604	146	750	184	14 634	3	-236		15 335
of which electricity (in primary MJ)	MJ	16	84	100	0	0	0	-6		94
Water (process)	ltr	3	1	5	0	0	0	-1		4
Water (cooling)	ltr	35	35	70	0	0	0	-4		66
Waste non-haz./ landfill	g	10 179	726	10 906	143	102	123	-4 089		7 185
Waste hazardous/ incinerated	g	3	0	3	3	0	0	0		5
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	38	8	46	13	809	0	-15		853
Acidification emissions	g SO2 eq.	183	36	220	39	237	0	-72		424
Volatile Organic Compounds (VOC)	g	1	0	1	1	11	0	0		13
Persistent Organic Pollutants (POP)	ng i-Teq	152	20	172	1	2	0	-61		114
Heavy Metals	mg Ni eq.	27	47	74	7	0	0	-11		70
PAHs	mg Ni eq.	197	0	197	5	2	0	-79		125
Particulate Matter (PM dust)	g	50	6	56	209	5	0	-20		250
Emissions (Water)										
Heavy Metals	mg Hg/20	91	2	92	0	1	0	-36		57
Eutrophication	g PO4	1	0	1	0	0	0	0		0

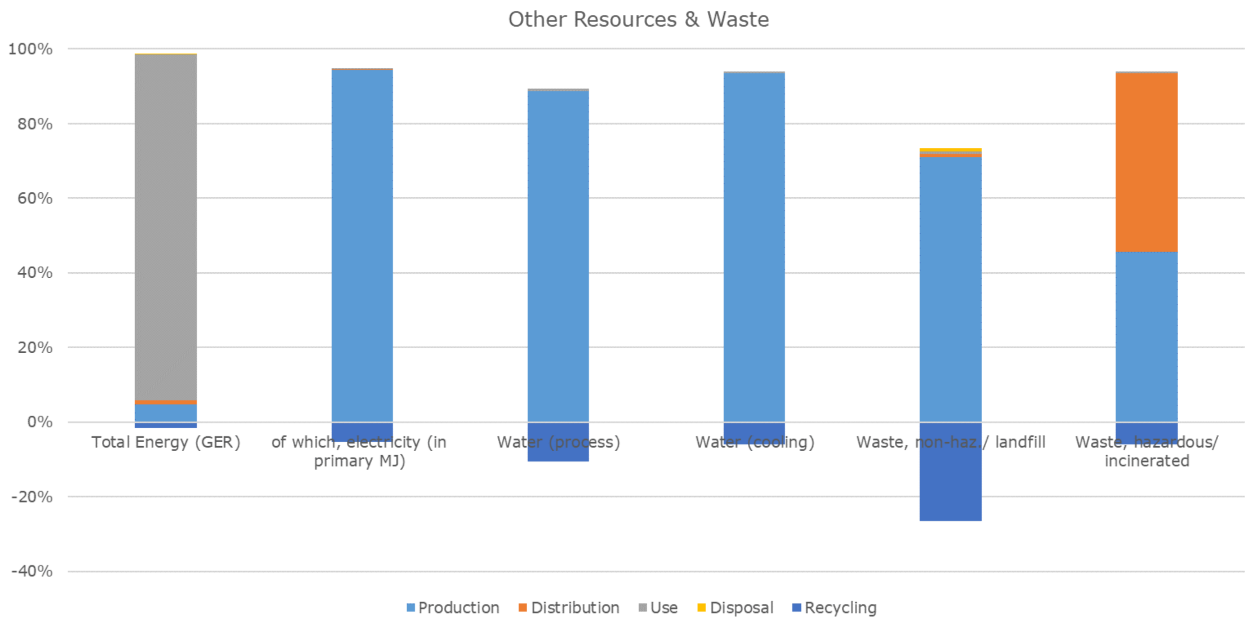


Figure 215: Contribution of each lifetime stage of a gas hob to resources and waste

Figure 215 shows that the use phase clearly dominates the consumption of energy (90%) while the production phase is predominant in the rest of indicators.

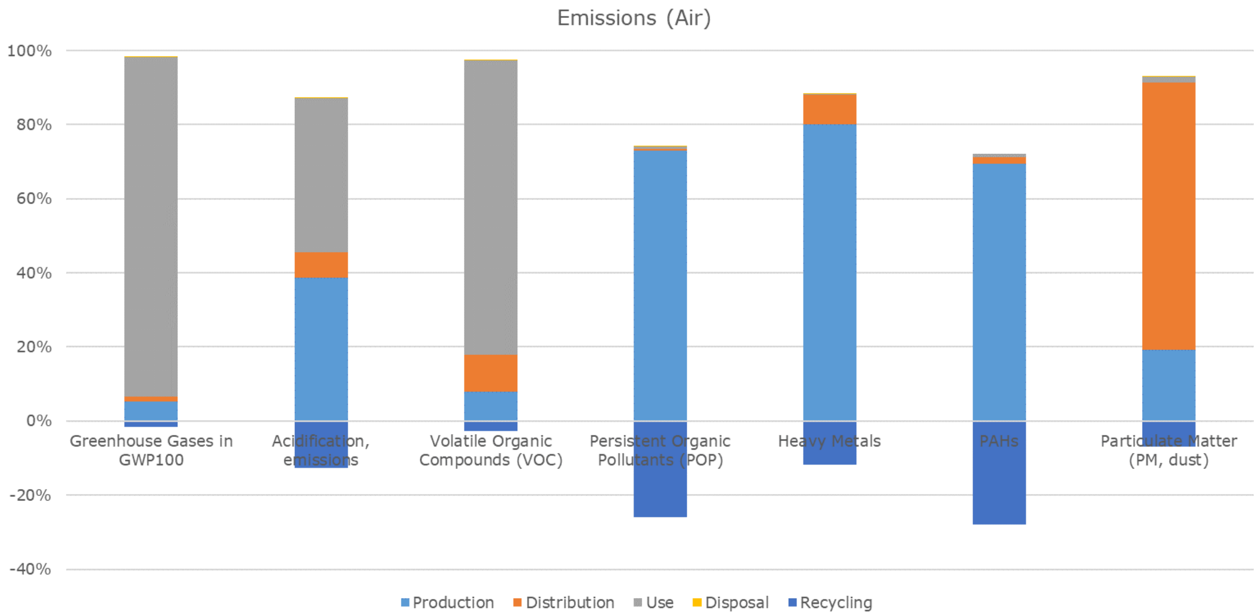


Figure 216: Contribution of each lifetime stage of a gas hob to emissions to air

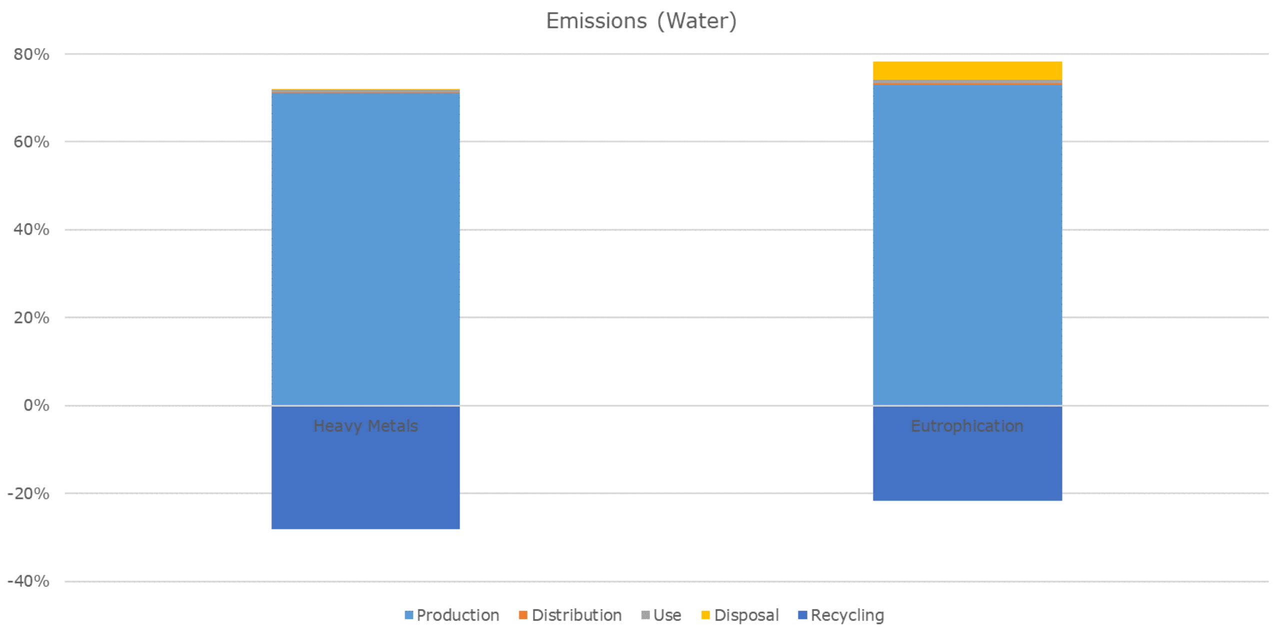


Figure 217: Contribution of each lifetime stage of a gas hob to emissions to water

Regarding the emissions to air and water (Figure 216 and Figure 217), the use phase also dominates global warming potential (GWP100) (≈ 90%) and volatile organic compounds (VOC) (≈ 80%). For acidification potential (AP), the use phase contributes around 40%.

The contribution of the production phase significantly contributes in the following impacts categories: acidification potential (AP) (40%), persistent organic pollutants (POP) (75%), heavy metals (HM) to air (80%), and HM water getting approximately 70% of the total of this category. This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation PM (75%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance, the contribution of the EoL to POP, PAHs and HM to air and water is around -25%.

5.3.2.4 Environmental impact assessment of EU totals for hobs

The environmental impacts and the LCC under real-life conditions are aggregated using stock and market data indicating

- the life cycle environmental impact of all new products designed in 2020 (reference year)
- the annual environmental impacts of the stock of cooking fume extractors in 2020 (including production use and end-of-life)
- the annual monetary costs for consumers (also for 2020) (including acquisition use and maintenance and repair).

Table 85 shows the environmental impacts of all cooking fume extractors produced in 2020 over their lifetime.

Table 85: Life cycle environmental impacts of all hobs reflected for both base cases produced in 2020 (over their lifetime)

	Unit	Base Case 1 (radiant)	Base Case 2 (induction)	Base Case 3 (gas)
Total Energy (GER)	PJ	38.22	73.03	27.28
of which electricity (in primary PJ)	PJ	37.17	65.77	0.17
Water (process)	mln. m^3	0.24	4.57	0.01
Water (cooling)	mln. m^3	2.16	3.09	0.12
Waste non-haz./ landfill	Kt	25.08	64.98	13.00
Waste hazardous/ incinerated	Kt	0.74	1.92	0.01
Greenhouse Gases in GWP100	mt CO_2 eq.	0.95	2.57	1.52
Acidification emissions	kt SO_2 eq.	8.72	21.73	0.76
Volatile Organic Compounds (VOC)	Kt	0.97	1.28	0.02
Persistent Organic Pollutants (POP)	g i-Teq	0.12	0.46	0.21
Heavy Metals	ton Ni eq.	0.64	5.26	0.13
PAHs	ton Ni eq.	0.17	1.40	0.23
Particulate Matter (PM dust)	Kt	1.09	9.95	0.45
Heavy Metals	ton Hg/20	0.25	1.64	0.10
Eutrophication	kt PO_4	0.01	0.04	0.00

*GER stands for Gross Energy Requirement

Table 86 shows the annual environmental impact of the stock of hobs in the reference year (2020). The stock refers to

- the environmental impact through the production of the annual sales of cooking fume extractors in the reference year
- the environmental impact of 1 year use of the whole stock
- the end-of-life treatment of the amount of cooking fume extractors discarded in that year (according to the EcoReport tool: “simplified model assuming produced = EoL”)

Table 86: EU Total Impact of STOCK of hobs in reference year 2020 (produced in use discarded) (real-life conditions)

	Unit	Base Case 1 (radiant)	Base Case 2 (induction)	Base Case 3 (gas)
Resources & Waste				
Total Energy (GER*)	PJ	70.1	72.2	50.2
of which electricity (in primary PJ)	PJ	68.9	64.7	0.2
Water (process)	mln. m^3	0.4	4.9	0.0
Water (cooling)	mln. m^3	3.9	3.0	0.1
Waste non-haz./ landfill	Kt	53.0	66.5	20.3
Waste hazardous/ incinerated	Kt	1.4	2.0	0.0
Emissions (Air)				
Greenhouse Gases in GWP100	mt CO_2 eq.	1.7	2.6	2.8
Acidification emissions	kt SO_2 eq.	16.1	22.0	1.3
Volatile Organic Compounds (VOC)	Kt	1.8	1.2	0.0
Persistent Organic Pollutants (POP)	g i-Teq	0.3	0.5	0.3
Heavy Metals	ton Ni eq.	1.2	5.6	0.1
PAHs	ton Ni eq.	0.3	1.5	0.4
Particulate Matter (PM dust)	Kt	1.5	10.5	0.5
Emissions (Water)				
Heavy Metals	ton Hg/20	0.5	1.8	0.2
Eutrophication	kt PO_4	0.0	0.0	0.0

5.3.3 Environmental impact assessment of cooking fume extractors

The environmental impacts have been calculated with the MEErP EcoReport tool and the data inputs presented in the previous section. This section shows the results of these calculations in the MEErP format for

- Raw materials use and manufacturing
- Distribution
- Use phase
- End-of-life phase.

5.3.3.1 Base Case 1: cabinet cooking fume extractor

Table 87 shows the material consumption of a cabinet cooking fume extractor over the whole life cycle of 15 years. The material consumption during the production equals the input values of the bill of materials. The materials consumed during the use phase correspond to the materials consumed for maintenance and repair that account for 1% of the bill of materials. The material consumption during the End-of-Life phase is split in disposal, recycling and the stock. The latter value results from the effect that the mass discarded seldom equals the mass of new products sold.

Table 87. Material consumption of a cabinet cooking fume extractor

Life Cycle phases -->		Production	Distribution	Use phase	End-of-Life		
Material	Unit				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	418	-	4	152	124	146
TecPlastics	g	334	-	3	121	99	117
Ferro	g	7 190	-	72	237	4 506	2 519
Non-ferro	g	251	-	3	8	157	88
Coating	g	0	-	0	0	0	0
Electronics	g	167	-	2	54	56	59
Misc.	g	0	-	0	0	0	0
Extra	g	0	-	0	0	0	0
Auxiliaries	g	0	-	0	0	0	0
Refrigerant	g	0	-	0	0	0	0
Total weight	g	8 360	-	84	572	4 942	2 929

Table 88 shows the environmental impacts of a cabinet cooking fume extractor over the whole lifecycle of 15 years under the conditions set by 9-points method, i.e. an average of minimum, maximum and boost speeds.

The results are also shown in terms of relative contributions (%) of each life cycle phase (i.e. manufacturing, distribution, use and end of life) to the overall results. The results are presented for each impact category as the sum of the contributions (%) of all the phases in absolute value summing up to 100%. Negative values in the end-of-life phase represent credits, i.e. avoided impacts.

Table 88. Environmental impacts of a cabinet cooking fume extractor

Life Cycle phases -->		**Production**			**Distri butio n**	**Use phase**	**End-of-Life**			**Total** (of absolute values of impacts)
	Unit	Materia l	Manufacturi ng	Total			Disposal	Recycl.	Total	
Resources & Waste										
Total Energy (GER)	MJ	949	161	1 110	195	5 351	17	-176		6 497
of which electricity (in primary MJ)	MJ	404	93	497	0	5 345	0	-64		5 779
Water (process)	ltr	22	1	24	0	0	0	-4		20
Water (cooling)	ltr	220	40	259	0	285	0	-26		518
Waste non-haz./ landfill	g	12 426	761	13 187	148	3 401	108	-3 502		13 343
Waste hazardous/ incinerated	g	8	0	8	3	100	0	-1		111
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	56	9	65	14	124	0	-11		192
Acidification emissions	g SO2 eq.	157	40	197	41	1 203	0	-40		1 401
Volatile Organic Compounds (VOC)	g	1	0	1	2	142	0	0		145
Persistent Organic Pollutants (POP)	ng i-Teq	186	19	206	1	17	0	-53		171
Heavy Metals	mg Ni eq.	52	45	96	8	65	0	-15		154
PAHs	mg Ni eq.	3	0	3	6	15	0	-1		23
Particulate Matter (PM dust)	g	24	6	30	241	26	0	-6		291
Emissions (Water)										
Heavy Metals	mg Hg/20	57	1	58	0	28	0	-16		71
Eutrophication	g PO4	1	0	1	0	1	0	0		2

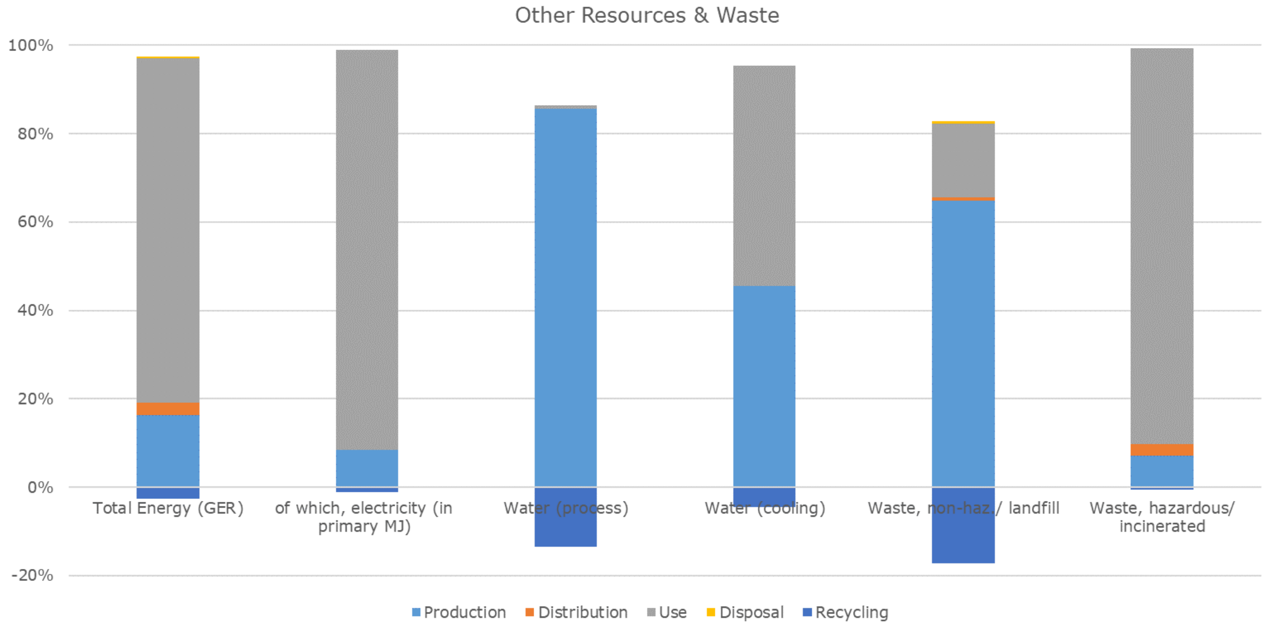


Figure 218. Impact of resources and waste of cabinet cooking fume extractor

Figure 218 shows that the use phase clearly dominates the consumption of energy (80%) and the generation of hazardous/incinerated waste along the life cycle (90%). Consumption of electricity is the main contribution to all the other indicators of these three macro categories.

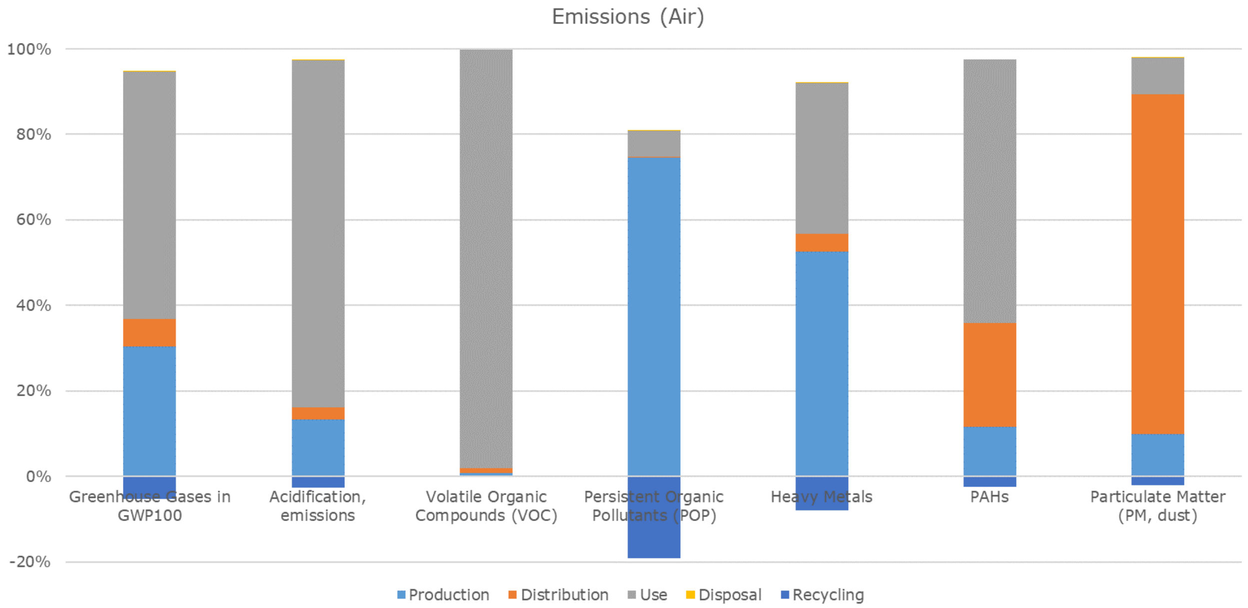


Figure 219: Impact of emissions to air of cabinet cooking fume extractor

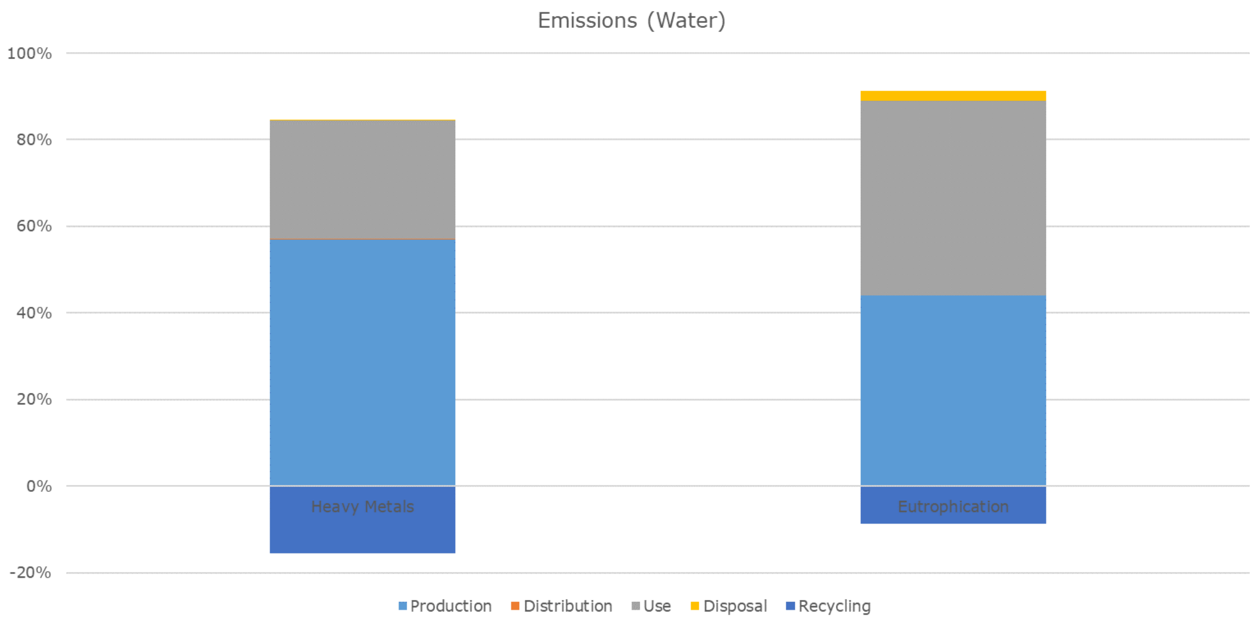


Figure 220. Impact of emissions to water of cabinet cooking fume extractor

Regarding the emissions to air and water (Figure 219 and Figure 220) the use phase also dominates global warming potential (GWP100) (≈ 60%) acidification potential (AP) (≈ 80%) volatile organic compounds (VOC) (≈ 95%) and polycyclic aromatic hydrocarbons (PAHs) (≈60%). For persistent organic pollutants (POP) heavy metals to air (HM air) particulate materials (PM dust) and heavy metals to water (HM water) the use phase has a contribution ranging from 5% to close to over 30% from the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impacts categories: non-hazardous waste (≈ 70%) POP (≈ 75%) HM air (≈ 55%) and HM water getting approximately 60% of the total of this category. This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation PM (80%) due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance the contribution of the EoL POP is close to -20%.

5.3.3.2 Base Case 2: chimney cooking fume extractor

Table 89 shows the material consumption of a chimney cooking fume extractor over the whole life cycle of 15 years.

Table 89. Material consumption of a chimney cooking fume extractor

Life Cycle phases ->		Production	Distribution	Use phase	End-of-Life		
Material	**Unit**				**Disposal**	**Recycling**	**Stock**
Bulk Plastics	g	199	-	2	73	60	68
TecPlastics	g	199	-	2	73	60	68
Ferro	g	9 334	-	93	312	5 924	3 192
Non-ferro	g	99	-	1	3	63	34
Coating	g	0	-	0	0	0	0
Electronics	g	99	-	1	33	34	34
Misc.	g	0	-	0	0	0	0
Extra	g	0	-	0	0	0	0
Auxiliaries	g	0	-	0	0	0	0
Refrigerant	g	0	-	0	0	0	0
Total weight	g	9 930	-	99	494	6 140	3 396

Table 90. Environmental impacts of a chimney cooking fume extractor

Life Cycle phases -->		Production			Distribution	Use phase	End-of-Life			Total (of absolute values of impacts)
	Unit	Material	Manufacturing	Total			Disposal	Recycl.	Total	
Resources & Waste										
Total Energy (GER)	MJ	835	185	1 020	390	4 862	10	-163		6 118
of which electricity (in primary MJ)	MJ	280	106	387	1	4 856	0	-44		5 199
Water (process)	ltr	310	1	311	0	3	0	-77		237
Water (cooling)	ltr	155	45	200	0	258	0	-22		437
Waste non-haz./ landfill	g	13 263	914	14 177	246	3 110	101	-3 355		14 279
Waste hazardous/ incinerated	g	4	0	4	5	91	0	0		100
Emissions (Air)										
Greenhouse Gases in GWP100	kg CO2 eq.	60	11	71	26	113	0	-13		198
Acidification emissions	g SO2 eq.	306	46	352	79	1 094	0	-75		1 450
Volatile Organic Compounds (VOC)	g	1	0	2	5	129	0	0		135
Persistent Organic Pollutants (POP)	ng i-Teq	170	25	196	1	15	0	-43		169
Heavy Metals	mg Ni eq.	614	58	672	13	65	0	-156		594
PAHs	mg Ni eq.	1	0	2	13	13	0	0		28
Particulate Matter (PM dust)	g	48	7	55	797	24	0	-12		864
Emissions (Water)										
Heavy Metals	mg Hg/20	372	2	374	0	29	0	-94		309
Eutrophication	g PO4	10	0	10	0	1	0	-2		9

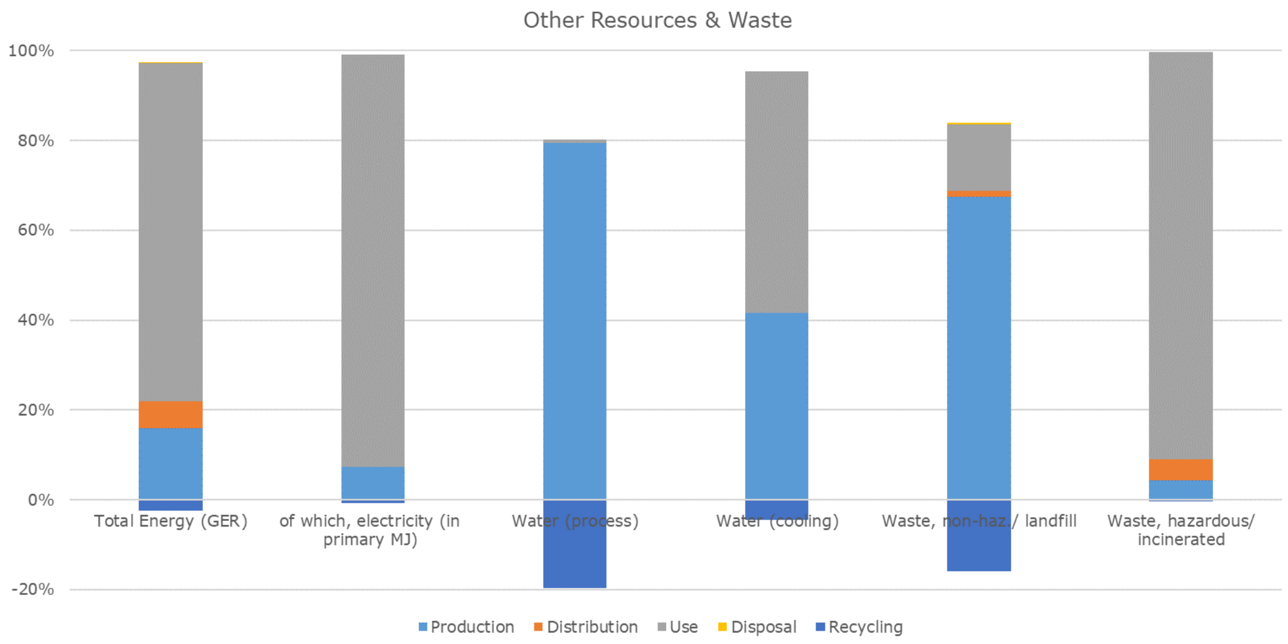


Figure 221. Impact of resources and waste of chimney cooking fume extractor

Figure 221 (BC2) shows very similar results to Figure 218 (BC1). The use phase clearly dominates the consumption of energy (80%) and the generation of hazardous/incinerated waste along the life cycle. Consumption of electricity is the main contribution to all the other indicators of these three macro categories.

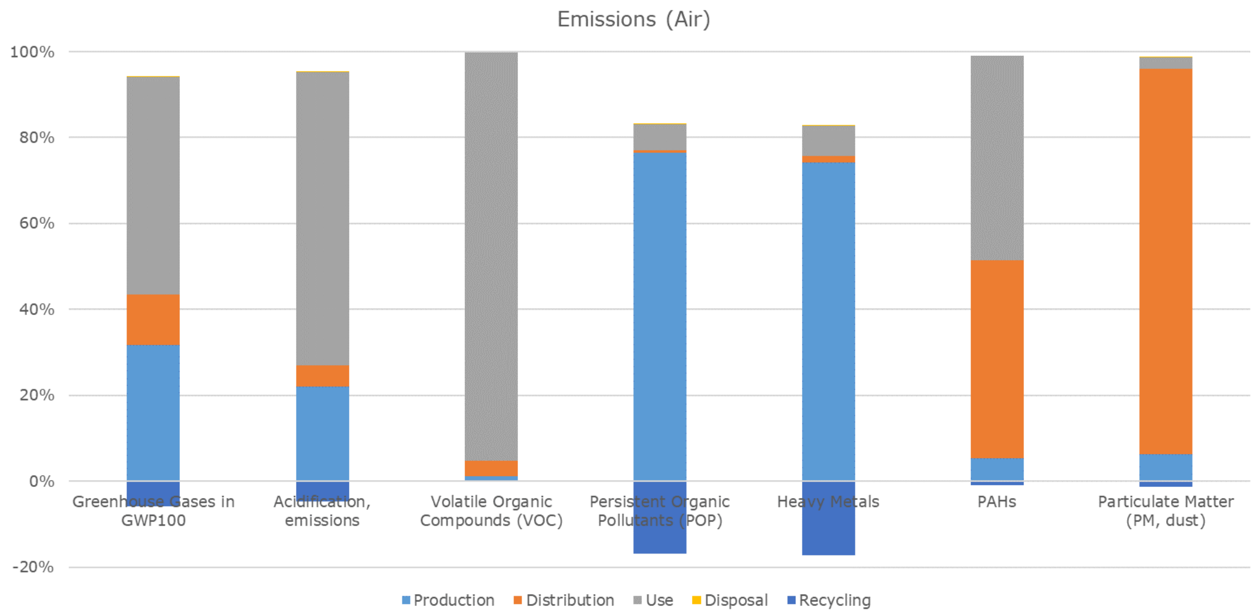


Figure 222. Impact of emissions to air of chimney cooking fume extractor

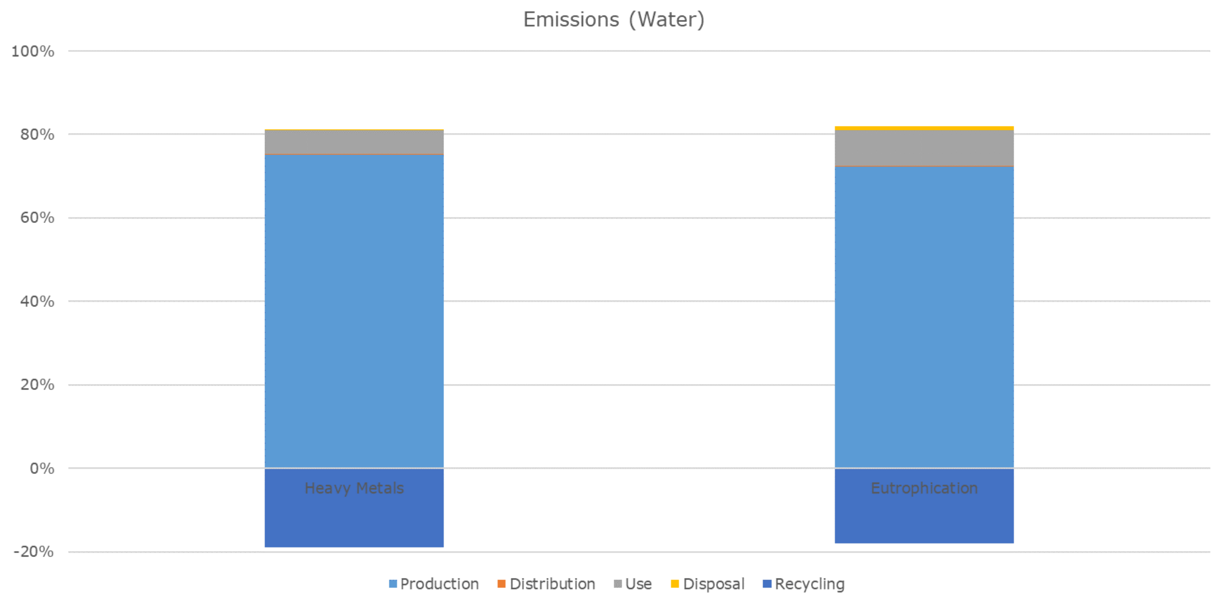


Figure 223: Impact of emissions to water of chimney cooking fume extractor

Regarding the emissions to air and water (Figure 222 and Figure 223) the use phase also dominates global warming potential (GWP100) (≈ 60%) acidification potential (AP) (≈ 70%) volatile organic compounds (VOC) (≈ 95%) and polycyclic aromatic hydrocarbons (PAHs) (≈50%). For persistent organic pollutants (POP) heavy metals to air (HM air) particulate materials (PM dust) and heavy metals to water (HM water) the use phase has a contribution ranging from 5% to close to over 10% from the total of each category. This is mainly caused by the consumption of electricity.

The contribution of the production phase significantly contributes in the following impacts categories: non-hazardous waste (≈ 70%) POP (≈ 75%) HM air (≈ 75%) and HM water getting approximately 80% of the total of this category. This is mainly due to the extraction of raw materials such as minerals and the further manufacturing to steel or processing of raw materials to get the different types of plastics.

The distribution phase is relevant only for the generation PM (90%) and polycyclic aromatic hydrocarbons (PAHs) (≈45%). due to the transport of the packaged products.

The EoL presents significant negative impacts in some categories. This is due to the credits (avoided impacts) that EcoReport tool assigns to the recycling of materials. For instance the contribution of the EoL to POP and HM to air and water is close to -20%.

5.3.3.3 Environmental impact assessment of EU totals for cooking fume extractors

The environmental impacts and the LCC under real-life conditions are aggregated using stock and market data indicating

- the life cycle environmental impact of all new products designed in 2020 (reference year)
- the annual environmental impacts of the stock of cooking fume extractors in 2020 (including production use and end-of-life)
- the annual monetary costs for consumers (also for 2020) (including acquisition use and maintenance and repair).

Table 91 shows the environmental impacts of all cooking fume extractors produced in 2020 over their lifetime.

Table 91. Life cycle environmental impacts of all new cooking fume extractors reflected for both base cases produced in 2020 (over their lifetime)

	Unit	Base Case 1 (cabinet)	Base Case 2 (cabinet)	Total
Resources & Waste				
Total Energy (GER)	PJ	18.48	21.27	39.75
of which electricity (in primary PJ)	PJ	16.43	18.07	34.5
Water (process)	mln. m^3	0.06	0.82	0.88
Water (cooling)	mln. m^3	1.47	1.52	2.99
Waste non-haz./ landfill	Kt	37.95	49.64	87.59
Waste hazardous/ incinerated	Kt	0.31	0.35	0.66
Emissions (Air)				
Greenhouse Gases in GWP100	mt CO_2 eq.	0.55	0.69	1.24
Acidification emissions	kt SO_2 eq.	3.98	5.04	9.02
Volatile Organic Compounds (VOC)	Kt	0.41	0.47	0.88
Persistent Organic Pollutants (POP)	g i-Teq	0.48	0.59	1.07
Heavy Metals	ton Ni eq.	0.44	2.06	2.5
PAHs	ton Ni eq.	0.07	0.10	0.17
Particulate Matter (PM dust)	Kt	0.83	3.00	3.83
Emissions (Water)				
Heavy Metals	ton Hg/20	0.20	1.07	1.27
Eutrophication	kt PO_4	0.01	0.03	0.04

*GER stands for Gross Energy Requirement

Table 92 shows the annual environmental impact of the stock of cooking fume extractors in the reference year (2020). The stock refers to

- the environmental impact through the production of the annual sales of cooking fume extractors in the reference year
- the environmental impact of 1 year use of the whole stock
- the end-of-life treatment of the amount of cooking fume extractors discarded in that year (according to the EcoReport tool: "simplified model assuming produced = EoL")

Table 92. EU Total Impact of STOCK of cooking fume extractors in reference year 2020 (produced in use discarded) (real-life conditions)

	Unit	Base Case 1 (cabinet)	Base Case 2 (cabinet)	Total
Resources & Waste				
Total Energy (GER*)	PJ	36.3	39.2	75.5
of which electricity (in primary PJ)	PJ	33.9	35.6	69.5
Water (process)	mln. m^3	0.1	1.1	1.2
Water (cooling)	mln. m^3	2.5	2.5	5
Waste non-haz./ landfill	Kt	58.6	72.1	130.7
Waste hazardous/ incinerated	Kt	0.6	0.7	1.3
Emissions (Air)				

	Unit	Base Case 1 (cabinet)	Base Case 2 (cabinet)	Total
Greenhouse Gases in GWP100	mt CO_2 eq.	1.0	1.1	2.1
Acidification emissions	kt SO_2 eq.	8.0	9.2	17.2
Volatile Organic Compounds (VOC)	Kt	0.9	0.9	1.8
Persistent Organic Pollutants (POP)	g i-Teq	0.7	0.8	1.5
Heavy Metals	ton Ni eq.	0.7	2.8	3.5
PAHs	ton Ni eq.	0.1	0.1	0.2
Particulate Matter (PM dust)	Kt	0.9	3.1	4
Emissions (Water)				
Heavy Metals	ton Hg/20	0.3	1.5	1.8
Eutrophication	kt PO_4	0.0	0.0	0

5.4 Life cycle costs of the base cases

The life cycle costs have been calculated with the EcoReport tool. The methodology and the assumptions (regarding product price, energy and water costs, repair and maintenance costs) are described in section x.

5.4.1 Life cycle costs of ovens

The life cycle costs per appliance over a lifetime of 15 years are summarised for the three base cases in Table 93 and Figure 224.

Table 93. Life cycle costs of ovens

	BC1 (Euro)	BC2 (Euro)	BC3 (Euro)
Product price	446	342	60
Installation	82	82	0
Fuel (gas)	0	407	0
Electricity	561	14	72
Water	0	0	0
Repair & maintenance costs	63	52	0
Total	1152	897	132

The total life cycle cost of an electric oven (1152 Euro) is higher than the cost of a gas cooker (897 Euro) and a microwave oven (132 Euro), across 15 years. These differences are mainly related to the higher product price of the electric oven, and the higher relative cost of electricity versus gas. It is interesting to note that, in the case of microwave ovens, the cost of electricity over its lifetime (72 Euro) is higher than the cost of acquisition of the product (60 Euro).

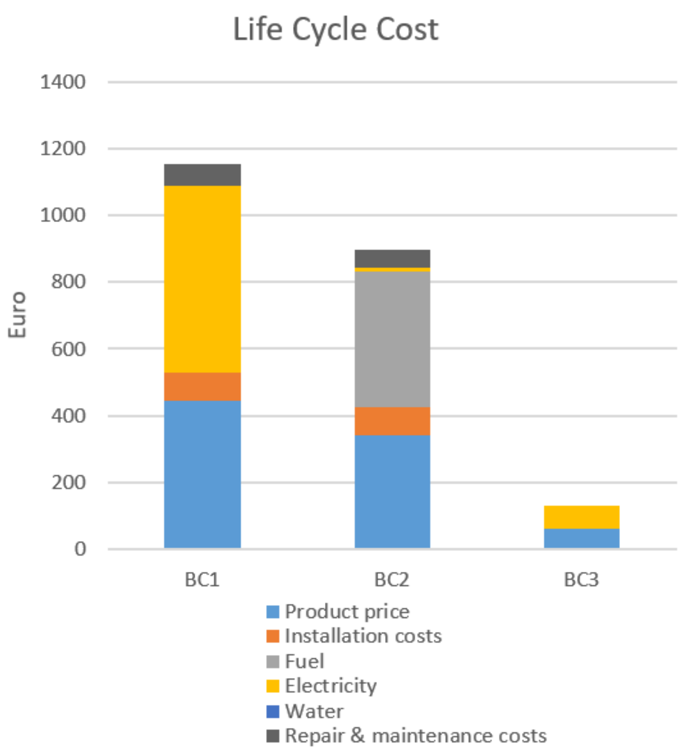


Figure 224. Life cycle cost of ovens

Table 94. Annual consumer expenditure of all EU consumers for 2020 (in Euro) (including annual sales of 2020 (product price) and annual usage of stock

	Unit	**Base Case 1 (electric)**	**Base case 2 (gas)**
Product price	Million EUR	3381	132
Installation	Million EUR	622	32
Energy	Million EUR	5014	635
Repair & maintenance costs	Million EUR	187	30
Total	Million EUR	9203	853

5.4.2 Life cycle costs of hobs

The life cycle costs have been calculated with the EcoReport tool. The methodology and the assumptions (are described in section 5.2.

The life cycle costs per appliance over a lifetime of 15 years are summarised for both base cases in Table 95.

Table 95: Life cycle costs for the base cases over the whole product life cycle (in euro)

	Unit	**Base Case 1 (radiant)**	**Base case 2 (induction)**	**Base case 3 (gas hob)**
Product price	EUR	252	557	210
Installation	EUR	82	82	82
Energy	EUR	375	365	286
Repair & maintenance costs	EUR	16	28	11
Total	EUR	725	1031	589

Table 96 shows the total annual consumer expenditure of all EU consumers for 2020

Table 96: Annual consumer expenditure of all EU consumers for 2020 (in Euro) (including annual sales of 2020 (product price) and annual usage of stock

	Unit	**Base Case 1 (radiant)**	**Base Case 2 (induction)**	**Base case 3 (gas)**
Product price	Million EUR	680	1 966	380
Installation	Million EUR	221	289	148
Energy	Million EUR	1 727	1 120	887
Repair & maintenance costs	Million EUR	73	83	34
Total	Million EUR	2 701	3 458	1 450

5.4.3 Life cycle costs of cooking fume extractors

The life cycle costs per appliance over a lifetime of 15 years are summarised for both base cases in Table 97.

Table 97. Life cycle costs for the base cases over the whole product life cycle (in euro)

	Unit	**Base Case 1 (cabinet)**	**Base Case 2 (chimney)**
Product price	EUR	189	334
Installation	EUR	82	82
Electricity	EUR	149	135
Repair & maintenance costs	EUR	30	35
Total	EUR	451	586

The contribution of the different cost elements are shown in Figure 225 both base cases. The largest contributions to the overall costs are coming from the purchase price and the expenditures in electricity. Installation costs represent also a significant share (20% in BC1 and 10% in BC2).

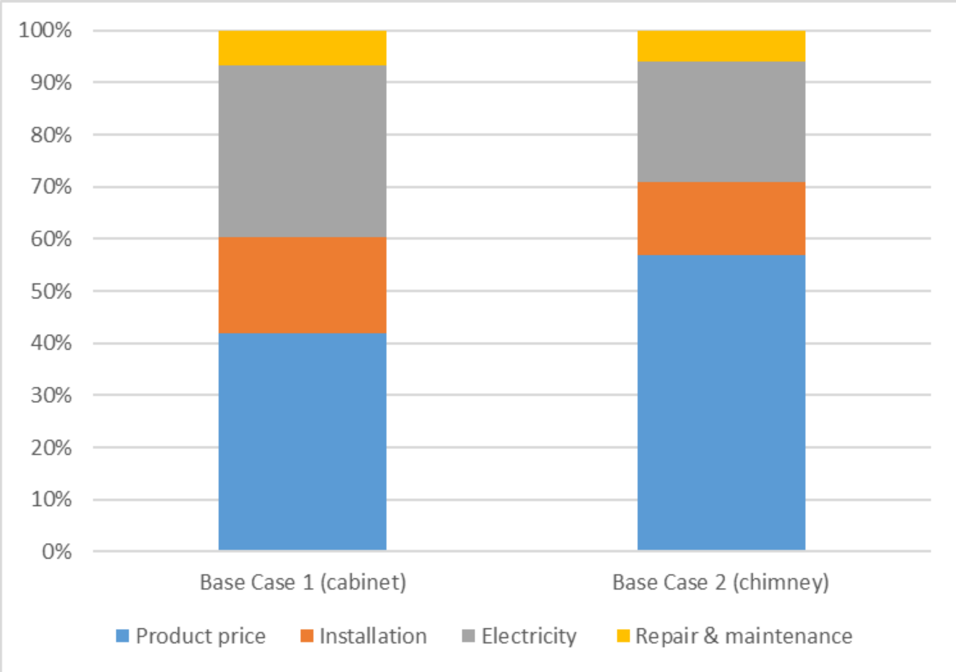


Figure 225. Life cycle cost of cooking fume extractors

Table 98 shows the total annual consumer expenditure of all EU consumers for 2020.

Table 98. Annual consumer expenditure of all EU consumers for 2020 (in Euro) (including annual sales of 2020 (product price) and annual usage of stock

	Unit	Base Case 1 (cabinet)	Base Case 2 (chimney)
Product price	Million EUR	539	1 162
Installation	Million EUR	233	285
Electricity	Million EUR	771	783
Repair & maintenance costs	Million EUR	157	200
Total	Million EUR	1 700	2 430

5.4.4 Sensitivity analysis: discount rate = 0%

In this section, a sensitivity analysis is conducted for the three product groups, assuming that the discount rate is 0% (instead of the 4% value assumed for the life cycle cost analysis of the base cases).

5.4.4.1 Ovens

Table 100 shows the results of the sensitivity analysis for Base Case 1 of ovens. The life cycle costs when applying a discount rate of 0% are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4%), thus both effects compensate each other. By setting the discount rate to 0% only the escalation rate is effective, i.e. the operating expenses are increased over the time.

Two main effects can be seen:

- the overall LCC is higher compared to the base case and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 32% to 26%) while the relative contribution from the electricity consumption is increased.

As a result from the latter effect, the additional costs of design options would payoff quicker if a discount rate of 0% is applied.

Table 99. Life cycle costs – sensitivity analysis “discount rate = 0%” (over the whole product life cycle in euro) – calculated with the RRP

	Base Case 1 (electric oven) discount rate = 4%		Sensitivity analysis: discount rate = 0%	
	Absolute LCC (**EUR)**	Relative contribution	Absolute LCC (**EUR)**	Relative contribution
Product price	446	39%	446	34%
Electricity	561	49%	707	54%
Installation	82	7%	82	6%
Repair & maintenance costs	63	5%	70	5%
Total	1152	100%	1305	100%

5.4.4.2 Hobs

Table 100 shows the results of the sensitivity analysis for Base Case 1 of hobs. The life cycle costs when applying a discount rate of 0% are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4%), thus both effects compensate each other. By setting the discount rate to 0% only the escalation rate is effective, i.e. the operating expenses are increased over the time.

As in the case of ovens, two main effects can be seen:

- the overall LCC is higher compared to the base case and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 32% to 26%) while the relative contribution from the electricity consumption is increased.

As a result from the latter effect, the additional costs of design options would payoff quicker if a discount rate of 0% is applied.

Table 100. Life cycle costs – sensitivity analysis "discount rate = 0%" (over the whole product life cycle in euro) – calculated with the RRP

	Base Case 1 (electric) discount rate = 4%		Sensitivity: discount rate = 0%	
	Absolute LCC (**EUR)**	Relative contribution	Absolute LCC (**EUR)**	Relative contribution
Product price	252	32%	252	26%
Electricity	365	51%	507	58%
Installation	82	12%	82	9%
Repair & maintenance costs	38	5%	52	6%
Total	725	100%	881	100%

5.4.4.3 Cooking fume extractors

Table 101 shows the results of the sensitivity analysis for Base Case 1 of cooking fume extractors. The life cycle costs when applying a discount rate of 0% are higher compared to the base case. This results from the fact that in the base case both the discount and the escalation rate have the same value (4%) thus both effects compensate each other. By setting the discount rate to 0% only the escalation rate is effective i.e. the operating expenses are increased over the time (the resulting present worth factor (PWF) is 16.45 years).

Similarly to ovens and hobs, two main effects can be seen:

- the overall LCC is higher compared to the base case and
- the relative contribution of the purchase price at the overall LCC is lower (reduced from 42% to 36%) while the relative contribution electricity consumptio is increased.

As a result from the latter effect the additional costs of design options would payoff quicker if a discount rate of 0% is applied.

Table 101. Life cycle costs – sensitivity analysis "discount rate = 0%" (over the whole product life cycle in euro) – calculated with the RRP

	Base Case 1 (cabinet) discount rate = 4%		Sensitivity: discount rate = 0%	
	Absolute LCC (**EUR)**	Relative contribution	Absolute LCC (**EUR)**	Relative contribution
Product price	189	42%	189	36%
Electricity	149	33%	207	40%
Installation	82	18%	82	16%
Repair & maintenance costs	30	7%	42	8%
Total	451	100%	520	100%

6 Task 6: Design options

6.1 Definition of oven design options

As outlined in section 5.1.1.4, the energy consumption of an electric oven is 156.6 kWh/year and the energy consumption of a gas cooker is 1051 MJ/year. In Task 6, different design options to improve the energy efficiency and their relative impacts are discussed.

In Task 4, several technologies related to domestic ovens have been described in detail. Some of them can be considered as design options with the capacity of improving energy efficiency and consumption.

In various occasions during the development of this preparatory project, the authors have been in touch with association of manufacturers, asking specifically information regarding base cases and best available technologies for current domestic ovens. When asked specifically about ovens, manufacturers responded that:

- The most common electric oven today is in the A energy class
- A potential best available technology today is an electric oven that has an enhanced sealing system, which makes use of residual heat, allowing it to reach A+ or A++ classes.
- These ovens with enhanced insulation reaching A+ or A++ classes are, in terms of components and materials, fundamentally the same than the A oven (the Base Case)
- The only difference between the A and the A+, A++ ovens will be related to the use of residual heat in the energy saving mode (the heating mode used to declare energy consumption and get the energy class).

Based on that, an A+ or an A++ is a particular design: in terms of materials and components, it is fundamentally the same appliance as the base case. The only difference between them is the presence of an energy saving mode that is able to use residual heat. On top of those considerations, it must be noted that the use of energy saving modes for energy declaration has been challenged by some stakeholders and their use in new regulation may be reviewed as part of this work. Table 102 summarizes the design options considered for ovens.

Table 102. Summary of oven design options

Design options	Reference Base Case	Description
Option 1 (DO1): Electric oven with enhanced sealing reaching A+ energy class	BC1	- The most common electric oven today is in the A energy class - A potential best available technology today is an electric oven that has an enhanced sealing system, which makes use of residual heat, allowing it to reach A+ or A++ classes. - Based on this feedback from manufacturers, two design options have been defined in this project: DO1 and DO2.
Option 2 (DO2): Electronic oven with enhanced sealing reaching A++ energy class	BC1	
Option 3 (DO3): Gas oven reaching A+ energy class	BC2	- The most common gas cooker today is in the A energy class - A potential best available technology today is a gas cooker that has an enhanced sealing system, which makes use of residual heat, allowing it to reach A+ or A++ classes. - Based on this feedback from manufacturers, two design options have been defined in this project: DO3 and DO4.
Option 4 (DO4): Gas oven reaching A++ energy class	BC2	
Option 5 (DO5): Electric oven with microwave-assisted combined function	BC1	As described in Section 4.1.4.8 of this preparatory study, some manufacturers offer ovens with combined function of forced-air convection and microwave. Feedback from industry highlights that there are energy and time saving potentials in these microwave combined modes. DO5 has been defined based on this feedback.
Option 6 (DO6): Electric oven with automatic functions	BC1	According to some manufacturers, automatic features in ovens can guide the consumer in a more efficient use of their oven, by helping them choose the most appropriate heating mode and cooking time, depending on recipe. DO6 has been defined based on this feedback.

Based on a questionnaire, manufacturers were asked to provide specific technical and cost data of the above listed design options. These options are compared to the base cases (BC1 and BC2). Changes induced by the design options will be compared to the base cases with regard to:

- Energy consumption
- Material composition (compared to the BoM of the base cases)
- Manufacturing costs, maintenance and repair costs
- Product price

Based on this input and additional expert knowledge, the project team has assumed the input for further calculations as described in the following sections.

Design Options 1 and 2 (DO1 & DO2)

Design Options 1 (DO1) and 2 (DO2) have been defined in reference to Base Case 1 (BC1), so they will represent technologies with the potential of improving the energy consumption of current domestic electric ovens.

In various occasions during the development of this preparatory project, the authors have been in touch with association of manufacturers, asking specifically information regarding base cases and best available technologies. Regarding domestic electric ovens, manufacturers responded that:

a) The most common electric oven today is in the A energy class

b) A potential best available technology today is an electric oven that has an enhanced sealing system, which makes use of residual heat, allowing it to reach A+ or A++ classes.

Based on this feedback from manufacturers, DO1 and DO2 have been defined:

- DO1 will be an electric oven with an enhanced sealing system and appropriate use of residual heat that allows to reach A+ energy class (with brickmethod 1.0).
- In the same way, DO2 will be an electric oven with an enhanced sealing system and appropriate use of residual heat that allows to reach A++ energy class (with brickmethod 1.0).

Current energy labelling regulation identifies A+ and A++ ovens with EEI values as in Table 103:

Table 103. EEI of energy classes A+ and A++

Energy class	EEI range	EEI (mid value)
A+	62 – 82	72
A++	45 - 62	53.5

For DO1 and DO2, it will be considered that the ovens are at the middle of the A+ and A++ bands, respectively, as indicated in the table. Considering the formulas for EEI calculation for electric ovens and a volume of 70 litres (as BC1), the estimated energy consumption of DO1 and DO2 are presented in Table 104:

Table 104. Energy consumption of DO1 and DO2

	Energy consumption Conventional (kWh/cycle)	Energy consumption Fan-forced (kWh/cycle)
DO1	0.89	0.61
DO2	0.89	0.45

For DO1, 0.61 kWh/cycle can be interpreted as the energy consumption of a hypothetical electric oven of 70l, placed in the middle of the A+ band. Compared with BC1, it is a 27% improvement. In the same way, for DO2, 0.45 kWh/cycle can be interpreted as the energy consumption of a hypothetical electric oven of 70l, placed in the middle of the A++ band. Compared with BC1, it is a 46% improvement. In both DOs, the improvement has been applied to the fan-forced heating mode only.

In terms of materials, as indicated above, they are fundamentally the same as the base case (the benefit is obtained through the use of residual heat in the energy saving mode).

- DO1: no change in material composition
- DO2: no change in material composition

Based on manufacturers' feedback, there is no change in the manufacturing process in DO1 and DO2 when compared to the Base Case.

- DO1: manufacturing costs as in BC1
- DO2: manufacturing costs as in BC1

It will also be considered that the installation, maintenance and repair costs will be not significant when compared to BC1.

Regarding product price, in Task 2 an analysis has been conducted on the market of domestic ovens. Comparing the average prices of ovens in the A class with ovens in the A+ class, there are price increases between 26% and 49%, depending on the country. For the analysis on this section, an indicative 35% price increase between A and A+ will be assumed. In a similar way, the price increase between A+ and A++ will be assumed as 35%.

- DO1: product price 35% higher than BC1
- DO2: product price 35% higher than DO1

Design Options 3 and 4 (DO3 & DO4)

Following a similar approach as described in the section above, Design Options 3 (DO3) and 4 (DO4) have been defined in reference to Base Case 2 (BC2), so they will represent technologies with the potential of improving the energy consumption of current domestic gas ovens (cookers).

The authors have been in touch with association of manufacturers, asking specifically information regarding base cases and best available technologies. Regarding domestic gas cookers, manufacturers responded that:

a) The most common gas cooker today is in the A energy class

b) A potential best available technology today is a gas cooker that has an enhanced sealing system, allowing it to reach A+ or A++ classes.

Based on this feedback from manufacturers, DO3 and DO4 have been defined:

- DO3 will be a gas cooker with an enhanced sealing system that allows to reach A+ energy class (with brickmethod 1.0).
- DO4 will be a gas cooker with an enhanced sealing system that allows to reach A++ energy class (with brickmethod 1.0).

For DO3 and DO4, it will be considered that the cookers are at the middle of the A+ and A++ bands, respectively, as indicated in the table. Considering the formulas for EEI calculation for gas ovens and a volume of 65 litres (as BC2), the estimated energy consumption of DO3 and DO4 are:

- DO3: 4.6 MJ/cycle
- DO4: 3.4 MJ/cycle

For DO3, 4.6 MJ/cycle can be interpreted as the energy consumption of a hypothetical gas oven of 65l, placed in the middle of the A+ band. Compared with BC2, it is a 20% improvement. In the same way, for DO4, 3.4 MJ/cycle can be interpreted as the energy consumption of a hypothetical gas oven of 65l, placed in the middle of the A++ band. Compared with BC2, it is a 40% improvement.

In terms of materials, as indicated above, they are fundamentally the same as the base case (the benefit is obtained through the use of residual heat in the energy saving mode).

- DO3: no change in material composition
- DO4: no change in material composition

Based on manufacturers feedback, there is no change in the manufacturing process in DO3 and DO4 when compared to the Base Case.

- DO3: manufacturing costs as in BC2
- DO4: manufacturing costs as in BC2

It will also be considered that the installation, maintenance and repair costs will be not significant when compared to BC2.

Regarding product price, the assumptions will be analogous as the ones taken in DO1 and DO2: an indicative 35% price increase between A and A+ and an additional price increase of 35% between A+ and A++.

- DO3: product price 35% higher than BC2
- DO4: product price 35% higher than DO2

Design Option 5 (DO5)

As described in Section 4.1.4.8 of this preparatory study, some brands offer ovens with microwave combined function. Feedback from industry highlights that there are energy and time saving potentials in these microwave combined modes. These saving potentials were observed in tests with real food (not standardised). Depending on the type of dish being prepared, when compared to forced-air convection without microwave, the energy savings range between 5 and 20%. For the purpose of this design option, it will be considered that an electric oven with microwave-assisted combined function is a design option with the capacity of reducing energy consumption by an average of 10%. In this case, the improvement has been considered for both conventional and fan-forced heating modes (Table 105).

Table 105. Energy consumption of DO5

	Energy consumption Conventional (kWh/cycle)	Energy consumption Fan-forced (kWh/cycle)
DO5	0.80	0.71

In terms of materials, DO5 obtains its energy consumption benefits through the use of a microwave combined function. Therefore, the additional materials considered will be the ones used in the components required for the microwave function. These materials have been taken from the microwave oven bill of materials that defines Base Case 3 (BC3):

- Magnetron: 668 g of Copper; 74 g of ceramics
- Electronic components: 333 g of controller boards, 161 g of ABS, 15 g of PC

Taking into account that an oven with microwave combined function is a product with a higher level of complexity than the one defined in BC1, it will be assumed that in DO5, manufacturing costs are 15% higher.

- DO5: manufacturing costs 15% higher than BC1

Following a similar reasoning, it will be assumed that installation, maintenance and repair costs are 10% higher than in BC1.

- DO5: installation, maintenance and repair costs 10% higher than BC1

Regarding product price, the average price of electric ovens with microwave function is between 1089-1454 Euro, depending on the country. For the analysis in this section, an indicative product price of 1200 Euro will be assumed.

Design Option 6 (DO6)

According to some manufacturers, automatic features in ovens can guide the consumer in a more efficient use of their oven, by helping them choose the most appropriate heating mode and cooking time, depending on the recipe being cooked.

For the purpose of this design option, it will be considered that an electric oven with automatic features is a design option with the capacity of reducing energy consumption by an average of 15%. In this case, the improvement has been considered for both conventional and fan-forced heating modes (Table 106).

Table 106. Energy consumption of DO6

	Energy consumption Conventional (kWh/cycle)	Energy consumption Fan-forced (kWh/cycle)
DO6	0.76	0.67

In terms of materials, DO6 obtains its energy consumption benefits through the use of timers and sensors. Therefore, the additional materials considered will be the ones used in those components. These materials have been as in the list below:

- Electronic components: 300 g of controller boards, 150 g of ABS, 15 g of PC

Taking into account that an oven with automatic functions is a product with a higher level of complexity than the one defined in BC1, it will be assumed that in DO6, manufacturing costs are 30% higher.

- DO6: manufacturing costs 30% higher than BC1

Following a similar reasoning, it will be assumed that installation, maintenance and repair costs are 10% higher than in BC1.

- DO6: installation, maintenance and repair costs 10% higher than BC1

Regarding product price, an indicative 50% increase in the product price will be assumed.

Design Options involving Microwave ovens

In terms of design options with the capacity of reducing energy consumption of microwave ovens, in section 4.1.4.7 of this report, the authors mentioned a publication from 2005 by the Energy Conservation Center of Japan (ECCJ, 2005), where some of the conclusions was that there was still room for improvement in efficiency of microwaves, possibly by improving the radiation method and thermal insulation performance. However, in the previous preparatory study for domestic and commercial cooking appliances (Mudgal, 2011), manufacturers assured that modern microwave ovens are close to maximum efficiency. Cavity size had no effect on it, whereas internal coatings could only improve it by 1-2%. Over the development of this project, no other specific technology has been mentioned by stakeholders with the capacity of reducing energy consumption of microwave ovens.

In section 4.1.6 of this report, the authors mentioned solid-state semiconductors as a potential best not available technology, which could help in the future to make a more efficient use of these appliances, by adjusting and producing just the right amount of microwaves, at the right power of level and for the correct length of time, to heat food evenly. However, currently there is no scientific evidence regarding potential improvements in terms of energy efficiency of this technology. Moreover, feedback from manufacturers indicate that the efficiency of generating microwaves by a semiconductor is much lower than with a magnetron; and the oven needs to be dimensioned for a specific frequency to assure an efficient use and avoid microwave leakage. The costs of this technology are currently significantly high.

As a summary from this section it could be stated that:

- The room for reducing energy consumption of current microwave ovens is very small or non-existent
- Potential technologies that are still not available to reduce energy consumption of microwave ovens are too expensive or have not shown evidence of their reduction capacity.

For the reasons pointed out above, the authors of this report took the decision of not including a design option to model the energy reduction of microwave ovens.

Summary of oven design options

As a conclusion from this section, a summary of the characteristics of the different Design Options that will be evaluated further are presented in Table 107.

Table 107. Summary of oven design options

Design option	Ref. Base Case	Description	Energy consumption Conventional	Energy consumption Fan-forced	Changes in material composition	Manufacturing costs	Maintenance and repair costs	Product price
DO1	BC1	An electronic oven with appropriate sealing/insulation reaching A+, with current measurement method. This oven also reuses residual heat/eco-mode	0.89 kWh/cycle	0.61 kWh/cycle	No change	No change	no change	35% higher than BC1
DO2	BC1	An electronic oven with appropriate sealing/insulation reaching A++, with current measurement method. This oven also reuses residual heat/eco-mode	0.89 kWh/cycle	0.45 kWh/cycle	No change	No change	no change	35% higher than DO1
DO3	BC2	A gas oven reaching A+	4.60 MJ/cycle	n/a	No change	No change	no change	35% higher than BC2
DO4	BC2	A gas oven reaching A++	3.40 MJ/cycle	n/a	No change	No change	no change	35% higher than DO3
DO5	BC1	An electric oven with MW-assisted heating function	0.80 kWh/cycle	0.71 kWh/cycle	add materials related to MW oven: magnetron, electronics	15% higher than BC	10% higher than BC	1200 Euro
DO6	BC1	An electric oven with smart features to select optimum heating modes and cooking times, that allows reducing average energy consumption	0.76 kWh/cycle	0.67 kWh/cycle	add materials related to electronics	30% higher than BC	10% higher than BC	50% higher than BC1

6.2 Definition of hob design options

In Task 4, several technologies related to hobs were described, including the typical energy consumption range of electric hobs. This information can be translated into design options that represent the improvement potential of this product. Table 108 summarizes the initial design options.

Table 108. Hob design options

Design options	Reference Base Case	Description
Option 1 (DO1): (Best induction technology)	BC2	Most efficient Induction technology. The energy consumption is 170 Wh/kg
Option 2 (DO2): A gas hob with better energy efficiency	BC3	According to the information provided by manufacturers, gas hobs can reach a maximum of 58 %.

Manufacturers were asked to provide specific technical and cost data of the above listed design options. These options are compared to the base cases (BC2 and BC3). Changes induced by the design options will be compared to the base cases with regard to:

- Energy consumption
- Material composition (compared to the BoM of the base cases)
- Manufacturing costs, maintenance and repair costs
- Product price

Based on this input and additional expert knowledge, the project team has assumed the input for further calculations as described in the following sections.

Design Option 1

Design Options 1 (DO1) has been defined in reference to Base Case 2 (BC2), so they will represent technologies with the potential of improving the energy consumption of current domestic induction hobs.

Manufacturers shared the range of energy consumption that the three types of electric hobs (solid plate, radiant heater and induction) typically perform (Figure 226. Energy consumption ranges of electric hobs (APPLIA). In a red line, the ecodesign limit for energy consumption after 2019 is displayed (195 Wh/kg).

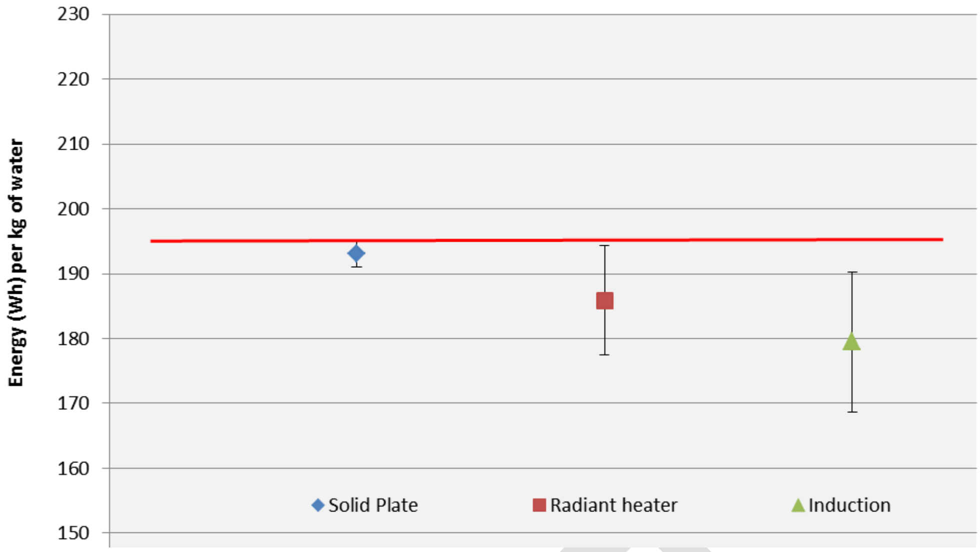


Figure 226. Energy consumption ranges of electric hobs (APPLIA)

The ranges observed in the graph correspond to the variety of sizes and number of heating zones within radiant and induction hobs. They do not represent different performances for a given base case.

Manufacturers have provided specific information about base cases and best available technologies. Regarding domestic electric hobs, manufacturers responded that:

a) No further energy savings can be achieved for radiant hobs. The margin allowed by improving controls have been fully developed.

b) A potential best available technology today is induction technology.

Based on this feedback from manufacturers, DO1 has been defined as the best available induction hobs with 4 defined cooking areas. The energy consumption is 175 Wh/kg.

In terms of materials, DO1 would not entail any change in the weight or the Bill of Materials, compared to BC2.

The best induction technology would require additional costs due to better materials and quality controls in the production. It is assumed an additional manufacturing cost of 10%, which will lead to an increase of product price of 20%.

Design Option 2

Following a similar approach as described in the section above, Design Options 2 has been defined in reference to Base Case 2 (BC2), so they will represent the potential of improving the energy consumption of current domestic gas hobs.

The authors have been in touch with association of manufacturers, asking specifically information regarding base cases and best available technologies. Regarding domestic gas hobs, manufacturers responded that gas hobs can reach a maximum energy efficiency of 58%. Higher efficiencies would jeopardise safety requirements, therefore no further design options have been considered. Apart from that, this efficiency would not be feasible for the special case of hobs having one burner only, which are normally very powerful dual burners, and usually perform lower efficiencies.

In terms of materials, DO2 obtains the energy consumption benefits by improving the heat transference. No additional materials would be needed

In order to achieve the assumed energy consumption reductions, the DO2 will require slightly different manufacturing processes, potentially with higher levels of quality control. Therefore, it will be assumed that manufacturing costs will be 10% higher than in BC3.

Regarding product price, in Task 2 an analysis has been conducted on the market of domestic hobs. For the analysis on this section, an indicative 20% price increase between BC3 and DO2 will be assumed.

Summary of hob design options

As a conclusion from this section, a summary of the characteristics of the different Design Options that will be evaluated further are presented in Table 109.

Table 109. Summary of hob design options

Design option	**Ref. Base Case**	**Description**	**Energy consumption vs BC**	**Changes in material composition**	**Manufacturing costs**	**Maintenance and repair costs**	**Product price**
DO1	BC2	Best available induction	170 vs 185 Wh/Kg	No change	+10%	No change	+20%
DO2	BC3	A gas hob with better energy efficiency	60% vs 55%	Negligible	+10%	No change	+20%

6.3 Definition of cooking fume extractors design options

In Task 4, several technologies related to cooking fume extractors were described, the different technical options to improve the energy efficiency of this product. This information can be translated into design options that represent the improvement potential of this product. Table 110 summarizes the initial design options.

Table 110. Cooking fume extractor design options

Design options	Reference Base Case	Description
Option 1 (DO1): more efficient capacitor motor	BC1	According to the information provided by manufacturers, capacitor motor perform energy efficiencies that range from 60 to 70%. This option will reduce the annual energy consumption of the base case by 23% in cabinet cooking fume extractors
Option 2 (DO2, DO3): Brushless motor	BC1, BC2	According to the information provided by manufacturers, brushless motors perform energy efficiencies that range from 70 to 80%. This option will reduce the annual energy consumption of the base case by 55% in T-shape cooking fume extractors and 60% in cabinet cooking fume extractors.
Option 3 (DO4, DO5): Optimisation of working conditions	BC1, BC2	The application of 9-points method will entail that the cooking fume extractors will be set up at optimal efficiencies at the three speeds. This may increase the real efficiency of motors around 10%

Manufacturers were asked to provide specific technical and cost data of the above listed design options. These options are compared to the base cases (BC1 and BC2). Changes induced by the design options will be compared to the base cases with regard to:

- Energy consumption
- Material composition (compared to the BoM of the base cases)
- Manufacturing costs, maintenance and repair costs
- Product price

Based on this input and additional expert knowledge, the project team has assumed the input for further calculations as described in the following sections.

Design Options 1, 2 and 3

Design Options 1 (DO1) and 2 (DO2) have been defined in reference to Base Case 1 (BC1), and Design option 3 (DO3) in reference to Base Case 2 (BC2). They will represent technologies with the potential of improving the energy consumption of current domestic electric hobs.

Manufacturers shared the range of energy efficiencies of the motors that cooking fume extractors are equipped with, as follows:

- **Brushless motors**: they are components of high-end models that can reach energy classes between A++ and A+++. They perform high motor efficiencies, within the range of 70 and 85%. They are smaller and lighter than capacitor or shaded poles motors.
- **Asynchronous capacitor motors**: they are components of middle and high-end models that can reach energy classes between D and A+. They perform lower motor efficiencies than brushless motors, within the range of 55 and 70%.
- **Asynchronous shaded poles motors:** they are components of low-end models whose energy classes are between D and C. They perform the lowest efficiencies, within the range of 20 and 30%, and they are the most economical ones.

Design option 1 consists of a cabinet cooking fume extractor equipped with an improved motor of the same technology, i.e. capacitor. This can be considered a standard improvement option as it can be achieved without change of technology. The reduction in the annual energy consumption has been estimated by comparing the performance of the base case cabinet cooking fume extractor and a similar (in terms of maximum airflow) cabinet cooking fume extractor, also equipped with a capacitor motor. The data come from APPLiA database.

In contrast, design option 2 and 3 will entail a shift of technology to brushless motor. Besides, this option represents the best energy classes currently in the market, and therefore it can be considered best available technology. Likewise design option 1, the base cases have been compared to a similar cooking fume extractor equipped with a brushless motor.

In terms of materials, DO1 obtains the energy consumption benefits by improving the base case technology. The additional materials needed are considered negligible, according to manufacturers.

In the case of DO2 and DO3, the change of technology would entail a change of materials. Since brushless motors are usually smaller, the weight of the cooking fume extractor could be reduced. This reduction is assumed to be 5%.

In order to achieve the assumed energy consumption reductions, the DO1 will require an improved motor that will entail an additional manufacturing cost 5 EUR. The change to brushless motors will require higher costs, based on manufacturers information, which will be 18 EUR of additional cost.

Regarding product price, in Task 2 an analysis has been conducted on the market of domestic hobs.. For the analysis on this section, an indicative 30% price increase between BC1 and DO1 will be assumed. In a similar way, the price increase between BC2 and DO2 will be assumed as 115%.

- <u>DO1</u>: product price 30% higher than BC1
- <u>DO2 and DO3</u>: product price 110% higher than BC1 and BC2

Design Option 4 and 5

Design options 4 (referred to BC1) and 5 (referred to BC2) will be derived from the application of the 9-points method to calculate the annual energy consumption and EEI of cooking fume extractors. The current methodology measures these parameters at best efficiency point, which is usually the maximum or boost speed. This means that at lower speeds the motor delivers the power at lower efficiencies. The 9-points method will drive the design of the cooking fume extractors towards optimal efficiencies in real life conditions, which will lead to a reduction of the annual energy consumption of 10%.

This improvement option will not require additional materials or additional costs, since it will only need a best match between the motor design and the actual conditions of usage.

Summary of cooking fume extractors design options

As a conclusion from this section, a summary of the characteristics of the different Design Options that will be evaluated further are presented in Table 111.

