Development of European Ecolabel and Green Public Procurement Criteria for Hydronic Central Heating Systems Draft Report

Product definition and scope
Economic and market analysis
Technical analysis

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0 Introduction

0.1 Background and aim

This report is the interim report of the technical background study in support of an environmental product policy for heating systems.

The background study is part of the IPTS (Institute for Prospective Studies in Seville, Spain) effort to support Directorate General Environment (DG ENV) in the development of Ecolabel and Green Public Procurement (GPP) criteria for the specific product group "hydronic central heating systems". The context of this study is the European Sustainable Consumption and Production (SCP) Action Plan (EC, July 2008) [1], which mentions as pillars the Ecodesign ErP Directive[2] , Ecolabel Regulation[3] and the Communication on GPP[4] .

The technical background study aims to provide:

- a technical/economical/environmental analysis of hydronic central heating systems;
- a discussion on which approach to take for setting of criteria levels;
- a proposal for criteria levels for hydronic central heating systems;
- all other information, calculation, explanation required by the description of tasks.

The study scope, methodology and planning were discussed during the kick-off meeting which took place on February 3rd 2011 at the IPTS premises in Seville, Spain. This deliverable takes the conclusions of that meeting, as discussed in the Inception Report[5,] into account.

0.2 Scope

In the tender specifications the actual product group within the generic product group 'heating systems' was not defined. In the kick-off meeting the following specification of the scope was agreed.

Included are:

- Hydronic central heating boilers, either electric, gas, oil or biomass-fired;
- 'Block heating' boilers (i.e. a central heating boiler serving multiple apartments within the same building), providing heat to individual apartments by 'flat stations' (tapping heat from the central loop to the individual dwelling) are included.
- Solar thermal heating, heat pumps as well as (micro) CHP systems providing heat to hydronic heating systems. CHP units (combined heat and power units) that serve a single building (as in block heating) are also included;
- As indicated above hydronic central heating systems of which the heat is generated by biomass-boilers are considered within the scope of this study. The main source of information will be the finalised Ecodesign preparatory study 'Lot 15'. The underlying study will give consideration to the discussions regarding the technical standards for measuring efficiency and emissions. The Lot 15 approach on how to consider CO2 emissions and the renewable nature of many fuels (wood pellets, logs) will be adopted. Since several environmental label schemes address these products these labels and other

[1] COM (2008) 397 final.
[2] Directive 2009/125/EC establishing a framework for the setting of Ecodesign requirements for energy related products.
[3] Regulation (EC) No 66/2010 of the European Parliament and the Council of 25 November 2009 on the EU Ecolabel.
[4] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Public Procurement for a better environment (COM/2008/0400).
[5] Inception Report of 15 march 2011.

relevant developments will be considered, including a discussion on the environmental criteria developed for these products;

The maximum nominal power input[6] of boilers considered within this scope is 400 kW (see also discussion regarding Ecodesign proposals in task 2).

Excluded are:

- 'Dedicated water heaters', ie. products specifically designed for production of heated sanitary water (for bathing, showering, cleaning);
- Large scale collective central heating facilities, providing heat to individual end-users by means of ‘district heating’. The reason is that the heat generator itself and the distribution system are outside the sphere of influence of the end-user.
- Central heating systems that provide air-based central heating (where hot air is generated centrally and transported through ducts) are not included as primary subject of the study, since the relevant Ecodesign preparatory study has not been finalized yet. However, some methodological elements (related to stratification and distribution losses) are shared with -but not identical to- hydronic central heating systems. Therefore the developments (if any) will be noted so that if agreement on the issues mentioned is achieved, this shall be reflected in the report, including a discussion on how these products can be considered in the light of the underlying study.

The scope of the study covers central heating in household, commercial and industrial buildings.

0.3 Methodology

The methodology to be applied in the study follows five tasks, as defined in the study tender specifications.

Task 1: Definition and scope

In this task the product scope will be defined, by describing applicable product definitions, product categories and legislation and standards that apply to the product group. Consideration will be given especially to the application of renewable energy in hydronic heating systems (solar thermal systems, heat pumps and biomass as fuel) and micro-CHP.

Task 2: Economic and market analysis

This task covers an economic and market analysis according to the Ecolabel regulation (EC 66/2010 of 25 November 2009). The market analysis will include general trends within the product group as regards product features, the current and future potential for market penetration of the product group, and will consider possible trade issues.

Task 3: Technical analysis

In this task a life cycle model will be constructed which will allow comparison of environmental aspects of central heating systems across various categories (electric, gas, oil, biomass-fired, including consideration of solar heating, heat pumps and micro-CHP).

[6] The maximum nominal power input of large boilers, refers to the energy input (eg. m^3 of gas per hour, expressed as kW, or electric power consumption in kW electric) at nominal conditions. Nominal conditions are standardised test conditions (aka standard rating conditions) and usually refer to the maximum power input of the boiler (which may occur in normal operating conditions and can be sustained over a certain length of time) for certain set system parameters (flow rate of medium, etc.). It is therefore not the same as the maximum power output, because the boiler introduces generator losses (except for heat pumps, where the nominal power input in electric kW is lower than the power output in kW of heat, since the renewable energy input is not counted). However, for smaller boilers (e.g. <50 kW) the nominal rating often refers to OUTPUT power.

Task 4: Policy analysis

In this task the possible impacts of Ecolabel and GPP requirements are described.

Task 5: Elaboration of draft criteria and technical reports

In this task the possible criteria for Ecolabel and GPP requirements, plus the supporting analysis will be described.

The project deliverables will meet the criteria for such documents as established by the Ecolabel Regulation EC 66/2010.

1 Task 1: Definition and scope

1.1 Subtask 1.1 - Product definition

In this subtask the product group of hydronic central heating systems, using electric, gas oil and biomass-fired heat generators, including heat pumps, CHP and solar thermal systems, is defined and a screening analysis of volume of sales and trade, environmental impact and improvement potential is provided. .

1.1.1 Prodcom categorisation

A product definition's purpose is to define the product, most often by describing defining characteristics and thereby giving guidance to the interpretation of what is inside and outside the intended scope. The Prodcom list is often cited as a possible source of defining product groups.

The Prodcom list, or better 'database', is a European database, presenting for a huge number of product groups 'economic activities', such as data on production - and for some product groups also import and export - expressed in value (euros) or quantities (kg or units), by Member State, over multiple years.

Only the following product categories relate specifically to central heating. For **central heating boilers** themselves these are:

25.21.12.00	Boilers for central heating, other than those of HS 8402
25.21.13.00	Parts of boilers for central heating

The description is not very useful as product definition. Former versions of Prodcom allowed a categorization of central heating boilers by fuel type (gas or oil) but the current (2009 and onwards) version have removed this segmentation.

In the related "CN8" database (CN8 = Combined Nomenclature, 8 digit level descriptions) boilers are categorized in more detail, by main (heat exchanger) material, but neither this provides a satisfying product definition:

84.03.10.10	Central heating boilers of cast iron (excl. vapour generating boilers and superheated water boilers of heading 8402)
84.03.10.90	Central heating boilers, non-electric, of materials other than cast iron (excl. vapour generating boilers and superheated water boilers of heading 8402)

Solid fuel domestic appliances are categorized in a very generic product group, which also contains various combinations of heating with kitchen equipment. According the Lot 21 study[7] this group also comprises wood burning boilers for central heating (including pellets), but the actual share of solid fuel central heating boilers in this product group is not known.

27.52.12.70	Iron or steel solid fuel domestic appliances, including heaters, grates, fires and braziers (excluding cooking appliances and plate warmers)

[7] 'Lot 21' refers to the Ecodesign Preparatory study on local heating products - see www.eceee.org/ecodesign for more information.

Heat pumps are described by Prodcom also in a very generic way, without reference to either capacity or type (water-to-water, or brine-to-water, etc.).

28.25.13.80	Heat pumps other than air conditioning machines of HS 8415

Prodcom distinguishes some related product group categories, such as radiators and thermostatic valves:

25.51.11.00	Radiators for central heating, not electrically heated, and parts thereof, of iron or steel
28.14.12.53	Central heating radiator thermostatic valves
28.14.12.55	Central heating radiator valves, other

There are **no Prodcom categories** for **solar thermal systems** and for **cogeneration boilers** (cogeneration may be included in the overall group 'generators' but even this can not be confirmed).

The above list of Prodcom category descriptions shows that the Prodcom database includes descriptions of 'central heating products', but that these descriptions can not be used as definitions.

1.1.2 Product definition

As decided during the kick-off meeting, the scope of the study is: hydronic central heating systems, in all relevant combinations, up to a maximum input power of 400 kW.

In order to further define this product group, inspiration can be drawn from the definitions applied in the latest proposals for the Ecodesign requirements for 'boilers'.

The product definitions for central heating boilers are as follows (using nested definitions):

1) "boiler" means a device which meets all of the following criteria:
   a) it provides heat to a water-based central heating system in order to reach and maintain the indoor temperature of an enclosed space such as a building, a dwelling, or a room, at a desired level;
      i) "water-based central heating system" means a system using water as heat transfer medium to distribute centrally generated heat to heat emitters for space heating of buildings, or parts thereof;
   b) it uses a heat generator using the processes listedbelow;
      i) "heat generator" means the part of a boiler that generates the heat using the following processes:
         (1) combustion of gaseous or liquid fossil fuels ("fossil fuel" means a gaseous, liquid or solid fuel of fossil origin);
         (2) use of the Joule effect in electric resistance heating elements;
         (3) capture of ambient heat from air, water or ground source, and/or waste heat;
2) "cogeneration" means the simultaneous generation in one process of heat and electricity;
3) "combination boiler" means a boiler that is designed to provide also hot sanitary water to desired temperature levels, quantities, flow rates and intervals;

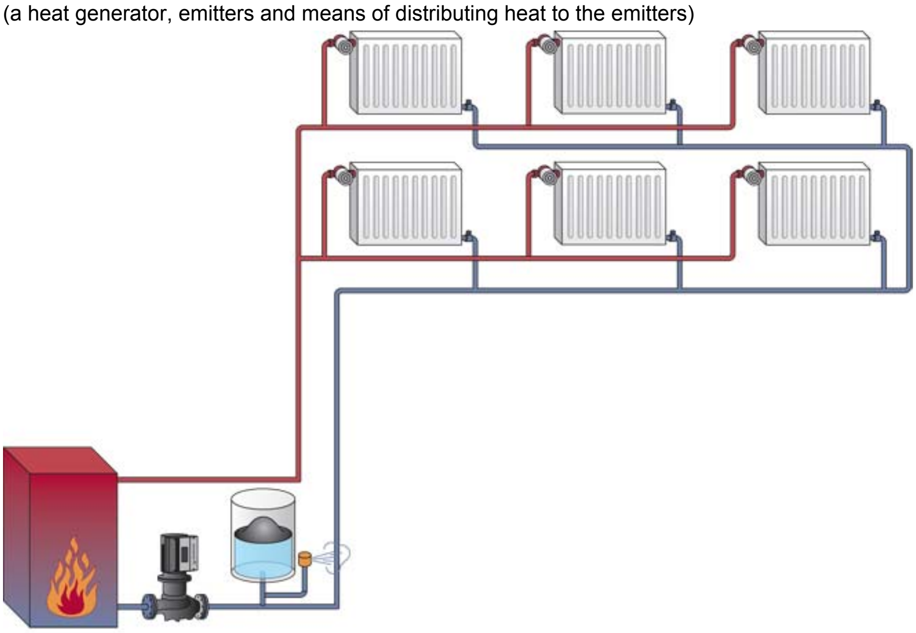
The above definition gives the basic elements of what constitutes a central heating boiler (a heat generator and a connection to a water-based central heating system with heat emitters).

The above definition also allows fossil fuel fired boilers as well as electric resistance boilers and heat pumps meet the definition of "a boiler". Biomass is not mentioned, since the Regulation does not apply to these boilers, but it is easy to add "combustion of biomass" to the principles of heat generation.

Although it is not explicitly stated in the definitions above, it may be that the circulator forms part of the 'boiler' (is incorporated into). For larger boilers the circulator is usually supplied separately. In case the boiler is placed on the market as 'parts' (burner supplied separately from the heat exchanger, etc.) the individual products do not meet the actual definition. The supplier of these parts may however decide to label them as a configuration (see product fiche-sheet 2 in Annex IX).

All in all the definitions describe a typical central heating system as pictured below.

Figure 1 Basic representation of a central heating system
(a heat generator, emitters and means of distributing heat to the emitters)



The Regulation also includes definitions for products that are not "boilers": complementary products, such as:

4) “solar collector” means a device designed to absorb solar irradiation and to transfer the resulting thermal energy to a fluid passing through it;
5) “passive flue heat recovery device” means a device that captures latent heat from exhaust gas of boilers using fossil fuels: passive flue heat recovery devices have been on sale in the UK since several years as an aftermarket / retrofit solution for boilers. They transfer remaining latent and sensible heat from flue gas to cold incoming sanitary water, thereby pre-heating this water;
6) “storage tank” means a vessel for storing room heating or sanitary hot water, including with additives, and including vessels equipped with the means for indirect heating or cooling of the water content by an external heat source or heat sink: storing energy may improve the energy efficiency of heat generators;
7) “temperature control” means equipment that interfaces with the end-user regarding the values and timing of desired indoor temperature and communicates/translates relevant data, such as registered actual indoor and/or outdoor temperature(s), to an interface of the boiler

such as a central processing unit, thus contributing to the regulation of the indoor temperature(s).

With these definitions also solar thermal heating is described and can be added to the group of definitions, describing the basic elements of a central heating product and possible variations thereof.

The table and figure below present the combined options generally available in central heating systems.

Table 1: Overview of components discussed in section 1.1.2

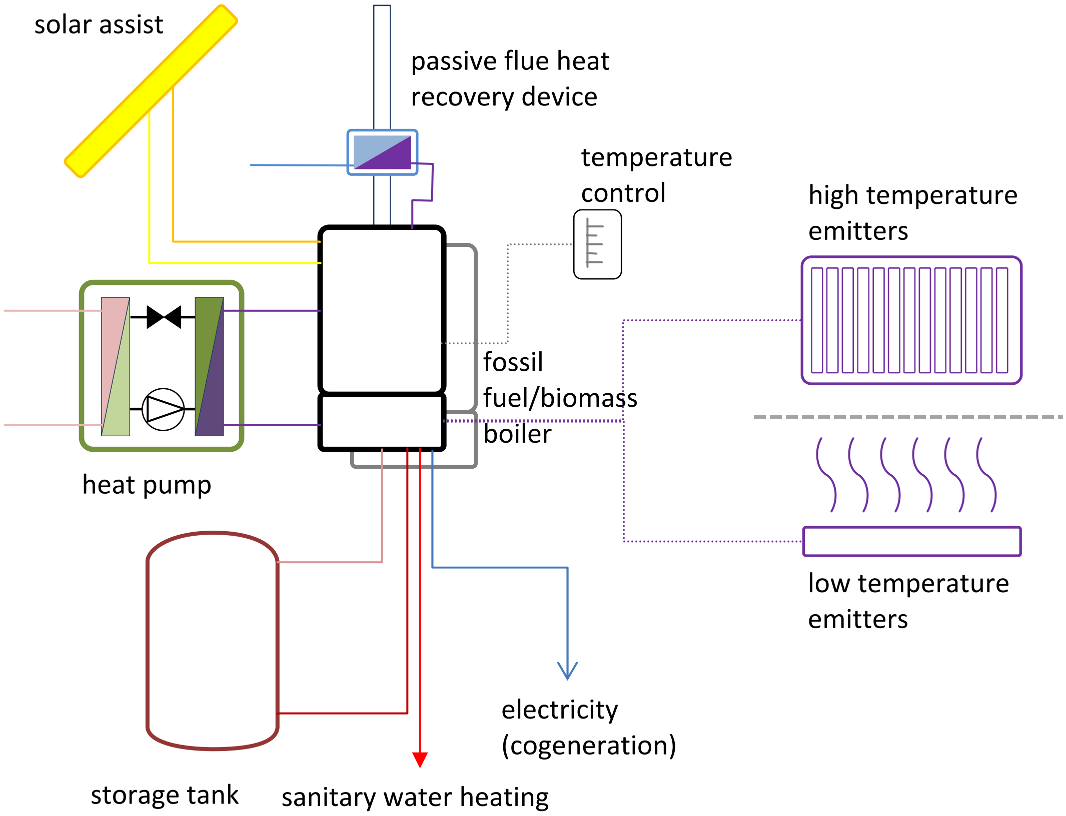
Component of heating system	Fuel	Nominal input power	Working principle
'boiler', by heat generator principe			
- gas/oil boiler	gas (natural or propane) or oil	4-400 kW	combustion
- biomass boiler	biomass (logs or pellets)	4-400 kW	combustion
- heat pump boiler	electricity	4-50 kW (indicatively)	electric compressor, driving a vapour cycle
	gas (possibly in combination with waste heat and/or solar heat)		gas driven engine, driving a compressor for a vapour compression cycle gas-fired combustion, driving a sorption process
- CHP or cogeneration boiler	gas (natural or propane) or oil (including bio-oil)	4-400 kW	Micro: external combustion (Stirling engine) Mini: internal combustion (piston engine driving a generator) Other: fuel cells, based on electrochemical principles
Solar thermal	solar energy i.c.w. electric energy for pumps/controls Needs other heat generator to fulfill heating demands in all circumstances	not applicable (sized depends on location, budget and application)	capturing and storage of solar irradiation
Distribution	circulators (electric pumps)	up to 2500 W electric power input	glandless impeller pump
Storage tank	Storage cylinders	up to several m^3	storage of sensible[8] heat, storage of latent heat is an option
Passive flue heat recovery device	waste heat from hot combustion gases	currently only available for small combustion boilers (indicatively max. 30 kW)	heat transfer of sensible and latent heat
Temperature control	electricity	(not relevant)	electronic control, gives feedback to boiler as regards heating load to be met by boiler

[8] "Sensible heat" relates to the properties of storing/releasing thermal energy: Sensible means the energy content of a medium is in direct relation to the temperature of that medium as can be measured by thermometers. Different to sensible heat is 'latent heat' where energy is stored/released by smelting or solidifying (freezing) of media, a process which occurs at the same temperatire. Here the temperature is not in direct relation with the energy content of the medium.

The primary function of a central heating product is the capability to reach and maintain the indoor climate of an enclosed space (building, dwelling, room) at a desired level under normal and extreme circumstances, in as much as is possible through heating, using hydronic heat emitters.

All the components that can contribute to this aim could be considered in possible measures.

Figure 2 Possible configuration of central heating system



As recuperation of the central heating system defined above, the following text explains in more detail the actual functions of the components of the heating system:

Central to the system is the heat generator. This is commonly referred to as 'boiler' if using fuels or the electric Joule effect (aka 'resistance heating') to generate heat. Condensing boilers use the latent heat content of water vapour formed during combustion and are significantly more energy efficient.

Heat pumps are heat generators (ie. 'boilers' according the definition provided above) that capture forms of ambient heat. Heat pumps can be electrically or fuel-driven. The first includes mainly devices using the vapour compression cycle, driven by electric compressors. The latter includes heat pumps using ad- or absorption cycles and also combustion engines that drive a vapour compression cycle. Heat pumps are more efficient if the temperature shift to realize is as small as possible (using heat sources of high temperatures and heat sinks – emitters – with relatively low temperatures).