Table 111. Summary of cooking fume extractor design options

Design option	**Ref. Base Case**	**Description**	**Energy consumption vs BC**	**Changes in material composition**	**Manufacturing costs**	**Maintenance and repair costs**	**Product price**
DO1	BC1	More efficient capacitor motor	23% reduction of the AEC	No	+5 EUR	no change	+30%
DO2	BC1	Brushless motor	60% reduction of the AEC	Smaller motor, 5% reduction of cooking fume extractor weight	+18 EUR	No change	+110%
DO3	BC2	Brushless motor	55% reduction of the AEC	Smaller motor, 5% reduction of cooking fume extractor wight	+18 EUR	No change	+110%

DO4, DO5	BC1, BC2	Optimisation of working conditions	The application of 9-points methods will entail that the cooking fume extractors will be set up at optimal efficiencies at the three speeds. This may increase the real efficiency of motors around 10%

6.4 Environmental analysis of design options

6.4.1 Environmental analysis of ovens

Design options related to oven BC1

Base Case 1 is a 70 litre electric oven with an A energy class. Potential improvements regarding this BC are equivalent ovens in superior energy classes: A+ (DO1) and A++ (DO2). A direct and obvious consequence of these design options is the reduction of electricity consumption, both in terms of Total Energy and Electricity, as can be observed in Figure 227 and Table 112. In DO1, Total Energy is reduced by 25% and in DO2 41%. Also related with this improvement in energy consumption is the reduction in Greenhouse Gases: 9% in DO1 and 18% in DO2.

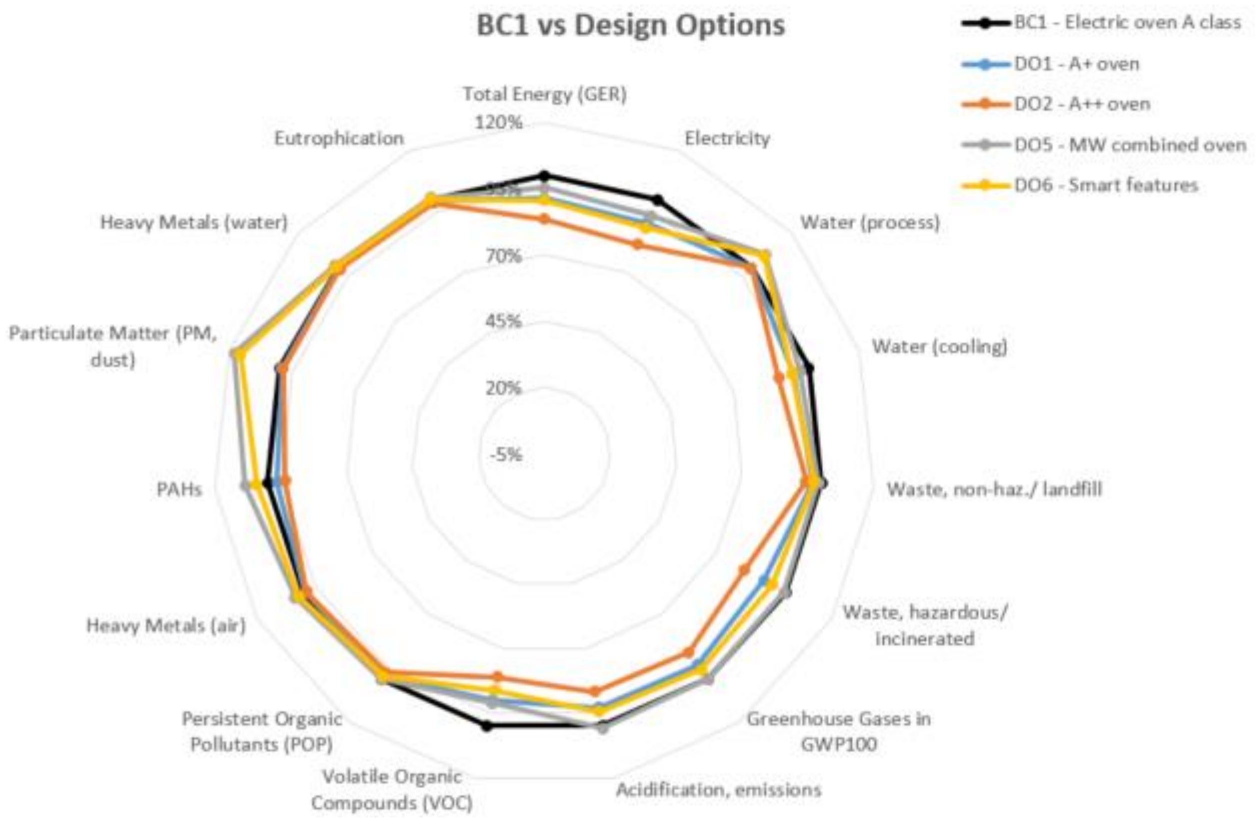


Figure 227. Environmental analysis BC1 oven design options

Significant improvements are also observed in Hazardous waste/incinerated (9% in DO1 and 18% in DO2): if less electricity is required, less waste related to electricity generation will be produced. A similar situation is observed in Acidification and Volatile Organic Compounds. These are emissions that are directly related to electricity generation. When less electricity is needed, the emissions are reduced drastically.

The improvements above related to DO1 and DO2 come with no trade-offs in other categories: by definition, DO1 and DO2 only differ from BC1 in the fact that they consume less energy (they are the same oven in terms of material composition). Therefore, reducing energy consumption of the base case can only have beneficial consequences.

DO5 is an electric oven with microwave-combined function, assumed to reduce energy consumption per cycle by 10% over BC1. This reduction in energy consumption is translated in improvements in categories such as Total Energy (5%), Electricity (7%) or VOCs (9%), all of them emissions directly related to the generation of electricity. The main changes of DO5 when compared to BC1 are the addition of materials related to microwave oven components: the magnetron and the electronics. The addition of those materials has a direct effect on the increased impact of categories such as Water/process (7%), Particulate Matters (18%), PAHs (8%) and Heavy Metals (4%).

Finally, DO6 is an electric oven with automatic features, assumed to reduce energy consumption per cycle by 15% over BC1. Similarly to the design option above, this reduction in energy consumption is translated in improvements in categories such as Total Energy (9%), Electricity (12%), Greenhouse Gas Emissions (4%) or VOCs (14%). The addition of electric components related to an oven with automatic features has a negative effect on categories such as Water/process (7%), Particulate Matters (16%), PAHs (4%) and Heavy Metals (2%)

All the results commented in this section can be seen in Table 112.

Table 112. Results of oven BC1 design options

Other Resources & Waste					
	BC1	**DO1**	**DO2**	**DO5**	**DO6**
Total Energy (GER) [MJ]	21285.5	19437.1	17781.5	20317.3	19295.2
% vs BC1		-9%	-16%	-5%	-9%
Electricity [MJ]	22576.7	20376.2	18405.2	21051.6	19946.5
% vs BC1		-10%	-18%	-7%	-12%
Water (process) [ltr]	1682.7	1682.7	1682.7	1805.6	1793.4
% vs BC1		0%	0%	7%	7%
Water (cooling) [ltr]	1525.3	1427.5	1339.9	1472.8	1423.2
% vs BC1		-6%	-12%	-3%	-7%
Waste, non-haz./ landfill [g]	37148.6	36014.6	34998.9	36771.0	36144.5
% vs BC1		-3%	-6%	-1%	-3%
Waste, hazardous/ incinerated [g]	371.7	336.9	305.9	369.4	349.5
% vs BC1		-9%	-18%	-1%	-6%
Emissions (Air)					
	BC1	**DO1**	**DO2**	**DO5**	**DO6**
Greenhouse Gases in GWP100 [kg CO2 eq.]	650.7	607.8	569.4	651.5	623.7
% vs BC1		-7%	-12%	0%	-4%
Acidification, emissions [g SO2 eq.]	5983.2	5567.5	5195.2	6037.1	5659.5
% vs BC1		-7%	-13%	1%	-5%

Volatile Organic Compounds (VOC) [g]	495.3	446.1	402.1	450.8	427.1
% vs BC1		-10%	-19%	-9%	-14%
Persistent Organic Pollutants (POP) [ng i-Teq]	320.5	315.4	310.8	320.9	316.1
% vs BC1		-2%	-3%	0%	-1%
Heavy Metals [mg Ni eq.]	3534.5	3512.2	3492.3	3665.3	3614.5
% vs BC1		-1%	-1%	4%	2%
PAHs [mg Ni eq.]	147.7	142.5	137.9	160.6	154.0
% vs BC1		-3%	-7%	9%	4%
Particulate Matter (PM, dust) [g]	1322.2	1313.4	1305.5	1560.5	1530.5
% vs BC1		-1%	-1%	18%	16%
Emissions (Water)					
	BC1	**DO1**	**DO2**	**DO5**	**DO6**
Heavy Metals [mg Hg/20]	2006.6	1997.1	1988.7	2031.7	2021.1
% vs BC1		0%	-1%	1%	1%
Eutrophication [g PO4]	56.6	56.1	55.8	57.0	56.7
% vs BC1		-1%	-1%	1%	0%

Design options related to ovens BC2

Base Case 2 is a 65 litre gas cooker with an A energy class. Potential improvements regarding this BC are equivalent ovens in superior energy classes: A+ (DO3) and A++ (DO4). As described in previous section, the direct and obvious consequence of these design options is the reduction of gas consumption, mainly in terms of Total Energy (17% in DO3 and 36% in DO4), as can be observed in Figure 228 and Table 113.

Also related with this improvement in Total Energy consumption is the reduction in Greenhouse Gases: 18% in DO3 and 37% in DO4.

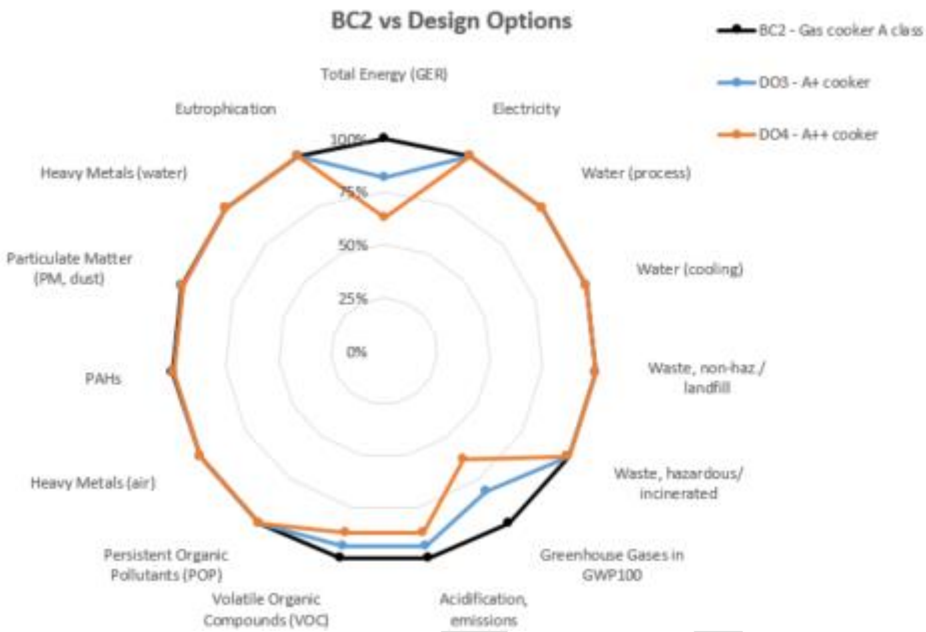


Figure 228. Environmental analysis of BC2 oven design options

All the results commented in this section can be seen in Table 113.

Table 113. Results of oven BC2 design options

Other Resources & Waste			
	BC1	**D03**	**D04**
Total Energy (GER) [MJ]	21775.0	17781.1	13694.0
% vs BC1		-18%	-37%
Electricity (Primary Energy) [MJ]	943.8	943.8	943.8
% vs BC1		0%	0%
Water (process) [ltr]	546.2	546.2	546.2
% vs BC1		0%	0%
Water (cooling) [ltr]	748.0	748.0	748.0
% vs BC1		0%	0%
Waste, non-haz./ landfill [g]	18020.7	18020.7	18020.7
% vs BC1		0%	0%
Waste, hazardous/ incinerated [g]	34.9	34.9	34.9
% vs BC1		0%	0%
Emissions (air)			
	BC2	**D03**	**D04**
Greenhouse Gases in GWP100 [kg CO2 eq.]	1205.3	984.5	758.5
% vs BC1		-18%	-37%
Acidification, emissions [g SO2 eq.]	1030.1	965.8	900.0
% vs BC1		-6%	-13%
Volatile Organic Compounds (VOC) [g]	48.2	45.3	42.4

% vs BC1		-6%	-12%
Persistent Organic Pollutants (POP) [ng i-Teq]	236.7	236.7	236.7
% vs BC1		0%	0%
Heavy Metals [mg Ni eq.]	916.4	916.4	916.4
% vs BC1		0%	0%
PAHs [mg Ni eq.]	39.0	38.8	38.7
% vs BC1		0%	-1%
Particulate Matter (PM, dust) [g]	1496.6	1495.5	1494.3
% vs BC1		0%	0%
Emissions (water)			
	BC2	**D03**	**D04**
Heavy Metals [mg Hg/20]	531.6	531.6	531.6
% vs BC1		0%	0%
Eutrophication [g PO4]	23.4	23.4	23.4
% vs BC1		0%	0%

6.4.2 Environmental analysis of hobs

Design options related to hobs BC2

Base Case 2 is a four heating zones induction hob that consumes 185 Wh/kg water. There is a margin of improvement in these products, and the only design option identified is the most efficiency induction hob currently in the market, which can reach a consumption of 170 Wh/kg water. This improvement would not entail any addition of materials. A direct consequence is a reduction of electricity consumption, in terms of Total Energy (12%), as can be observed in Figure 229 and Table 114. Also related with this improvement in Total Energy consumption is a similar reduction in Greenhouse Gases, Acidification and VOC emissions.

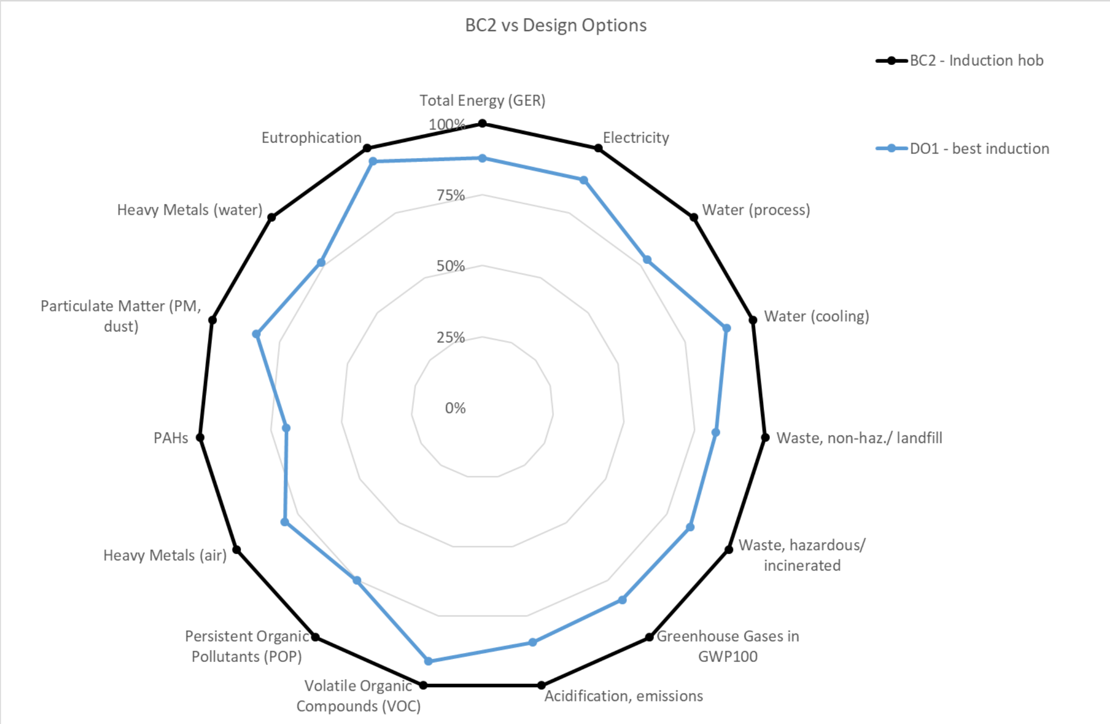


Figure 229. Environmental analysis of BC2 hob design options

All the results commented in this section can be seen in Table 114.

Table 114. Results of hob BC2 design options

Other Resources & Waste		
	BC2	**DO1**
Total Energy (GER) [MJ]	20687.3	18172.2
% vs BC2		-12%
Primary Energy [MJ]	18633.0	16349.4
% vs BC2		-12%
Water (process) [ltr]	1295.7	1009.1
% vs BC2		-22%
Water (cooling) [ltr]	874.2	789.1
% vs BC2		-10%
Waste, non-haz./ landfill [g]	18408.2	15207.8
% vs BC2		-17%
Waste, hazardous/ incinerated [g]	544.2	458.4
% vs BC2	20687.3	18172.2
Emissions (Air)		
	BC2	**DO1**
Greenhouse Gases in GWP100 [kg CO2 eq.]	727.4	608.3
% vs BC2		-16%
Acidification, emissions [g SO2 eq.]	6154.6	5199.1

% vs BC2		-16%
Volatile Organic Compounds (VOC) [g]	363.5	332.2
% vs BC2		-9%
Persistent Organic Pollutants (POP) [ng i-Teq]	131.0	98.7
% vs BC2		-25%
Heavy Metals [mg Ni eq.]	1491.2	1198.0
% vs BC2		-20%
PAHs [mg Ni eq.]	398.0	276.5
% vs BC2		-31%
Particulate Matter (PM, dust) [g]	2819.6	2358.5
% vs BC2		-16%
Emissions (Water)		
	BC2	**D01**
Heavy Metals [mg Hg/20]	465.0	355.9
% vs BC2		-23%
Eutrophication [g PO4]	10.2	9.7
% vs BC2		-5%

Design options related to hobs BC3

Base Case 3 is a four burners gas hob with an efficiency of 56%. There is little margin of improvement in these products, though the only design option identified is the most efficiency gas hob currently in the market, which can reach 58% energy efficiency. This improvement would not entail any addition of materials. A direct consequence is a modest reduction of gas consumption, in terms of Total Energy (3%), as can be observed in Figure 230 and Table 115. Also related with this improvement in Total Energy consumption is the same reduction in Greenhouse Gases, Acidification and VOC emissions.

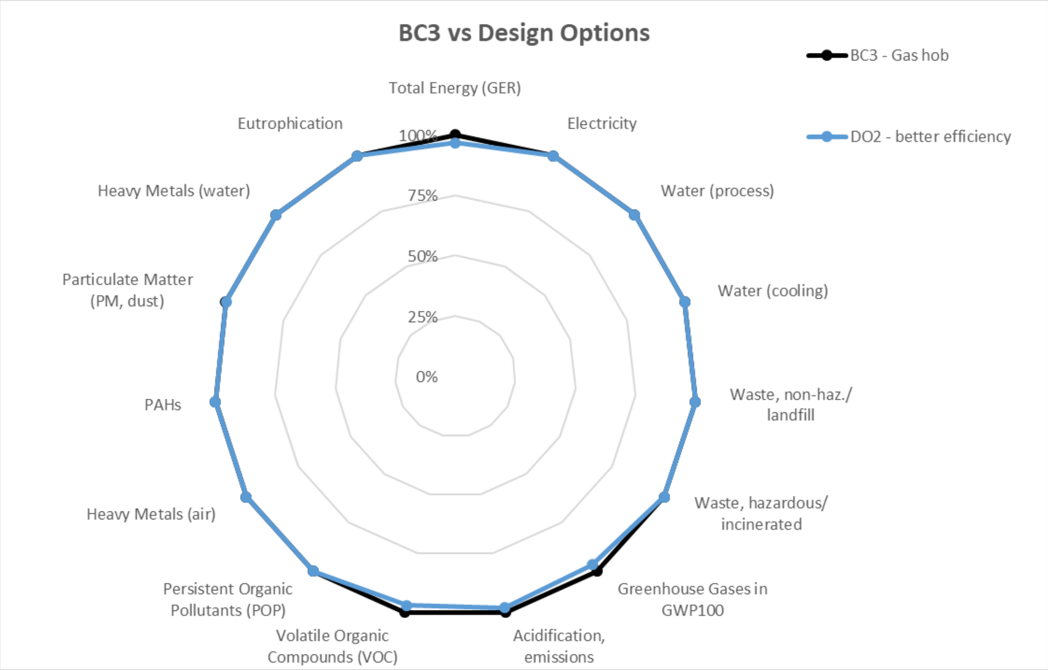


Figure 230. Environmental analysis of BC3 hob design options

. All the results commented in this section can be seen in Table 115.

Table 115. Results of hob BC3 design options

Other Resources & Waste		
	BC3	**DO2**
Total Energy (GER) [MJ]	15073.9	14561.9
% vs BC3		-3%
Primary Energy [MJ]	94.5	94.5
% vs BC3		0%
Water (process) [ltr]	4.0	4.0
% vs BC3		0%
Water (cooling) [ltr]	65.9	65.9
% vs BC3		0%
Waste, non-haz./ landfill [g]	7184.5	7184.5
% vs BC3		0%
Waste, hazardous/ incinerated [g]	5.2	5.2
% vs BC3		0%
	BC3	**DO2**
Greenhouse Gases in GWP100 [kg CO2 eq.]	839.1	810.7
% vs BC3		-3%
Acidification, emissions [g SO2 eq.]	419.8	411.6
% vs BC3		-2%
Volatile Organic Compounds (VOC) [g]	12.5	12.2

% vs BC3		-3%
Persistent Organic Pollutants (POP) [ng i-Teq]	113.6	113.6
% vs BC3		0%
Heavy Metals [mg Ni eq.]	70.4	70.4
% vs BC3		0%
PAHs [mg Ni eq.]	125.4	125.4
% vs BC3		0%
Particulate Matter (PM, dust) [g]	249.9	249.8
% vs BC3		0%
Emissions (water)		
	BC3	**DO2**
Heavy Metals [mg Hg/20]	57.0	57.0
% vs BC3		0%
Eutrophication [g PO4]	0.4	0.4
% vs BC3		0%

6.4.3 Environmental analysis of cooking fume extractors

Design options related to cooking fume extractors BC1

Base Case 1 is a cabinet cooking fume extractor equipped with a capacitor motor and annual energy consumption of 47.1 kWh (9-points method). Potential improvements regarding this base case are a more efficient capacitor motor (DO1), a brushless motor (DO2) and optimised working conditions (DO4). These design options lead to the reduction of electricity consumption, both in terms of Total Energy and Electricity, as can be observed in Figure 231 and Table 116. In DO1, Total Energy is reduced by 19%, 50% and 8% in DO1, DO2 and DO4 respectively. The significant reduction of DO2 is due to the lower weight of the brushless motor. Also related with this improvement in energy consumption is the reduction in Greenhouse Gases: 15%, 40% and 6% respectively.

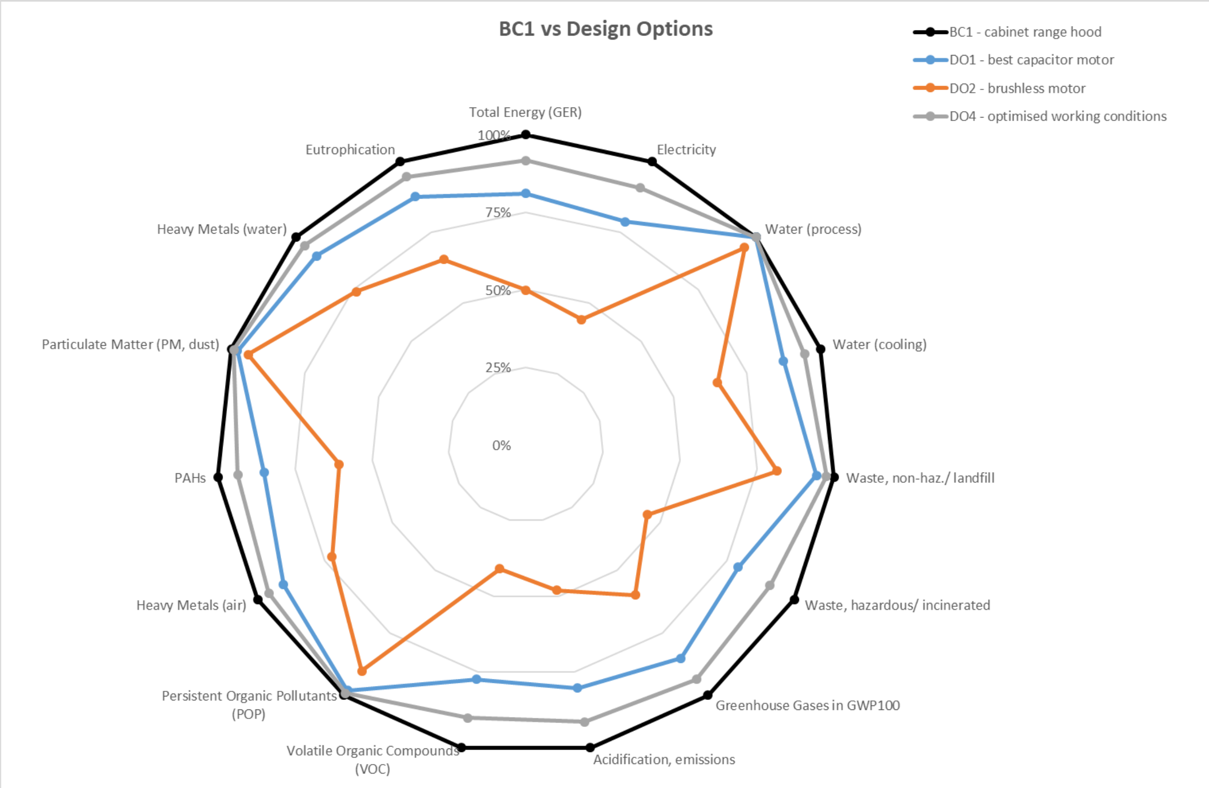


Figure 231. Environmental analaysis of BC1 cooking fume extractor design options

Significant improvements are also observed in Hazardous waste/incinerated (21% in DO1, 55% in DO2 and 9% in DO4): if less electricity is required, less waste related to electricity generation will be produced. A similar situation is observed in Acidification and Volatile Organic Compounds.

All the results commented in this section can be seen in Table 116.

Table 116. Results of cooking fume extractor BC1 design options

Other Resources & Waste				
	BC1	**DO1**	**DO2**	**DO4**
Total Energy (GER) [MJ]	6496.6	5268.1	3243.9	5962.5
% vs BC1		-19%	-50%	-8%
Primary Energy [MJ]	5778.8	4550.4	2552.3	5244.7
% vs BC1		-21%	-56%	-9%
Water (process) [ltr]	20.1	20.1	19.1	20.1
% vs BC1		0%	-5%	0%
Water (cooling) [ltr]	518.1	453.1	336.8	489.9
% vs BC1		-13%	-35%	-5%
Waste, non-haz./ landfill [g]	13342.7	12589.1	10880.8	13015.1
% vs BC1		-6%	-18%	-2%
Waste, hazardous/ incinerated [g]	110.5	87.4	50.0	100.5
% vs BC1		-21%	-55%	-9%
Emissions (Air)				

	BC1	DO1	DO2	DO5
Greenhouse Gases in GWP100 [kg CO2 eq.]	192.5	164.0	115.4	180.1
% vs BC1		-15%	-40%	-6%
Acidification, emissions [g SO2 eq.]	1400.5	1124.3	672.0	1280.4
% vs BC1		-20%	-52%	-9%
Volatile Organic Compounds (VOC) [g]	144.5	111.8	59.3	130.3
% vs BC1		-23%	-59%	-10%
Persistent Organic Pollutants (POP) [ng i-Teq]	170.5	167.1	153.9	169.0
% vs BC1		-2%	-10%	-1%
Heavy Metals [mg Ni eq.]	154.3	139.5	111.6	147.8
% vs BC1		-10%	-28%	-4%
PAHs [mg Ni eq.]	22.9	19.5	13.9	21.4
% vs BC1		-15%	-39%	-6%
Particulate Matter (PM, dust) [g]	291.1	285.2	274.6	288.5
% vs BC1		-2%	-6%	-1%
Emissions (Water)				
	BC1	**DO1**	**DO2**	**DO5**
Heavy Metals [mg Hg/20]	70.7	64.4	52.1	67.9
% vs BC1		-9%	-26%	-4%
Eutrophication [g PO4]	2.2	2.0	1.5	2.1
% vs BC1		-12%	-35%	-5%

Design options related to cooking fume extractors BC2

Base Case 1 is a chimney cooking fume extractor equipped with a capacitor motor and annual energy consumption of 42.8 kWh (9-points method). Potential improvements regarding this BC are a brushless motor (DO3) and optimised working conditions (DO5). A direct and obvious consequence of these design options is the reduction of electricity consumption, both in terms of Total Energy and Electricity, as can be observed in Figure 232 and Table 118. In DO1, Total Energy is reduced by 44% and 8% in DO3 and DO5 respectively. Also related with this improvement in energy consumption is the reduction in Greenhouse Gases: 33% and 6% respectively.

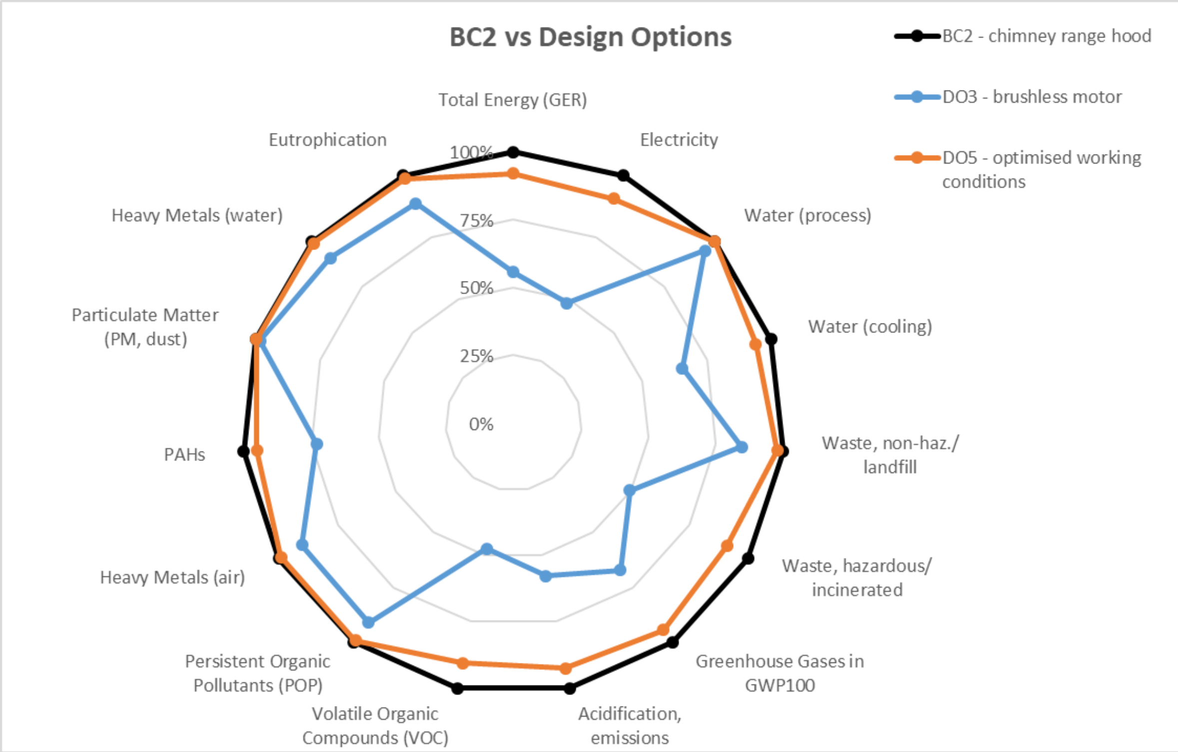


Figure 232. Environmental analysis of BC2 cooking fume extractor design options

Similar to BC1, significant improvements are also observed in Hazardous waste/incinerated (50% in DO3 and 9% in DO5): if less electricity is required, less waste related to electricity generation will be produced. The same is observed in Acidification and Volatile Organic Compounds.

It is important to highlight the significant improvement of the indicators mentioned in DO3. This technology leads to a significant reduction of electricity at the use phase which is the major contributor to this improvement. It also has an impact at the production phase because of the lower weight of the brushless motor, however, it only represents 1% of the total energy reduction.

All the results commented in this section can be seen in Table 117.

Table 117. Results of BC2 cooking fume extractor design options

Other Resources & Waste			
	BC2	**DO3**	**DO4**
Total Energy (GER) [MJ]	6118.4	3405.2	5633.1
% vs BC1		-44%	-8%
Primary Energy [MJ]	5199.5	2512.8	4714.1
% vs BC1		-52%	-9%
Water (process) [ltr]	237.1	225.3	237.1
% vs BC1		-5%	0%
Water (cooling) [ltr]	436.7	286.4	411.0
% vs BC1		-34%	-6%
Waste, non-haz./ landfill [g]	14279.3	12088.9	13981.6
% vs BC1		-15%	-2%
Waste, hazardous/ incinerated [g]	100.0	49.6	90.9

% vs BC1		-50%	-9%
Emissions (air)			
	BC2	**DO3**	**DO4**
Greenhouse Gases in GWP100 [kg CO2 eq.]	197.6	132.8	186.4
% vs BC1		-33%	-6%
Acidification, emissions [g SO2 eq.]	1450.4	836.2	1341.3
% vs BC1		-42%	-8%
Volatile Organic Compounds (VOC) [g]	135.2	64.2	122.3
% vs BC1		-53%	-10%
Persistent Organic Pollutants (POP) [ng i-Teq]	168.9	153.8	167.6
% vs BC1		-9%	-1%
Heavy Metals [mg Ni eq.]	593.8	535.5	587.9
% vs BC1		-10%	-1%
PAHs [mg Ni eq.]	27.8	20.3	26.4
% vs BC1		-27%	-5%
Particulate Matter (PM, dust) [g]	864.2	849.3	861.9
% vs BC1		-2%	0%
Emissions (water)			
	BC2	**DO3**	**DO4**
Heavy Metals [mg Hg/20]	308.6	280.7	306.1
% vs BC1		-9%	-1%
Eutrophication [g PO4]	8.8	7.8	8.7
% vs BC1		-11%	-1%

6.5 Life cycle cost of design options

6.5.1 Life cycle cost of oven design options

In terms of life cycle costs for BC1, as it can be seen in Figure 233 and Table 118, only one design option is cheaper for the consumer than BC1: the life cycle cost of DO1 (A+ electric oven) is 40 Euro cheaper over its lifetime. In this particular case, the savings obtained in electricity consumption compensate the product price increase

The rest of design options presented in this section are more costly for the consumer than the base case. It is interesting to note that. DO5 (oven with MW-combined function) is penalised by its currently high product price (average of 1200 Euro).

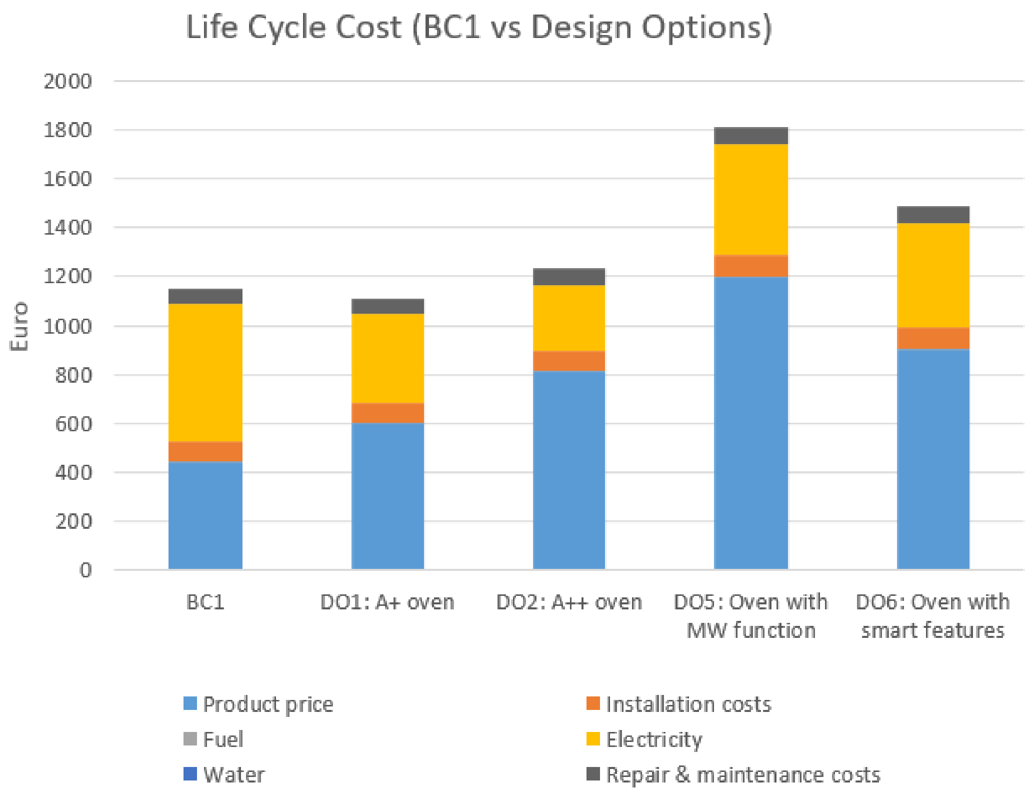


Figure 233. Life cycle cost BC1 oven design options

Table 118. Life cycle cost of BC1 oven design options

Euro	BC1	DO1	DO2	DO5	DO6
Product price	446	602	813	1200	903
Installation	82	82	82	90	90
Fuel	0	0	0	0	0
Electricity	561	365	273	452	423
Water	0	0	0	0	0
Repair & maintenance	63	63	63	69	69
Total	1152	1112	1231	1812	1486

A similar situation can be observed in Base Case 2 and its design options (Figure 234 and Table 119). DO3 shows exactly the same price as BC1 over its lifetime. The higher product price is compensated with the lower gas consumed after 15 years. DO4 is more costly to the consumer than BC2. In this case, the assumed increase in product price cannot be compensated by the reduction in energy consumption.

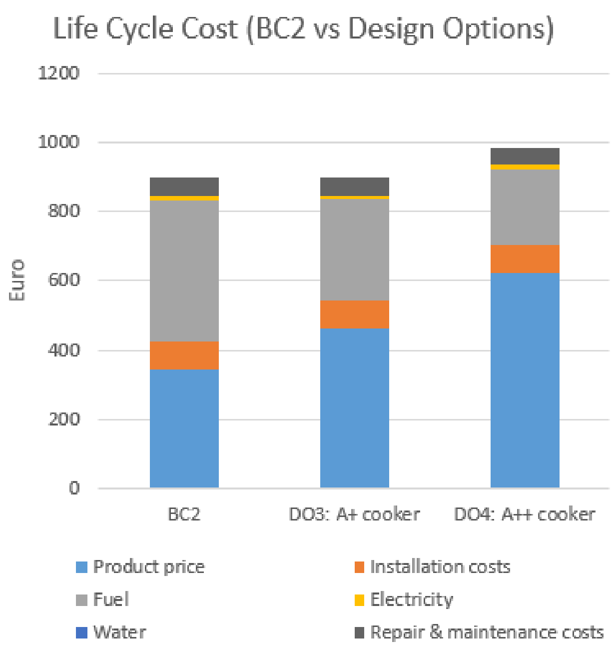


Figure 234. Life cycle cost of BC2 oven design options

Table 119. Life cycle cost of BC2 oven design options

Euro	BC2	DO3	DO4
Product price	342	462	623
Installation	82	82	82
Fuel	407	291	215
Electricity	14	14	14
Water	0	0	0
Repair & maintenance	52	52	52
Total	897	901	986

The life cycle costs and the environmental impacts of the base cases and design options are plotted together in Figure 235 and Figure 236 for BC1 and BC2, respectively. As environmental impact indicator the total energy consumption (MJ) over the lifecycle is chosen, although similar trends would be seen in categories such as Greenhouse Gases, Acidification or VOCs.

From the analysis of Figure 235, it can be seen that DO1 and DO2 appear to be good alternatives for BC1, since they provide energy savings, with some additional savings (DO1) or for a small increase in life cycle cost for the consumer (DO2). DO5 and DO6 provide a similar energy saving to DO1, with a significant drawback in terms of cost.

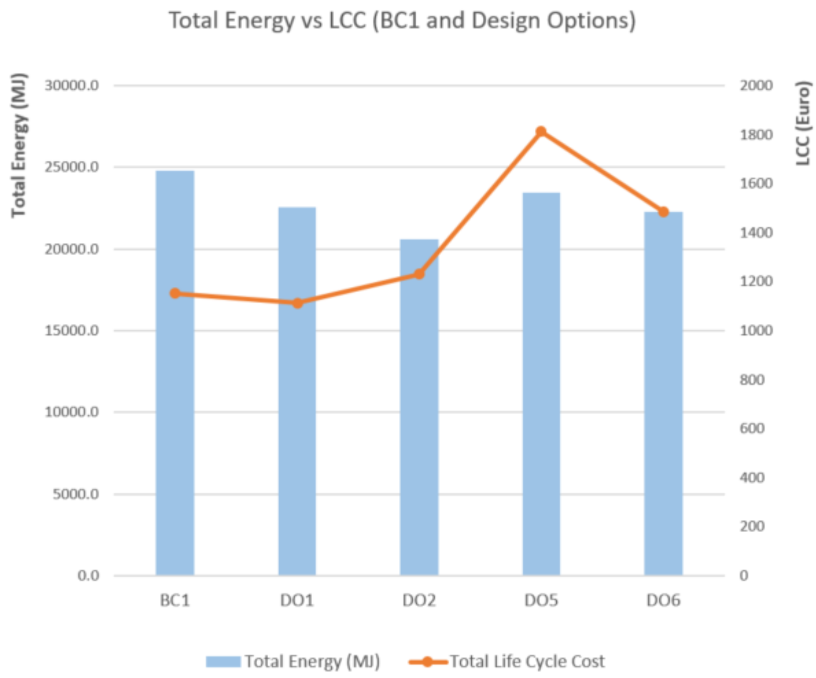


Figure 235. Life cycle cost and energy consumption of BC1 oven design options

In the case of BC2, both design options are beneficial in terms of energy consumption. As said above, DO3 costs approximately the same as BC2 for the consumer after 15 years and is beneficial in total energy consumption. DO4 is even more beneficial from the energy point of view but the savings in gas consumption cannot compensate the price increase.

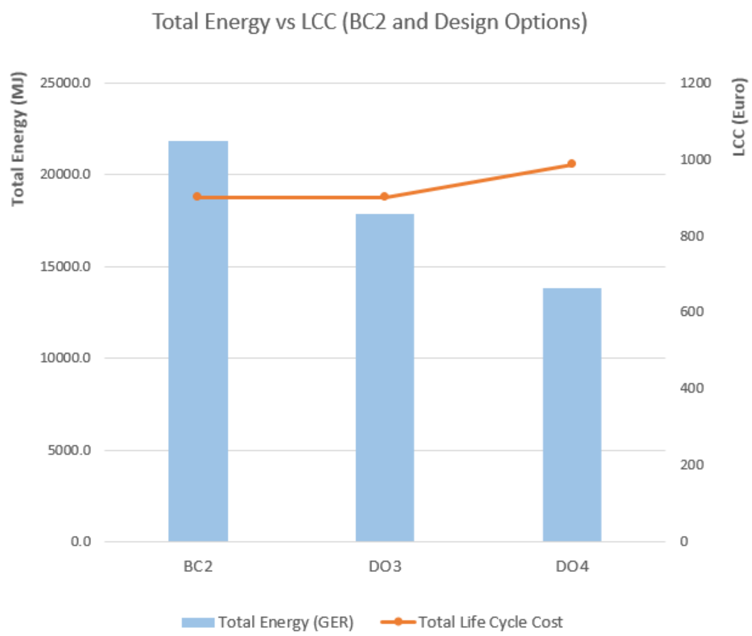


Figure 236. Life cycle cost and environmental consumption of BC2 oven design options

6.5.2 Life cycle cost of hobs design options

In terms of life cycle costs for BC2, as it can be seen in Figure 237 and Table 120, every design option presented in this section is more costly for the consumer than the base case. The reduction in electricity consumption at the use phase does not compensate the increase of the purchase price.

Table 120. Life cycle cost of BC2 hob design options

Euro	BC2	DO1: best induction
Product price	557	668
Installation	82	82
Fuel	0	0
Electricity	365	346
Water	0	0
Repair & maintenance	27	27
Total	1031	1123

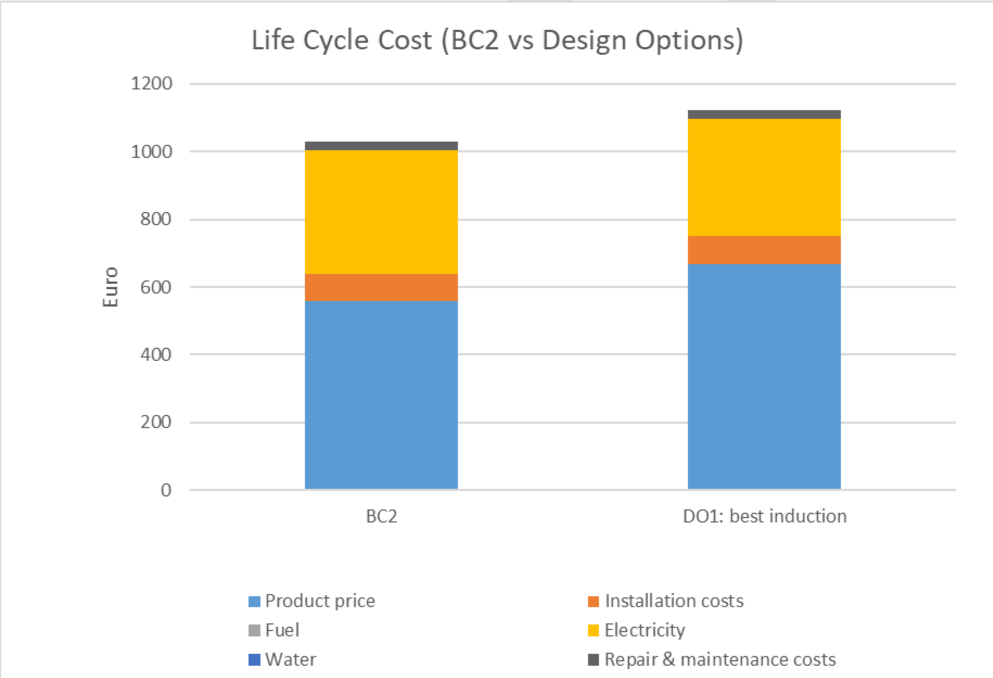


Figure 237. Life cycle cost BC2 hob design options

In Base Case 3, the increase of the life cycle cost of design option 1 is not so significant. The additional purchase price also outweighs the reduction of fuel costs due to the better efficiency.

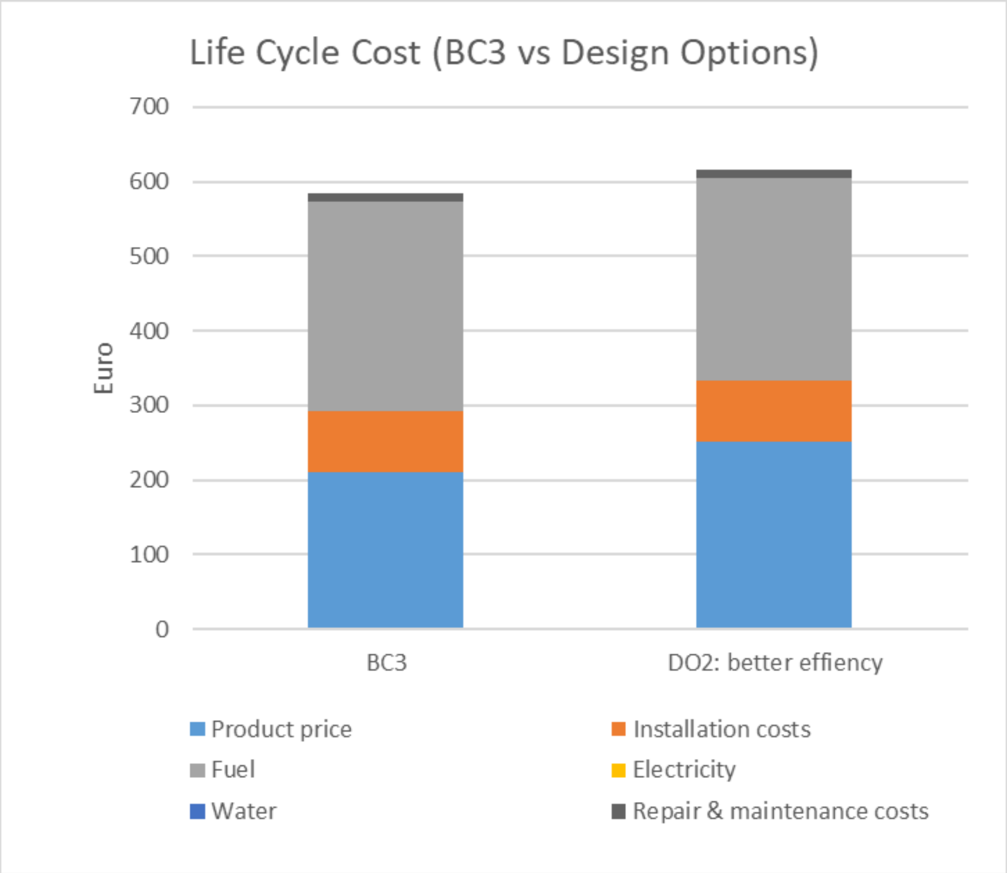


Figure 238. Life cycle cost of BC3 hob design options

Table 121. Life cycle cost of BC3 design options

Euro	BC3	DO2
Product price	210	252
Installation	82	82
Fuel	281	271
Electricity	0	0
Water	0	0
Repair & maintenance	11	11
Total	584	616

The life cycle costs and the environmental impacts of the base cases and design options are plotted together in Figure 239 and Figure 240 for BC2 and BC3, respectively. As environmental impact indicator the total energy consumption (MJ) over the lifecycle is chosen, although similar trends would be seen in categories such as Greenhouse Gases, Acidification or VOCs.

From the analysis of Figure 239, it can be seen that DO1 provides a significant decrease in total energy consumption for BC1, with a life cycle cost increase around 5%.

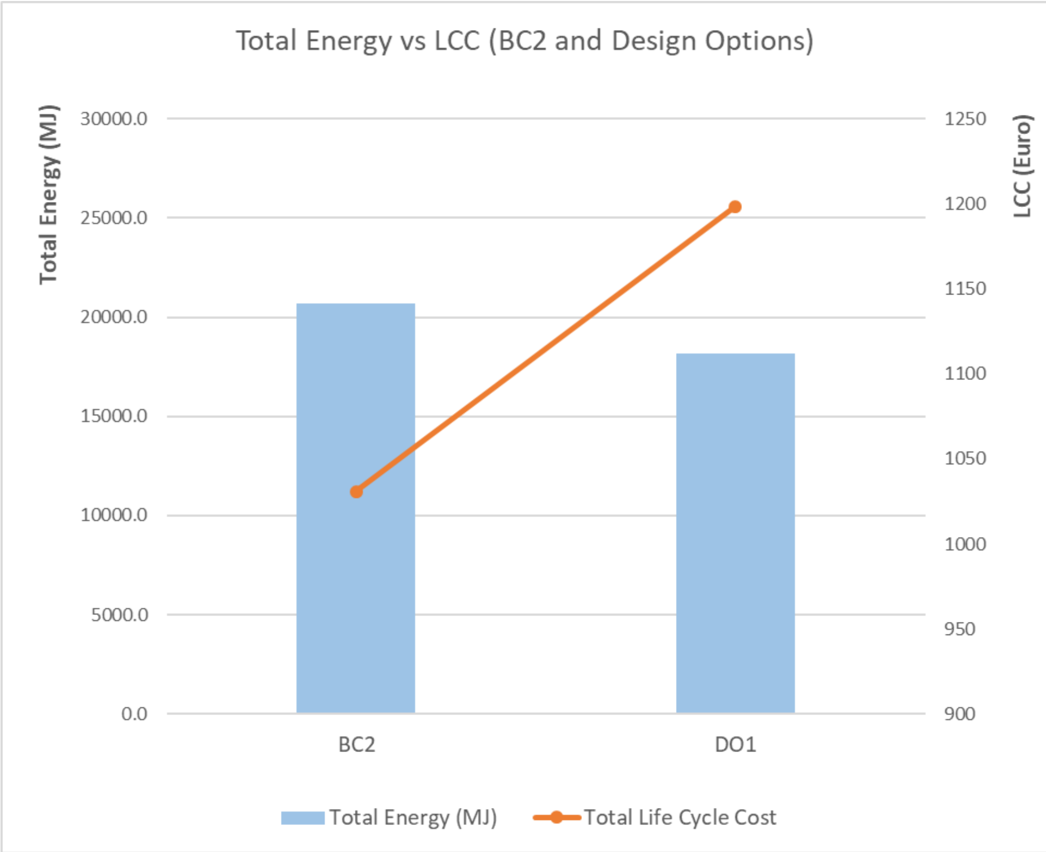


Figure 239. Life cycle cost and energy consumption of BC2 hob design options

In BC3, the design option is slightly beneficial for energy consumption with an increase of life cycle cost of 5%.

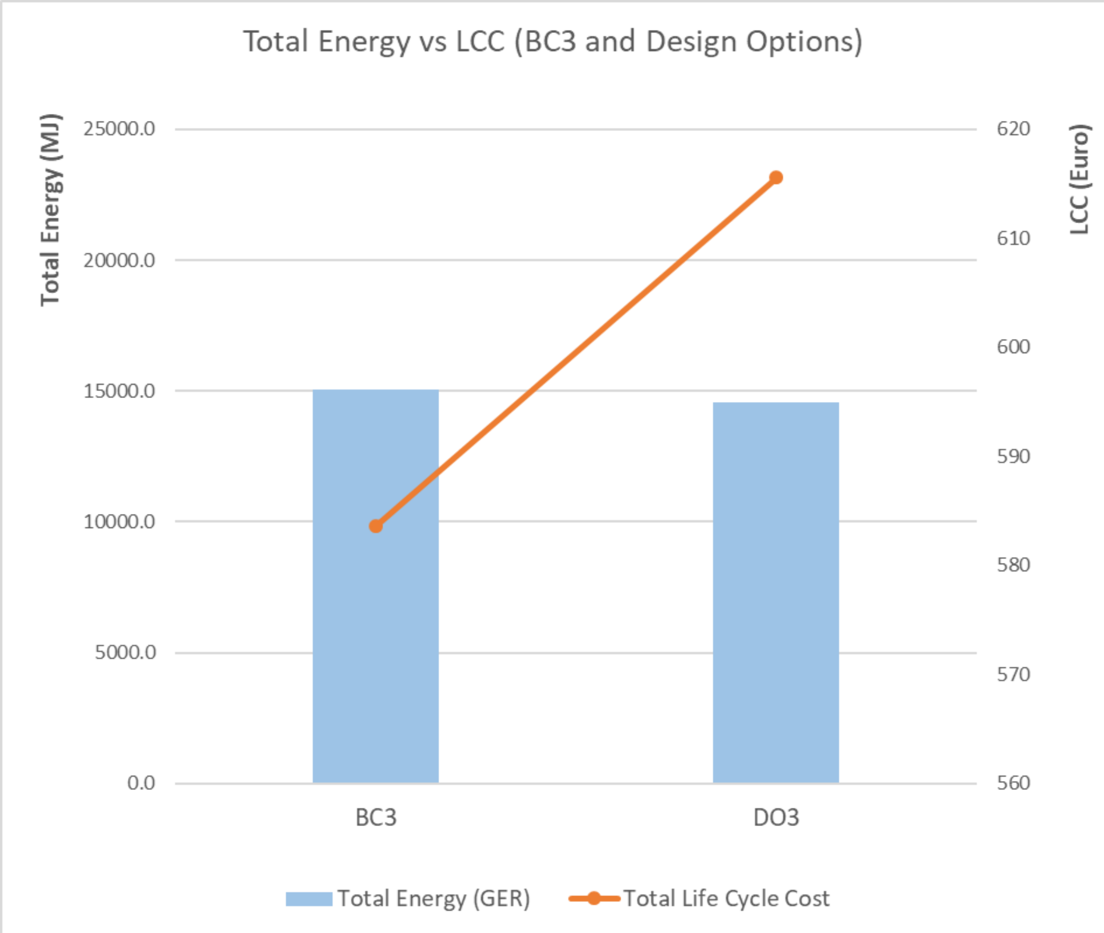


Figure 240. Life cycle cost and energy consumption of BC3 hob design options

6.5.3 Life cycle cost of cooking fume extractors design options

In terms of life cycle costs for BC1, as it can be seen in Figure 241 and Table 122, every design option presented in this section is more costly for the consumer than the base case, except DO4. DO1 entails a modest additional cost, and the savings obtained in electricity consumption almost compensate the product price increase. DO2 (cooking fume extractor equipped with a brushless motor) is penalised by its currently high product price.

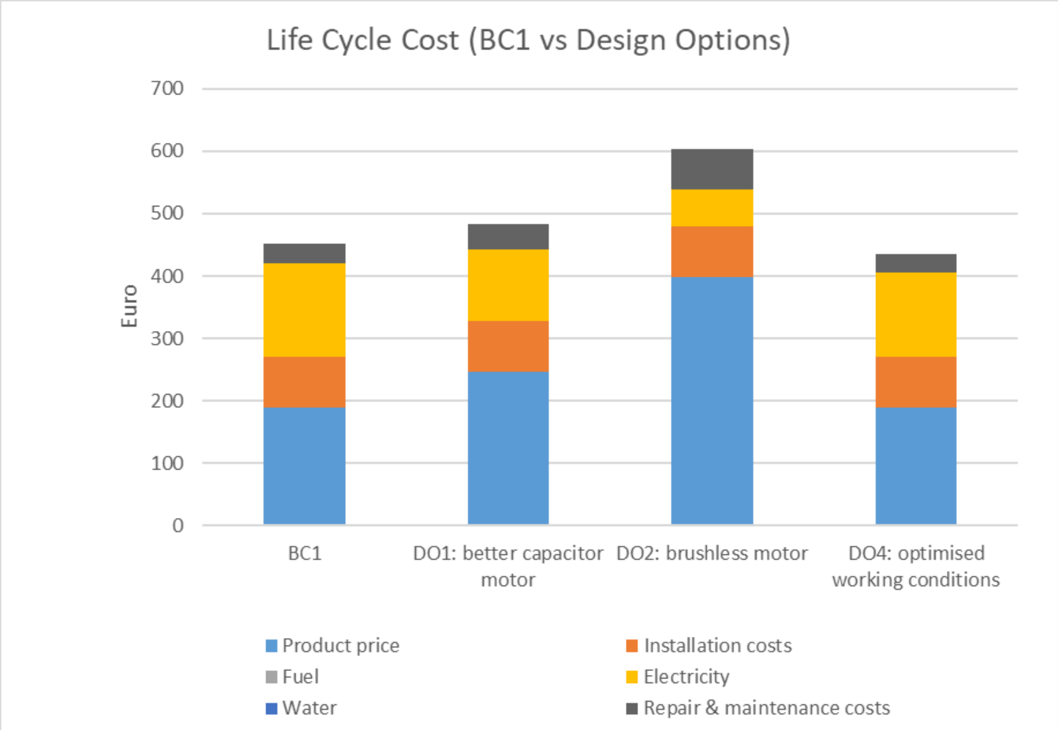


Figure 241. Life cycle cost of BC1 cooking fume extractor design options

Table 122. Life cycle cost of BC1 cooking fume extractor design options

Euro	**BC1**	**DO1**	**DO2**	**DO4**
Product price	189	246	398	189
Installation	82	82	82	82
Fuel	0	0	0	0
Electricity	149	115	60	134
Water	0	0	0	0
Repair & maintenance	30	39	64	30
Total	451	482	603	436

A similar situation can be observed in Base Case 2 and its design options (Figure 242 and Table 123). DO3 is much more costly to the consumer than BC2, due to the additional purchase price.

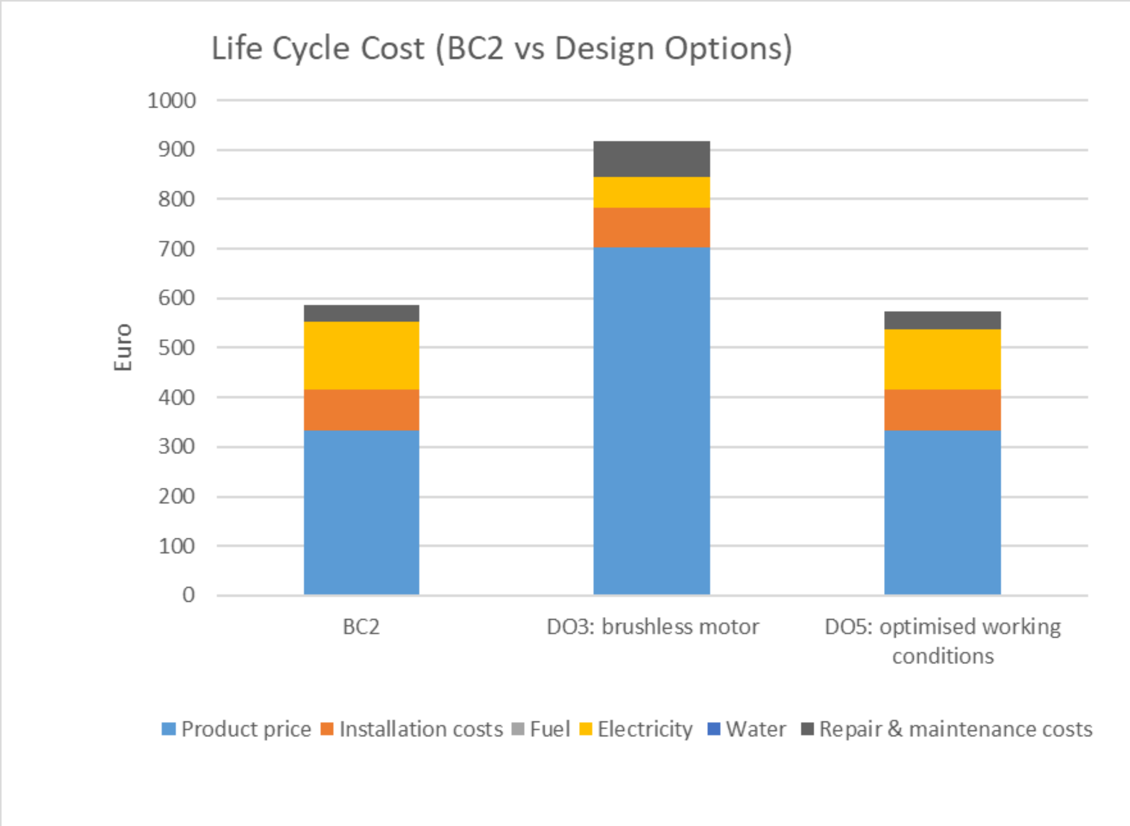


Figure 242. Life cycle cost of BC2 cooking fume extractor design options

Table 123. Life cycle cost of BC2 design options

Euro	**BC2**	**DO3**	**DO5**
Product price	334	702	334
Installation	82	82	82
Fuel	0	0	0
Electricity	135	61	122
Water	0	0	0
Repair & maintenance	34.6	73	35
Total	586	918	573

The life cycle costs and the environmental impacts of the base cases and design options are plotted together in Figure 243 and Figure 244 for BC1 and BC2, respectively. As environmental impact indicator the total energy consumption (MJ) over the lifecycle is chosen, although similar trends would be seen in categories such as Greenhouse Gases, Acidification or VOCs.

From the analysis of Figure 243, it can be seen that DO1 appears to be good alternative for BC1, since they provide significant energy savings (-19%) for a small increase in life cycle cost for the consumer (+7%). DO4 provides both energy and life cycle cost reductions, since it would be the expected result of a better energy efficiency methodology. DO2 would entail a significant reduction of energy (-50%), though at the expense of an increase of cost (34%).

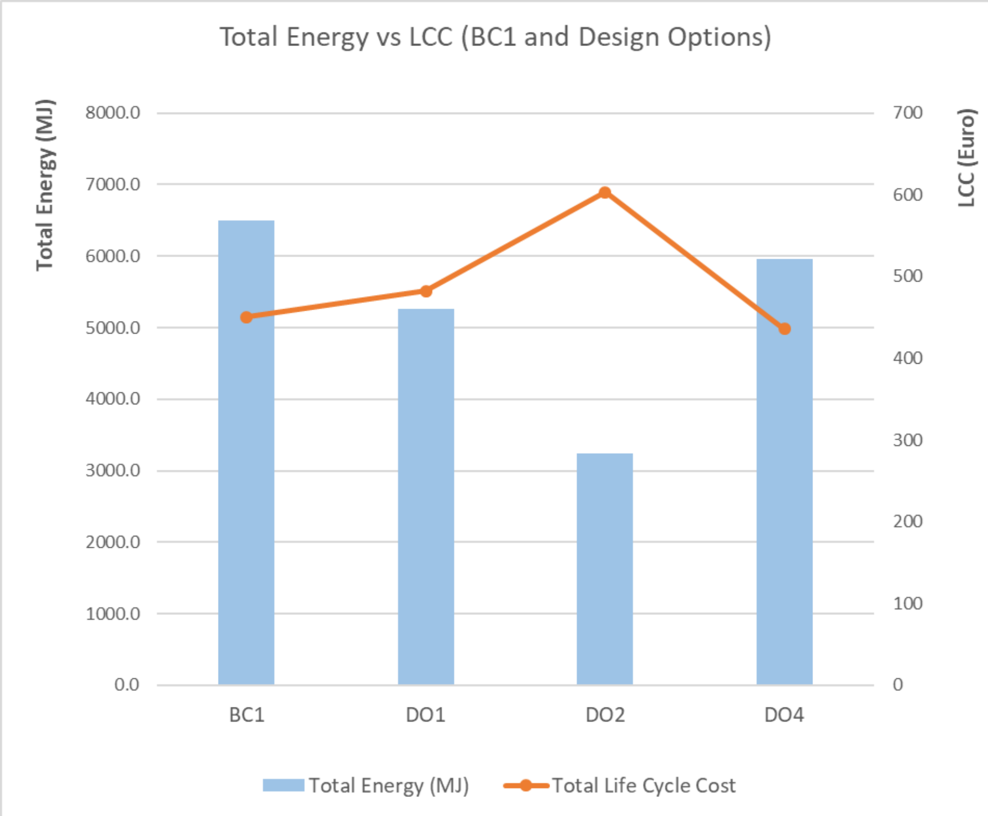


Figure 243. Life cycle cost and energy consumption of BC1 cooking fume extractor design options

The situation is similar for BC2, where the additional purchase price of a brushless cooking fume extractor would increase the life cycle cost (+57%), though the energy saving potential of this technology is remarkable (-44%).

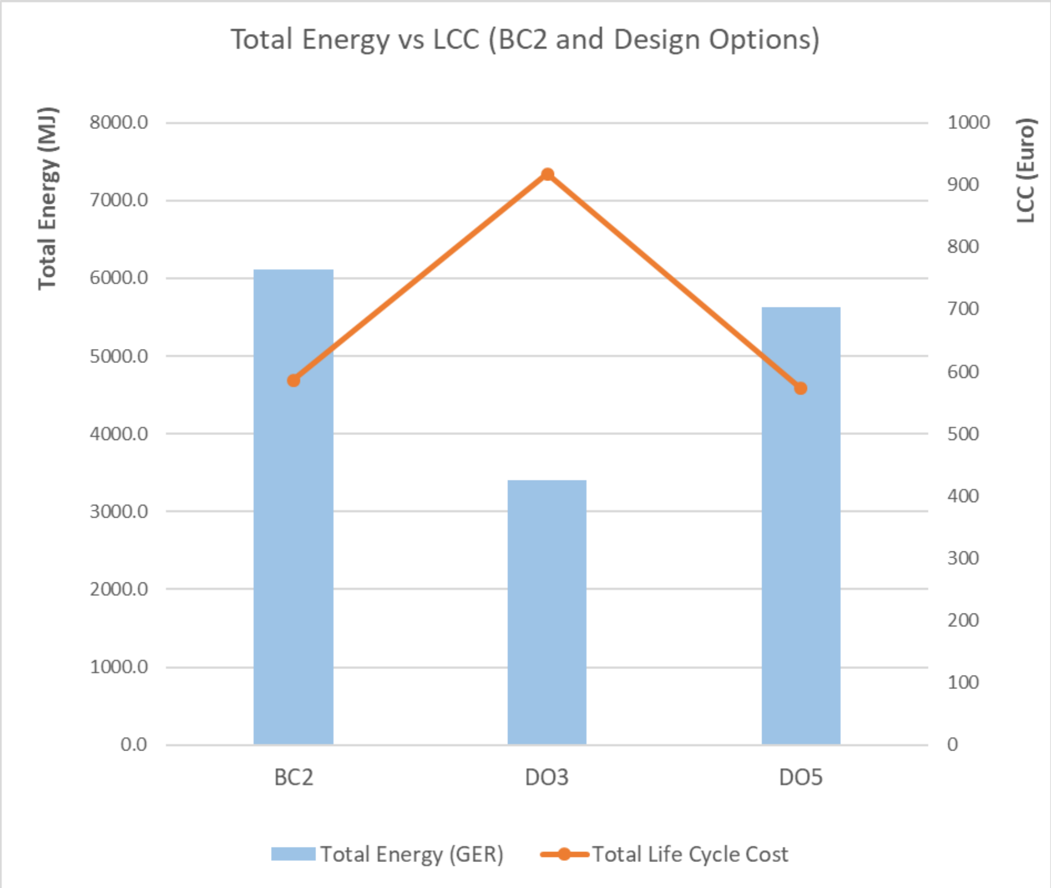


Figure 244. Life cycle cost and energy consumption of BC2 cooking fume extractor design options

7 Task 7: Policy analysis and scenarios

EU initiatives and legislation address several sustainability aspects of products. Ecodesign Directive, for instance, regulates energy efficiency and some circularity features of energy-related products. The Circular Economy Action Plan presented in 2020 aims at accelerating the transformational change required by the European Green Deal, while building on circular economy actions implemented since 2015.

As announced in the CE Action Plan 2020, the Commission will propose a sustainable product policy legislative initiative. The core of this initiative will be to widen the Ecodesign Directive beyond energy-related products to make the Ecodesign framework applicable to the broadest possible range of products and make it deliver on circularity. As part of it, the Commission will consider establishing sustainability principles and other appropriate ways to regulate the following aspects:

- Improving product durability, reusability, upgradability and reparability
- Addressing the presence of hazardous chemicals in products
- Increasing their energy and resource efficiency
- Increasing recycled content in products, while ensuring their performance and safety
- Enabling remanufacturing and high-quality recycling
- Reducing carbon and environmental footprints
- Restricting single-use and countering premature obsolescence
- Introducing a ban on the destruction of unsold durable goods
- Incentivising product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle
- Mobilising the potential of digitalisation of product information, including solutions such as digital passports, tagging and watermarks
- Rewarding products based on their different sustainability performance, including by linking high performance levels to incentives

In the particular case of domestic cooking appliances, as seen in Tasks 5 and 6, the most relevant life cycle stage in terms of environmental impact is the use phase: the energy consumption of the three product groups is therefore the most significant aspect to take into account when defining policy options. In response to that, policy options related to energy efficiency will be specifically proposed for each product group in sections 7.3, 7.4, 7.5 and 7.6.

Other aspects mentioned in the CE Action Plan 2020 that are relevant for domestic ovens, hobs and range hoods are durability and reparability. Therefore, a set of policy options that address those concepts will be presented horizontally for the three products groups in section 7.7.

The policy options presented in the above sections are related to a variety of topics: from scope to energy consumption declaration, minimum requirements and energy label re-scaling. Some of them are straightforward and have been already agreed between the different stakeholders, whereas others still need further debate and development. Many of the policy options presented are complementary and put together will define different scenarios. Scenarios based on the different policy options will be presented and evaluated in section 7.8.

7.1 Stakeholder consultation during the preparatory study

During the preparatory work for developing this report a continuous stakeholder consultation has taken place. Stakeholders have been contacted bilaterally for information exchange and one technical working group (TWG) meeting has been organised so far. The meeting was public and composed of experts from Member States' administration, industry, NGOs and academia. This meeting took place in March 2020 and focused on tasks 1-4. The second TWG meeting is planned for March 2021 and will be dedicated to tasks 5-7.

Additionally, the project team has visited different manufacturers and test labs to investigate the products in detail and to stay up to date with the latest developments. Two questionnaires have been distributed to the stakeholders along the process, addressing information and data updates, and gathering opinions on scope, definitions, and performance parameter specifications. An online communication system BATIS has been set-up for easy exchange of documents between registered stakeholders. A website was made available to have the final working documents in the public domain.

As a result of this contact with industry and other agents involved, a series of topics have been detected as relevant for the revision of the domestic cooking appliances ecodesign regulation. Some of these topics have been debated extensively across the development of this preparatory study, whereas others have only been mentioned as a single comment in BATIS. In the next sections, JRC tries to provide a response to every relevant topic brought up by stakeholders.

7.2 Current status of domestic cooking appliances in the policy landscape of ecodesign and energy label

The first ecodesign and energy labelling regulations entered into force in January 2015. The development of this preparatory study is the first step in the review of the current regulation.

7.2.1 Ovens

Ovens are a very relevant appliance in the European context: 75% of households have one. Consumers use them significantly for their cooking activities: 182 times/year according to the user behaviour study presented in Task 3. Moreover, market analysis shows that oven sales have been increasing over the past few years and that their stock is around 174 million units in 2020. Of those, 85% use electricity as energy source.

In Task 4 of this report, several technology areas related to domestic ovens have been discussed: energy source, cavity materials and volume, heating modes, insulation materials, steam heating functions, microwave heating functions, self-cleaning systems and automatic functions. According to some sources (Green Kitchen Project, 2014), ovens are one of the least energy-efficient appliances in a household, since only about 10-12% of the input power is used to heat the food being prepared. Therefore, according to those sources they offer one of the best areas for improvement in regards to energy efficiency. In opposition to that, feedback received from manufacturers is that the potential for energy efficiency improvement in some of these areas has already been depleted or is close to maximum. In their view, there is not much room for further energy efficiency improvements, since there are no simple solutions that can be implemented. According to them, the oven system has already reached the top efficiency and with the current physical system, it is already close to optimal condition. To support that, manufacturers highlight that the top energy class (A+++) has not been reached.

In the development of the previous preparatory study, similar considerations were made. In fact, the design options presented then (Mudgal, 2011) already showed small or marginal improvement potential (enhanced glazing system: 1.5%; reflective layers: 2%; enhanced insulation: 4%). Some others have already been implemented into current ovens (low standby, electronic control). From that information, one might conclude that there is potential of improvement in the energy efficiency of ovens, but it is likely small.

Based on the research conducted in Task 4, energy savings can be expected in areas such as microwave combined modes and with the use of smart and automatic functions. However, those energy savings cannot be shown to consumers with current energy declaration methodology. Ovens with microwave function are excluded from regulation and current standards do not have a method to measure energy consumption of those heating modes. Similarly, in the case of automatic functions, current standards do not have a method to evaluate the effect of using them in domestic ovens. Other potential areas of improvement (new insulation materials, glazing with multiple layers, for instance) have been mentioned in Task 4 of this report, although their potential is considered smaller.

One of the options for improvement in terms of energy efficiency in domestic ovens is related to energy saving modes. These heating modes generally work by using residual heat during the cooking cycle to reduce energy consumption. Energy saving modes are a good solution to improve energy efficiency, provided that they maintain cooking performance of the oven. In fact, this is the main reason why the use of energy saving modes for energy declaration has been challenged by some stakeholders. According to them, due to the use of residual heat, energy saving modes can provide unsatisfactory cooking results. In addition to that, energy saving modes are not the most frequently used by consumers, so their use for energy declaration should be limited or banned, according to some stakeholders. This is a key topic: on one hand, the heating mode used for energy declaration should be a mode that is frequently used by consumers and should be able to cook appropriately. On the other hand, limiting or banning the use of energy saving modes for energy declaration may hinder a significant opportunity for improvement in energy efficiency.

The declaration of energy consumption in regulation relies directly on the existence of robust test standards. Certain weaknesses of those standards have been detected over the past few years. To tackle those issues, a new measurement method is currently being developed to modify the method described in EN 60350-1. The new method is commonly known as Brickmethod 2.0 (BM2.0).

Other aspects that need revision regarding ovens are the potential inclusion into the scope of products that are currently excluded, such as solo microwave ovens, solo steam ovens or small and portable ovens.

In terms of ecodesign minimum requirements and energy classes, current regulation states that after 2019, only ovens with EEI lower than 96 can be commercialized in the EU. Based on the feedback received regarding the limited opportunities of improvement in terms of energy efficiency, it is relevant to explore the possibility of removing the energy label of ovens, especially if no meaningful differentiation between appliances can be achieved. The removal of the energy label for ovens would be a drastic approach compared to current situation and should be carefully analysed and substantiated with data.

If an energy label for ovens is maintained, energy efficiency classes will need to be re-scaled, in order to incentivize innovation and the introduction of the most efficient technologies described in this report. REG 1369/2017 states that a newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised.

To conclude, in 2020, the European Commission launched the New Circular Economy Action Plan. As part of this legislative initiative, the Commission will consider establishing sustainability principles to regulate aspects such as product durability, reusability, upgradability and reparability; the increase of resource efficiency and the use of recycled material in products; as well as countering premature obsolescence. In response to this initiative, a set of requirements related to the above-mentioned material efficiency aspects will be proposed in this preparatory study.

7.2.2 Hobs

Hobs are present in all kitchens in the EU and it is the cooking appliance more frequently used: 12 times per week, 624 times per year, according to the user behaviour study presented in Task 3. Moreover, market analysis shows that oven sales have been increasing over the past few years and that their stock is around 174 million units in 2020 (70% of those use electricity as energy source).

In Task 4 of this report, the three heating technologies were described: radiant, induction and gas. The latest developments driven by the current Ecodesign measures have pushed these technologies to their optimum. The improvement margins of induction and gas hobs are very limited. In the case of gas hobs, there are some design options that are not recommended: reducing the distance between the pot and the flame may lower energy consumption but at the expense of the safety of the hob.

For the same reasons, there are not sufficient differentiation among the products in the market to deploy an energy labelling measures.

The identified best available technologies show that there is no further room for improvement of radiant hobs, and limited margin for induction and gas. In the case of gas hobs, the efficiencies of the BATs described in Task 6 are feasible for four heating zones hobs, since those efficiencies are measured as an average value. One ring hobs could no achieve that value. Specific provision would need to be developed to factor in the impact of the number of the cooking zones in the efficiency.

7.2.3 Cooking fume extractors

Cooking fume extractors penetration in EU households has gradually increased until reaching around 70% of households. Range hoods sales have been growing over the past few years, reaching 6.2 million units in 2020.

In Task 4 of this report, several technology areas related to domestic cooking fume extractors have been discussed: fans, electric motors, filters and smart and connected cooking fume extractors. Task 6 revealed that electric motors are a key technology are to improve the energy efficiency of cooking fume extractors.

The current methodology to calculate the EEI and the annual energy consumption has been analysed and discussed during the review process. The most important issues were the following:

- The parameters were measured at the best efficiency point, which equals to maximum or boost speed. The frequency of use of this speed is too low to be considered consumer relevant. This issue has been solved by a new method which takes minimum, maximum and boost speeds and their average time of use. This is called the 9-points method.
- The market data showed that best energy class cooking fume extractors were more concentrated in the range of larger airflows. This suggested that the current EEI could be promoting larger airflow extractors. This effect is smoothed by the 9-points method.
- The current methodology does not take into account the function unit, i.e. the odour reduction efficiency. The current test method based on MEK is able to measure the odour reduction efficiency of cooking fume extractors in recirculation mode, but no in extraction mode. A test method needs to be developed in order to integrate the functional unit of cooking fume extractors in the energy efficiency calculation method within Ecodesign and Energy labelling. In the meantime, another method that can partly capture this issue will be required.

The inclusion into the scope of only recirculation cooking fume extractors is strongly related to the odour reduction efficiency. The key element of these extractors are the odour filters, which may or not be sold together with the cooking fume extractors. For the inclusion of these products, a declaration of the odour reduction efficiency based on MEK test method and eventually an ecodesign requirement will be required.

7.3 Policy options for electric ovens

In this section, a set of policy options will be presented for domestic electric ovens. In section 7.3.2, a set of policy options related to scope of new regulation regarding scope will be presented. As already described in Task 1 of this report, decisions will need to be made regarding the inclusion of steam, microwave, portable and professional ovens.

In section 7.3.3, the need of an energy label for ovens will be discussed. If it is considered that an energy label is still necessary, certain aspects of the declaration of energy consumption will need to be discussed. This will be done in section 7.3.4. The aspects under discussion will be the definition of the Standard

Energy Consumption (SEC), the measurement method (BM1.0 or BM2.0), the heating mode used for energy declaration and other aspects (such as the use of real food in testing).

Based on the outcome of section 7.3.4, different ecodesign requirements and energy class definitions will be evaluated in sections 7.3.5 and 7.3.6, respectively.

7.3.1 A new database of ovens: APPLIA2020

To contribute to the definition of policy options for ovens, a database was provided by APPLIA to JRC between November 2020-January 2021. This database contains information on 54 ovens, regarding their energy consumption, cavity volume and other relevant aspects. This database of ovens will be used to evaluate the consequences of the different policy options in subsequent sections. In this document, the authors will refer to this database as "APPLIA2020".

It is important to highlight before conducting any analysis the limitations of this database. At the moment of publication of this report, it contained data on 54 ovens only. In the next sections, it will be assumed that APPLIA2020 is a good representation of the stock of ovens today, and its data will be used to present different policy options and their potential consequences in terms of ecodesign limits and energy class. However, due to the reduced number of ovens, the consequences related to each policy option must be taken with caution and should be used as an indication only. Ideally, an analogous analysis should be conducted when data is available for a considerable amount of ovens.

Similarly, every oven in APPLIA2020 uses electricity as an energy source, so there is no information on gas ovens. When defining policy options with this database, the authors might need to decide whether each policy option is directly applicable to gas ovens as well, or whether specific data on gas ovens is needed. Policy options specifically for ovens will be discussed in section 7.4, using a different database.

In Figure 245, the energy consumption shown is the corresponding to the best performing mode (BPM), measured with BM1.0. The cavity volumes of ovens in APPLIA2020 range from 30 to 110 litres. Energy consumption of BPM measured with BM1.0 range from 0.53 kWh/cycle to 0.95 kWh/cycle.

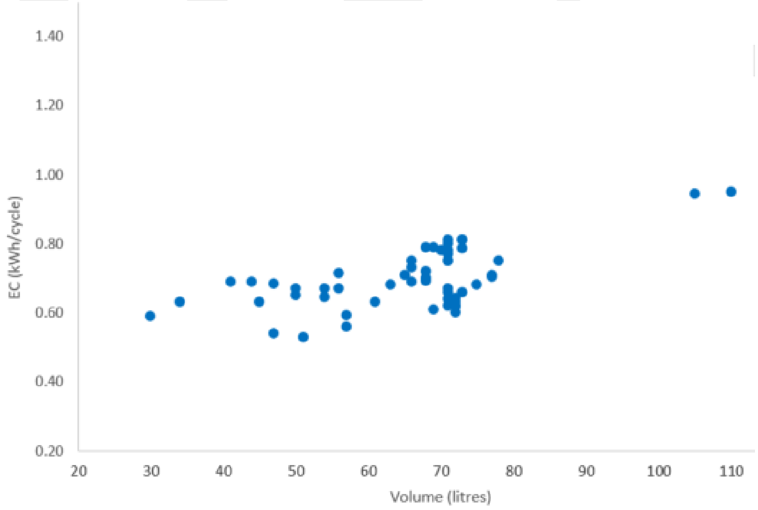


Figure 245. APPLIA database of ovens 2020 (APPLIA2020)

More data is available in APPLIA2020 in terms of heating modes, measurement methods and oven characteristics. In Figure 246, an analysis has been conducted to check the influence of the availability of steam functions on the energy consumption of the oven (BPM). It can be observed that ovens with steam function tend to be in the lower side of the graph, confirming what was already seen in previous sections of this report: ovens with steam function have higher efficiency when energy consumption is measured with current standard method.

Figure 246. APPLIA2020 – Steam function availability

In Figure 247, an analysis has been conducted to check the influence on the energy consumption of the oven (BPM) of eletromechanic or electronic ovens. It can be clearly seen that electromechanic ovens perfom worse than electronic ovens in terms of energy consumption.

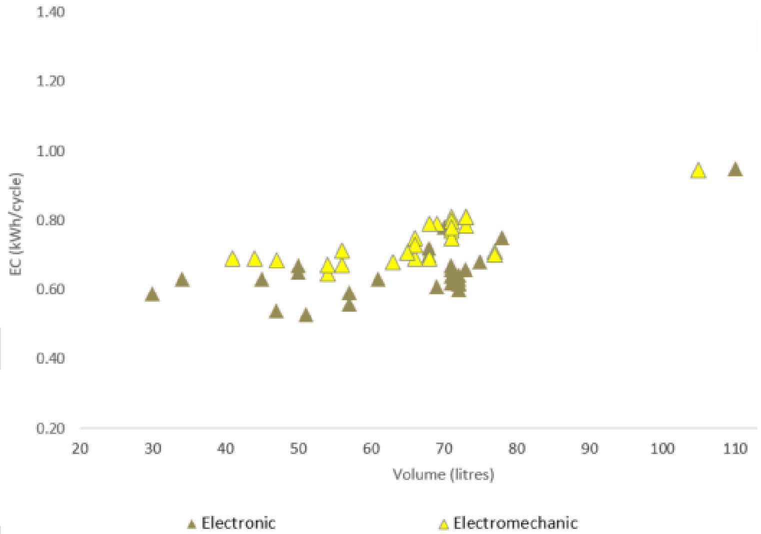


Figure 247. APPLIA2020 – Electromechanic and electronic ovens

7.3.2 Policy options related to scope

In this section, different policy options related to scope are described. A summary of those options, their expected benefits, drawbacks and risks can be seen in Table 124. The options are explained in more detail in the subsequent sections.

Table 124. Summary of policy options related to scope

Policy options for ovens related to Scope	Options	Expected benefits	Possible drawbacks and risks
1. Inclusion of solo steam ovens in scope	1.a Not including solo-steam in Ecodesign or Energy labelling scope	- Reduced bureaucracy and testing expenditure	- It does not incentivize innovation in energy efficiency - It does not provide information to consumer

Policy options for ovens related to Scope	Options	Expected benefits	Possible drawbacks and risks
	1.b Including solo-steam ovens in Ecodesign scope for Material Efficiency requirements only	- It promotes Material Efficiency principles in the cooking appliances sector	- It does not incentivize innovation in energy efficiency - It leaves the least energy efficient products in the market
	1.c Including solo-steam ovens in Ecodesign scope for both Material Efficiency requirements and Minimum Energy Efficiency requirements	- It promotes Material Efficiency principles in the cooking appliances sector - It ensures that least energy efficient products are removed from market	- More bureaucracy and testing expenditure for manufacturers
	1.d Including solo-steam ovens in Ecodesign and Energy labelling scope	- It is an incentive for innovation in energy efficiency - It provides information to consumer on label	- More bureaucracy and testing expenditure for manufacturers
2. Inclusion of solo MW ovens in scope	2.a Not including solo-MW in Ecodesign or Energy labelling scope	- Reduced bureaucracy and testing expenditure.	- It does not incentivize innovation in energy efficiency. - It does not provide information to consumer.
	2.b Including solo-MW ovens in Ecodesign scope for Material Efficiency requirements only	- It promotes Material Efficiency principles in the cooking appliances sector	- It does not incentivize innovation in energy efficiency - It leaves the least energy efficient products in the market
	2.c Including solo-MW ovens in Ecodesign scope for both Material Efficiency requirements and Minimum Energy Efficiency requirements	- It promotes Material Efficiency principles in the cooking appliances sector - It ensures that least energy efficient products are removed from market	- More bureaucracy and testing expenditure for manufacturers
	2.d Including solo-MW ovens in Ecodesign and Energy labelling scope	- It is an incentive for innovation in energy efficiency. - It provides information to consumer on label	- Energy labelling may not provide meaningful information due to similarities between least and most efficient product, and small room for improvement. - More bureaucracy and testing expenditure for manufacturers
3. Inclusion of ovens with MW-combined functions in scope	3.a Not including ovens with MW-combi functions in Ecodesign or Energy labelling scope	- Reduced bureaucracy and testing expenditure	- It does not incentivize innovation in energy efficiency - It does not provide information to consumer
	3.b Including ovens with MW-combi function in Ecodesign scope for Material Efficiency requirements only	- It promotes Material Efficiency principles in the cooking appliances sector	- It does not incentivize innovation in energy efficiency - It leaves the least energy efficient products in the market
	3.c Including ovens with MW-combi function in Ecodesign scope for both Material	- It promotes Material Efficiency principles in the cooking appliances sector	- More bureaucracy and testing expenditure for manufacturers

Policy options for ovens related to Scope	Options	Expected benefits	Possible drawbacks and risks
	Efficiency requirements and Minimum Energy Efficiency requirements	- It ensures that least energy efficient products are removed from market	
	3.d Including ovens with MW-combi functions in Ecodesign and Energy labelling scope	- It is an incentive for innovation in energy efficiency - It provides information to consumer on label	- More bureaucracy and testing expenditure for manufacturers
4. Inclusion of small and portable ovens in scope	4.a Not including small and portable in Ecodesign or Energy labelling scope	- Reduced bureaucracy and testing expenditure	- It does not incentivize innovation in energy efficiency - It does not provide information to consumer
	4.b Including small and portable ovens in Ecodesign scope for Material Efficiency requirements only	- It promotes Material Efficiency principles in the cooking appliances sector	- It does not incentivize innovation in energy efficiency - It leaves the least energy efficient products in the market
	4.c Including small and portable ovens in Ecodesign scope for both Material Efficiency requirements and Minimum Energy Efficiency requirements	- It promotes Material Efficiency principles in the cooking appliances sector - It ensures that least energy efficient products are removed from market	- More bureaucracy and testing expenditure for manufacturers
	4.d Including small and portable ovens in Ecodesign and Energy labelling scope	- It is an incentive for innovation in energy efficiency - It provides information to consumer on label	- More bureaucracy and testing expenditure for manufacturers
5. Inclusion of professional cooking appliances in scope	5.a Develop specific regulation for the professional cooking appliances sector	- It regulates a sector with potentially high impact in energy consumption. - It incentivizes innovation in energy efficiency in the mid term. - It takes into account the specific characteristics of professional products and their differences with domestic.	- It delays the introduction of energy efficiency measures in a sector with potentially high impact in energy consumption.
	5.b Including professional cooking appliances in scope of domestic cooking appliances regulation	- It regulates a sector with potentially high impact in energy consumption. - It incentivizes innovation in energy efficiency in the short term.	- It does not take into account the specific characteristics of professional products and their differences with domestic.
	5.c Not including professional cooking appliances in scope of domestic cooking appliances regulation	- Reduced bureaucracy and testing expenditure.	- It does not regulate a sector with potentially high impact in energy consumption. - It does not incentivize innovation in energy efficiency.

7.3.2.1 Inclusion of solo steam ovens in scope

In the previous preparatory study (Mudgal et al, 2011), solo steam ovens were considered a niche market so they were left out of the scope of ecodesign and energy labelling regulations.

Figure 248 summarizes the different policy options that could be applied to solo steam ovens, depending on the ambition level (*Policy options 1a – 1d*).

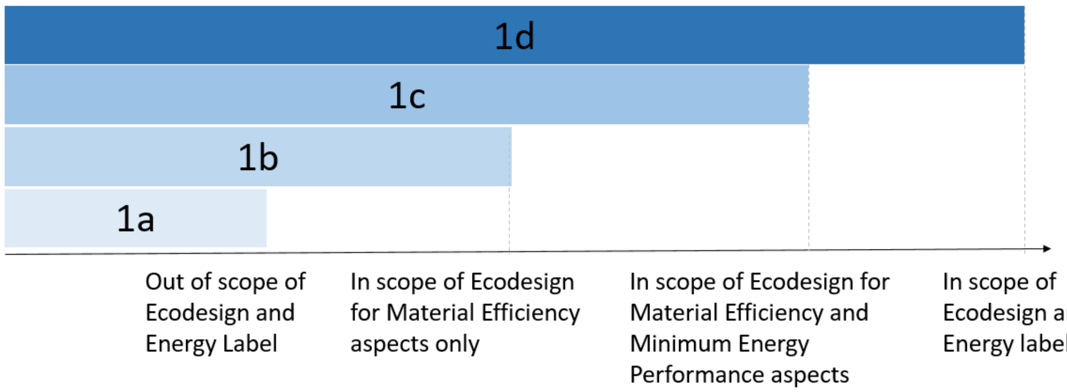


Figure 248. Policy options and ambition level

Policy option 1a would be to maintain current situation, not including these appliances into the scope.

Regarding ecodesign, considering the new Circular Economy Action Plan, it is relevant to include these appliances into the scope to introduce material efficiency requirements (*Policy option 1b*). These aspects will be developed in more detail in section 7.7.

The main reason for considering their inclusion in terms of minimum energy performance or in the energy label directive is that this niche market consideration may not be correct any more nowadays. Some stakeholders provided data indicating that in some markets (such as in Germany), their sales doubled from 2006 to 2010. If the stock of solo steam ovens were significant, their total energy consumption in the EU might also be significant, so their inclusion within the scope of ecodesign for minimum energy performance (*Policy option 1c*) or energy labelling regulation (*Policy option 1d*) would be necessary.

The user behaviour study presented in Task 3 of this report indicates that solo steam ovens are available in 4.8% of European households. In the households where a solo steam oven is present, 40% use it at least once a week. The penetration rate of other cooking appliances analysed in this study (ovens: 87.5 %, hobs: 71.5 %, range hoods: 74.4 %) is considerably higher than the one of solo steam ovens.

Based on these figures, it can be assumed that the total energy consumption of solo steam ovens is still negligible when compared to the appliances mentioned above, so their inclusion in the scope of energy labelling regulation (*Policy option 1d*) does not seem urgent. In terms of ecodesign, this lack of urgency also applies to include them in terms of minimum energy performance (*Policy option 1c*).

Moreover, there is currently no standard test method that allows the estimation of energy consumption of solo-steam modes. With a view of applying *Policy options 1c* and *1d* in future revisions of this regulation, it is recommended to start the development of a method to measure the energy consumption of solo-steam ovens.

7.3.2.2 Inclusion of solo MW ovens in scope

Solo MW ovens are excluded from the scope of current regulation. Figure 248 can also be used as a reference to understand the different policy options that could be applicable to these appliances.

Policy option 2a would be to maintain current situation. During the development of this preparatory study, the potential inclusion of solo microwave ovens within the scope of ecodesign and energy labelling regulations was discussed.

Regarding ecodesign, considering the new Circular Economy Action Plan, it is relevant to include these appliances into the scope to introduce material efficiency requirements (*Policy option 2b*). These aspects will be developed in more detail in section 7.7.

Some stakeholders consider that the market size of these appliances is big enough to include them either in terms of minimum energy performance requirements or in the energy label scope, since their overall energy consumption at EU level might not be negligible.

Results from the user behaviour study presented in Task 3 indicate that solo MW ovens are present in 75.3% of EU households and they are used an average of 842 times/year. According to studies provided by these stakeholders, the annual energy consumption of MW ovens is 45 kWh/year. Scientific literature estimates are around 72 kWh/year (Gallego-Schmidt et al, 2018). In the previous preparatory study, it was estimated as 86 kWh/year. In current study, it has been estimated around 33 kWh/year.

The numbers above suggest that energy consumption of solo MW is not negligible and that therefore, these appliances should be somehow included within the scope of ED/EL regulation (*Policies 2c or 2d*). However, in current regulation, solo microwave ovens were left out of the scope for a variety of reasons that are still valid today:

- Small difference between most and least efficient appliance
- Small improvement potential in terms of energy consumption (in previous preparatory study, the combined improvement potential of these appliances was estimated as 4%)

Those reasons make the inclusion of microwave oven into the scope of energy labelling regulation (*Policy option 2d*) not particularly useful. From the consumer perspective, it will be difficult to establish meaningful differences between appliances.

In Detz et al (2020), it is concluded that although enormous microwave oven capacity is available worldwide, the overall energy consumption of domestic microwave ovens is fairly limited, since the average usage time amounts to typically only a few minutes per day. In the study of Gallego-Schmidt et al. (2018), it is concluded that microwaves are mature products from the energy-efficiency perspective and, therefore, efforts to reduce energy consumption should focus on improving consumer behaviour to use them more efficiently; for example, by adjusting the time of heating to each type of food. The provision of best practices and guidelines by microwave manufactures could help consumers to integrate these into daily practices.

In terms of ecodesign, it might be of interest to include them in terms of minimum energy performance requirements (*Policy option 2c*), in order to remove the least energy efficient appliances from the market. The lack of a standard method to measure their energy consumption prevents from applying this policy at this point. Therefore, with a view of implementing Policy option 2c in future revisions of this regulation, it is recommended to start the development of a standard method to measure energy consumption of solo-MW ovens. .

7.3.2.3 Inclusion of MW-combi ovens in scope

Ovens that include any form of microwave heating function are currently excluded from ecodesign and energy labelling regulation. Reasons for currently being out of scope are:

- These appliances were a niche market product in 2014, when current regulation entered into force, so their overall energy was not significant at EU level
- There is no standard test method to estimate the energy consumption of a microwave-combined heating mode

Figure 248 can also be used as a reference to understand the different policy options that could be applicable to these appliances. *Policy option 3a* would be to maintain current situation.

Regarding ecodesign, considering the new Circular Economy Action Plan, it is relevant to include these appliances into the scope to introduce material efficiency requirements (*Policy option 3b*). These aspects will be developed in more detail in section 7.7.

Leaving these appliances out of the scope of ecodesign for energy performance (*Policy option 3c*) or energy labelling (*Policy option 3d*) may bring two fundamental issues:

- It could be a loophole for conventional ovens not complying with some elements of current regulation (for instance, minimum energy performance of heating modes).
- Consumers are not aware of the potential for reduction of energy consumption of these appliances. As already indicated in Task 6 of this report, ovens with microwave-combined function can help to reduce energy consumption per cycle by an average of 10%.

Policy option 3c would overcome the first of the issues above, mainly by the introduction of minimum energy performance requirements for conventional or fan-forced modes. Ovens with MW-combi modes could also be included in the scope of energy labelling regulation (*Policy option 3d).* Some stakeholders suggest that they should be included, but only in their conventional or fan-forced modes. This would solve the first of the issues above, but the energy savings of these modes would still not be visible for consumers.

To solve both of the issues identified above, ovens with microwave-combined function should be included in the scope of energy labelling regulation. Since there is no available standard method to measure energy consumption of those heating modes, these appliances will need to be included in next revision of this regulation. In the meantime, this standard test method to measure energy consumption of these modes should be developed. This approach could incentivize the development of more efficient MW-combined modes, as well as lower purchase prices for ovens with this functionality.

7.3.2.4 Inclusion of small and portable ovens in scope

Small ovens (width < 250mm, length < 250 mm, height < 120 mm) and portable ovens (mass < 18 kg) are currently out of scope of ecodesign and energy labelling regulations. Reasons for their exclusion are:

- They were a niche market when current regulation was developed
- There is no standard test method to measure energy consumption and compare them with conventional ovens

The above reasons still appear valid in the 2020 context. In the questionnaire circulated among stakeholders for the development of this preparatory study, the adoption of *Policy options 4c or 4d* for small and portable ovens did not seem urgent.

Figure 248 can also be used as a reference to understand the different policy options that could be applicable to these appliances. *Policy option 4a* would be to maintain current situation.

Regarding ecodesign, considering the new Circular Economy Action Plan, it appears relevant to include these appliances into the scope to introduce material efficiency requirements (*Policy option 4b*). These aspects will be developed in more detail in section 7.7.

Results from the user behaviour study presented in Task 3 point out that portable ovens are present in 14% of European households (far from the 87% of conventional ovens). Their small size suggests that they require lower power to heat a similar load. However, there is currently not available information on their average energy consumption. Also, there is no standard method for their measurement (brickmethod test is not applicable to small ovens due to their reduced size).

In any case, considering a hypothetical oven of 250x250x120 mm (7.5 litres) and the EC vs Volume regression line of the market average (BM1.0 and BPM), its energy consumption could be around 0.47 kWh/cycle.

If the 14% presence in European households is deemed significant, in terms of ecodesign it might be of interest to include them in terms of minimum energy performance requirements (*Policy option 4c*), in order to remove the least energy efficient appliances from the market. Depending on product differentiation, it might be of interest to consider their inclusion in energy labelling regulation in future revisions (*Policy option 4d*). Since there is no available standard method to measure energy consumption of those heating modes, these appliances will need to be included in next revision of this regulation. In the meantime, this standard test method to measure energy consumption of these modes should be developed.

7.3.2.5 Inclusion of commercial and professional cooking appliances in scope

Current regulation does not include commercial or professional cooking appliances into the scope. *Policy option 5a* would be to maintain current situation. The potential inclusion of professional cooking appliances under the project scope was considered from the very beginning of this preparatory study, since in Article 7, ecodesign regulation 66/2014 indicates that:

> *The review of the regulation shall assess, amongst others, the inclusion of professional and commercial appliances.*

First of the aspects to consider was whether commercial and/or professional cooking appliances should have ecodesign and energy labelling regulation at all. Against the development of regulation, three main arguments were provided: different usage patterns, wider variability of products and the fact that commercial products are commonly part of a wider system (see Task 1 for more detail). In favour of developing regulation two main arguments were provided: the professional sector may be potentially high in energy consumption, and it could be a driver for improvement in energy efficiency.

If ED/EL regulation was developed, it could be either together with the regulation for domestic appliances (*Policy option 5b*) or separated (*Policy option 5c*). The advantages of separating regulation is that it would be easier to address the different usage patterns and needs from consumers, and it would also give time for the development of testing standards in the professional sector. However, separating would potentially delay the introduction of energy efficiency measures in the sector.

Considering the reasoning above provided by relevant stakeholders, it has been concluded that regulation for commercial/professional cooking appliances is necessary, since it is potentially a high impact energy consumption sector with potential for improvement. Regulation in the commercial/professional sector could boost innovation and be a driver for efficiency.

In order to provide appropriate ecodesign requirements, the regulation for commercial/professional cooking appliances is proposed to be specific and separated from the domestic cooking appliances regulation (*Policy option 5c*). This will ensure that every requirement and energy labelling category defined are suitable and meaningful, considering sector-specific user needs.

7.3.2.6 Summary of recommendations regarding scope of ovens

Table 125 is a summary of the recommendations presented in previous sections regarding the scope of ovens in new ecodesign and energy labelling regulation.

Table 125. Summary of recommendations regarding scope of ovens

	Ecodesign for Material Efficiency	Ecodesign for Minimum Energy Performance	Energy label
Solo steam ovens	Include	Consider inclusion in future regulation depending on product penetration. Develop standard method to measure energy consumption.	
Solo MW ovens	Include	Include in future regulation. Develop standard method to measure energy consumption	Not include.
Combi MW ovens	Include	Include in future regulation. Develop standard method to measure energy consumption	
Small and portable ovens	Include	Include in future regulation. Develop standard method to measure energy consumption	Consider inclusion in future regulation depending on product differentiation.
Commercial and Professional ovens	Develop specific regulation for commercial and professional ovens		

7.3.3 The need of an energy label for ovens

The EU Energy label is an established instrument to provide information and raise attention to energy consumption characteristics of household appliances, helping consumers to make better purchase choices. It plays an important role in the increase of energy efficiency and protection of the environment. As highlighted in Russo et al (2018), the introduction of an energy label boosts the economic growth, alongside consumer demand and competitive position, creating high quality jobs in several sectors related to energy efficiency. Different studies have also shown that the energy label directive has provided significant benefits to consumers in terms of monetary savings, to industry in terms of design innovation and competitiveness and to the environment in terms of reduced impacts. Therefore, having an energy label on a product category must be considered as a fundamentally positive aspect.

However, an energy label classification is meaningful if there is enough differentiation between the products in the market in terms of energy efficiency. As already indicated in previous sections, there are no big improvements on energy efficiency of electric ovens foreseen, beyond the already mentioned improvements related to energy saving modes, microwave combined and automatic functions. In addition to that, the potential adoption of BM2.0 will lead to even less differentiation among the products. Considering that, some stakeholders wonder whether an energy label is still of interest for electric ovens in the current landscape.

The distribution of energy classes in APPLIA2020 can be seen in Figure 249: A (65%) and A+ (35%). With current energy classification (best performing mode and BM1.0), it can be seen that there is not much differentiation in terms of energy class in these appliances. However, looking specifically at the ovens around 70 litre, there is a significant difference between the best and the worst (0.54 vs 0.81 kWh). This suggests that there is enough difference between different appliances, but that current energy classification does not show it with clarity.

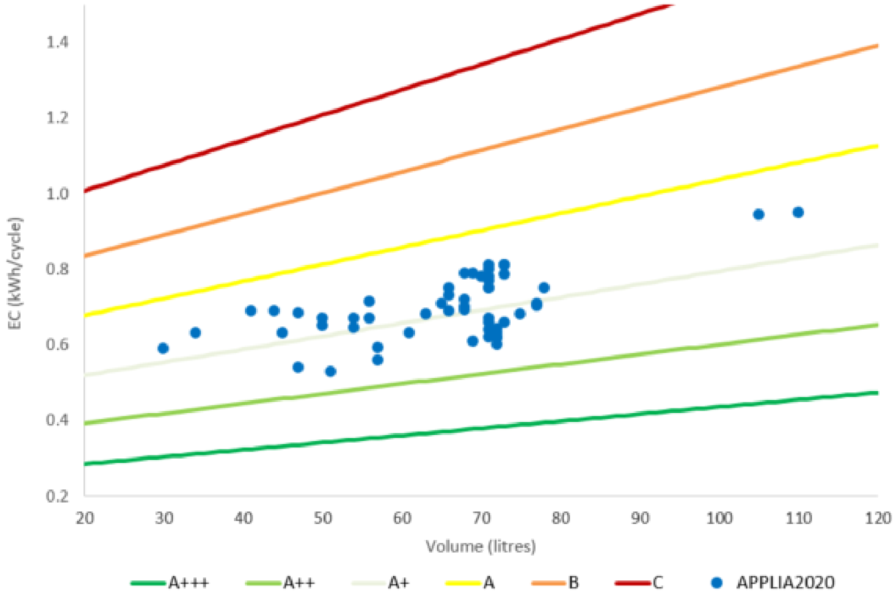


Figure 249. Energy classes of ovens in APPLIA2020

In Article 11, REG 2017/1369 states that, the Commission shall review the label with a view to rescaling if it estimates that:

> (a) 30 % of the units of models belonging to a product group sold within the Union market fall into the top energy efficiency class A and further technological development can be expected; or
>
> (b) 50 % of the units of models belonging to a product group sold within the Union market fall into the top two energy efficiency classes A and B and further technological development can be expected.

In Task 2 of this report, market data was presented regarding the energy classes of ovens sold between 2015 and 2018 in five reference countries in the EU. According to that data, energy classes of sold ovens are mostly distributed between A (70%) and A+ (30%). Therefore, a re-scaling of the energy classes would be necessary.

However, it must be taken into account that it is likely that the new measurement method for energy consumption (BM2.0) will be adopted. As already explained in previous sections, this method is stricter than current method in some aspects, and it is likely that the declared energy consumption values with BM2.0 will be higher. Therefore, the adoption of BM2.0 may work as an energy label rescaling. This will be evaluated in section 7.3.4.2..

When defining energy classes, it is also necessary to consider that between the different energy classes steps, there must be enough difference to avoid repeatability and reproducibility issues. In current version of the standard method (BM1.0), the criteria for accepting the test results is 0.05 kWh standard deviation. Feedback from WG17 in CENELEC is that the steps between the energy classes should not be smaller than 0.15 kWh, which seems a reasonable threshold. From now on, when assessing policy options, the authors will ensure that the energy classes steps are within the 0.10-0.15 kWh range.

In APPLIA2020, looking at best performing modes measured with BM1.0, the oven with the highest energy consumption has 0.95 kWh/cycle and the lowest 0.54 kWh/cycle. Considering this spread of values and the 0.10-0.15 kWh range for difference between energy classes steps, the ovens in APPLIA2020 could be distributed in 3 energy classes only.

Table 126 shows the step difference between the different energy classes with current regulation, using as an example three cavity volumes (35, 70 and 100 litres). Every step difference is higher than 0.10 kWh, with some of them slightly lower than 0.15 kWh (fundamentally in smaller ovens and top energy classes).

	Step difference (kWh)			Step difference (%)		
	35 l	70 l	100 l	35 l	70 l	100 l
A+++ - A++	0.12	0.14	0.16	27%	27%	27%
A++ - A+	0.14	0.17	0.19	24%	24%	24%
A+ - A	0.17	0.21	0.24	23%	23%	23%
A - B	0.17	0.21	0.24	19%	19%	19%
B - C	0.19	0.23	0.26	17%	17%	17%

Table 126. Step difference between energy classes

In the next sections, several policy options will be presented in relation to energy classes. In every case, it will be analysed whether there is enough differentiation between products in terms of energy class, and it will be checked that the step difference does not risk causing repeatability or reproducibility issues.

7.3.4 Policy options related to the declaration of energy consumption

In this section, different policy options related to the declaration of energy consumption of ovens are described. A summary of those options, their expected benefits, drawbacks and risks can be seen in Table 127. The options are explained in more detail in the subsequent sections.

Table 127. Summary of policy options related to declaration of energy

Policy options for ovens related to declaration of Energy consumption	Options	Expected benefits	Possible drawbacks and risks
6. Definition of Standard Energy Consumption (SEC)	6.a Maintain current relation and equation	- Carry on with calculations exactly as today	- Current trendline does not reflect current relationship between energy consumption and cavity volume of ovens
	6.b Maintain current relation with updated equation	- New trendline reflects current relationship between energy consumption and cavity volume of ovens - Market of ovens is pushed towards the development of more efficient products - Overall energy consumption attributable to oven is reduced	- Significant impact on manufacturers.
7. The adoption of Brickmethod 2.0	7.a Maintain Brickmethod 1.0 as main measurement method for energy consumption	- Carry on with measurements and calculations exactly as today	- Loophole for jeopardy effects and circumvention due to incorrect use of residual heat
	7.b Adopt Brickmethod 2.0 as main measurement method for energy consumption	- Additional control over use residual heat	- Method not completely agreed and finished
8. Heating mode used to declare energy consumption	8.a To use BPM to declare energy consumption, measuring with BM1.0 (current situation).	- Carry on with calculations exactly as today	- Loophole for jeopardy effects and circumvention due to incorrect use of residual heat
	8.b To use BPM to declare energy consumption, measuring with BM2.0	- Incentive for innovation (development of energy saving modes) - Additional control over use residual heat of BM2.0	- BM2.0 method not completely agreed and finished
	8.c To use a weighted sum	- Incentive for innovation	- BM2.0 method not completely

Policy options for ovens related to declaration of Energy consumption	Options	Expected benefits	Possible drawbacks and risks
	between BPM and Conventional mode to declare energy consumption, measuring with BM2.0	- Additional control over use residual heat of BM2.0 - Energy value declared closer to real use	agreed and finished
	8.d To use Conventional mode to declare energy consumption, measuring with BM2.0	- No risk of incorrect use of residual heat at energy declaration	- BM2.0 method not completely agreed and finished - No incentive for innovation
9. A non-linear relation between energy consumption and cavity volume	9.a The flat approach	- It may be harder for larger cavity ovens to reach top energy classes, driving consumers towards smaller cavity ovens ("right-sizing" ovens)	- It may affect the demand of larger cavity ovens
	9.b Logarithmic or power approach	- It may be slightly harder for larger cavity ovens to reach top energy classes, driving consumers towards smaller cavity ovens (a less drastic approach than the flat approach)	- It may affect the demand of larger cavity ovens
10. Cooking real food as a quality check to declare energy consumption	10.a Not use food as a quality check for energy declaration	- Carry on with measurements and calculations exactly as today	- The capacity of ovens to cook appropriately with the energy declared value is not checked
	10.b Using food as a quality check for energy declaration of energy saving modes	- If an energy saving mode is used to declare energy consumption, its capacity to cook food appropriately is checked	- It requires a robust standard test - It may increase significantly costs of testing activities
	10.c Using food as a quality check for energy declaration of every heating mode	- The capacity of ovens to cook appropriately with the energy declared value is checked for every heating mode	- It requires a robust standard test - It may increase significantly costs of testing activities
11. Energy declaration of steam-assisted heating modes	11.a Not declare energy consumption of steam-assisted modes	- Carry on with measurements and calculations exactly as today	- Transparency issues with consumers. Energy consumption benefits incorrectly attributed to use of steam - Not considering energy consumption of a heating mode which is increasingly present in ovens and used by consumers
	11.b Declare energy consumption of steam-assisted heating modes in the energy label	- Consumer is informed of energy consumption of steam-assisted heating function	- It requires development of test standard
	11.c Declare energy consumption of steam-assisted heating modes in the user manual	- Consumer is informed of energy consumption of steam-assisted heating function	- It requires development of test standard
12. Energy declaration of MW-combi modes	12.a Not declare energy consumption of MW-combi modes	- Carry on with measurements and calculations exactly as today	- Potential benefits of MW-combi modes are not seen by consumer
	12.b Declare energy consumption of MW-combi modes in the user manual	- Potential benefits of MW-combi modes are seen by consumer	- A standard method should be defined to measure energy consumption of MW-combi modes
	12.c Apply percentage of reduction in the Energy Efficiency Index of ovens with MW-combi modes	- Potential benefits of MW-combi modes are seen by consumer and affect the energy class	- Agreement on the potential energy savings of MW-combi modes is needed
13. Energy declaration of automatic functions	13.a Not declare energy consumption of automatic	- Carry on with measurements and calculations exactly as today	- Potential benefits of automatic functions are not

Policy options for ovens related to declaration of Energy consumption	Options	Expected benefits	Possible drawbacks and risks
	functions		seen by consumer
	13.b Declare energy consumption of automatic functions in the user manual	- Potential benefits of automatic functions are seen by consumer	- A standard method should be defined to measure energy consumption of automatic functions
	13.c Apply percentage of reduction in the Energy Efficiency Index of ovens with automatic functions	- Potential benefits of automatic functions are seen by consumer and affect the energy class	- Agreement on the potential energy savings of automatic functions is needed
14. Measurement of cavity volume to declare energy consumption	14.a With side racks	In both cases, the expected benefits will be a common and standard approach for the measurement of the cavity volume that allows fair comparisons between ovens	- Side racks may cause repeatability issues during testing
	14.b Without side racks		- A less consumer relevant approach
15. The inclusion of self-cleaning systems energy consumption in product information requirements	15.a Not to declare energy consumption of self-cleaning systems	- Carry on with measurements and calculations exactly as today	- No information given to consumer about a feature with potentially high impact on energy consumption
	15.b Declare energy consumption of self-cleaning systems	- Information on energy consumption given to consumer about self-cleaning systems might foster a reasonable use of this feature	- It requires development of a test standard that allows the measurement of cleanliness of self-cleaning systems
	15.c Include information of recommended frequency of use of self-cleaning systems as an information requirement	- Recommendations on frequency of use about self-cleaning systems might foster a reasonable use of this feature It does not require development of test standard	- No information given to consumer about energy consumption of self-cleaning system
16. The inclusion of pre-heating phase energy consumption in product information requirements	16.a Not to declare energy consumption of pre-heating phase	- Carry on with measurements and calculations exactly as today	- No information given to consumers - Consumers pre-heat their oven potentially too often. Inefficient cooking behaviour
	16.b To declare energy consumption of pre-heating phase	- Providing consumers with information about an inefficient cooking behaviour might reduce this behaviour	- It requires modification of current standard test
	16.c To provide recommendations on when to pre-heat the oven	- Providing consumers with recommendations about when to pre-heat their oven behaviour might reduce this behaviour	- It does not provide specific information on energy consumption about an inefficient cooking behaviour

Before going into the detail of each policy option, it is worth coming back to the definition of the Energy Efficiency Index (EEI) of ovens. In current regulation, the EEI for electric ovens is defined as:

$$EEI_{cavity} = \frac{EC_{electric\ cavity}}{SEC_{electric\ cavity}}\ x\ 100 \qquad EEI_{cavity} = \frac{EC_{gas\ cavity}}{SEC_{gas\ cavity}} \times 100$$

EC is the energy required to heat a standardised load, considering the best performing mode. SEC is the standard energy consumption required to heat a standardised load, represented as a linear regression that relates energy consumption and cavity volume, based on the market at a specific time. In current regulation, SEC is defined as:

$SEC_{electric\ cavity} = 0.0042\ x\ V + 0.55\ (in\ kWh)$ $SEC_{gas\ cavity} = 0{,}044 \times V + 3{,}53\ (\text{in MJ})$

Based on the EEI value, ovens get their energy class according to Table 128.

Table 128. Energy efficiency classes and EEI

Energy efficiency class	Energy Efficiency Index
A+++	EEI < 45
A++	45 ≤ EEI < 62
A+	62 ≤ EEI < 82
A	82 ≤ EEI < 107
B	107 ≤ EEI < 132
C	132 ≤ EEI < 159
D	EEI < 159

EEI is therefore a ratio between the energy consumed by the oven (EC) and the energy consumed by a standard reference based on the market (SEC). Based on feedback received from stakeholders, there is currently no particular need to change the definition of the Energy Efficiency Index. However, there are certain aspects of the EEI that are under debate. For simplification, all those aspects will be evaluated individually in the following sections:

- Update of SEC: Section 7.3.4.1
- Adoption of BM2.0: 7.3.4.2
- Heating mode to declare energy consumption and determine energy class: 7.3.4.3
- A non-linear relation between energy consumption and cavity volume: 7.3.4.4
- Cooking real food as a quality check: 7.3.4.5
- Energy declaration of steam assisted, MW-combi and automatic functions: 7.3.4.6
- Cavity volume measurement: 7.3.4.7
- Energy declaration of self-cleaning functions: 7.3.4.8
- Energy declaration of pre-heating: 7.3.4.9

7.3.4.1 Definition of Standard Energy Consumption (SEC)

In current regulation, SEC was defined as a linear regression relating energy consumption and cavity volume. It was considered that cavity volume was a valid parameter for comparison between ovens, consumer relevant and directly related to the energy consumption and therefore to the energy class of the appliance. It also allowed larger cavity ovens access to the top energy classes

Based on the feedback received by stakeholders, it might be of interest to evaluate a change in the definition of SEC, using either other functions (power, logarithmic, etc.) or even to decouple the relationship between SEC and cavity volume. These analysis will be presented in Section 7.3.4.4.

In this section, analysis will be conducted assuming that SEC is still a linear regression of cavity volume. The parameters of this linear function were selected during the development of current regulation to represent an average of the market at that time:

<u>Current regulation</u>: SEC = 0.0042*V + 0.55 (in kWh)

Policy option 6a would be to maintain current situation and use the same regression line in new regulation.

Policy option 6b considers that energy consumption of electric ovens has evolved over the years; therefore, it is reasonable to evaluate if the SEC regression needs to be updated for the new version of regulation. Taking into account the models in APPLIA2020, an updated version of SEC can be calculated. In

Figure 250, SEC is calculated using energy consumption of best performing mode, measuring with brick method 1.0.

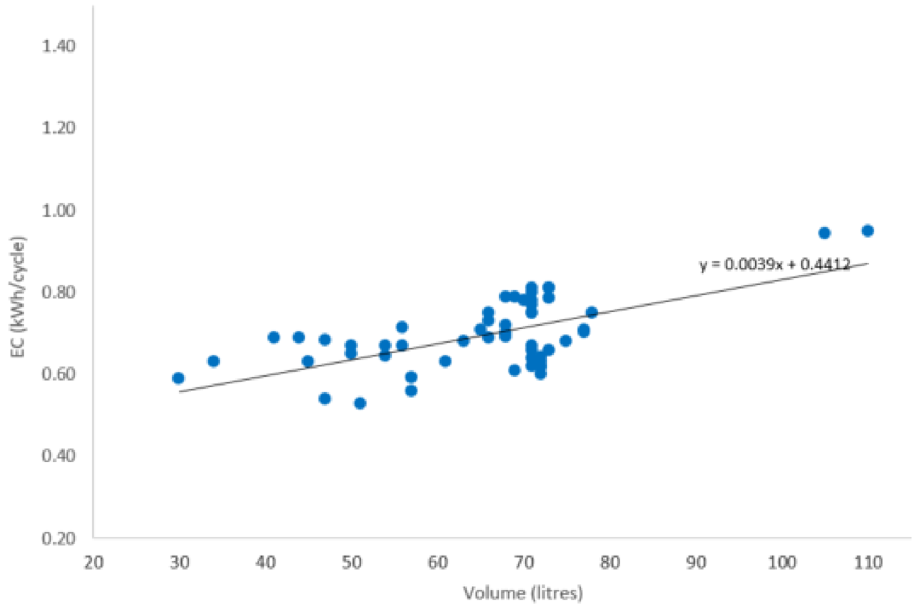


Figure 250. Updated SEC, BPM, BM1.0

Updated version, Best Performing Mode, BM1.0: SEC = 0.0039*V + 0.4412

As it can be seen in Figure 251, just by updating the SEC linear regression, ovens in the APPLIA2020 database would get a different energy class. With the updated SEC, 67% would be A and 33% B. Energy classification is the same as in current regulation (Table 128).

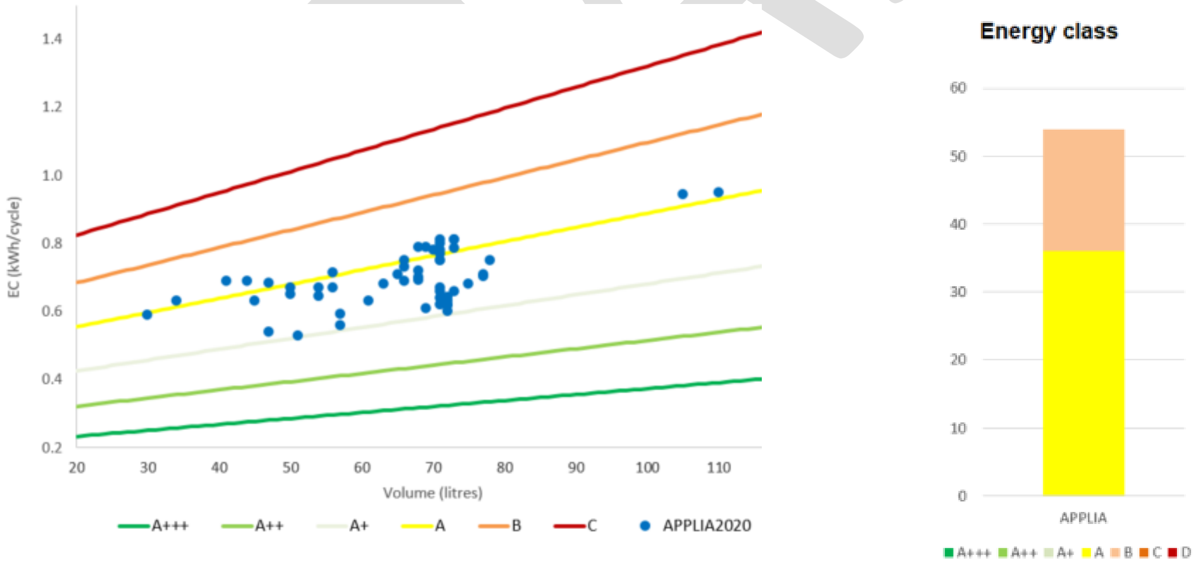


Figure 251. APPLIA2020, Updated SEC, Best Performing mode, BM1.0

In principle, it seems reasonable to update the SEC curve for the new version of the regulation (*policy 6b*). Moreover, the update on the SEC would work as a strengthening of the requirements to reach top energy classes (without rescaling). The specific parameters of SEC will depend on the approach taken to declare energy consumption, in terms of heating mode (best performing mode, conventional, weighted sum) and measurement method (BM1.0 or BM2.0).

7.3.4.2 The adoption of Brickmethod 2.0 as measurement method for energy consumption

As already explained in section 1.2.1.4 of this report, the main aim of the development of Brickmethod 2.0 (BM2.0) is to address some of the weaknesses identified in the previous method that might be leading to jeopardy effects or circumvention in the domestic oven market. The main differences between the current method (BM1.0) and BM2.0 are: new definitions of heating modes, different temperature settings in the measurement method, the separation of phases and the introduction of the c-factor (see section 1.2.1.4 for further details).

One of the key aspects of BM2.0 is that it unifies the temperature settings for every heating function (Figure 252).

temperature rise	Heating functions		
	Conventional (ic)	Forced air circulation (if)	Hot steam (ih)
ΔT_1^i	(140 ± 10) K	(135 ± 10) K	(135 ± 10) K
ΔT_2^i	(180 ± 10) K	(155 ± 10) K	(155 ± 10) K
ΔT_3^i	(220 ± 10) K[a]	(175 ± 10) K[a]	(175 ± 10) K[a]

[a] or the maximum temperature rise if this value cannot be reached.

Temperature rise	
ΔT_1	(135 ± 15) K
ΔT_2	(165 ± 15) K
ΔT_3	(195 ± 15) K[a]

[a] or the maximum temperature rise if this value cannot be reached.

Figure 252. Temperature settings in BM1.0 (left) and BM2.0 (right)

Observing the above temperature settings, an obvious consequence is that conventional heating functions will obtain a lower energy consumption with BM2.0 because the temperature point chosen is lower; and the opposite will happen with fan-forced heating functions. This can be confirmed with data from APPLIA2020. Figure 253 compares energy consumption of conventional and fan-forced functions with BM2.0 and BM1.0. Most of the ovens tested with conventional heating function are below the red line, which means that most of them have a conventional heating mode that gets a lower energy consumption with BM2.0 than with BM1.0. In contrast, most of the ovens tested with fan-forced function are over the red line, which means that the energy consumption of the fan-forced mode with BM2.0 is higher than the energy consumption of the fan-forced mode with BM1.0.

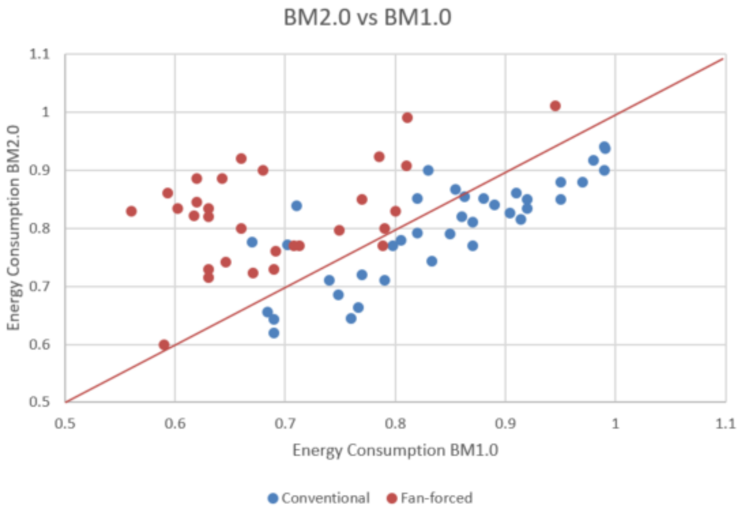


Figure 253. APPLIA2020. Conventional heating mode with BM1.0 and BM2.0

In terms of energy classes, the consequences of the adoption of BM2.0 can be observed comparing Figure 254 and Figure 255. Energy classification is the same as in current regulation (Table 128).

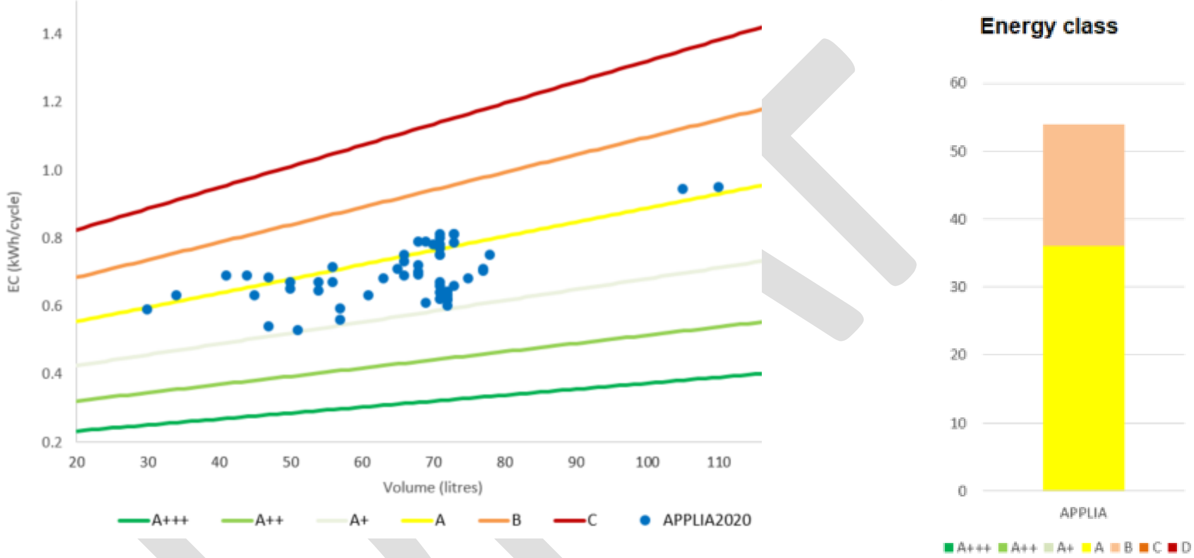


Figure 254. APPLIA2020, Updated SEC, Best Performing mode, BM1.0

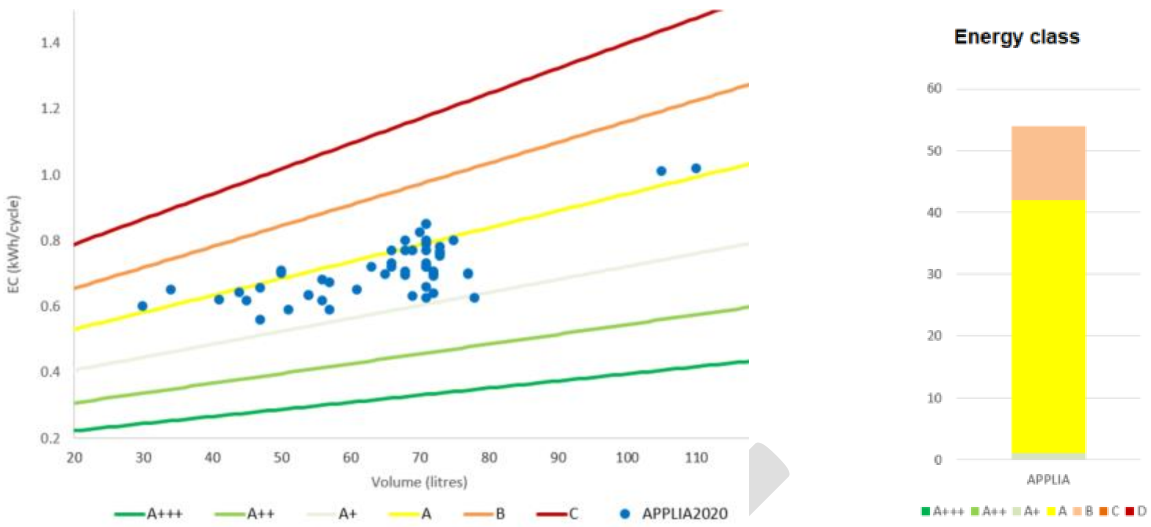


Figure 255. APPLIA2020, Best Performing mode, BM2.0

With the adoption of BM2.0, 76% of the ovens in APPLIA2020 would be A energy class, 22% would be B and 2% would get the A+ class. Some appliances appear to get a considerably worse EEI with BM2.0. This suggests an incorrect use of residual heat in those appliances, which BM2.0 might be able to detect and penalize with a poor EEI and low energy class.

The analysis conducted in this section indicates that the adoption of BM2.0 has some obvious benefits:

- The unification of temperature settings for every heating mode facilitates the comparison of energy consumption of different heating modes
- Ovens that might be making an incorrect use of residual heat can be identified easier with BM2.0. Manufacturers in general do not obtain a benefit in terms of energy declaration with the adoption of BM2.0.

BM2.0 is a new method under development and is therefore not a perfect or consolidated method. In its current version it has some drawbacks and improvement points. This is the positon of some stakeholders, mainly regarding the separation of phases. As explained in section 1.2.1.4, to assure that the checking of the temperature (empty oven, phase 2) is done on the same setting than with the brick (phase 1), BM 2.0 mandates a cooling down and switching off of the appliance between phase 1 and phase 2. In phase 2, the temperature is checked for 20 minutes only and not for the whole cycle (Figure 256).

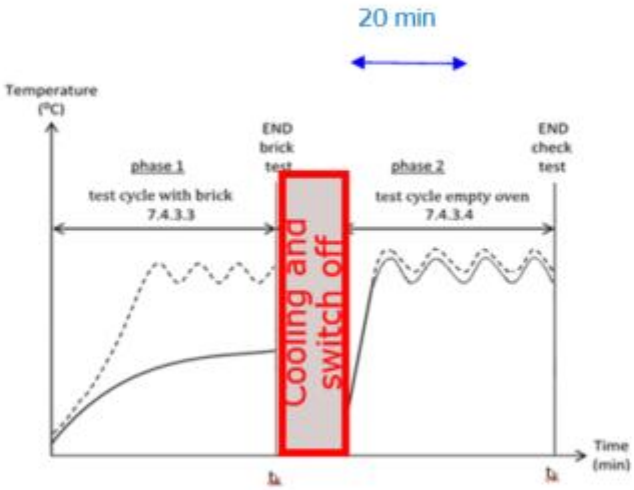


Figure 256. Separation between phases in BM2.0

This is the main concern of some stakeholders, who see this as loophole and a potential for using residual heat in the time out of these 20 minutes where the temperature is not checked. Their recommendation is to control the temperature setting for the whole cycle in phase 2 of the test. A stricter control of the temperature in the oven –as suggested by these stakeholders- has advantages and drawbacks. On one hand, controlling whole phase 2 will ensure that the temperature is always close to the temperature setting, reducing the risks of burning or undoneness related to the use of residual heat. On the other hand, limiting the use of residual heat with reduce the opportunities of reducing energy consumption..

7.3.4.3 Heating mode used to declare energy consumption

Current energy labelling regulation establishes that "energy consumption shall be measured for one standardised cycle, in a conventional and in a fan-forced mode". These two modes (conventional and fan-forced) are defined in regulation. *Policy option 8a* would be to maintain current situation.

Energy saving modes are a feature in electric ovens that allow the reduction of energy consumption. Generally, they work using residual heat to reduce the consumption of energy. The topic of energy saving modes has been debated extensively during the development of this preparatory study. The main issue in this discussion, brought by a variety of stakeholders, is whether to allow the use of energy saving modes for energy declaration and energy label classification.

Currently, there is no definition of what an energy saving mode is, nor in regulation or in the standards. An energy saving mode can easily fall within the definitions of conventional or fan-forced modes (particularly the latter). So nowadays, manufacturers are allowed to use an energy saving mode to declare their energy consumption. In fact, manufacturers are already using different variations of these modes to declare their energy consumption.

Some stakeholders highlight the implications of the situation described above:

- Energy saving modes reduce temperature during different phases of the cooking cycle. This can produce unsatisfactory results when cooking some recipes, in the form of undoneness or burning, depending on the temperature profile used to reduce energy consumption.
- Energy saving modes are not the most frequently used modes, according to the results of the user behaviour study presented in Task 3. Therefore, in real-life use, consumers might be observing energy consumption values that are higher than the ones marked in the energy label of the appliance.

To overcome these issues, BM2.0 is being developed and its adoption is under discussion (it is only applicable to electric ovens). In previous section, it has been concluded that, even though there are still some specifics of the method under debate, with information available at this point, it is reasonable to conduct measurements with BM2.0 as soon as the method is ready.

The key question in this section is:

Should energy saving modes be allowed for the declaration of energy consumption and to determine the energy class of ovens?

Some stakeholders are in favour of allowing their use; some others are against their use; and some stakeholders recommend some sort of commitment between energy saving modes and conventional modes for energy declaration. Within the industry, these conventional modes are also referred to as "standard" modes. There are benefits and drawbacks related to each option.

Allowing the use of energy saving modes for energy declaration can be seen as an incentive for innovation. This does not mean that energy saving modes are the only path for innovation, but one of them. If manufacturers are allowed to use certain amount of residual heat, this is a potential for improvement. If most of the ovens in the market have energy saving modes and their use is promoted appropriately among consumers, there is potential for overall energy savings. On top of that, another stakeholder suggested that on ecodesign regulation, there could be an information requirement where manufacturers need to explain what the mode referenced to as "energy saving mode" actually does.

Allowing the use of energy saving modes for energy declaration can obviously have some risks. For instance, if these modes are not controlled in some manner, there is a risk of having ovens in the market that cannot cook appropriately due to incorrect use of residual heat. Moreover, if energy saving modes do not work properly or are not promoted among consumers (for instance, encouraging its use in the instructions manual), the energy consumption values on the label will differ greatly from the energy actually consumed by the user.

At this point, it can be stated that, to take advantage of the benefits and reduce the associated risks, energy saving modes should be allowed for energy declaration, ensuring that they can cook appropriately. One way of ensuring it is with the adoption of BM2.0. An additional way of ensuring it is with the use of real food in the energy consumption test (this aspect will be discussed further in section 7.3.4.5).

Based on this background, some policy options are identified (Table 129).

Table 129. Summary of policy options related to heating modes

Policy option	Heating mode to determine energy class	Method to measure energy consumption	Applicable to Electric/Gas
8.a current situation	Best performing mode (BPM)	BM 1.0	Electric & Gas
8.b	Best performing mode	BM 2.0	Electric
8.c	Weighted sum between BPM and Conventional mode (1)	BM 2.0	Electric
8.d	Any conventional heating mode (1) that does not use residual heat	BM 2.0	Electric

(1) A conventional mode can be either a static mode or a fan-forced mode. These are also known as "standard" modes.

As seen in the previous sections, each of the policy options will have different EC values and slightly different SEC regression lines. Therefore, each of the policy options defined in Table 129 will have different consequences in terms of energy classes. In this section, the consequences of each of those policy options is presented, using as a basis APPLIA2020.

Policy option 8a

Policy option 8a consists in maintaining current situation: declare energy consumption with best performing mode (BPM), measuring with BM1.0, implementing only the change of an updated SEC (based on the oven market today), as discussed in section 7.3.4.1. This policy option would be applicable to both electric and gas ovens. With *policy option 8a*, 67% would be A energy class and 33% would be B. Only 8% would remain in the A+ class (Figure 257). Energy classification is the same as in current regulation (Table 128).

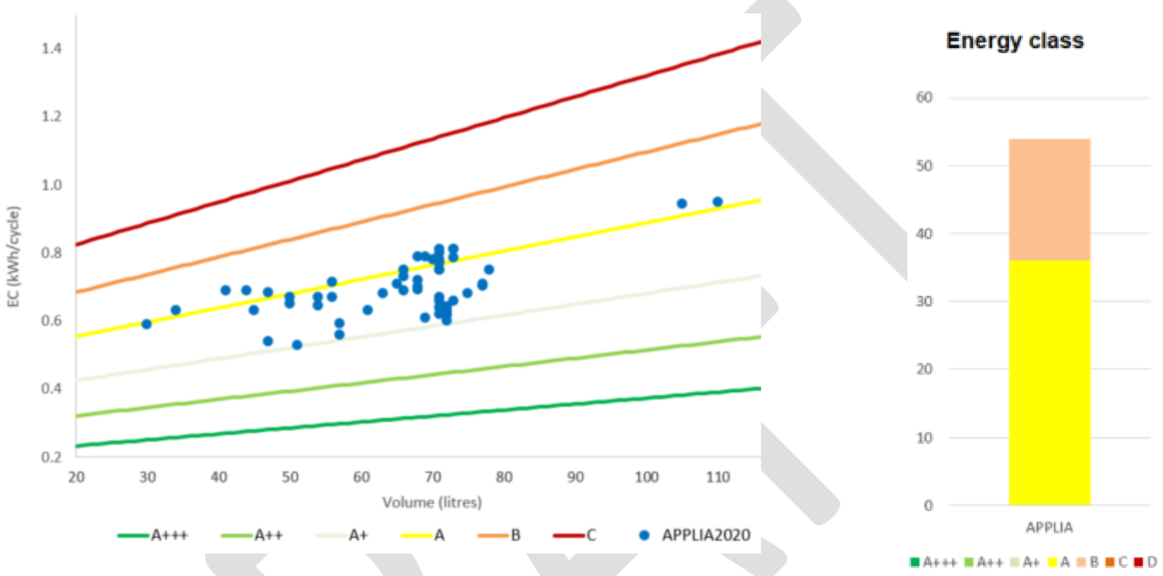


Figure 257. APPLIA2020, Policy option 8a

A benefit of this policy option is that, in terms of legislative change, it only requires the update of the SEC regression line. Another benefit is that it is a stricter version of current regulation in terms of energy class. On top of that, it is applicable to both electric and gas ovens. However, it comes with some drawbacks, since it does not have the additional control of energy saving modes related to the adoption of BM2.0.

Policy option 8b

Policy option 8b consists in declaring energy consumption with the best performing mode (BPM), measuring with BM2.0, with an updated SEC regression. This policy option would be applicable to electric ovens only. The consequences of the adoption of BM2.0 have already been presented in previous section but they are included here again for clarification (Figure 258). Energy classification is the same as in current regulation (Table 128).

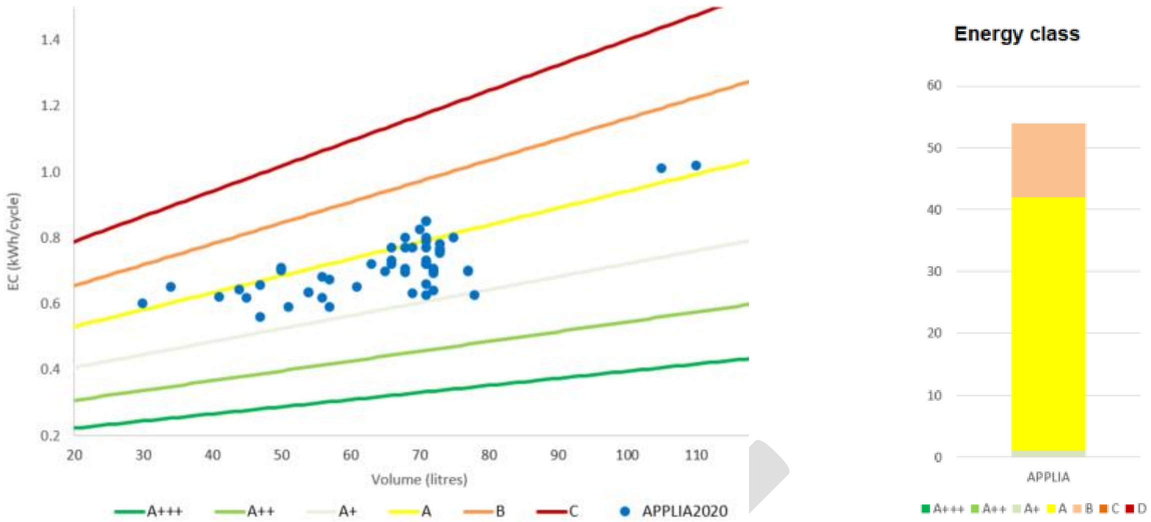


Figure 258. APPLIA2020, Policy option 8b

With *policy option 8b*, 76% would be A energy class, 22% would be B and 2% would remain in the A+ class. By switching to BM2.0, some appliances appear to get a considerably worse EEI with BM2.0. This suggest an incorrect use of residual heat, which BM2.0 might be able to detect and penalize with a poor EEI and low energy class.

A benefit of this policy option is that it is a stricter version of current regulation in terms of energy class. Moreover, it has the additional control of energy saving modes related to the adoption of BM2. A drawback of this option is that it would only be applicable to electric ovens.

<u>Policy option 8c</u>

Policy option 8c consists in declaring energy consumption as a weighted sum between best performing mode (BPM) and a conventional mode, measuring with BM2.0, with an updated SEC regression. This conventional mode can be either a static heating mode or a fan-forced mode (a “standard” mode). This policy option would be applicable to electric ovens only.

There are multiple options in terms of weighted sum. Two options will be evaluated: a 50/50 approach and a 80/20 approach (80% to conventional and 20% to BPM). The 80/20 approach would be the closest to the current use profile by consumers today (see Figure 107 in Task 3 for time spent with each heating mode). The 50/50 approach would be an approach giving more weight to one of the areas of ovens with higher opportunity for improvement (energy saving modes).

With *policy option 8c 50/50*, 91% would be A, and 9% would be B (Figure 259). Energy classification is the same as in current regulation (Table 128).

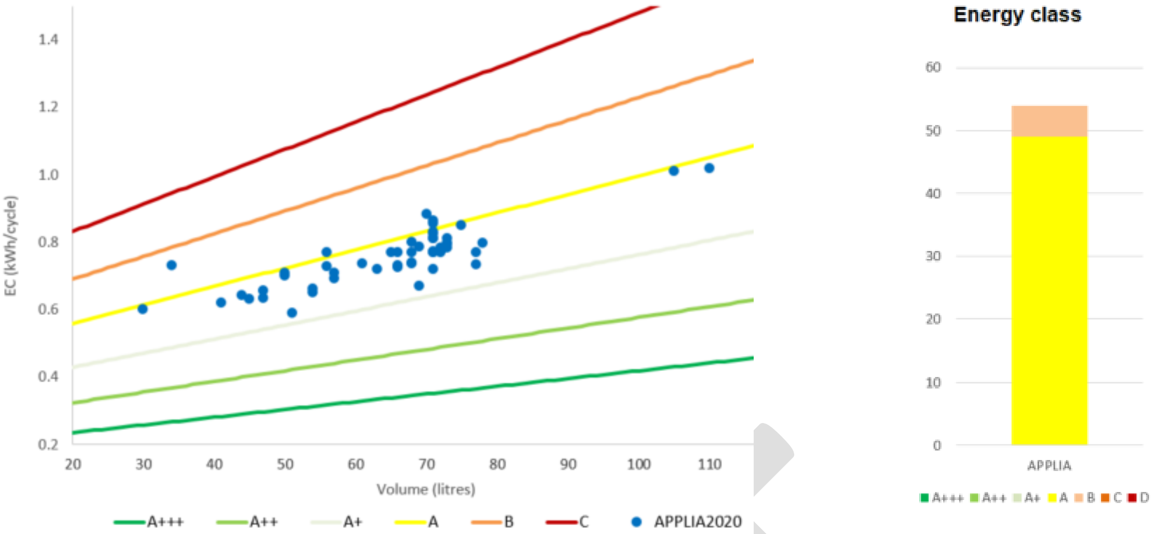


Figure 259. APPLIA2020, Policy option 8c, 50/50

With *policy option 8c 80/20*, 93% would be A and 7% would be B (Figure 260). Energy classification is the same as in current regulation (Table 128).

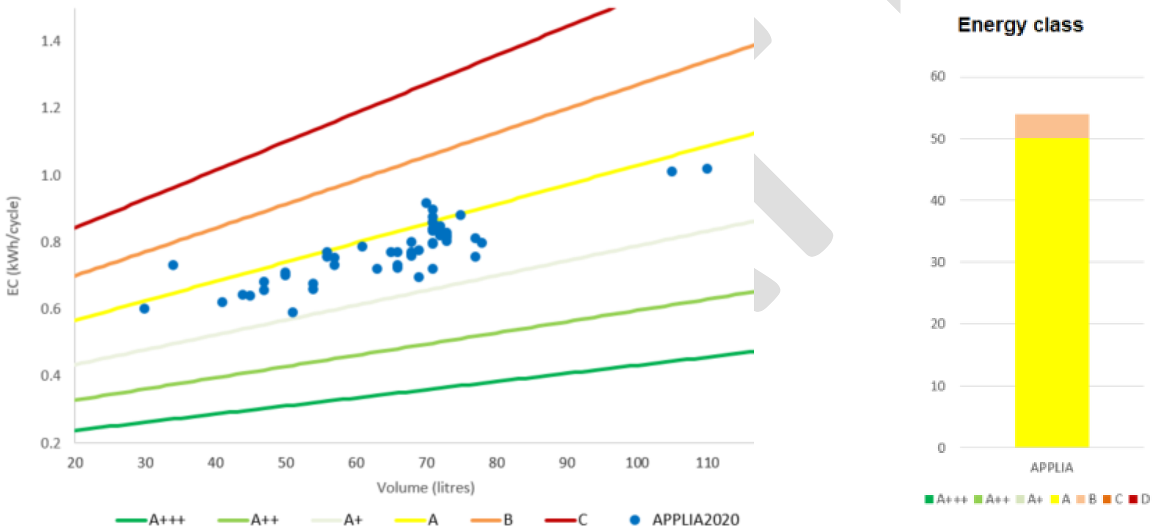


Figure 260. APPLIA2020, Policy option 8c, 80/20

A benefit of any of these two options (50/50 or 80/20) is that they are stricter versions of current regulation in terms of energy class (without an actual rescaling). Moreover, they have the additional control of energy saving modes related to the adoption of BM2.0. A drawback of this option is that it would only be applicable to electric ovens. It can be observed that there is not much difference between a 50/50 approach and a 80/20 approach in terms of energy class obtained by the ovens.

For *policy option 8c* to work appropriately, there should be enough differentiation between the conventional mode and the best performing mode. Otherwise, there is a risk that some manufacturers can use to declare energy consumption an energy saving mode (as BPM) and something very similar to an energy saving mode (but considered a fan-forced mode).

To avoid this, some stakeholders recommend having clear technical requirements based on the expected features of the "standard" functions. According to them, and considering consumers' expectations:

- Low power functions shall not be considered as standard functions
- Cooking functions with residual heat shall not be considered as standard functions
- Cooking functions with low c-factor shall not be considered as standard functions

Based on that, they recommend that standard functions shall fulfil certain requirements:

- The time to reach the set temperature in phase 2 measured in the center of the oven for all three temperature rises shall be within 20 minutes from the end of the test and the c-factor calculated should be higher than 0.9
- The temperature rise for the three settings should be as below:

Temperature rise	
ΔT_1	(135 ± 10) K
ΔT_2	(165 ± 10) K
ΔT_3	(195 ± 10) K

- The average of the temperature measured in the center of the oven in the last 10 minutes of phase 2 for all three temperature rises should be compliant with the reference temperatures in the table above
- The c-factor calculated in the last 10 minutes for the three temperature rises shall be above 0.9.

Another aspect that would be useful if this policy option is adopted is a clear definition of energy saving modes, inexistent today. This lack of definition for energy saving modes is an aspect to improve from current regulation and standards. It is not possible to evaluate the appropriateness of using these heating modes for energy declaration is there is no agreed definition for such modes. To tackle this issue, in recent publications from WG17 in CENELEC, an attempt to provide a definition for energy saving modes has been made. The proposal is to define "eco functions" in the new standard method (Brickmethod 2.0) as:

Heat transmission by natural air circulation and/or forced air circulation and/or radiation for certain applications using efficient technical solutions. Examples of these technical solutions are residual heat usage, low power heating or a combination of both.

<u>Policy option 8d</u>

Policy option 8d consists in declaring energy consumption with a conventional mode only, measuring with BM2.0, with an updated SEC regression. This conventional mode can be either a static heating mode or a fan-forced mode (a "standard" mode). This policy option would be applicable to electric ovens only. With *policy option 8d*, 92% would be A energy class and 8% would be B (Figure 261). Energy classification is the same as in current regulation (Table 128).

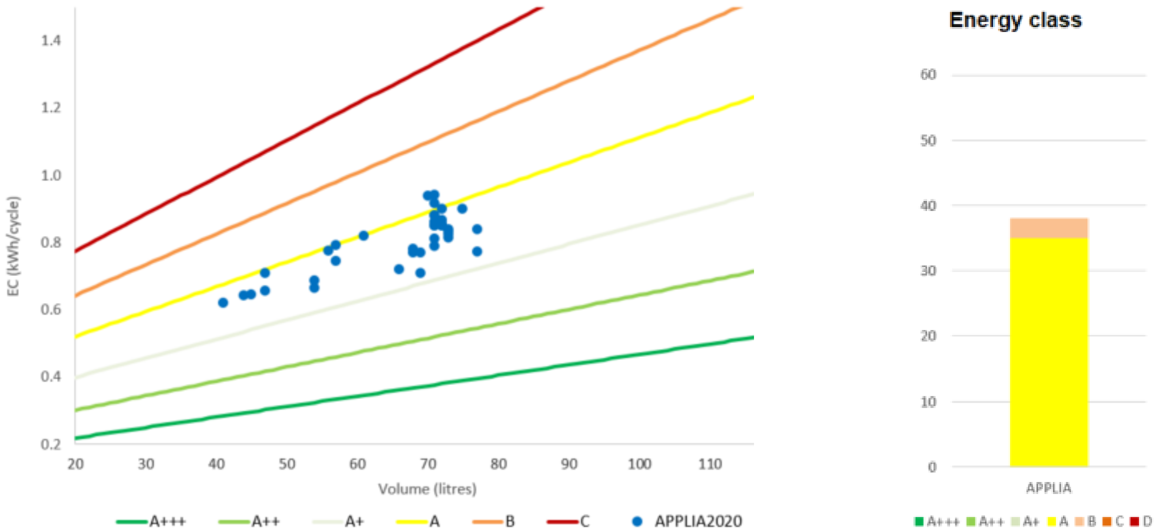


Figure 261. APPLIA2020, Policy option 8d

A benefit of this policy option is that it is a stricter version of current regulation in terms of energy class. Moreover, it has the additional control of energy saving modes related to the adoption of BM2.0. However, this option does not allow the use of energy saving modes for energy declaration, which could be a disincentive for manufacturers for the development of these modes.