District heating is defined as a central heating system where the heat is generated by a cogeneration plant, or alternatively a boiler, solar heating, or other sources. The common medium for heat distribution is water, but steam is also used. The terms district heating and CHP are often indistinctively used; district heating however usually means a larger system where heat is distributed to several houses or large urban areas. In contrast, CHP units can be sized to fit a single building. (outside scope of this study). The 'district heating boiler' itself is too large for the scope of the study (these are large combustion plants of over 400 kW).

Combined Heat and Power (CHP) units are boilers that provide both heating and power (electricity). They are categorised on the basis of the nominal electric power output. If the maximum output is less than 50 kW electric power, the unit is labelled 'micro-CHP', if the unit provides power above 50 kW but below 1 MW, it is defined as 'small scale CHP'. CHP units may be powered by a variety of energy sources including biomass and biogas.

The heated water is circulated in the heating system by using dedicated glandless 'wet runner' pumps or 'circulators' which in most cases (for heat generators $\leq$ 70 kW thermal output) may be integrated in the heat generator product (the boiler or heat pump) itself, or may be supplied separately and installed as a separate component in the central heating system. Multiple circulators may be present in a central heating system, for instance for a separate underfloor heating loop.

Alternative ways to distribute heating in a central system (but outside the scope of the proposed study) are the distribution of heat by means of air forced through ductwork, or steam fed through pipes.

The heat is emitted to the spaces by heat emitters such as radiators, convectors (fan coil units) or low temperature under floor/wall/ceiling heating systems.

The heat output of the complete system is controlled by temperature sensors and valves that either provide feedback to the boiler or apply volume (flow rate) control to influence the heat output of the boiler.

1.1.3 Screening analysis

A first assessment of Prodcom sales data (see also task 2) shows annual production of 6.9 million boilers in 2009, representing 4715 million Euro. Considering the limited value of import and export (respectively some 230 and 807 million euro) the conclusion holds that most of the EU production is meant for the EU market. This sales value is coherent with the estimates in the Lot 1 preparatory study for central heating boilers (note that year 2009 falls within the economic recession period of 2007-2010) which predicted the same sales value. Therefore the results of this study are deemed to be applicable to the current situation.

The Lot 1 study estimated in 2010 boiler sales of around 6.9 million units, a boiler stock of approximately 110,9 million boilers and an annual energy consumption of 10.5 PJ. CO2 emissions were estimated to be some 600 Mton and SOx emissions are some 700 kton.

The screening analysis shows that central heating boilers are among the product groups with the highest energy-consumption in Europe. Development of environmental policies, like EU Ecolabel or Green Public Procurement criteria, appears feasible, also given the current proposals for Ecodesign requirements for 'boilers' and Energy labeling of 'boilers'.

The improvement potential very much depends on the assumption one makes regarding the penetration of condensing boilers and heat pumps in the existing buildings sector. Realistic assumptions indicate an energy saving potential of some 20% on the energy consumption of the stock in 2020. Other major environmental impacts will show similar reduction percentages.

1.2 Subtask 1.2 - Legislation, labelling and standards

This subtask provides a description of relevant legislation, test and other standards, in and outside the EU, applicable to hydronic central heating systems, including EPBD related standards.

1.2.1 Legislation

1.2.1.1 EU Level

The following text is a list of European Directives and Regulations that apply to central heating products.

Dealing with energy efficiency and other environmental aspects are:

Boiler Efficiency Directive 92/42/EEC

This Directive[9], commonly known as the Boiler Efficiency Directive (BED) sets minimum efficiency requirements for boilers that are fired with liquid or gaseous fuels only. It includes boilers with a rated output of no less than 4kW and no more than 400kW.

Efficiency requirements at rated output of 84 %, 87.5 % and 91 % are set for standard boilers, low-temperature boilers and gas condensing boilers respectively.

Article 6 of the BED also included a labelling system; however the Ecodesign Directive (2005/32/EC) deleted this article. The Ecodesign Directive also integrated the efficiency requirements set out in the BED into the overall Ecodesign framework with the addition of Article 10a, which states that the efficiency requirements set out in the BED form part of the implementing measures under the Ecodesign Directive and they can be deleted or amended under the provisions of the Ecodesign Directive.

This Directive was also amended by 93/68/EEC[10], which amended a number of Directives, to update references relating to the European Conformity CE Mark[11]. The Directive will be repealed immediately once the proposed Regulation for Ecodesign requirements is published.

Ecodesign of energy related products 2009/125/EC

The Directive on the eco-design of energy related products[12] was adopted in 2009. It provides clear EU wide rules for eco-design, aimed at avoiding disparities in regulation amongst individual Member States, which could impede the free movement of products within the internal market.

The EcodesignDirective does not in itself set binding requirements for specific products, however it does define conditions and criteria for setting, through subsequent implementing measures, minimum requirements regarding environmentally relevant product characteristics and allows them to be improved quickly and efficiently.

The framework provided by the Directive aims to encourage manufacturers to develop products where they have taken into account the environmental impact of the product throughout its entire life cycle.

Implementing measures setting binding requirements are gradually developed, and would only be set for those Energy using Products which meet certain criteria, for example, key environmental

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[9] OJ L 167, 22.6.1992, p. 17–28 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0042:EN:HTML

[10] OJ L 220, 30.8.1993, p. 1–22 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31993L0068:EN:HTML

[11] http://www.ce-marking.org/what-is-ce-marking.html

[12] OJ L 191, 22.7.2005, p. 29–58

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:191:0029:0058:EN:PDF impact and volume of trade across the internal market and only if there is clear potential for improvement of a product.

The Lot 1[13] Preparatory Study in relation to boilers is of particular relevance to this product group, as is the Preparatory Study for Lot 2[14] on the eco-design of water heaters. In addition to these, Lot 15[15], regarding the eco-design of solid fuel small combustion installations, which includes solid fuel biomass boilers is also finalised. These ecodesign studies have provided valuable input to the underlying report.

Implementing measures for boilers, based on the above preparatory study will follow. Once minimum requirements have been set for boilers under the implementing measures of the Eco-design for energy-using Products Directive, these will represent the minimum standards for products on the market.

The Ecodesign Directive has been revised in view of expanding its scope to cover other energy related products and ensure that minimum requirements are set not only for energy use but also for major environmental parameters[16].

An overview of the technical requirements proposed in March 2011 is provided in Annex IX.

Energy labelling Directive 2010/30/EU

The ELD[17], originally adopted in 1992, requires retailers to display a comparative label showing the level of energy consumption of household appliances to consumers at the point of sale. It is estimated that energy labelling has contributed to annual energy savings in the order of 3 Mtoe[18] corresponding to emission reductions of some 14 Mt of CO_2 annually over the period 1996-2004. The ELD complements other instruments including the Ecodesign Directive, the Energy Star Regulation and the Eco-label Regulation.

The Directive is recently revised to expand the scope to cover 'energy related' products. The recast of the Energy Labelling Directive proposes to improve the overall environmental performance of products and to help consumers buy more eco-friendly products, through its application to ‘energy related products’ such as doors, windows, construction materials and coatings.[19] The Action Plan on "Sustainable Consumption and Production and Sustainable Industrial Policy" foresees the application of Eco-Design Directive 2005/32/EC and of the Energy Labelling Directive 92/75/EC to a wider range of products.[20] The recast has been related to construction products such that:

This Directive shall apply to energy-related products*, including construction products,* which have a significant *direct or indirect* impact on the consumption of energy and, where relevant, other essential resources during use.

WEEE Directive 2002/96/EC

[13] http://www.ecoboiler.org/
[14] http://www.ecohotwater.org/
[15] http://www.ecosolidfuel.org/
[16] http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm
[17] *OJ L 297, 13.10.1992, p. 16–19* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0075:EN:NOT
[18] This does not take into account energy savings from related self commitments by Ceced (white goods) and Eicta (TVs)
[19] Opinion of the European Economic and Social Committee on the Proposal for a Directive of the European Parliament and of the Council on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (recast), OJL 228/90, 29.9.2009.
[20] European Commission, Environment, http://ec.europa.eu/environment/eussd/escp_en.htm

The WEEE Directive[21] and RoHS Directive[22], which is discussed below, were developed and adopted to address the increasing amount of waste electrical and electronic equipment generated in Europe, therefore reducing the environmental burden on conventional disposal routes whilst closing the loop and improving resource efficiency through recycling.

Whilst Boilers are not classified as WEEE, thermostats are listed in Annex IB of the WEEE Directive under 'Monitoring and Control Instruments' and are therefore subject to the requirements of the Directive. Producers will be required to take responsibility for the treatment and recycling of their products when they become waste at the end of their life.

The requirements of the Directive are transposed into national law by individual Member States and it is important to be aware of national take back and recycling schemes and arrangements in specific Member States. The Directive requires electrical and electronic equipment to be taken to a suitable authorised treatment facility at the end of its life so that it can be treated/dismantled and materials recovered for recycling where possible. The Directive outlines minimum requirements for the treatment and recovery of WEEE.

The WEEE Directive also requires products to be labelled, in order to identify them as EEE, with the aim of minimising the wrong disposal of WEEE. Where it is not feasible to put the label on the actual product it should be included in the documentation accompanying the product.

This Directive therefore deals with many of the end-of-life environmental impacts of electrical and electronic equipment.

A stakeholder consultation on the WEE Directive took place in 2008, resulting in a proposed revised WEEE Directive that sets a new binding target for the collection of electrical and electronic equipment. The Commission proposes to differentiate the targets by setting mandatory collection targets equal to 65% of the average weight of electrical and electronic equipment placed on the market over the two previous years in each Member State. The recycling and recovery targets of such equipment now include the re-use of whole appliances, and weight-base targets will increase by 5%.[23]

ROHS Directive 2002/95/EC

The RoHS Directive, in tandem with the WEEE Directive prevents the use of certain hazardous materials in new electrical and electronic equipment (EEE) placed on the market from 1 July 2006 onwards. This will limit the impact of the EEE at the end of its life and it also ensures harmonisation of legislation on the use of hazardous materials in EEE across all Member States.

Again, this Directive does not necessarily relate directly to boilers, however it may apply to other elements of the heating system, for example thermostats and other control devices.

Electrical and Electronic Equipment must not contain the following substances; lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). There are some exemptions and limit values listed in the Annex to the Directive for some equipment where it is understood that one or more these substances is required for their functioning and no economically viable alternatives exist in sufficient quantity at present. Therefore, some of these substances may still be found in some electrical and electronic equipment.

[21] OJ L 37, 13.2.2003, p. 24–39 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:EN:HTML
[22] OJ L 37, 13.2.2003, p. 19–23 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML
[23] http://ec.europa.eu/environment/waste/weee/index_en.htm

The Annex has been revised on a number of occasions, altering the list of exclusions and limit values.

Directive on Packaging and Packaging Waste 94/62/EC

The EC Packaging Directive seeks to reduce the impact of packaging and packaging waste on the environment by introducing recovery and recycling targets for packaging waste, and by encouraging minimisation and reuse of packaging . A scheme of symbols, currently voluntary, has been prepared through Commission Decision 97/129/EC . These can be used by manufacturers on their packaging so that different materials can be identified to assist end-of-life recycling.

Dealing with basic environmental aspects but mainly safety aspects is:

Construction Products Directive (89/106/EC) - to become Construction Products Regulation

The Construction Products Directive (CPD) is aimed at creating a single market for construction products, through the use of CE Marking. It outlines key requirements relating to materials intended for construction, which is defined in the Directive as products that are manufactured to form a permanent part of structures.

The materials must meet fundamental requirements including mechanical strength and stability, fire safety, health and environment effects, safety of use, sound nuisance and energy economy. The Directive mandates that standardisation organisations such as CEN develop standards in consultation with industry. A list of these standards can be found on the European Commission's website[24]. Where harmonised standards are not available, existing national standards apply.

Standard EN 12809:2001 is of relevance to residential independent boilers fired by solid fuel, and outlines requirements and test methods for appliances with a nominal heat output if up to 50 kW.

The Commission has recently adopted a proposal to replace Council Directive 89/106/EEC by a Regulation (CPR) with the aim to better define the objectives of Community legislation and make its implementation easier[25]. It now includes a specific extra essential requirement related to the sustainable use of natural resources, stating that:

"The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and ensure the following:

(a) Recyclability of the construction works, their materials and parts after demolition.

(b) Durability of the construction works.

(c) Use of environmentally compatible raw and secondary materials in the construction works."

The Construction products Directive is linked to other DIrectives that more specifically address certain safety aspects. These are for example:

Gas Appliances Directive 2009/142/EC

This Directive, commonly known as the Gas Appliance Directive[26] (GAD) outlines requirements relating to safety, materials, design and construction that a gas appliance will need to meet before it can be placed on the European market.

[24] http://ec.europa.eu/enterprise/newapproach/standardization/harmstds/reflist/construc.html
[25] http://ec.europa.eu/enterprise/construction/index_en.htm
[26] OJ L 196, 26.7.1990, p. 15–29

The Directive is aimed at removing technical barriers to trade and creating a single market for gas appliances across the European Union and therefore requires the CE marking of most gas fired domestic and commercial appliances that are to be sold in Europe.

This Directive was also amended by 93/68/EEC, which amended a number of Directives, to update references relating to the CE Mark.

Other general safety and performance Directives

Several other Directives have relevance to central heating products, but mainly relate to safety aspects. These Directives are:

Electromagnetic Compatibility Directive (EMC) 2004/108/EC

The Electromagnetic Compatibility Directive was adopted on 15th December 2004 and repealed Directive 89/336/EEC. The EMC[27] is in place to ensure that electrical equipment is designed such that it doesn't interfere with or get disturbed by other electrical equipment and thus functions properly.

Before equipment is placed on the market (including both apparatus and fixed installations) they must be shown to meet the requirements set out in the EMC Directive.

Low Voltage Directive (LVD) 2006/95/EC

The LVD Directive[28] covers electrical equipment designed for use with a voltage rating of between 50 and 1000 V for alternating current (AC) and between 75 and 1500 V for direct current (DC). These voltages refer to the input or output voltage and not to those found inside the equipment. The Directive's main objectives are to ensure a high level of protection for the European public and that these products enjoy a single market within the EU.

Please note that this Directive is a codified version of the original Directive (73/23/EEC) which was published for the purpose of clarity following numerous amendments.

Machinery Directive 98/37/EC

The Machinery Directive[29] sets out essential health and safety requirements for machinery at a European level. It is another of the new approach directives aimed at promoting a single market, with the unrestricted movement of products. It also aims to provide protection to those using the machinery.

The Machinery Directive has been revised (2006/42/EC) and the new version will come into force from 29th December 2009, until which time 98/37/EC remains in force.

Pressure Equipment Directive (PED) 97/23/EC

The Pressure Equipment Directive[30] (PED) became obligatory throughout the EU from 29 May 2002 and provides the legislative framework for equipment subject to a pressure hazard. The main aims are to harmonise standards regarding the design, manufacture, testing and conformity assessment of pressure equipment and assemblies of pressure equipment.

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http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0396:EN:HTML

[27] OJ L 390, 31.12.2004, p. 24–37 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:390:0024:0037:EN:PDF
[28] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF
[29] OJ L 207 23.7.98 p. 1-46 http://europa.eu/eur-lex/pri/en/oj/dat/1998/l_207/l_20719980723en00010046.pdf
[30] OJ L 181, 9.7.1997, p. 1-55 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31997L0023:EN:HTML

Compliance with these Directives is -depending on requirements- by 3rd party or self certification, depending on the risks involved. Harmonized technical standards describe the tests needed to show compliance.

An example of what essential requirements have to be met by boilers is presented below (from harmonised standard EN 483).

EN 483:1999

Annex ZA (informative)

Clauses of this European standard addressing essential requirements or other provisions of EU Directives.

This European standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EU Directive 90/396/EEC (Gas Appliance Directive) .

Warning: other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

The following clauses of this standard are likely to support requirements of the Gas Appliance Directive.

Compliance with these clauses of this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

Table ZA.1

GAD Annex I clause no.	Essential Requirement (Annex I of the Gas Appliance Directive)	Relevant clauses in this standard
1	**GENERAL CONDITIONS**	
1.1	design and construction	1, 5
1.2	installation instructions user's instructions warning notices on the appliance warning notices on the packaging official language	8.2.1 8.2.2 8.1.5 8.1.4 8.2.4
1.2.1	installation instructions contain: type of gas gas supply pressure flow of fresh air – for combustion air supply – danger of unburned gas (3.2.3) dispersal of combustion products forced draught burners	 8.2.1 8.2.1 8.2.1 not applicable 8.2.1 not applicable
1.2.2	user's instructions contain: all instructions for safe use restrictions on use	 8.2.2 8.2.2
1.2.3	warning notices state: – type of gas – gas supply pressure – restrictions on use	 } 8.1.4, } 8.1.5 }
1.3	fittings	not applicable
2	**MATERIALS**	
2.1	fitness for purpose	5.3
2.2	properties of the materials	not applicable
3	**DESIGN AND CONSTRUCTION**	
3.1	**General**	
3.1.1	safety of construction	5.3, 5.4
3.1.2	condensation	5.3.6
3.1.3	risk of explosion in the event of external fire	5.4.3
3.1.4	water/air penetration into gas circuit	5.4.3.1

GAD Annex I clause no.	Essential Requirement (Annex I of the Gas Appliance Directive)	Relevant clauses in this standard
3.1.5	normal fluctuation of auxiliary energy	6.5.1, 7.5.7.1, 7.6.1.3.10
3.1.6	abnormal fluctuation or failure of auxiliary energy	5.4.7, 6.5.1, 7.5.8.2
3.1.7	hazards of electrical origin	5.5
3.1.8	pressurised parts	6.8
3.1.9	failure of control and safety devices gas circuit automatic shut-off valves flame supervision device combustion products discharge safety device air proving device automatic burner control system thermostat/overheat protection governor multifunctional control	5.6.1 6.5.1 5.6.3.3, 6.5.3 5.6.6, 6.5.5 not applicable 5.4.4, 6.5.8,7.5.8 5.6.6.3 5.6.7 5.6.4 5.6.1
3.1.10	overruling of safety devices	5.6.1
3.1.11	adjustment protection	5.6.2.1
3.1.12	clear marking of devices	5.6.3.2
3.2	**Unburned gas release**	
3.2.1	risk of gas leakage :	5.4.3.1, 6.2.1
3.2.2	risk of gas accumulation, – during ignition – during re-ignition – after extinction	 5.6.5, 6.5.4, 6.5.5 6.5.5.2.3, 6.5.5.2.4, 6.5.5 6.5.5
3.2.3	safety device fitted rooms with sufficient ventilation	5.6.6 not applicable
3.3	**Ignition**	
	ignition re-ignition cross-lighting	5.6.5, 6.4.2.1, 6.5.5.2 6.4.2 6.4.2
3.4	**Combustion**	
3.4.1	flame stability unacceptable concentrations harmful to health	6.4.2 6.5.8, 6.6.1
3.4.2	no accidental release of combustion products	5.4.3.2, 6.2.2
3.4.3	no release in dangerous quantity	not applicable
3.4.4	CO concentration	not applicable
3.5	**Rational use of energy**	6.7.1, 6.7.2, EN 483/prA2
3.6	**Temperatures**	
3.6.1	floor and adjacent walls	6.4.1.2, 6.4.1.3
3.6.2	knobs and levers	6.4.1.1
3.6.3	external parts	6.4.1.2, 6.4.1.4
3.7	**Foodstuffs and water used for sanitary purposes**	
	sanitary water	not applicable

Not directly aimed at central heating products, but nonetheless related are these Directives:

Energy performance of buildings Directive 2002/91/EC

This Directive was adopted in 2002 and is concerned with promoting energy efficiency in buildings across Europe using cost effective measures, whilst at the same time harmonising standards across Europe to those of the more ambitious Member States.[31] It is important to tackle this

[31] OJ L 1, 4.1.2003, p. 65–71 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0091:EN:NOT

‘sector’ as energy use in buildings, for space heating, cooling and lighting account for around 40 % of total energy use in Europe.

The Directive centres around four key strands:

- Providing a Methodology for calculating the energy performance of buildings, taking into account local climatic conditions;
- Applying energy performance standards to both new build and existing building stock;
- Providing a certification scheme for all buildings;
- Regular assessments of any heating and cooling equipment installed.

These components had to be ratified by Member States by 4 January 2006, however most States opted to defer this for three years.

The EU launched a public consultation on the recasting of the EPBD in 2008, with adoption in 2009. After much debate a compromise was reached in November 2009. The agreement ensures that all new buildings must comply with high energy-performance standards as well as generating a significant proportion of their own energy through renewables after 2020. The intention is that the public sector will lead the way through using buildings with "nearly zero" energy standards two years earlier, in 2018. However the definition of "nearly zero" was left vague, and this will allow member states to define their own standards.

The provision for existing buildings states that where major renovations are carried out these must increase energy-savings if doing so is “technically, functionally and economically feasible”. In addition Member States will have to develop national plans that encourage owners to install smart meters, heat pumps and heating and cooling systems using renewables energy sources, as well as listing incentives from technical assistance and subsidies to low-interest loans by mid-2011 for the transition to near zero-energy buildings.

Boilers are specifically mentioned within this Directive. It highlights the importance of regular maintenance to ensure boilers are correctly adjusted and continue to achieve optimum performance. Article 8 (a) outlines the frequency of inspections in relation to the size of the boiler, and sets out requirements for a one off inspection of the whole heating installation where they have a boiler older than 15 years. An alternative approach is permitted under Article 8 (b), as long as its impact is broadly equivalent to that arising from the provisions set out in (a).

CHP Directive 2004/8/EC

The Combined Heat and Power Directive creates a framework for the promotion and development of high efficiency cogeneration. Member States are obliged to produce reports covering their analysis of the state of CHP in their own countries, to promote CHP and show what is being done to promote it, to report on and remove barriers, and to track progress of high-efficiency cogeneration within the energy market.[1]

High efficiency cogeneration is in this Directive defined by the energy savings obtained by combined production instead of separate production of heat and electricity. Energy savings of more than 10 % qualify for the term ‘high-efficiency cogeneration’. CHP units smaller than 1 MW e qualify if they achieve any primary energy saving.

The Commission has established harmonised efficiency reference values for separate production of electricity and heat and will review these harmonised values for the first time on 21 February 2011, and every four years thereafter, to take account of technological developments and changes in the distribution of energy sources. The values (reference and high-efficiency) shall be based on annual energy input and and output (includes losses during normal operating conditions).

The relevance of the CHP Directive for possible GPP and/or Ecolabel thresholds lies in the definition of high-efficiency cogeneration. The threshold level must lie above the threshold of 10% saving compared to reference separate production.

Large Combustion Plants Directive 2001/80/EC

This Directive applies to combustion installations of minimum 50 MW thermal output and regulates emission limits. This equipment may provide heat to District Heating installations, but the combustion installation itself is outside the scope of this study.

REACH Regulation EC 1907/2006

The REACH Regulation[32] came into force on 1 June 2007 and deals with the Registration, Evaluation, Authorisation and Restriction of Chemical substances. It provides an improved and streamlined legislative framework for chemicals in the EU, with the aim of improving protection of human health and the environment and enhancing competitiveness of the chemicals industry in Europe.

REACH places the responsibility for assessing and managing the risks posed by chemicals and providing safety information to users in industry instead of public authorities, promotes competition across the internal market and innovation.

Manufacturers are required to register the details of the properties of their chemical substances on a central database**,** which is run by the European Chemicals Agency in Helsinki. The Regulation also requires the most dangerous chemicals to be progressively replaced as suitable alternatives develop.

The Montreal Protocol on Substances That Deplete the Ozone Layer

The Montreal Protocol[33] was a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992, it stipulated that the production and consumption of compounds that deplete ozone in the stratosphere, including chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform, were to be phased out by 2000 (2005 for methyl chloroform).

The Vienna Convention (1985) outlined Member States' responsibilities for protecting human health and the environment against the adverse effects of ozone depletion and established the framework under which the Montreal Protocol was negotiated.

Regulation on Substances that Deplete the Ozone Layer EC 2037/2000

This Regulation[34] applies to organisations that produce, import, export, sell and recover/recycle or destroy substances such as CFCs and HCFCs, which are classified as ozone depleting substances (ODSs). One difference to the Montreal protocol is that it specifies an accelerated HCFC phase-out schedule.

[32] OJ L 396, 30.12.2006, p. 1–849 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF
[33] http://www.ciesin.org/TG/PI/POLICY/montpro.html
[34] OJ L 244, 29.09.2000 p. 1 – 24 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:244:0001:0024:EN:PDF

Foaming agents used in the insulation for boilers have the potential to involve the use of fluorinated gases. Regulation EC 2037/2000[35] on controls of ozone depleting substances regulates the production, trade, use, and recovery of ozone-depleting substances.

It is unlikely that ozone depleting substances will be found in new products, following developments in product design and manufacture, however it is worth being aware of this regulation, as it will be applicable to the recovery of ozone depleting substances from older products as they are replaced.

Directive on the Promotion of Energy from Renewable Energy Sources 2009/28/EC

The Directive on the promotion of the use of energy from renewable sources and amending and subsequently appealing Directive 2001/77/EC and 2003/30/EC was adopted on 23rd April 2009 and published in the official journal of 5th June 2009[36]. Member States are required to implement it by December 2010.

The Directive aims to promote the use of renewable energy through the setting of overall and Member State specific targets. For the EU as a whole, a target of a 20% share of energy from renewable sources by 2020 has been set and a 10% share of renewable energy specifically in the transport sector. Each Member State has been set their own target to contribute towards these overarching targets.

In addition to setting these targets the Directive outlines an improved framework to promote the use of renewable electricity. It requires Member States to develop action plans for the development of renewable energy sources that need to be published by June 2010, following a template that has been developed.

Sustainability criteria are also included in relation to biofuels and cooperation mechanisms created to help achieve the targets cost effectively.

1.2.1.2 Member State level

In many member States combustion appliances such as central heating boilers, are subject to national legislation, mostly dealing with air quality. The text below gives an overview, country by country, of legislation relevant for central heating boilers. Requirements may relate to energy efficiency and emission limit values ('ELV'):

Austria

In Austria emission limit values are defined for small combustion installations (< 50 kW) and larger installations (> 50 kW).

Table 2 Austrian ELV for boilers

< 50 kW		
Appliance type	**Fuel type**	**ELV (mg/MJ) -1**

[35] OJ L 244, 29.9.2000, p. 1–24

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000R2037:EN:NOT

[36] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF

		CO	NOx	OGC	dust
manual stoking	biomass	1100	150 -2	80	60
automatic stoking	biomass	500 -3	150 -2	40	60
1 - In relation to the energy content (net claorific value) of the fuel used. 2 - The NOx limits apply only to wood fired boilers. 3 - At partial load with 30% of the nominal heat output, the limit may be exceeded by 50%					

> 50 kW						
Capacity (MW)	**ELV (mg/m3)**					
	CO	NOx			HC	dust
		w1	w2	w3		
≤ 0.1	800	300	250	500	50	150
> 0.1-0.35	800	300	250	500	50	150
> 0.35-2	250	300	250	500	20	150
>2-5	250	300	250	500	20	50
>5-10	100	300	250	350	20	50
>10	100	200	200	350	20	50
w1 - Beech tree, oak tree, untreated bark, brushwood w2 - other untreated wood w3 - leftovers of derived timber products or wooden construction elements free of heavy metal and halogen compounds						

Belgium

In Belgium minimum efficiency and ELVs are defined for various biomass equipment:

Table 3 Belgium ELV

Type	**Min. output eff. (%) -1**		**ELV**			
			CO (%)		dust (mg/Nm3)	
	step I	step II	step I	step II	step I	step II
Pellet applaince (EN 14785)	≥ 75	≥ 75	≤ 0.12	≤ 0.04	≤ 300	≤ 75
Boiler stove (EN 12809)	≥ 65	≥ 75	≤ 0.8	≤ 0.3	≤ 300	≤ 75
Boiler (EN 303-5) -2	≥ 65	≥ 75	≤ 0.8	≤ 0.3	≤ 300	≤ 75
1- In accordance with applicable standard (on a net calorific basis) 2- not harmonised						

Denmark

The Danish requirements for boilers correspond to EN 303-5, class 3, with measurement as described in the EN 303-5.

Table 4 Danish ELV

Firing principle	**Fuel type**	**Nominal heat output (kW)**	**ELV at 10% O2, 0ºC and 1013 mbar (mg/m3 dry flue gas)**		
			CO	Carbon	dust
manual	biomass -1	<50 > 50 to 150 > 150 to 300	5000 2500 1200	150 100 100	150 150 150

automatic	biomass -1	<50 > 50 to 150 > 150 to 300	3000 2500 1200	100 80 80	150 150 150
1- Wood, plant seed and other residual products covered b y the Statutory Order on Biomass Waste					

Finland

In Finland there are efficiency and ELV for heating appliances using wood fuels up to 300 kW. The primary system is considered the main heatin g system of the building. The secundary systems is additional and therefore not within the scope of this study (hydronic central heating is considered to be the primary system).

Table 5 Finissh ELV

Type	**nominal capacity (kW)**	**Efficiency (%)**	**ELV at 10% O2 (mg/m3)**	
			CO	OGC
primary heating system	P ≤ 50 kW	67 + 6logP	3000	100
	50 kW ≤ P ≤150kW	67 + 6logP	2500	80
	150 kW < P	67 + 6logP	1200	80

France

French legislation regarding emission limit values only apply to boilers with a capacity between 400 kW and 50 MW and are therefore outside the scope of this study.

Germany

in Germany[37] the legal requirement entitled *Erste Bundes-Immissionsschutz Verordnung*, 1.BimSchV in short (the First Federal Emissions Protection Order) sets out limit values for NO_x and carbon monoxide (CO) for all boilers, including conventional gas and oil boilers.

As regards biomass boilers German ELV are:

Table 6 German ELV

Fuel	**Nominal capacity (kW)**	**ELV at 13% O2**	
		dust (g/m3)	CO (g/m3)
step 1			
untreated wood	≥ 4 - 500	0.10	1.0
pellets etc.	≥ 4 - 500	0.06	0.5
straw etc.	≥ 4 - 100	0.10	1.0
step 2			
(all fuels above)		0.04	0.4

Ireland

[still to check]

[37] http://www.bundesrecht.juris.de/bimschv_1_1988/index.html

Sweden

In Sweden there are ELV for solid fuel appliances:

Table 7 Swedish ELV

Appliance type	Nominal heat output (kW)	OGC at 13% O2 (mg/m3)
manual stoking	≤ 50	150
	> 50 ≤ 300	100
automatic stoking	≤ 50	100
	> 50 ≤ 300	80

United Kingdom

In the UK efficiency and ELV vary according the fuel and installation type:

Table 8 UK ELV

Category	Description	Efficiency (GCV)	Feeding
E2	logs only	65%	batch
E3	multifuel	65%	batch
J1/2/3	independent boiler	65%	batch
J5	independent boiler - wood logs/pellets/chips	65%	automatic

International

Other (conventional gas/oil) boiler minimum efficiency requirements exist in countries like Japan, USA and Canada: 80-83% (GCV) for gas boilers and some 3-4% higher values for oil-fired boilers. Japan is the most stringent and China is expected to follow the example by Japan.

International emission limits values for NOx and CO emissions of conventional boilers are still rare. The most stringent are found in California (USA): NOx 15-20 ppm for residential, 9 ppm for very large boilers. CO is 400 ppm.

1.2.2 Labelling

Compulsory (mandatory) labeling schemes have not been identified in the EU, but voluntary labeling schemes (ISO 14024 type I) addressing boilers and other central heating products are present in multiple Member States.

Labeling initiatives may be endorsement labels (indicating a preferred choice) or quality/certified performance labels (for product information). The following text presents an overview.

1.2.2.1 Endorsement labels

Table 9 Endorsement labels for central heating boilers

Product	Geographical coverage	Description
DE, Blauer Engel	Gas/oil Central heating boiler	Low-Emission and Energy-saving Gas-Fired Calorific Value Heating Devices (#61) There have been criteria for (not applicable anymore):

		Low-Emission Atomizing Oil Burners (#9) Special Gas Boilers (#39) Combined Water Heaters and Circulating Water Heaters for the Use of Gaseous Fuels (#40) Combined Burner and Boiler Units equipped with Gas Burner and Fan (#41) Combined Oil Burner and Boiler Units (#46) Low-Emission Fan Assisted Gas Burners (#80)
	Biomass boilers	Pellet boilers UZ 112
	Heat Pumps	Energy-Efficient Heat Pumps using Absorption and Adsorption Technology or operating by use of Combustion Engine-Driven Compressors (#118) Energy-Efficient Heat Pumps using an Electrically Powered Compressor (#121)
	Cogeneration	Small-Scale Gas-Fired Cogeneration Modules (#108) Small-Scale Liquid-Fired Cogeneration Modules (#109)
	Solar collectors	Solar kollektors UZ 73
	Hot water storage	Energy-Efficient Hot Water Tanks (#124)
Nordic Swann Scandinavian countries	Solid fuel boilers	Nordic Swann label for biomass boilers (#38)
	Heat pumps	Nordic Swann label for heat pumps
Czech Rep., national label	Gas/oil Central heating boiler	National Programme for Labelling Environmentally Friendly Products - Gas Boilers (--) Boilers (Gas) Czech Republic Boilers with atmospheric burners (05-2004) Boilers with forced air (06-2004) Burners for Liquid Fuels to an Output of 120kW 27-2004 Hot-Water Boilers for Liquid Fuel to an Output of 70kW 28-2004
	Solid fuel boilers	Biomass-Fuel Hot-water Boilers 13-2006
Slovakia, national label	Gas/oil Central heating boiler	National Programme of Environmental Assessment and Eco labelling in the Slovak Republic (NPEHOV) - Heating Boilers for Gaseous Fuels with Atmospheric Burner
UK, Energy Saving Trust Recommended	Gas/oil Central heating boiler	Natural Gas and Liquid Petroleum Gas (LPG) Boilers (2007) Oil Boilers (2006) Boilers (Oil-fired)
	Controls	Gas Central Heating Controls (2006) Central Heating Systems
EU, ecolabel	Heat Pumps	EU Eco-Labelling Programme
Extra EU	JP	Combustion Apparatus Using Waste Cooking Oil 59
	S-Korea	Gas Cabinet Heaters 173 Gas Boilers 261 Oil- and gas burners and burner-boiler combinations
	NA	Heating/Cooling Systems for Building(s)CCD-001
	NC	Solid Biofuel Boilers
	USA	Energy efficiency of boilers

The text below is more detailed presentation of the main endorsement labels, especially the ones for biomass:

[38] http://www.svanen.se/en/Buy-Svanenmarkt/Ecolabelled_products/?categoryID=254

Blaue Engel

General Blue Angel requirements for wood-pellet stoves and boilers are:

Table 10 Blue Angel efficiency requirements for pellet boilers

Requirements	Wood-pellet stoves (RAL-UZ 111) and boilers (RAL-UZ 112)
Structural engineering and safety behaviour	As per DIN EN 303-5
Energy efficiency (net calorific value basis)	Efficiency ≥90% at rated load and partial load (determined as per DIN 18 894 or DIN EN 14785)
Auxiliary Power demand	<1% of the produced thermal output at rated thermal output

ELV for wood-pellets stoves and boilers to be Blue Angel labelled

Table 11 Blue Angel ELV for pellet boilers

Appliance	ELV [mg/Nm]							
	CO		NOx		Organic substances Total carbon		Dust	
	at rated load	at partial load	at rated load	at partial load	at rated load	at partial load	at rated load	at partial load
Wood-Pellet Stoves (RAL-UZ 111)	180	400	150	NA	10	15	25	NA
Wood-Pellet Boilers (RAL-UZ 112)	90	200	150	NA	5	5	20	NA

Nordic Swann

The Nordic Swan, official Nordic ecolabel, has been introduced by the Nordic Council of Ministers: it is a common system for Sweden, Norway, Denmark and Finland. It provides criteria for closed fireplaces and solid biomass boilers.

Nordic Swan ELV for boilers:

Table 12 Nordic Swann ELV requirements for biomass boilers

Appliance		ELV at 10% O_2 [mg/m3 dry gas]			
		CO	NO_2	OGC	dust
Automatically fed boiler	≤300 kW	400	340	25	40
Manually fed boiler	≤100 kW	2 000	340	70	70
	100<P≤300 kW	1 000	340	50	70
Particles and NOx emissions are only tested at nominal load. The limit values for OGC and CO are tested under the following conditions: - Nominal load for manually fed boilers equipped with a hot-water tank. - Nominal load and low load for automatically fed boilers.					

Nordic Swan minimum efficiency requirement for boilers:

Table 13 Nordic Swann efficiency requirements for biomass boilers

Appliance type	Efficiency*
Manually fed boiler	$\eta_k = 73 + 6 \log Q_N$ (Q_N is the nominal output of the boiler)
Automatically fed boiler	$\eta_k = 75 + 6 \log Q_N$, and $\eta_x \geq 86\%$; $\eta_x = (\eta_{20} + \eta_{40} + \eta_{60})/3$ where η_{20}, η_{40} ,η_{60} stand for the measured efficiency at 20, 40 and 60% load
* on a net calorific value basis	

EFA labelling scheme

EFA is the European association of fireplace-manufacturers. It has introduced a voluntary labelling scheme to ensure high-quality fireplaces in Europe, including requirements for emissions and efficiencies (Table 1-28). Since the scope covers hydronic central heating the EFA labels are not applicable.

Umweltzeichen 37 (Austria)

Introduced by the Austrian government, the “Umweltzeichen 37” is a voluntary scheme that is based on existing Austrian standards, but with improved emission values.

Emission limit values for automatically fed appliances and for manually fed appliances are presented below.