<u>Conclusions based on discussions with stakeholders</u>

Based on the analysis of the different policy options presented in this section, and considering feedback gathered in bilateral meetings with different stakeholders, some preliminary conclusions can be made at this point.

- Energy saving modes can a positive feature that can help reducing overall energy consumption and are an incentive for innovation, providing they ensure satisfactory cooking results. Based on this, *policy option 8d* (using conventional heating modes only for energy declaration) should be discarded

- In *policy option 8c*, a weighted sum is conducted between the BPM and a conventional mode. According to the analysis conducted in this section, there is not a significant difference between the use of a 50/50 approach and a 80/20 approach, in terms of energy class obtained by ovens. Therefore, for simplification from now on, only *policy option 8c 50/50* will be considered. This policy option would require a precise definition of what the “standard” modes are.

- Since *policy options 8b and 8c* are based on the use of BM2.0, and this method is only applicable to electric ovens, these policy options will only be related for electric appliances.

- Both *policy options 8b* and *8c* would work as a strengthening of the requirements to reach top energy classes in comparison to the current label

- A decision still needs to be made between *policy options 8b* (BPM only) or *policy option 8c* (weighted sum between BPM and Conventional).

In the following sections, more policy options are presented and analysis conducted in terms of ecodesign limits and energy classes definitions. For simplification from this point, in those sections, only variations of *policy options 8b and 8c* will be taken into account for electric ovens.

7.3.4.4 Non-linear relationship between Standard Energy consumption and volume

As indicated in previous sections, some stakeholders have questioned whether current formulas to calculate EEI are driving consumers to buy larger ovens than they actually need. Coming back to the analysis conducted in Task 2 of this report, it appears that there is a bigger proportion of larger cavity volumes in the top energy classes (A++ and A+) than in the low energy classes (A and B).

Some stakeholders have suggested decoupling the Energy Efficiency Index from cavity volume. In their view, this approach has high consumer relevance, since the label value (and energy class) would show the actual energy consumption and there would be no distortions associated to size of the oven. As explained in Waechter et al (2015), consumers focus on the energy efficiency class and disregard information on an appliance’s expected electricity consumption in kWh. The authors argue that this could cause a misleading effect of the energy label if product size is a considerable driver of electricity use (as in the case of domestic ovens). Consumers tend to judge an appliance only based on the energy efficiency class despite size-related differences in electricity consumption. This effect is called by some authors as the “energy efficiency fallacy”, which is particularly driven by the visual representation of the energy class.

With this approach, EEI would be calculated as:

EEI = EC / SEC

Where SEC would be a fix value, based on the market database (for instance, the average energy consumption).

For simplification, this approach will be known as the "flat approach" in this report (*Policy option 9a*). With the flat approach, BPM and BM2.0, energy classes would be as in Figure 262: 2% of ovens would be C, 70% D, 24% E and 4% F.

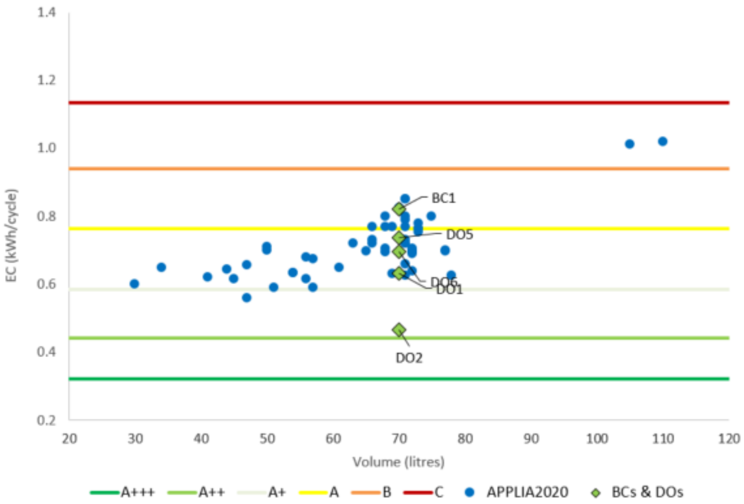


Figure 262. Flat approach and policy option 8b

In a similar way, the results of adoption the flat approach and a weighted sum 50/50 between BPM and conventional, the energy classes would be as in Figure 263: 4% of ovens would be C, 76% D, 17% E, and 4% F.

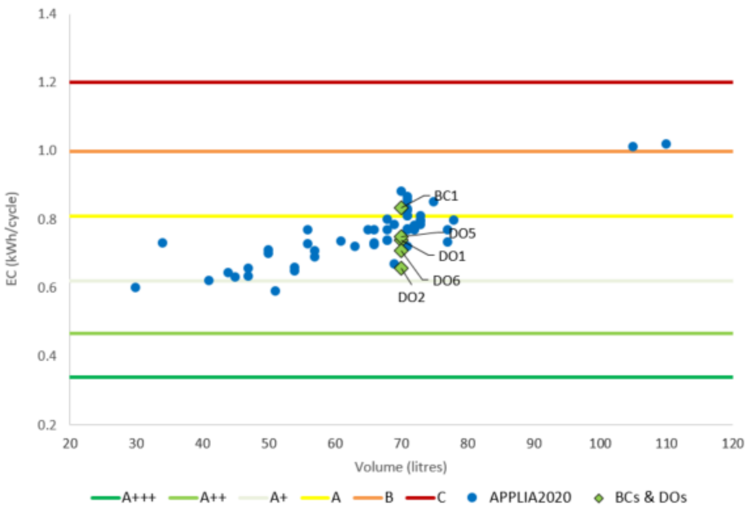


Figure 263. Flat approach and policy option 8c 50/50

With the adoption of the flat approach, a potential trend towards larger cavities could be slowed down, helping to reduce overall energy consumption. It would also limit the incentive for manufacturers to produce ovens with high rated volume. On top of that, the best energy classes would almost always be related to smaller size ovens.

It must also be noted that the flat approach could reduce the demand of large cavity ovens, which could affect some manufacturers offering a wide range of these appliances. Also, in terms of ecodesign minimum requirements, it would be difficult for larger ovens to comply (the two ovens larger than 80 litres in APPLIA2020 would not comply). To reduce this impact, some stakeholders suggest establishing a threshold between "regular" and "large" ovens, for instance at 85 litres. Therefore, ovens below 85 litres would have a minimum ecodesign requirement which is stricter than the minimum ecodesign requirement for ovens larger than 85 litres. An example of this approach is shown in Figure 264. The specific ecodesign limits for each group of ovens still would need to be decided, based on the market average of "regular" and "large" ovens.

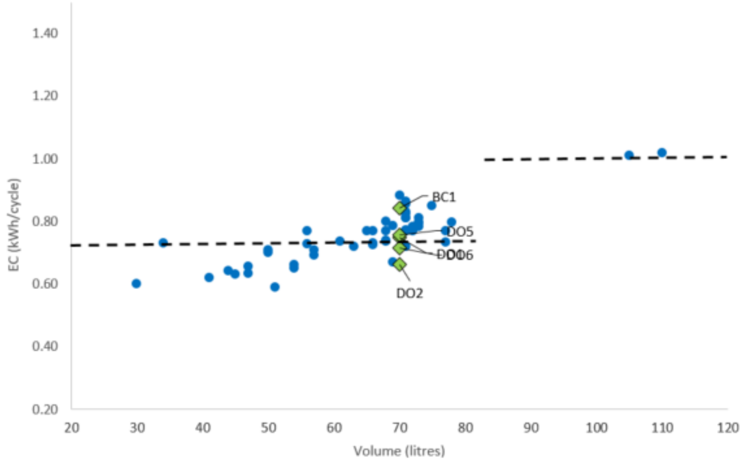


Figure 264. Flat approach and different ecodesign thresholds

If a goal of new regulation is to somehow make it harder for larger cavity ovens to get top energy classes, an intermediate alternative approach to current regulation and to the flat approach could be to use a non-linear relationship between energy consumption and cavity volume (essentially, a curve that is flatter on the side of the larger volumes). According to some stakeholders, such an approach could bring a potential reduction in total energy consumption by promoting the purchase of "the right-size" of ovens.

In Figure 265 to Figure 268, in addition to the linear regression, three different functions are tested, using for that APPLIA2020: logarithmic, power and exponential. The best-fit equation is presented in each case. For simplification on this section, only *weighted sum 50/50* between BPM and Conventional is tested.

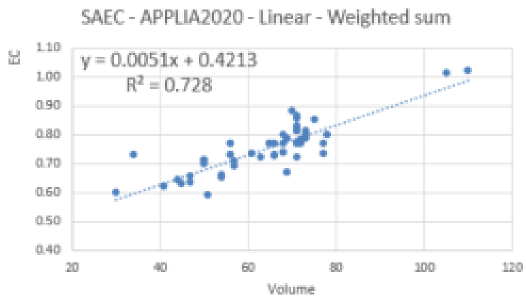


Figure 265. Linear regression

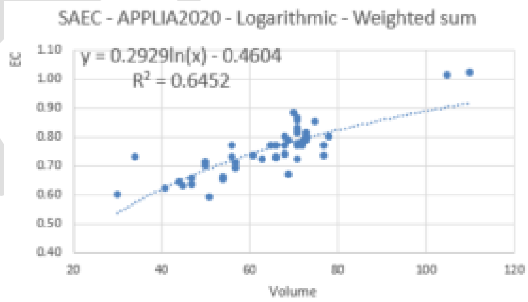


Figure 266. Logarithmic regression

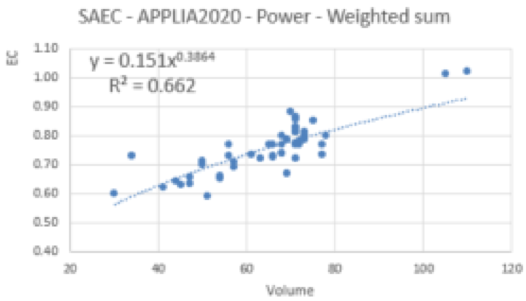


Figure 267. Power regression

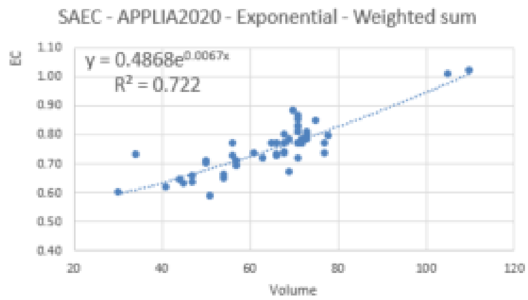


Figure 268. Exponential regression

Using a non-linear approach would have consequences to the energy classes obtained by ovens. If the aim is to make it more difficult for larger cavity ovens to reach top energy classes, the ideal curve is either a logarithmic or a power regression (*Policy option 9b*). The consequences of using alternatives regression lines to define SEC can be seen in Figure 269 and Figure 270.

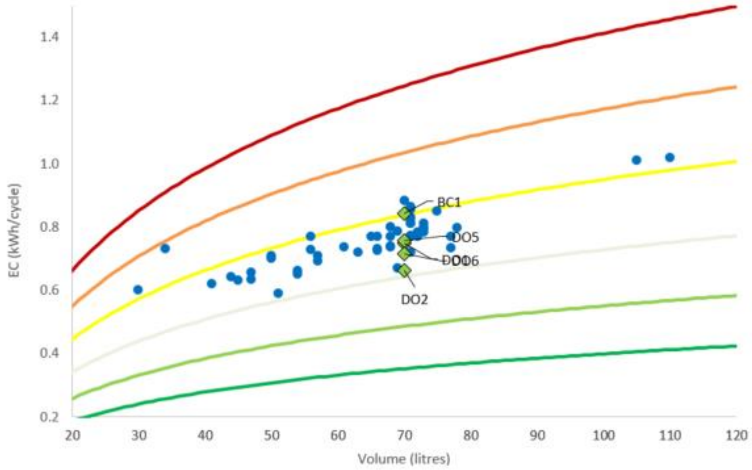


Figure 269. Logarithmic regression and policy option 8c 50/50

SEC = 0.293*ln(V) – 0.46

The flatter right side of the curve makes it more difficult for larger cavity ovens to access the top energy classes.

In a similar way to the logarithmic regression, the consequences of using a power regression to define SEC can be seen in Figure 270. As it happened with the logarithmic regression, the flatter right side of the curve makes it more difficult for larger cavity ovens to access the top energy classes.

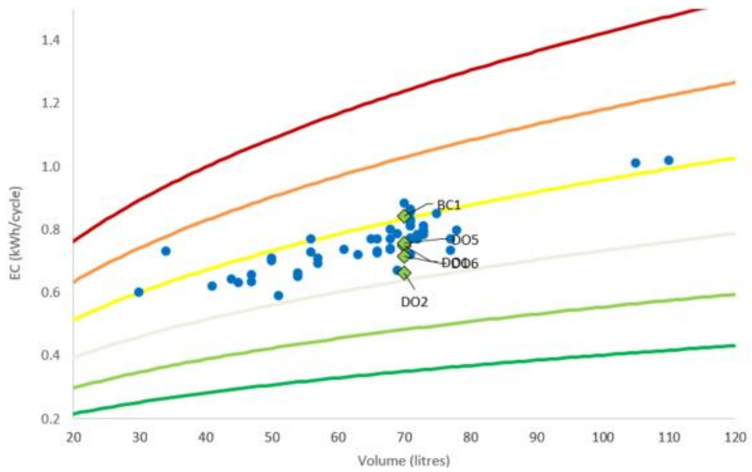


Figure 270. Power regression and policy option 8c 50/50

SEC = 0.151*V$^{0.39}$

7.3.4.5 Cooking real food to declare energy consumption

Current version of the standard (EN 60350-1) is based on heating up a brick, useful to represent a relevant load and the energy needed to cook it, but unable to test aspects such as browning or doneness. This standard includes methods to evaluate the capacity of heat distribution and heat supply of ovens. However, these methods are not linked with the test for energy consumption declaration. Current regulation does not specify the need to use real food to ensure the good performance of heating modes used for energy declaration.

In the view of some stakeholders, performance -understood as the ability to produce quality food- should be included in the next version of the energy label, to allow consumers a better comparison of ovens. A potential way solving of this could be to introduce the testing of real food in some part of the energy declaration test.

Policy option 10a would be to maintain the current situation in terms of the use of real food.

An alternative to current situation (*Policy option 10b*) would be to use real food as a quality check, to ensure energy saving modes are able to cook appropriately. The use of residual heat in energy saving modes may cause a decrease in the cooking quality results. Therefore, it might be interesting to introduce this quality check if energy saving modes are still allowed for the use in energy declaration. With this policy, it would be easier to ensure an appropriate cooking performance of energy saving modes. However, this requires a robust procedure.

An even more ambitious option (*Policy option 10c*) would be to use real food as a quality check, to ensure that every heating mode can cook appropriately (and not only energy saving modes). With this policy, it would be easier to ensure an appropriate cooking performance of every heating mode tested.

Using real food as a quality check is seen as a good idea and is of capital importance for consumer and standardisation agencies, particularly in the current landscape, where energy saving modes are widespread. In their view, linking energy consumption and cooking performance seems necessary for ovens, since it has been foreseen since the beginning of the regulation process. They add that not including cooking performance in the first version of the label is acceptable, but in the long run it should be included so as to enable the consumer to better compare different ovens. *Policy option 10a* should be discarded based on this feedback from standardisation agencies.

Currently, there is a standard method under development to be used as verification of the energy declaration test, to check if that energy is sufficient in terms of core temperature, volume and browning intensity. This method is commonly known within the industry as the "Energy cake test". This method provides materials and procedure to cook a standard cake, as well as acceptance criteria for temperature, volume and browning. The main difficulty of developing such a method is related to reproducibility, since food can only be standardized to a very limited extent, which leads to high uncertainties. At this point in time, there are still open topics in the development of this new test, mainly related to:

- Ingredients of the cake. Some stakeholders question about the use of palm fat, which could have harmful effects if it is not processed appropriately. Also, there is debate around how representative of the real consumers is the use of ingredients such as milk powder or egg powder (which are used because they have advantages related to logistics).
- Issues with the test procedure related to the thermocouple, which in some occasions does not allow a proper rising of the cake, leading to reproducibility issues.
- Issues with evaluation of the standard deviation.
- Measurement of the core temperature. Issues related with insufficient specification. To tackle those, an alternative measuring rack construction is under development.
- Issues related to positioning and distances of the thermocouples, the evaluation of the browning intensity of the cake, the determination of the set temperature, etc.

It might also be of interest in this section to mention the investigation carried out by Favi et al. (2020), where the authors characterize cooking performance of different EU diets in terms of environmental impact for the development of ecodesign actions related to cooking appliances. In this experiment, four different diets are defined and standardized in terms of type and quantity of food, procedure, sequence, containers, temperature and cooking functions. The cooking procedures are defined with accuracy in order to guarantee repetitiveness. Due to their complexity, the recipes used in this experiment might not be completely adequate for a standardised method, but the work conducted to define the procedures might inspire a way forward in this field.

At this point, a common dilemma is presented. On one hand, testing performance with real food cannot be made mandatory if there is no robust test to measure it. On the other hand, if testing with real food is not made mandatory by regulation, there is no urge to develop such a test. Regulation cannot be based on testing methods that still do not exist formally, but could work as an incentive to finalise the testing methods that are under development. How this incentive could work is still unclear and open to debate.

Therefore, as a conclusion from this section, it is recommended that testing the cooking performance of ovens should be mandatory for energy saving modes only (*policy option 10b*) in the new regulation, *as soon as* there is a robust test with no reproducibility issues.

In order to incentivize the completion of this test, some of the thresholds formulated in the new regulation (for ecodesign or for energy labelling) could be linked with the development of the test. Examples of incentives could work like this:

- With current version of regulation, in order to get an A+ energy class, an oven needs to get an EEI=82. In new regulation, this threshold could be conditional to the availability of a standard method with the use of real food. When the test is available, that same threshold might be changed to a 10% higher value (EEI=90), making it less strict when the testing of real food is in place.

- If *policy 8c* is adopted, the weighted sum could be conditional to the availability of the test with real food. For instance, a 80/20 approach is taken if there is no test to ensure that energy saving modes can cook appropriately; and the 50/50 approach will be taken as soon as there is a test.

7.3.4.6 Energy declaration of steam-assisted, MW-combi and automatic functions

Solo-steam ovens are out of the scope of current regulation. Other ovens with steam functions (such as the ones presented in Table 130) are included in the scope.

Table 130. Steam ovens and their heating functions

Type oven	Heating functions available
Combi-steam oven	- Steam cooking - Steam cooking with fan-forced convection - Fan-forced convection
Steam-assisted oven	- Steam cooking with fan-forced convection - Fan-forced convection

However, the above appliances are covered in regulation just by their conventional or fan-forced heating functions (and not the ones using steam). In principle, it is rare to find in the market gas ovens with these type of functions, so policy options presented in this section would only be applicable to electric ovens.

Policy option 11a would be to maintain current situation: not declaring energy consumption of any steam-related mode.

As already seen in Task 2, sales of ovens with steam-assisted heating functions are growing over the past years. The availability of steam-assisted functions is confirmed in the results of the user behaviour results presented in Task 3: they are present in 19% of ovens older than 5 years and in 51% of ovens younger than 5 years. Moreover, 33% of consumers use it either often/very or often/almost always.

Data from TopTen database presented in Task 4 of this report suggested that ovens that include steam-assisted functions tend to perform well in terms of energy class. An analysis with APPLIA2020 reveals that both with *policy option 8b* (Figure 271) and with *Policy option 8c 50/50* (Figure 272), ovens with steam-assisted function simply get an A energy class.

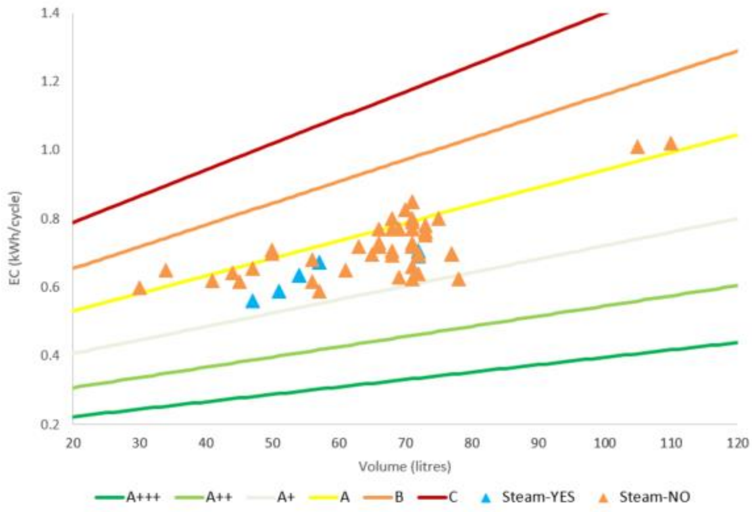


Figure 271. APPLIA2020 Policy option 8b

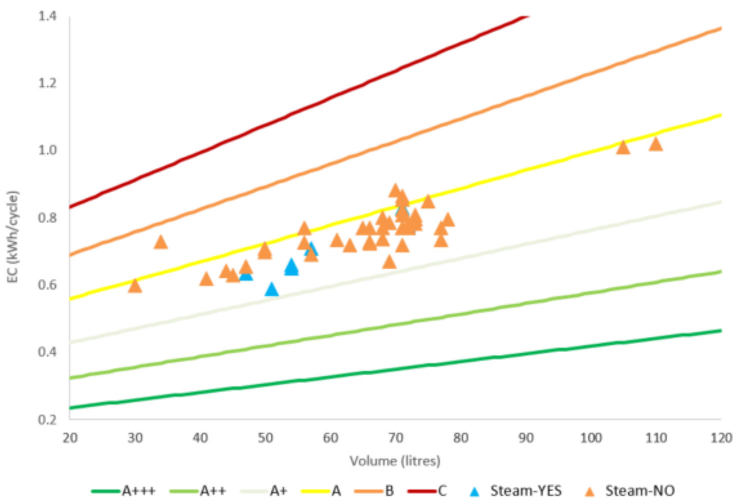


Figure 272. APPLIA2020, Policy option 8c, 50/50

Feedback from industry points out that ovens with steam-assisted function have better sealing and isolation characteristics with reduced vapour outlet, when compared to conventional ovens. This better sealing leads to better results in the energy consumption test. Manufacturers highlight that the support of steam does not necessarily lead to lower energy consumption (it is commonly the opposite).

In summary, steam-assisted heating functions are:

- Gradually growing their availability in electric ovens and their use by consumers
- Generally more energy consuming than conventional or fan-forced modes
- Indirectly helping to achieve good energy efficient classification with current regulation
- Not declared or regulated

The situation described above invites to consider the inclusion of steam-assisted heating functions into the scope of new regulation. Two policy options can be identified at this point. *Policy option 11b* would be to declare energy consumption of steam assisted heating modes, not affecting the energy class. In this case, these modes could be declared in the energy label alongside conventional or fan-forced modes.

Policy option 11c would be to declare energy consumption of steam assisted heating modes, including this information in the user manual, instead that in the energy label.

Declaring the energy consumption of steam-assisted functions comes with additional difficulties. Currently there is no standard method to measure energy consumption of these functions. Therefore, both for *Policy option 11b* and *11c*, a new test standard should be available to allow their energy declaration.

MW-combi and automatic functions

A similar issue to the above is related to MW-combi or automatic functions. *Policy options 12a* and *13a* would be to maintain current situation (not declare their energy consumption or associated savings).

As explained in previous sections, some ovens have functions that have the potential of reducing energy consumed during cooking, such as microwave-combi modes or automatic functions. According to feedback received from stakeholders, microwave-combi modes can reduce energy consumption by 10% and automatic functions by 15% (see corresponding sections in Task 4 for more details). However, the benefits of these settings are not directly perceived by consumers.

Ideally, in order to declare energy consumption in the user manual and to take into account the benefits of those settings in achieving a better energy class, a standard method should be developed for both of them: the use of a microwave-combi mode (*Policy option 12b*) and the use of automatic settings (*Policy option 13b*).

Until standard test methods are developed, a possible way to show consumers the potential energy consumption savings of these functions is to apply a percentage reduction during the calculation of the Energy Efficiency Index. For instance, a 10% reduction in the energy consumption (EC) declared value could be used in the case of appliances with microwave-combi modes (*Policy option 12c*) and a 15% in the case of appliances with automatic setting (*Policy option 13c*).

7.3.4.7 Measurement of cavity volume to declare energy consumption

The Energy Efficiency Index (EEI) of an oven (and therefore its energy class) is directly related to its energy consumption and cavity volume. Regarding cavity volume measurement, current version of the standard EN 60350-1 states that:

> "Removable items specified in the user instruction to be not essential for the operation of the appliance in the manner for which is intended shall be removed before measurement is carried out"

According to some stakeholders, this sentence should be revised as it may lead (and in many cases does lead) to higher declared volumes and thus better EEI compared to real-life usage of the ovens. In order to declare higher cavity volumes, side racks are often removed during the test. It might be argued if side racks are essential or not for the operation of the appliance. Policy options presented in this section would be applicable to both electric and gas ovens.

As already indicated in Section 1.2.1.2 of this report, the authors of the ANTICSS project concluded that the use of an oven without the side racks seems to be an exceptional use and not the operation of the appliance in the manner for which it is usually intended. In their view, there is a loophole in the standard that should be solved. Their recommendation is that all relevant parameters should be measured in the same conditions. Therefore, if the side racks are needed for the measurement of the energy consumption, then the volume should be measured with the side racks (*Policy option 14a*).

However, members of CENELEC Working Group 17 working on standard methods for ovens disagree with ANTICSS point of view. They indicate that in the new version of the energy consumption test, the rule will be to measure cavity volume after removing the side racks. According to these members of WG17, conducting the energy consumption test with the side racks adds reproducibility issues, that could be eliminated by just conducing the test without them (*Policy option 14b*).

7.3.4.8 The inclusion of energy consumption of self-cleaning systems in product information requirements

The most common self-cleaning system in ovens today is pyrolytic cleaning. With this system, the oven is heated in a special heating cycle up to 500C for long periods of time (1-3 hours). This causes fat deposits to pyrolyse, mainly to gaseous by-products. Organic residues are incinerated, then easily removed as dust. The pyrolytic cleaning cycle has high energy consumption. Total annual energy consumption will depend on how frequent this system is used.

Results from Task 3 regarding the use of the pyrolytic function indicate that 15% of consumers use the pyrolytic function almost always or very often. Some stakeholders suggest that pyrolytic function represents around 25% of the lifetime energy consumption of the oven. Results shown in Task 5 of this report indicate that a moderate use of pyrolytic cleaning (6 times/year) can increase total energy consumption of the oven by 10%.

Currently, it is not mandatory to declare the energy consumption of pyrolytic cleaning. *Policy option 15a* would be to maintain current situation. However, its impact in total energy consumption seems significant. Some stakeholders suggest that it is important that consumers have access to information about the energy consumption of pyrolytic cleaning and that it should be declared. Their proposal is to include information on energy consumption of self-cleaning systems in the user manual. Providing the consumer with information on energy consumption of self-cleaning systems might foster a reasonable use of this feature (*Policy option 15b*).

The main difficulty of declaring energy consumption of the pyrolytic function is the fact that it would be very challenging to evaluate different levels of cleanliness and to compare self-cleaning programmes with manual cleaning. There is currently no standard method to evaluate the performance of cleaning systems in ovens.

A potential solution for this situation could be to include recommendations about frequency of use of this systems (in times per year, for instance) as an information requirement in product documentation (*Policy option 15c*). Providing consumers with these recommendations on frequency of use of self-cleaning systems might promote a reasonable use of this feature, without the need of developing a new standard method.

7.3.4.9 The inclusion of pre-heating phase energy consumption in product information requirements

According to the results of the user behaviour study presented in Task 3, around 28% of consumers pre-heat their oven before use. Pre-heating the oven is considered within the industry as an inefficient activity. Most of recipes do not require a pre-heated oven, however many consumers still perceive this is a necessary step in cooking with the oven. Based on this, it appears that a significant amount of energy is wasted on this inefficient cooking habit. Policy options presented in this section would be applicable to both electric and gas ovens.

Current regulation does not require to declare the energy consumption of the pre-heating phase. *Policy option 16a* would be to maintain current situation.

In current and new version (brickmethod 2.0) of the EN 60350-1 test method, the oven is tested at ambient temperature, so pre-heating is not considered. Some stakeholders indicate that the inclusion of the preheating phase in the energy consumption declaration should be explored, as it is the way consumers use their oven. In this case (*Policy option 16b*), the energy consumption of pre-heating should be declared using a cycle with an empty cavity (no standard load).

It must be taken into account that including the declaration of energy consumption of pre-heating in product documentation might convey the idea that this is a necessary step in the cooking process. An alternative to avoid this issue would be to include, as an information requirement, recommendations on when to pre-heat and when not to pre-heat the oven (*Policy option 16c*).

7.3.5 Ecodesign minimum energy performance requirements

In this section, different options in terms of ecodesign minimum requirements will be evaluated. Based on the content presented in previous sections, it will be assumed that:

- BM2.0 is the preferred measurement method for electric ovens.
- As heating mode to declare energy consumption, two options will be considered: using BPM (*Policy option 8b*) or using weighted sum between Conventional and BPM (*Policy option 8c 50/50*)
- SEC linear regression

Current ecodesign regulation establishes minimum requirements in terms of EEI for domestic ovens as seen in Table 131.

Table 131. Ecodesign minimum requirements in current regulation

	EEI minimum requirements
February 2015	EEI <146
February 2016	EEI <121
February 2019	EEI <96

In Annex II of Directive 2009/2015 on ecodesign requirements for energy related products, it is stated that:

> *"Concrete measures must be taken with a view to minimising the product's environmental impact. Concerning energy consumption in use, the level of energy efficiency must be set aiming at the life cycle cost minimum to end-users"*

Results presented in Task 6 of this report indicate that the Least Life Cycle Cost (LLCC) design option is DO1. According to ecodesign regulation, the level of energy efficiency should be set to promote these type of products. In order to achieve that, lower thresholds of ecodesign compliance could be used as tiers for different years in the future.

With *policy option 8b* and current ecodesign limit (EEI=96), 69% of ovens in APPLIA2020 would not comply with minimum ecodesign requirements (blue dots above the black line in Figure 273). If new ecodesign thresholds are set at the LLCC, the limit should be set at EEI=86. In that case, 92% of ovens in APPLIA2020 would not comply.

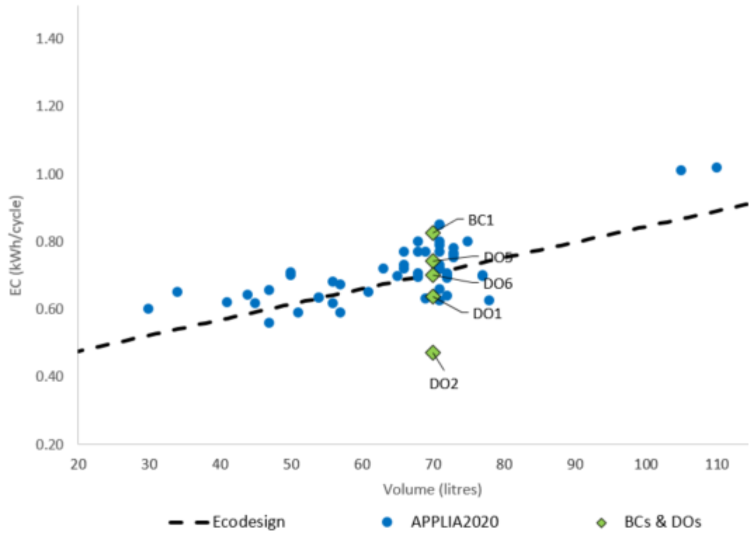


Figure 273. Policy option 8b – Ecodesign threshold

In a similar way, with *policy option 8c 50/50* and current ecodesign limit (EEI=96), 85% of ovens in the database would not comply with minimum ecodesign requirements (Figure 274). If new ecodesign thresholds are set at the LLCC, the limit could stay at current value (EEI=96). If the limits were set at EEI=86, no ovens in APPLIA2020 would comply.

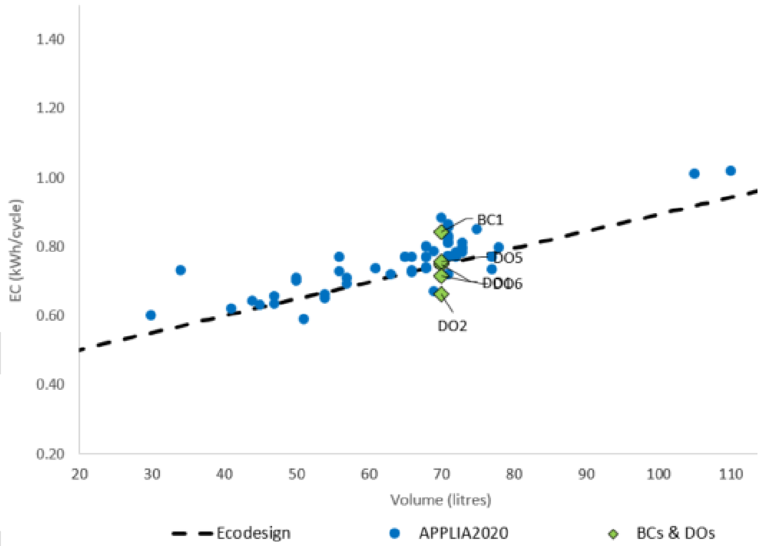


Figure 274. Policy option 8c – Ecodesign threshold

The consequences in terms of ecodesign compliance of the different ecodesign thresholds presented in this section can be seen in Figure 275.

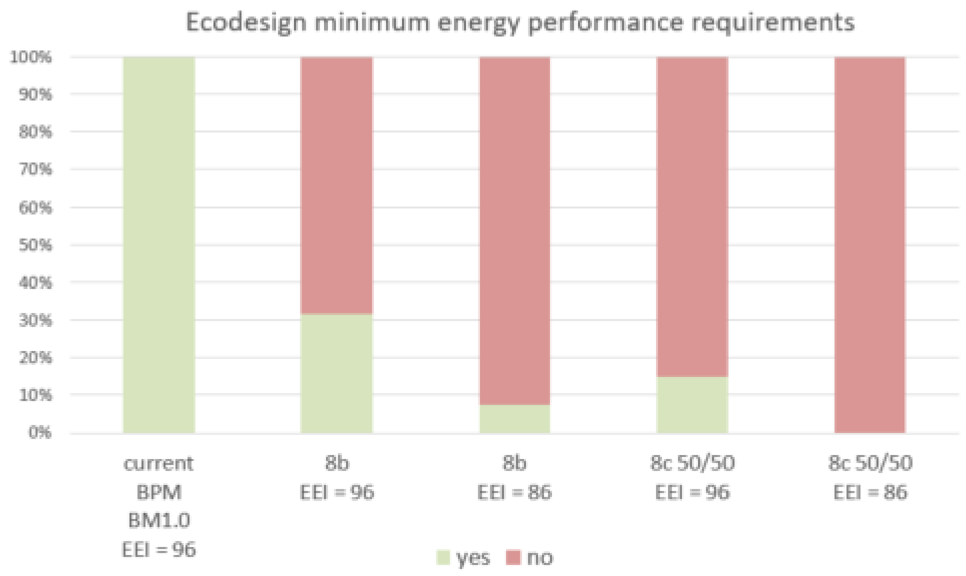


Figure 275. Consequences of lowering minimum ecodesign requirements

Firstly, it can be interpreted that the mere adoption of *Policy options 8b* or *8c* 50/50 (2nd and 4th columns in Figure 275) can be considered a significant strengthening of current ecodesign minimum requirements (compared with 1st column). Lowering the thresholds to EEI=86 makes it even stricter in terms of ecodesign compliance.

Therefore, different tiers could be used for the introduction of these minimum requirements, for instance the ones presented in Table 132.

Table 132. Ecodesign minimum energy performance requirements

Tier 1: 2025	**Tier 2: 2027**	**Tier 3: 2030**
Adoption of either *Policy option 8b* or *8c 50/50*. Ecodesign minimum: EEI < 96	Adoption of either *Policy option 8b* or *8c 50/50*. Ecodesign minimum: EEI < 91	Adoption of either *Policy option 8b* or *8c 50/50*. Ecodesign minimum: EEI < 86

7.3.6 Definition of energy label and energy classes

In this section, different options in terms of energy label and energy classes will be evaluated. Based on the content presented in previous sections, and in the same way it was done for ecodesign minimum requirements, it will be assumed that:

- BM2.0 is the preferred measurement method for electric ovens
- As heating mode to declare energy consumption, two options will be considered: using BPM (*Policy option 8b*) or using weighted sum between Conventional and BPM (*Policy option 8c 50/50*)
- SEC linear regression will be used by default

Current version of the energy label of ovens can be seen in Figure 276.

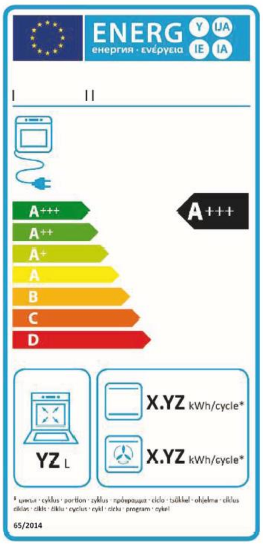


Figure 276. Current energy label

Energy consumption of the oven is an essential parameter for the energy label and should be visible in some manner. Current version of the label provides energy consumption as energy per cycle. Other cooking appliances (range hoods, for instance), provide energy consumption as annual energy. In the case of ovens, energy per cycle appears to be more relevant, as it is easier to define what a cycle is (in contrast with range hoods). According to user behaviour study: energy consumption for given standard program ranks 3rd in terms of importance, whereas assumed energy consumption per year ranks 5th. Some studies have analysed whether providing information in monetary terms (instead than in physical terms, such as electricity consumption) has an effect (Stadelman, 2018). Against their initial expectations, the authors indicate that a label with monetary and lifetime-oriented information does not lead to a larger reduction in mean expected electricity consumption than the current version of the EU Energy label.

Current version of the label includes information on the **energy consumption of different heating modes**: conventional and fan-forced. It has been suggested to declare the energy consumption of more heating modes in the oven. These additional heating modes could be declared either in the energy label – adding their respective symbols- or in simpler way in the user manual. To add any of those heating modes to the energy label or to the user manual, standard methods to measure their energy consumption would need to be available.

Current version of the label includes information on the **cavity volume**, in litres. As discussed in this section, cavity volume still is a relevant factor that defines and differentiates ovens. Cavity volume is also related to Standard Energy Consumption, and therefore to the EEI and the energy class (with current approach). However, cavity volume ranks quite low in terms of importance for the energy label, according to results from the user behaviour study: it is 9th parameter in terms of importance for consumers asked.

Some **material efficiency** aspects have been highlighted as important by consumers. For instance, expected lifetime ranks 4th in importance. The presence in the energy label of other aspects such as repairability (11th) and recyclability (13th) appear less relevant for consumers. However, material efficiency aspects are currently not considered for the label.

Smart and automatic functionality of ovens has not been highlighted as very important by consumers, as it ranks 12th among all the parameters available. However, it has been mentioned in this report that they can provide up to 15% energy savings when compared to conventional/fan-forced declared modes. These energy savings are not apparent to the consumer, since standard methods to measure energy consumption are not able to show them. Current version of the label does not show to consumers the energy saving benefits of ovens with such smart features. A potential modification of future energy label might include information on this aspect. Currently, it is difficult to determine the specific energy savings of cooking with these automatic features. Therefore, it does not seem feasible to include any figure in terms of percentage informing about the potential savings. An alternative to that could be to introduce a symbol in the label that indicates the availability of automatic functionality.

Other functions of the oven are in a similar situation as the automatic functionality. This is the case of **microwave combined heating modes**. As it has been presented in various sections of this report, this function might offer an average of 10% energy savings when compared to conventional/fan-forced modes. These energy savings are not apparent to the consumer, since there are no standard methods to measure energy consumption of these modes. Current version of the label does not show to consumers the energy saving benefits of ovens with microwave combined modes. A potential modification of future energy label might include information on this aspect. Currently, it is difficult to determine the specific energy savings of cooking with these MW combined features. Therefore, it does not seem feasible to include any figure in terms of percentage informing about the potential savings. An alternative to that could be to introduce a symbol in the label that indicates the availability of microwave combined modes.

Other parameters with different level of importance mentioned by consumers that could be evaluated for inclusion in the next version of the energy label are: **maximum temperature** the oven can operate (7th), time needed for **pre-heating** (8th) and product **dimensions** (9th).

In terms of label layout, Russo et al (2018) highlighted some of the potential limitations of current labels. For instance, the authors indicate that style and format sometimes do not allow easy comparison with other similar product models in the market, limiting the label effectiveness. Grankvist et al (2004) also found differences in consumers' response, depending on their viewpoint about environmental issues and on the fact that the label is "positive" or "negative". According to their results, people with less environmental concerns were more sensitive to "negative" labels, for instance, warnings informing that a product is disadvantageous from an environmental point of view respect to another one.

Another aspect to consider is the **rescaling of the energy classes**. According to energy label regulation, "rescaling" means an exercise making the requirements for achieving the energy class on a label for a particular product group more stringent. As already indicated at the beginning of this section, REG 2017/1369 states that:

> *The Commission shall review the label with a view to energy classes rescaling if it estimates that:*
>
> *(a) 30 % of the units of models belonging to a product group sold within the Union market fall into the top energy efficiency class A and further technological development can be expected; or*
>
> *(b) 50 % of the units of models belonging to a product group sold within the Union market fall into the top two energy efficiency classes A and B and further technological development can be expected.*

Market data available at this point shows that these conditions are met, so in principle, a rescaling of the energy classes would be necessary. Also on the matter of rescaling, REG 2017/1369 states that:

> *For several labels established by delegated acts adopted pursuant to Directive 2010/30/EU, products are available only or mostly in the top classes. This reduces the effectiveness of the labels. The classes on existing labels, depending on the product group have varying scales, where the top class can be anything between classes A to A+++. As a result, when customers compare labels across different product groups, they could be led to believe that better energy classes exist for a particular label than those that are displayed. To avoid such potential confusion, it is appropriate to carry out, as a first step, an initial rescaling of existing labels, in order to ensure a homogeneous A to G scale.*
>
> *A newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised. In exceptional cases, where technology is expected to*

develop more rapidly, no products should fall within the top two classes at the moment of introduction of the newly rescaled label.

With the aim of showing the potential consequences of a rescale, in the next sections different options will be presented:

- Rescaling of the energy classes: 7.3.6.1
- Adjusting thresholds to promote product differentiation: 7.3.6.2
- Adjusting thresholds to promote product innovation: 7.3.6.3

7.3.6.1 Rescaling energy classes

As already mentioned above, a newly rescaled label should leave the top class empty to encourage technological progress, provide for regulatory stability, limit the frequency of rescaling and enable ever more efficient products to be developed and recognised.

One way of rescaling could be with the adoption of *policy options 8b* and *8c 50/50* and renaming the energy classes from A to G (Table 133).

Table 133. Rescaling of energy classes

Energy efficiency class	Energy Efficiency Index
A	EEI < 45
B	45 ≤ EEI < 62
C	62 ≤ EEI < 82
D	82 ≤ EEI < 107
E	107 ≤ EEI < 132
F	132 ≤ EEI < 159
G	EEI < 159

With *policy option 8b* and a renaming of the energy classes, 2% of ovens in APPLIA2020 would be C, 76% would be D and 22% would be E (Figure 277).

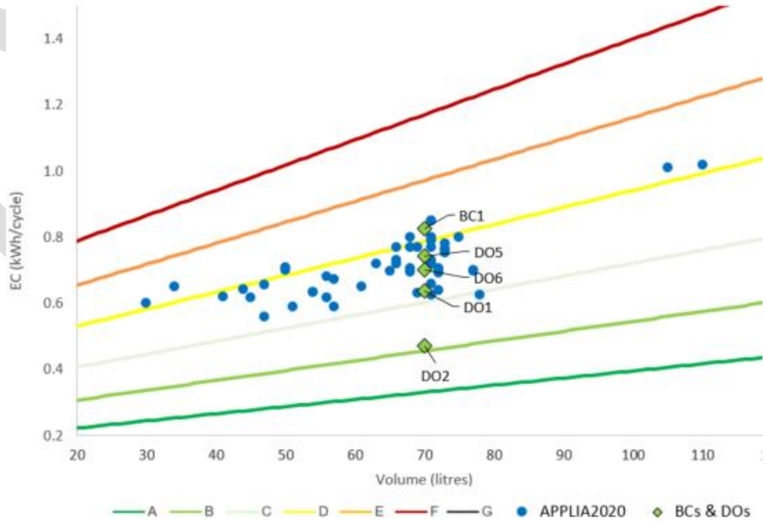


Figure 277. Policy option 8b and rescaling energy classes

With *policy option 8c 50/50* (Figure 278) and a renaming of the energy classes, 91% of ovens in APPLIA2020 would be D and 9% would be E.

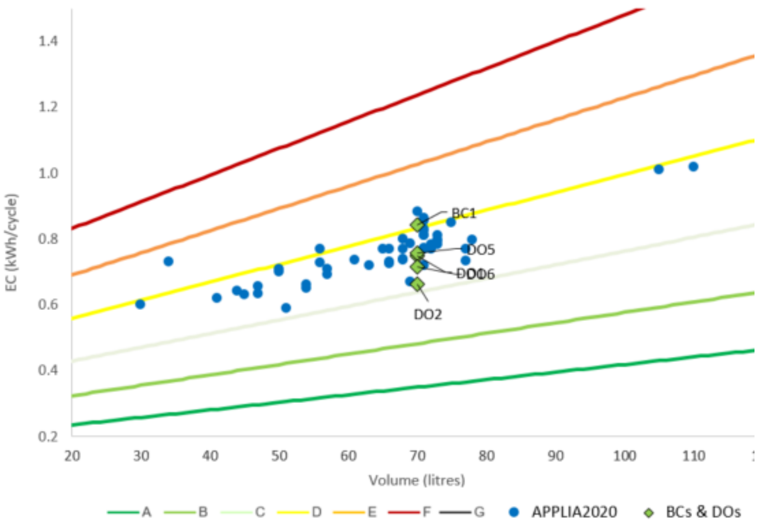


Figure 278. Policy option 8c 50/50 and r energy classes

The mere adoption of *policy options 8b* or *8c 50/50* would be a drastic change for electric ovens in terms of energy class. For instance, with *policy option 8b*, a 70-litre oven should have a BPM of 0.34 kWh/cycle in order to reach class A. With *policy option 8c 50/50*, a 70-litre oven should have a weighted sum energy consumption of 0.37 kWh/cycle.

The best 70-litre oven in APPLIA2020 has a BPM of 0.63 kWh/cycle and a weighted sum energy consumption of 0.67 kWh/cycle. The best design option presented in this report has a BPM of 0.47 kWh/cycle and a weighted sum energy consumption of 0.66 kWh/cycle. In summary, the mere adoption of *policy options 8b* or *8c 50/50* makes it a challenge to reach the top energy class A.

The size of the steps between energy classes must also be taken into account. Both with *policy options 8b* and *8c 50/50*, the step difference between energy classes is smaller than 0.15 kWh in some areas, but still within the 0.10-0.15 kWh range (Table 134 and Table 135).

Table 134. Step difference with policy option 8b

	Step difference (kWh)			Step difference (%)		
	35 l	70 l	100 l	35 l	70 l	100 l
A+++ - A++	0.10	0.13	0.15	27%	27%	27%
A++ - A+	0.11	0.15	0.18	24%	24%	24%
A+ - A	0.14	0.18	0.22	23%	23%	23%
A - B	0.14	0.18	0.22	19%	19%	19%
B - C	0.15	0.20	0.24	17%	17%	17%

Table 135. Step difference with policy option 8c 50/50

	Step difference (kWh)			Step difference (%)		
	35 l	70 l	100 l	35 l	70 l	100 l
A+++ - A++	0.10	0.13	0.16	27%	27%	27%
A++ - A+	0.12	0.16	0.19	24%	24%	24%
A+ - A	0.15	0.19	0.23	23%	23%	23%
A - B	0.15	0.19	0.23	19%	19%	19%
B - C	0.16	0.21	0.25	17%	17%	17%

A simple rescaling of the energy classes has certain disadvantages. First, most of the ovens are shared among few energy classes. Also, the gap between the top energy classes is still considerably wide, reducing the incentive for manufacturers to invest in technologies that allow closing that gap. In next sections, alternative energy classifications are presented to tackle those disadvantages**.**

7.3.6.2 Adjusting thresholds to promote differentiation

One of the key aspects of an energy label is product differentiation in terms of energy classes. The analysis of APPLIA2020 in previous sections has shown that most of the ovens in the market are located in few energy classes. The improvement potential of design options presented in Task 6 reinforces that idea, since the technologies presented reduce energy consumption by a low margin.

In this section, an alternative energy classification is presented, in order to promote a higher differentiation between appliances. In this classification, the threshold of the top energy class has been risen by 25% in order to make it more achievable than with current thresholds. Then, an equal 14% different has been established between each energy class. The resulting classification can be seen in **Table 136**.

Table 136. Energy classification to promote differentiation

Energy efficiency class	Current Energy Efficiency Index	Energy Efficiency Index adjusted
A	EEI < 45	EEI < 56
B	45 ≤ EEI < 62	56 ≤ EEI < 65
C	62 ≤ EEI < 82	65 ≤ EEI < 76
D	82 ≤ EEI < 107	76 ≤ EEI < 89
E	107 ≤ EEI < 132	89 ≤ EEI < 103
F	132 ≤ EEI < 159	103 ≤ EEI < 120
G	EEI > 159	EEI > 120

With this alternative classification, the ovens in APPLIA2020 would be in the energy classes shown in Figure 279. As it can be seen, the top energy classes would still remain empty with this approach. 4% of the ovens would be D, 67% E, 28% F and 2% G.

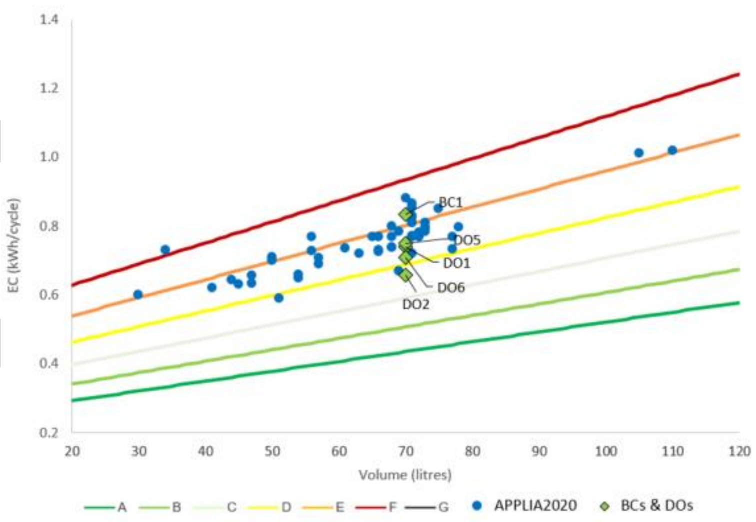


Figure 279. Adjusting thresholds to promote differentiation

However, there is a drawback with this approach. Since ovens in APPLIA2020 are clustered in a small area of the EC-Volume graph, if the energy class thresholds are narrowed to promote product differentiation, the steps between the energy classes are smaller (Table 137).

Table 137. Step difference with energy classes to promote differentiation

	Step difference (kWh)			Step difference (%)		
	35 l	70 l	100 l	35 l	70 l	100 l
A+++ - A++	0.06	0.07	0.09	14%	14%	14%
A++ - A+	0.06	0.08	0.10	14%	14%	14%

A+ - A	0.08	0.10	0.12	14%	14%	14%
A - B	0.09	0.11	0.14	14%	14%	14%
B - C	0.10	0.13	0.16	14%	14%	14%

7.3.6.3 Adjusting thresholds to promote innovation in top energy classes

A potential way to promote innovation in the top energy classes could be to have energy classes where the steps are shorter in the top ones and larger in the bottom ones. This way, it would reward manufacturers investing in the most innovative and potentially most expensive technologies. An example of this approach is shown in this section. In this classification, the threshold of the top energy class has been risen by 25% in order to make it more achievable than with current thresholds. Then, a gap of 11% has been established between the top 3 energy classes and a 20% gap between the rest. The thresholds of this classification can be seen in Table 138.

Table 138. Energy classification to promote innovation in top energy classes

Energy efficiency class	Current Energy Efficiency Index	Energy Efficiency Index adjusted
A	EEI < 45	EEI < 56
B	45 ≤ EEI < 62	56 ≤ EEI < 63
C	62 ≤ EEI < 82	63 ≤ EEI < 71
D	82 ≤ EEI < 107	71 ≤ EEI < 80
E	107 ≤ EEI < 132	80 ≤ EEI < 100
F	132 ≤ EEI < 159	100 ≤ EEI < 125
G	EEI > 159	EEI > 125

With this alternative classification, the ovens in APPLIA2020 and the BC and DOs would be in the energy classes shown in Figure 280. As it can be seen, the top energy classes would still remain empty with this approach. 54% of the ovens would be E and 46% F.

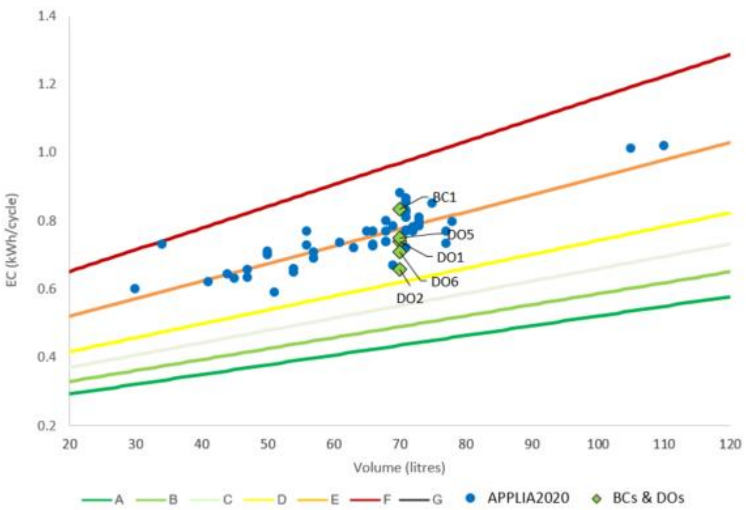


Figure 280. Adjusting thresholds to promote innovation in top energy classes

With this approach, an oven in the E energy class is very close to the D energy class and relatively close as well to the top A, B and C energy classes. This could work as an incentive to invest in those technologies that allow reducing this gap, generally more costly that the technologies needed to progress between E and D classes, for instance.

One of the potential disadvantages of this approach is that it requires very short steps between the top energy classes (Table 139).

Table 139. Step difference with energy classes to promote innovation in top energy classes

	Step difference (kWh)			Step difference (%)		
	35 l	70 l	100 l	35 l	70 l	100 l
A+++ - A++	0.04	0.05	0.07	11%	11%	11%
A++ - A+	0.05	0.06	0.07	11%	11%	11%
A+ - A	0.05	0.07	0.08	11%	11%	11%
A - B	0.12	0.16	0.19	20%	20%	20%
B - C	0.15	0.19	0.23	20%	20%	20%

7.3.6.4 Summary of energy classifications proposed for electric ovens

In this section, a comparison of the three alternative energy classifications shown in previous sections is presented (Figure 281).

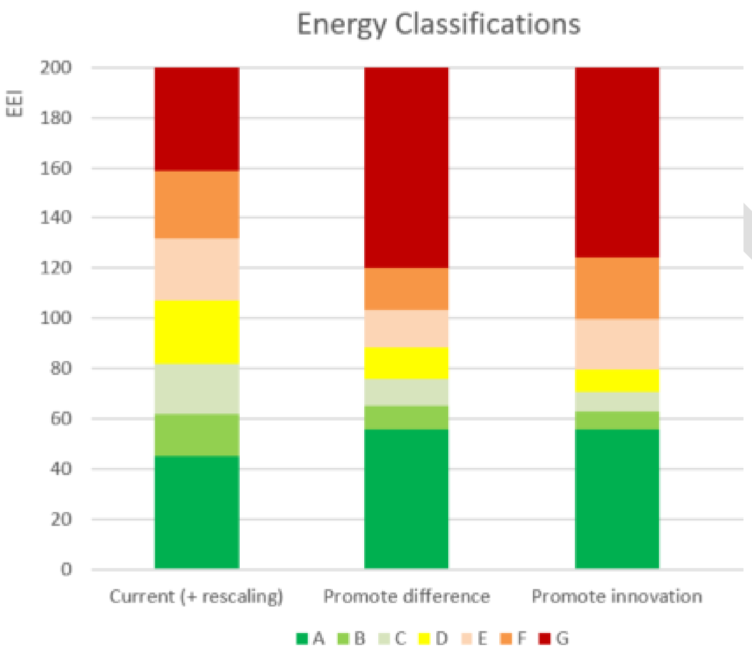


Figure 281. Comparison of energy classifications

With current thresholds and rescaling, the top energy class A is stricter than the other two alternatives. Then, thresholds for the lower energy classes are less strict with this option (see F energy class, for instance).

With the second alternative (promote difference), it becomes easier to get an A energy class, but the limits for the lower energy classes are stricter. In a similar way happens with the third alternative (promote innovation). In this case, the gap between the top energy classes is narrower to promote investment in technologies with significant potential of improvement.

7.4 Policy options for gas ovens

In 2020, the stock of gas ovens is estimated as 15% of the total. Although the total stock of ovens will grow between 2020-2040, by that year, it is estimated that the stock of gas ovens will be around 8% of the total. Despite this decreasing tendency, due to issues related to access to energy source, there will always be certain demand of gas ovens. Therefore, it makes sense to consider some specific policy options for gas ovens in new version of the regulation.

In 2012, CECED generated a database of ovens in support of previous preparatory study (Mugdal et al, 2011). This database contained information on 1456 gas ovens. In Figure 282, the database is represented using best performing mode and measuring with BM1.0. In absence of more recent data, preliminary analysis will be conducted on gas ovens using this database. In this report, this database will be known as CECED2012.

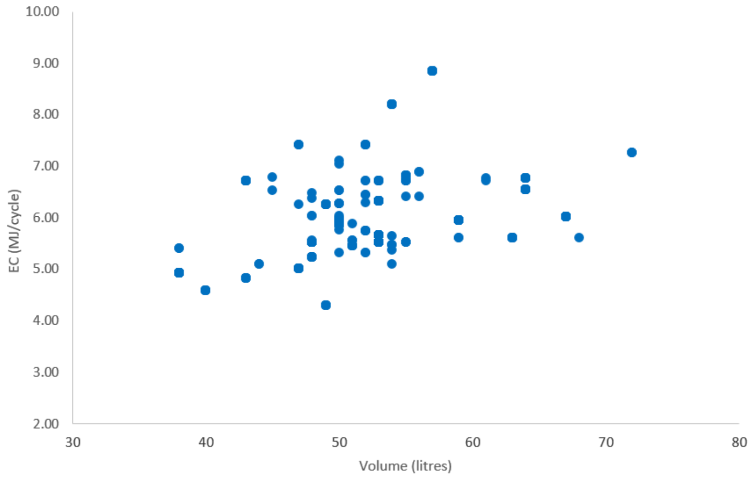
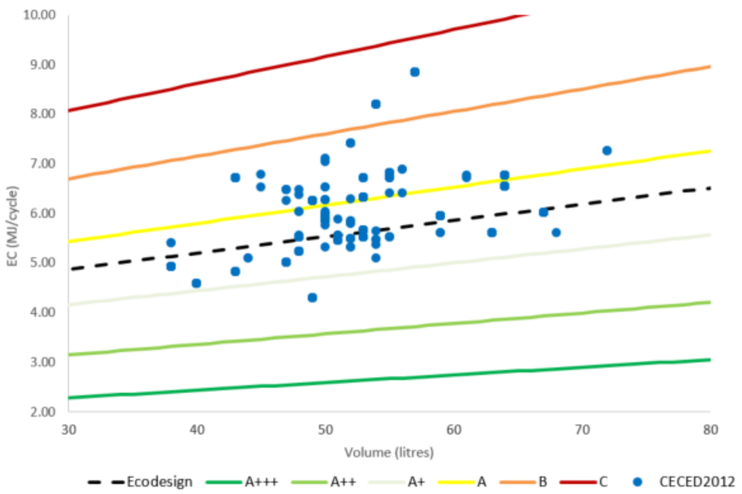


Figure 282. CECED database of gas ovens 2012 (CECED2012)

Current SEC for gas ovens in regulation is:

SEC = 0.044*V + 3.53 (in MJ).

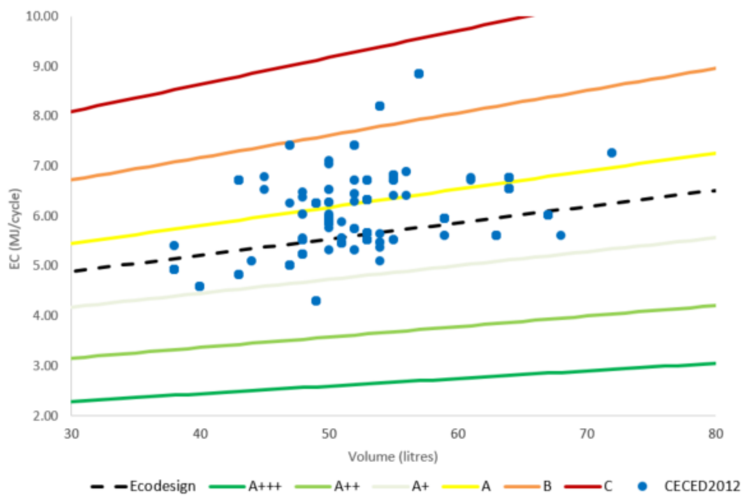
In section 7.3.4.1, an analysis was conducted regarding the update of the SEC curve for electric ovens. Ideally, when data is available, a similar analysis should be made for gas ovens, to evaluate if the market of these appliances has evolved towards more efficient products. Considering data from CECED2012, measuring energy consumption with BM1.0, taking into account best performing mode and current energy classification thresholds, ovens in CECED2012 would get the energy classes as in Figure 283: 1% of ovens would be A+, 82% would be A, 14% would be B and 3% would be C.



SEC = 0.034*V + 4.05 (in MJ)

Figure 283. CECED2012. Best Performing Mode

In section 7.3.4.3, an analysis was conducted regarding which heating mode should be used for energy declaration and obtaining the energy class. When new data is available for gas ovens, a similar analysis should be made for gas ovens. For now, a preliminary analysis has been conducted with CECED2012. For instance, if an equivalent to *policy option 8c 50/50* is taken for gas ovens, the consequences in terms of energy classes can be observed in Figure 175. The percentages between energy classes are equivalent to the previous policy option.



SEC = 0.034*V + 4.08

Figure 284. CECED2012. Weighted sum 50/50 between Conventional and BPM

In section 7.3.5, ecodesign minimum energy performance requirements were presented for electric ovens, taking into account the Least Life Cycle Cost of the design options presented in Task 6. The LLCC of gas ovens is BC2. According to this, ecodesign minimum requirements for gas ovens in new regulation should be set at EEI=91. Any ovens with EEI higher than this value should be progressively removed from the market. (Figure 285). With this measure in place, only 7% of ovens in CECED2012 would comply with them.

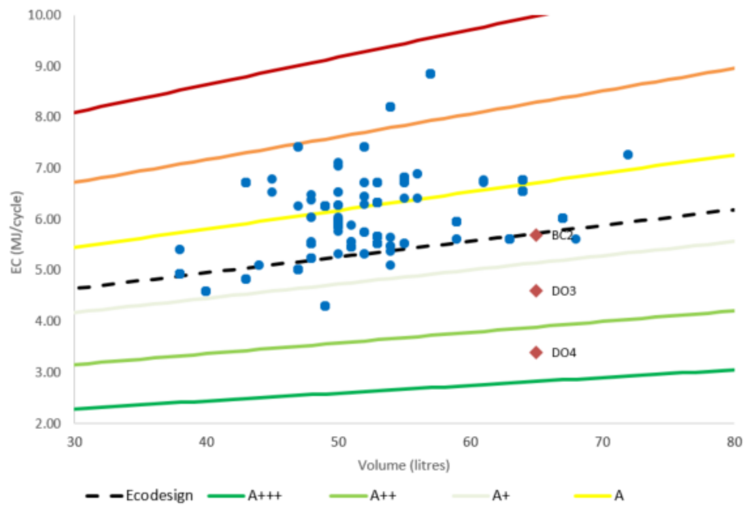


Figure 285. CECED2012. Weighted sum 50/50 and Ecodesign thresholds

In section 7.3.6, some alternatives were presented in relation to the definition of energy classes for electric ovens. Ideally, an equivalent analysis on gas ovens should be conducted when new data is available. For now, preliminary equivalent analysis have been conducted with CECED2012. In Figure 286, a pure renaming of the energy classes (from A to G) has been evaluated: 1% would be C, 82% would be D, 15% would be E and 3% would be F.

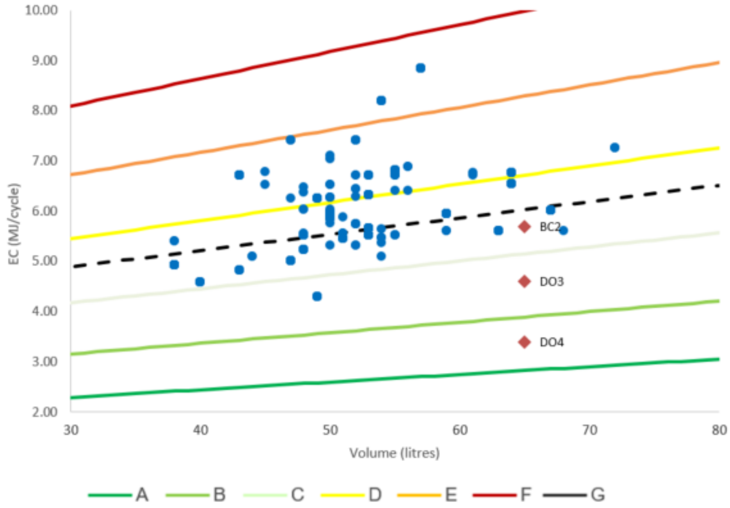


Figure 286. CECED2012. Renaming of energy classes

In Figure 287, the threshold of the top energy class A is raised by 25% and a 14% gap has been established between energy classes. With this approach, 1% would be C, 4% would be D, 68% would be E, 21% would be F and 6% would be G.

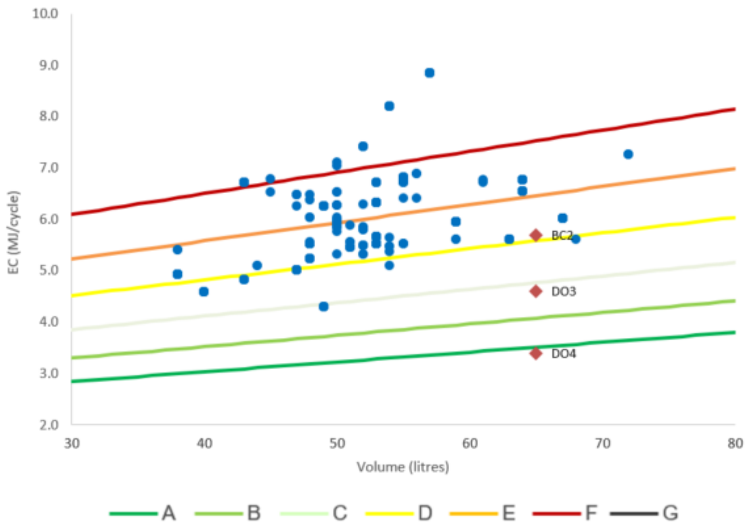


Figure 287. CECED2012. Promote differentiation

In Figure 288, the threshold of the top energy class A is raised by 25% and an unequal gap has been established between energy classes: 11% gap between A, B and C energy classes, and 20% between the rest. With this approach, 1% would be D, 64% would be E, 31% would be F and 3% would be G.

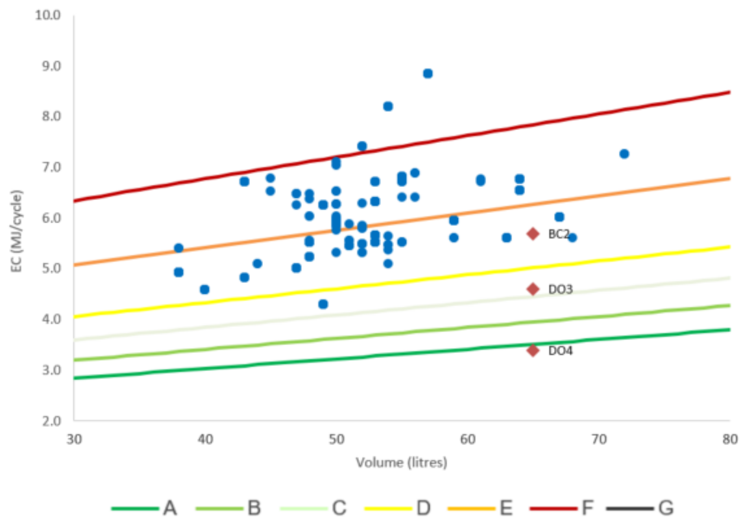


Figure 288. CECED2012. Promote innovation

In Figure 289, the flat approach for SEC is evaluated for gas ovens (with constant 14% gap between classes). With this approach, 1% would be C, 9% would be D, 71% would be E, 16% would be F and 4% would be G.

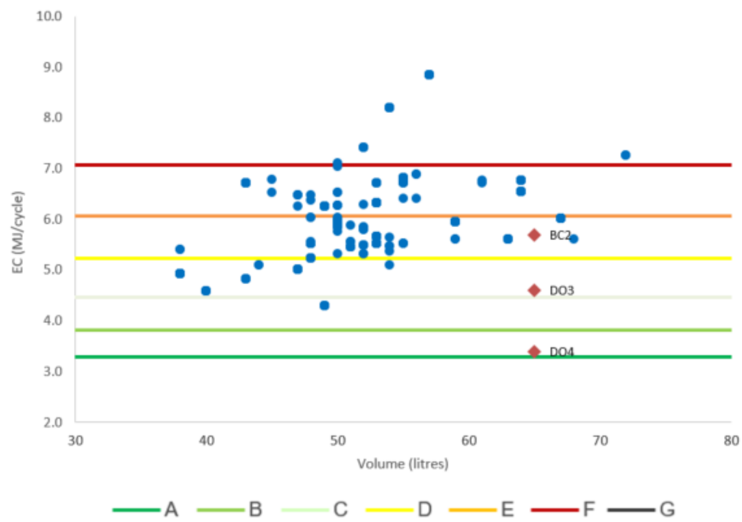


Figure 289. CECED2012. Flat approach and promote differentiation

In Figure 290, the logarithmic approach for SEC is evaluated for gas ovens (with constant gap of 14% between classes). With this approach, 1% would be C, 4% would be D, 68% would be E, 21% would be F and 6% would be G.

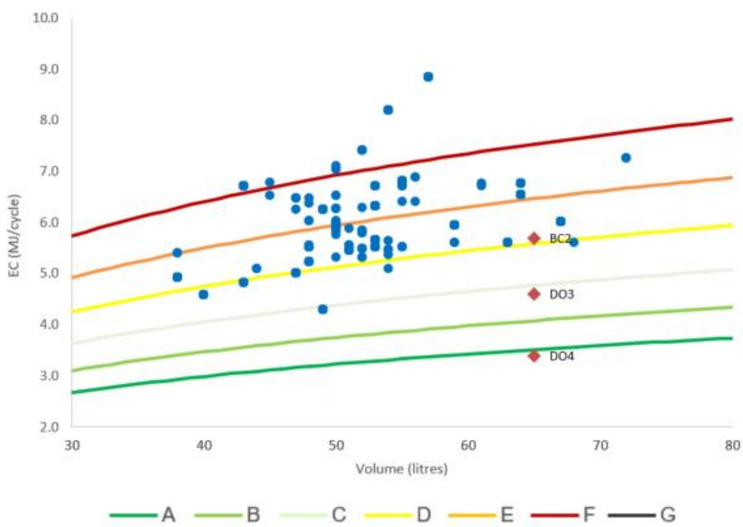


Figure 290. CECED2012. Logarithmic approach and promote differentiation

In Figure 291, the power approach for SEC is evaluated for gas ovens (with a constant 14% gap between classes). With this approach, 1% would be C, 2% would be D, 65% would be E, 27% would be F and 6% would be G.

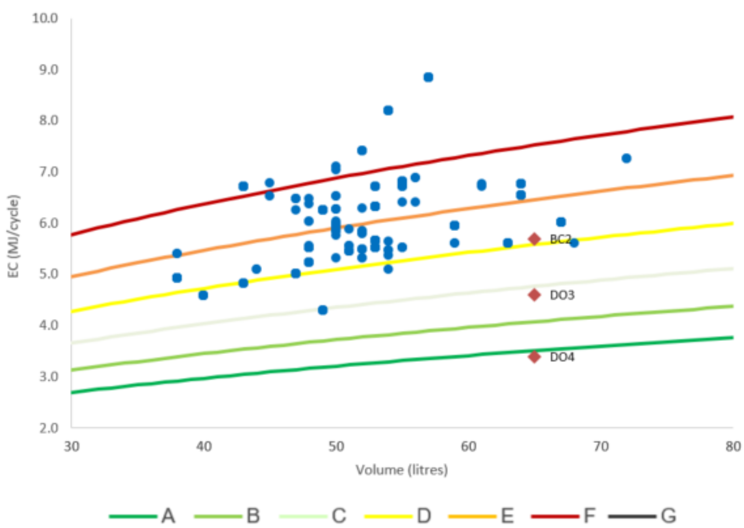


Figure 291. CECED2012. Power approach and promote differentiation

As already indicated in this section, there is no available data on current gas ovens, so all analysis have been conducted using CECED2012. Therefore, it should be to taken into account that average energy consumption of gas ovens might have improved between 2012 and 2020. Ideally, the analysis conducted in this section should have been done with more up to date data.

As in the case of electric ovens, several different approaches are available for gas ovens. For simplification, it is recommended that the approaches taken for electric and gas ovens are equivalent. For instance, if a weighted sum 50/50 approach is taken to declare energy consumption of electric ovens, the same should be done with gas ovens. Equally, if a flat approach is followed for the definition of SEC in electric ovens, it should be done in the same way for gas ovens.

7.4.1 A combined label for electric and gas ovens

Current energy label regulation has two different labels for ovens: one for electric and one for gas appliances. From a customer perspective, it might appear that it is just one label, since the appearance between the two is almost identical, only differentiated by the symbol identifying the energy source on the top left corner.

It might also appear that electric and gas ovens are under the same energy classification, since the thresholds of the classes are the same. However, they are different. EEI for energy and gas appliances is calculated taking as reference the market average for each of those energy sources, separately. In other words, an electric oven is compared with the market of electric ovens; and a gas oven is compared with the market of gas ovens. Therefore, energy classes of electric and gas ovens cannot be compared directly. An "A+++" electric oven would the best among the electric ovens only; the same way that a "G" gas oven would be the worst, only among gas ovens.

This approach assumes that, although they are used for the same purpose, electric and gas ovens are slightly different type of appliances, not only in terms of energy source, but also in terms of functionalities. Due to the nature of the energy source, gas ovens are generally more basic in terms of functionalities and heating modes.

An issue related with this approach is that one consumer might understand that it is the same label for electric and gas appliances, so they can directly compare electric and gas appliances in terms of their energy performance. If that consumer can choose between electric and gas as an energy source, they might understand that an "A" electric oven and an "A" gas oven have the same energy performance.

A relevant question at this point is: "*How likely is it that a consumer will make that comparison and make the choice of energy source based on that?*" According to the User behaviour study presented in Task 3, the main aspects when buying a new oven are, in order of importance: energy efficiency/class (2.8), purchase price (3.0), energy source (3.2). The number in brackets is the average score obtained, from most important (1) to least important (6). The scores for energy efficiency/class and energy source are very close, so from the study it cannot be concluded that one aspect is significantly more important than the other.

Some stakeholders support a comprehensive and comparable labelling that does not differentiate between gas and electricity. In their view, the main objective of ecodesign and energy labelling regulation is to reduce overall energy consumption (primary energy), so every decision should be taken assessing how much primary energy is consumed or saved. When gas and electricity are compared, what needs to be compared is the primary energy consumed, so a factor to convert electric energy to primary energy should be applied (today this factor is assumed as 2.1).

There are some drawbacks related to a combined label for electric and gas ovens. First, current standards methods for electric and gas ovens are not directly comparable because the cycles are slightly different, so the direct application of a factor to convert electric energy to primary energy is not feasible. The new version of the electric standard method (BM2.0) is even more different to the gas method. Second, the average consumer is not aware of the "primary energy" concept, so a significant effort to educate them would be required, in order to explain a potentially big change in the positioning of electric and gas appliances within the energy classes.