"Umweltzeichen 37" requirements for automatically fed appliances:

Table 14 UZ37 ELV requirements for automatic feed mass boilers

Appliance	Type of fuel	ELV [mg/MJ]			
		CO		NOx	Dust
		at nominal load	at partial load		
Boiler	pellet	60	135	100	15
	wood chips	150	300	120	20
Roomheating	pellet	120		100	30
	wood chips		255		

"Umweltzeichen 37" requirements for manually fed appliances:

Table 15 UZ37 ELV requirements for manual feed biomass boilers

Appliance	ELV [mg/MJ]			
	CO		NO_x	Dust
	at nominal load	at partial load		
Boiler	250	750	120	30
Roomheating	700	---	120	30

Flamme Verte (France)

"Flamme verte" (Green Flame) is a voluntary agreement created in 2000 by French public authorities and manufacturers of wood combustion installations (closed fires, inserts, stoves, cookers and boilers), in the purpose of improving the performances of these appliances. To this aim, performance criteria to be "Flamme verte" labelled are continuously improved (Table 1-31). Currently, more than 50 companies sell appliances with the "Flamme Verte" label.

"Flamme Verte" requirements for boilers:

Table 16 Flamme Verte ELV requirements for biomass boilers

Boiler type		Efficiency* [%]	ELV [ppm]		
			CO	VOC	dust
Manual	P_n < 50 kW	70	6 500	225	165
	50 kW < P_n < 70kW	70	3 750	150	165
Automatic	P_n < 50 kW	75	4 000	150	165
	50 kW < P_n < 70kW	75	3 500	115	165

P_n = Nominal Power
* on a net calorific value basis

1.2.2.2 Rating labels

Sedbuk Boiler efficiency database UK

SEDBUK efficiencies are expressed as a percentage, and an A to G scale of percentage bands was also in use until October 2010. This has been withdrawn to avoid confusion with the proposed European energy label using similar ratings based on different principles. The classification of the SEDBUK bands was as follows:

Figure 3 SEDBUK efficiency classes

Band	SEDBUK range
A	90% and above
B	86% - 90%
C	82% - 86%
D	78% - 82%
E	74% - 78%
F	70% - 74%
G	below 70%

1.2.2.3 Certified performance labels

In addition to endorsement and rating labels there are also certified performance labels. They aim to indicate that the product in question meets certain minimum standards as regards performance aspects. They are generally not mandatory, although the market parties may consider them as an obligation.

Heat pumps: EHPA Quality label

The EHPA quality label for heat pumps originates in activities of the heat pump associations of Austria, Germany and Switzerland to create a common set of requirements to ensure product and service quality for heat pumps (named D-A-CH quality label after the countries international codes). The idea has been further developed in the European Heat Pump Association and the country scope is currently extending. In order to reflect this development, the name D-A-CH quality label has been gradually replaced by EHPA quality label. In addition to the founding countries the EHPA quality label was introduced in Sweden (2007), Finland (2008), Belgium and France (2010). Its use in more countries is under preparation.

The label can be granted to standardized space heating electrically driven heat pumps, with or without domestic hot water heating capability, with a capacity up to 100 kW from air, geothermal or water heat sources. In order to qualify for the EHPA quality label, the heat pump in question must comply with EHPA heat pump test criteria and the distributor must provide a defined level of service. The key requirements are (list not exhaustive):

a) Conformity of all main components and compliance with the national rules and regulation (CE marking)

b) Minimum efficiency values defined as follows (operating points - required COP), tested in labs accredited to ISO 17025 to perform heat pump test according to EN 14511:

- Brine to water B0/W35 - 4.30
- Water to water W10/W35 - 5.10
- Air to water A2/W35 - 3.10
- Direct exchange ground coupled to water E4/W35 - 4.30
- Hot water heat pump (currently under revision)

c) Declaration of sound power level.

d) Existence of sales & distribution, planning, service and operating documents in the local language of the country where the heat pump is distributed.

e) Existence of a functioning customer service network in the sales area that allows for a 24h reaction time to consumer complaints.

f) A two year full warranty which shall include a declaration stating that the heat pump spare parts inventory will be available for at least ten years.

The full set of requirements and/or further information can be obtained from EHPA's quality label committee or the associations' websites:

- Bundesverband WärmePumpe Austria (BWP)
- Bundesverband WärmePumpe Deutschland (BWP)
- Fördergemeinschaft Wärmepumpen Schweiz (FWS)
- SP Technical Research Institute of Sweden

Solar heating: Keymark

The Solar Keymark is a voluntary third-party certification mark for solar thermal products, demonstrating to end-users that a product conforms to the relevant European standards and fulfills additional requirements. The Solar Keymark is used in Europe and increasingly recognized worldwide.

The Solar Keymark is a CEN/CENELEC European mark scheme, solely dedicated to:

- Solar thermal collectors (based on European standard series EN 12975)
- Factory made solar thermal systems (based on European standard series EN12976)

The Solar Keymark was developed by the European Solar Thermal Industry Federation (ESTIF) and CEN (European Committee for Standardization) in close co-operation with leading European test labs and with the support of the European Commission. It is the main quality label for solar thermal products and is widely spread across the European market and beyond.

The voluntary Solar Keymark quality label is already in place since 2003, and is now working very well as the general accepted "passport" for national subsidy schemes and regulations. So far Solar Keymark is available for collectors and "factory made systems". Solar Keymark is also under consideration for solar tanks and "custom built systems".

The upcoming obligatory Energy Labelling of water heaters will also include solar water heaters. Existing standards shall be revised into harmonised standards taking into account the specific requirements for Energy Labelling given by the Commission. Work on harmonised standards will start this year and this labelling can then be in force in about 3-4 years.

Obligatory CE-marking for solar thermal products is underway (most probably only collectors shall be CE-marked). This process is still in a very initial phase, and some years will pass before the CE-marking is in force.

Dutch Gaskeur

GASKEUR (with associated labels) is a quality mark of the foundation Energie Prestatie Keur (EPK), an independent organisation which stimulates the use of low-energy, clean and efficient heating appliances, domestic hot water appliances and other installation products, renewable energy, such as thermal solar energy and heat recovering equipment. The quality mark is accessible for all suppliers on the Dutch market and has been recognised by the Council for the Accreditation, from which appears that the inspecting mark on independent and expert manner is granted. The implementation of the procedures for attribution of the quality inspecting mark is done by Kiwa Gastec Certification.

The following criteria for central heating products have been devised:

Table 17 Overview of NL Gaskeur criteria

Gaskeur criteria for central heating products
Criteria for the GASKEUR/CV label for gas-fired central heating appliances with nominal heat inputs of up to 900 kW
Criteria for the GASKEUR/HR label for gas-fired central heating appliances with nominal heat inputs of up to 900 kW
Criteria for EPK GASKEUR/HRe®-label for gas fired central heating appliances with combined generation of space heating and electricity with a nominal gas input up to 70 kW (Hi) and an electrical output up to and including 2 kW
Criteria for the GASKEUR/SV label for gas-fired central heating appliances with nominal heat inputs of up to 900 kW
Criteria for the GASKEUR/CW and HRww label for gas-fired tap water heaters with nominal heat inputs of up to 70 kW
Criteria for the GASKEUR/NZ label for gas-fired tap water heaters that are suitable for use as reheater in a solar water heater system with nominal heat inputs of up to 70 kW
Criteria for WP-1 : 2009- Label for electric heat pumps with the space heating function, sanitary hot water production or cooling or combinations of these
Criteria for ZONNEKEUR-label for solar therma systems

HRe - a cogeneration label

These criteria have been written within the framework of certification of the Gaskeur appliance labeling. The Gaskeur appliance label is one of the labels of EPK.

These criteria were drawn up for certification purposes within the framework of GASKEUR appliance labelling. This certification is voluntary and supplementary, which implies that the label is neither obligatory for admission nor permits admission in its own right. To be admitted each appliance is required by law to bear the CE Marking. GASKEUR labels are supplementary, i.e. they provide information on a certain aspect of the appliance not clearly indicated by the CE Marking.

Beside the Gaskeur/basis label, which give information concerning quality and efficiency of appliances for the Dutch installation practice, there are additional labels, such as HRe®-label for which these criteria contain the additional requirements.

The efficiency tests in these criteria are based on the European standard for condensing heating appliances, NEN-EN 677 appliances, however with more freedom degrees with respect to the regulation of the appliances. The reason for this is that appliances innovations with energy saving, comfort increase and emission reduction take place as an aim, for a large part in control systems.

Moreover, these criteria are based on the EU Directive 2004/8/EC (Directive Cogeneration) which main points indicates for the testing of appliances with a common production of heat and electricity. Main point in this Directive is that the energy saving which is obtained by local production of electricity shall be brought in relation with avoided losses of central electrical production. The saving is expressed in the Primary Energy Saving (PES) factor in which the saving is stipulated by local production of electricity with respect to the most modern usual techniques for the separated production of heat and electricity. Because of advancing technology in separated production of heat and electricity, the PES comparison method must be reviewed regularly on this main point according to the Directive Cogeneration. References for a central production of electricity and of the "modern" central heating appliances has been European harmonised. The efficiency for heating with modern HR appliances has been put on 90 % (Hi).

In the Netherlands, however, the condensing appliances have a considerable higher efficiency for heating. An efficiency of 107% (Hi) is usual. These appliances are labelled as "Gaskeur HR 107". Use of the PES value (with a comparison based on 90% efficiency) would, with respect to the technique of the normal Dutch condensing boiler, give a too optimistic picture.

For this reason a new definition is made in which the good Dutch efficiency of condensing boilers (107%) finds expression and in which in the spirit of the Directive Cogeneration the avoided heat losses to the central electrical production have been discounted in the efficiency for heating. The new output is indicated with HRe, with that indicating that there is a high efficiency for both heating and the production of electricity. The name HRe® has been registered.

With the HRe® efficiency a good, direct comparison with the Gaskeur HR 107 central heating appliances has become possible. The PES value is stipulated in accordance with the Directive Cogeneration but intends especially for communication at European level.

The HRe criteria apply to gas fired central heating boilers:

- which are assembled with a production unit for the production of heat and electricity;

- which are CE certified;

- with a nominal heat input up to 70 kW (Hi);

- with a nominal electrical output up to and including 2 kW;

- with a high efficiency;

- for water systems;

- combined or not combined with a production of domestic hot water.

Under a central heating appliance is understood, an appliance where the facility for the production of electricity is built in or is combined with a boiler as part of the delivery.

1.2.3 Technical standards

Like any other energy/using product central heating boilers have to carry the CE type approval marking, which means the product has undergone conformity assessment and complies with relevant EU legislation. The harmonized technical standards describe the tests needed to show compliance with the applicable legislative measures.

1.2.3.1 Boilers

The most cited performance parameter of the boiler is the (nominal) power input in kW[39]. The heating capacity is an essential parameter for correct sizing of boiler to the building load. The heating capacity of boilers should be sufficient to cover the space heating need of a dwelling or building on the coldest day of the year or rather the last decade (as defined in relevant test standards). On the other days the boiler will function in part load.

For that reason, the test standards, discussed in the following chapters, distinguish between heating energy efficiency not only at full load, but also at 30% part-load and —on occasion— in stand-by/zero load. As will be argued in the following chapters, this is still a very crude approximation of what happens in real-life. Various studies have shown that the average load over the heating season is more in the range of 10%. This not only due to the outdoor temperature variations over a heating season, but also due to over-sizing and —for a combi-boiler or boiler heating an indirect cylinder— due to sizing of the boiler primarily for the water heating function. Furthermore, the fixed low return (or average) boiler water temperatures for part-load operation, which are a very important parameter for flue gas energy losses and latent heat recovery, are rarely achieved in real-life. Therefore, many boiler tests describe part load tests.

Table 18: Overview of standards applicable to central heating boilers - gas, oil and biomass-fired

Standard	Fuel	Description
EN 267:2009	Oil	*Automatic forced draught burners for liquid fuels*
EN 297:1994	Gas	Gas-fired central heating boilers – Type B11 and B11BS boilers fitted with atmospheric burners of nominal heat input not exceeding 70 kW
EN 303-1:1999	Gas	*Heating boilers - Part 1: Heating boilers with forced draught burners - Terminology, general requirements, testing and marking, up to 1000 kW*
EN 303-2:1998	Oil	*Heating boilers - Part 2: Heating boilers with forced draught burners - Special requirements for boilers up to 1000kW (EN 303-1) or 70kW (EN 303-4) with atomizing oil burners*
EN 303-3:1998	Gas	*Heating boilers - Part 3: Gas-fired central heating boilers - Assembly comprising a boiler body and a forced draught burner*
EN 303-4:1999	Oil	Heating boilers - Part 4: Heating boilers with forced draught burners - Special requirements for boilers with forced draught oil burners with outputs up to 70 kW and a maximum operating pressure of 3 bar - Terminology, special requirements, testing and marking
EN 303-5:1999	Solid fuels	**heating boilers - Part 5: Heating boilers for solid fuels, hand and automatically stoked, nominal heat output of up to 300 kW - Terminology, requirements, testing and marking**
EN 303-6:2000	Liquid	Heating boilers - Part 6: Heating boilers with forced draught burners - Specific requirements for the domestic hot water operation of combination boilers with atomizing oil burners of nominal heat input not exceeding 70 kW
EN 303-7:2006	Gas	Heating boilers – Part 7: Gas-fired central heating boilers equipped with a forced draught burner of nominal heat output not exceeding 1 000 kW
EN 304:1993	Liquid	*Heating boilers - Test code for heating boilers for atomizing oil burners*
EN 483:1999/A2:2001/AC:2006	Gas	Gas-fired central heating boilers – Type C boilers of nominal heat input not exceeding 70 kW
EN 625:1995	Gas	Gas-fired central heating boilers – Specific requirements for the domestic hot water operation of combination boilers of nominal heat input not exceeding 70 kW
EN 656:1999	Gas	Gas-fired central heating boilers – Type B boilers of nominal heat input

[39] Nominal power input is explained in section 1

		exceeding 70 kW but not exceeding 300 kW
EN 676	Gas	Gas-fired Burners
EN 677:1998	Gas	Gas-fired central heating boilers – Specific requirements for condensing boilers with a nominal heat input not exceeding 70 kW
EN 12809	Solid fuels	Residential independent boilers fired by solid fuel - Nominal heat output up to 50 kW - Requirements and test methods
EN 13836:2006	Gas	Gas fired central heating boilers – Type B boilers of nominal heat input exceeding 300 kW, but not exceeding 1 000 kW
EN 15034	Oil	Condensing Oil-fired central heating boilers – < 1000 kW
EN 15035	Oil	Oil-fired central heating boilers type C
EN 15270	Solid fuels	Pellet burners for small heating boilers - Definitions, requirements, testing, marking (applies to burners applied to non-integral boiler)

1.2.3.2 Solar heating

Table 19: Overview of standards applicable to solar heating products

Standard	Year	Description
EN ISO 9488	1999	Solar energy - Vocabulary
EN 12975-1	2006 +A1 2010	Thermal solar systems and components – Solar collectors - Part 1: General requirements
EN 12975-2	2006	Thermal solar systems and components – Solar collectors - Part 2: Test methods
EN 12976-1	2006	Thermal solar systems and components - Factory made systems - Part 1: General requirements
EN 12976-2	2006	Thermal solar systems and components - Factory made systems - Part 2: Test methods
ENV 12977-1	2010	Thermal solar systems and components - Custom built systems - Part 1: General requirements for solar water heaters and combisystems
ENV 12977-2	2010	Thermal solar systems and components - Custom built systems - Part 2: Test methods for solar water heaters and combisystems
ENV 12977-3	2008	Thermal solar systems and components - Custom built systems - Part 3: Performance test methods for solar water heater stores
ENV 12977-4 (2010)	2010	Thermal solar systems and components - Custom built systems - Part 4: Performance test methods for solar combistores
ENV 12977-5 (2010)	2010	Thermal solar systems and components - Custom built systems - Part 5: Performance test methods for control equipment
EN 806		Specifications for installations inside buildings conveying water for human consumption. General
EN 1717		Protection against pollution of potable water in water installations and general requirements of devices to prevent pollution by backflow
EN 60335		Specification for safety of household and similar electrical appliances. (2-21) UNE 94002:2005 Thermal solar systems for domestic hot water production. Calculation method for heat demand

1.2.3.3 Heat pumps

Table 20: Overview of standards applicable to heat pumps

Standard	Description
ISO 5151:2010	Non-ducted air conditioners and heat pumps—Testing and rating for performance
ISO 2151:2004	Acoustics—Noise test code for compressors and vacuum pumps—Engineering method (Grade 2)
ISO 13253:1995	Ducted air-conditioners and air-to-air heat pumps—Testing and rating for performance
ISO 13256-1:1998	Water-source heat pumps—Testing and rating for performance—Part 1: Water-to-air and brine-to-air heat pumps
ISO 13256-2:1998	Water-source heat pumps—Testing and rating for performance—Part 2: Water-to-water and brine-to-water heat pumps [40]
prEN14825:2010	Seasonal performance of airconditioners and heat pumps

1.2.3.4 Cogeneration

Table 21: Overview of standards applicable to cogeneration (Combined heat and Power)

Standard	Description
PAS 67: 2008	Laboratory tests to determine the heating and electrical performance of heat-led micro-cogeneration packages primarily intended for heating dwellings
G83/1: September 2003	Recommendations for the connection of small-scale embedded generators (up to 16A per phase) in parallel with Public Low-Voltage Distribution Networks Method to evaluate the annual energy performance of micro-cogeneration heating systems in dwellings, 9 October 2008 Prepared for Sustainable Energy Policy Division
EN 15036-1: 2006	Heating boilers – Test regulations for airborne noise emissions from heat generators – Part1: Airborne noise emissions from heat generators
CEN/TR 1749: 2005	European scheme for the classification of gas appliances according to the method of evacuation of the combustion products (types)[41]

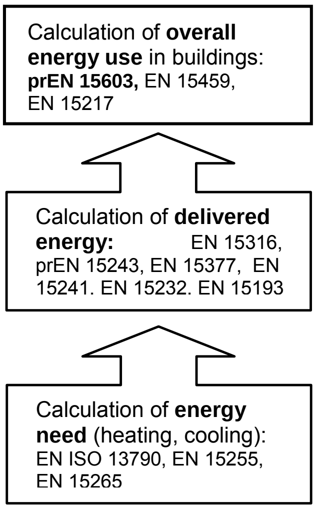
1.2.3.5 Buildings

Following the adoption of the Energy Performance of Buildings Directive a range of standards has been (or is currently underway) to provide guidance to and harmonise the way the energy performance of buildings is calculated. A complete overview of building related standards is provided for in Annex XI , but a simple explanation of how these standards interlock is shown in the figure below.

Figure 4 Buildings standards interlocking

[40] http://www.iso.org/iso/search.htm?qt=heat+pumps&searchSubmit=Search&sort=rel&type=simple&published=true

[41] http://www.microgenerationcertification.org/admin/documents/MCS%20014%20-%20Issue%201.1%20Product%20Certification%20Scheme%20Requirements%20-%20Micro%20CHP%20-%20Heat%20Led%20Standard%207th%20February%202011.pdf



The boiler standards do aim to achieve some level of harmonisation, e.g. the EN 15316-4-7 (Heating systems in buildings - biomass boilers) requires input values based on a full load test at 70ºC system temperature, according EN 303-5 (for gas boilers). This work is however ongoing.

1.2.3.6 Summary and conclusions

Conclusion of test standards[42]

- Most standards used for determining boiler characteristics as well as the fuels to use for testing have been harmonised, also following the Construction Products Directive (Regulation). An important standard which is currently not yet harmonised is EN 303-5;
- Standards provide description of measurement of heat output and energy efficiency at a defined nominal power output, as well as emissions of selected pollutants. They also include information on allowable surface temperature and electrical safety;
- All standards specify the precision of measurement;
- The harmonised standards specify quality parameters for test fuels.
- All test standards mention testing method and precision of determination of CO emissions but they do not specify a reference method. There are also similar testing standards covering the measurement of NOx and VOC which also quote measurement techniques in a number of countries;
- Currently, EN 303-5:1999 is the only EN standard containing specifications on OGC (organic compounds such as fuel residues) and dust emissions. However, the standard does not contain a detailed description of testing methods, nor a specification of reference methods, for these emissions. The alternative methods employed do not provide comparable results and a quality comparison of different boilers is therefore impossible.
- Technical Committee CEN/TC 295 "Residential solid fuel burning appliances" is currently working on a test standard "Residential solid fuel burning appliances - Emission test methods" (TC 295 Work item 017), which covers the measurement of emissions of NOx and VOCs to add to the measurement of CO given in the suite of appliance EN standards. This Technical Specification (CEN prTS15883) is now going through the standardisation process prior to publication. CEN TC 295 has found it the most difficult of tasks to "harmonise" particulate test methods: the proposed draft Technical Specification for

[42] As presented in Lot 15 Task Report 1, April 2009, by Bio Intelligence, France.

gravimentric PM measurement by dilution tunnel has been rejected in the end of 2008. A proposal for a new work item to develop a Technical Specification covering a particle counting technology is under developmetn by CEN/TC 295.

2 Task 2: Economic and market analysis

This task includes a market and economic analysis according to the Ecolabel regulation (EC 66/2010 of 25 November 2009).

The first subtask describes the generic economic data as extracted from Eurostat databases.

The second subtask is the analysis of market and stock based on other sources of data.

The third subtask describes the market and production structures and the fourth subtask covers general product trends and future potential.

Consideration will be given especially to the market development of solar heating, heat pumps and micro-CHP

2.1 Subtask 2.1 - Generic economic data

This section presents market data on central heating systems based upon Eurostat's Prodcom database. Ideally the data should relate to the latest full year for which at least half of the Member States have reported, but this is not always possible. The current data refers to year 2009.

The data is in physical volume (units) and split up per Member State and product type. The products categories covered are mainly boilers:

Boilers

25.21.12.00 - boilers for central heating other than those of HS 84.02. These are generally speaking gas-fired and oil-fired boilers. There is no information whether this category also comprises coal-fired boilers , but even if these are present the share in overall sales will be minute. Neither does the Prodcom category give information on the capacity range, but it can be assumed that the number of boilers exceeding 400 kW input power is also very limited.

27.52.12.70 - Iron or steel solid fuel domestic appliances, including heaters, grates, fires and braziers (excluding cooking appliances and plate warmers): As can be seen this product group is very diverse. According the Lot .. study this group also comprises wood burning boilers for central heating (including pellets), again without indication of capacity.

28.25.13.80 - Heat pumps other than air conditioning machines of HS 8415. The Prodcom category description does not allow identification of the type of heat pump (air-to-air, air-to-water, brine-to-water, direct expansion water-based, etc.). Also the capacity range is not indicated and neither whether the heat pump is intended (or sold) for central heating purposes or other applications (industrial or process heating).

As regards solar thermal heating products or cogeneration the Prodcom **offers no product category descriptions**. The sales of cogeneration products may be hidden in generator set data, and cannot be extracted with sufficient level of reliability.

The data provided by Prodcom allows estimation of production, intra-extra EU trade and apparent consumption (ie. sales) in monetary terms and physical units where available.

Annex I provides detailed tables of various central heating products.

2.1.1 Production

This table presents the production data as available in Prodcom for various central heating products. Please note that the actual share of relevant products in each group is not always known.

Table 22: 2009 Prodcom data on EU production of central heating products

Production 2009	Boilers for central heating		Solid fuel		Heat pumps		Central heating radiator thermostatic valves		Central heating radiator valves, other	
Unit	in mln. Euro	in 1.000 units	in mln. Euro	in 1.000 units	in mln. Euro	in 1.000 units	in mln. Euro	kg	in mln. Euro	kg
Austria	223	56	74	43						
Belgium										
Bulgaria	1,7	2,5	17	127		0,05				
Cyprus										
Czech Rep.	100	145	61	125						
Denmark	28	0,7	76	96	40	23				122
Estonia			1,8	23						
Finland	25	9,1	22	90	14	1,6				
France	610	719	166	160	458					
Germany	799	1.194	75	55	392	109			80	6.8 81
Greece	6	10	0,5	1,7						
Hungary	19	18	81	261	40	44				
Ireland										
Italy	1.101	1.992	163	165	116	53	65	3.154		
Latvia	3,4	1,6								
Lithuania	6,4	9,1	0,6	1	0,01	0,004				
Luxemburg										
Malta										
Netherlands	543	594	19	11	14					
Poland	197	420	13	64						
Portugal	64	180	2,9	3,8	16	19				
Romania	9,7	15								
Slovakia	100	164	19	28						
Slovenia										
Spain	51	53	44	111	54	20	12	421		
Sweden					185	73				
UK	689	1.178	52	167	27	14				
EU27	4.715	6.944	1.041	1.696	1.521	559	212	11.51 4	401	31. 427

2.1.2 Import - export

This table shows the trade for individual member states of various central heating products (if available) for the year 2009. Major exporting countries are: Germany, Italy, Austria, Netherlands and France, but also Poland and Slovakia are countries with significant export - indication the relevance of low-wage countries for boiler production.

Table 23: 2009 Prodcom data on EU import/export of central heating products

Export-Import 2009	Boilers for central heating		Solid fuel		Heat pumps		Central heating radiator thermostatic valves		Central heating radiator valves, other	
In mln €	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
Austria	259	87	77	52	38	31	0,7	3,5	1,3	7,5
Belgium	44	189	57	35	14	37	3,4	9,6	2,7	15
Bulgaria	0,2	7,1	17	1,2	0,1	5,8	1,6	1	0,04	1,4
Cyprus										
Czech Rep.	77	50	62	17	7,1	21	7,9	5,1	3,5	5,3
Denmark	21	42	61	16	41	18		4,2	12	11
Estonia	0,4	1,7	1,8	2,3	0,2	1,9		0,3		0,02
Finland	5,8	4,3	7,8	4,1	2,3	31	0,3	0,7	0,03	3,1
France	163	227	59	85	336	139	20	21	5,2	12
Germany	945	361	87	164	235	86	51	17	68	28
Greece	0,8	23	0,2	4,5	3,4	16	0,2	0,7	1,8	1,5
Hungary	9,9	40	73	4,9	0,7	6,1	0,2	2,2	0,2	4,3
Ireland	35	20	0,3	1,8	143	3,7	4,3	2	4,6	1,8
Italy	480	219	121	29	124	39	11	7,2	134	10
Latvia	7,7	8,2	1,8	1,8	0,4	1,7	0,1	0,5		0,01
Lithuania	8,2	10	0,7	2,7	2,1	5,4	0,5	0,7	0,4	0,6
Luxemburg	0,9	8,9	4,3	7,7	0,2	2,4	0,2	0,8		0,5
Malta		0,05		0,2		0,2				
Netherlands	266	82	12	14	14	31	0,5	21	23	12
Poland	136	98	16	31	3,1	26	6,2	17	16	11
Portugal	22	16	2,6	13	0,6	17	0,5	1	0,3	1,4
Romania	12	75	0,2	4,1	0,1	3,9	0,8	1,8	1,3	3,7
Slovakia	139	33	30	6,3	13	3,1	4,1	2,4	1,6	2,5
Slovenia	4,6	15	4,8	3,7	1,8	5,4	0,3	1	5,9	2,6
Spain	33	171	16	16	26	27	0,5	1,8	1,4	6,3
Sweden	16	17	21	8,7	106	31	9,4	4,4	7,2	4,4
UK	33	217	3,8	33	3,6	80	8,2	16	5,1	37
EU27	687	193	90	106	281	73	22	17	87	29

The table below shows the size of EU import and export for 2000, 2005 and 2010. Noticeable is the relative modest share of cast iron boilers (also called 'floor standing' boilers, as opposed to 'wall hung', see next section) .

Table 24: CN8 data on EU import/export of central heating boilers

	84031010 central heating boilers of cast iron (excl. Vapour generating boilers and superheated water boilers of heading 8402)			**84031090 central heating boilers, non-electric, of materials other than cast iron (excl. Vapour generating boilers and superheated water boilers of heading 8402)**		
	2000	2005	2010	2000	2005	2010
Import						
Value in mln. €	23,9	38,3	19,9	70,8	113,5	212,4
Quantity in 100 kg.	58.473	83.370	65.667	101.533	158.037	246.244
Export						
Value in mln. €	54,8	102,9	107,1	203,5	462,0	700,7
Quantity in 100 kg.	183.781	335.779	292.996	312.834	657.997	826.269
Balance (exports - imports)						
Value in €	30,9	64,6	87,1	132,7	348,5	488,2
Quantity in 100 kg.	125.308	252.409	227.329	211.301	499.960	580.025

The table below presents the import-export between the EU and extra-EU countries and the import-export between EU countries internally. It shows that the 'domestic' trade (INTRA EU) outweighs the EXTRA EU trade, but that EXTRA EU trade is also becoming more important.

Table 25: CN8 data on intra and extra EU import/export of central heating boilers

REPORTER	**PERIOD**	**PARTNER**	**EU27_EXTRA in mln €**		**EU27_INTRA in mln €**	
		FLOW/PRODUCT	84031010	84031090	84031010	84031090
EU27	Jan.-Dec. 2004	IMPORT	33,7	121,1	307,2	1.470,1
		EXPORT	88,9	395,0	276,1	1.655,4
	Jan.-Dec. 2005	IMPORT	38,3	113,5	298,0	1.666,9
		EXPORT	102,9	462,0	311,4	1.769,0
	Jan.-Dec. 2006	IMPORT	33,0	135,9	320,5	1.923,0
		EXPORT	124,8	679,2	329,8	2.009,1
	Jan.-Dec. 2007	IMPORT	34,3	121,8	272,8	1.733,7
		EXPORT	108,6	737,5	321,0	1.829,8
	Jan.-Dec. 2008	IMPORT	23,8	161,8	284,0	1.847,0
		EXPORT	118,4	837,5	325,8	2.016,5
	Jan.-Dec. 2009	IMPORT	19,0	173,8	240,2	1.592,8
		EXPORT	91,6	595,3	292,5	1.739,6
	Jan.-Dec. 2010	IMPORT	19,9	212,4	234,5	1.627,5
		EXPORT	107,0	700,7	251,4	1.845,3

2.1.3 Apparent consumption

The apparent consumption (defined as production plus imports minus exports) can only be calculated in monetary terms.

Table 26: 2009 Calculated apparent consumption of central heating products

Apparent 2009	Boilers	Solid fuel	Heat pumps	Central heating radiator thermostatic valves	Central heating radiator valves, other
Unit	in mln €	in mln €	in mln €	in mln €	in mln €
Austria	51	49	-7	2,8	6,2
Belgium	145	-22	23	6,2	12,3
Bulgaria	8,6	1,2	5,7	-0,6	1,36
Cyprus					
Czech Rep.	73	16	13,9	-2,8	1,8
Denmark	49	31	17	4,2	-1
Estonia	1,3	2,3	1,7	0,3	0,02
Finland	23,5	18,3	42,7	0,4	3,07
France	674	192	261	1	6,8
Germany	215	152	243	-34	40
Greece	28,2	4,8	12,6	0,5	-0,3
Hungary	49,1	12,9	45,4	2	4,1
Ireland	-15	1,5	-139,3	-2,3	-2,8
Italy	840	71	31	61,2	-124
Latvia	3,9		1,3	0,4	0,01
Lithuania	8,2	2,6	3,31	0,2	0,2
Luxemburg	8	3,4	2,2	0,6	0,5
Malta	0,05	0,2	0,2		
Netherlands	359	21	31	20,5	-11
Poland	159	28	22,9	10,8	-5
Portugal	58	13,3	32,4	0,5	1,1
Romania	72,7	3,9	3,8	1	2,4
Slovakia	-6	-4,7	-9,9	-1,7	0,9
Slovenia	10,4	-1,1	3,6	0,7	-3,3
Spain	189	44	55	13,3	4,9
Sweden	1	-12,3	110	-5	-2,8
UK	873	81,2	103,4	7,8	31,9
EU27	4221	1057	1313	207	343

The table shows the apparent consumption as can be calculated from the official Eurostat data and as required by contract. At the same time the table implicitly also shows the very limited reliability of these data, as some values are highly unlikely or just plain wrong (e.g. data for Germany).

In the remainder of the study the above dataset is not used, but instead the sales data from various other sources is used, as indicated in the next section.

2.2 Subtask 2.2: Market and stock data

The section below describes the market and stock as identified in the relevant preparatory studies. For boilers the data of the Lot 1 study is used, because it is deemed to be still very relevant (the sales data as predicted by Lot 1 for 2010 provides a very good match with the Prodcom sales of 2009: both 6.9 million units).

The other sections describe boiler market segmentation, the structures/characteristics of the production and distribution chain and other related aspects.

2.2.1 Sales of central heating products

Reliable sales data of central heating boilers are notoriously difficult to come by, mostly due to an intensely competitive market with only a few companies responsible for over 70% of the sales. Some market research companies have specialized in describing this market through contacts with boiler manufacturers. Each of their market assessment reports represent a value of a few thousand euros, the acquisition of which was not inside the scope of the budget of this study.

Nonetheless, in 2006 the Lot 1 study, led by VHK, teamed up with BRG Consult (BRGC), one of main specialized market research companies for heating products and produced the most extensive market assessment of central heating boilers available in the public domain. Given the slow renewal rate of central heating boilers (average product life is some 15-20 years, which means that annually only 5-7% of the stock is renewed[43]) the conclusions of this assessment still largely apply.

On the basis of this market assessment and taking into account various demographic, economical and technological aspects, estimates of future sales were derived. The assumptions can be found in the Lot 1 Task 2 report.

The sales of solid fuel (incl. biomass) boilers and air-based central heating systems have been added using the available data from the respective preparatory studies.

The sales of heat pumps, cogeneration boilers and solar thermal systems were assessed by checking data from relevant industry associations (respectively EHPA, COGEN and ESTIF). These data also include an industry outlook towards future sales.

Table 27: Sales of central heating products (source: various)

Product group	Unit	1990	1995	2000	2005	2010	2015	2020	2025
central heating Boilers	in ‘000 units	4.765			6.989	7.374			8.900
Solid fuel [44]	in ‘000 units	288	220	200	250	436	367	325	296
- 50% of which are biomass boilers[45]		140	120	100	150	250	300	300	280

[43] Also considering that sales to first time installations and new buildings are modest compared to replacement sales.

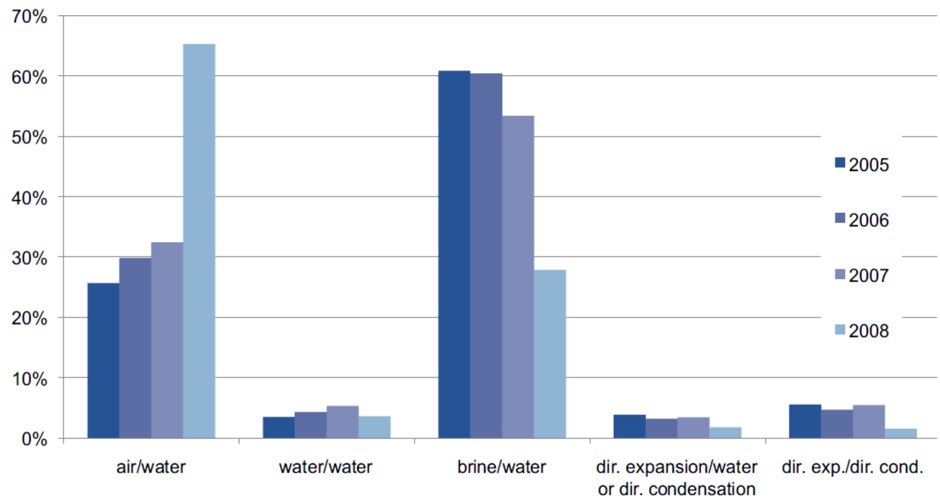
[44] LOT 15 Solid fuel small combustion installations EU 22 Member states

Air-based central heating	in ‘000 units					5.000[46]			
Heat pumps	in ‘000 units				250[47]	490	1.000		
CHP	in ‘000 units					20	140	300	
Solar heating[48]	In ‘000 m^2	42,9	71,4		2.100				

Heat pump sales have increased strongly in the past 5 years (although the economic crises has had its effects on sales in 2009-2010). The sales increased from some 250 thousand units in 2005 to over 580 thousand units in 2008. Cuurent expectations for 2010 are some 490 thousand units.

As regards types of (heating only) heat pumps, the air/water heat pumps shows a significant growth in sales, whereas the sales of other types of het pumps remain constant or decline (especially brine/water is in decline).

Figure 5 Heat pump sales by type (source EHPA, 2009)



(source: EHPA statistics: Heat pump outlook 2009)

The IEA report “Technology roadmaps – Energy-eficient buildings: heating and cooling equipment” indicates on page 10 room air conditioner sales of some 4 million units in 2010. Note that this figurecovers mainly air-to-air systems, whereas the underlying study focuses on the remaing half million hydronic systems. The IEA report also indicates over 16 GWth of thermal solar systems installed in Europe, which coincides with the Estif figure provided above, considering a conversion factor of 1 m2 = 0.7 kWth.

2.2.1.1 Market segmentation of boilers

An more detailed overview of the 2004 gas/oil boiler market, per Member State is provided below (note: the sales data below relates to 2004, whereas table above gives 2005 data).