Another relevant question at this point is: "*Can electric and gas appliances be compared using a final energy approach?*" In current situation, final energy consumption of electric and gas ovens can be compared with a simple change of units (1 kWh = 3.6 MJ), assuming best performing mode and BM1.0 (Figure 292). Electric ovens correspond to ovens tested in 2020 and gas ovens are appliances tested in 2012 (CECED2012).

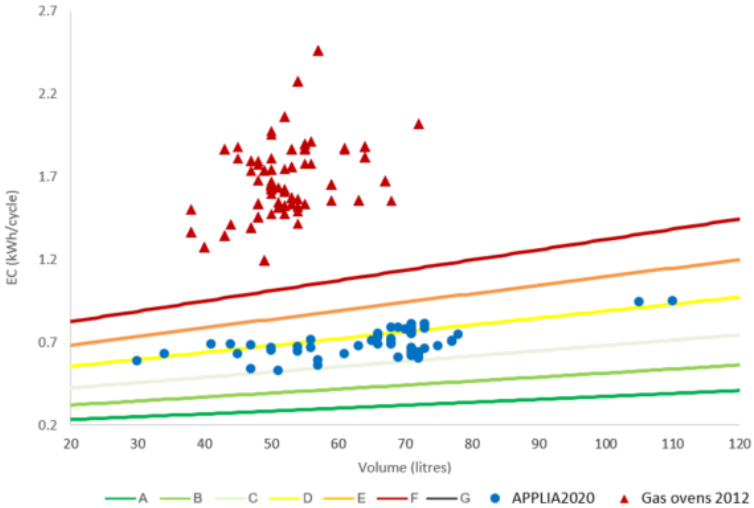


Figure 292. Current energy label – BPM BM1.0 – APPLIA2020 vs CECED2012

As it can be seen, electric and gas ovens are represented in completely different areas of the EC-Volume graph. If they were combined under the same label (with current energy classification), gas ovens would only get D class, and none of them would comply with ecodesign regulation.

However, one must consider if such a comparison is correct. Electricity is an energy carrier that can be generated from primary sources such as coal, oil, gas, solar, air, nuclear, etc. Generating that electricity has energy losses along the production and distribution chain. Therefore, a direct comparison between gas and electricity in terms of final energy consumption can be considered as "unfair", since it does not account for those upstream losses. Hence the use of the primary energy factor (PEF).

If a PEF=2.1 is used for the electricity consumed by ovens, the comparison between electric and gas appliances start to make sense (Figure 293). Electric and gas appliances would be represented in the same areas of the EC-Volume graph. However, most of the least efficient ovens would still be gas.

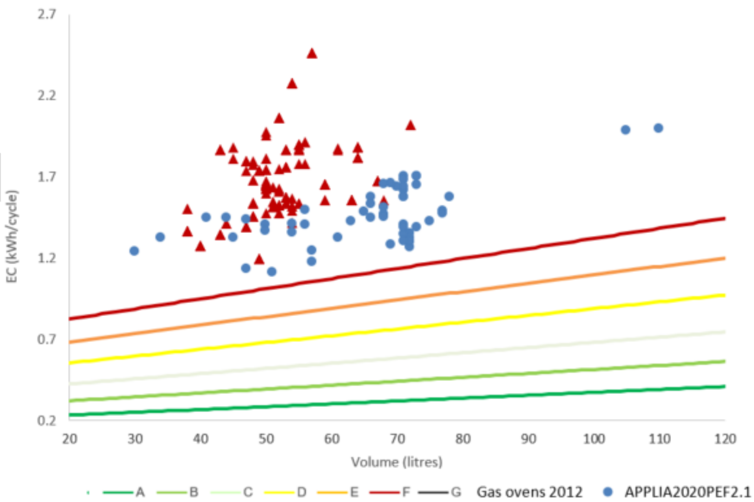


Figure 293. Current energy label – BPM BM1.0 – APPLIA2020 (PEF=2.1) vs CECED2012

From the analysis of the above graphs, it can be concluded that, any approach that combines electricity and gas under the same label that does not consider a PEF for electricity would remove almost every gas appliance from the market. Even with a PEF = 2.1, if no significant improvement has happened in gas ovens between 2012 and 2020, most of the gas appliances would be removed from the market with current energy classification.

Another relevant question regarding the comparison between gas and electricity is: "*Can electric and gas ovens be compared in terms of functionality?*" In the case of hobs, some stakeholders defend that this direct comparison is unfair, as the cooking techniques (and results) of cooking with gas and electricity are not the same. In fact, some consumers will always prefer cooking with gas hobs (or the other way around) due to these specific results in the food. It is unclear if the same reasoning can be applied for the comparison between gas and electric ovens.

Due to the nature of the two energy sources, electric and gas ovens offer very different functionalities to the users. Electric ovens can easily offer energy saving or automatic functions, as well as other modes such as steam-assisted or microwave-combi, whereas gas ovens generally offer two or three basic modes. The price of the appliances is also different, accordingly. If gas ovens are removed from the market due to the introduction of a combined label, a significant proportion of basic (and cheaper) ovens will not be available for consumers.

On top of that, it must be considered that the oven industry has been developing over the last years a standard method to measure energy consumption of electric ovens, with the aim of tackling issues related to circumvention in the use of energy saving modes. This method (known as BM2.0) is at the end of its development phase and will be applicable to electric ovens only. Therefore, although the general principles of the methods for electric and gas ovens will be similar (heating up a brick), the specific conditions of the tests will be different (for instance, different temperature settings). Therefore, a direct comparison –that is, a combined label- will not be possible if the new standard method is adopted for electric ovens. The comparison between electric and gas ovens is only valid if BM1.0 is used in both cases.

7.5 Policy options for hobs

7.5.1 Policy options related to scope

As explained in Task 1, small (auxiliary) burners with a nominal heat input under 1.16 kW are not covered by the current standard, since the test procedure is not optimal for them (they are not normally used for boiling big amounts of water).

The inclusion of small burners within the scope of Ecodesign measures have discussed during the review process. A specific simmering test method is being studied in order to measure their efficiency.

In terms of type of gases being covered by ecodesign regulation of cooking appliances, it is worth reminding at this point that current regulation leaves out of the scope, those appliances designed for use only with gases of the 3rd family (butane and propane). However, this exception has no big sense nowadays, so appliances which work with gases of the 3rd family are recommended to be included in the scope.

7.5.2 Feasibility of energy labelling for hobs

An energy label classification is meaningful if there is enough differentiation between the products in the market in terms of energy efficiency. Manufacturers shared the range of energy consumption that the three types of electric hobs (solid plate, radiant heater and induction) typically perform (Figure 175). In a red line, the ecodesign limit for energy consumption after 2019 is displayed (195 Wh/kg).

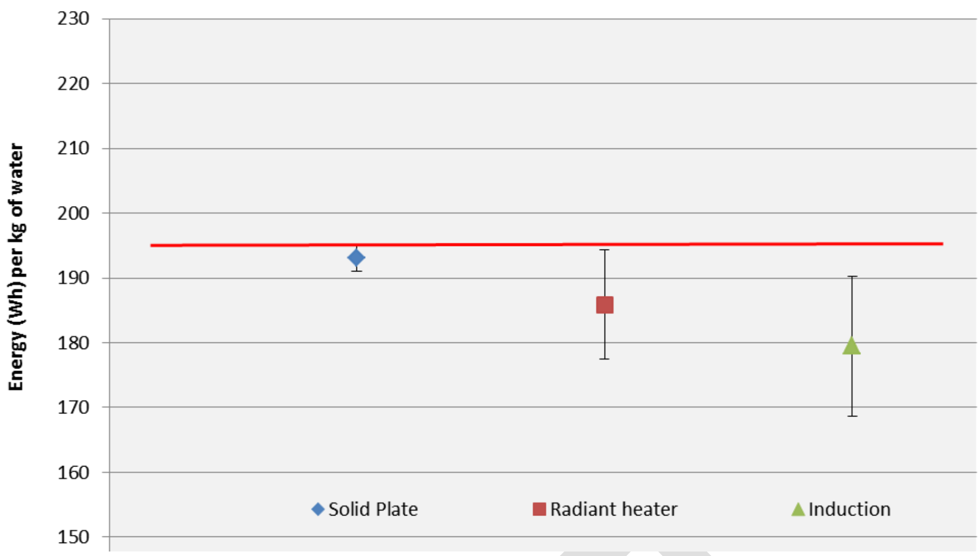


Figure 294. Energy consumption ranges of electric hobs (APPLIA)

As can be seen in Figure 175, there is a small difference between the energy consumption of the three technologies under comparison. It is important to notice that this differentiation is also due to the number of heating zones, i.e. the graph shows the range of efficiencies of hobs of different numbers of heating zone. If the figure represented the efficiencies of hobs with the same number of heating zones, this range would be smaller.

7.5.3 Ecodesign minimum requirements

In this section, different options in terms of ecodesign minimum requirements will be evaluated.

Current ecodesign regulation establishes minimum requirements in terms of energy consumption for domestic hobs as seen in Table 140.

Table 140: Minimum energy consumption for hobs requirements in current Ecodesign

	Electric hob (Energy consumption in Wh/kg)	**Gas-fired hob (energy efficiency in %)**
February 2015	< 210	> 53
February 2017	< 200	> 54
February 2019	< 195	> 55

The current regulation included the following indicative benchmarks:

Table 141: Indicative benchmarks for hobs in current Ecodesign

Technology	**Benchmark**
Electric	169.3 Wh/kg
Gas	63.5%

It is important to highlight that these indicative benchmarks do not distinguish among the different number of heating zones that has an influence in the efficiency of the hob.

The policy options proposed for the update of the minimum requirement is shown in Table 142.

Table 142: Policy options proposed for electric and gas hobs

Option 1: common minimum requirement for electric hobs			
	Electric hob (Energy consumption in Wh/kg)	**Gas-fired hob (energy efficiency in %)**	
February 2021	< 190	> 56	
February 2023	< 180	> 57	
February 2025	< 175	> 58	
Option 2: different minimum requirements for radiant and induction hobs			
	Radiant hob (Energy consumption in Wh/kg)	**Induction hob (Energy consumption in Wh/kg)**	**Gas-fired hob (energy efficiency in %)**
		< 185	> 56
February 2023	< 190	< 180	> 57
February 2025	< 185	< 175	> 58

The market analysis shows that induction technology is steadily replacing radiant technology in the EU households. The sales of induction hobs double the sales of radiant hobs, and the stock projection shows that by 2030, the number of induction hobs will surpass the radiant hobs. This technology replacement has been underpinned by the current Ecodesign regulation, which sets a common requirement for electric hobs. This requirement is much easier to fulfil for induction hobs. At this point, stricter common requirements would equal to banning radiant hobs, since no further improvement is feasible. This would result in energy savings, though its impact on the consumer's choices would be severe. According to the User behaviour study, 'Purchase price' and 'Convenience of use' are features with a significant weight on the purchase decision, therefore induction technology may not fulfil the consumer's budget and/or cooking habits. However, setting different thresholds for radiant and induction hobs would deviate from the current technology-neutral approach, which would be deemed the appropriate approach for products delivering the same function and using the same type of energy.

The indicative benchmarks are proposed to remain unchanged. In the case of gas hobs, there is no evidence that the technology is able to go beyond the current benchmark, without compromising the safety of the product. In the case of electric hobs, the improvement potential is linked to the induction technology, which is developing towards flexible cooking zones hobs. The flexible cooking area has an impact on the efficiency of the hob, increasing the energy consumption as measured by EN 60350-2. According to TopTen, there is no flexible hob within the group of most efficient induction hobs. However, the market penetration of this product is steadily increasing: from 500 000 units in 2015 to 800 000 in 2018.

Some stakeholders (NGOs) have proposed to set a technology-neutral approach for all types of hobs, i.e. common requirements for electric and gas hobs. This option is not recommended at this moment, since the test methods available for electric and gas hobs are completely different and not comparable. Besides, the energy consumption would need to be expressed as primary energy, to allow for a fair comparison among the different energy sources. That would require to consider the evolution of the electricity and gas mixes in EU and its shares of renewable energy sources. This would constitute an external factor that would dilute the impact of the product design and technology in the energy saving potential.

7.5.4 Possible policy options for future revisions

As explained in the previous sections, the improvement potential of induction hobs is reaching a peak and the technology is expected to plateau in the next years. However, there is room for improvement if induction technology is considered as a cooking system that encompasses cookware.

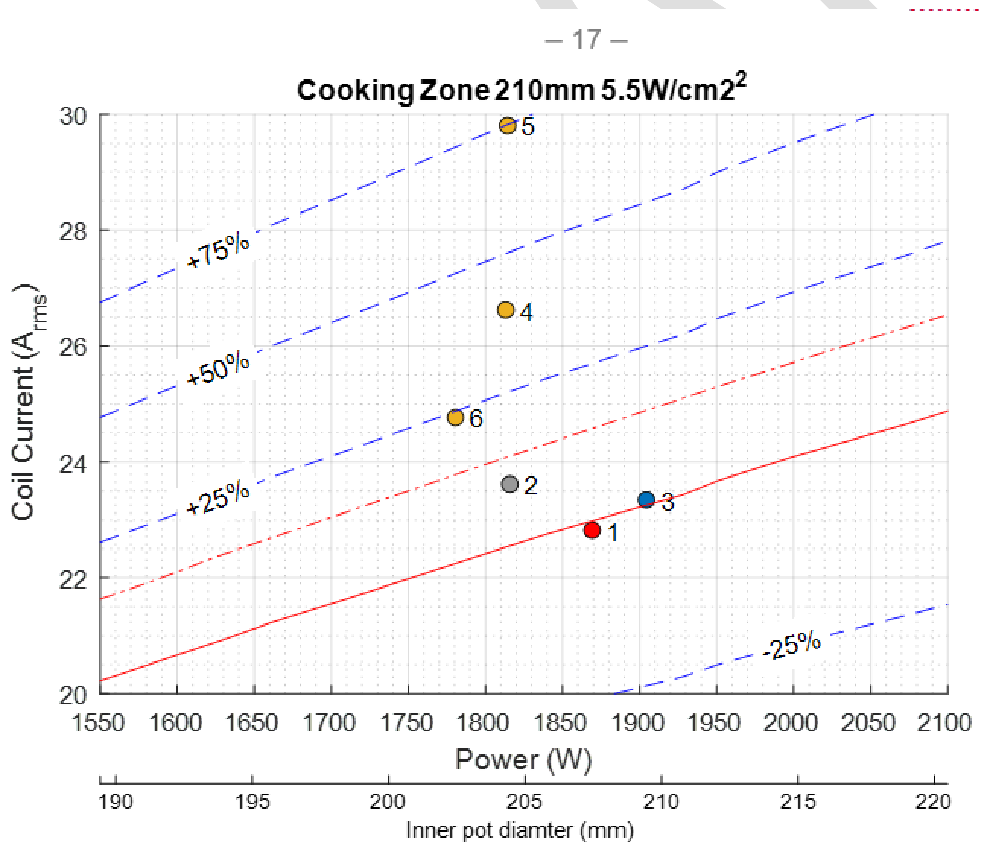
CLC TC 59X wg 5 “Induction Suitability” is actually working on a method to determine the electrical parameters for compatibility of cookware and induction hobs for household use. The standard is expected to be available in 2022.

According to an informative note provided by CLC TC 59X wg, this method will positively affect along the induction supply chain:

- *Manufacturers of cookware and hobs can use the measurements to identify various properties of induction hobs and cookware.*
- *Standards application business, e.g. testing laboratories, can use the standard for product test clearly to identify the suitability of cookware for induction hobs and to assess the performance regarding the power output of induction hobs.*
- *Finally, the consumer benefit is on one hand a better-harmonized product range (cookware/hob) and on the other hand, a clear product information regarding suitability based on a standardized method.*

To illustrate the potential impact of cookware, CLC TC 59X wg provided the following extract of the draft Standard:

The Figure 3 clearly shows that in comparison with the reference cookware No.1 different current levels are needed to supply the same power to the CUT (=cookware under test). E.g., cookware 5 causes up to 75 % more losses in the cooktop compared with No 1. The blue dashed lines are an indication of coil currents, which are equivalent to the additional ***estimated*** *power losses in %, compared to losses of the reference cookware No 1. The specified test machine measures electric parameters and is not focusing on losses. The losses are calculated by a rough estimation and may vary among induction technologies.*



Key

Sample 1 to 6 are pieces of cookware with following material:

1 *reference cookware*

2 *Stainless steel with ferromagnetic sidewall*

3 *Cast Iron*

4 *Aluminium with normal size ferromagnetic grid*

5 *Aluminium with small size ferromagnetic grid*

6 *Aluminium with ferromagnetic coating*

Solid line I_{coil} *(rms) vs Power for the reference cookware with a diameter of 210 mm*

Dash-dot line I_{coil} *(rms) vs Power for the reference cookware with a diameter of 180 mm*

Dashed lines *Indication of coil current, which are equivalent to the additional estimated power losses in %, compared to the losses of the reference cookware*

Figure 4 - Test A - Coil current and estimated power losses comparison for a 210mm cooking zone (examples)

The additional estimated power losses in % are calculated by formula (8):

$$\left[\left(\frac{I}{I_{ref}}\right)^2 - 1\right](\%) \qquad (8)$$

Where

I is the coil Irms for the CUT (see y axis);

I_{ref} is the rms current measured with the reference cookware at the respective power.

A specific study on the energy saving potential linked to the compatibility of cookware and induction hobs for household use would be beneficial, taking into account the timeline of the standard, which will be essential to propose any policy measure.

7.6 Policy options for cooking fume extractors

7.6.1 Policy options related to only recirculation cooking fume extractors

As explained in previous sections, the inclusion of only recirculation cooking fume extractors is related to the odour reduction efficiency. In this regard, EN 61591 contains a test method for the odour reduction with the substance MEK. There are several issues around this test method, mainly that it is just appropriate to measure the odour reduction efficiency of recirculation extractor. Apart from that, the odour reduction test should not only represent the removal of odorous substances, but the removal of all small pollutants in general that are emitted during cooking processes. However, this test method can be considered a good starting point to develop ecodesing measures for recirculation cooking fume extractors.

The Danish Energy Agency and the Swedish Energy Agency have proposed a threshold of 75% for odour reduction efficiency for both recirculation and ducted cooking fume extractors. This figure is based on the tests carried out on a sample of ducted cooking fume extractors. They were tested according to standards on the area (EN 61591 and EN 13141-3).

However, according to manufacturers, a threshold of 75% based on EN 61591 will phase out the majority of recirculation modes in the market, while most of extraction modes will be compliant.

Another issue raised by manufacturers is that some recirculation cooking fume extractors are sold without odour filter, which is purchased apart by the installation company, or by the user. In this case, it is recommended to test the recirculation cooking fume extractor with a standard odour filter, which will need to be defined. The manufacturer will inform the consumer that the odour reduction efficiency declared is only guaranteed if a similar filter is installed.

7.6.2 Current situation

For the review of the Ecodesing and Energy labelling measures, APPLiA has provided a dataset of 143 models of cooking fume extractors. Figure 295 shows the annual energy consumption (AEC) calculated with the current methodology versus the power measured at best efficiency point. The figure distinguishes the three motor technologies.

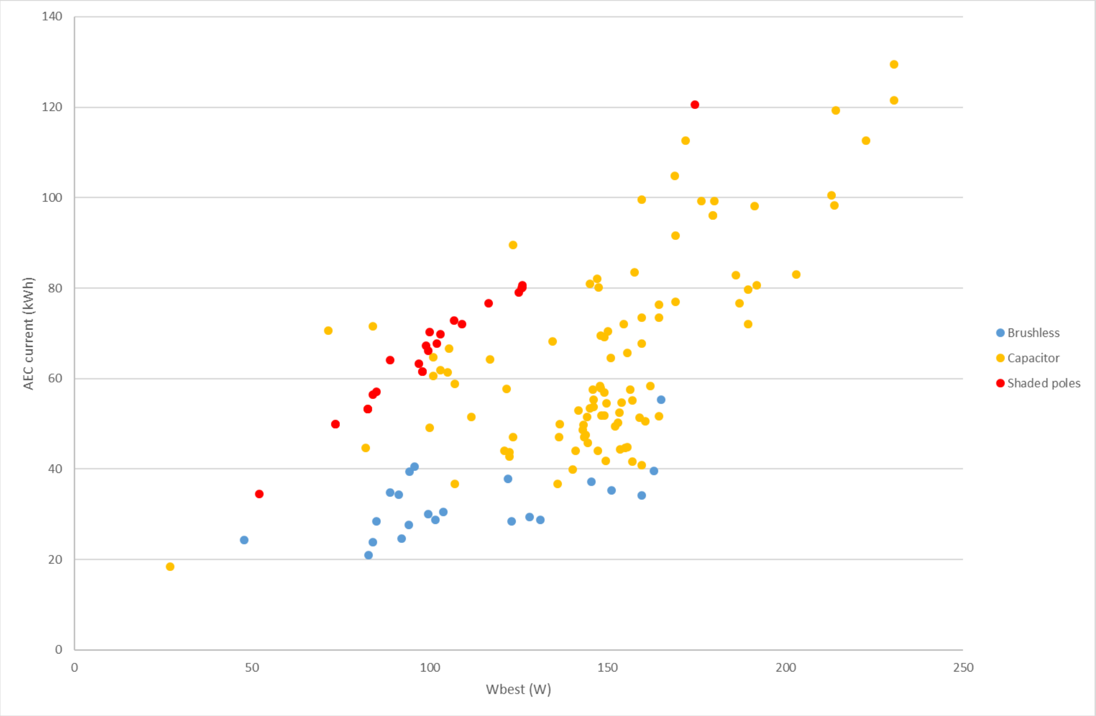


Figure 295: AEC and Wbest calculated with existing methodology of the 143 models of APPLiA dataset

The most common technology is capacitor motor, which performs a large range of AEC and power. The most efficient technology is brushless motors, and the least shaded poles motor.

Figure 296 shows the Energy Efficiency Index (EEI) calculated according to the current methodology versus the power at best efficiency point.

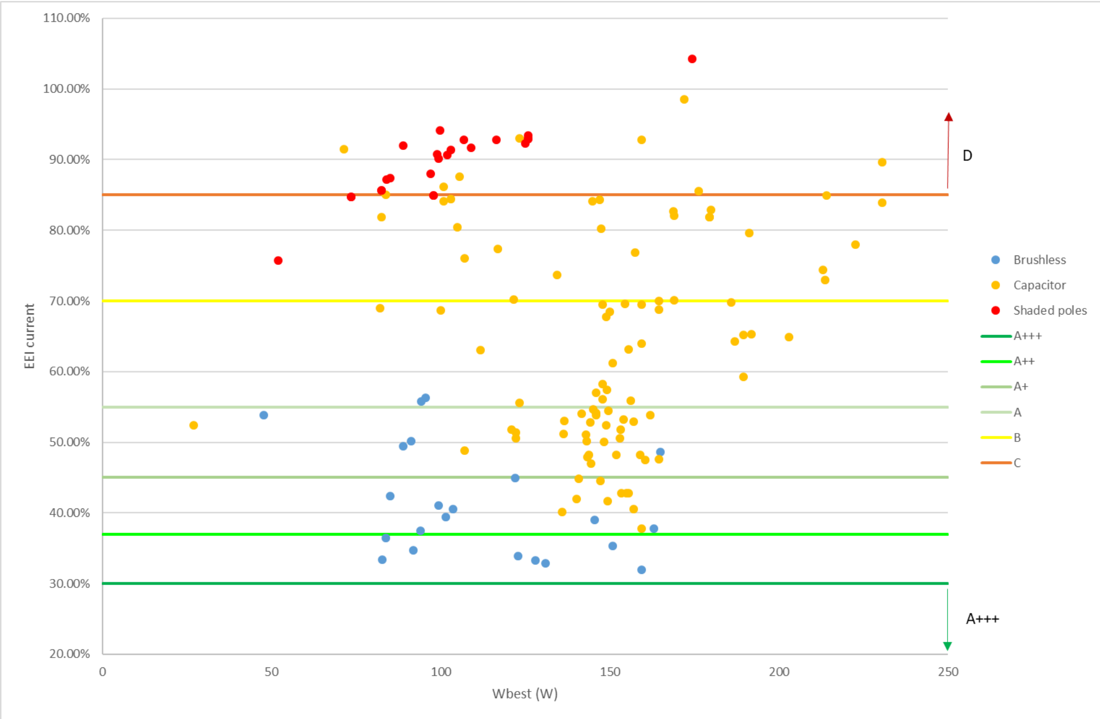


Figure 296: EEI and Wbep calculated with existing methodology of the 143 models of APPLiA dataset and current energy classes

The distribution of the models among the different energy classes in presented in Table 143

Table 143: Distribution of the models among the different energy classes according to existing energy classes

Energy class	Shaded poles	Capacitor	Brushless	Total
A++	0	0	9	9
A+	0	10	8	18
A	0	29	3	32
B	0	24	2	26
C	4	26	0	30
D	20	8	0	28

Figure 297 displays the same EEI than the previous figure, but versus the maximum airflow that the cooking fume extractor can deliver, usually at boost speed.

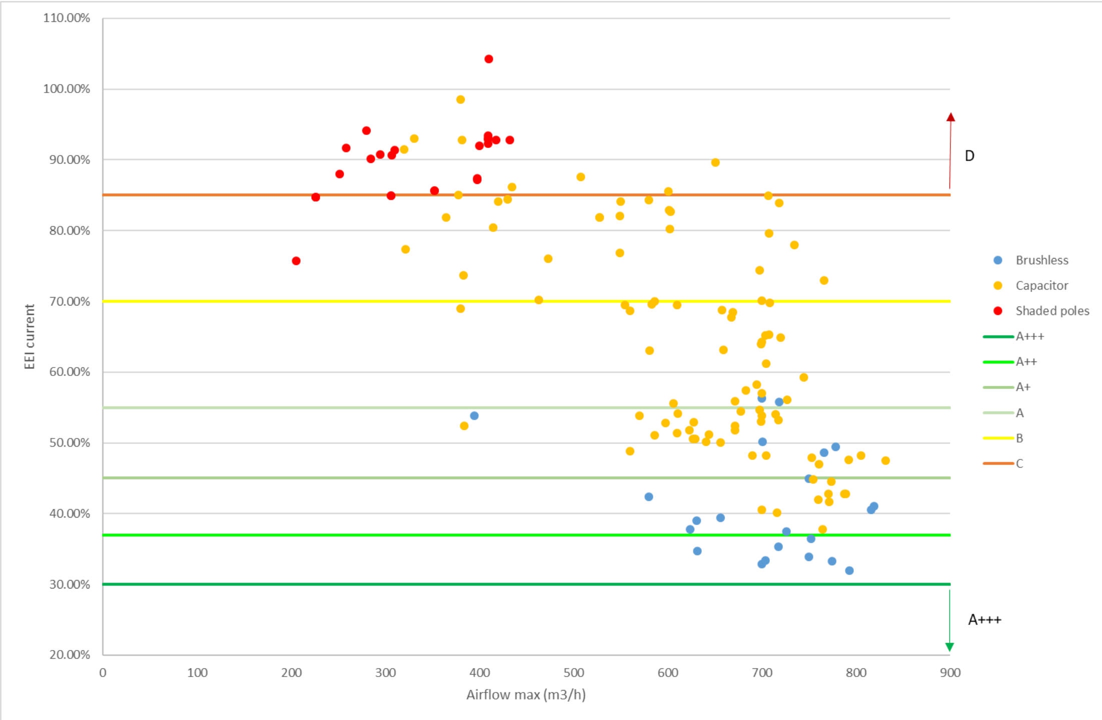


Figure 297: EEI and maximum airflow calculated with existing methodology of the 143 models of APPLiA dataset and current energy classes

This figure suggests that the current EEI benefits those cooking fume extractors with larger airflow capacities. However, it is also possible best technologies are able to provide large ranges of airflows. This is showed in Figure 298 where the current EEI versus the 9-points average airflow is displayed.

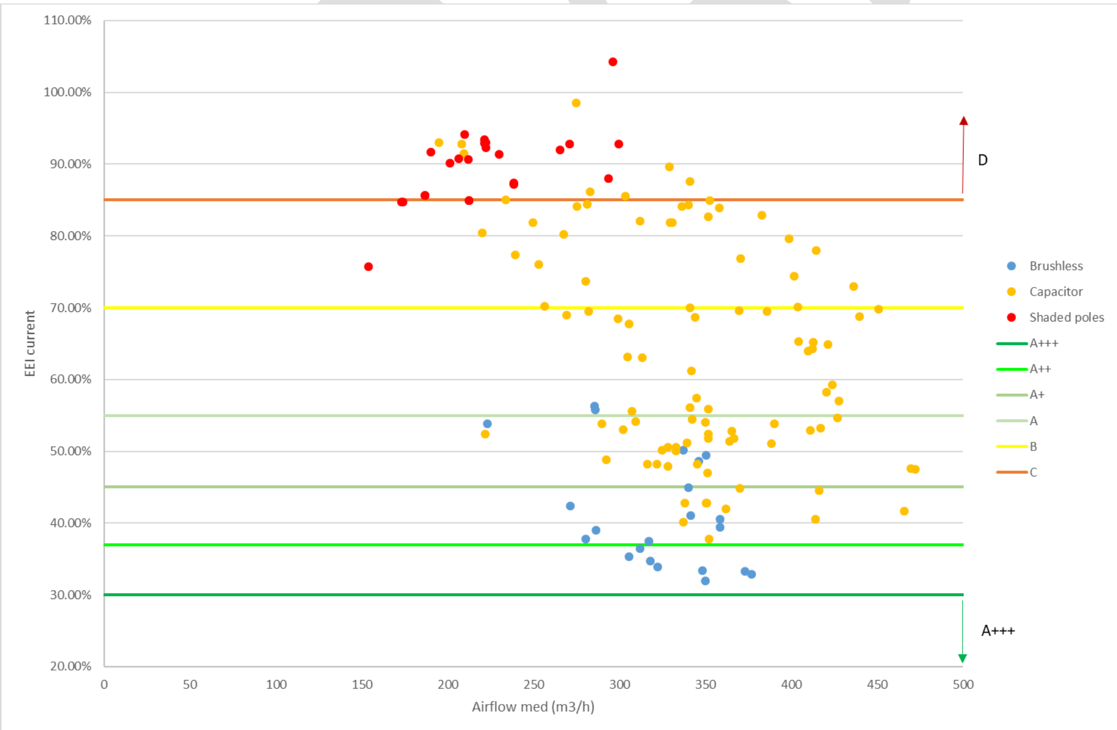


Figure 298: EEI calculated with existing methodology and airflow 9-points average of the 143 models of APPLiA dataset and current energy classes

The 9-points method helps to better characterise the main parameters of cooking fume extractors, according to a representative usage of the three different speeds, and the different range of airflows. This effect is amplified if EEI is also based on the 9-points AEC, as shown in the Figure 299.

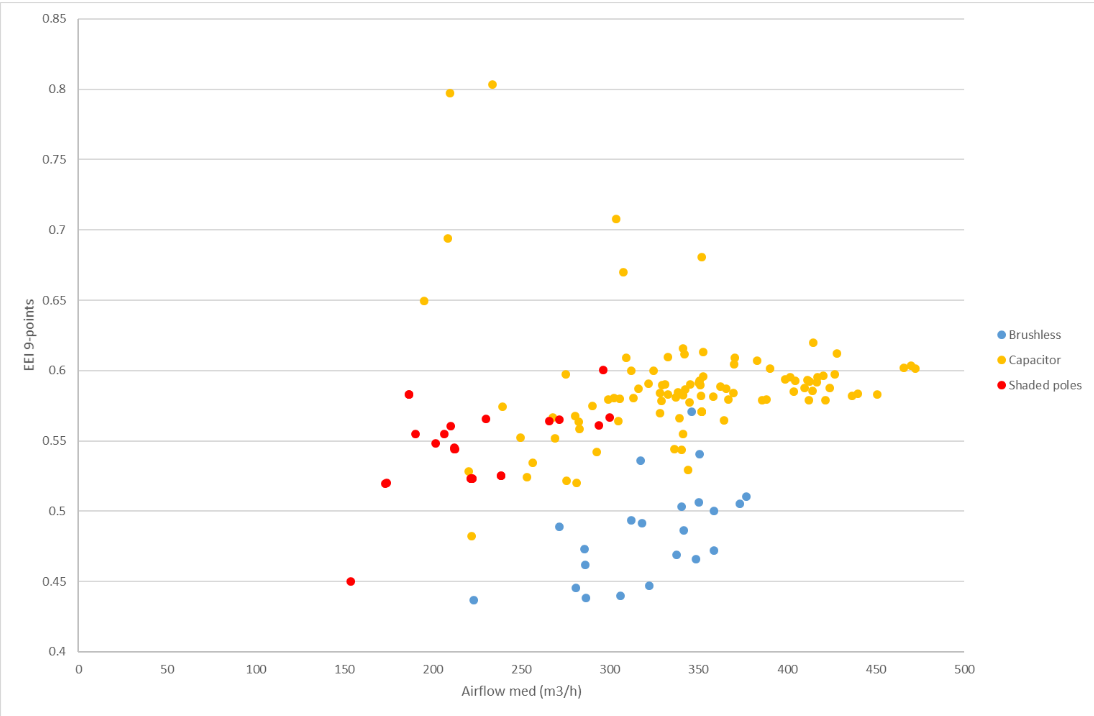


Figure 299: EEI and airflow 9-points average of the 143 models of APPLiA dataset and current energy classes

7.6.3 Options for the revision of EEI

Different options for the revision of the Energy Efficiency Index have been identified, in order to address the issues described in the sections above.

7.6.3.1 Integrating odour reduction efficiency and heating/cooling in the annual energy consumption

The Danish and Swedish Energy Agencies proposed two modification in the methodology to calculate the annual energy consumption and the EEI of cooking fume extractors:

First, the EEI should take into account the odour reduction, as a primary function of the cooking fume extractor. The objective is limiting the use of excessive air flow rates, which influence the indirect energy consumption for heating or cooling replacement air.

Besides, the annual energy consumption should include the indirect energy consumed for heating/cooling, due to air renewal. This indirect energy consumption would require an average EU climate factor. \

The advantages, disadvantages and obstacles of these proposals are described in Table 144.

Table 144: Advantages, disadvantages and obstacles of integrating odour reduction efficiency and heating/cooling in the annual energy consumption

Proposal	Advantages	Disadvantages/obstacles
Odour reduction efficiency	• Identify best products in terms of function, i.e. those that consume less energy to provide the same function • Take into account the product as a whole, i.e. considering the design, shape, etc. that may have an impact in the product performance • Cover recirculation modes	• The test method currently available is only valid for recirculation modes
Indirect energy consumption in heating and cooling	• Extend the boundaries of the system to include the indirect impact of excessive airflow.	• It requires the integration of the odour reduction efficiency • It dilutes the impact of the direct energy consumption, which may discourage the technology improvement.

It is recommended that an appropriate odour reduction test for ducted cooking fume extractors is developed for the next revision of the Ecodesign and Energy labelling measures for this product.

7.6.3.2 EEI based on fluid dynamic efficiency

APPLiA proposed a methodology based on the fluid dynamic efficiency (FDE) together with the 9-points method.

The 9-points to measure the cooking fume extractor parameters are plotted in Figure 300 PA curves represent different drawback pressures depending on the building and installation of the extractor. The parameters pressure, airflow and power are measured at minimum, maximum and boost speed, at those three drawback pressures, i.e. in nine points.

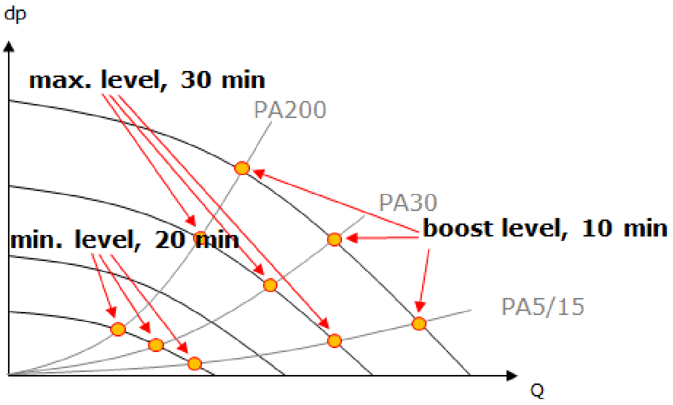


Figure 300: P and Q curves and 9 points of measure

FDE is the ratio between the power delivered by the cooking fume extractor (pressure multiplied by airflow) and the power consumed. The following formula expresses the FDE as average of the three drawback pressures:

$$FDE_i = \frac{1}{3}\sum_{j=1}^{3} \frac{p_{i,j}}{3600} \frac{Q_{i,j}}{W_{i,j}}$$

Where:

- p means pressure delivered
- Q means airflow delivered
- W means power consumed
- j = 1: Crossing point with pressure curve 200 Pa @ 200 m^3/h
- j = 2: Crossing point with pressure curve 30 Pa @ 200 m^3/h
- j = 3: Crossing point with pressure curve 15 Pa or 5 Pa @ 200 m^3/h

The following formula expressed the FDE as average of the three speeds:

$$FDE = \sum_{i=1}^{3} FDE_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

The advantages and disadvantages of this proposal are gathered in Table 145.

Table 145: Advantages and disadvantages of EEI based on fluid dynamic efficiency

Proposal	Advantages	Disadvantages
EEI based in FDE	• The current method only takes into the FDE as a time factor. This proposal provides a figure of real energy efficiency, as ratio between power delivered and power consumed. • The ratio airflow/power would help smooth the apparent benefits of large airflow extractors	• The odour reduction efficiency is not considered. • It is probable that motors that are more powerful perform better FDE. A reference FDE is require to compensate this effect.

7.6.3.3 EEI based on SAEC as function of airflow

The current EEI is based on the annual energy consumption (AEC) and the standard annual consumption (SAEC) as functions of the power consumed by the cooking fume extractors. Another option may be developing a formula to calculate the SAEC as a function of the airflow measured as 9-points average. The first step would be representing the AEC versus the airflow, as shown in Figure 301. The first approximation for a SAEC could be a trendline for capacitor motors, as expressed in the formula within the figure.

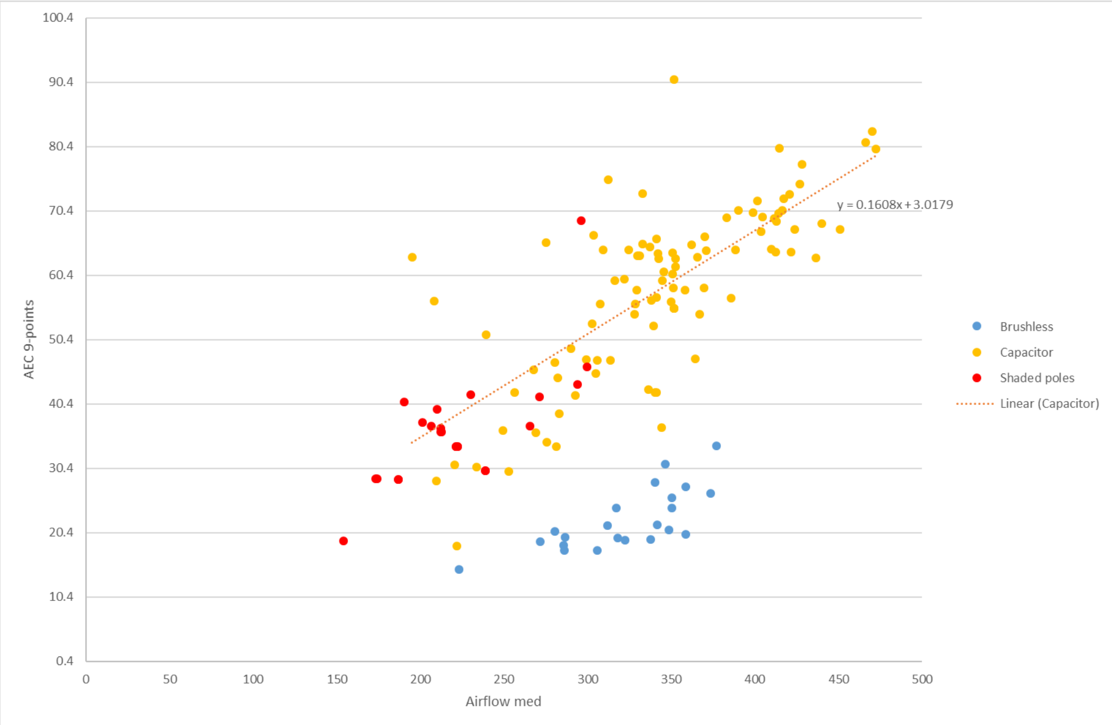


Figure 301: AEC and airflow calculated as 9-points average

The advantages and disadvantages of this proposal are gathered in Table 146.

Table 146: Advantages and disadvantages of EEI based on airflow

Proposal	Advantages	Disadvantages
EEI based on SAEC as function of airflow	• The AEC is confronted to the airflow provided by cooking fume extractor, which is a parameter related to functionality • EEI distinguishes the three motor technologies.	• The odour reduction efficiency is not considered. • It is probable that motors that are more powerful perform better EEI, because their FDE are higher.

7.6.3.4 Update of the existing EEI based on power

This option would update the existing EEI according to the AEC, FDE and power consumption calculated as 9-points average. The AEC is represented versus power consumption in Figure 302, together with the linear trendline for capacitor motors.

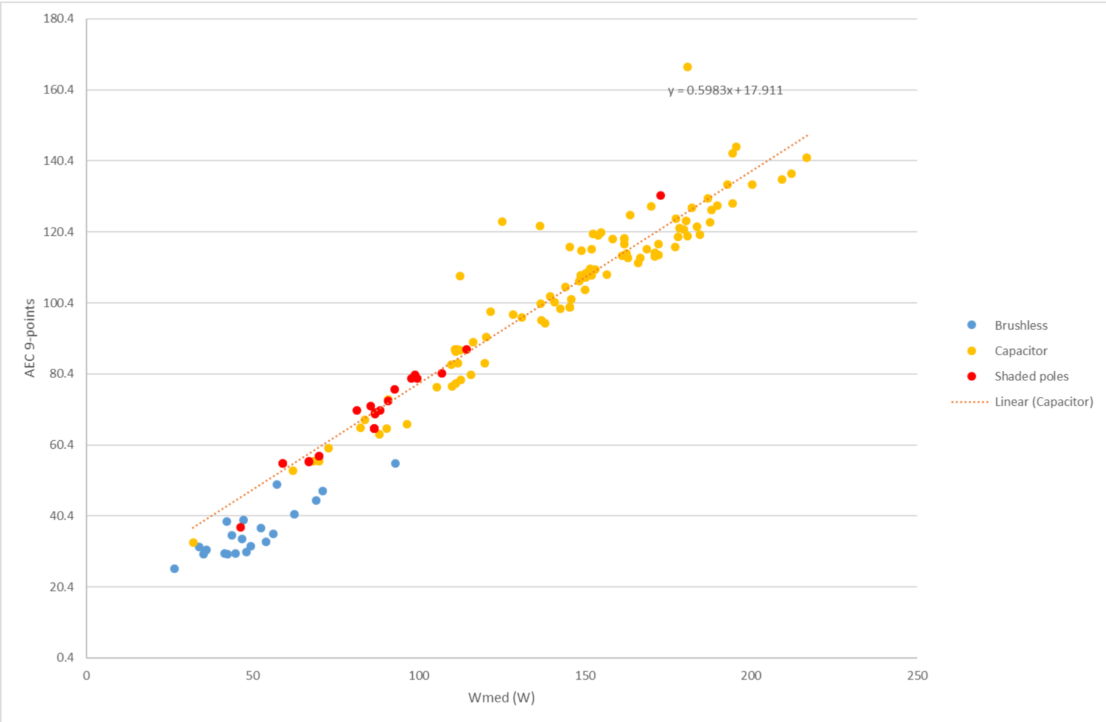


Figure 302: AEC and power calculated as 9-points average

The advantages and disadvantages of this proposal are gathered in Table 147:

Table 147: Advantages and disadvantages of EEI based on power

Proposal	Advantages	Disadvantages
Update of existing EEI based on SAEC as function of power	• Energy labels principles are unchanged, and are improved by 9-points average • EEI distinguishes the three motor technologies.	• The odour reduction efficiency is not considered. • Airflow is not considered either, i.e., the work or function delivered by power unit is not considered

7.6.4 Development of EEI and energy classes based on the different options

7.6.4.1 EEI and energy classes based on FDE

For the review of the Ecodesign and Energy labelling measures, APPLiA has provided a dataset of 143 models of cooking fume extractors. Figure 303 shows FDE of these models versus power (9-points average) for the three motor technologies.

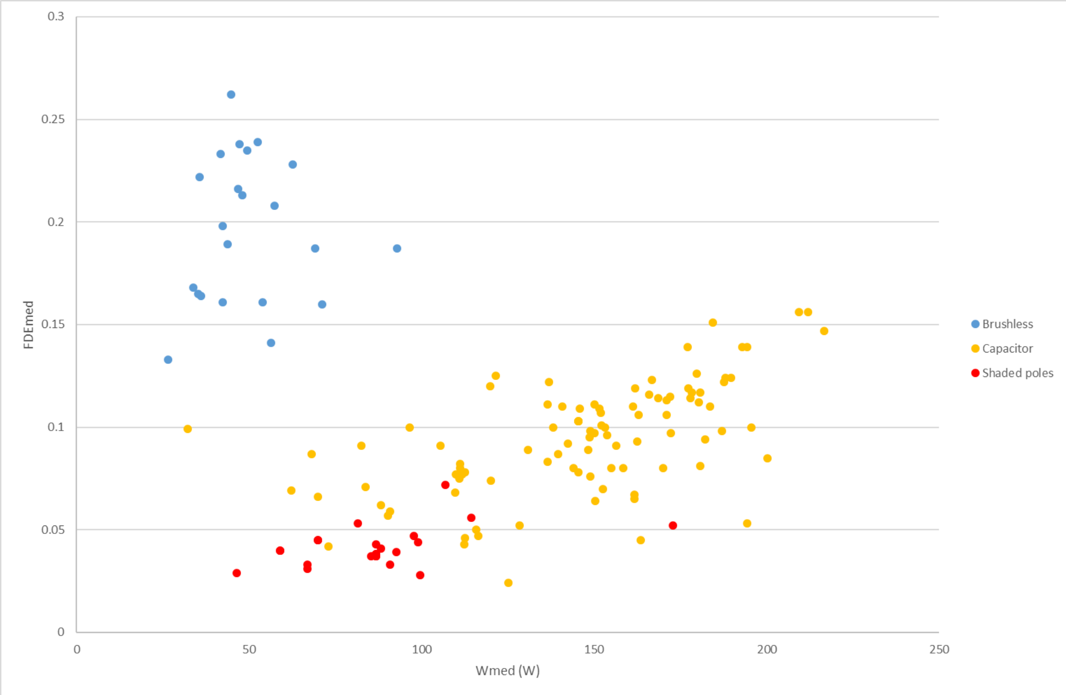


Figure 303: FDE and power calculated as 9-points average

As can be observed, shaded poles motors perform the lowest FDE, followed by capacitor motors. Brushless is the best available technology and performs very high FDE at very low power. More powerful capacitor motors, which are the most common, tend to perform higher FDE. For this reason, there needs to be a reference FDE that takes into account the limitations of this technology. In this regard, APPLiA has proposed the following formula to calculate EEI as a function of FDE and reference FDE:

$$EEI = \sum_{i=1}^{3} \frac{FDE_i}{FDE_{refi}} \frac{t_i}{(t_1 + t_2 + t_3)} 100$$

The reference FDE would be a function of the power in order to normalize the higher efficiency or more powerful capacitor motors, as follows:

$$FDE_{refi} = 0.0003 \cdot W_i + 0.0629$$

However, this method hinders the use of FDE for the modelling of scenarios, so the following option is proposed as an approximation:

$$EEI = \frac{FDE}{FDE_{ref}}$$

$$FDE_{ref} = 0.0003 \cdot W_{med} + 0.0629$$

$$W_{med} = \sum_{i=1}^{3} W_i \frac{t_i}{(t_1 + t_2 + t_3)}$$

The results are not exactly the same but are very similar, and would not significantly affect the EEI of the cooking fume extractor, as can be observed in Figure 304

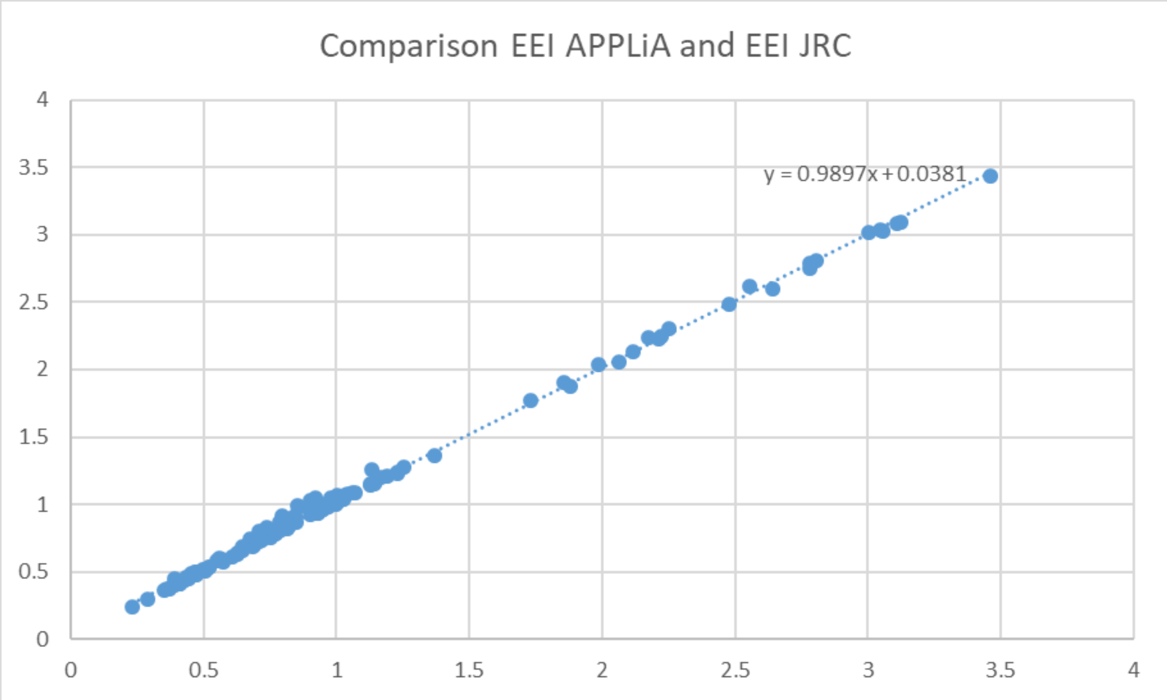


Figure 304: Comparison between EEI calculated with APPLiA proposal and EEI calculated with JRC proposal

The results of FDE and FDEref versus power as 9-points average are shown in Figure 305:

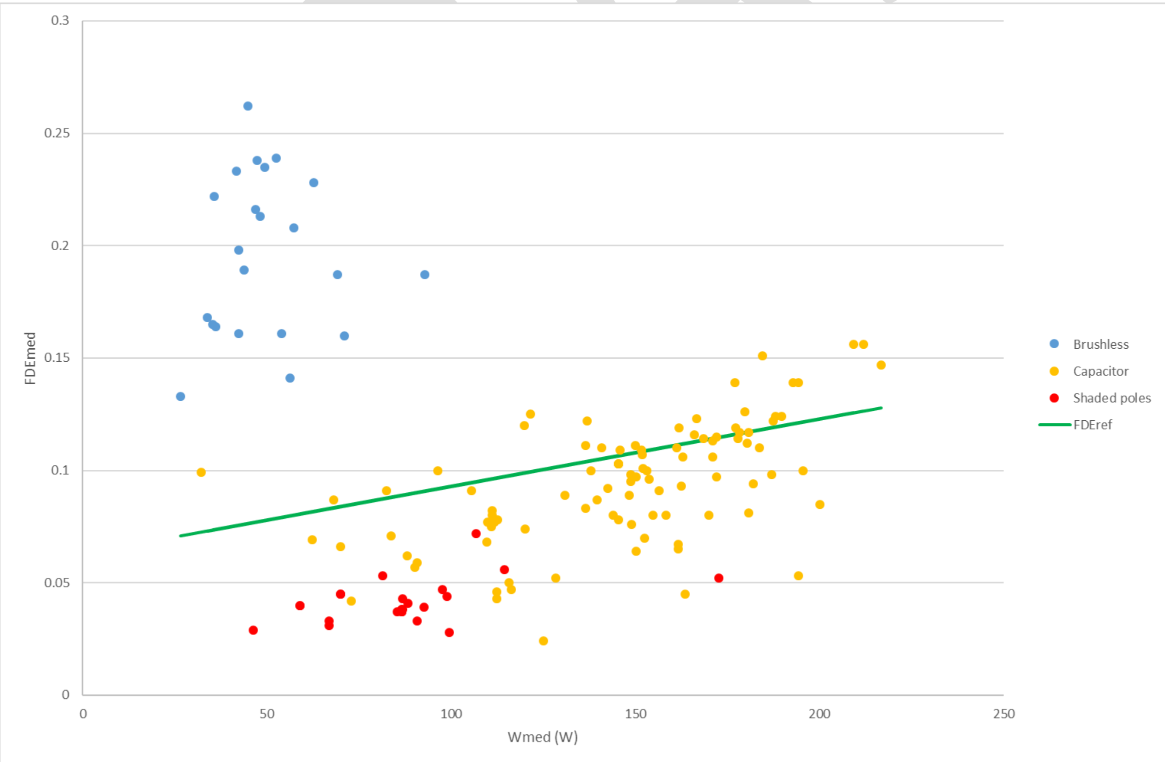


Figure 305: FDE, FDEref and power calculated as 9-points average

Figure 306 shows the results of EEI according to the formulas explained above.

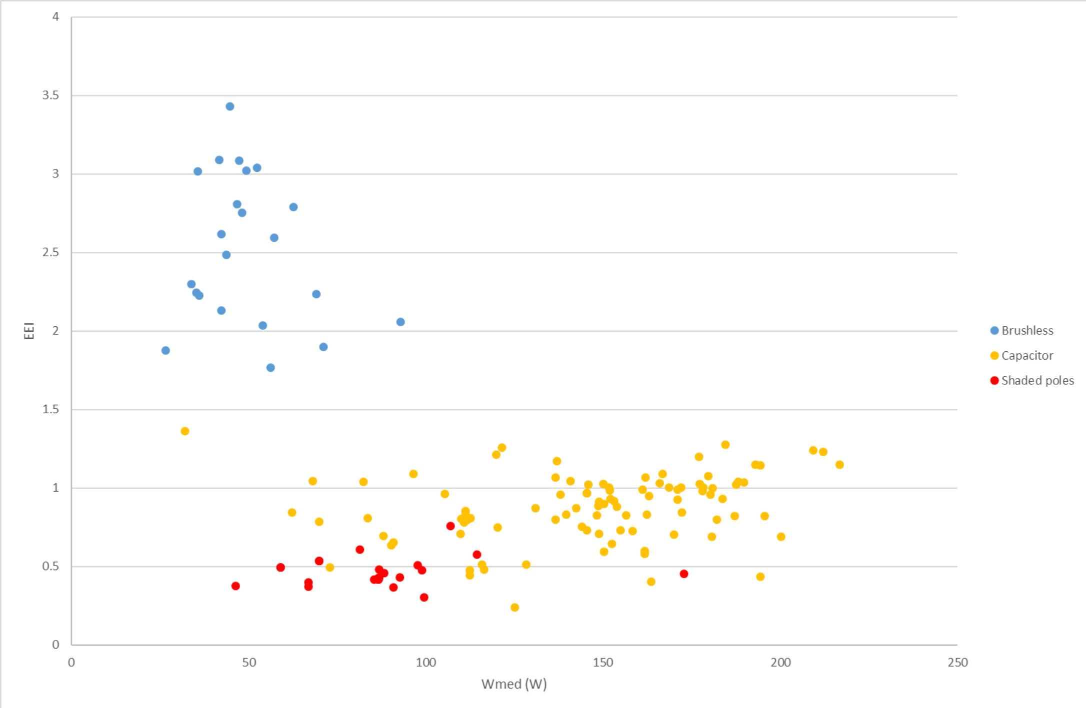


Figure 306: EEI based on FDE and power calculated as 9-points average

The new EEI would clearly differentiate the three motor technologies, in a way that only brushless motors would be able to reach the best energy classes. Capacitor motors would remain in middle energy classes, regardless the size of the motor. This would have two benefits: the energy classes would promote the shift of technology towards the BAT and they would be power-neutral, i.e. they would not either penalise or benefit larger motors.

The results of EEI show a significant difference between the BAT, i.e. brushless motor, and the other two motor technologies. The energy classes will be thus distributed so consumers can identify:

- First, those cooking fume extractors equipped with the BAT
- Second, within each technology, those that perform highest efficiency.

In order to come up with the ranges of the energy classes (B to G), cooking fume extractors have been divided and analysed according to their motor technology. APPLiA database has been used for this purpose.

Two different options have been used to determine the thresholds of the energy classes.

- **Option a**: the thresholds of the energy classes are even along all energy classes, i.e. the difference of EEI between energy classes is the same or very similar.
- **Option b**: the thresholds have been determined in a way that the number of models is evenly distributed among the energy classes.

<u>Option a</u>

Energy classes B, C, D and E identify brushless motor cooking fume extractors. Energy classes F and G identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 149 and Figure 308.

Table 148: Distribution on models among the new energy classes based on FDE in option a

Energy class	Brushless (total =22)	Capacitor (total = 96)	Shaded poles (total = 25)
A (EEI > 350)	0	0	0
B (350 ≥ EEI> 300)	6	0	0
C (300 ≥ EEI> 250)	5	0	0
D (250 ≥ EEI > 200)	8	0	0
E (200 ≥ EEI > 150)	3	0	0
F (150 ≥ EEI > 75)		72	1
G (EEI ≤ 75)		25	23

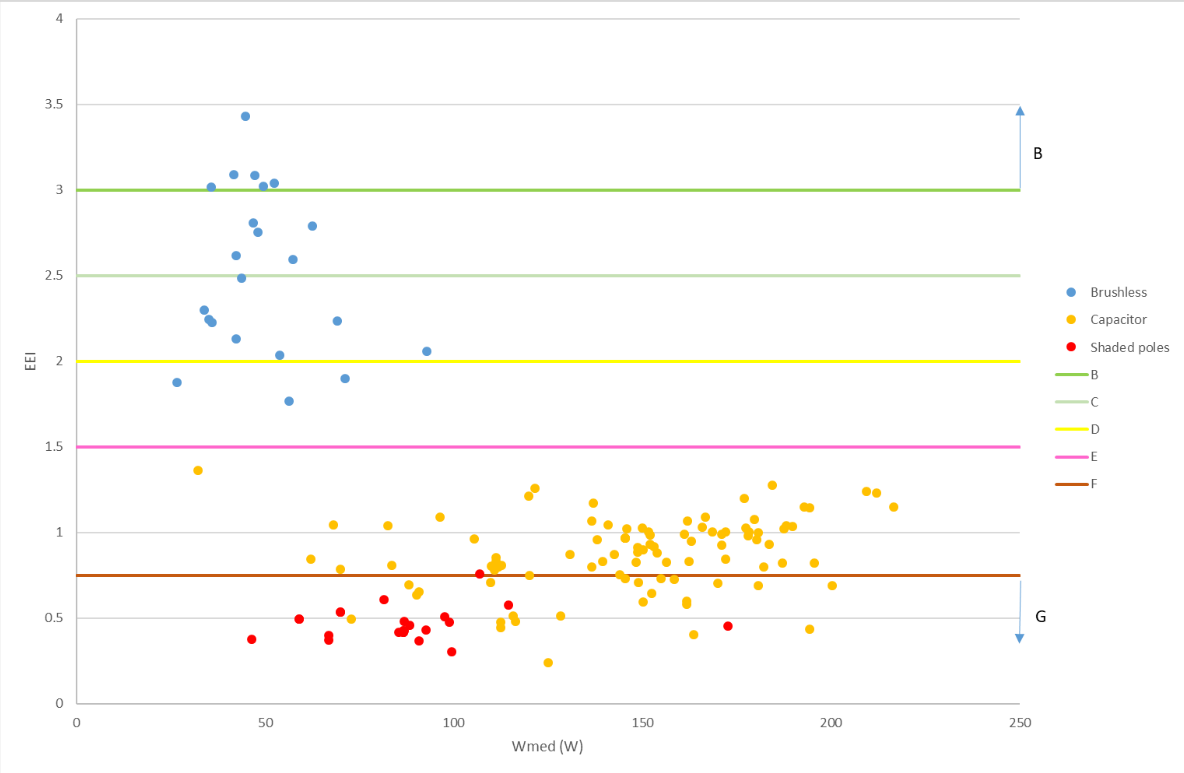


Figure 307: Distribution on models among the new energy classes based on FDE in option a

This option will allow consumers to identify the best technologies and to differentiate the leaps between energy classes with similar EEI performance. Best and middle energy classes will be populated with the brushless motor cooking fume extractors, while capacitor and shaded poles will be labelled as lowest energy classes. This option would push towards BATs, though it would not allow the comparison between the current most common technology, i.e. capacitor motors.

Option b

Energy classes B and C identify brushless motor cooking fume extractors. Energy classes D, E, F and G identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 149 and Figure 308.

Table 149: Distribution on models among the new energy classes based on FDE in option b

Energy class	Brushless (total =22)	Capacitor (total = 96)	Shaded poles (total = 25)
A (EEI > 350)	0	0	0
B (350 ≥ EEI> 250)	11	0	0
C (250 ≥ EEI> 150)	11	0	0
D (150 ≥ EEI > 98	0	33	0
E (98 ≥ EEI > 80)	0	28	2
F (80 ≥ EEI > 58)		23	3
G (EEI ≤ 58)		16	16

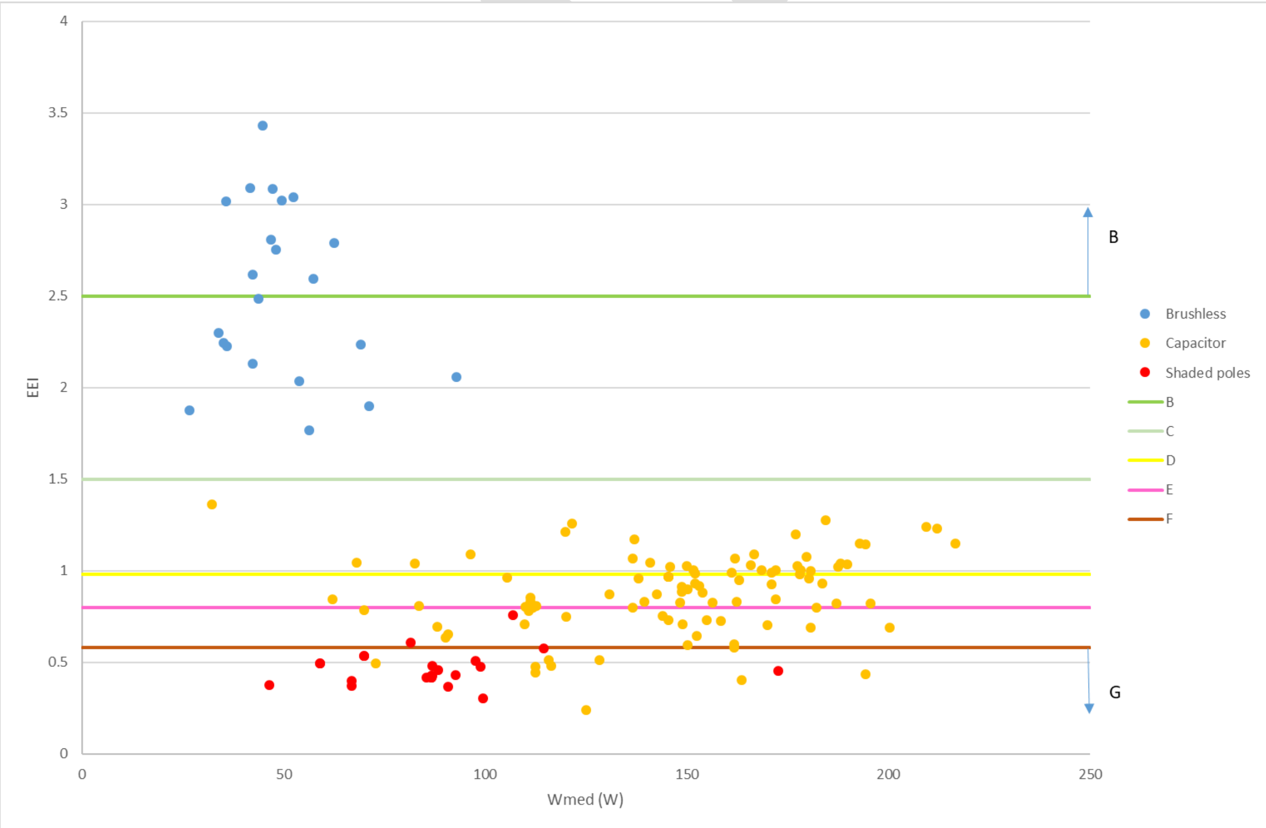


Figure 308: Distribution on models among the new energy classes based on FDE in option b

The steps that separate the energy classes are not even, since the brushless motors show a larger spread than capacitor and shade poles motors. The largest step matches to the class B and C, which sets the border between technologies. The leap from class D to C will require a shift of technology that will significantly improve the energy efficiency.

7.6.4.2 EEI and energy classes based on SAEC as function of airflow

The current EEI is based on the annual energy consumption (AEC) and the standard annual consumption (SAEC) as functions of the power consumed by the cooking fume extractors. Another option may be developing a formula to calculate the SAEC as a function of the airflow measured as 9-points average. The first step would be representing the AEC vs the airflow, as shown in Figure 309.

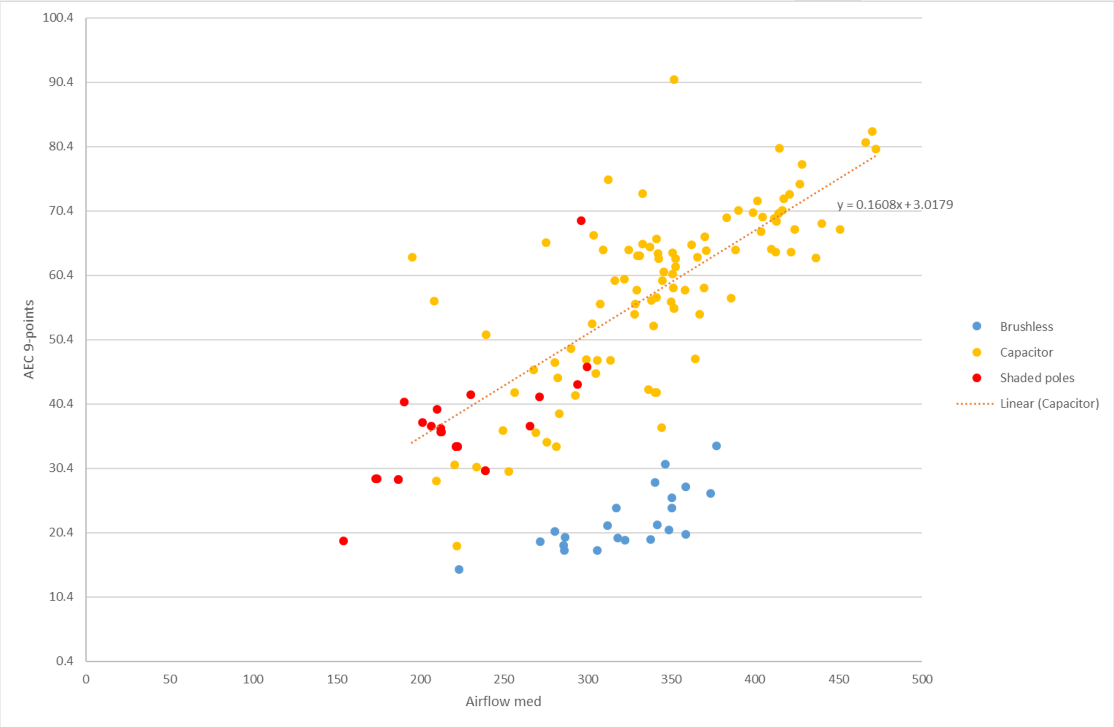


Figure 309: AEC and airflow calculated as 9-points average

The first approximation for a SAEC could be a trendline for capacitor motors, as expressed in the formula within the figure, as follows:

$$SAEC = 0.1608 \times Q_{med} + 3.0179$$

where Qmed means airflow as 9-points average in m³/h.

Figure 310 shows the results of the EEI calculated as the ratio AEC/SAEC.

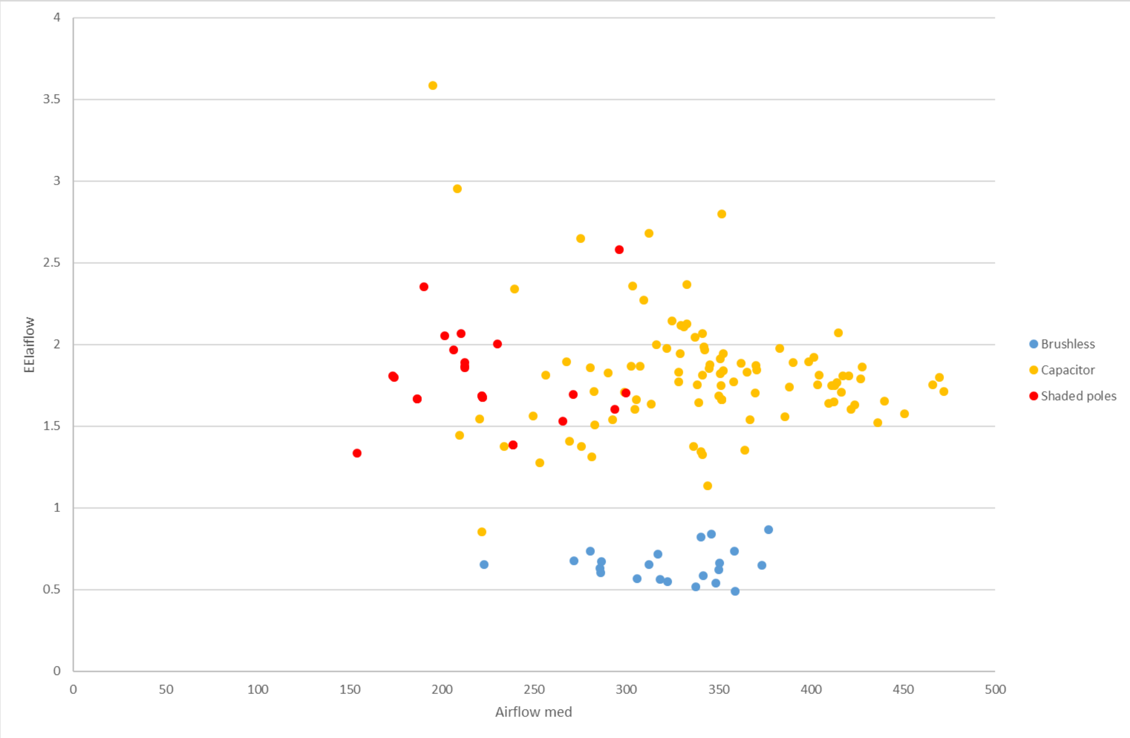


Figure 310: EEI based on airflow and airflow calculated as 9-points average

The new EEI would differentiate BAT from the rest of technologies. Capacitor motors and shaded pole motors would not be distinguished, remaining middle energy classes.

In order to come up with the ranges of the energy classes (B to G), cooking fume extractors have been divided and analysed according to their motor technology. APPLiA database has been used for this purpose.

Two different options have been used to determine the energy classes thresholds.

- **Option a**: the thresholds of the energy classes are even along all energy classes, i.e. the difference of EEI between energy classes is the same or very similar.
- **Option b**: the thresholds have been determined in a way that the number of models is evenly distributed among the energy classes.

Option a

Energy class B and C correspond mainly to brushless motor cooking fume extractors. The rest of energy classes identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 151 and Figure 312.

Table 150: Distribution on models among the new energy classes based on airflow in option a

Energy class	Brushless (total =22)	Capacitor (total = 96)	Shaded poles (total = 25)
A (EEI < 25)	0	0	0
B (25 ≤ EEI < 70)	16	0	1
C (70 ≤ EEI < 100)	6	1	0
D (100 ≤ EEI < 130)	0	2	4

E (130 ≤ EEI < 160)	0	17	14
F (160 ≤ EEI < 190)	0	51	4
G (EEI ≥ 190)	0	25	2

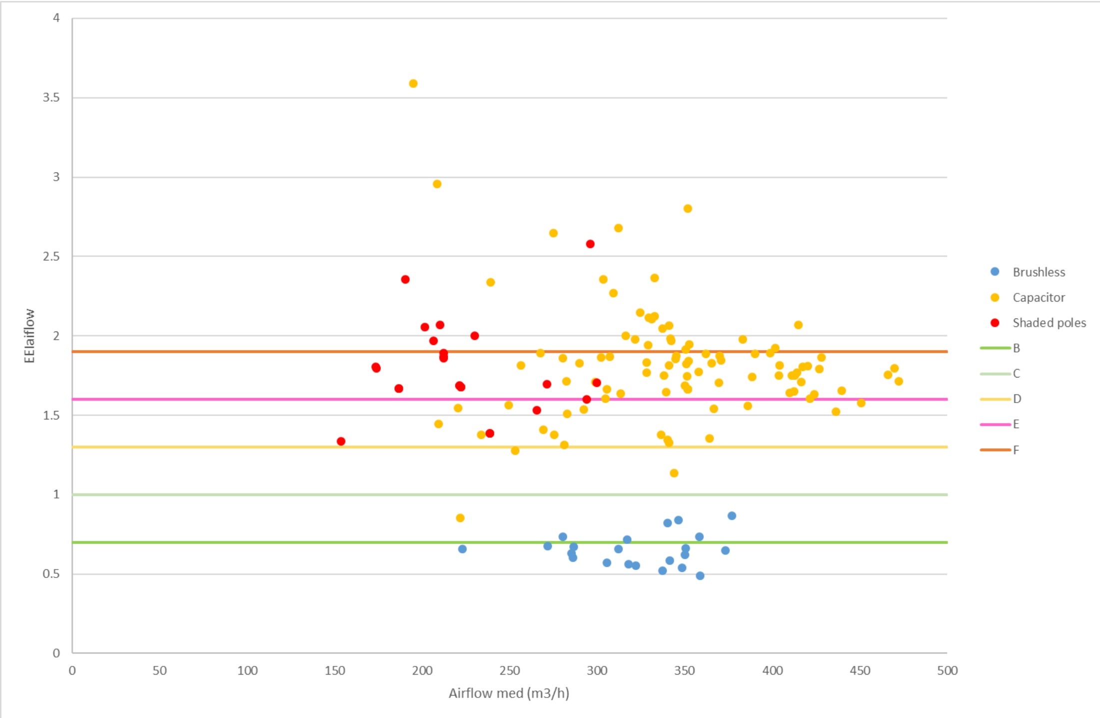


Figure 311: Distribution on models among the new energy classes based on airflow in option a

In contrast to EEI based on FDE, this option enables to differentiate best models with capacitor and shaded pole motors, though the best classes could be reached by capacitor motors, meaning that best energy classes may not require a change in technology.

<u>**Option b**</u>

Energy class B corresponds mainly to brushless motor cooking fume extractors. The rest of energy classes identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 151 and Figure 312.