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[45] Lot 15, Task 3, table 3-26.For year beyond 2010 biomass hsare is thought to increase to 90% in 2030 (VHK estimate)

[46] Estimate page 7 task2 LOT21 for 2008

[47] European heat pump statistics 2010 EHPA outlook, p.6

[48] 1 MW_{th}=1.428,57 m^2 (1 m^2=0,7 kW_{th}) provisional ESTIF figures on the EU solar thermal market 2007

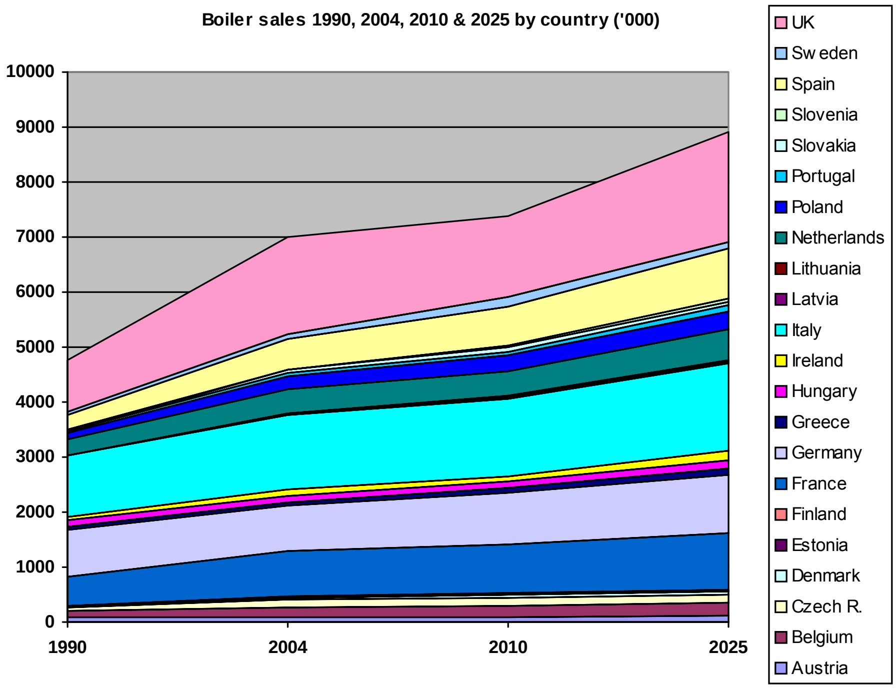
Table 28: Market segmentation of sales of central heating boilers (year 2004) (source : Lot 2, Task 2)

SECTOR	RESIDENTIAL (incl. boilers shared with small non-residential)											NON-RESIDENTIAL			TOTAL
application	individual							collective			total			total	
TYPE	gas wh				gas fs	oil jet	total Indiv.	gas fs	oil jet	total Coll.		gas fs	oil jet		
Output in kW	8-15	16-25	26+	tot wh	< 35	< 30		> 35	> 30			> 35	>.30		
Austria	4	23	17	44	4	9	57	1	2	3	59	1	2	8	67
Belgium	8	61	36	105	17	22	144	4	9	13	157	5	11	13	170
Czech Rep.	12	12	61	85	8	0	93	2	0	2	95	2	1	1	96
Denmark	17	2	2	21	0	5	25	0	0	1	26	0	0	0	26
Estonia	–	–	–	2	0	1	3	0	0	0	3	0	0	0	3
Finland	–	–	–			12	12	0	0	0	12	0	0	9	21
France	–	430	107	537	64	153	754	7	16	23	777	9	19	38	815
Germany	72	359	64	495	46	117	658	16	38	54	711	19	47	47	758
Greece	0	8	3	12	1	27	39	0	18	18	57	0	22	29	86
Hungary	9	69	8	86	8	1	95	5	0	5	101	6	0	0	101
Ireland	20	35	3	58	2	35	96	0	5	5	101	0	6	10	111
Italy	1	1084	145	1230	59	21	1310	3	12	14	1324	3	14	14	1338
Latvia	–	–	–	6	1	1	7	0	0	0	7	0	0	0	7
Lithuania	–	–	–	8	3	1	12	0	0	0	12	0	0	3	15
Netherlands	210	153	44	408	2	0	410	3	0	3	413	3	0	6	419
Poland	2	114	11	126	8	7	141	4	5	9	150	5	6	6	157
Portugal	–	30	3	33	0	4	37	0	5	6	43	1	7	10	53
Slovakia	2	6	18	26	13	0	39	2	0	2	42	3	0	0	42
Slovenia	1	6	1	8	1	10	18	0	0	0	18	0	0	4	22
Spain	3	371	64	438	1	24	463	3	34	37	500	4	42	42	542
Sweden	0	1	–	1	0	0	1	0	1	1	3	0	1	6	9
UK (>44 kW)	203	1044	318	1565	59	92	1715	4	6	10	1726	5	8	75	1801
EU22	**564**	**3810**	**904**	**5295**	**296**	**541**	**6132**	**51**	**152**	**203**	**6335**	**67**	**186**	**253**	**6588**
avg. kW	12	22	29	22,1	22	22	22,1	120	93	100	25	120	93	100	27
mln. kW	6,8	83,8	26,2	116,8	6,5	11,9	135,2	6,1	14,2	20,2	155	8,0	17,3	25,3	181

2.2.1.2 Sales forecast

The figure below shows the sales forecast for central heating boilers close to 9 million units in 2025. Note that the reduced trend between 2004 and 2010 is a result of the relative high pace in stock renewal in the years before and will also result in a slower sales trend, after 10-15 years time, in 2025 and beyond, when most of these boilers will be up for replacement.

Figure 6 Boiler sales forecast 2025 (source: Lot 1, Task 2)



The forecast of boiler sales assumes new construction to be stable at an average long term level, and the potential for first time installations necessarily declining, as penetration of central heating approaches saturation. The growth is expected to come mostly from an increasing demand for replacement. This can be seen as resulting from several factors:

- Considerable growth in most EU boiler markets in the last 10-20 years, largely driven by first time installation, or displacement of collective heating by individual systems. This section of the park is now gradually coming up for replacement;
- The trend towards wall hung boilers and away from floor standing (or from old cast iron models in the UK/Ireland) in several European markets, means that a growing proportion of the park has a shorter average life, thus requiring replacing more frequently. It is also generally considered that more technologically advanced boilers now on the market may have a shorter life than simpler models (the combination with domestic hot water is also a contributing factor);
- Improvement in the living conditions in new accession member states from Eastern Europe, where still a considerable stock of old solid fuel or oil boilers will eventually need replacing.

Negative impacts on growth can be expected from:

- Approach of central heating saturation and a slowing of first time installation demand;
- A continuing expansion of district heating;
- A worsening of economic performance of EU member states;
- Any eventual appearance of heating systems with longer life, which will need replacing less often.

As regards the product mix, under "a business as usual" scenario:

- The trend towards wall hung boilers is expected to continue in the long term, and within that a marked shift towards condensing boilers, even without the introduction of additional legislation;
- The share of floor standing boilers (including and jet burner) is expected to fall, and a similar trend towards condensing is likely to continue;
- Biomass boilers have experienced a "revival" over the last few years, and all else equal it is reasonable to expect that this growth will continue to some extent, although a "natural ceiling" to the penetration of this type of boilers is posed by the cumbersome requirements in terms of storage and fuel supply;
- Electric boilers are expected to maintain their marginal position, and their future is particularly related to overall energy policy decisions;
- Sales of heat pumps are expected to grow, although the pace of this growth is very difficult to evaluate. It is possible that the forecast presented could be conservative.

2.2.2 Average age and product life

The average product life is an pivotal parameter in a stock model, linking sales and stock ('park') data.

Average age and product life of existing stock

BRGC[49] has estimated that on average of the 100 mln. boilers are in stock and that the replacements sales are 60% (4,2 mln. units) of the 7 mln. boilers sold annually. This translates to an average product life of boilers in stock of 23 years. With an equal age distribution this means that the age of the average installed boiler should be around 11,5 years.

The SAVE Heating System study and the 1999 Gas/oil boiler replacement study, both for the European Commission, found considerable average age differences, not so much per country but especially per fuel type. Gas-fired boilers had an average age of 12 to 14 years, whereas oil-fired boilers showed an age of between 15 and 25 years. A Belgian study by VITO on boiler replacement in Belgium confirmed these findings and showed an average boiler age of 12,4 years for gas-fired boilers and 12-7 to 15 years for oil-fired types. In Germany, BBT presented a breakdown of the boiler age classes, resulting in an average age of around 13-14 years.

Both Belgium and Germany have a high share of oil-fired (jet) burners, which are practically indestructible. In contrast, the UK is mainly a country with gas-fired boilers, which presents a different picture. In a 2005 study for the DTI an average age of 'heating only' gas boilers of 8,4 years was found.

The above information is of course only anecdotal, but it seems to suggest that the product life of 23 years is a reasonable estimate, resulting in an average boiler age of 11-13 years, depending on market characteristics.

Product life of new sales

The average product life of **new boiler sales** is expected to be shorter than that of the existing stock, given the trend to replace (long lived) floor standing boilers by more compact (shorter-lived) wall hung boilers. Therefore, the average product life for new sales is estimated to be closer

[49] BRGC is the specialist boiler marketing consultancy, whome together with VHK crafted the Lot 2 market data on central heating boilers.

to 17 years (considering that more than 80% of current sales are wall hung gas-fired boilers with an average product life of 15 years).

2.2.3 Stock of central heating boilers

Combining the information on new sales (including demographic and other trends), the average product life an estimate of current installed stock of boilers is made. The table below presents the expected stock of boilers (and their energy consumption) from the year 1990 to 2025 as calculated in the Lot 1 study (forecast, Business-as-usual).

Table 29: Sales and stock of central heating boilers, including forecast of energy consumption (source: lot 1, Task 2)

	1990	1995	2000	2005	2010	2013	2015	2020	2025
net load (kWh/a)	15162	13868	12684	11602	10595	10033	9675	8835	8068
sales (000)	4778	5520	5993	6600	6952	7240	7432	7911	8686
stock (000)	74660	86236	97964	109709	120975	127183	131058	140638	150734
Efficiency									
Freeze_2005	42%	44%	46%	48%	48%	48%	48%	48%	48%
BaU	42%	44%	46%	48%	52%	52%	53%	54%	55%
kWh/a.unit									
Freeze_2005	36099	31518	27575	23942	21863	20704	19965	18232	16649
BaU	36099	31518	27575	23942	20572	19257	18428	16514	14669
TWh primary/a									
Freeze_2005	172	174	165	158	152	150	148	144	145
BaU	172	174	165	158	143	139	137	131	127
Sales year energy									
Freeze_2005	3062	3105	3095	3035	2942	2873	2827	2730	2661
BaU	3062	3105	3095	3035	2915	2815	2747	2586	2445
Stock energy in TWh/a									
Freeze_2005	11024	11178	11142	10926	10593	10341	10178	9827	9581
BaU	11024	11178	11142	10926	10493	10134	9890	9309	8801
CO_2 in Mt (1 PJ= 0,0577 Mt)									
Freeze_2005	636	645	643	630	611	597	587	567	553
BaU	636	645	643	630	605	585	571	537	508
Acidification (in kt SOx equivalent; gas 60 mg/kWh; oil 310 mg/kWh)									

Freeze_2005	665	615	561	500	449	418	398	365	336
BaU	665	615	561	500	469	437	417	381	353

Information on stock of other types of boilers (biomass, air-based), heat pump boilers, cogeneration boilers and solar heating is scarce (see also market data). The forecasts for stock as given below is based on the preparatory studies and industry association forecasts.

Table 30: Estimated stock of central heating products - projections (source: Lot 1, Task 2)

Product group	Unit	1990	1995	2005	2010	2015	2020	2025
Boilers	in '000 units	74660	86236	109709	120975	131058	140638	150734
Solid fuel boilers	in '000 units	8.864		6.500	+/- 8.000			
- of which biomass (50%)		4.400		3.250	4.000			
Heat pumps	in '000 units				1,4 [50]			
CHP	in '000 units				38	498	1.658	
Solar heating	In '000 m^2				31.625[51]			
Air-based central heating	in '000 units	not assessed yet						

The lot 15 study also identified a specific pellet boiler stock of some 205.000 units in mainly Austria, Denmark, Germany and Sweden. Therefore some 3.800 thousand other units must be fuelled by wood logs and wood chips, which makes the initial assumption of 4 million biomass boilers seem rather high. In Task 2 of Lot 15 such conclusions are however not presented.

2.3 Subtask 2.3: Market and production structures

2.3.1 Main market trends

The following assessment is based upon the market trends as identified in the Lot 1 study, accompanied by anecdotal data of more recent origin.

The key market trends in central heating products are:

- The growth in the share of wall hung boilers - they are relatively cheap and easy to install and have become the dominant boiler type;
- The growth in the share of condensing boilers, especially wall hung. With the revision of the Building Regulation Part L in the UK in 2005 (plus trends in other markets) the condensing share of wall hung has risen from 14% in 2004 to 37.6% in 2005 (with the UK accounting for 52% of all EU wall hung condensing sales). There are no indications that the forecasts of the Lot 1 study, assuming a 'condensing' share of 54% in 2010, have not been met. By 2010 Italy, France and Spain are expected to account for 75% of all non-condensing wall hung boiler sales.

[50] Based on 1.356 million installed in 2008, which includes air/air heating only heat pumps in Scandinavian countries. Therefore the number of hydronic systems is in relaity much lower.Source: EHPA Heat pump outlook 2009.

[51] Data of 2009 ESTIF page 9 (solar thermal markets in Europe trends and market statistics)

- The decline in the share of gas and oil floor standing boilers, is set to continue. The condensing share of floor standing boilers has developed more slowly than for wall hung gas. It stood at some 6.3% in 2004, rising to 8% in 2005 and is forecast to increase to 28% by 2010, but the growth is limited due to market shifts towards wall-hung condensing boilers.
- The growth in sales of solid fuel (mainly biomass pellet) boilers. This is a relatively recent phenomenon, after a long period of declining solid fuel sales. The surge accelerated in 2005 when sales grew by nearly 30% (notably in Austria, Czech Republic, Denmark, Finland, France, Poland and Sweden). There is a great deal of optimism about the prospects in these countries, backed by a certain amount of official encouragement. The Lot 1 study expected the share of solid fuel rising from 3.4% in 2004 to 5.9% in 2010, but this latest figure could not be backed up by more recent market data. A limiting factor is that only a limited proportion of homes can handle solid fuel, so saturation could be reached at some stage in the not too distant future, followed by a sharp and sudden fall in sales.
- A similar surge of interest is witnessed in heat pumps. In fact several countries had toyed with heat pumps in the early 1980s, but with a withdrawal of subsidies and some product problems, the movement fizzled out. Sweden has been the pioneer of the recent revival, and in 2004 accounted for 50% of sales of hydronic heat pumps used for space heating. In 2005 the market grew by some 20%. Sweden followed this trend, and there were sharp increases in France, Germany and to a lesser extent in Austria and Finland. Given the high initial costs, heat pump sales are sensitive to subsidies and incentives and like biomass boilers they are not suited to all homes. However it is likely that the growth will be more sustainable than biomass boilers (and the ecological benefits greater, especially with regards to emissions).
- The overall market estimate is that over the next 20 years replacement growth will more than compensate for the decline in first time installations. The growth patterns will neither be consistent between countries nor follow a smooth progression. To give two examples:
- the UK market, which has seen strong growth over the ten year up to 2004, looks set for a downturn in 2005-2010, followed by a significant upturn to 2025. Although the revisions to Part L may have had some short term impact in 2005/06, it could be dangerous to attribute to this measure any sustained dip in sales up to 2010. It was probably due to happen anyway.
- Conversely, BRG CONSULT believes that the long term suppressed German market is due for a revival in replacement demand over the next five years.

Movements Towards Improving Heating Efficiency

Shifts in Attitude:

- Public (and even official) awareness of the environmental impact of heating systems has developed slowly and unevenly in Europe. The Lot 1 study recognised three groups of countries:
- the environmentally aware Western European countries (the Nordic Countries, the Netherlands, Germany, Austria and Switzerland);
- the less aware Western European countries (UK, Ireland, Belgium, France, Italy, Spain, Portugal and Greece);
- Eastern Europe, emerging from a regime where the impact of pollution on health was of greater concern to the public than climate change or the depletion of fossil fuel reserves.

If these differences have not disappeared, there has been considerable progress, especially over the past 2-3 years. Apart from cleaning up the air in most of Eastern Europe, perhaps the biggest change has come in the UK, which needed to make a step jump in boiler efficiency just to meet the 1992 Boiler Efficiency Directive provisions, and then made another large change to move almost entirely to condensing boilers.

Product Trends: Established Technologies

It is widely acknowledged that even non-condensing (eg. "low temperature") boilers have shown improvements in efficiency and reductions of harmful emissions since the 1992 Boiler Efficiency Directive (even if the labeling scheme associated with that directive may not have had a notable impact at the consumer level).

The product developments that have gone beyond that basic improvement have mostly been covered in the preceding section, being: the growing share of condensing boilers and the (small) increases in sales of biomass boilers and heat pumps.

Product Trends: New, Emerging and Alternative Technologies

There is a great deal of speculation about the likely future impact of newer technologies on the boiler market and on the environmental performance of the heating sector. Of the various alternatives identified:

- Modern district heating schemes of the type developed in Denmark probably require too much infrastructural work for them to be developed on a large scale in countries where systems are not already in place.
- Biomass boilers are obviously enjoying an upsurge at the present time and this could last for some years. However, as already mentioned, the Lot 1 study indicated that saturation will at some point put this growth into reverse. It is also not clear which side of the environmental argument biomass boilers will fall: while they use renewable energy they are still responsible for significant polluting emissions.
- Heat pumps do look like an attractive energy efficient alternative, and there are now signs that the technology is starting to move into the mainstream of the heating market. However, the (still) high initial investment is likely to mean that this solution needs the support of subsidies and incentives on a long term basis. The development of ever more efficient air-source heat pumps may help to overcome the high initial investment threshold, since the installation requirements are less costly. Gas heat pumps are gaining ground as well, but only very slowly, since most of the models offered do not suit the needs of the largest markets .
- Solar thermal has been at the forefront of discussion, because of the initiatives in Spain, but since Spain has removed its favorable regulations, the market is in decline. In other countries the situation has changed little, with on/off incentives provided by governments. Keeping in mind that solar thermal works best under circumstances when space heating is least needed, this technology is likely to remain primarily associated with water heating, together with a supplementary role for space heating.
- Micro CHP boilers have finally left the development stage and witnessed a full scale market introduction in 2010 (mostly BDR Thermea products). Most micro-CHP products that have or will enter the market shortly are based on Stirling engines, with limited electric efficiency. Somewhat larger CHP systems (Enertec Dachs, with 5 kW electric output) have been on offer for a few years, but sales are still below 20.000 units/year. Hydrogen fuel cells for space heat are still in the development stage.

Reversible air conditioning (air-to-air air conditioners, especially wall-hung split units) are seen more as an environmental threat than an opportunity. The heat wave of 2003 combined with cheap products arriving from China demonstrated how suddenly demand can soar for such products. They may constrain part of the further penetration of boiler ownership in the still unequipped stock of dwellings in the Mediterranean countries. However in general the Lot 1 study regarded (reversible) domestic air conditioning as a supplementary discretionary technology which probably in most cases is not used throughout the whole dwelling. Of course in the commercial sector air conditioning has already taken share on a large scale from wet system space heating.

Official Initiatives

From back in the 1980s numerous attempts have been made to improve the ecological performance of central heating products by official initiatives.

Many were either on too small a scale or too short lived to have any profound lasting effect. Examples include:

- the program in France to subsidize condensing boilers in the late 1980s;
- early incentivisation of heat pumps in a number of countries (including Sweden, Germany, France, Austria).

There were however some initiatives which had a grater impact:

- notably the Blauer Engel in Germany, which provided a focal point for German environmental awareness, as well as imposing specific requirements for boilers to conform
- the subsidisation of condensing boilers in the Netherlands, which can claim to have given birth to the whole condensing boiler movement in Europe;
- the Swiss LRV ’92, which is significant in that it was taken up later by Austria;
- the German §82a of the EstDV, which had a dramatic if brief impact in stimulating boiler replacements just before it expired at the end of 1991. After that from the point of view of the boiler market the impact of the two rounds of BimSchV has been much less striking.

The lessons from these early initiatives would seem to be that they work most effectively as part of a package of measures (the subsidy scheme in the Netherlands was supported by building regulations and a labeling scheme) and they need to be sustained over a long period.

In recent years the number of measures has proliferated, as witnessed by the long inventory provided in the BRG Consult report:

- Easily the most dramatic example has been the revision of Part L of the UK Building Regulations, which from April 2005 requires all boilers sold in England and Wales, with very few exemptions, to be condensing models conforming to SEDBUK A or B. This coercive move followed a number of measures intended to boost condensing sales, such as HEES Programme.
- Denmark has now adopted much the same position, although the quantities of boilers involved are obviously far smaller.
- Across the EU there have been (still are) numerous national and local schemes which seem to be lifting the share of condensing boilers, as well as heat pumps and biomass boilers (including France, Belgium, Austria, Sweden).
- Coming on top of these measures, is a whole raft of recent or impending national legislation necessary for the implementation of the Energy Performance of Buildings

Directive (notably the RT2005 in France and Legge 192 in Italy). Although directed overtly to the whole building rather than specifically to heating systems, its impact on the boiler market is expected to be considerable.

- There is ongoing speculation that Legge 192 in particular will ultimately lead to the market going largely over to condensing boilers, but neither the specifics of such requirements nor the timing are yet clear. For the time being BRG CONSULT forecasts do not assume any such compulsion regarding condensing boilers, but we believe that if this does happen in Italy, it could have a knock-on effect throughout Europe.

With the possible exception of condensing boilers in the Netherlands and heat pumps in Sweden, the evidence would appear to suggest that subsidies and incentives on their own have a very limited lasting effect on sales. Apart from anything else they are too easy to remove. §82a in Germany showed that incentives aimed at the park can be effective, although to have a single long anticipated expiry date leads to a short term distortion on the market that is difficult for the manufacturers to handle.

Coercive legislation such as building regulation are likely to have a longer lasting impact. Long term incentivisation to bring forward replacements on a discretionary basis within the existing park have yet to be tried, although they are being talked about. They would probably need to target those specific segments of the park that are generating the most energy consumption and CO2 emissions.

Expectations regarding current proposed measures

If the proposed Ecodesign requirements on minimum seasonal efficiency are introduced, the market share of condensing boiler will rise significantly within one year after the regulation has come into force (excluding those markets where condensing boilers are de facto standard as in the UK, The Netherlands, Scandinavian countries and Germany). The overview below gives the estimates of condensing boiler market share WITH Ecodesign requirements in place.

Table 31: Market share (% of sales) of condensing boilers 1998-2009 and projections 2010-2014 (source: BRGC 2010)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	**2009**	2010	2011	2012	2013	2014
UK	4%	4%	4%	8%	12%	14%	25%	66%	85%	93%	96%	**97%**	98%	98%	99%	99%	99%
NL	70%	75%	81%	83%	86%	87%	88%	90%	93%	94%	96%	**96%**	97%	98%	98%	99%	99%
DK	12%	17%	21%	34%	39%	51%	58%	70%	83%	88%	89%	**92%**	94%	95%	97%	98%	99%
SV	2%	3%	4%	4%	6%	10%	17%	29%	43%	52%	67%	**78%**	91%	98%	99%	99%	99%
IRE	0%	0%	0%	0%	1%	2%	3%	6%	7%	23%	50%	**77%**	83%	90%	93%	95%	97%
DE	19%	24%	28%	33%	38%	44%	49%	52%	59%	64%	71%	**73%**	75%	79%	82%	85%	88%
BE	2%	2%	4%	8%	10%	14%	17%	23%	33%	46%	58%	**63%**	69%	74%	80%	86%	89%
AT	18%	18%	22%	26%	30%	32%	34%	41%	41%	46%	49%	**51%**	57%	64%	72%	80%	85%
SK	0%	1%	1%	3%	5%	8%	15%	21%	28%	31%	37%	**43%**	47%	52%	60%	67%	73%
FR	0%	0%	0%	1%	2%	3%	5%	11%	19%	25%	32%	**38%**	47%	58%	74%	87%	92%
PL	0%	1%	1%	2%	4%	7%	9%	13%	18%	24%	30%	**35%**	42%	50%	56%	63%	67%
SI	0%	0%	1%	2%	4%	5%	8%	16%	22%	27%	32%	**33%**	32%	33%	33%	35%	37%
CZ	1%	1%	1%	3%	5%	7%	9%	13%	16%	20%	26%	**31%**	38%	48%	58%	69%	78%
IT	1%	1%	2%	3%	3%	4%	5%	7%	10%	20%	29%	**28%**	34%	43%	62%	80%	87%
EST	0%	0%	0%	0%	3%	4%	8%	14%	20%	27%	28%	**28%**	27%	27%	28%	29%	30%
HU	0%	0%	1%	1%	1%	1%	2%	3%	7%	11%	20%	**27%**	29%	31%	33%	36%	39%
LT	0%	0%	0%	0%	0%	4%	4%	5%	11%	15%	22%	**20%**	22%	23%	25%	27%	29%
BU	0%	0%	0%	0%	0%	0%	2%	2%	8%	13%	14%	**19%**	19%	19%	20%	20%	20%
LV	0%	0%	0%	0%	1%	2%	7%	10%	16%	20%	20%	**18%**	19%	21%	24%	27%	33%
ES	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	9%	**16%**	20%	36%	65%	78%	84%
RO	2%	2%	1%	0%	0%	0%	1%	2%	3%	6%	7%	**7%**	8%	10%	12%	15%	18%

FIN	0%	0%	0%	0%	0%	1%	1%	2%	2%	3%	4%	**6%**	6%	6%	7%	8%	11%
PO	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	2%	**4%**	8%	28%	60%	77%	88%
GR	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%	2%	**3%**	3%	3%	4%	5%	6%
EU 27	**9%**	**10%**	**11%**	**13%**	**14%**	**16%**	**20%**	**32%**	**40%**	**47%**	**55%**	**59%**	**63%**	**69%**	**77%**	**85%**	**88%**

2.3.2 Manufacturers trends

Ongoing globalization continues to affect the market for heating and hot water solutions. Larger manufacturers of thermo-technology products have an international presence and generate a growing portion of their revenues outside their home markets. So far, however, there is no truly global thermo technology manufacturer who holds material shares of the three large continental markets, i.e. North America, Asia and Europe.

Europe, the most important market for thermo technology products, continues to be dominated by German suppliers. According the Lot 1 study the leading manufacturers in 2003 were Vaillant (Germany), BBT (Bosch Buderus Technik, Germany) and Baxi (UK).

Around 2006 the league table was again led by three German manufacturers – BBT Thermotechnik, Vaillant Group and Viessmann Werke – followed by the British Baxi Group and the Italian MTS Group, who switched places as compared to the previous year. Other companies with significant market shares are Ferroli and Riello from Italy, Atlantic from France, Remeha/De Dietrich from the Netherlands/France and Weishaupt from Germany.

Between them, the top ten holds just under 70 % of the European market for gas and oil-fired heating systems in 2006. When including the heavily fragmented sub-markets for systems using renewable energies, the share of the top ten declines to 58 %. These relatively new markets are characterized by a large number of smaller specialist companies, many of which operate only regionally.

Competition in the thermo technology sector continued to increase in the past year. The growing technological standards of the systems, combined with strong pressure on prices led to continued market consolidation with numerous cooperations and acquisitions, especially in the western European heating technology market. Nearly all of the larger manufacturers are currently adopting an increasingly international positioning with a view to benefiting from future growth opportunities, also outside western Europe.

The consolidation process goes hand in hand, however, with a major structural change. The trend towards highly efficient heat generators powered by a growing proportion of renewable energies continues. As a result, a large number of new players such as manufacturers of electric heat pumps, solar collectors or solid fuel heating systems have entered the market. Accordingly, investment in companies with this kind of special expertise has increased.

In 2009 Remeha/De Dietrich (in 2009 listed as #7) took over Baxi (which suffered from a setback of the market in the homeland UK and was listed #4 in 2009, probably after Viessmann) and the alliance is now believed to be back in the top-4 position.

Table 32: Major manufacturers, brand names and relative ranking (source: VHK, on basis of Lot 1 and recent data)

probable ranking	Manufacturer group	Brand names
1	Vaillant	Vaillant, AWB, Bulex, Glow-Worm, Saunier Duval
2	BBT	Bosch, Buderus, Nefit, ELM Leblanc, Geminox, Worcester

3	BDR Thermea (previously Baxi and Remeha/DeDietrich):	De Dietrich, Oertli, Remeha, Serv'elite en Sofath Baxi, Heatrae Sadia, Potterton, Chappée, Ideal Standard,, BaxiRoca, Brötje, Baymak
4	Viessmann	Viessmann, Tasso
5	MTS	MTS, Rendamax, Ariston, Chaffoteaux & Maury, Elco
6	Riello	Riello, Beretta, Thermital
7	Ferroli	Ferroli, Joannes, Rapido, Euroterm
8	Immerfin	Hydrotherm
9	Caradon	Ideal Stelrad
10	others	a.o. Fonderie SIME, Biasi, MCC, TUI, Intergas, Frisquet, Atlantic, Ravenheat, ZDB, etc.

2.3.3 Wholesale / retail trends

Competition has also become much more intense at the wholesale level. Faced with declining margins, wholesalers have stepped up their efforts to cut costs, increase their range of services and expand their activities across regional and national borders. This led to a growing number of mergers and acquisitions in the past two years, in which larger wholesalers in Europe played an active role. The Richter + Frenzel Group, for instance, took over 80 branches with roughly 700 employees from the bankrupt Schulte Group in mid-January 2007. Wolseley, the world's largest wholesaler of sanitary and heating products, also announced four more acquisitions at the beginning of 2007. Since August 2006, Wolseley has made 29 acquisitions with a sales volume of 560 million British pounds in Europe and North America. The French Saint-Gobain Group also attracted attention with a large number of cross-border acquisitions, most of them in Europe. Nevertheless, the acquisitions in the wholesale sector represent only isolated activities, which have not changed the sector structure materially so far.

The prevalent form of distribution is: manufacturer/importer > wholesaler > installer/contractor. For two main boiler categories the distribution is presented in the figures below.

Figure 7 Sales structure for wall hung boilers

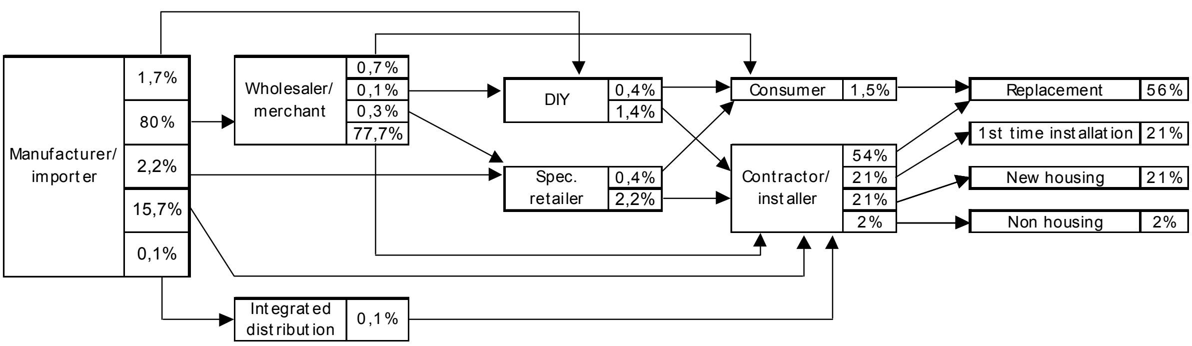
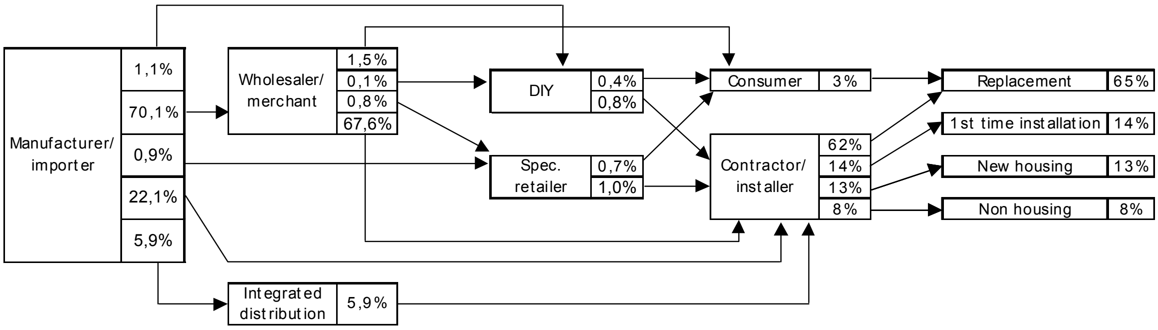


Figure 8 Sales structure for floor standing boilers



Note that the bulk of sales (80% of production) go through wholesalers/merchants. Especially for wall hung gas boiler market wholesalers are becoming increasingly concentrated (less wholesalers serving the market), with Wolsely and SaintGobain taking the lead.

Another significant portion of sales (approximately 15%) are delivered from factory to installers, sometimes through integrated distribution channels (e.g. the Buderus-brand has its own sales organization).

When looked upon at country level the amount of boilers sold through DIY channels is still limited in volume and ranges from 1 to 3% maximum. The amount of boilers installed by consumers themselves (including boilers obtained through installers) ranges from 5 to 17% for a specific number of countries for which these sales are known (FR, NL, PL, SK).

A recent phenomenon related to such sales is the increased importance of online sales. Although factual data is lacking, the mere (growth in) presence of websites that offer boilers to end consumers indicate a market demand for these services.

Most of these online sales channels focus on wall hung gas boilers, that are relatively easy to ship, but oil and solid fuel fired boilers are being offered as well. Offers for heat pumps remain relatively modest but are growing, also because of the fact that all the larger manufacturers now also offer heat pump solutions (often by mergers with or take-overs of heat pump producers).

The installation of the boiler is often optional: consumers may decide to install the boilers themselves, leaving only the commissioning of the system (final check of safety and performance) to certified installers, depending on what local or national regulation prescribes/allows.

2.3.4 Market segmentation

The boiler market can be segmented on the basis of various product characteristics. To name but a few: fuel type, installation type, capacity, combined function, etc.

The most comprehensive overview of the market segmentation of central heating boilers is available from the lot 1 study, for year 2004. Although outdated with regard to actual sales data, it does present a good overview of the different market segments on offer.

Table 33: EU boiler market: Technical segmentation 2004

Product characteristics	WALL HUNG		FLOOR		JET BURNER

		GAS		STANDING GAS *					
		‘000	%		‘000	%		‘000	%
		pieces			pieces			pieces	
Total	total: 6595	5 281	100,0%		423	100,0%		891	100,0%
Condensing	No	3 985	75,5%		371	87,6%		857	96,2%
	Yes	1 296	24,5%		53	12,4%		34	3,8%
Hot water production	Non-combis / Heating only:								
	- with built-in cylinder				66	15,6%		239	26,8%
	- with external cylinder	801	15,2%		136	32,1%		363	40,7%
	- without cylinder	295	5,6%		171	40,5%		276	31,0%
	Mounted on fs cylinder	65	1,2%						
	Combis:				44	10,4%			
	- conventional/pre-heat	3 612	68,4%						
	- storage	507	9,6%						
Heat exchanger	copper	3 159	59,8%		22	5,1%		-	-
	steel***	884	16,7%		97	23,0%		495	55,6%
	aluminium	951	18,0%		15	3,5%		-	-
	cast iron	270	5,1%		283	67,0%		383	43,0%
Output (kW)	8-15	564	10,7%	<30	224	53,0%	<35	422	47,3%
	16-25	3 810	71,9%	30-<70	138	32,7%	35-<50	281	31,5%
	26+	904	17,1%	70+	55	12,9%	50-<70	108	12,2%
							70-<120	33	3,8%
							120+	34	3,8%
Burner type	conventional	3 668	69,5%		253	59,8%			
	fan assisted premix	1 353	25,6%		59	14,0%			
	other low NO_x	243	4,6%		105	24,8%			
Flue type	open	1 232	23,3%		305	72,1%		627	70,4%
	room sealed	4 033	76,4%		112	26,5%		251	28,2%
Ignition type	pilot	293	5,5%		100	23,6%			
	electronic	4 972	94,2%		317	75,0%			
Fuel type	natural gas	5 047	95,6%		403	95,2%	oil/gas**	251	28,1%
	LPG	218	4,1%		14	3,3%	oil	518	58,1%
							gas	110	12,3%

* Excluding Jet Burner Boilers

**=inc.bifuel

***= for jet burners ‘steel/mixed’

NB: segmentation does not always cover 100% of sales, as data is not always available for a number of countries (Estonia, Latvia, Lithuania, Greece, Hungary, Slovakia, Slovenia)

BRGC estimates that for gas-fired wall hung boilers 10,7% have outputs <15 kW. Sales are concentrated in the 16-25 kW range (average 22 kW). Some 24,5% of sales are condensing units. The overwhelming majority of wall hung boilers (>94%) are sold as dual purpose appliances (space heating and hot water) with 79% being 'combis' and some 15% with external cylinders. Of the 5,6% that are neither combis nor sold with a hot water cylinder, it is likely that some will be replacement boilers that will be fitted to existing indirect cylinders. Copper heat exchangers account for the majority of sales, typically associated with non-condensing models sold in Italy, UK, France and Spain. Most condensing models have (stainless) steel or aluminium heat exchangers. Fanned room-sealed systems (Type C) account for 73% of sales. However, in Germany (50%) and France (43%) open flues –typically associated with dedicated boiler rooms- retain a substantial share. In Italy and Spain the share is 22-23%. Pilot flame ignition has almost disappeared (94% are electric). BRGC estimates a 4% market share for LPG-fired boilers, with non gasified areas in Italy, Spain, France, UK and Portugal accounting for 90% of demand.

Floor standing gas boilers can be found both in the residential and the non residential market. 54% of sales are <30 kW, 30% are in the 30-70 kW range and finally 13% have outputs above 70 kW. The condensing penetration stays much lower than for wall-hung. For 2004 BRGC reports the sales of 55000 condensing models representing 12,7% of the market. By 2006, mainly due to legislation in the UK, this should have risen to 82000 (26%). The BRGC analysis shows that around 60% of floor standing gas boilers were sold with a sanitary hot water facility. Around 10% were 'combis' (BRGC definition) and 48% were sold with a cylinder: 16% with a built-in cylinder (including tank-in-tank and bain marie models) and 32% with an external cylinder.