Table 151: Distribution on models among the new energy classes based on airflow in option b

Energy class	**Brushless (total =22)**	**Capacitor (total = 96)**	**Shaded poles (total = 25)**
A (EEI < 25)	0	0	0
B (25 ≤ EEI < 100)	22	0	1
C (100 ≤ EEI < 154)	0	18	2
D (154 ≤ EEI < 170)	0	22	3
E (170 ≤ EEI < 184)	0	29	1
F (184 ≤ EEI < 207)	0	26	4
G (EEI ≥ 207)	0	12	4

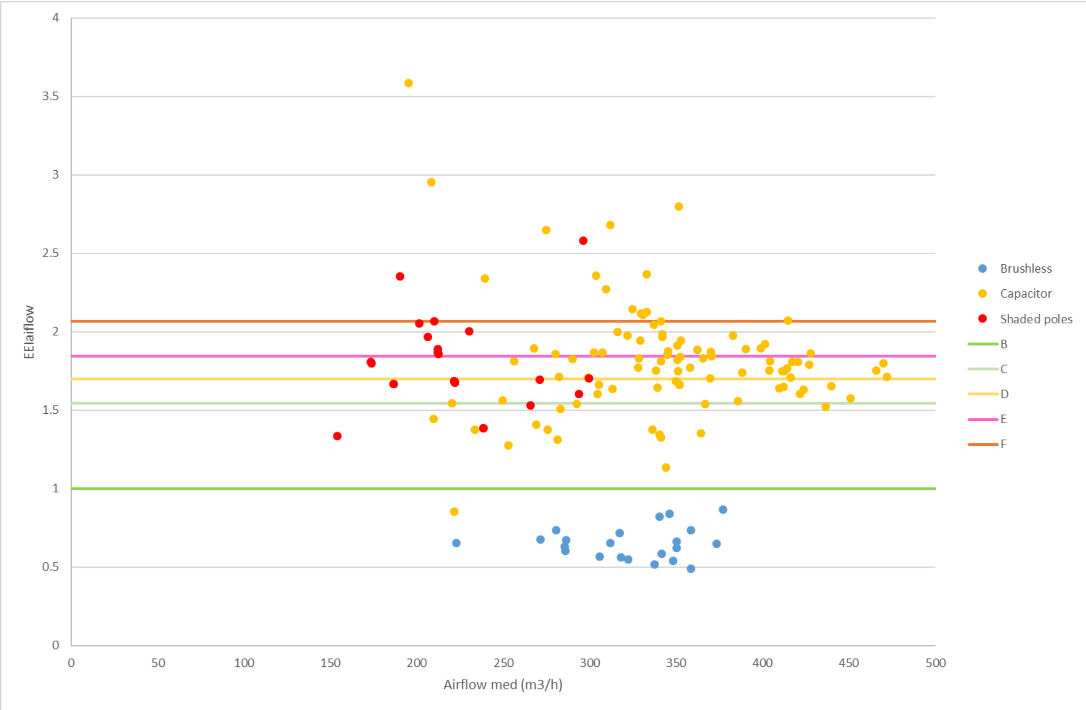


Figure 312: Distribution on models among the new energy classes based on airflow

In contrast to EEI based on FDE or EEI based on airflow in option a, this alternative does not enable to identify the best EEI within brushless motors, and energy classes C to F encompass by both capacitor and shaded pole motors.

7.6.4.3 Update of the existing EEI based on power

This option would update the existing EEI according to the AEC, FDE and power consumption calculated as 9-points average. The AEC is represented vs power consumption in Figure 313, together with the linear trendline for capacitor motors.

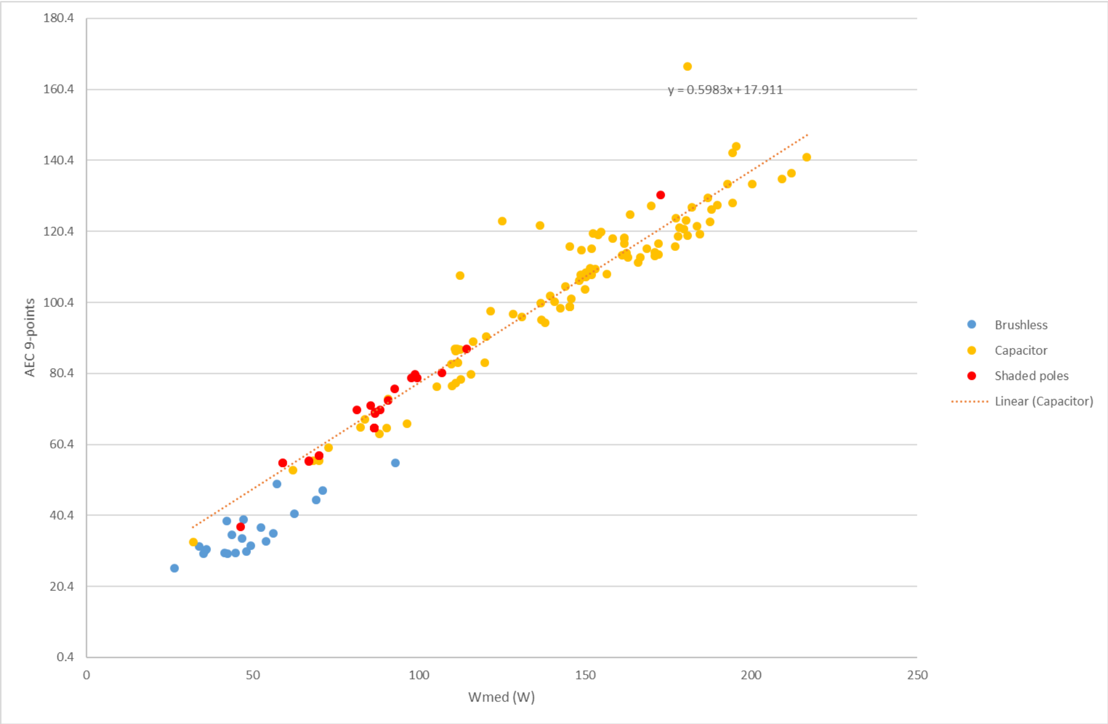


Figure 313: AEC and power calculated as 9-points average

The first approximation for a SAEC could be a trendline for capacitor motors, as expressed in the formula within the figure, as follows:

$$SAEC = 0.5983 \times W_{med} + 17.911$$

where Qmed means power as 9-points average in W.

Figure 314 shows the results of the EEI calculated as the ratio AEC/SAEC.

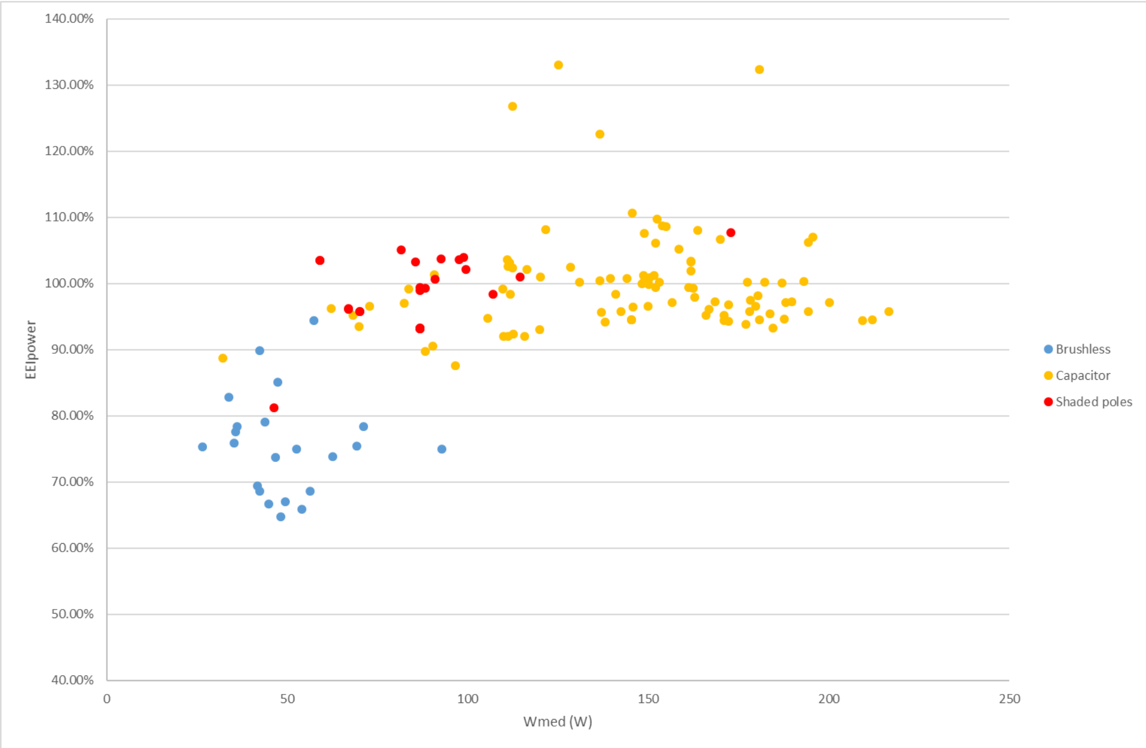


Figure 314: EEI based on power and airflow calculated as 9-points average

The new EEI would differentiate BAT from the rest of technologies. Capacitor motors and shaded pole motors would not be distinguished, remaining middle energy classes. Capacitor motors would show the worst EEI.

In order to come up with the ranges of the energy classes (B to G), cooking fume extractors have been divided and analysed according to their motor technology. APPLiA database has been used for this purpose.

Two different options have been used to determine the energy classes thresholds.

- **Option a**: the thresholds of the energy classes are even along all energy classes, i.e. the difference of EEI between energy classes is the same or very similar.
- **Option b**: the thresholds have been determined in a way that the number of models is evenly distributed among the energy classes.

<u>Option a</u>

Energy class B, C and D correspond to brushless motor cooking fume extractors. D class also covers capacitor and shaded pole motors. The rest of energy classes identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 153 and Figure 316: Distribution on models among the new energy classes based on power.

Table 152: Distribution on models among the new energy classes based on power in option a

Energy class	Brushless (total =22)	Capacitor (total = 96)	Shaded poles (total = 25)
A (EEI < 60)	0	0	0
B (60 ≤ EEI < 70)	7	0	0
C (70 ≤ EEI < 80)	11	0	0
D (80 ≤ EEI < 90)	3	3	1

E (90 ≤ EEI < 100)	1	54	12
F (100 ≤ EEI < 110)	0	35	11
G (EEI ≥ 110)	0	5	0

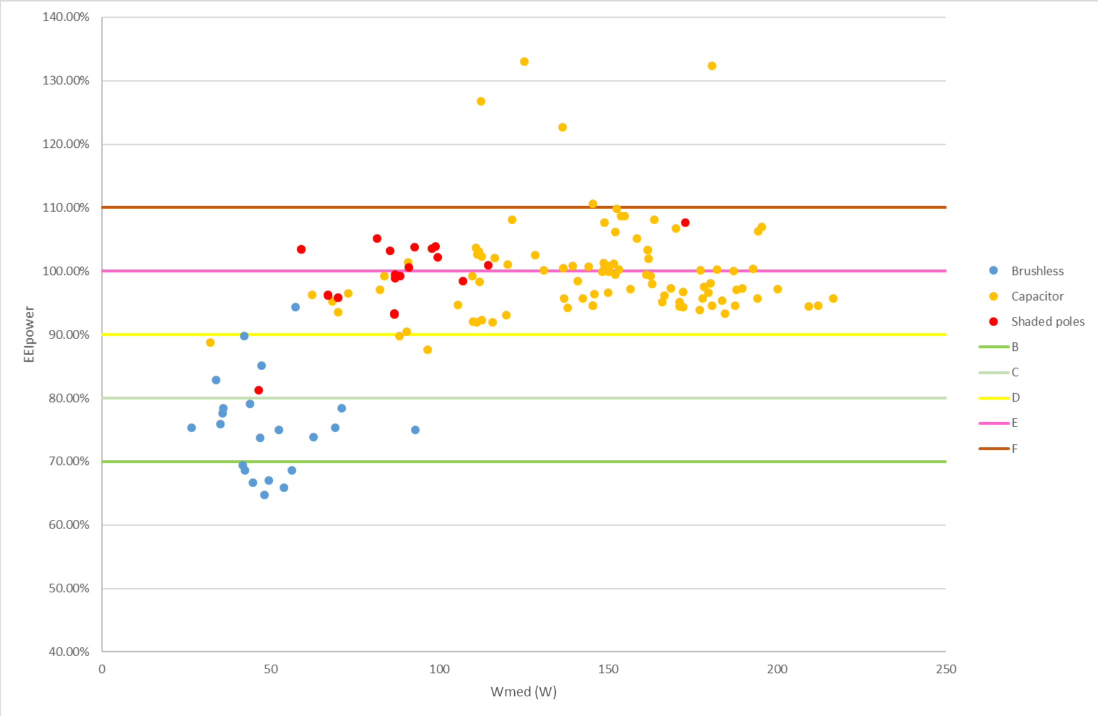


Figure 315: Distribution on models among the new energy classes based on power in option a

This option enables to identify the best EEI within brushless motors by means of classes B, C and D, though the data shows that C and D classes can be also be achieved by the other motor technologies. Energy classes D to F encompass both capacitor and shaded pole motors.

Option b

Energy class B and C correspond mainly to brushless motor cooking fume extractors. C class also covers capacitor and shaded pole motors The rest of energy classes identify capacitor and shade poles motor cooking fume extractors. The distribution of the different models is shown in Table 153 and Figure 316: Distribution on models among the new energy classes based on power.

Table 153: Distribution on models among the new energy classes based on power in option b

Energy class	**Brushless (total =22)**	**Capacitor (total = 96)**	**Shaded poles (total = 25)**
A (EEI < 60)	0	0	0
B (60 ≤ EEI < 75)	9	0	0
C (75 ≤ EEI < 90)	12	1	1
D (90 ≤ EEI < 95)	1	18	1
E (95 ≤ EEI < 98)	0	32	3
F (98 ≤ EEI < 103)	0	32	7
G (EEI ≥ 103)	0	19	7

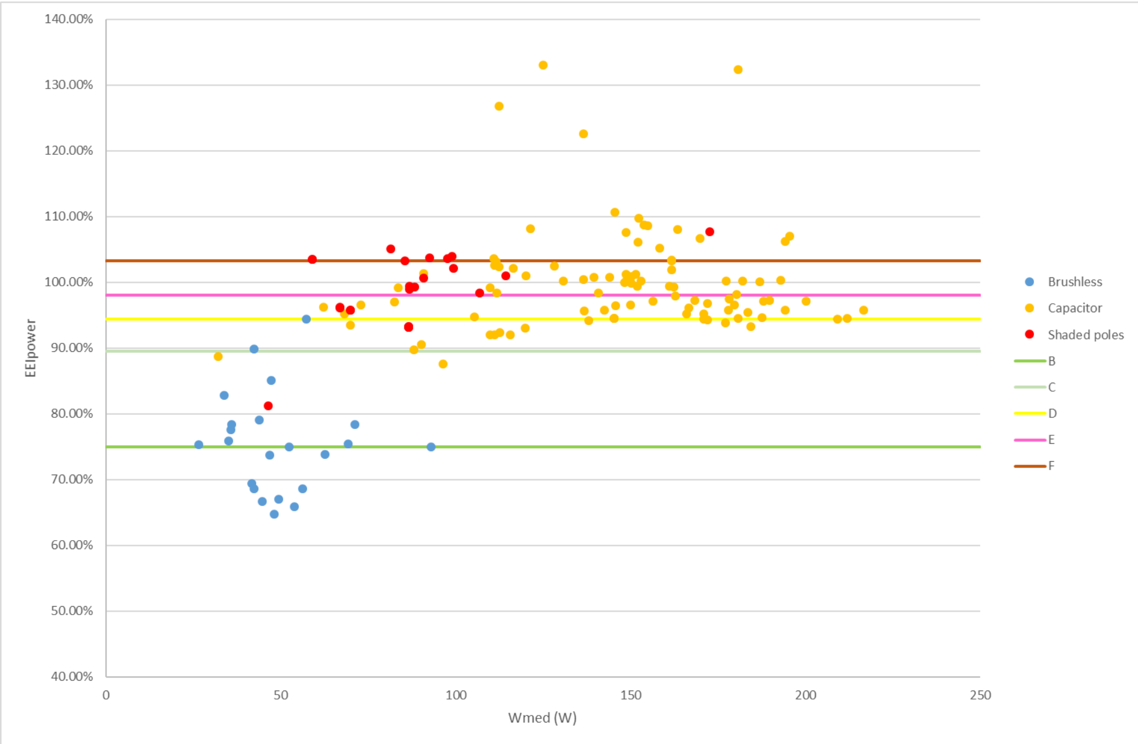


Figure 316: Distribution on models among the new energy classes based on power in option b

This option enables to identify the best EEI within brushless motors by means of classes B and C, though the data shows that these classes can be also be achieved by the other motor technologies. Energy classes D to F encompass both capacitor and shaded pole motors.

7.6.5 Ecodesign minimum requirements

The existing Ecodesign minimum requirements for cooking fume extractors are summarised in Table 154:

Table 154: Ecodesign minimum requirements for cooking fume extractors

February 2015	EEI_{hood}<120 FDE_{hood} >3
February 2017	EEI_{hood}<110 FDE_{hood} >5
February 2019	EEI_{hood}<100 FDE_{hood} >8
February 2015	Air flow ≤ 650m3/h
February 2015	E_{middle} > 40 lux

There are also requirements on low power modes, which were suggested to be replaced by including the cooking fume extractors within the scope of Ecodesign regulation (EC) No 1275/2008 for standby and off mode.

There are different options to set minimum energy performance standards according to the EEI described in the previous section. If a minimum energy class F is required, the models in Table 155 would be affected:

Table 155: Models affected by a minimum energy class F for the different options

EEI	Brushless (total =22)	Capacitor (total = 96)	Shaded poles (total = 25)
G based on FDE option a (EEI ≤ 75)	0	25	23
G based on FDE option b (EEI ≤ 58)	0	16	16
G based on airflow option a (EEI ≥ 190)	0	25	2
G based on airflow option b (EEI ≥ 207)	0	12	4
G based on power option a (EEI ≥ 110)	0	5	0
G based on power option b (EEI ≥ 103)	0	19	7

In order to establish FDE minimum requirements, the following figures show the three options of EEI and the respective FDE of the models.

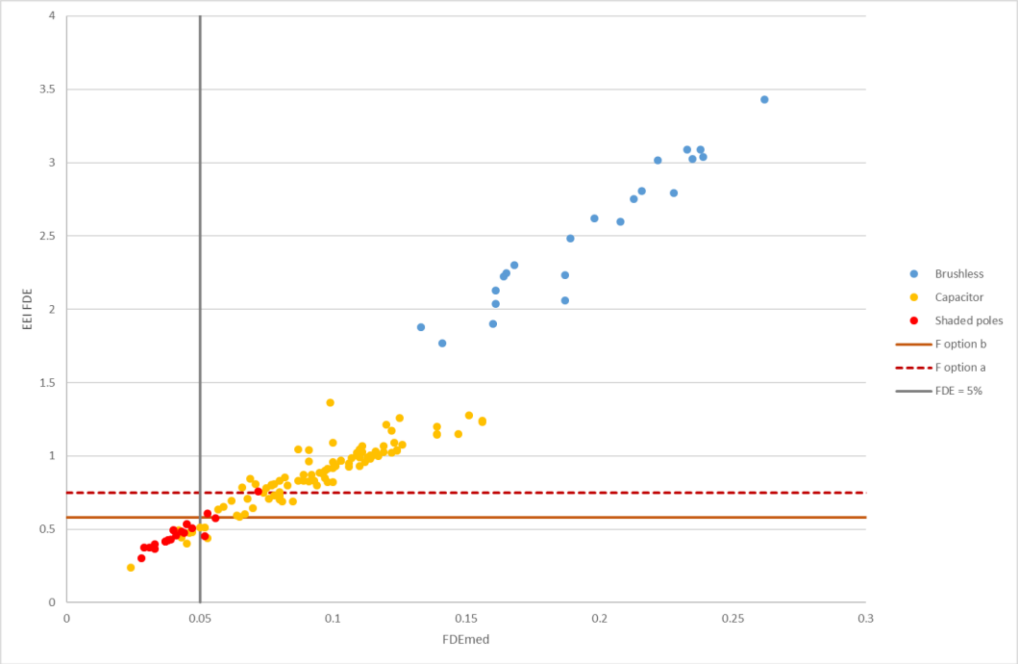


Figure 317: EEI based on FDE vs FDE

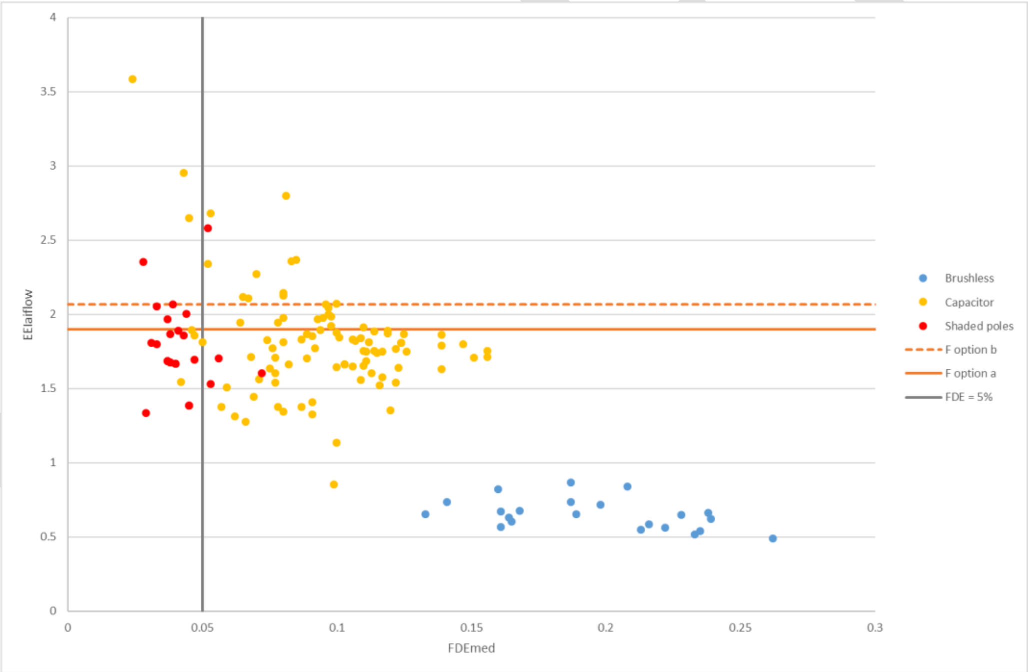


Figure 318: EEI based on airflow vs FDE

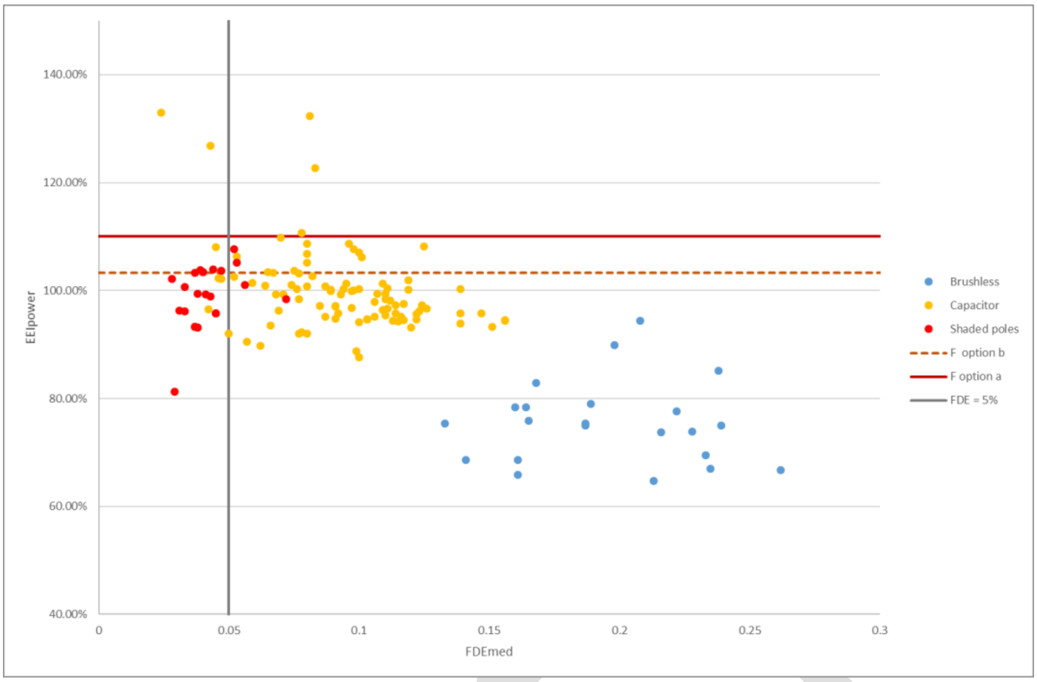


Figure 319: EEI based on power versus FDE

As can be observed, a minimum requirement on FDE calculated as 9-points average of 0.05 or 5% would affect to cooking fume extractors equipped with shaded pole motors. The energy class G based on FDE covers all these cooking fume extractors, while using the other two parameters, the removal of shade pole motors from the market would be additional to the minimum energy class required.

7.7 Horizontal policy options related to material efficiency

Since 2009, EU ecodesign and energy labelling are gradually introducing requirements on material efficiency, initially of informational character only, but lately also including specific thresholds. Material efficiency requirements are also present in a number of examples of voluntary agreements and labels such as EU Ecolabel, German Blue Angel or the Nordic Swan. This development has been accompanied by increasing importance of research on the feasibility of implementing resource efficiency aspects into product policies, as reflected in at least six European research studies published since 2013 (Ardente & Talens Peirò 2015; Benton et al. 2015; Bobba et al. 2015; Deloitte 2016; Prakash et al. 2016; Ricardo-AEA 2015).

There are various causes for the slower uptake of requirements in mandatory policies, including for instance the lack of enforceable and relevant metrics, the lack of proper standards to measure the requirements, and the lack of data demonstrating the benefits of minimum material efficiency requirements, to justify the thresholds. It is widely accepted that any new resource efficiency requirement should be measurable, enforceable, and relevant and should not hinder innovation and competitiveness. Additionally, any new requirements should have a proven environmental benefit and thus be based on robust data, methodologies and widely recognised standards that confirm this. Generic standard methods related to material efficiency applicable to energy related products have been recently published and described in Section 1.2.4 of this report.

Manufacturers have also stressed the need to make sure that ecodesign product measures do not overlap with other existing regulations that are already imposing end-of-life provisions and material/resource provisions, such as REACH, RoHS, WEEE and F-Gas.

Policy options related to material efficiency have already been presented in preparatory studies for other energy related products (dishwashers, washing machines, etc.). The assessment of those preparatory studies show that there is general agreement on the need for requirements that improve durability, such as information about the technical lifetime of the products, of spare part availability, or of design for upgrades and repairs. This section describes an array of policy options for extending the durability of domestic cooking appliances and facilitating reparability, as well as a proper management of the appliance during the end-of-life stage.

In Section 4.4.3 of this report, some information was provided regarding critical parts and failures in domestic cooking appliances specifically. In ovens, for instance, the most common problems are related to the following components:

- Failure of fan. These components are prone to failure since they are subject to stress of quick heating and cooling.
- Failure of thermostat, the most probable cause being oven overheating.
- Light not working
- Dials or controls not working, potentially due to faulty thermostat or thermal fuse
- Door not closing properly, potentially due to failure in sealing, rollers or hinge runners. This may cause uneven cooking, higher energy use and damage to adjacent units.
- Oven cutting out after being ON for a while
- Noise, potentially due to moving parts being misaligned or due to bearing failures
- Glass door breaking, potentially due to overheating or the presence of temperature differentials
- Handles breaking

In external reports, some data is provided regarding frequency of failure and main components requiring attention (see Task 4 of report). According to manufacturers, they have no reliable data available about the most frequent occurring failures and defects. In terms of the most common failures in components for ovens, hobs and cooking fume extractors, their feedback is:

7 **Ovens**: a very wide variety of technologies is used. From very basic models up to highly complex appliances with integrated microwave and/or steam function with TFT displays and Wifi connection (e.g.). Therefore, any general recommendation about most failing components cannot be made.

8 **Hobs**: as there are many hob technologies available (radiant, gas, induction) and different solutions are offered within one technology, a general answer about occurring failures/defects cannot be given.

9 **Cooking fume extractors**: the main recurrent complaints are “the appliance is too loud” and “does not evacuate well”. In most of the cases this is due to incorrect installation.

Based on that background information, a summary of potential policy options that could be considered for domestic cooking appliances is presented in Table 156. These policy options have been inspired by what has already been proposed in preparatory studies for the mentioned product groups, since they are relevant as well to ovens, hobs and range hoods.

Table 156. Summary of material efficiency policy recommendations

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
Unsatisfactory mechanical robustness / durability of certain components and/or the whole appliance which lead to early failure rates	Requirement on **performing durability tests of certain components** which are known to be prone for early failures	Decreased failure rate of appliance components	- No clear evidence of certain components which usually fail more often (might be different from appliance to appliance) - High effort / costs for testing - Quality of just performing tests might be variable from manufacturer to manufacturer - Testing alone would not lead automatically to higher durability
Same as above	Requirements on a **minimum operational lifetime** of certain components which are known to be prone to early failures	Decreased failure rate of appliance components	- High effort for market surveillance authorities
Same as above	Consumer information on the operational lifetime of certain components	-Transparency to consumer - Manufacturers can actively use this as a competitive argument	- Claims on operational lifetime must be backed with verifiable durability tests (not only marketing instrument) - It does not ensure that other components / the whole appliance are defective due to other reasons
Same as above	Requirement on **performing durability tests of the whole product**	- Decreased failure rate of appliances	- Specification of typical extreme stresses for those appliances needed - Measurement standards needed - High effort / costs for testing - Quality of just performing tests might be variable from manufacturer to manufacturer - Testing alone may

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
			not lead automatically to higher durability
Same as above	Requirements on a **minimum operational lifetime** of the whole appliance (e.g. machines to run a minimum number of cycles)	- Decreased failure rate of appliances	- Market intervention which might hinder/prevent innovations - Few incentives for manufacturers to design the appliance beyond this mandatory minimum lifetime - Disadvantage for those manufacturers providing already better quality (as market surveillance might not be effective enough to override bad quality products to a large extent) - It must be combined with legal rights for consumers to claim if the minimum lifetime is in practice not reached - Testing conditions need to reflect normal use patterns which means that testing procedures are lengthy and expensive. This bears significant risk of market distortions as market surveillance authorities cannot manage this task, let alone in a timely manner. Infringers would not have to fear prosecution.
Same as above	Consumer information about the **expected operational lifetime of the whole product** (e.g. label, manual)	- Transparency to consumers - They might choose higher quality products - Manufacturers can actively use this information as a competitive argument	- Claims on operational lifetime must be backed with verifiable durability tests (not only marketing instrument) - It does not ensure that other components / the whole appliance are defective due to other

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
			reasons - This would probably not lead to an additional benefit for the consumer because also manufacturers of rather low priced appliances would probably not indicate a shorter expected operational lifetime, and until standards are available to test this, it cannot be enforced. Poor quality device manufacturers could say depends on usage: e.g. lifetime 10 years …when used once a week.
Wrong user behaviour leading to defects of appliances (e.g. incorrect use, insufficient maintenance)	General consumer information about correct use and maintenance of appliances	- Decreased misuse - Decreased defects of appliances	- Already mostly available in the manuals - Is does not generally prevent consumers from misuse (precondition is that they read the information at all and act accordingly) - A standard format could help enforcement of such requirements
Same as above	Compulsory **direct feedback** on necessary maintenance intervals via machine's **display**	- A more regular maintenance done by consumers	- Not all appliances are equipped with a display - Communication of such information requires special displays and a sensor which measures the next maintenance interval to be necessary - Significant raise of appliances prices expected especially in the low-price segment - Not clear if consumers would really change their behaviour - Such messages risk

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
			to disturb consumers and would increase resource usage. - This service is a competitive feature
Early replacement of appliances due to **changes in consumer preferences and needs**	Consumer information about the environmental (and economic) benefits of prolonged product use (e.g. campaign, sign on the appliance etc.)	- Might reduce early replacements by consumers	- No clear evidence of the impact - Consumers might have still other predominant arguments / reasons for exchanging products - This is rather a general issue for which general information campaigns could be appropriate. - Educational effects might be limited. - Proper information on disposal and more efficient WEEE collection/recycling should be the priority.
In case of a defect, appliances are increasingly discarded although a **repair** might have increased the lifetime; reasons might be e.g. a certain product design impeding repairs, missing and/or no access to spare parts, high costs for repairs compared to purchase of a new product etc.	**Design for upgrades and repairs**: components being prone to early failures should **not be designed in a manner prohibiting repairs** (e.g. high integration of different components)	- Modular design facilitates repairs in a cost-effective manner	- Modular design might be more expensive - No clear evidence of certain components which usually fail more often (might be different from appliance to appliance) - Market intervention possibly hindering innovations - Highly integrated components might have advantages themselves (e.g. better quality of the whole component group due to integration) - This requirement would need to be specifically aimed at certain components to be effective.

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
Same as above	**Design for upgrades and repairs**: components being prone to early failures should be **easily accessible and exchangeable** by the use of universal tools	- Facilitates repairs in a cost-effective manner	- No clear evidence of certain components which usually fail more often (might be different from appliance to appliance) - High effort / costs for testing / market surveillance; "easily accessible" should be well defined - Early failures of products are covered by the warranty and defects liability regulation.
Same as above	**Appliance internal failure diagnosis systems** to report error specific messages to the user	- Digital pre-diagnosis of the specific failure would reduce duration and costs of repairs	- Not all appliances are equipped with such a system and display - Communication of such information requires special displays and a system which recognizes the kind of failure - Significant raise of appliances prices expected especially in the low-price segment - Impact is not clear - Particularly relevant for electronic control systems, which may make finding defects difficult for repairers. - Relevant information is already given for most of the appliances. This information should target the after-sale services.
Same as above	**Information requirements on reparability** (e.g. repair label), e.g. 1) indicating if the machine can be repaired or not; 2) indicating which components are not	- Transparency for consumers - Consumers might choose products being better reparable or which contain e.g. modular components	1) - Manufacturers would always claim reparability - Difficult to define / measure, i.e. difficult to prove non-compliance 2)

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	reparable		- Difficult to define - In general, most components will be reparable or exchangeable - cost factor - This kind of self-declared claims is prone to creating market distortion - Even if an old product is repairable, if the costs of repair are 150 euros, purchasing a new product may be more desirable for the consumer.
Same as above	**Consumer information about access to professional repairs** (e.g. information in user instruction / manufacturer's website / on the appliance itself to let the user know where to go to obtain professional repairs and servicing of the product, including contact details)	- Facilitates the possibilities for repairs	- Those consumer information is already mostly available in the manuals - Tt does not generally prevent consumers from not repairing the devices as other reasons might play a role (e.g. costs of repairs, inconvenience of long waiting times) - Often only authorized repair shops listed which might be more expensive than independent ones - It seems questionable if such requirements should be set on a product by product case or if an overarching respectively horizontal regulation would be more advantageous - For safety and liability reasons, it is crucial that no obligation is set to make repair and disassembly information available to end-consumers. - The repair of

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
			products needs appropriate technical skills that most consumers do not have.
Same as above	Information about the availability (and price) of spare parts (current practice: from 0 to 10-15 years after production)	- Transparency to consumers - They might choose higher quality products - Manufacturers can actively use this information as a competitive argument	- Price indications are variable and dependent on several factors - Cost of spare parts is only one factor of the total costs of repair (labour costs, travel costs) - Indication of prices in advance might even discourage consumers from doing repairs - Detailed documentation of spare parts availability should be reserved to professionals. A general information, in principle, would be feasible. However, it would be difficult to verify the claims and false claim would endanger producers with a strong performance (and high costs) in this field. - Several pieces of legislation, in particular REACH, can also negatively affect the possibilities to repair products. As contrary to RoHS Directive, where the principle "repair as produced" is foreseen as a legal provision, within REACH this principle is not implemented. It is essential to provide equivalent items to ensure the repair is safely done. However, due to the frequent

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
			addition of substances to the Authorisation and Restriction lists of REACH, the production of spare parts could be limited. - It is not easy to check the claims of availability (and price) of spare parts..
Same as above	**Guarantee of public availability of spare parts** for a certain period following the end of the production of the model; ensure original and backwardly compatible spare parts	- Facilitates that products can be repaired for a long period and by repair centres which are not manufacturer-bound	- Costly for manufacturers to hold a stock of spare parts for a long time - For long-lasting large household appliances, this period might be at least 5 years to cover early breaks, but up to 10-15 years - Environmental benefits not clear (if spare parts are not needed in this period, the might be destroyed without being used) - A guarantee bears the risk of 1) changes in the policy framework and 2) an oversupply of spare parts that become WEEE at a later point in time.
Same as above	**Repair manual: clear disassembly and repair instructions** to enable non-destructive disassembly of product for the purpose of replacing key components or parts for upgrades or repairs. **Information publicly available** or by entering the products unique serial number on a webpage **to facilitate access**	- Might decrease repair costs for consumers if independent repair organisations and approved re-use centres have information access and are able to perform repairs	- Accountability (e.g. safety, lifetime, guarantee) and confidentiality of manufacturers might not be ensured if information is public available / non-authorized repair centres can do the repairs - Repair manuals are available for approved service providers. - Public availability bears the risk of abuse causing liability

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	for recognized / independent repair centres. A diagram of the inside of the housing showing the location of the components available online for at least 5 years		issues or damage to consumers
Same as above	**Commercial guarantee** providing a minimum of 3 years guarantee effective from the purchase of the product during which manufacturers shall ensure the goods are in conformity with the contract of sale (without passing the burden of proof to the consumer). It includes **service agreement** with a pick-up and return option.	- Manufacturers might improve the quality of their products to prevent claims	- Costly for manufacturers - Risk that costs are transferred to the total product purchase price - Risk that appliances (especially low-cost) would be replaced by a new model instead of being repaired
Same as above	**Mandatory consumer information about commercial guarantees**, i.e. the number of years the producer guarantees the full functioning of the appliance for free and without passing the burden of proof to the consumer	- Transparency to consumers - They might choose higher quality products - Manufacturers can actively use this information as a competitive argument	- Information already available in the contract signed by a consumer buying the appliance. The 1999 Directive sets minimum requirements at EU level, with the possibility for Member States to increase the protection at national level : 2 years of period of conformity and 6 months of the reversal of the period of the burden of the proof - Any commercial guarantee applied by a manufacturer is part of its commercial strategy and thereby de facto a competitive issue.

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
The design of appliances can influence the practicability of recycling facilities at the EoL according to WEEE requirements (dismantling of certain PCBs, displays, refrigerant containing components like heat pumps etc.) or to recover valuable resources (e.g. rare earth elements in permanent magnets of motors)	**Design for recovery and recycling** which allows better / easier access to dismantle / separate WEEE relevant components or components containing valuable resources	- These requirements are devised to help recyclers to better comply with the WEEE directive by providing information relevant for depollution, disassembly and or shredding operations	- Measurement standard needed otherwise it would be too generic - High effort for manufacturers and market surveillance authorities - Current technologies involve only a minimum of manual labour in dismantling, mainly for depollution. Thus design has a limited influence on this stage of the life cycle. Further, future technologies in WEEE treatment cannot properly be anticipated in the design phase - Specific components should be named. Components with particular environmental relevance should be easy to separate from the machine. - Setting a dismantling description would be meaningful only if products were actually dismantled in the prescribed way at the end of life - PCB of domestic appliances is not comparable to those of ICT, having a lower content of copper and precious metals. This makes measures in this field less effective than some studies suggest - Recycling is following price signals in the up taking markets and the level of material recovery (in a broad sense)

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
			depends more on the profitability of the recycling activity than on parameters the producers of products can influence by design.
Same as above	**Marking of plastic parts containing hazardous substances** (e.g. halogenated flame retardants); example: brominated fire retardants logo as proposed in the ED draft for electronic displays	- Might improve to get recyclates without hazardous substances (avoid contamination)	- Effective only if it is possible to separate the recycled plastic streams (those free from hazardous substances) - A minimum threshold must be set and all components must be checked for compliance by market surveillance. - Br-free logo implies no retardants in device, however small fittings or cables may still contain these. - Testing is difficult for market surveillance to carry out. - Large parts with markings may be useful, but it depends on recycling regimes (shredding or manual separation). - Should be aligned with the proposals on the same issues for electronic displays regulation
Same as above	**"End-of-life report"** for recyclers containing information relevant for disassembly, recycling and recovery at end-of-life at least on exploded diagram of the product labelling the targeted components defined together with a documentation of the sequence of dismantling	- These requirements might help recyclers to better comply with the WEEE directive by providing information relevant for depollution, disassembly and or shredding operations	- In the daily recycling practice such documents might not be used at all. - Feedback from recyclers signals that any written documentation had little value for the recycling process.

Rationale	Possible Policy Measures	Expected benefits	Potential disadvantages, challenges and/or drawbacks
	operations needed to access to the components		
Same as above	Declaration of the **recyclability index** for products indicating the share of recyclable materials	- Transparency - Market differentiation	- Well developed and widely accepted procedures needed; - So far only a theoretical number as the real treatment of the specific appliances and thus their recyclability depends of further factors - It does not help to improve the real recycling process - There is no consensus about the recyclability of single materials; - This currently is item to research and should be subsequently item to standardisation. - The declaration would not be relevant for consumers, but invite free riders for providing unrealistic values that cannot be verified - Recyclers should be asked if this is useful - Added value of this information needs to be verified as it does not guarantee recycling of certain materials in real-life. - As an aggregated index it might be too simplistic compared to targeted measures to promote recovery of key materials

7.8 Scenario analysis

The objective of this section is to set up a stock model (2020-2040) and calculate the impact of different policy scenarios regarding resource use (energy and water), emissions (CO_2eq), consumer expenditure and employment depending on the market evolution of domestic cooking appliances. The different policy options are defined in the previous sections.

Note that the calculated impacts for the different scenarios are indicative. The scenarios defined in this section are a simplification and do not have the aim of working as a forecast of the future market behaviour in this sector. A full impact assessment will be developed later in the policy process where the findings from this study can be refined.

7.8.1 Stock of domestic cooking appliances

The stock of domestic cooking appliances has been presented and detailed in Task 2 of this report. As a summary, the total stock of ovens (both built-in and cookers) is estimated to grow between 2019-2040 up to almost 200 million units in 2040 (Figure 320). The evolution of gas ovens is slightly downward which is consistent with the expected growth in sales for the period 2015-2018.

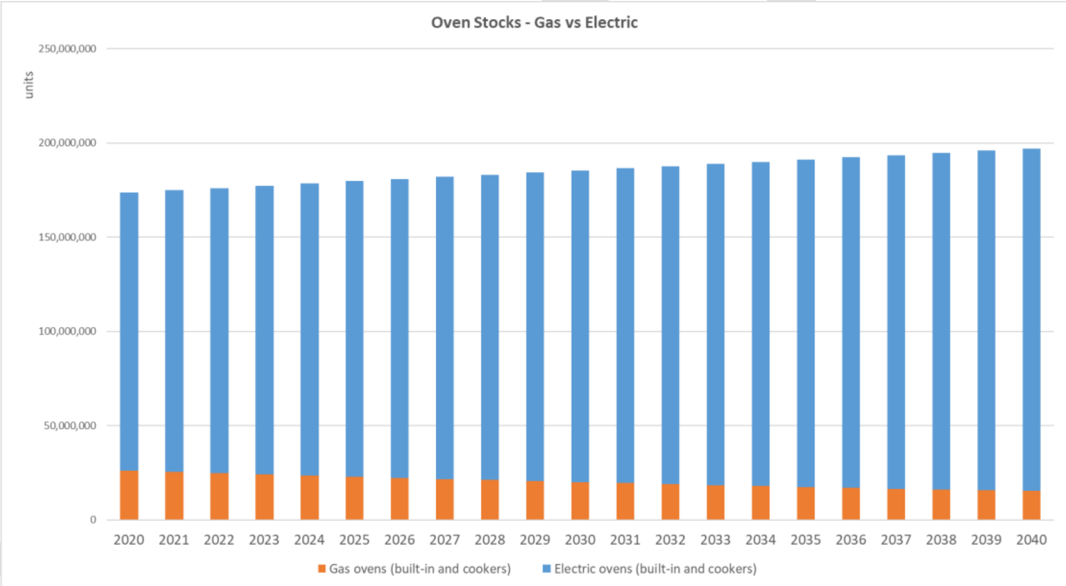


Figure 320. Estimated oven stocks 2020-2040

In the same way, as it can be seen in Figure 321, the total stock of hobs shows a similar pattern.

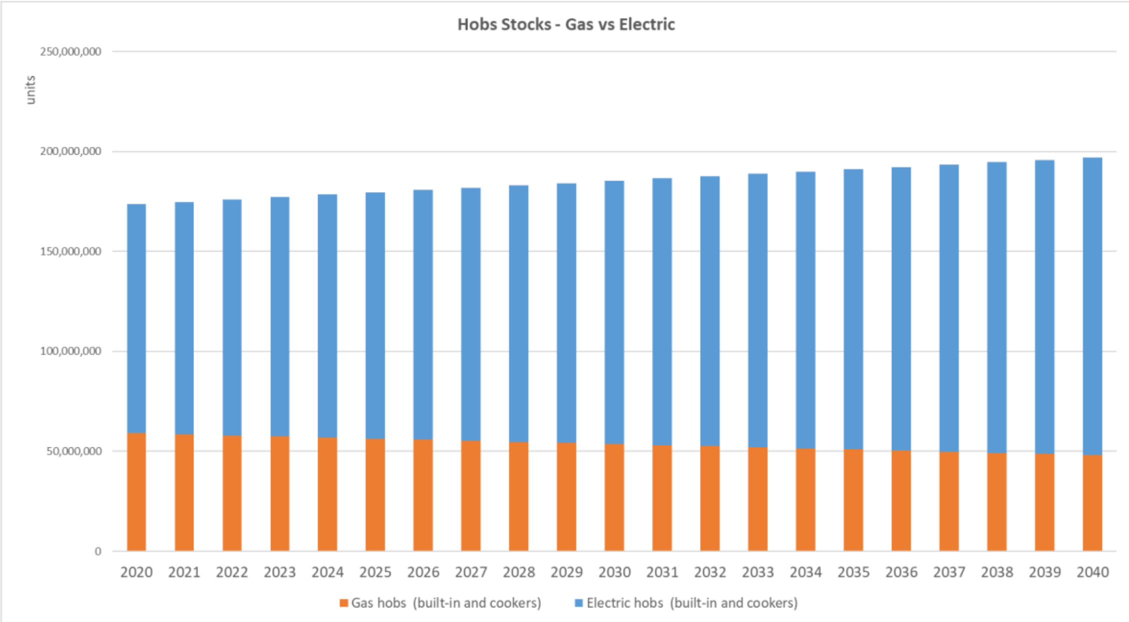


Figure 321. Estimated hob stock 2020-2040

According to the sales data, induction will grow significantly, becoming the most common technology is the coming years (Figure 322).

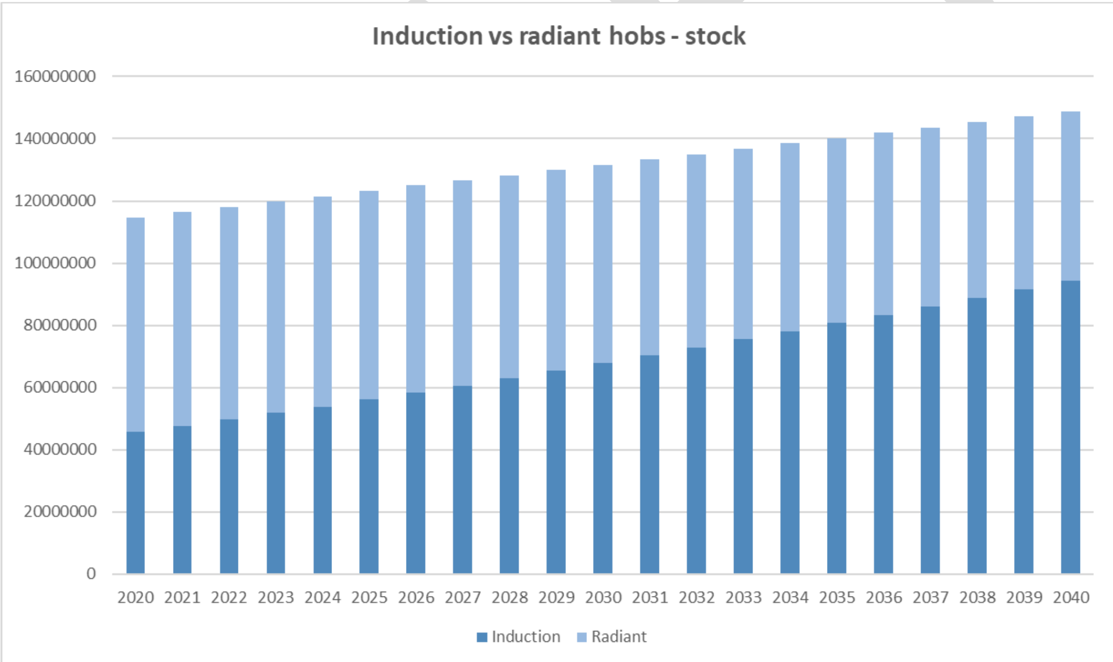


Figure 322. Estimated induction / radiant hob stock 2020-2040

As it can be seen in Figure 323, the total stocks of cooking fume extractors is estimated to grow between 2019-2040 up to 160 million units in 2040. This growth is consistent with the expected growth in sales for the period 2015-2018.

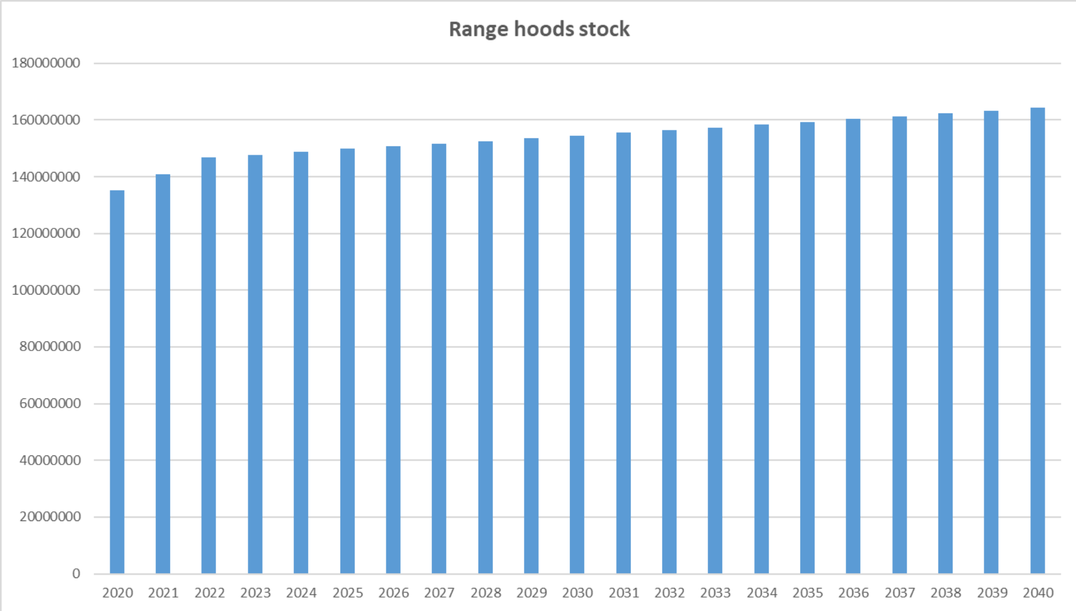


Figure 323. Estimated cooking fume extractors stock 2020-2049

7.8.2 Policy scenarios for ovens

This section aims at defining and evaluating different policy scenarios for domestic ovens. The scenarios will consist in a combination of different policy options presented in previous sections. The implementation of certain policies will have consequences on the market. The aim of this section is not to conduct a comprehensive market analysis of the domestic oven sector or to forecast the market evolution, but to evaluate what are the potential consequences of some of the presented policies, as well as their benefits and drawbacks in terms of overall EU energy consumption, CO2 emissions or consumer expenditure.

The scenarios analysed in this section will be focused on electric ovens only. The lack of data on gas ovens makes it very difficult to evaluate the potential consequences on the market of the different policy options. In any case, it must be noted that gas ovens represent around 15% of the current stock of ovens, with an expected decreasing tendency for the next years. .

Before defining the different scenarios to evaluate, different aspects related to previous sections need to be established. For instance, it has been observed that the adoption of BM2.0 has certain benefits and there is a significant level of agreement within industry about them.

On top of that, for the declaration of energy consumption and determination of the energy class, based on feedback received from stakeholders, the weighted sum approach seems to be accepted by different members of the industry. It has also been observed that there is not much difference between the 50/50 approach and the 80/20 approach (in terms of the energy class that the appliances get). Therefore, in this section, every scenario will be evaluated with energy consumption measured with BM2.0, declaring it as a weighted sum at 50/50 between a conventional mode and the best performing mode (BPM). This was presented as *policy option 8c* in previous section.

The definition of scenarios need a starting reference point (2020), in terms of stock of appliances and distribution of technologies and energy classes. For ovens, it has been decided to use as a reference of the market the data from APPLIA2020. As already presented in previous sections, when representing APPLIA2020 with BM2.0 and the 50/50 approach, 91% of ovens are A and 9% B. For 2020 –the starting point of the analysis- it will be considered that this is the distribution of energy classes in the market (the stock).

The calculation of the overall EU27 energy consumption is conducted in the following manner. As an example, the formulas show the overall energy consumption of Class A ovens in year 2020:

Overall Energy Consumption Class A (kWh) in year 2020 =

*Stock Ovens 2020 (units) * Market Penetration Class A 2020 (%) * Annual Energy Consumption Class A (kWy/year)*

Identical calculations are then made for every year between 2020 and 2040, and for every energy class in the market. To conduct the above operations, a value for Annual Energy Consumption is required for each energy class. For ovens, this will be related with the base cases and design options presented in Tasks 5 & 6.

Base cases and design options in Tasks 5 & 6 were presented using the current measurement method for energy consumption (BM1.0). However, the scenario evaluation will be conducted assuming that BM2.0 has been adopted. The base cases and design options cannot be measured with BM2.0 because these are hypothetical appliances: an average representation of the market. Therefore, in order to use these base cases in the scenario evaluation, their energy consumption values will need to be *translated* to BM2.0. To do that, the correction factors below will be used. These correction factors have been calculated using APPLIA2020.

Table 157. Conversion factors BM1.0 to BM2.0

Conventional	Fan-forced
0.95	1.04

With BM2.0 and a weighted sum 50/50 approach, BC1 would have an EEI of 102, which would leave it in the top part of the A energy class (very close to B). The best design option would be DO2, that would get an EEI=80 and an A+ energy class. The rest of design options (DO1, DO5 and DO6) would have similar EEI values and positions within the A energy class (Figure 324). At this point, it can already be seen that one of the main challenges in the definition of scenarios and policy options will be product differentiation. In previous sections, it has been observed that most of the ovens of APPLIA2020 are located in few energy classes. Figure 324 shows that if policy option 8c 50/50 is adopted, DO1, DO2, DO5 and DO6) would be A, and BC1 would be B (with current energy classification).

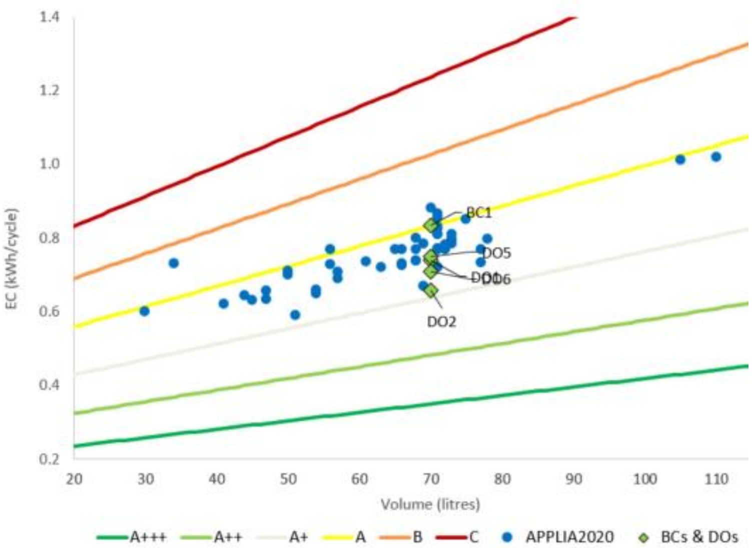


Figure 324. Energy class of base case and design options (current classification)

It might be interesting to note at this point that when the design options are defined, they are presented as an individual technology isolated from the rest. That means that the energy consumption savings of each technology are considered separately. For instance, the benefits of DO1 are not considered together with the benefits of DO6. It can be assumed that combinations of the design options presented could achieve higher energy savings, obtain lower EEI and therefore reach higher energy classes.

In terms of Annual Energy Consumption (AEC) of each energy class, it has been assumed that:

- The A++ ovens have an AEC equivalent to a 70 litre oven in the middle of the B band
- The A+ ovens have an AEC equivalent to DO2
- The A ovens have an AEC which is a weighted sum between BC1 (70%), DO1 (15%), DO5 (10%) and DO6 (5%)
- The A++ ovens have an AEC equivalent to a 70 litre oven in the middle of the A++ band
- The B ovens have an AEC equivalent to a 70 litre oven in the middle of the B band
- The C ovens have an AEC equivalent to a 70 litre oven in the middle of the C band

A summary of the above values can be seen in Table 158.

Table 158. Average annual energy consumption of energy classes

Energy class	Based on	Annual Energy Consumption (kWh/year)
A++	70 litre B oven in the middle of the A++ band	83.8
A+	DO2	123.3
A	BC1 (70%), DO1 (15%), DO5 (10%) and DO6 (5%)	150.3
B	70 litre B oven in the middle of the B band	182.1
C	70 litre C oven in the middle of the C band	220.3

Every scenario defined in this section will have as starting point the data presented in this section, in terms of energy class market penetration and annual energy consumption. The scenarios presented will mostly change the market penetration of each energy class and therefore the overall energy consumption. Energy savings will be estimated, considering a business as usual (BAU) situation and the different scenarios.

7.8.2.1 Business as usual scenario

The definition of the Business as Usual (BAU) scenario for domestic ovens is based on the assumption that no additional regulation is implemented. The BAU scenario is only used for reference as it is highly unlikely that nothing will change in the energy label given.

Sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 325). The sales percentage of each energy class remains constant for that period: 0.25% B. 69.96% A, 29.72% A+ and 0.07% A++. Sales of A ovens have been also shared between BC1, DO1, DO5 and DO6.

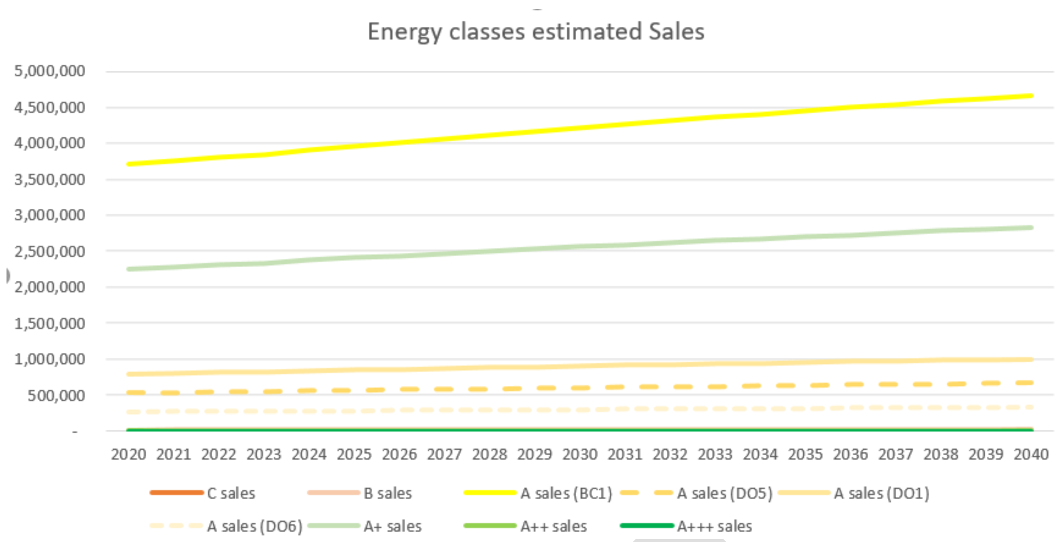


Figure 325. BAU estimated sales

In the BAU scenario it is assumed that current stock is approximately the same as the one represented by APPLIA2020. Based on that data and on the estimated sales profile, the estimated stock of ovens between 2020-2040 and the distribution of energy classes for Scenario BAU will be as in Figure 326.

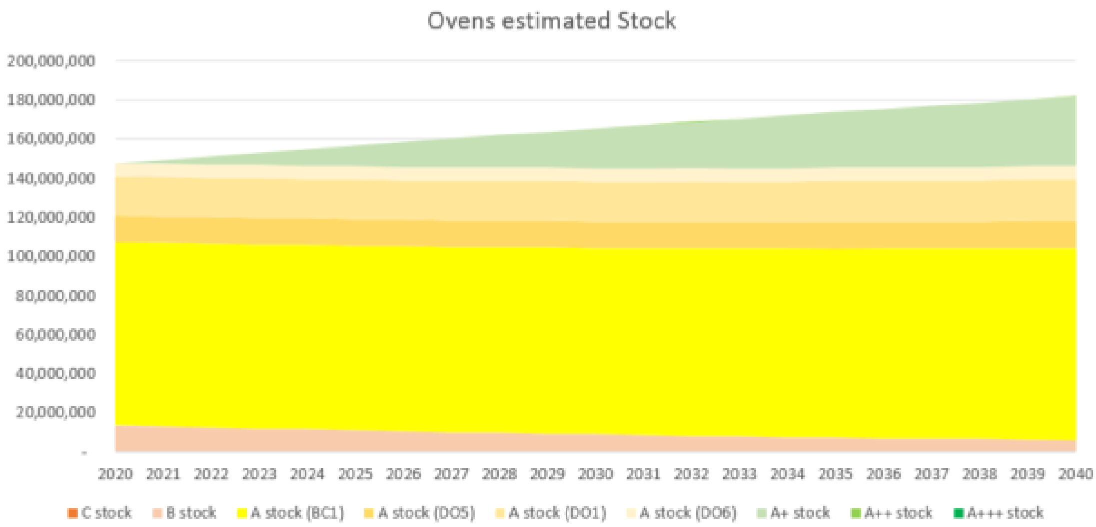


Figure 326. BAU estimated stock

The total energy consumption of the above stock of ovens is presented in Figure 327.

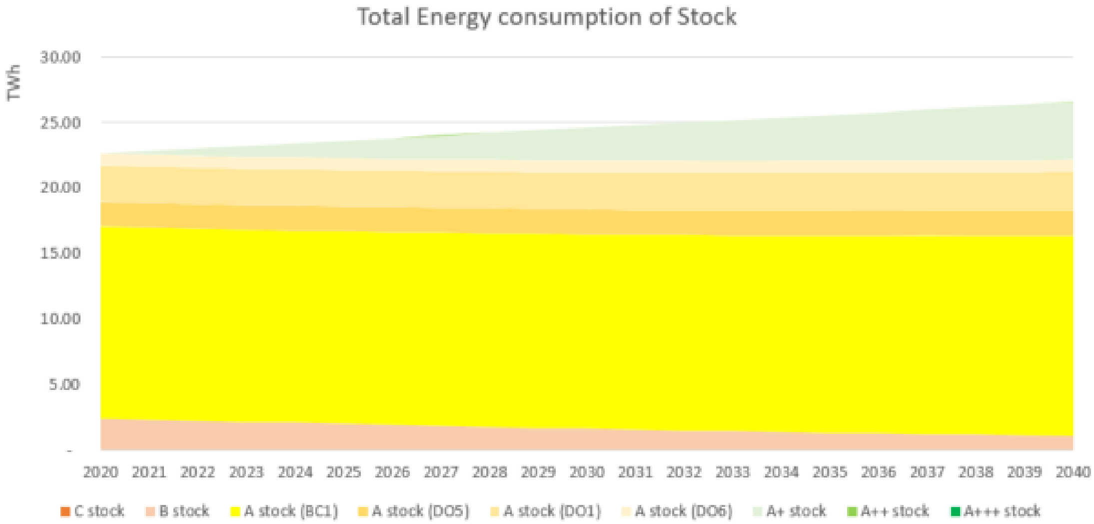


Figure 327. BAU estimated energy consumption

7.8.2.2 Scenario 1: Stricter minimum ecodesign requirements and removal of the energy label

In Section 7.3.5, different tiers were presented as proposals for ecodesign minimum energy performance requirements Table 159.

Table 159. Scenario 1. Proposed ecodesign thresholds

Tier 1: 2025	**Tier 2: 2027**	**Tier 3: 2030**
Adoption of either *Policy option 8b* or *8c 50/50*. Ecodesign minimum: EEI<96	Adoption of either *Policy option 8b* or *8c 50/50*. Ecodesign minimum: EEI < 91	Adoption of either *Policy option 8b* or *8c 50/50*. Ecodesign minimum: EEI < 86

A potential evolution of the sales of domestic ovens related to the introduction of the above tiers is shown in Figure 328. The sales of the starting point (2020) is based on market data from GfK: 69.95% of sales are A and 29.72% are A+ (with a marginal amount shared between A++ and B). Sales of A ovens have been also shared between BC1, DO1, DO5 and DO6.

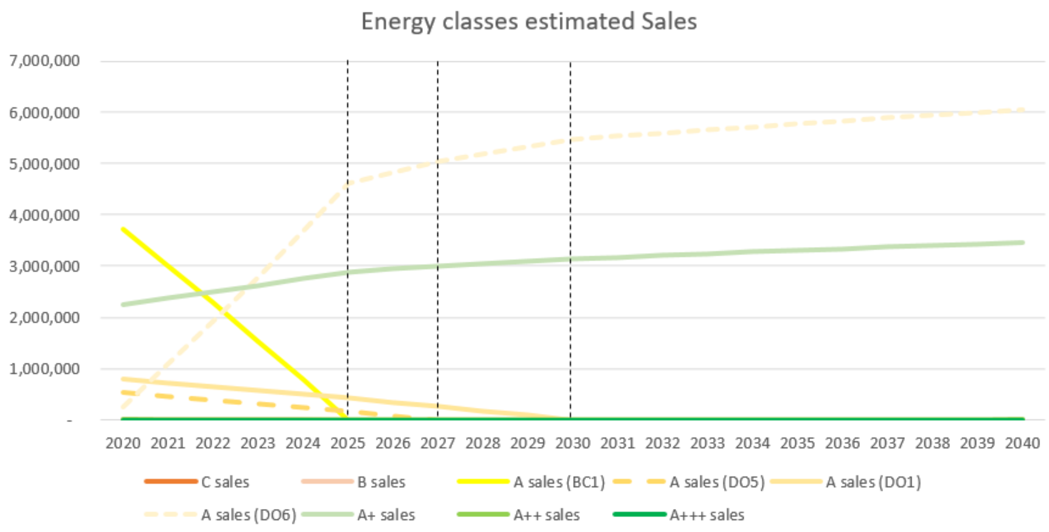


Figure 328. Scenario 1. Estimated sales

The introduction of Tier 1 (EEI>96 banned after 2025) would cause that the sales of A(BC1) ovens be zero by that year. It is assumed that the sales of A(BC1) ovens would decrease linearly between 2020-2025 and that those sales would be shared between A(DO6) and A+. In this scenario, there would not be energy label, so most of these sales would go to A(DO6), since there would be no incentive to reach a higher energy class. This is the reason why the A(DO6) line grows faster than the A+ line.

The introduction of Tier 2 (EEI>91 banned after 2027) would cause that the sales of A(DO5) ovens be zero by that year. It is assumed that the sales of A(DO5) ovens would decrease linearly between 2020-2027 and that those sales would be shared again between A(DO6) and A+, with a higher proportion going to A(DO6).

The introduction of Tier 3 (EEI>88 banned after 2030) would cause that the sales of A(DO1) would be zero by that year. It is assumed that the sales of A(DO1) ovens would decrease linearly between 2020-2030 and that those sales would be shared again between A(DO6) and A+, with a higher proportion going to A(DO6).

In Sc1 there would be no energy label, so in principle there would be no incentive for manufacturers to reach higher energy classes such as A++ or A+++. This has been represented with no sales for that range of ovens between the period 2020-2040.

With that sales profile for the years 2020-2040, the new stock profile for those years would be as in Figure 329.

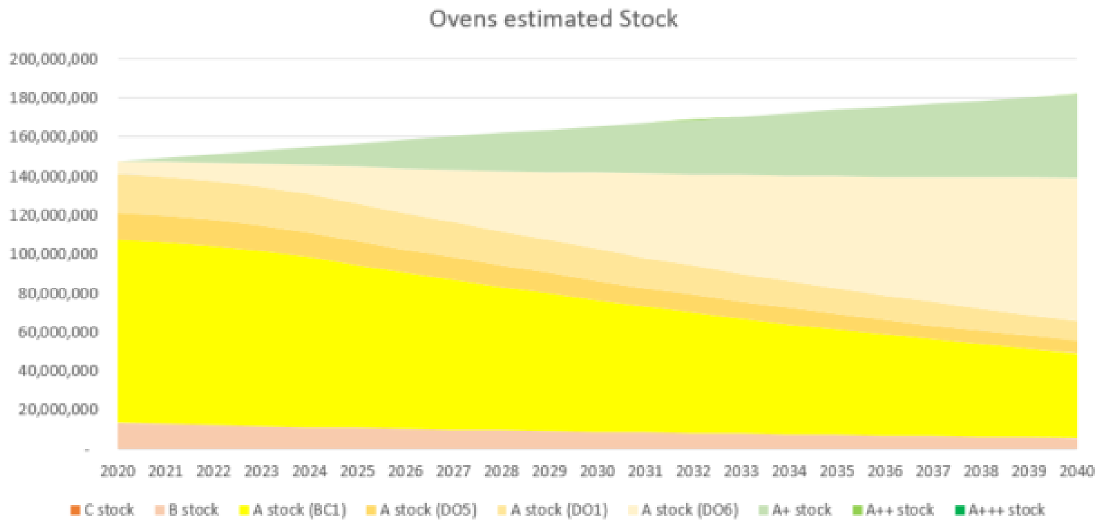


Figure 329. Scenario 1. Estimated stock

If compared with the stock of the BAU scenario, the stock of Sc1 shows some differences. First, the amount of A(BC1) ovens in households decreases significantly between 2020-2040, due to the Tier 1 introduced in 2025. The presence of A(DO1) and A(DO5) ovens also decreases. In 2040, the most common kind of oven in households would be an oven with characteristics similar to A(DO6), with significant presence of A+ ovens. The lack of incentive to sell A++ or A+++ ovens would cause that the stock of ovens would have A+ as the most efficient appliance in the market.

The total energy consumption of the above stock can be seen in Figure 330.

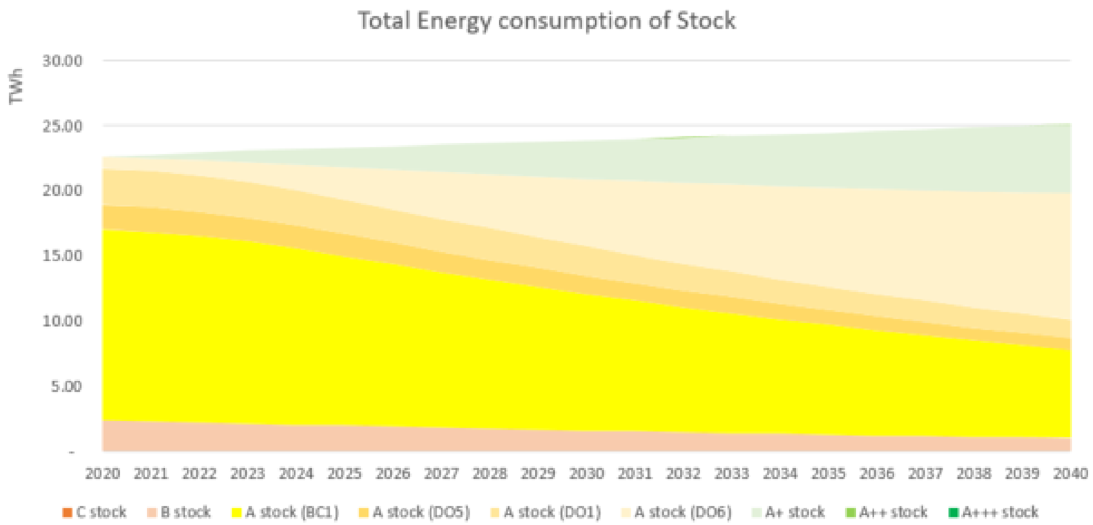


Figure 330. Scenario 1. Estimated energy consumption

7.8.2.3 Scenario 2a and 2b: Revised labelling classes

Energy labelling is a mechanism to help consumers making an informed decision regarding energy consumption of the appliance. It serves to differentiate products and identify the best energy performing machines. This scenario considers the policy options discussed in Section 7.3.6 regarding the implementation of new energy label classes.

In these scenarios, a new label class differentiation is created with a full scale of seven energy classes ranging from A to G. Ecodesign requirements defined in previous section are also put forward.

Scenario 2a consists in the adoption of *policy option 8c 50/50*, raising the top energy class by 25% and then an equal gap between classes of 14%. The aim of this scenario would be to promote energy class differentiation between ovens in the database.

Scenario 2b consists in the adoption of *policy option 8c 50/50*, raising the top energy class by 25%, then a 11% gap between the top 3 energy classes and a 20% gap between the rest (as described in Section 7.3.6.3). The aim of this scenario would be to promote innovation in top energy classes.

The label class thresholds for scenarios 2a and 2b are shown in Table 160.

Table 160. Scenarios 2a and 2b. Proposed energy classes

Energy efficiency class	Current Energy Efficiency Index	Scenario 2a (Promote differentiation)	Scenario 2b (Promote innovation)
A	EEI < 45	EEI < 56	EEI < 56
B	45 ≤ EEI < 62	56 ≤ EEI < 65	56 ≤ EEI < 63
C	62 ≤ EEI < 82	65 ≤ EEI < 76	63 ≤ EEI < 71
D	82 ≤ EEI < 107	76 ≤ EEI < 89	71 ≤ EEI < 80
E	107 ≤ EEI < 132	89 ≤ EEI < 103	80 ≤ EEI < 100
F	132 ≤ EEI < 159	103 ≤ EEI < 120	100 ≤ EEI < 125
G	EEI > 159	EEI > 120	EEI > 125

The main difference between Sc2a and Sc2b is the difficulty to reach the top energy classes. Sc2a has less strict limits, so top energy classes are easier to access, but the gap between them is wider, so it is harder to progress from C to B and A. In Sc2b, the limits of the top energy classes are stricter. However, the gap between them is considerably narrower, so it is easier to reach the best energy classes once the investment in the appropriate technologies have been made.

Considering first Sc2a, a potential evolution of the sales of domestic ovens related to the introduction of the above requirements is shown in Figure 331. The sales of the starting point (2020) is based on market data from GfK: 69.95% of sales are A and 29.72% are A+ (with a marginal amount shared between A++ and B). Sales of A ovens have been also shared between BC1, DO1, DO5 and DO6.

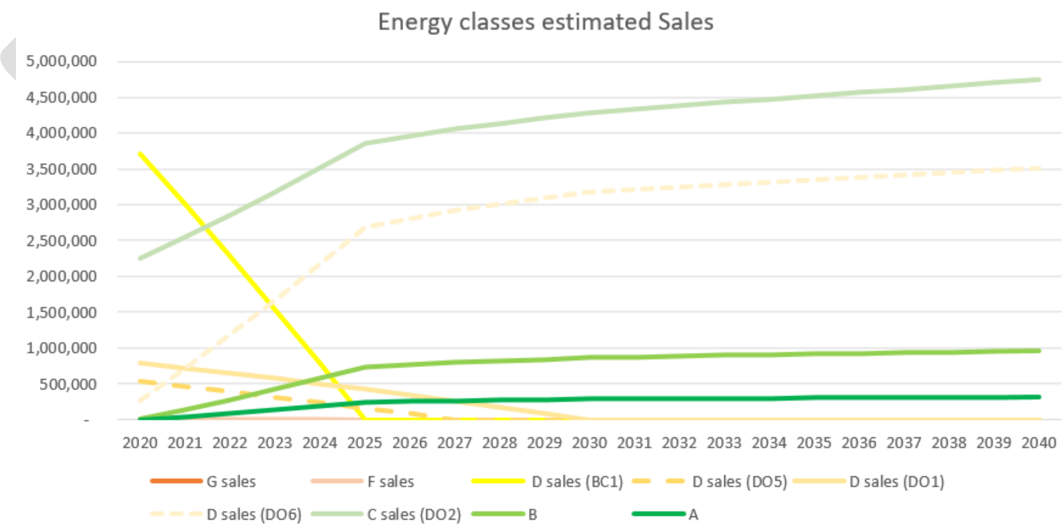


Figure 331. Scenario 2a. Estimated sales

The introduction of Tier 1, Tier 2 and Tier 2 (presented in Sc1) would cause that the sales of some type of ovens be zero by certain years. For instance, the sales of D(BC1) would need to be zero by 2025, the sales of D(DO5) would need to be zero by 2027 and the sales of D(DO1) would need to be zero by 2030.

The existence of an energy label in this scenario could work as an incentive for manufacturers to replace the above non-compliant appliances with ovens able to reach a higher energy class. To reflect that, it has been assumed that those appliances that are removed from the market are replaced by D(DO6) mostly, but also by B and A ovens (the top two energy classes). In this scenario, the gap between the top energy classes is wider, so it has been assumed that a higher proportion of the replaced ovens stay in the B energy class and do not progress up to A.

With that sales profile for the years 2020-2040, the new stock profile for those years would be as in Figure 332.

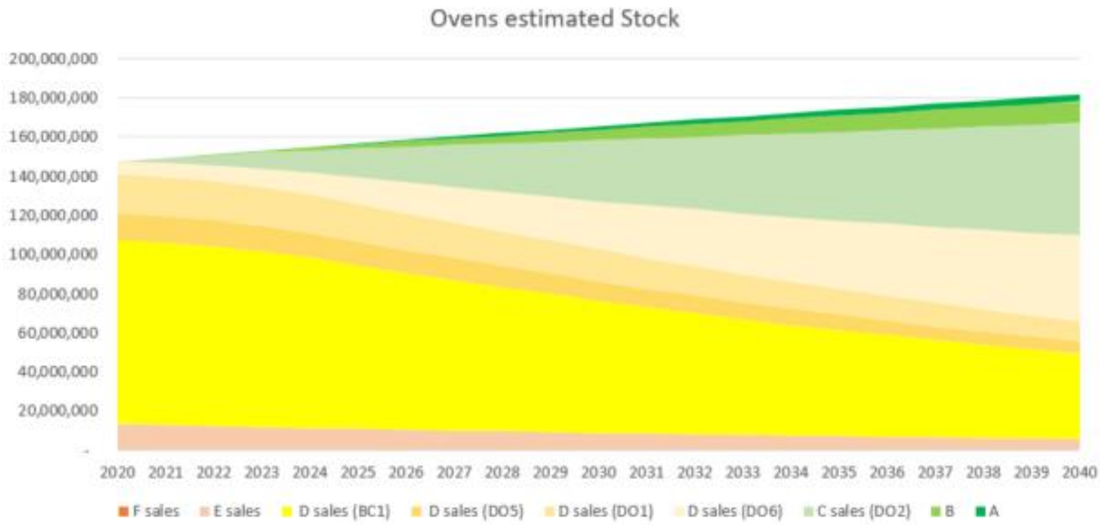


Figure 332. Scenario 2a. Estimated stock

Considering Sc2b, a potential evolution of the sales of domestic ovens related to the introduction of the above requirements is shown in Figure 333. The starting point in terms of sales is the same as in Sc1 and Sc2a.

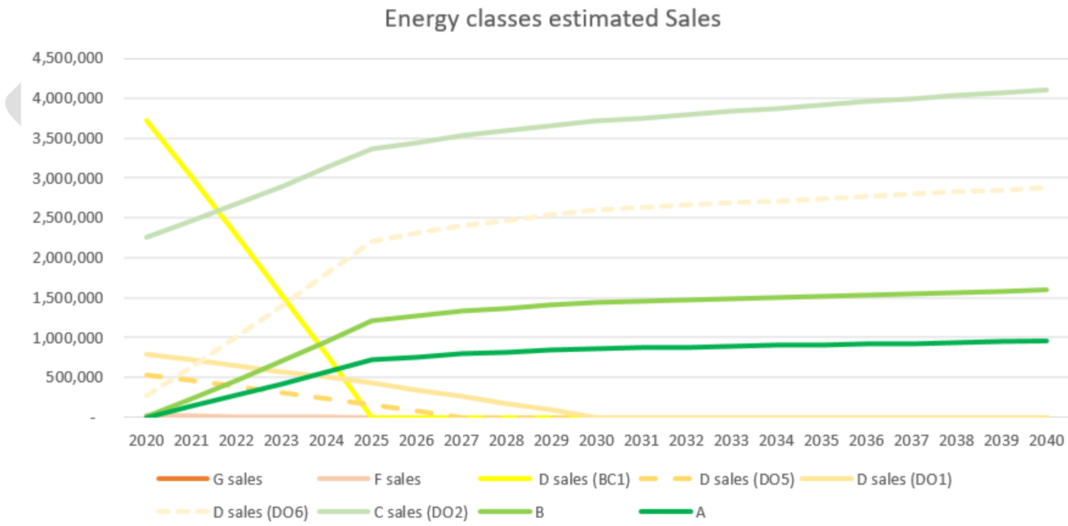


Figure 333. Scenario 2b. Estimated sales

The introduction of Tier 1, Tier 2 and Tier 2 (presented in Sc1) would cause that the sales of some type of ovens be zero by certain years. For instance, the sales of D(BC1) would need to be zero by 2025, the sales of D(DO5) would need to be zero by 2027 and the sales of D(DO1) would need to be zero by 2030.

The existence of an energy label in this scenario could work as an incentive to replace the above non-compliant appliances with ovens able to reach a higher energy class. To reflect that, it has been assumed that those appliances that are removed from the market are replaced by D(DO6) mostly, but also by B and A ovens (the top two energy classes). In this scenario, the gap between A, B and C classes is narrower, so it has been assumed that more of the replaced ovens go to the A and B energy class (compared to Sc2a).

With that sales profile for the years 2020-2040, the new stock profile for those years would be as in Figure 334.

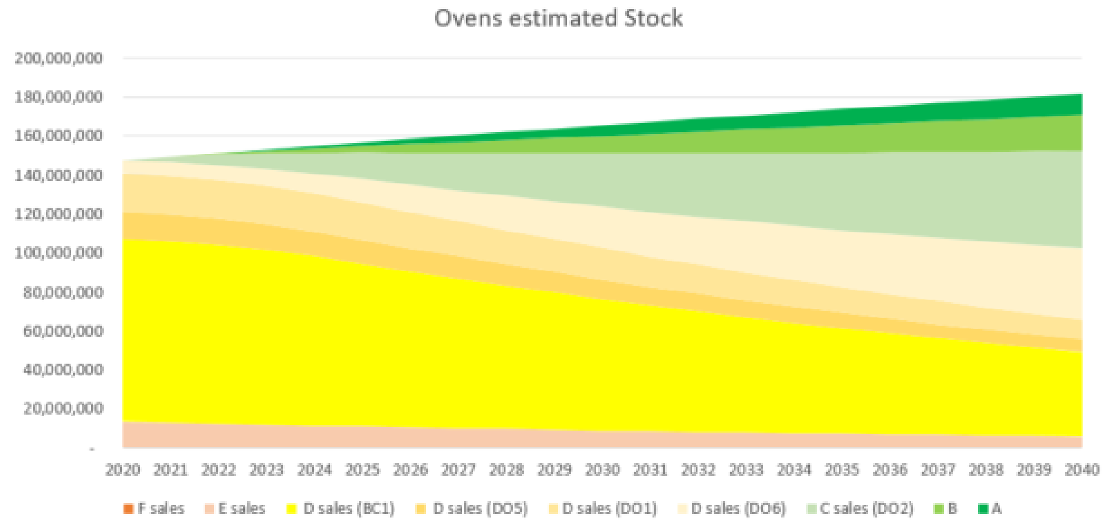


Figure 334. Scenario 2b. Estimated stock

The main differences between Scenario BAU, Sc1 and SC2a/SC2b is that the proportion of ovens with lower efficiency decreases even further. In SC2a and SC2b, it has been assumed that the top energy classes are reached, due to the incentive of the energy label for product differentiation. It has also been assumed that a narrower gap between the top energy classes (Sc2b) favours the development of such appliances.

The total energy consumption of the Sc2a and Sc2b stocks can be seen in Figure 335 and Figure 336.

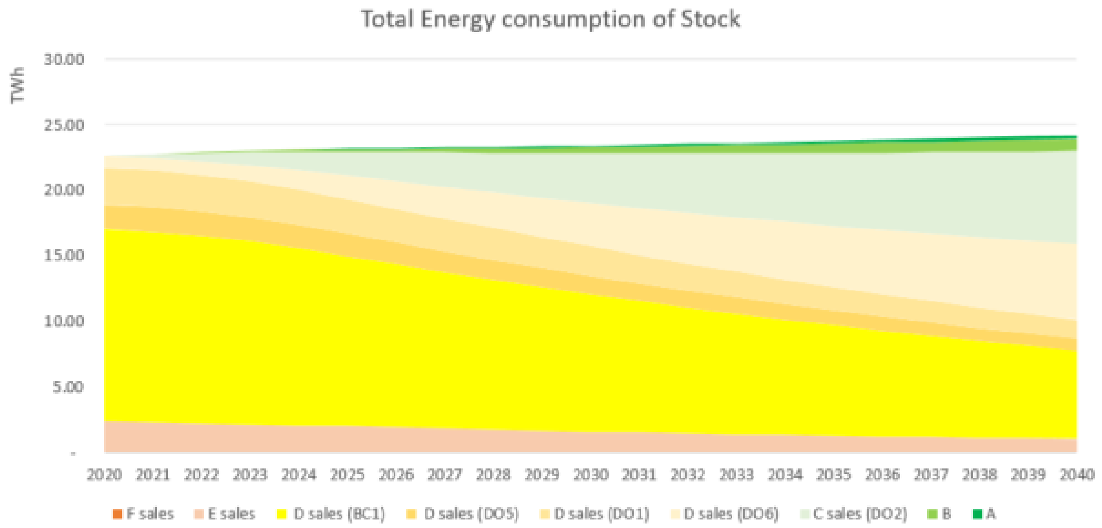


Figure 335. Scenario 2a. Estimated energy consumption

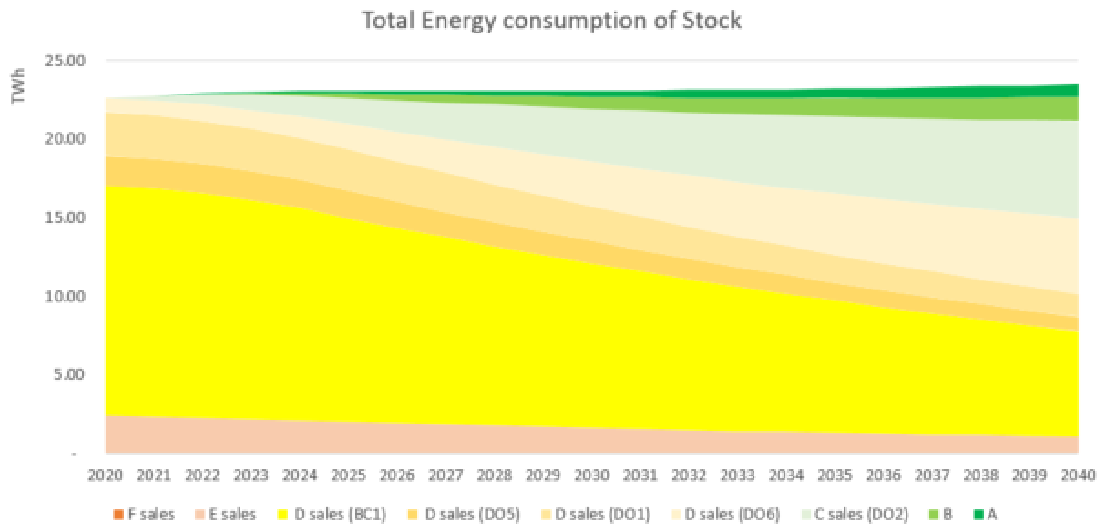


Figure 336. Scenario 2b. Estimated energy consumption

In both scenarios Sc2a and Sc2b, a larger proportion of high efficiency ovens (A and B in this case) help reducing the total energy consumption attributable to domestic ovens. For instance, the total energy consumption in Sc2b on 2040 is estimated approximately the same as in 2020, even considering that the stock of ovens will grow from 147 to 181 million approximately over that period. The improvement in energy efficiency in the stock can compensate the increase in the total number of appliances.

7.8.2.4 Scenario 3a and 3b: the flat approach

In this section, an analysis is conducted on the flat approach for ecodesign and energy label described in Section 7.3.4.4. This scenario (Sc3) implies that both ecodesign and energy label calculations are decoupled from the oven cavity volume. A similar approach to promote difference as in Sc2a has been taken (Figure 337).

For simplification, there is no differentiation between "regular" and "large" ovens, although this is something that should be considered, to avoid excluding large ovens from the market based on ecodesign minimum requirements.

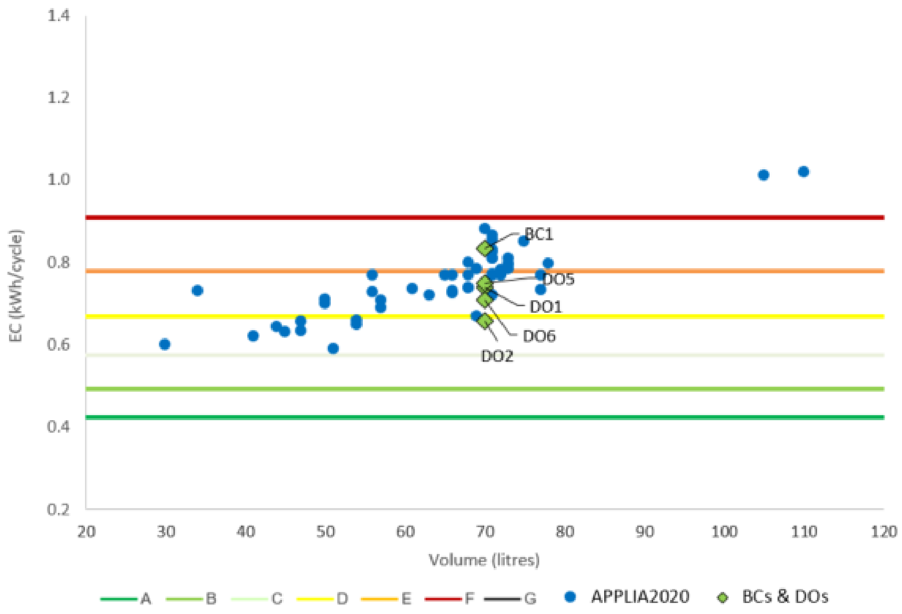


Figure 337. Scenario 3a and 3b. Energy class of base case and design options

In the scenarios of the previous sections, the stock of ovens was composed of different percentages of the base cases and design options. Therefore, for simplification, it was assumed that every oven in the market had the cavity volume of the base case: 70 litres.

As already indicated in previous sections, one of the potential consequences of the adoption of the flat approach is a shift towards smaller ovens. In scenarios 3a and 3b, it will be assumed that, due to the adoption of the flat approach, consumers will start buying ovens around 50 litres of volume, which will have lower energy consumption.

The evolution of technologies in scenarios with the flat approach will be identical to scenario 2a. The percentage of ovens sold in each energy class will be the same in scenarios 2a, 3a and 3b. The difference between each of those scenarios will be related to the amount of 70 and 50 litres ovens. In summary:

- In scenario 2a, the percentage of sales of 50 litre ovens was 0% and remains constant up to 2040 (100% of ovens are 70 litre)
- In scenario 3a, the percentage of sales of 50 litres ovens will grow from 0% in 2020 to 20% in 2040.
- In scenario 3b, the percentage of sales of 50 litre ovens will grow from 0% in 2020 to 50% in 2040.

It is obvious for the authors of this report that the assumptions presented in this section are a simplification of the market, which is unlikely to behave in this particular way. The goal of this section is to evaluate the potential consequences of shifting towards smaller cavity ovens, while maintaining the profile of technologies.

Considering the above assumptions, the total energy consumption of the Sc3a and Sc3b stocks can be seen in Figure 338 and Figure 339.

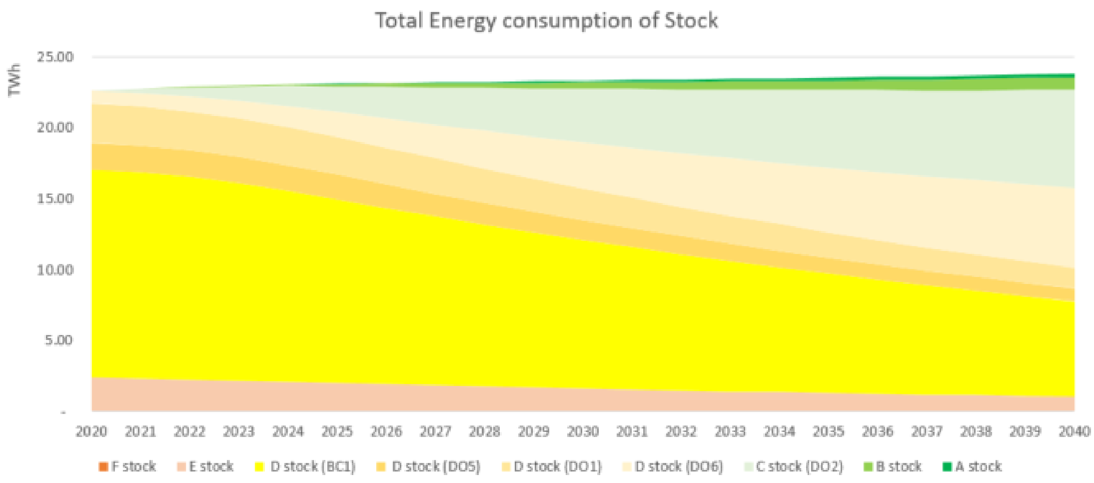


Figure 338. Scenario 3a. Estimated energy consumption

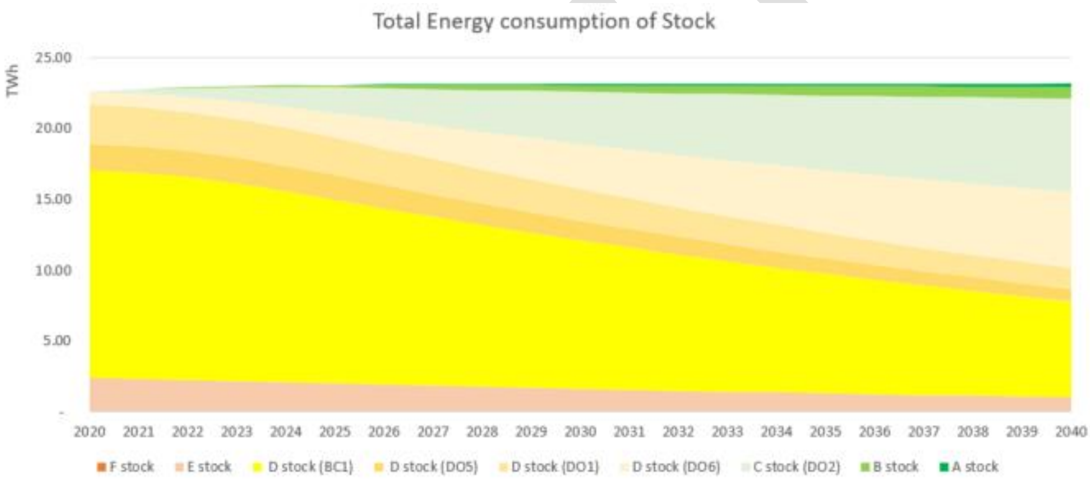


Figure 339. Scenario 3b. Estimated energy consumption

In both scenarios Sc3a and Sc3b, a certain proportion of smaller ovens (50 l) help reducing the total energy consumption attributable to domestic ovens. In Sc3b, the proportion of 50 l ovens sold is 50% (versus 20% in Sc3a), which helps reducing even further the overall energy consumption.

7.8.2.5 Impacts on energy consumption

In this section, an analysis is conducted on the impact on energy consumption of the different scenarios presented earlier. Figure 340 summarizes the total energy consumption of the stock of ovens between 2020 and 2040 of those scenarios.

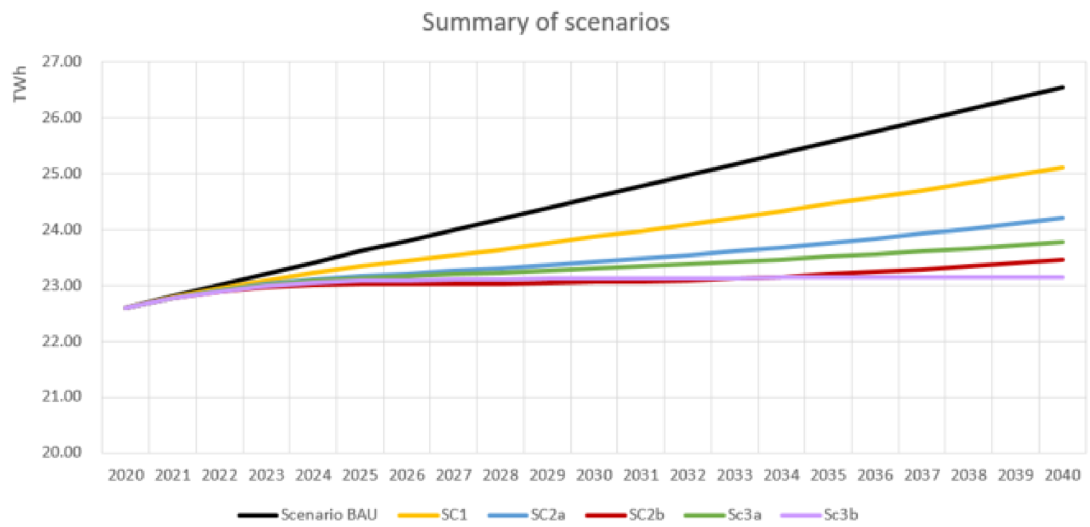


Figure 340. Energy consumption. Summary of scenarios

If no changes are made (scenario BAU), it is estimated that the total energy consumption attributable to domestic ovens will grow from 22.6 TWh in 2020 to 26.6 TWh in 2040 (15% increase). This increase in energy consumption is mostly related to the growth in sales and in stock of ovens between that period.

In scenario 1, stricter ecodesign requirements were considered. After 2025, ovens with EEI>96 would not be allowed. After 2027, the threshold would be lowered to 91 and finally to 88 after 2030. It has been assumed that these measures would cause the substitution in sales of the least efficient ovens by slightly better ovens in terms of energy consumption. It has been also assumed that there is no energy label in this scenario, so the best ovens in terms of energy consumption would have a marginal presence in the market. With this conditions, it has been estimated that the total energy consumption attributable to ovens would grow from 22.6 TWh in 2020 to 25.1 TWh in 2040 (10% increase). The adoption of scenario 1 would mean total savings of 14.7 TWh for the 2020-2040 period when compared to scenario BAU.

In scenarios 2a and 2b, the same ecodesign requirements as in scenario 1 were considered. On top of that, an energy label is defined, with energy classes thresholds as in

Energy efficiency class	Current Energy Efficiency Index	Scenario 2a (Promote differentiation)	Scenario 2b (Promote innovation)
A	EEI < 45	EEI < 56	EEI < 56
B	45 ≤ EEI < 62	56 ≤ EEI < 65	56 ≤ EEI < 63
C	62 ≤ EEI < 82	65 ≤ EEI < 76	63 ≤ EEI < 71
D	82 ≤ EEI < 107	76 ≤ EEI < 89	71 ≤ EEI < 80
E	107 ≤ EEI < 132	89 ≤ EEI < 103	80 ≤ EEI < 100
F	132 ≤ EEI < 159	103 ≤ EEI < 120	100 ≤ EEI < 125
G	EEI > 159	EEI > 120	EEI > 125

It has been assumed that these measures would cause the substitution in sales of the least efficient ovens by better ovens in terms of energy consumption. The presence of the energy label could work as an incentive for manufacturers to reach the top energy classes for product differentiation. In scenario 2a, the thresholds to reach top energy classes are stricter than in scenario 2b: for instance, the limit to reach A energy class is EEI=50 in Sc2a and EEI=54 in Sc2b. Because of that, it has been assumed that Sc2b will suppose a greater stimulus to reach energy classes (since the top energy class is closer to current technologies). This greater stimulus has been represented with a higher proportion of the most efficient ovens in Sc2b than in Sc2a.

With these conditions, it has been estimated that in Sc2a, the total energy consumption attributable to domestic ovens would grow from 22.6 TWh in 2020 to 24.2 TWh in 2040 (7% increase). In Sc2b, total energy consumption would grow from 22.6 TWh in 2020 to 23.5 TWh in 2040 (only 4% increase, as already highlighted in previous section). Total savings over the 2020-2040 period would be 23.9 TWh with Sc2a and 31.4 TWh with SC2b.

In scenarios 3a and 3b, the same ecodesign requirements and EEI threholds of Sc2a have been assumed. On top of that, the flat approach has been adopted (decoupling EEI from cavity volume), causing a progressive shift towards smaller ovens between the period 2020-2040. With these conditions, it has been estimated that in Sc3a, the total energy consumption attributable to domestic ovens would grow from 22.6 TWh in 2020 to 23.8 TWh in 2040 (5% increase). In Sc3b, total energy consumption would grow from 22.6 TWh in 2020 to 23.1 TWh in 2040 (only 2% increase). Total savings over the 2020-2040 period would be 27.1 TWh with Sc3a and 31.2 TWh with Sc3b.

7.8.2.6 Impacts on GHG emissions

The annual emissions of CO2eq related to the use of domestic ovens are estimated based on the annual electricity consumption. Emission factors (g of CO2eq/kWh) were considered to convert electricity consumption into greenhouse gas (GHG) emissions. The value of the emission factor depends on the electricity mix at EU-level. Historical data series show that this value has been changing along the years due to the higher proportion of renewable energy sources and the European targets to reduce the GHG emissions. The forecast for future emission factors was calculated with data from PRIMES, assuming average losses between 2.5 and 11% (CEER, 2020). This data is represented in Figure 341.

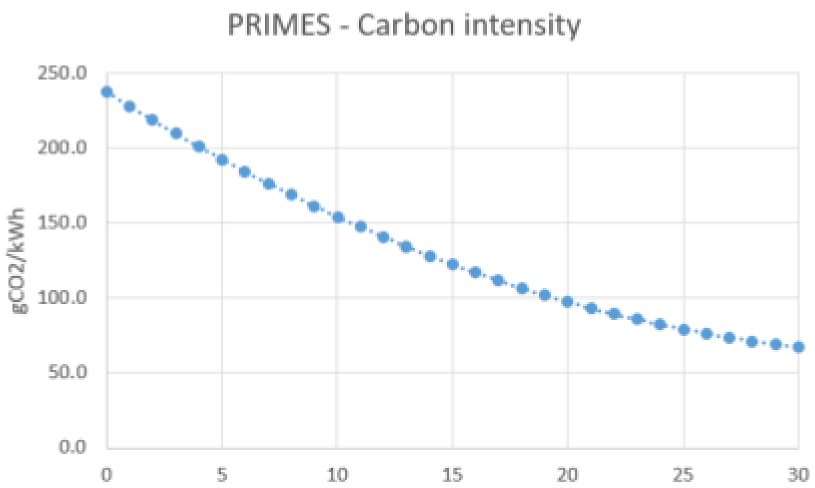


Figure 341. Carbon intensity of grid

Based on the above carbon intensity of the EU grid, the GHG emissions associated to the different policy scenarios for ovens is presented in Figure 342.

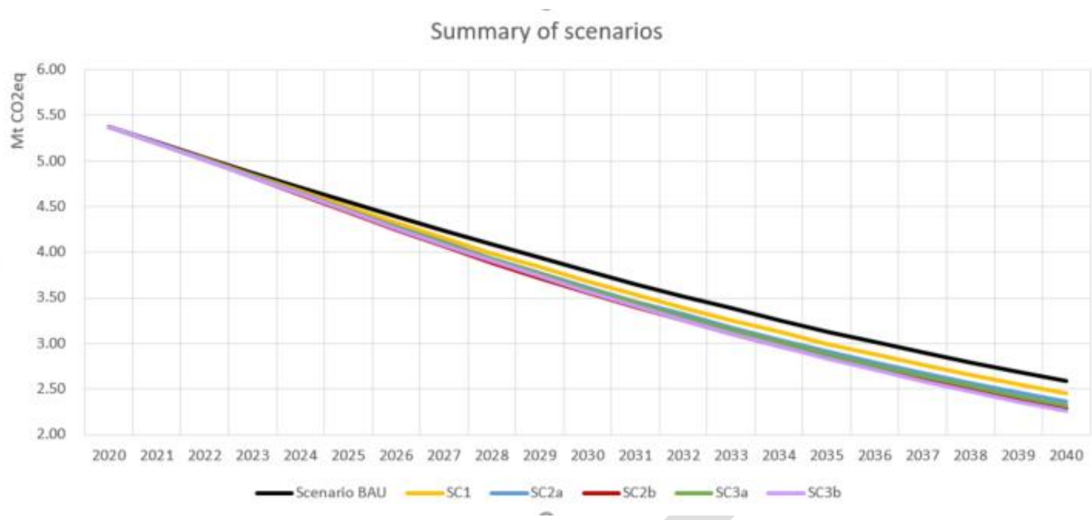


Figure 342. GHG emissions. Summary of scenarios

With scenario BAU, GHG emissions decrease from 5.4 to 2.6 MtCO2e between 2020-2040. Even though the stock of ovens and the overall energy consumption increase over that period, the reduction of the carbon intensity of the EU grid between those years help reducing the total GHG emissions.

With Sc1, GHG emissions decrease from 5.4 to 2.5 MtCO2e between 2020-2040, for a total savings of 1.9 Mt in comparison to Sc BAU.

With Sc2a, GHG emissions decrease from 5.4 to 2.4 MtCO2e between 2020-2040, for a total savings of 3.1 Mt in comparison to Sc BAU. With Sc2b, GHG emissions decrease from 5.4 to 2.3 MtCO2e between 2020-2040, for a total savings of 4.1 Mt in comparison to Sc BAU.

Finally, with Sc3a, GHG emissions decrease from 5.4 to 2.3 MtCO2e between 2020-2040, for a total savings of 3.5 Mt in comparison to Sc BAU. With Sc3b, GHG emissions decrease from 5.4 to 2.2 MtCO2e between 2020-2040, for a total savings of 4.1 Mt in comparison to Sc BAU.

7.8.2.7 Impacts on consumer expenditure

The impacts of policy measures on the consumer expenditure are analysed in this section. These impacts include a change in the operating expenses (which are usually decreased because of more energy efficient machines) and a change in the purchase price. The consumer expenditure is calculated as the life cycle cost (LCC), i.e. including purchase costs and operating costs (energy repair and maintenance costs). Purchase price of each type of oven is estimated using data from GfK, presented in Table 161.

Table 161. Estimated price of ovens

C oven	B oven	A oven (BC1)	A oven (DO5)	A oven (DO1)	A oven (DO6)	A+ oven (DO2)	A++ oven	A+++ oven
245	330	446	1200	602	903	813	1097	1481

Product prices presented in Table 161 correspond to the initial year of the period 2020-2040. Prices tend to decrease over the years. In absence of better data, to reflect this product price decrease, a 5% yearly decrease has been assumed.

In order to estimate the price difference between cavity volumes, data from GfK has been used. Data corresponding to five representative EU countries indicate that ovens of 50 litres are 30% less expensive than ovens of 70 litres.

The operating costs consist of the electricity, maintenance and repair costs. The energy price trends are estimated considering the projections in the EU Reference scenario 2016 (European Commission 2016) and shown in Figure 343. It is assumed that the cost of maintenance and repair does not change over the period 2020-2040.

It is important to notice that these are rough and simplified estimations on consumer expenditure. They will be improved in the next version of the report by means of a modelling tool that is currently being revised and updated.

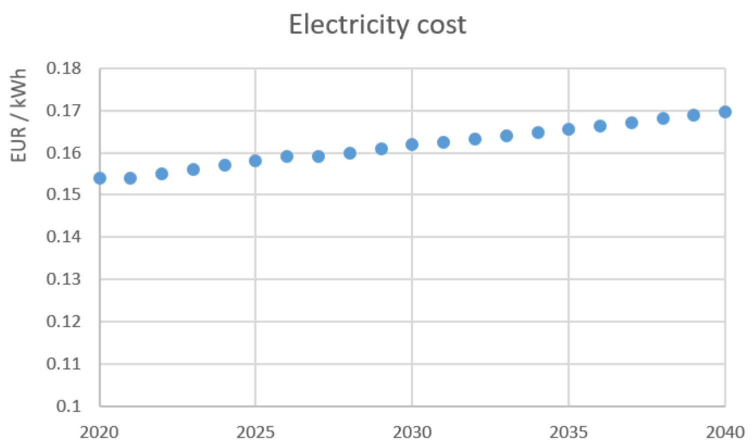


Figure 343. Electricity cost

For each year in the period between 2020-2040, consumer expenditure will be:

Expenditure Year x = Expenditure energy consumption Year x + Expenditure sales Year x

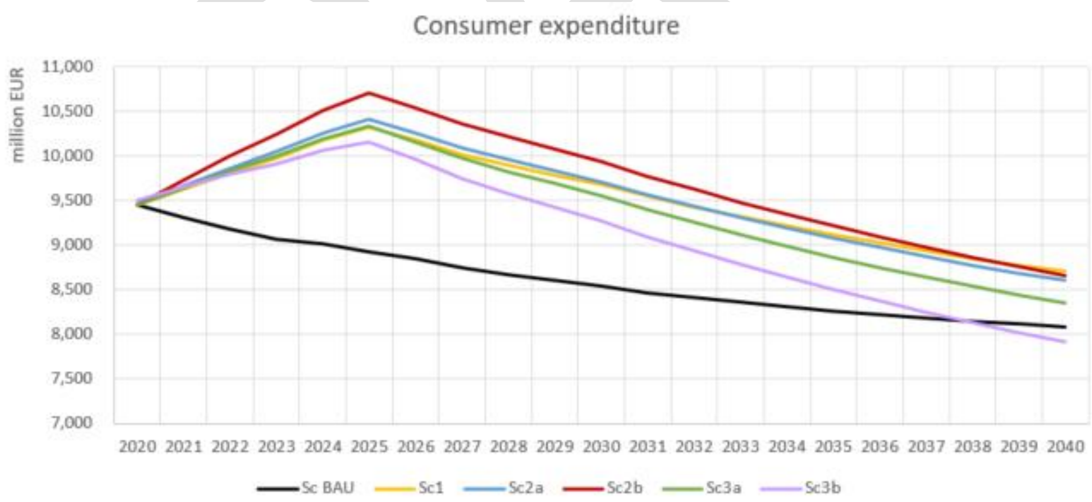


Figure 344. Consumer expenditure. Summary of scenarios

In the estimation presented in Figure 344, consumer expenditure of Scenario BAU decreases over the period 2020-2040, from 9.5 to 8.1 billion EUR. This tendency is explained by the 5% yearly decrease assumed for product prices. This decrease compensates the growth in total stock of domestic ovens.

In the alternative scenarios presented consumer expenditure grows between 2020-2025, and then decreases gradually up to 2040. The growth in the first period can be explained with the ecodesign measures assumed in those scenarios. By 2025, every oven with EEI>96 would need to be removed from the market. It has been assumed that between 2020-2025, those ovens are gradually substituted by higher efficiency ovens, which are significantly more expensive. This price increase cannot be compensated with savings related to energy consumption.

After 2025, once the higher efficiency ovens have fully substituted the lower efficiency appliances, the 5% yearly decrease in price reduces gradually overall consumer expenditure. In scenarios Sc1, Sc2a and Sc2b, the overall consumer expenditure would be approximately 7% higher than the BAU scenario. In scenario Sc3a (where by 2040 20% of sales will be 50 litre ovens) the consumer expenditure increase will be only 4% higher than with the BAU. In scenario Sc3b (50% of ovens sold are 50 litre) the consumer expenditure will be 3% lower than the BAU scenario. This is due to the reduced prices of smaller ovens and to their lower energy consumption.

7.8.2.8 Summary

A summary of the different policy scenarios analysed and their cumulative impact over 2020-2040 is shown in Table 162. Negative values indicate a decrease over time and positive values indicate an increase.

Table 162. Summary of the policy scenarios and their impacts for ovens

Scenario	**Technology impact**	**Energy cumulative impact (TWh electricity)**	**GHG impact cumulative (MtCO2)**	**LCC cumulative impact (billion EUR)**
Sc1: Adoption of BM2.0, energy declaration as weighted sum of BPM and conventional mode at 50/50, stricter minimum ecodesign requirements and removal of the energy label	Progressive removal from the market of ovens with high EEI. No incentive for manufacturers to reach top energy classes.	-14.7	-1.9	+19.0
Sc2a: Same as Sc1, with revised energy classes from current regulation	Progressive removal from the market of ovens with high EEI. Small increase in sales of ovens with top energy classes.	-23.9	-3.1	+19.2
Sc2b: Same as Sc2a, with less strict energy classes thresholds	Progressive removal from the market of ovens with high EEI. Considerable increase in sales of ovens with top energy classes.	-31.4	-4.1	+22.7
Sc3a: Same as Sc2a, adopting the flat approach, assuming low sales of small ovens for the period 2020-2040	Progressive removal from the market of ovens with high EEI. Small increase in sales of ovens with top energy classes. Slight shift towards small cavity ovens.	-27.1	-3.5	+16.1
Sc3b: Same as Sc2a,	Progressive removal	-31.8	-4.1	+10.8

adopting the flat approach, assuming high sales of small ovens for the period 2020-2040	from the market of ovens with high EEI. Small increase in sales of ovens with top energy classes. Big shift towards small cavity ovens.			

7.8.3 Policy scenarios for hobs

This section aims at defining and evaluating different policy scenarios for domestic hobs. The scenarios will consist in a combination of different policy options presented in previous section. The implementation of certain policies will have consequences on the market. The aim of this section is to evaluate what are the potential consequences of some of the presented policies, as well as their benefits and drawbacks in terms of overall EU energy consumption, CO_2 emissions or consumer expenditure.

7.8.3.1 Business as usual scenario

The definition of the Business as Usual (BAU) scenario for domestic hobs is based on the assumption that no additional regulation is implemented.

Electric hobs

Sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 345). The sales of induction increase at the expense of radiant sales, so induction is expected to be the dominant technology in the market.

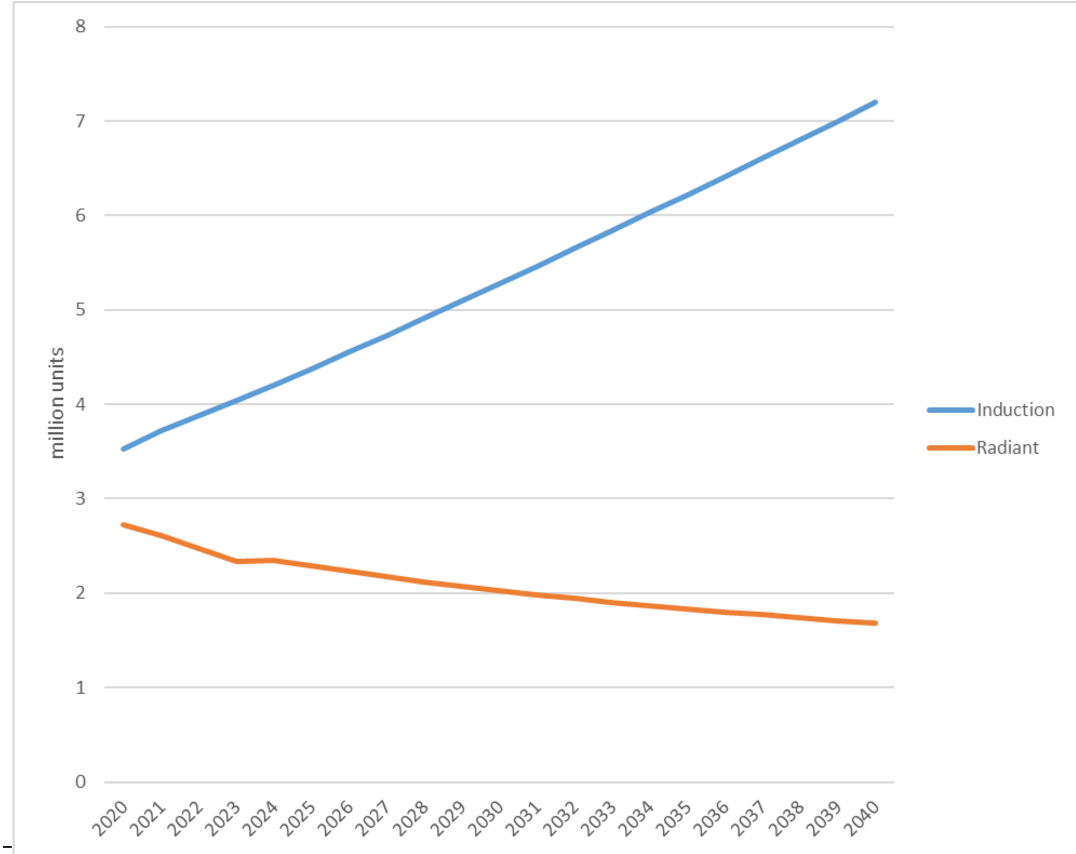


Figure 345: Electric hobs sales evolution

In the BAU scenario it is assumed that current stock (2020) consumes around 15% more energy than the new products, due to the technology improvement developed in the last years.

The total energy consumption of the BAU of electric hobs is presented in Figure 346.

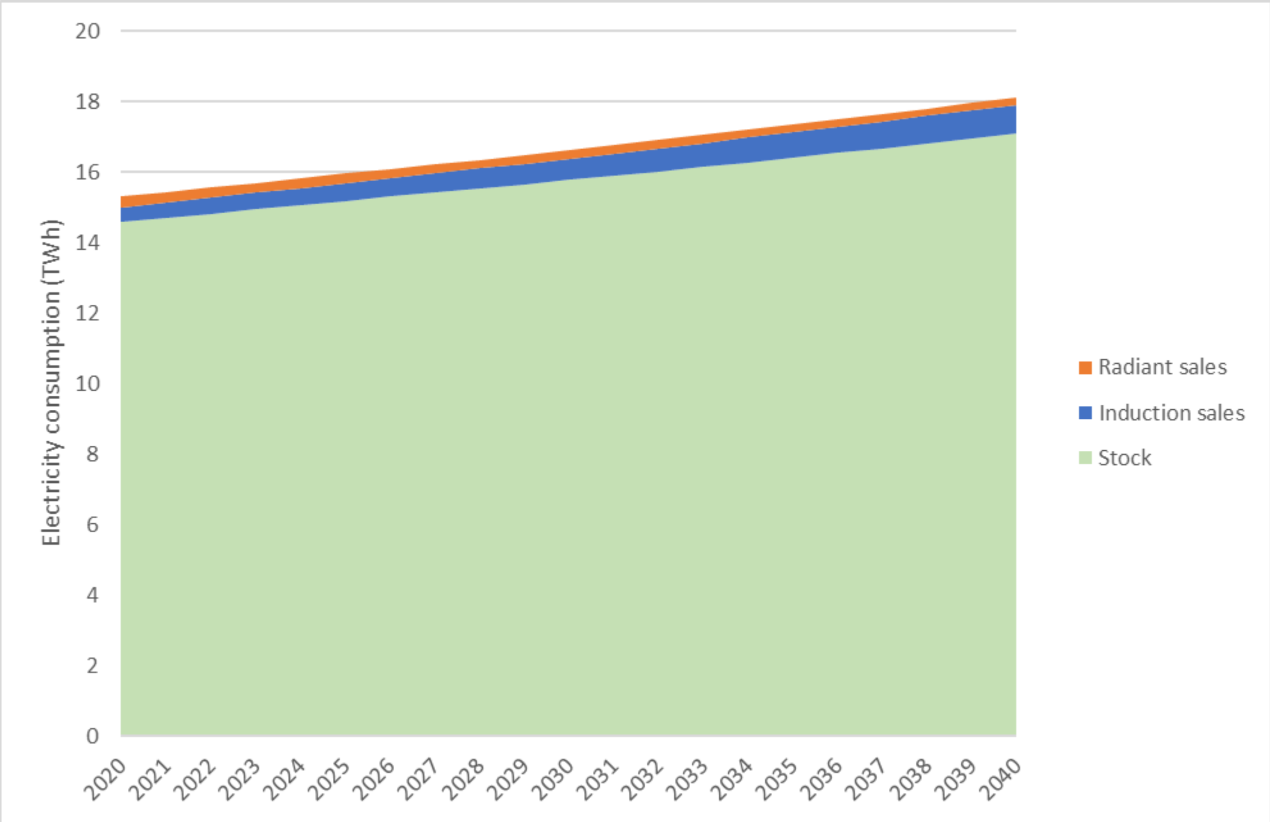


Figure 346: Electricity consumption of the BAU of electric hobs

Gas hobs

Sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 347).

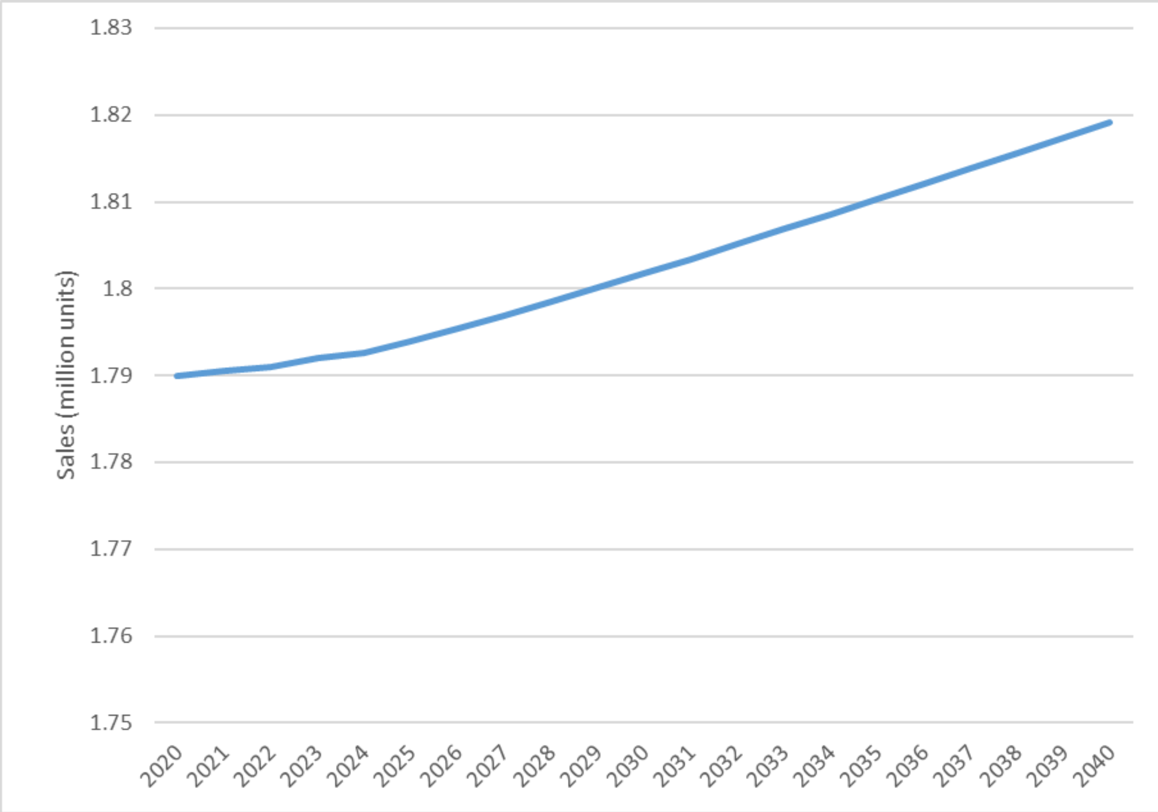


Figure 347: Gas sales evolution

In the BAU scenario it is assumed that current stock (2020) performs an efficiency of 50% according to the existing Ecodesign minimum requirements.

The total energy consumption of the BAU of gas hobs is presented in Figure 348.

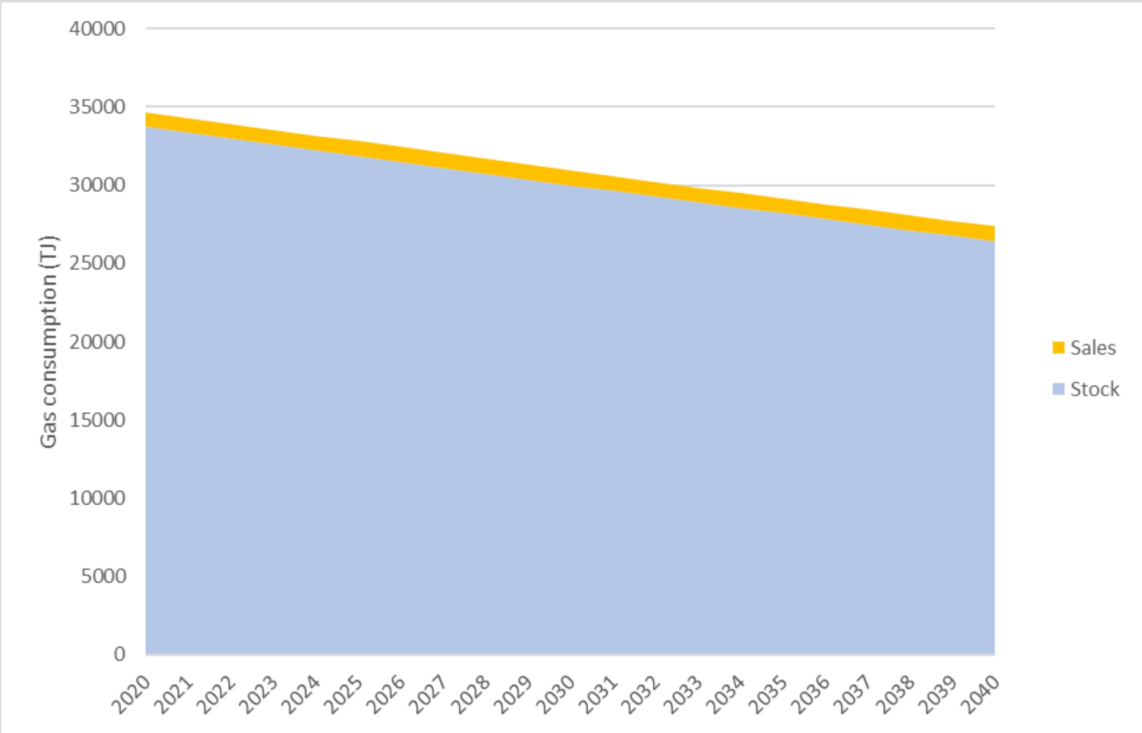


Figure 348: Gas consumption of the BAU of gas hobs

7.8.3.2 Scenario 1 electric hobs: same ecodesign requirements for induction and radiant hobs

The first option proposed for electric hobs is keeping the same approach as the existing Ecodesign, and setting common requirements for both induction and radiant hobs.

Table 163: Proposed common requirements for both induction and radiant hobs

	Electric hob (Energy consumption in Wh/kg)
February 2022	< 190
February 2023	< 180
February 2025	< 175

As explain in section 7.5.3, stricter common requirements would equal to banning radiant hobs, since no further improvement beyond 185 Wh/kg is expected to be feasible.

The total energy consumption of the Scenario 1 of electric hobs is presented in Figure 349.

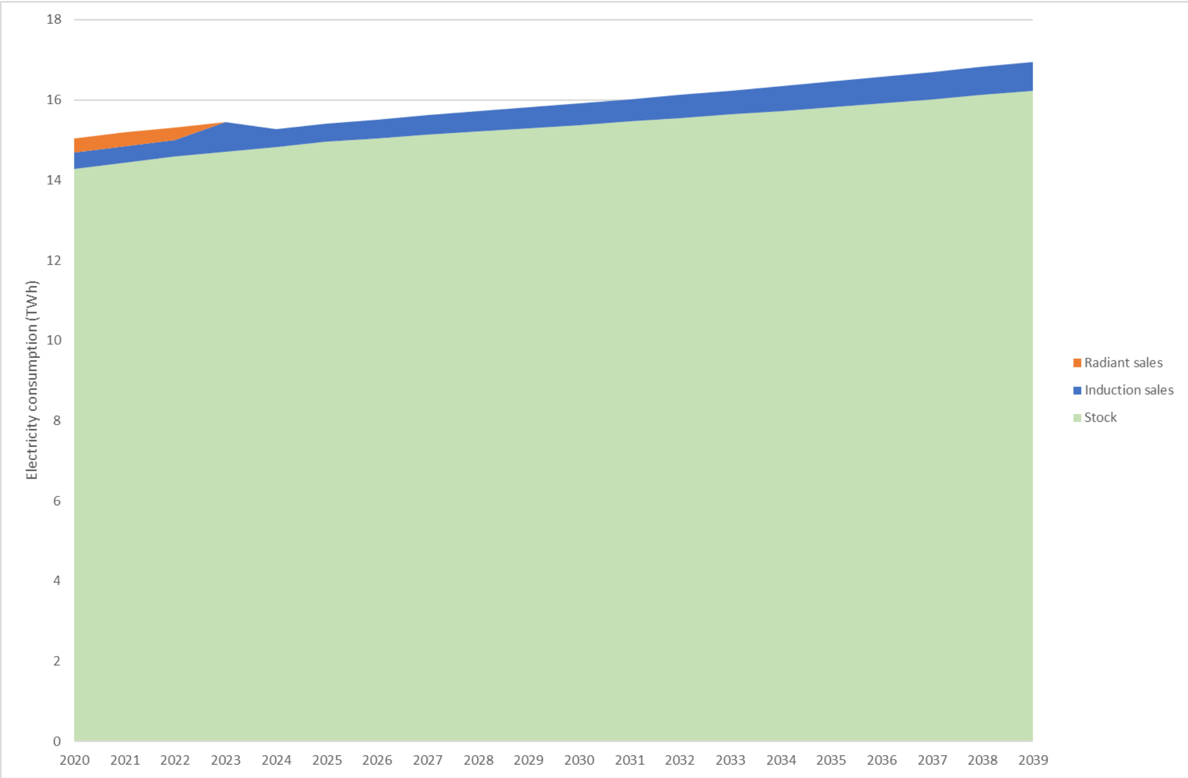


Figure 349: Total electricity consumption of the Scenario 1 of electric hobs

7.8.3.3 Scenario 2 electric hobs: different ecodesign requirements for induction and radiant hobs

The second option proposed for electric hobs is taking into account the technology cap in radiant technology and setting different requirements for induction and radiant hobs.

Table 164: Proposed different requirements for induction and radiant hobs

	Radiant hob (Energy consumption in Wh/kg)	**Induction hob (Energy consumption in Wh/kg)**
February 2022		< 185
February 2023	< 190	< 180
February 2025	< 185	< 175

As explain in section 7.5.3, this would allow radiant hobs to continue in the market and leave the decrease in sales to the natural evolution of the market towards induction hobs.

The total energy consumption of the Scenario 2 of electric hobs is presented in Figure 350.

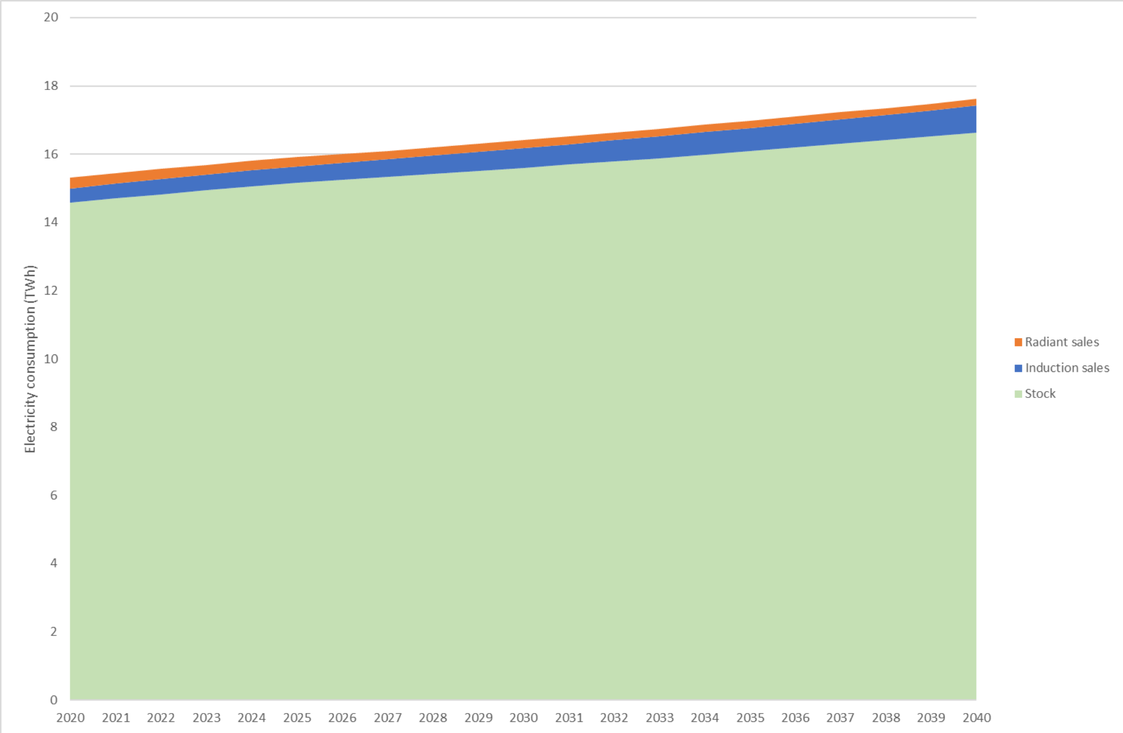


Figure 350: Total electricity consumption of the Scenario 2 of electric hobs

7.8.3.4 Scenario 1 gas hobs: ecodesign requirements

The option proposed for gas hobs is continuing the path of improving energy efficiency, setting yearly tiers for efficiency.

Table 165: Proposed energy efficiency tiers for gas hobs

	Gas-fired hob (energy efficiency in %)
February 2022	> 56
February 2023	> 57
February 2025	> 58

The total energy consumption of the Scenario 1 of gas hobs is presented in Figure 351

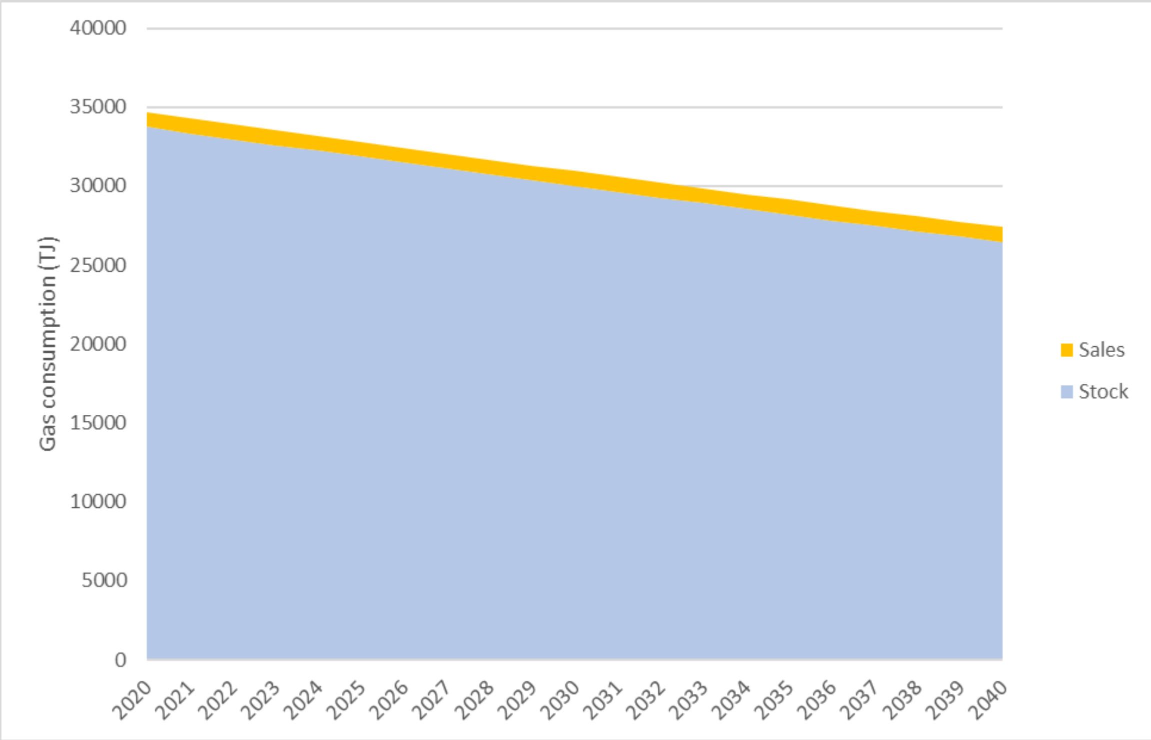


Figure 351: Total energy consumption of the Scenario 1 of gas hobs

7.8.3.5 Impacts on energy consumption

In this section, an analysis is conducted on the impact on energy consumption of the different scenarios presented earlier.

Electric hobs

Figure 352 summarizes the total energy consumption of the stock of electric hobs between 2020 and 2040 of those scenarios.

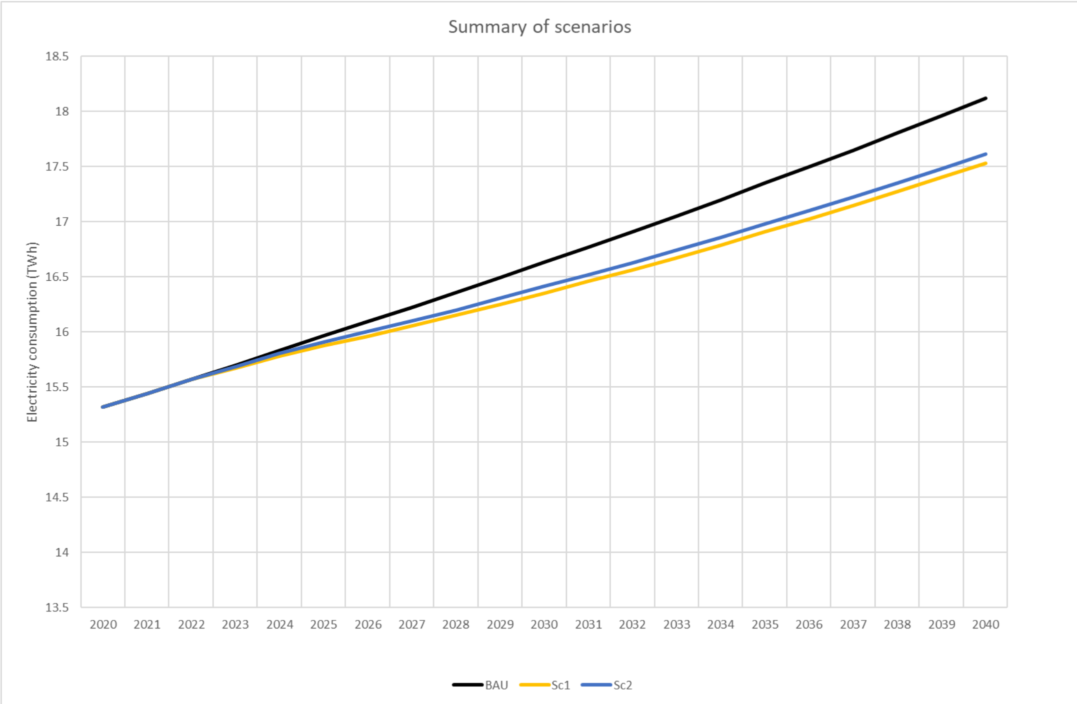


Figure 352: Electricity consumption in scenarios for electric hobs

If no changes are made (scenario BAU), it is estimated that the total energy consumption attributable to electric hobs will grow from 15.3 TWh in 2020 to 18.1 TWh in 2040 (18% increase). This increase in energy consumption is mostly related to the growth in sales and in stock of hobs between that period.

In scenario 1, common ecodesign requirements for induction and radiant were considered. After 2023, hobs with an energy consumption above 180 Wh/kg would not be allowed. Under this condition, it has been estimated that the total energy consumption attributable to electric hobs would grow from 15.3 TWh in 2020 to 17.5 TWh in 2040 (14.5% increase). The adoption of scenario 1 would mean total cumulative savings of 5.7 TWh for the 2020-2040 period when compared to scenario BAU.

In scenario 2, different ecodesing requirements for induction and radiant were considered. Under this condition, it has been estimated that the total energy consumption attributable to electric hobs would grow from 15.3 TWh in 2020 to 17.6 TWh in 2040 (15% increase). Total cumulative savings over the 2020-2040 period would be 4.7 TWh.

Gas hobs

Figure 353 summarizes the total energy consumption of the stock of gas hobs between 2020 and 2040 of those scenarios.

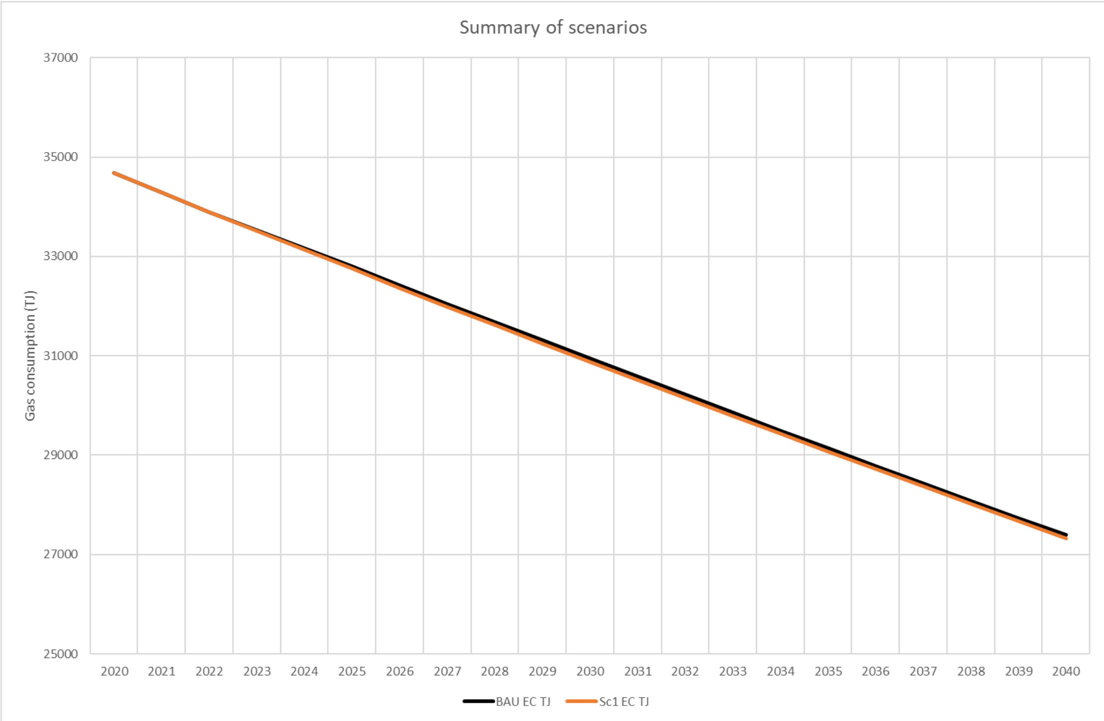


Figure 353: Gas consumption in scenarios for gas hobs

If no changes are made (scenario BAU), it is estimated that the total energy consumption attributable to gas hobs will grow from 34700 TJ in 2020 to 27400 TJ in 2040 (21% decrease). This decrease in energy consumption is mostly driven to a stable sales and stock and the natural replacement of old hobs for new and more efficient ones.

In scenario 1, stricter ecodesign requirements for gas hobs were considered. Under this condition, it has been estimated that the total energy consumption attributable to gas hobs would grow from 34700 TJ in 2020 to 27300 TWh in 2040 (21.5% decrease). The adoption of scenario 1 would mean total cumulative savings of 1092 TJ for the 2020-2040 period when compared to scenario BAU.

7.8.3.6 Impacts on GHG emissions

Electric hobs

Based on the above carbon intensity of the EU grid, the CO_2 emissions associated to the different policy scenarios for electric hobs is presented in Figure 354.

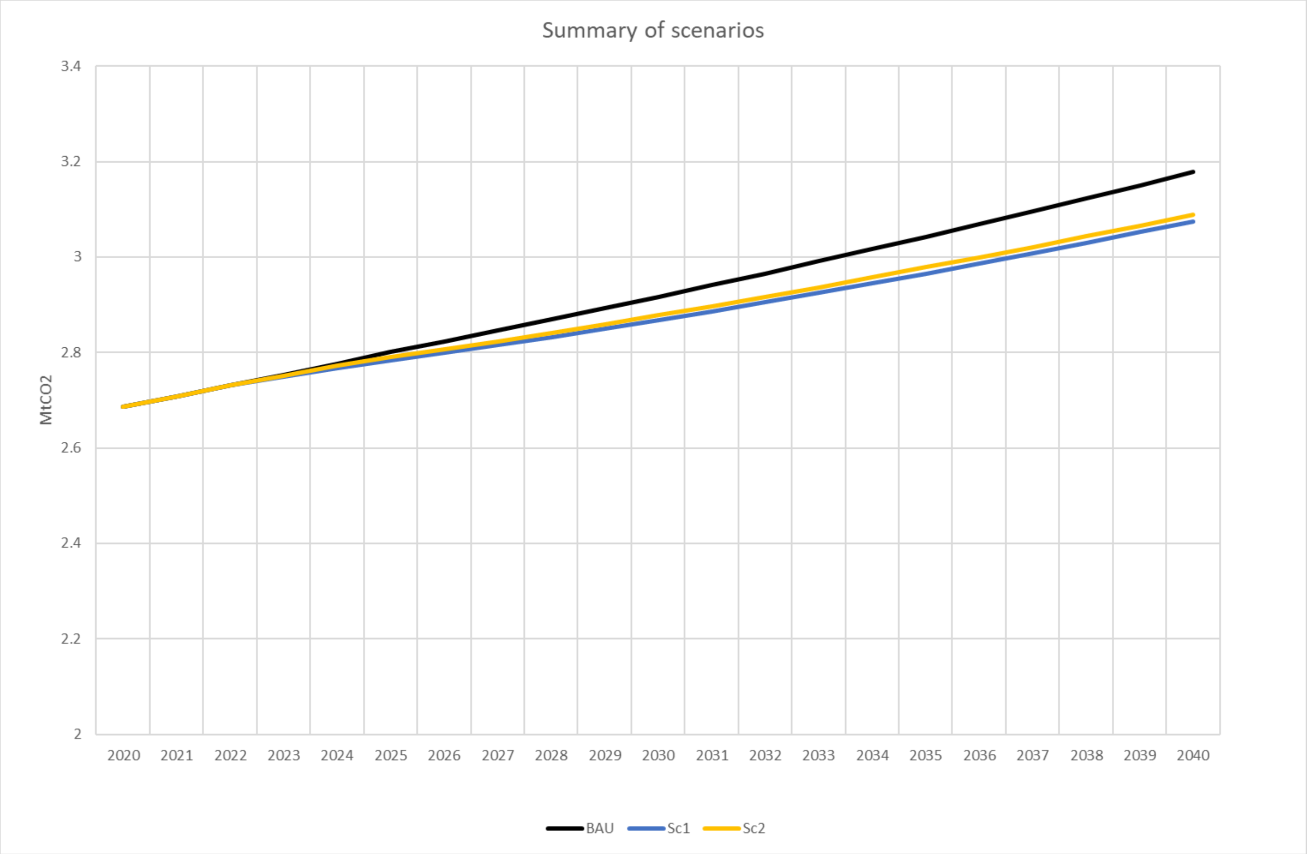


Figure 354: CO2 emissions of scenarios for electric hobs

With scenario BAU, GHG emissions decrease from 2.7 to 3.2 MtCO2e between 2020-2040.

With Sc1, GHG emissions increase from 2.7 to 3.07 MtCO2e between 2020-2040, for a total savings of 1.0 Mt in comparison to BAU.

With Sc21, GHG emissions decrease from 2.7 to 3.09 MtCO2e between 2020-2040, for a total savings of 0.8 Mt in comparison to Sc BAU.

Gas hobs

Based on the carbon intensity of natural gas from Ecoreport tool, the GHG emissions associated to the different policy scenarios for gas hobs is presented in Figure 355.

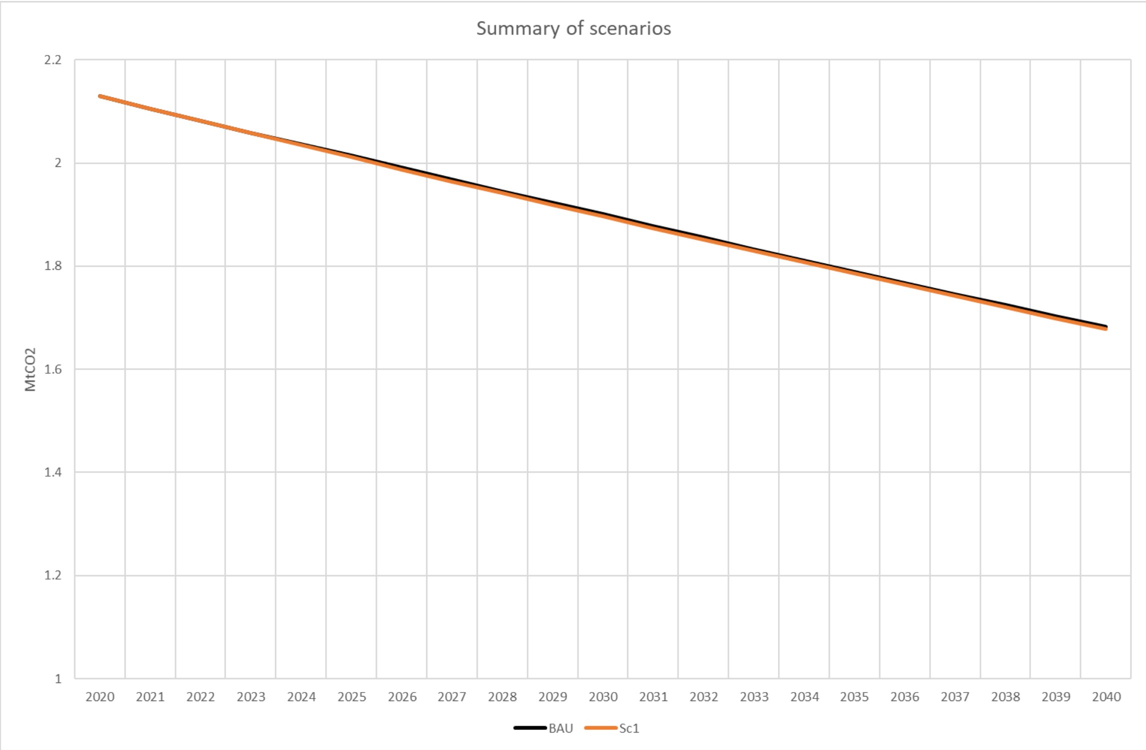


Figure 355: CO2 emissions of scenarios for electric hobs

In scenario BAU, GHG emissions decrease from 2.1 to 1.7 MtCO2e between 2020-2040. This decrease in energy consumption is mostly driven to a stable sales and stock and the natural replacement of old hobs for new and more efficient ones.

In Scenario 1, GHG emissions decrease from 2.1 to 1.7 MtCO2e between 2020-2040, for a total savings of 0.1 Mt in comparison to BAU

7.8.3.7 Impacts on consumer expenditure

The impacts of policy measures on the consumer expenditure are analysed in this section. These impacts include a change in the operating expenses (which are usually decreased because of more energy efficient machines) and a change in the purchase price. The consumer expenditure is calculated as the life cycle cost (LCC), i.e. including purchase costs and operating costs (energy repair and maintenance costs). Purchase price of each type of hobs is described Tasks 5 and 6. The potential purchase cost impact due to the disappearance of radiant hobs in Scenario 1 has not been modelled due to the uncertainty of the evolution of the induction technology price.

The operating costs consist of the electricity, natural gas, maintenance and repair costs. The energy price trends are estimated considering the projections in the EU Reference scenario 2016 (European Commission 2016).

It is important to notice that these are rough and simplified estimations on consumer expenditure. They will be improved in the next version of the report by means of a modelling tool that is currently being revised and updated.

Electric hobs

Figure 356 shows the consumer expenditure for the different scenarios considered for electric hobs.

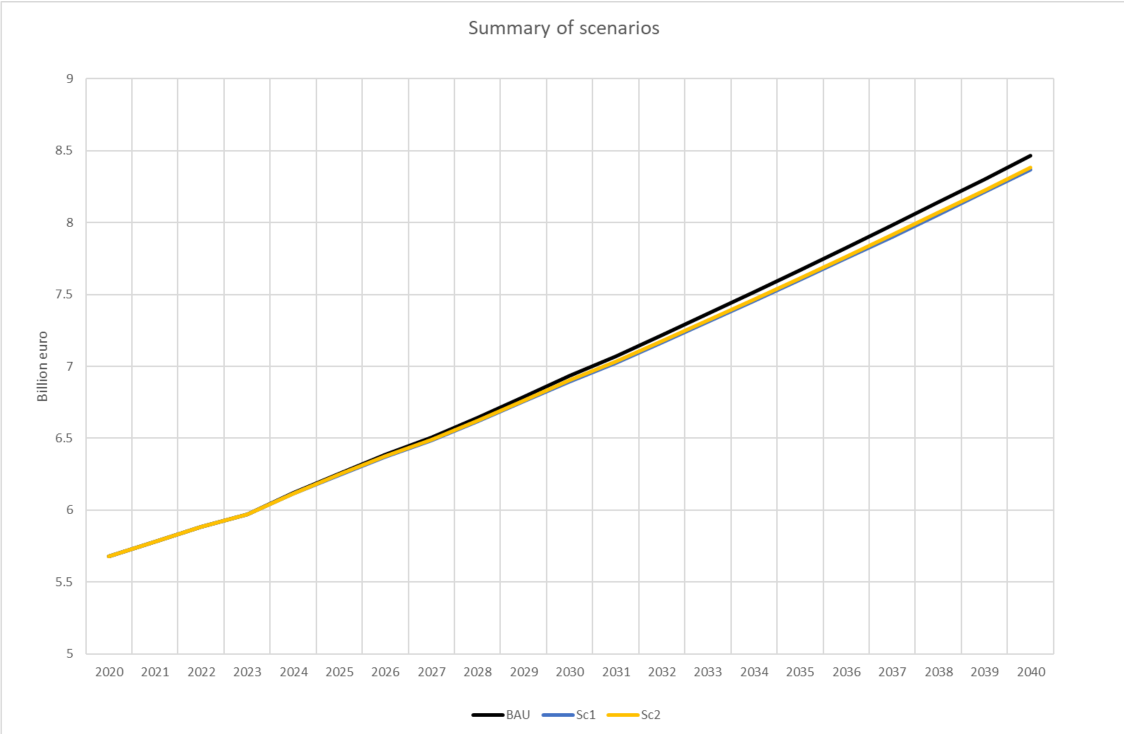


Figure 356: Consumer expenditure of scenarios for electric hobs

In the estimation presented in Figure 356, consumer expenditure of Scenario BAU decreases over the period 2020-2040, from 5.7 to 8.5 billion EUR.

In scenario 1, common ecodesign requirements for induction and radiant were considered. After 2023, hobs with an energy consumption above 180 Wh/kg would not be allowed. Under this condition, it has been estimated that the total consumer expenditure attributable to electric hobs would grow from 5.7 to 8.4 billion EUR. The adoption of scenario 1 would mean total cumulative savings of 0.9 billion EUR for the 2020-2040 period when compared to scenario BAU.

In scenario 2, different ecodesing requirements for induction and radiant were considered. Under this condition, it has been estimated that the total consumer expenditure attributable to electric hobs would grow from 5.7 to 8.4 billion EUR. The adoption of scenario 2 would mean total cumulative savings of 0.7 billion EUR for the 2020-2040 period when compared to scenario BAU.

Gas hobs

Figure 357 shows the consumer expenditure for the different scenarios considered for gas hobs.

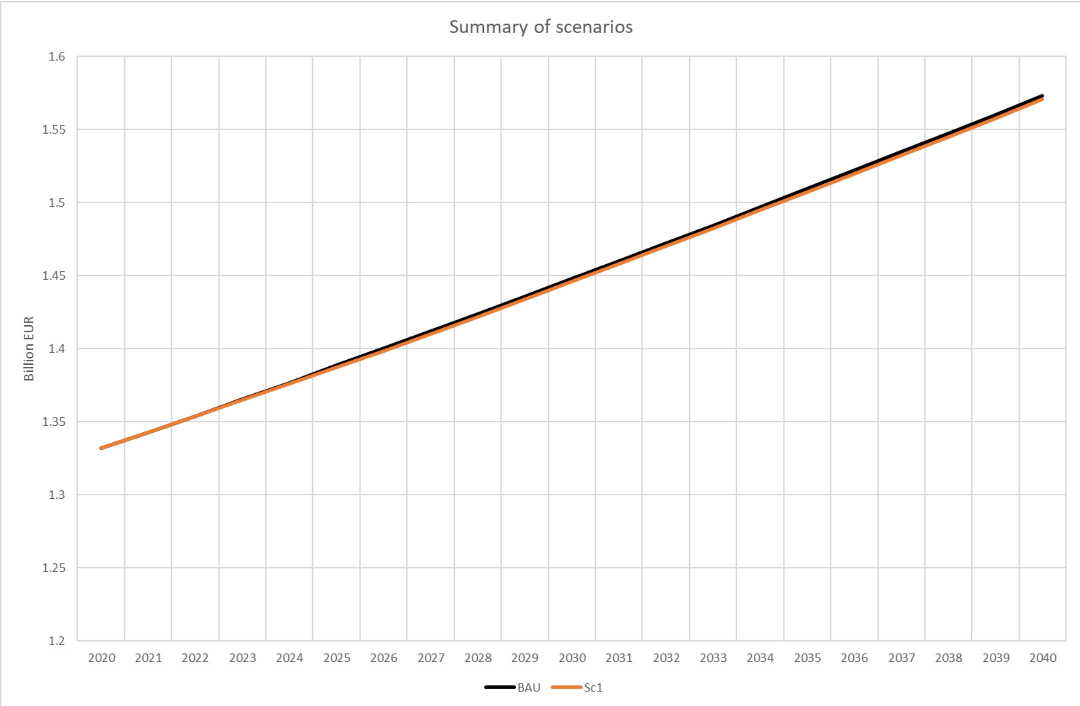


Figure 357: Consumer expenditure of scenarios for gas hobs

In the estimation presented in Figure 357, consumer expenditure of Scenario BAU decreases over the period 2020-2040, from 1.3 to 1.6 billion EUR.

In scenario 1, it has been estimated that the total consumer expenditure attributable to electric hobs would grow from 1.3 to 1.6 billion EUR. The adoption of scenario 1 would mean total cumulative savings of 0.03 billion EUR for the 2020-2040 period when compared to scenario BAU.

7.8.3.8 Summary

A summary of the different policy scenarios analysed and their cumulative impact over 2020-2040 is shown in Table 166. Negative values indicate a decrease over time and positive values indicate an increase.

Table 166: Summary of the policy scenarios and their impacts for hobs

Scenario	**Technology impact**	**Energy cumulative impact (TWh electricity / TJ natural gas)**	**GHG cumulative impact (MtCO2)**	**LCC cumulative impact (billion EUR)**
Sc1: electric hobs: same ecodesign requirements for induction and radiant hobs	Radiant hobs would not fulfil 2023 threshold.	-5.7	-1.0	-0.9
Sc2: electric hobs: different ecodesign requirements for induction and radiant hobs	Radiant hobs would remain in the market, and eventually be replaced by induction hobs by market evolution	-4.7	-0.8	-0.7
Sc1: gas hobs: ecodesign requirements	Gas hobs would be driven to reach their improvement potential, though it is very marginal	-1092	-0.1	-0.03

7.8.4 Policy scenarios for cooking fume extractors

This section aims at defining and evaluating different policy scenarios for domestic cooking fume extractors. The scenarios will consist in a combination of different policy options presented previous sections.

7.8.4.1 Business as usual scenario

The definition of the Business as Usual (BAU) scenario for cooking fume extractors is based on the assumption that no additional regulation is implemented. The BAU scenario is only used for reference as it is highly unlikely that nothing will change in the energy label given.

Sales evolution for the period 2020-2040 has been estimated using GfK data (Figure 358 and Figure 359).

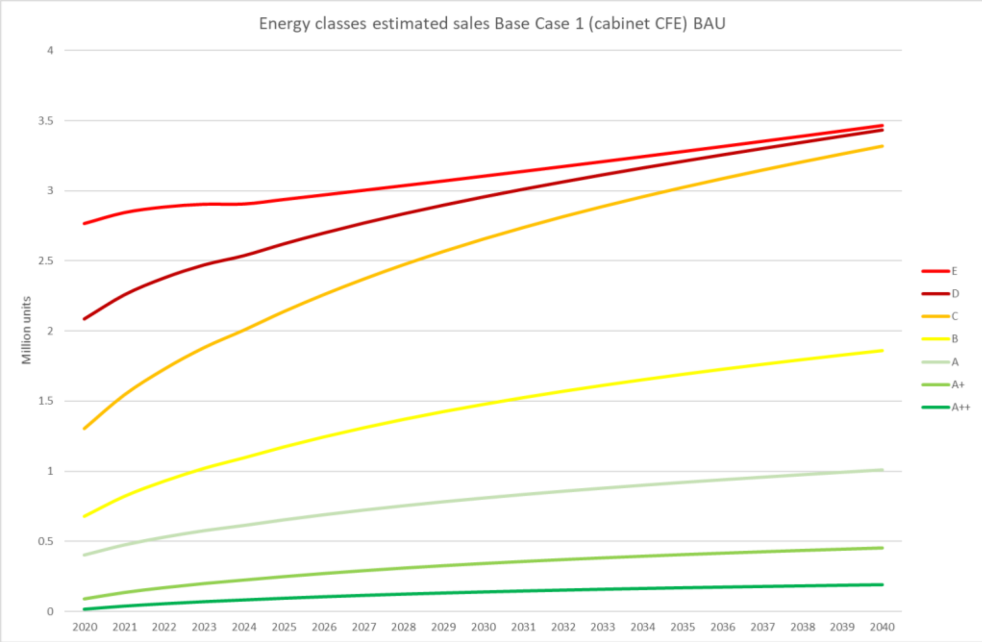


Figure 358: BAU sales estimations of base case 1 by energy classes

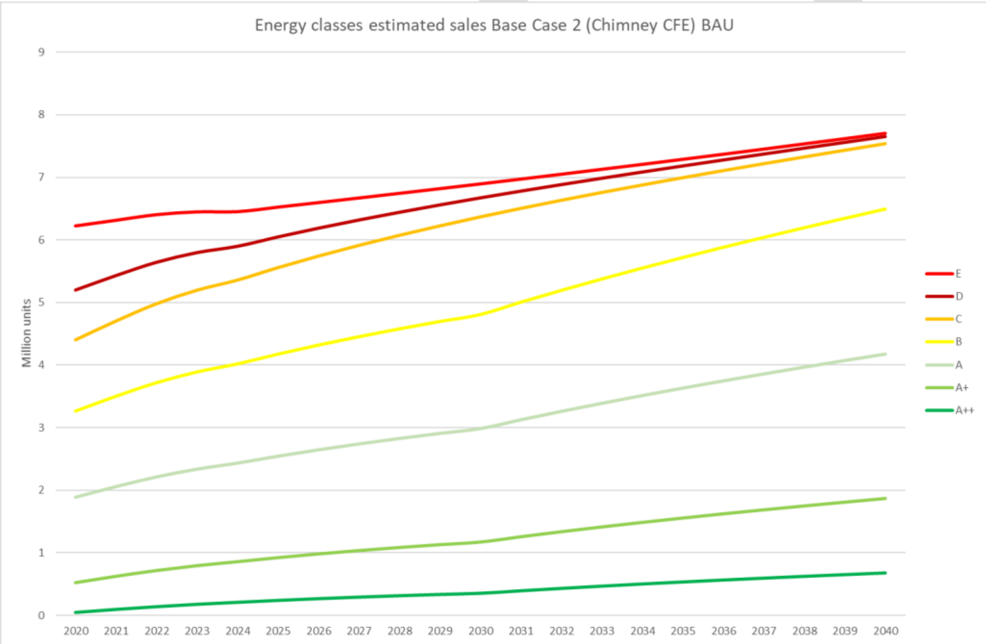


Figure 359: BAU sales estimations of base case 2 by energy classes

In the BAU scenario it is assumed that current stock consumes an average annual energy consumption 10% higher than the new products placed in the market.

The total energy consumption of the BAU for cooking fume extractors BC1, BC2 and total are presented in Figure 360, Figure 361 and Figure 362.

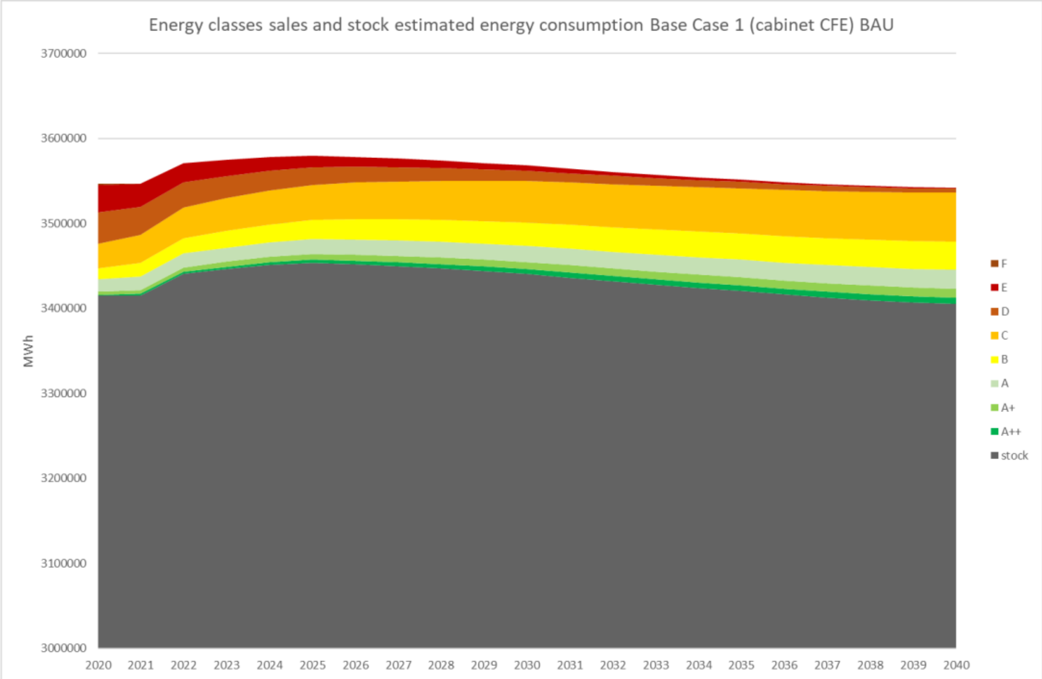


Figure 360: BAU energy classes sales and stock estimated energy consumption Base case1

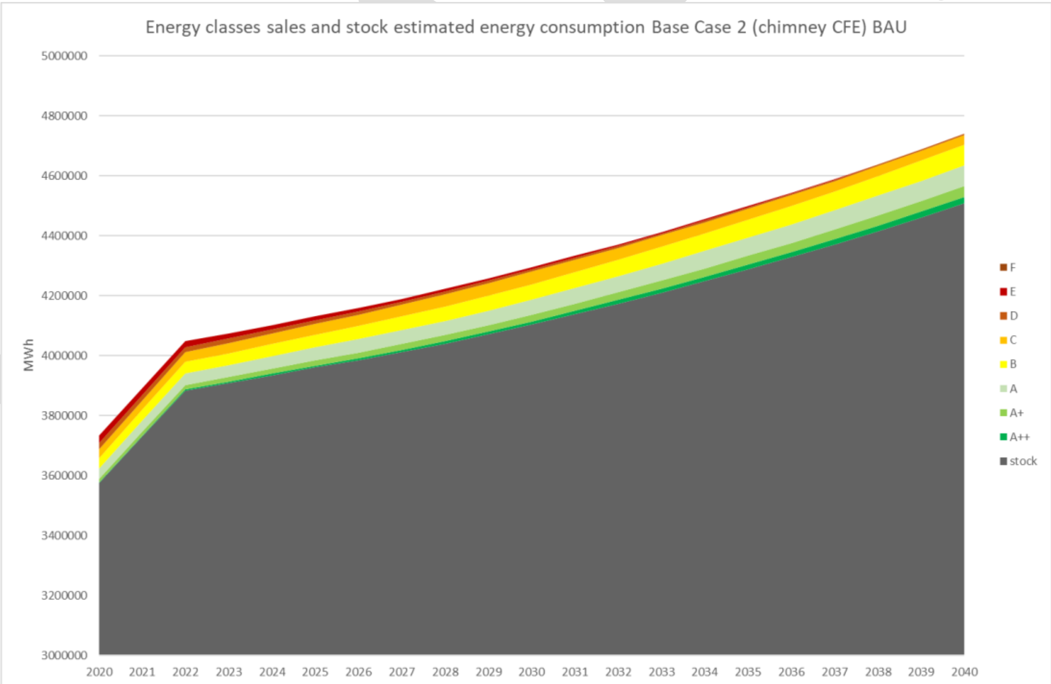


Figure 361: BAU energy classes sales and stock estimated energy consumption Base case2

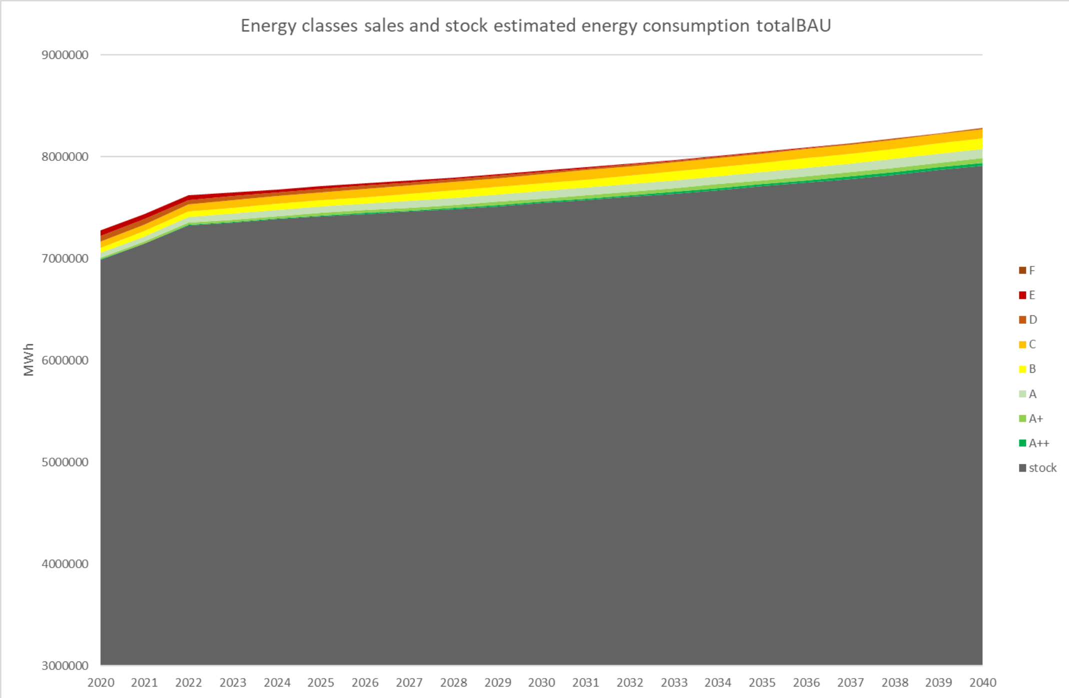


Figure 362: BAU energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.2 Scenario 1a: EEI and energy classes based on FDE option a

Scenario 1a is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based in FDE using option a for defining EEI thresholds, as explained in section 7.6.3.2. This is combined with a MEPS requiring a minimum class F

The estimated evolution of the new energy classes sales is presented in Figure 365.

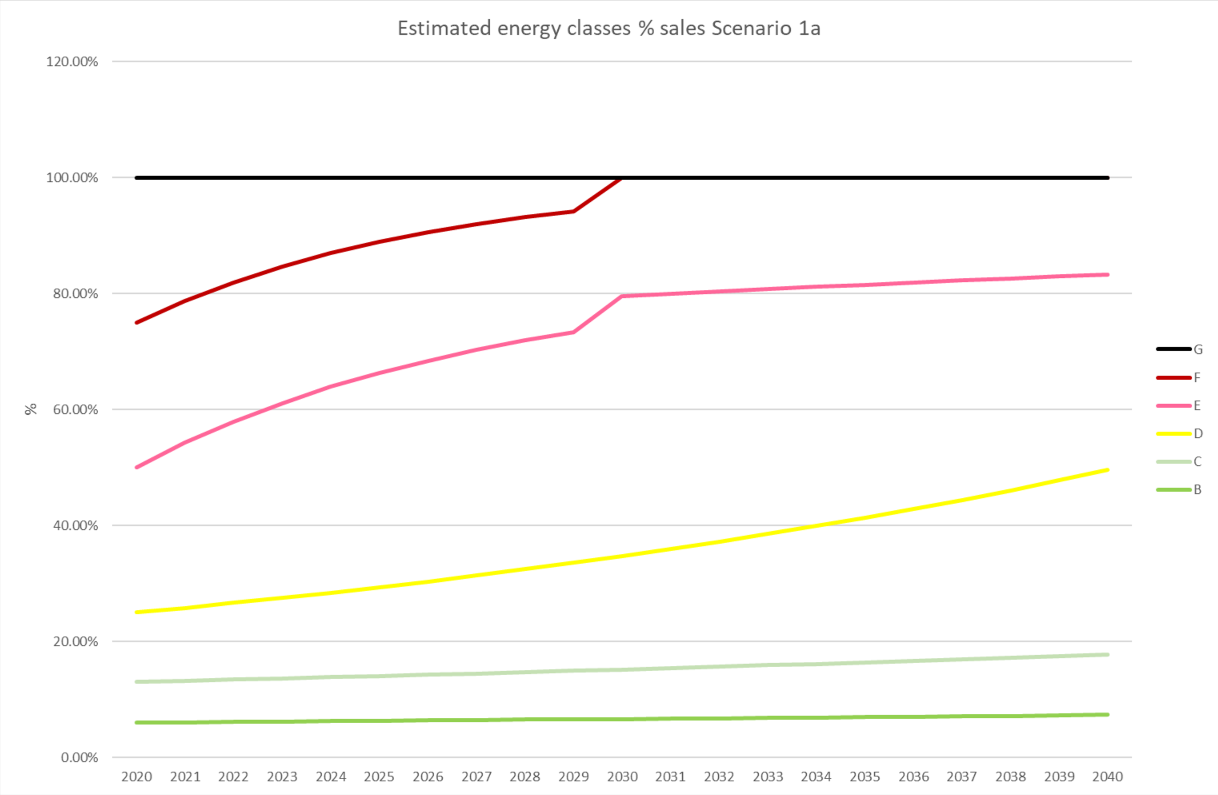


Figure 363: Estimated evolution of the FDE option a energy classes sales in %

The MEPS proposed (minimum energy class F required by 2030) would cause that the sales of class G cooking fume extractors would be zero by that year. It is assumed that those products would be replaced mainly by classes F and E.

Energy classes B, C and D would correspond to brushless motors, whose sales are assumed to annually grow by 1%, 2% and 5% respectively. E class would initially be composed by brushless motors but other technologies would reach the class until become relatively stable.

The annual energy consumption of each energy class has been calculated assuming that each one would deliver the same airflow and pressure than the base case. Since energy classes are based on FDE, a better energy class product would provide the same pressure and airflow at lower power. The annual energy consumption of the energy classes is shown in Table:

Table 167: Estimated annual energy consumption of FDE option a energy classes

Energy class	Annual energy consumption BC1	Annual energy consumption BC2
B	11.9	14.4
C	13.9	16.9
D	16.9	20.3
E	21.5	25.7
F	37.0	42.8
G	47.1	58.4

The total energy consumption of the above stock can be seen in Figure 366.

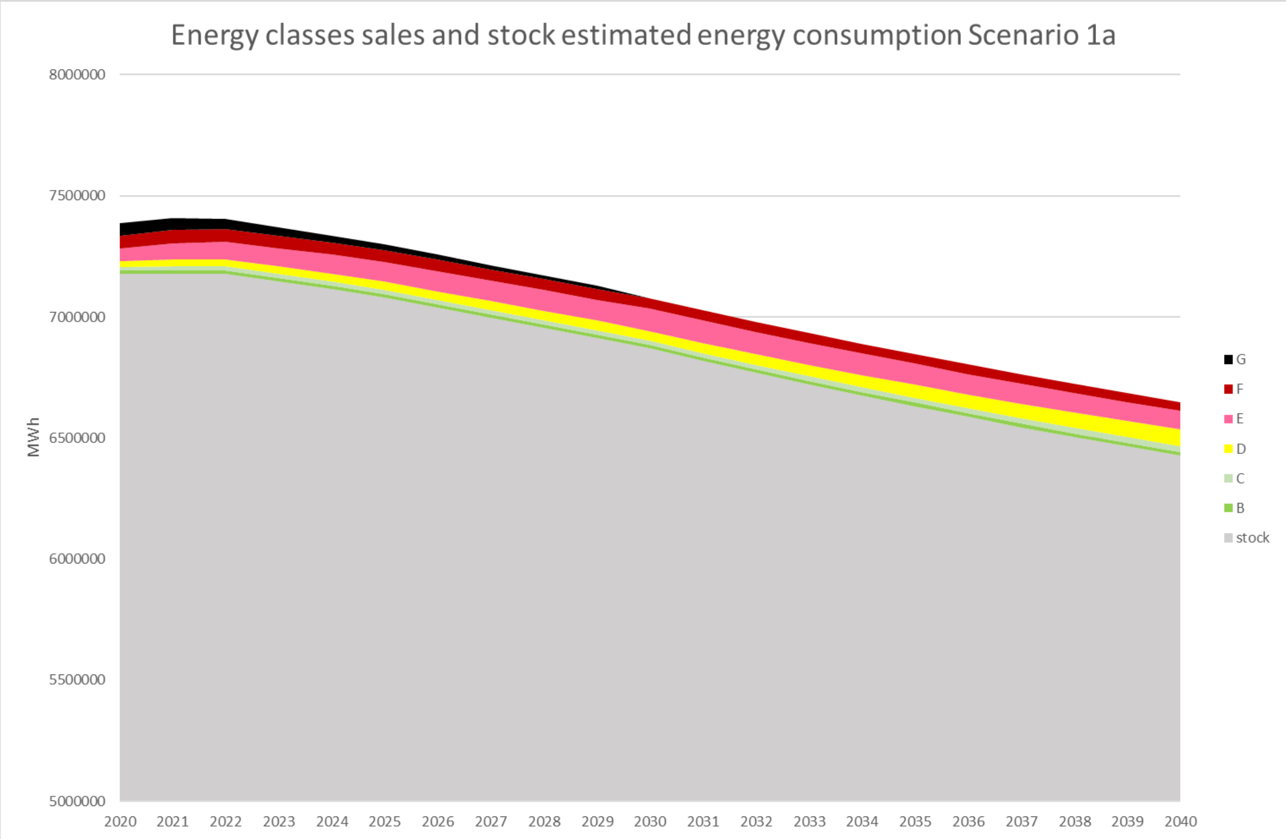


Figure 364: Scenario 1a energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.3 Scenario 1b: EEI and energy classes based on FDE option b

Scenario 1b is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based in FDE using option b for defining EEI thresholds, as explained in section 7.6.3.2. This is combined with a MEPS requiring a minimum class F

The estimated evolution of the new energy classes sales is presented in Figure 365.

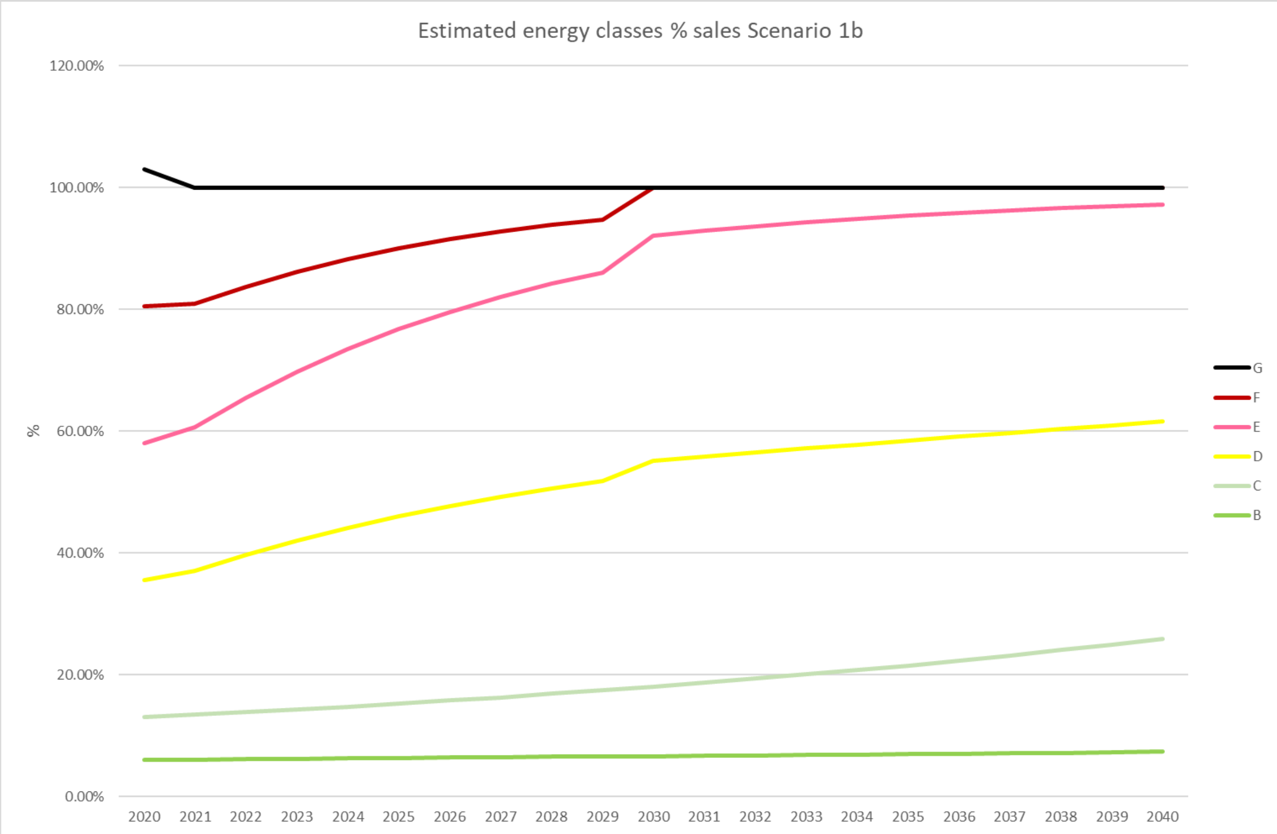


Figure 365: Estimated evolution of the FDE option b energy classes sales in %

The MEPS proposed (minimum energy class F required by 2030) would cause that the sales of class G cooking fume extractors would be zero by that year. It is assumed that those products would be replaced mainly by classes F and E, and partly by class D.

Energy classes B and C would correspond to brushless motors, whose sales are assumed to annually grow by 1% and 5%, respectively.

The annual energy consumption of each energy class has been calculated assuming that each one would deliver the same airflow and pressure than the base case. Since energy classes are based on FDE, a better energy class product would provide the same pressure and airflow at lower power. The annual energy consumption of the energy classes is shown in Table:

Table 168: Estimated annual energy consumption of FDE option b energy classes

Energy class	**Annual energy consumption BC1**	**Annual energy consumption BC2**
B	13.5	15.9
C	20.8	21.1
D	29.2	36.9
E	34.2	42.8
F	43.5	50.6
G	47.1	63.4

The total energy consumption of the above stock can be seen in Figure 366.

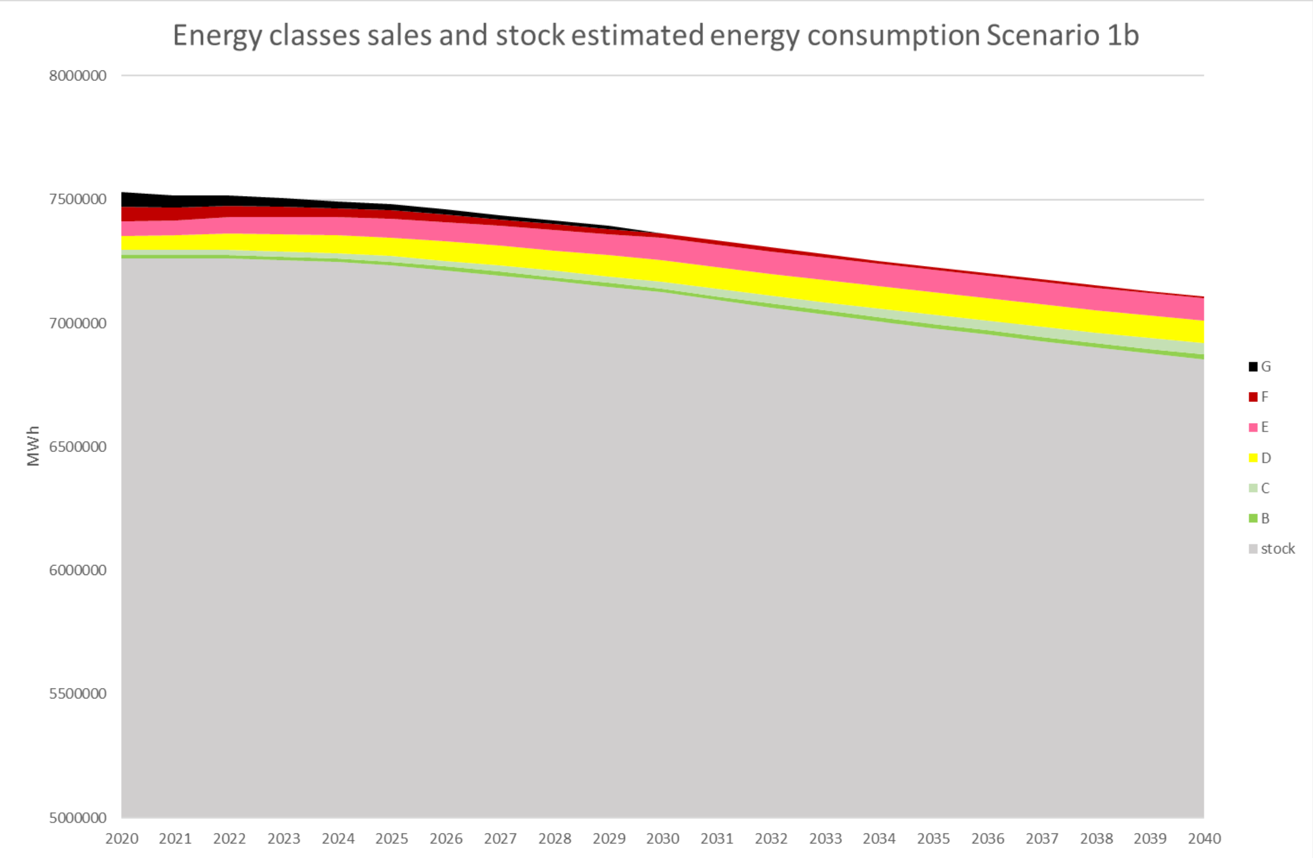


Figure 366: Scenario 1b energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.4 Scenario 2a: EEI and energy classes based on SAEC as function of airflow and option a

Scenario 2a is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based in airflow using option a for defining EEI thresholds, as explained in section 7.6.3.3. This is combined by a MEPS requiring a minimum class F and a minimum FDE of 5%

The estimated evolution of the new energy classes sales is presented in Figure 369.

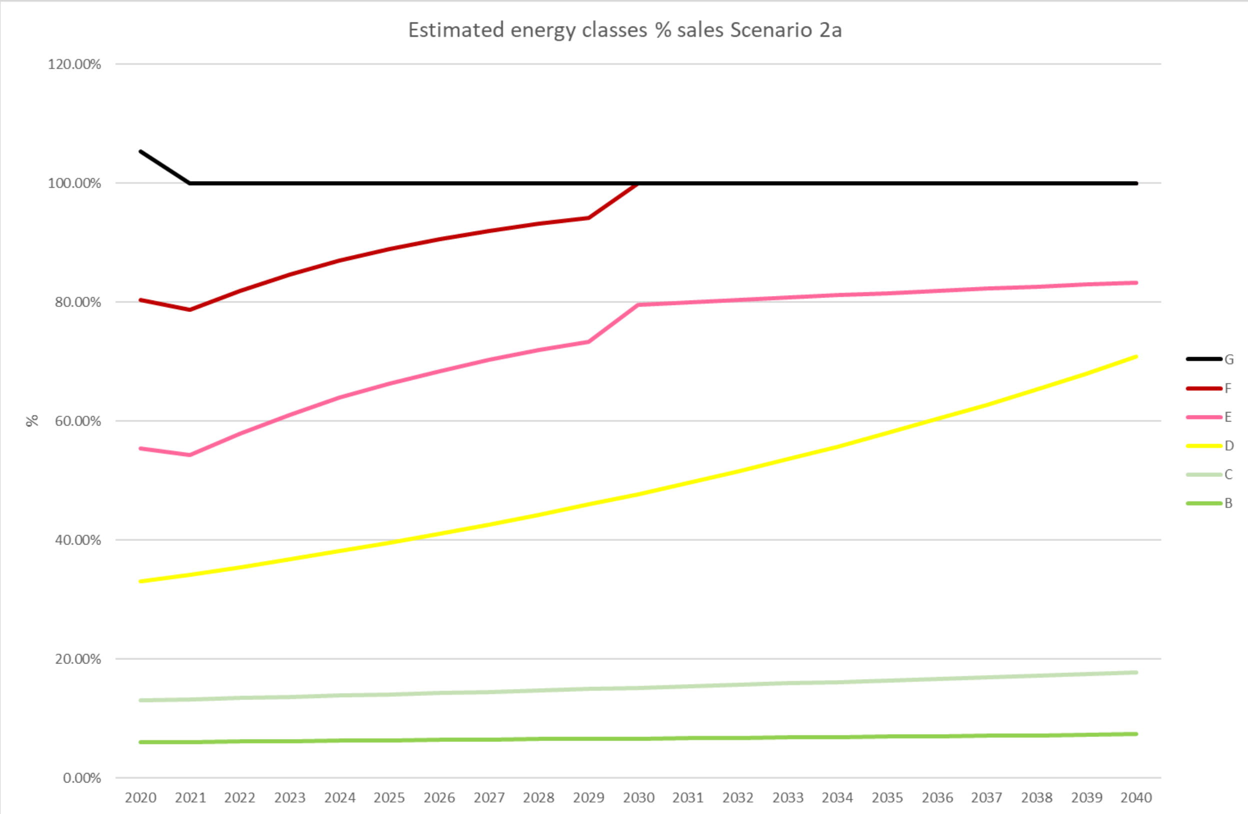


Figure 367: Estimated evolution of the airflow option a energy classes sales in %

Similarly to Scenario 1, the MEPS proposed (minimum energy class F required by 2030) would cause that the sales of class G cooking fume extractors would be zero by that year. It is assumed that those products would be replaced mainly by classes F, E and D.

Energy class B and C would correspond to brushless motors, whose sales are assumed to annually grow by 1% and 2% respectively. Class D would be quickly populated by capacitor motors.

The annual energy consumption of each energy class has been calculated assuming that each would deliver the same airflow than the base case. Since energy classes are based on airflow, a better energy class product would provide the same airflow at lower power. The annual energy consumption of the energy classes is shown in Table:

Table 169: Estimated annual energy consumption of airflow option a energy classes

Energy class	Annual energy consumption BC1	Annual energy consumption BC2
B	17.4	15.8
C	24.8	22.5
D	32.2	29.3
E	39.7	36.0
F	47.1	42.8
G	48.3	47.3

The main difference with scenario 1a is that there are two classes, instead of three, that encompasses brushless motors, entailing that the sales of cooking fume extractors equipped with brushless motors assumed to be less promoted.

The total energy consumption of the above stock can be seen in Figure 370.

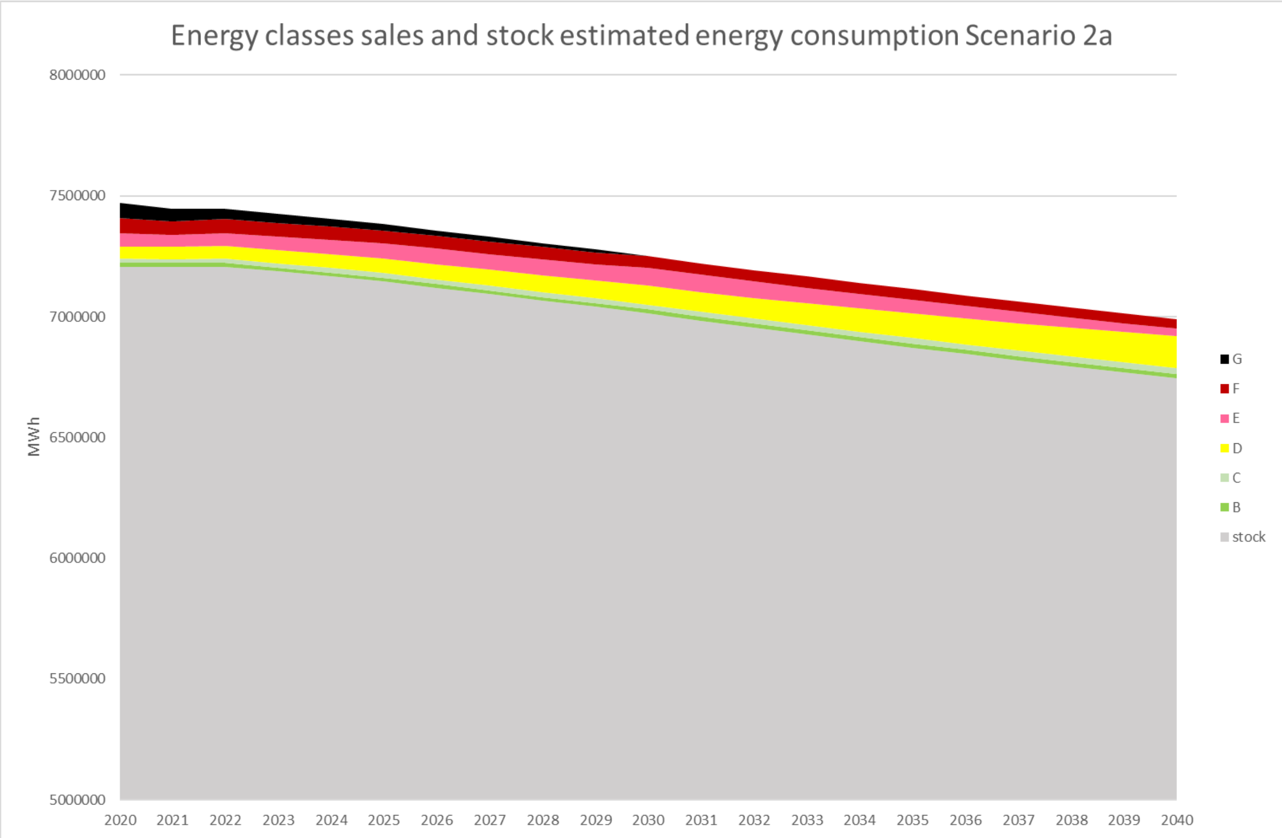


Figure 368: Scenario 2a energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.5 Scenario 2b: EEI and energy classes based on SAEC as function of airflow and option b

Scenario 2b is determined by a shift of the existing EEI and energy classes based on AEC to a methodology based in airflow using option b for defining EEI thresholds, as explained in section 7.6.3.3. This is combined by a MEPS requiring a minimum class F and a minimum FDE of 5%

The estimated evolution of the new energy classes sales is presented in Figure 369.

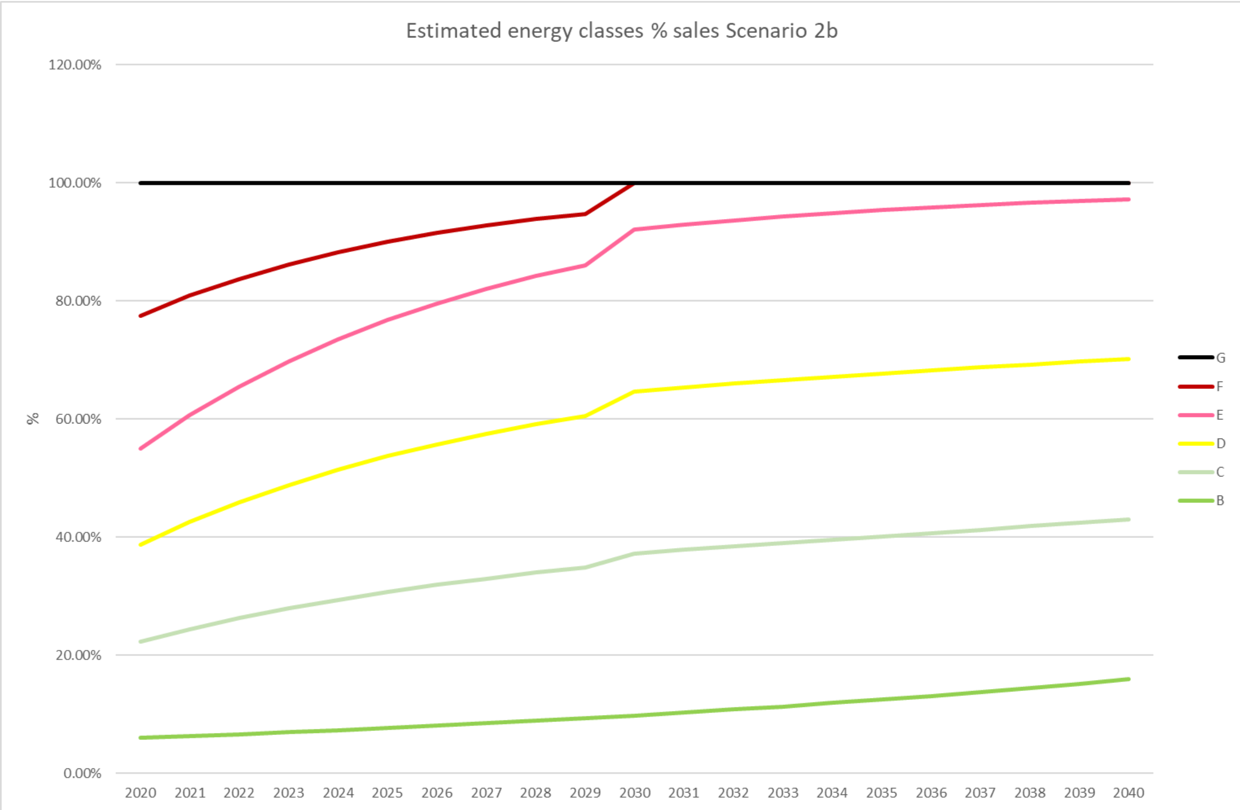


Figure 369: Estimated evolution of the airflow option b energy classes sales in %

Similarly to Scenario 1, the MEPS proposed (minimum energy class F required by 2030) would cause that the sales of class G cooking fume extractors would be zero by that year. It is assumed that those products would be replaced mainly by classes F and E, and partly by class D and C.

Energy class B would correspond to brushless motors, whose sales are assumed to annually grow by 5%.

The annual energy consumption of each energy class has been calculated assuming that each would deliver the same airflow than the base case. Since energy classes are based on airflow, a better energy class product would provide the same airflow at lower power. The annual energy consumption of the energy classes is shown in Table:

Table 170: Estimated annual energy consumption of airflow option b energy classes

Energy class	Annual energy consumption BC1	Annual energy consumption BC2
B	22.6	23.2
C	35.0	35.8
D	38.6	39.5
E	41.8	42.8
F	47.1	48.2
G	48.0	49.1

The main difference with scenario 1b is that there is only one class (B) that encompasses brushless motors, so the sales of cooking fume extractors equipped with brushless motors are assumed to be less promoted. Besides, the brushless motors can easily achieve energy class B, so the only driver towards best brushless motors is class A, which may be too strict.

The total energy consumption of the above stock can be seen in Figure 370.

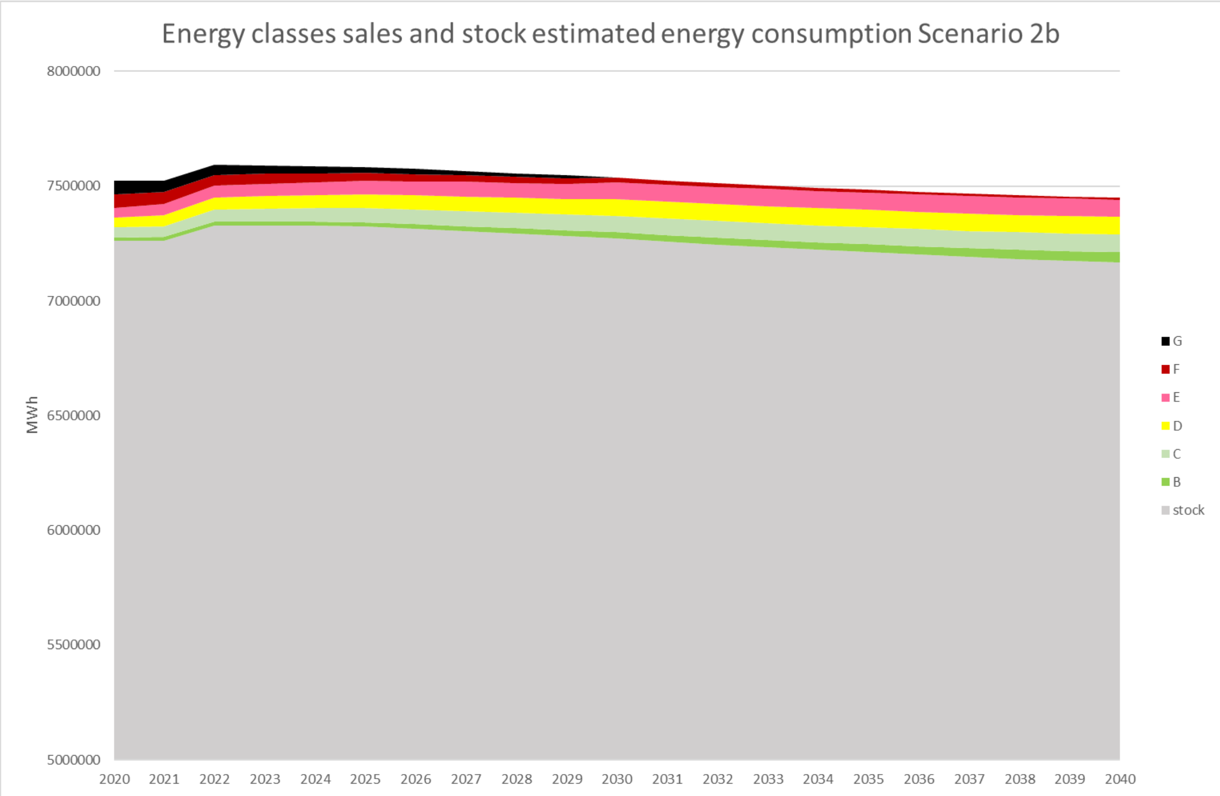


Figure 370: Scenario 2b energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.6 Scenario 3a: Update of the existing EEI based on power and option a

Scenario 3a consists of an update of the existing EEI and energy classes based on AEC to incorporate the 9-points method using option a for defining EEI thresholds, as explained in section 7.6.3.4. This combined with a MEPS requiring a minimum class F and a minimum FDE of 5%

Both EEI based on FDE (scenario 1a) and the updated EEI based on power (scenario 3a) are able to differentiate three energy classes (B, C and D) for those cooking fume extractors equipped with brushless motors. Therefore, the same evolution of the new energy classes sales is assumed for both scenarios.

The annual energy consumption of each energy class has been calculating assuming that each one would consume energy in proportion to EEI. Since airflow is not considered in this methodology, the different energy classes only ensure a lower energy consumption due to FDE (time factor) and power. However, it is not ensured that the same airflow, and additionally pressure, are delivered. Besides, the data suggests that best energy classes could be achieved by the other motor technologies. The annual energy consumption of the energy classes is shown in Table 172:

Table 171: Estimated annual energy consumption of power option a energy classes

Energy class	Annual energy consumption BC1	Annual energy consumption BC2
B	19.2	21.0
C	31.4	34.2
D	35.3	38.5
E	39.3	42.8

F	43.2	47.1
G	47.1	51.4

The total energy consumption of the above stock can be seen in Figure 372.

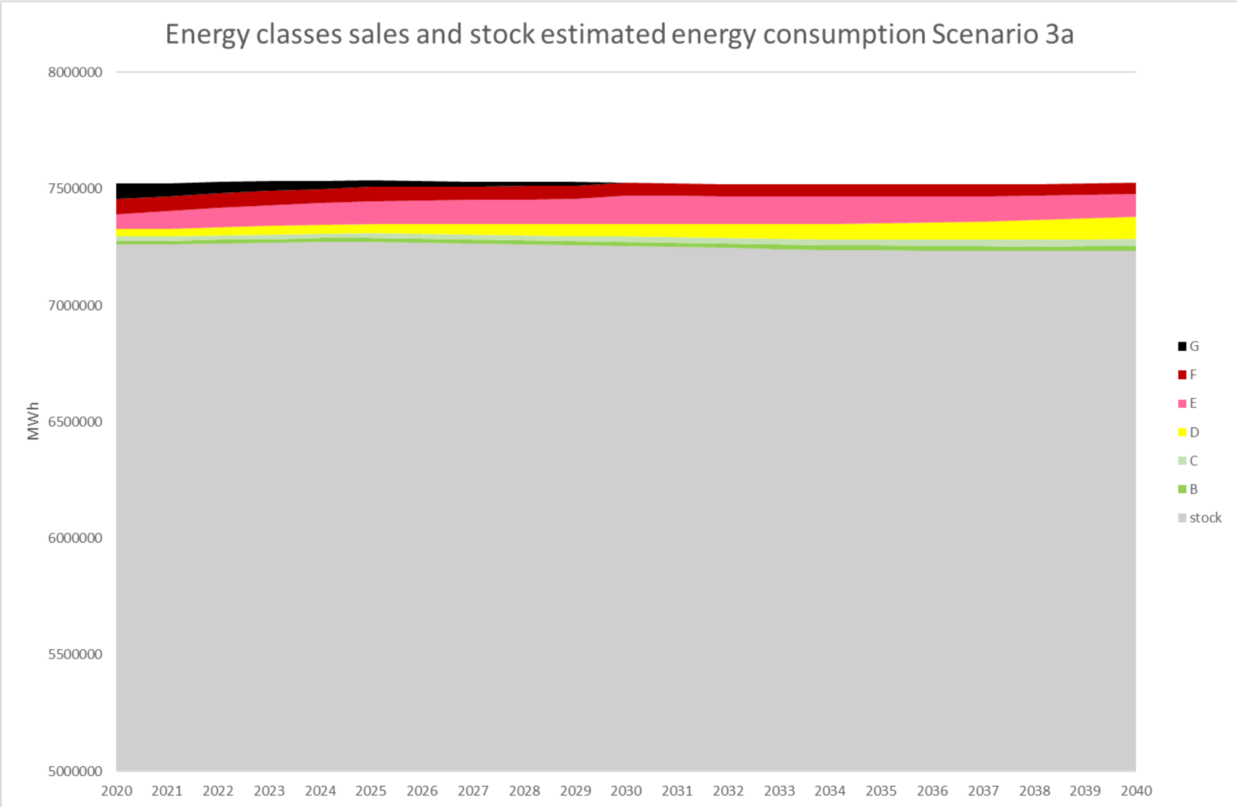


Figure 371: Scenario 3a energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.7 Scenario 3b: Update of the existing EEI based on power

Scenario 3b consists of an update of the existing EEI and energy classes based on AEC to incorporate the 9-points method using option b for defining EEI thresholds, as explained in section 7.6.3.4. This combined with a MEPS requiring a minimum class F and a minimum FDE of 5%

Both EEI based on FDE (scenario 1b) and the updated EEI based on power (scenario 3b) are able to differentiate two energy classes (B and C) for those cooking fume extractors equipped with brushless motors. Therefore, the same evolution of the new energy classes sales is assumed for both scenarios. Besides, the data suggests that energy classes B and C could be achieved by the other motor technologies. The annual energy consumption of the energy classes is shown in Table 172:

Table 172: Estimated annual energy consumption of power option b energy classes

Energy class	Annual energy consumption BC1	Annual energy consumption BC2
B	23.2	22.9
C	39.9	39.3
D	42.2	41.5
E	43.5	42.8
F	45.8	45.0
G	47.1	52.9

The total energy consumption of the above stock can be seen in Figure 372.

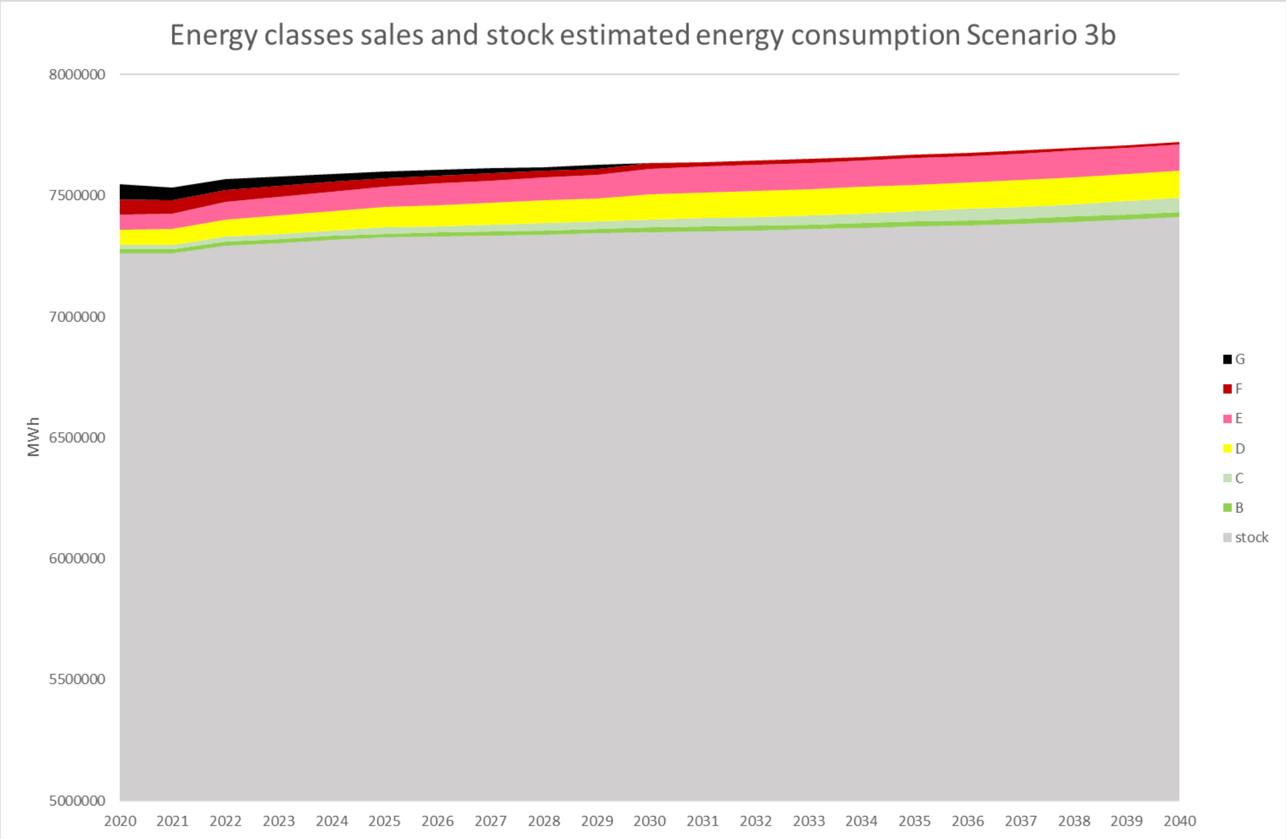


Figure 372: Scenario 3b energy classes sales and stock estimated total energy consumption (BC1+BC2)

7.8.4.8 Impacts on energy consumption

In this section, an analysis is conducted on the impact on energy consumption of the different scenarios presented earlier.

Figure 373 summarizes the total energy consumption of the stock of cooking fume extractors between 2020 and 2040 of those scenarios.

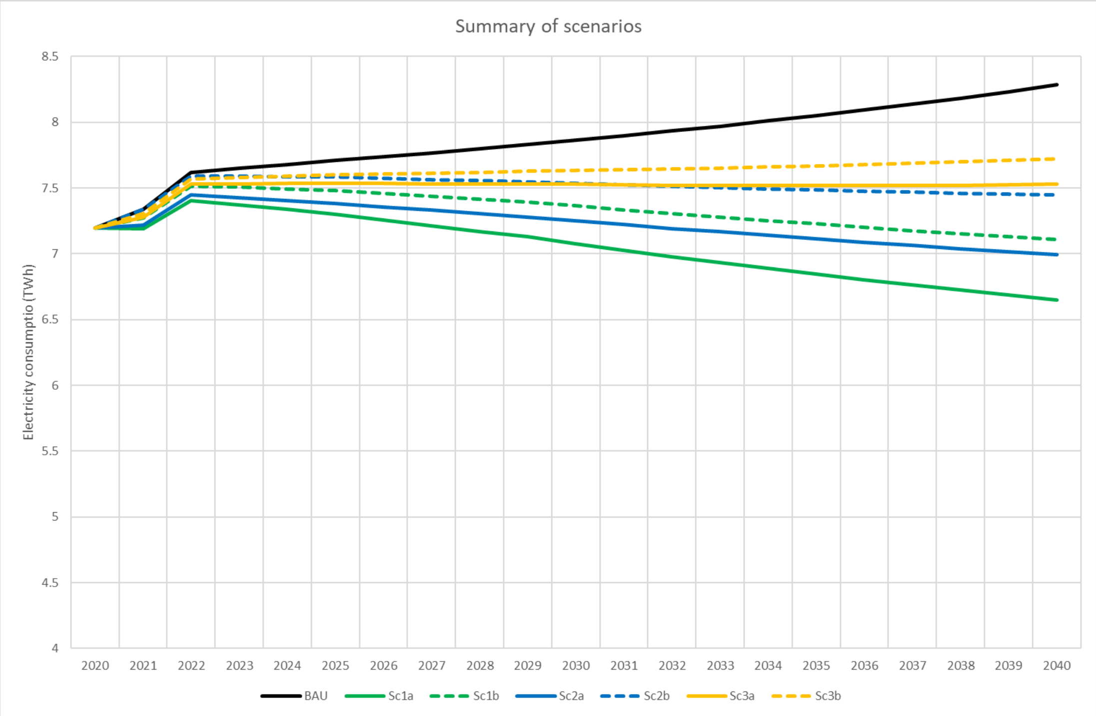


Figure 373: Electricity consumption in scenarios for cooking fume extractors

If no changes are made (scenario BAU), it is estimated that the total energy consumption attributable to cooking fume extractors will grow from 7.2 TWh in 2020 to 8.3 TWh in 2040 (15% increase). This increase in energy consumption is mostly related to the growth in sales and in stock of cooking fume extractors within that period.

Scenario 1a consists of a new methodology of EEI and energy classes based on FDE and a distribution based on even EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 7.2 TWh in 2020 to 6.7 TWh in 2040 (7.6% decrease). The adoption of scenario 1a would mean total cumulative savings of 17.0 TWh for the 2020-2040 period when compared to scenario BAU.

Scenario 1b consists of a new methodology of EEI and energy classes based on FDE and a distribution based on number of models. After 2030, cooking fume extractors with an energy class worse than F would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to cooking fume extractors would decrease from 7.2 TWh in 2020 to 7.1 TWh in 2040 (1.3% decrease). The adoption of scenario 1b would mean total cumulative savings of 11.3 TWh for the 2020-2040 period when compared to scenario BAU.

Scenario 2a consists of a new methodology of EEI and energy classes based on airflow and a distribution based on even EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to electric hobs would decrease from 7.2 TWh in 2020 to 7.0 TWh in 2040 (2.9% decrease). Total cumulative savings over the 2020-2040 period would be 13.3 TWh.

Scenario 2b consists of a new methodology of EEI and energy classes based on airflow and a distribution based on number of models. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to electric hobs would grow from 7.2 TWh in 2020 to 7.5 TWh in 2040 (3.5% increase). Total cumulative savings over the 2020-2040 period would be 7.5 TWh.

Scenario 3a consists of an update of the existing methodology of EEI and energy classes to incorporate the 9-points method, and a distribution based on even EEI thresholds. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to electric hobs would grow from 7.2 TWh in 2020 to 7.5 TWh in 2040 (4.6% increase).. Total cumulative savings over the 2020-2040 period would be 7.5 TWh.

Scenario 3b consists of an update of the existing methodology of EEI and energy classes to incorporate the 9-points method, and a distribution based on number of models.. After 2030, cooking fume extractors with an energy class worse than F and FDE below 5% would not be allowed. Under these conditions, it has been estimated that the total energy consumption attributable to electric hobs would grow from 7.2 TWh in 2020 to 7.7 TWh in 2040 (7.3% increase). Total cumulative savings over the 2020-2040 period would be 5.3 TWh.

7.8.4.9 Impacts on GHG emissions

In this section, an analysis is conducted on the impact on GHG emissions of the different scenarios presented earlier.

Figure 374 summarizes the total GHG emissions of the stock of cooking fume extractors between 2020 and 2040 of those scenarios.

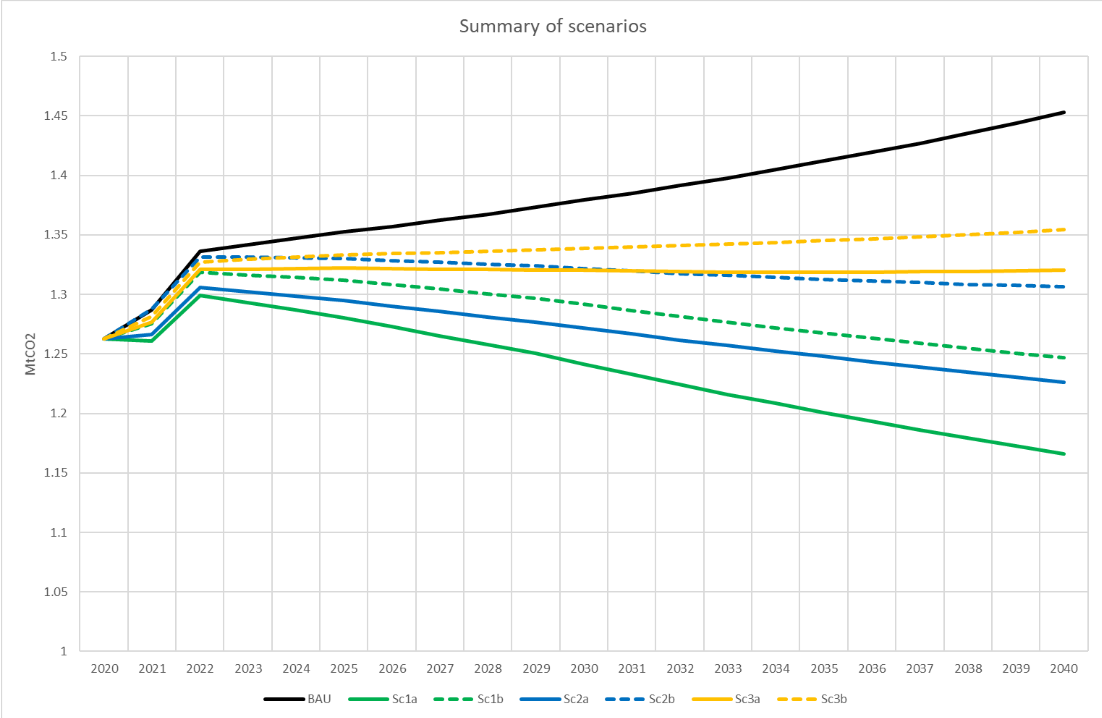


Figure 374: CO2 emissions in scenarios for cooking fume extractors

If no changes are made (scenario BAU), it is estimated that the total GHG emissions attributable to cooking fume extractors will grow from 1.3 MtCO2 in 2020 to 1.5 MtCO2 in 2040 (15% increase).

In Scenario 1a (EEI and energy classes based on FDE and even EEI thresholds), it has been estimated that the total GHG emissions attributable to cooking fume extractors would decrease from 1.3 MtCO2 in 2020 to 1.2 MtCO2 in 2040 (7.6% decrease). The adoption of scenario 1a would mean total cumulative savings of 3.0 MtCO2 for the 2020-2040 period when compared to scenario BAU.

In Scenario 1b (EEI and energy classes based on FDE and distribution based on number of models), it has been estimated that the total GHG emissions attributable to cooking fume extractors would decrease from 1.3 MtCO2 in 2020 to 1.25 MtCO2 in 2040 (1.3% decrease). The adoption of scenario 1b would mean total cumulative savings of 2.0 MtCO2 for the 2020-2040 period when compared to scenario BAU.

In Scenario 2a (EEI and energy classes based on airflow and even EEI thresholds), it has been estimated that the total GHG emissions attributable to cooking fume extractors would decrease from 1.3 MtCO2 in 2020 to 1.22 MtCO2 in 2040 (2.9% decrease). Total cumulative savings over the 2020-2040 period would be 2.3 MtCO2.

In Scenario 2b (EEI and energy classes based on airflow and distribution based on number of models), it has been estimated that the total GHG emissions attributable to cooking fume extractors would grow from 1.3 MtCO2 in 2020 to 1.31 MtCO2 in 2040 (3.5% increase). Total cumulative savings over the 2020-2040 period would be 1.3 MtCO2.

In Scenario 3a (update of the existing methodology of EEI and energy classes to incorporate the 9-points method and even EEI thresholds), it has been estimated that the total GHG emissions attributable to cooking fume extractors would grow from 1.3 MtCO2 in 2020 to 1.32 MtCO2 in 2040 (4.6% increase). Total cumulative savings over the 2020-2040 period would be 1.3 MtCO2.

In Scenario 3b (update of the existing methodology of EEI and energy classes to incorporate the 9-points method and distribution based on number of models), it has been estimated that the total GHG emissions attributable to cooking fume extractors would grow from 1.3 MtCO2 in 2020 to 1.35 MtCO2 in 2040 (7.3% increase). Total cumulative savings over the 2020-2040 period would be 0.9 MtCO2.

7.8.4.10 Impacts on consumer expenditure

The impacts of policy measures on the consumer expenditure are analysed in this section. These impacts include a change in the operating expenses (which are usually decreased because of more energy efficient machines) and a change in the purchase price. The consumer expenditure is calculated as the life cycle cost (LCC), i.e. including purchase costs and operating costs (energy repair and maintenance costs). Purchase price of each type of range hoods is assumed to be proportional to the energy class, taking as reference the data from GfK.

The operating costs consist of the electricity, maintenance and repair costs. The energy price trends are estimated considering the projections in the EU Reference scenario 2016 (European Commission 2016).

It is important to notice that these are rough and simplified estimations on consumer expenditure. They will be improved in the next version of the report by means of a modelling tool that is currently being revised and updated.

Figure 375 summarizes the total consumer expenditure of cooking fume extractors between 2020 and 2040 of those scenarios.

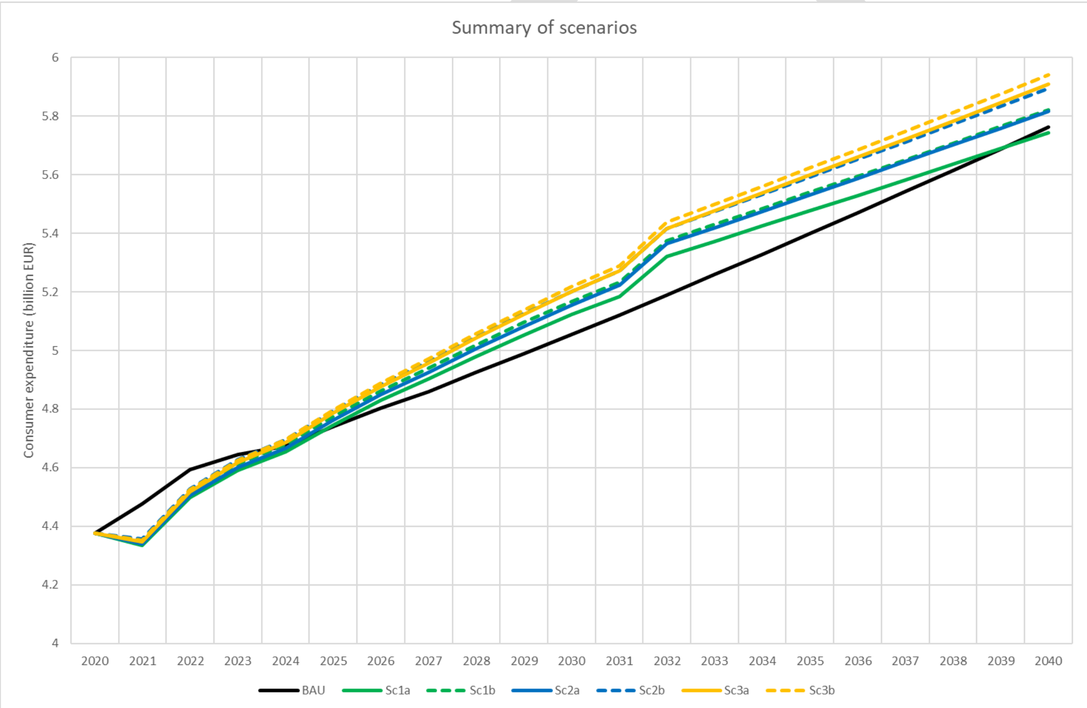


Figure 375: Consumer expenditure in scenarios for cooking fume extractors

If no changes are made (scenario BAU), it is estimated that the total consumer expenditure attributable to cooking fume extractors will grow from 4.4 billion EUR in 2020 to 5.76 billion EUR in 2040 (32% increase).

In Scenario 1a (EEI and energy classes based on FDE and even EEI thresholds), it has been estimated that the total consumer expenditure attributable to cooking fume extractors would increase from 4.4 billion EUR in 2020 to 5.7 billion EUR in 2040 (31% increase). The adoption of scenario 1a would mean total cumulative additional expenditure of 0.5 billion EUR for the 2020-2040 period when compared to scenario BAU.

In Scenario 1b (EEI and energy classes based on FDE and distribution based on number of models), it has been estimated that the total consumer expenditure attributable to cooking fume extractors would increase from 4.4 billion EUR in 2020 to 5.82 billion EUR in 2040 (33% increase). The adoption of scenario

1b would mean total cumulative additional expenditure of 1.5 billion EUR for the 2020-2040 period when compared to scenario BAU.

In Scenario 2a (EEI and energy classes based on airflow and even EEI thresholds), it has been estimated that the total consumer expenditure attributable to cooking fume extractors would grow from 4.4 billion EUR in 2020 to 5.8 billion EUR in 2040 (33% increase). Total cumulative additional expenditure over the 2020-2040 period would be 1.3 billion EUR.

In Scenario 2b (EEI and energy classes based on airflow and distribution based on number of models), it has been estimated that the total consumer expenditure attributable to cooking fume extractors would grow from 4.4 billion EUR in 2020 to 5.9 billion EUR in 2040 (35% increase). Total cumulative additional expenditure over the 2020-2040 period would be 2.2 billion EUR.

In Scenario 3a (update of the existing methodology of EEI and energy classes to incorporate the 9-points method and even EEI thresholds), it has been estimated that the total consumer expenditure attributable to cooking fume extractors would grow from 4.4 billion EUR in 2020 to 5.9 billion EUR in 2040 (35% increase). Total cumulative additional expenditure over the 2020-2040 period would be 2.2 billion EUR.

In Scenario 3b (update of the existing methodology of EEI and energy classes to incorporate the 9-points method and distribution based on number of models), it has been estimated that the total consumer expenditure attributable to cooking fume extractors would grow from 4.4 billion EUR in 2020 to 5.9 billion EUR in 2040 (36% increase). Total cumulative additional expenditure over the 2020-2040 period would be 2.6 billion EUR.

7.8.4.11 Summary

A summary of the different policy scenarios analysed and their cumulative impact over 2020-2040 is shown in Table 173. Negative values indicate a decrease over time and positive values indicate an increase.

Table 173: Summary of the policy scenarios and their impacts for cooking fume extractors

Scenario	**Technology impact**	**Energy cumulative impact (TWh electricity)**	**GHG cumulative impact (MtCO2)**	**LCC cumulative impact (billion EUR)**
Sc1a	Energy classes B, C, D and E identify BAT, which is significantly. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow and pressure. The most common technologies are concentrated in the lowest energy classes, which does not allow the comparison within them.	-17.0	-3.0	0.5
Sc1b: new EEI and energy classes based on FDE	Energy classes B and C identify BAT, which is moderately promoted. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow and pressure. The most common technologies are placed	-11.3	-2.0	1.5

	in medium and low energy classes, which allows the comparison within them.			
Sc2a	Energy class B and C correspond mainly to BAT. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow. The most common technologies are placed in medium and low energy classes, which allows the comparison within them.	-13.3	-2.3	1.3
Sc2b: new EEI and energy classes based on airflow	Energy class B identifies BAT, which is less promoted than Sc1. EEI is able to compare the efficiency of cooking fume extractors delivering the same airflow. The most common technologies are placed in high, medium and low energy classes, which allows the comparison within them.	-7.5	-1.3	2.2
Sc3a	Energy classes B, C and D identify BAT, which is significantly promoted. EEI compares AEC referred to SAEC, which is only based on power. EEI is detached from the airflow and pressure delivered and this may lead to lenient EEI thresholds. Data shows that classes C and D could also be achieved by the other motor technologies.	-7.5	-1.3	2.2
Sc3b: update of existing EEI and energy classes based on power	Energy classes B and C identify BAT, which is significantly promoted. EEI compares AEC referred to SAEC, which is only based on power. EEI is detached from the airflow and pressure delivered and this may lead to lenient EEI thresholds. Data shows that classes C and D could also be achieved by the other motor technologies.	-5.3	-0.9	2.6

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