Jet burner boilers (mostly oil-fired) are usually sited in dwellings or buildings which have a cellar or other area not frequented by occupants. Thus they are generally associated with larger properties. Just under half fall within the "normal" range for individual central heating (<35 kW), and a substantial proportion (44%) are in the intermediate range of 35-70 kW. 3,8 % are over 70 kW. In contrast to the gas boilers there is a substantial business in replacement burners. For 2004 BRGC reported sales of 0,64 mln. burners, of which 0,25 mln. for new boilers and 0,39 mln. for replacement. According to BRGC the majority of jet burners use open combustion systems (type B) but with a fan (e.g. type B23). Penetration of condensing technology in this segment is estimated to be low (2,4%): some 21000 units of which 20000 in Germany. Some 70% of jet burner boilers are sold with a cylinder (26,5% built-in and 41% external). As with the other boiler categories, many of the boilers sold without a cylinder may be fitted with to an existing cylinder.

The table above applies to the EU market. By showing data for individual countries, differences in the national markets, especially in the fuel mix, become visible - See Annex II for a segmentation by country.

As regards cogeneration systems, segmentation according electrical power output is customary.

Table 34: Segmentation of cogeneration by electrical output

Product category	defined by electrical output
Micro-CHP	<5 kWe
Mini-CHP	5-500 kWe
Small scale CHP	500 kWe – 5MWe
Medium scale CHP	5-50 MWe
Large scale CHP	> 50MWe

Other market segmentations on the basis of working principle (often related to fuel source) are possible but less relevant since only a limited number of principles are readily available. They however hint at a possible future trend in development.

Table 35: Segmentation of cogeneration by working principle

Working principle	Description	Fuel
conventional: combustion engine	as in most generators: a internal combustion engines drives shaft to which a electric generator is attached. The flue gases and cooling circuit are used to transfer useful heat.	natural gas, diesel, light fuel oil, biomass-based oil
market introduction: Stirling engine	most applied: hermetically sealed free-piston Stirling engines with external combustion of natural gas. The Stirling engine is heat-driven and generates a reciprocating piston that acts as a linear generator. The flue gases are used to transfer useful heat from.	natural gas, although a variety of combustible fuels is possible (external combustion)
in development: fuel cells	a variety of fuel cell types is possible: PEM – polymer exchange membrane, MCFC – molten carbonate fuel cell, SOFC – solid oxide fuel cell. The chemical process creates an electrical current, the waste heat can be used for heating purposes. The temperature levels vary per fuel cell type.	depends on the fuel type: PEM requires clean hydrogen, whereas SOFC may handle natural gas

2.3.5 Design cycle - lead times

The (re)design cycle of boilers in this study is defined as the time between and the development of two successive boiler platforms. With platform is meant the type of primary heat exchanger around which the boiler (range) is designed. Most other components (circulator, electronics, fan, valves, etc.) have more "drop-in replacement" characteristics and are subject to much shorter redesign cycles.

Based upon impressions of the largest European Biannual Trade Fair "ISH Frankfurt" it is noticed that modern platforms by major boiler manufacturers last two successive shows, indicating a platform life of 4 years. This does not mean that a platform is discontinued after 4 years. Most platforms stay in range longer than that, but the changes are most often limited to more cosmetic aspects.

Obviously redesign cycles of products that compete on technical features (e.g. condensing gas combis) are much shorter than those of products that use a more established technology and mainly compete on boiler price (e.g. standard wall hung gas combis, standard oil boilers). This is of course a simplification of reality since technical features and price play their role in whatever kind of market. Even today there is still a market for boiler designs that are essentially over 20 years old (e.g. cast iron gas/oil boilers). It is just to show the intrinsic character of the market and its effect on boiler (re)design.

2.3.6 Production costs

Production costs of central heating boilers are assessed on the basis of end-user (purchase) prices and assuming mark-up factors for the sectors involved (installer , wholesale). The result is the manufacturer selling price.

Table 36: Assessment of Manufacturing Selling Price (est. VHK 2006)

	Price in Euro	Factor of msp	mark-up
List price, incl. VAT 19%	1744		15%
Consumer street price, incl. VAT 19%	1500	1,84	19%
Consumer street price, excl. VAT 19%	1260	1,55	20%
Wholesale price	1055	1,3	30%
Msp: Manufacturer selling price	812	1	

The manufacturer selling price can then be broken down into cost price of various parts and labour.

Table 37: MSP (manufacturer selling price) split up (est. VHK 2006)

	% of MSP	**mark up's**	**cost (€)**	**cost (€)**	**cost (€)**
MSP (manufacturer selling price)	100%		812		
Overhead (marketing, admin, margin)	35%		284		
Labour (finishing, assembly, testing, packaging)	15%		122		
Subassemblies & components (OEM)	50%		406		
of which					
OEM: Overhead				81	
OEM: Labour		15% (=7,5% * msp)		61	
OEM: Raw materials		35% (=17,5% * msp)		142	
OEM: Secondary OEMs		30% (= 15% * msp)		122	
of which					
Sec. OEM: Overhead		15% (=2,2% * msp)			18
Sec. OEM: Labour		20% (=3% * msp)			24
Sec. OEM: Raw materials		65% (=9,8% *msp)			79
Overall: Overhead 47,2% (€ 383), labour 25,5% (€ 205), materials 27,3% (€ 221)					

2.3.7 End-use segment

Another market segmentation is according the end-use segment. Most of the central heating boilers sold will serve as replacement of an old existing boiler (some 60% of sales). The development of new housing also creates a market demand. Note that in the last three years the new housing development has suffered severely from the financial crisis that swept (and continues to affect) European housing/building development. The third major end-use segment is first-time installations: These are installations in existing housing that not had a central heating system before. here the central heating boiler often replaces local heaters or large out-dated collective heating systems. The fourth segment is non-housing (industrial, service sector, etc.).

Table 38: Sales by end-use segment, EU year 2004

Product	Total sales	New housing	First time install.	Replace ment	Non housing		Total	New housing	First time install.	Replace ment	Non housin g
	'000	'000	'000	'000	'000		%	%	%	%	%
Wall Hung Gas Non Cond	3985	924,1	580,0	2428,7	52,0		*100,0%*	*23,2%*	*14,6%*	*60,9%*	*1,3%*
Wall Hung Gas Cond	1296	327,7	177,9	739,6	50,9		*100,0%*	*25,3%*	*13,7%*	*57,1%*	*3,9%*
Gas Floor Standing (excl. JB)	424	54,3	47,1	279,9	42,4		*100,0%*	*12,8%*	*11,1%*	*66,1%*	*10,0%*
Jet Burner Boilers	890	139,3	111,2	546,6	93,3		*100,0%*	*15,6%*	*12,5%*	*61,4%*	*10,5%*
Solid Fuel	237	43,1	30,5	147,0	16,1		*100,0%*	*18,2%*	*12,9%*	*62,1%*	*6,8%*
Electric	39	4,1	7,6	26,5	0,4		*100,0%*	*10,6%*	*19,6%*	*68,7%*	*1,1%*
Heat Pumps	118	44,4	48,4	18,0	7,3		*100,0%*	*37,6%*	*41,0%*	*15,2%*	*6,2%*
Total	6989	1537	1003	4186	262		*100,0%*	*22,0%*	*14,3%*	*59,9%*	*3,8%*

2.4 Subtask 2.4: General trends and potential

2.4.1 Potential of ecolabelled/GPP products

The section required a discussion regarding the current and future potential for the market penetration of possible Ecolabelled / GPP products (note: In Task 4 and 5 -to do- this discussion will be elaborated). The potential of course very much depends on the actual criteria for Ecolabelling / GPP.

Several aspects should be considered:

1. Uniform criteria regardless of heating technology, or specific criteria per heating technology?

   If a uniform benchmark - regardless of technology and applicable to all central heating products - is proposed, then the criteria will set the lowest common denominator: If one chooses to allow condensing boilers and better, then all heat pumps, regardless of performance within the heat pump group, may comply. If however the criteria are set for specific technologies, as in the current Ecodesign proposal for 'small' (4-15 kW), 'medium' (15-70 kW) and 'large' (70-400 kW) fossil fuel boilers, for 'medium/high temperature heat pumps' and 'low temperature heat pumps', there will be more competition within the specific product groups. The possible effects of such considerations will be discussed in Task 4 of this report [Task 4 to be completed].

2. Criteria for boiler efficiency or configuration efficiency?

   If the criteria apply to seasonal space heating efficiency of the boiler alone (as is the basis for Ecodesign requirements and the Energy label) then there is little incentive for the market to propose configurations with parts not considered in that efficiency value, besides what is currently proposed for suppliers in the Energy label Regulation, using product fiche 'sheet 2'. If however the benchmark applies to the efficiency of the complete configuration (sheet 2), the market will have an incentive to supply such configurations. In addition, the criteria could also apply at both levels, a criterion for the configuration combined with a criterion for the boiler in that configuration (to prevent substandard boilers achieving a label).

3. Limitations for using specific technologies

Not all central heating products, especially those using renewable energy (ambient heat or solar thermal energy), can be installed in average installation environments. In many cases specific installation requirements apply:

- Condensing boilers require a flue gas systems that can withstand corrosive wet flue gases. Many chimneys in existing multi-family buildings need to be retrofitted for this purpose in order to enable installation of condensing boilers. In buildings with multiple-owners and a collective flue gas shaft this may pose problems. This is also the reason for not raising the space heating seasonal efficiency of low capacity boilers (4-15 kW) beyond 75%.
- Ground-coupled heat pumps need space for installing the ground probes or to dig/bore wells. Especially existing buildings in urban environments have severe space constraints.
- Air-based heat pumps emit noise and show lower efficiencies in colder temperatures. The noise can be a limiting factor in installation.
- Solar thermal energy systems require space on roof-level. Sloped or flat roofs are technically not a problem, but in multi-family housing it is difficult to realise individual systems since the roof space is either shared and/or too far away from lower level apartments. Collective systems have a better chance in multi-family, multi-owner buildings.
- There are however also options that foster the take-up of new energy efficient technologies: Buildings with collective heating systems may be converted to using central heat pumps, with individual transfer stations per apartment.

Overall, discussions during the preparation of the Ecoboiler / Energy label proposals have shown that only a small share of buildings in Europe have problems converting from existing boilers to condensing boilers.

As regards using solar thermal energy, ESTIF has provided estimates that approximately ... m2 can be installed on European roofs in 20.. . Of course this is a optimistic view assuming ideal market circumstances, but nonetheless it gives an idea of the potential.

As regards heat pumps, EHPA also provided estimates of the potential applications, to some ... units in 20.. . This also gives and idea of the potential.

As regards cogeneration, COGEN Europe indicated a potential of .. units in 20.. [to complete].

2.4.2 Possible trade issues;

As regards voluntary instruments such as the European Ecolabel there are not real trade issues, since the commitment is done by private companies on a voluntary basis.

Regarding Green Public Procurement (GPP) there might be legal issues regarding the tender procedure. In short the legal standpoint is that, if one sets purchase criteria that can be met by products carrying the European Ecolabel, the tender documents may refer to the Ecolabel as means to show compliance, but the specifications may not require the product to actually carry the label (the Ecolabel can not be a compulsory requirement). If the rules for transparent and open tender procedures are respected, then tendering procedures may include environmental criteria.

2.4.3 Other issues listed under subtask 2.4

Subtask 2.4 also required consideration of various other aspects, such as a determination of the best performing products within the group and the benchmarks of the environmental aspects that provide the top performance (approximately 10-20% of market) - this aspect is dealt with by subtask 3.3 “improvement potential”

As regards the public procurement volumes in the EU and other GPP specific data, no information could be identified.

3 Task 3: Technical analysis

This task comprises the description of environmental aspects of central heating products.

The first subtask involves the construction of a life cycle model, describing the environmental aspects and impacts associated with the life cycle of central heating products.

The second subtask involves a discussion on the use of toxic and/or hazardous substances in heating products and their contribution in the overall environmental impact of these products.

The third subtask involves the identification of the environmental improvement potential as identified using the least life cycle cost (LLCC) method.

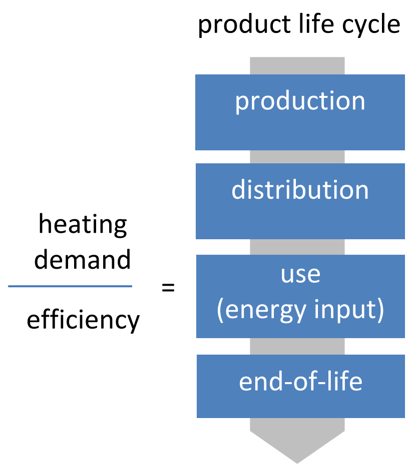
3.1 Subtask 3.1 - Construction of the life cycle model

The aim of this section is to describe and compare the environmental impacts of the central heating products over their complete life cycle. Central in this section is the work done in two previous preparatory studies: the 'Lot 1' preparatory study on gas/oil/electric central heating boilers and the 'lot 15' study on small solid fuel combustion installations, covering also biomass central heating boilers.

3.1.1 Life cycle model

The figure below indicates the place of heating demand and efficiency in the life cycle model.

Figure 9 Representation of product life cycle



The 'Life cycle model' describes the environmental impact of central heating products per life cycle phase. For practical reasons it is not possible to present the life cycle data for all possible variations and configurations of central heating products. Therefore, a selection of products had to be made.

3.1.1.1 Product cases

From the nine base cases described in the Lot 1 study the most popular M-size and the relatively large XXL-size boiler were selected. As regards biomass boilers a small manual stoked, small automatically stoked boiler and medium-sized automatically stoked boiler were selected. To this were added a 'M-size' electric heat pump and a 'M-size' cogeneration unit.

Table 39 Lot 1 base cases

Boiler type / fuel	Nominal capacity	Description
	kW output	
gas/oil M	22	standard non-condensing boiler, efficiency full load, high temperature: 80% GCV / 88% NCV part load, low temperature: 80% GCV / 88% NCV
gas/oil XXL	115	standard non-condensing boiler full load, high temperature: 80% GCV / 88% NCV part load, low temperature: 80% GCV / 88% NCV
small manual biomass boiler / wood logs	29	manually stoked full load efficiency 70% NCV
small automatic biomass boiler / pellets	29	automatically stoked full load efficiency 80% NCV
medium automatic biomass boiler / wood chips	110	automatically stoked full load efficiency 85% NCV
7 kW electric heat pump	7	inverter driven full load efficiency: COP > 4
Cogeneration-boiler Stirling-engine	22	Stirling engine: 1 kW electric output, 5 kW thermal output, overall efficiency 90% complementary boiler-part based on using condensing technology: full load, high temperature: 89% GCV / 99% NCV part load, low temperature: 96% GCV / 107% NCV

Note that the heat pump has a lower output capacity than the competing gas/oil boilers - for economic and energy efficiency reasons the heat pump is assumed to be better dimensioned to meet the actual heat demands (whereas normal boilers are usually seriousely overdimensioned). Therefore the 7 kW heat pump is deemed to meet the M-class heat demand.

These central heating boilers are selected since these are the bulk of the sales the coming years (gas/oil boilers), or cover significant growth areas (biomass, heat pumps, cogeneration).

The following sections describe for each boiler type the life cycle (phase by phase). The final section will present an overview of environmental impacts.

3.1.1.2 Production & manufacturing phase

The impacts during the production & manufaturing phase are determined by the type and quantity of material used and how these are processed. Both gas/oil/electric and biomass boilers have been assessed using using the MEEuP Ecoreport tool.

For the gas/oil and biomass boilers the studies presented the bill-of-materials of typical products A comparative overview is provided below:

Table 40 Gas/oil boiler bill-of-materials

Boiler		polymers	ferrous	non-ferro	coating	electr.	other	total

gas/oil-fired	22 kW ('M)	4.8	36.6	7.8	pm	0.7	pm	45.4
	115 kW ('XXL')	6.5	212.6	1.5	pm	0.9	pm	221.4
biomass	small-manual/wood log 25 kW	0	350	0.4	0.4	3	27.4	380
	small-automatic/pellet 25 kW	0	316	1.4	0.7	0.5	0.8	320
	medium-automatic chips 100 kW	1.8	270	6.5	0.9	2.4	7.7	289
el. heat pump	7 kW	9.8	154	54	pm	15	47	280
cogeneration	22 kW	14	96	24	0	2	0	136

The Lot 1 study did not provide a bill-of-materials for electric heat pumps, but the related Lot 2 study on water heaters did[52]. The bill-of-materials of the heat pump provided in Lot 2 originally covered a ground-source heat pump, but the total weight of 280 kg is believed to be representative for other heat pumps of similar capacity as well [53].

For cogeneration boilers no indication of material composition could be retrieved, but many components (apart from the stirling-generator and related equipment) are shared with conventional central heating boilers. and the overall weight (for a 22 kW boiler) is close to 130 kg[54]. Therefore as material composition the inputs of the gas/oil boiler multiplied by three are used (total weight becomes 136 kg).

Manufacturing impacts (shaping, forging, moulding, etc.) are added to the life cycle total on the basis of the materials indicated (depending on the material input either injection moulding, ferrous forming, non-ferro casting, etc. is applied,).

It is assumed that packaging materials have been added to the material inputs but previous studies have shown these to be of insignificant influence in life cycle impacts of central heating products.

By default 1% of total material input is added to the life cycle to account for repair and maintenance (replacement parts etc.).

3.1.1.3 Distribution phase

The distribution phase of central heating boilers is calculated accrding default Ecoreport scenarios using the transported volume and the 'type' of product as inputs (whereby installed products such as central heating boilers are assumed to be distributed over land, by trucks, rather than being transported by aeroplane).

The distribution (transport) of fuels is accounted for in the 'Use-phase' and included in the emission profiles of fuels.

[52] Electric heat pump bill-of-material was included in Lot 2 - Water heaters (done in parallel to Lot 1, also by VHK)

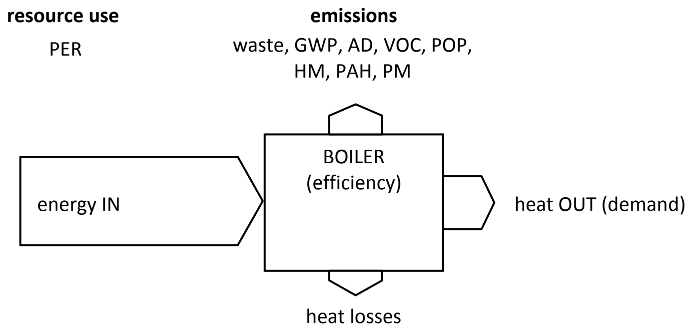
[53] For example, the Daikin Altherma range varies from 180 kg (monobloc) to over 260 kg (high temperature), excluding a storage tank. The Waterstage heat pumps from General vary from 100 to 183 kg (excluding storage tank).

[54] Based on product weight of Remeha Evita 25 kW Stirling cogeneration boiler: 130 kg.

3.1.1.4 Use phase

The use-phase describes the impacts of the energy consumption and other consumables during use. Here the lot 1 and the lot 15 study followed different approaches. The Lot 1 study established nine representative classes of heat demand and then calculated backwards to establish the energy input needed to realise this heating demand. The calculation involved a complete analysis of all relevant energy loss factors, including the system losses resulting from distribution, fluctuation and stratification effects.

Figure 10 Impacts from use phase: PER and Emissions



Fossil fuel boilers

In most product brochures only the nominal efficiency of boilers is indicated: This is the efficiency of a boiler in specific steady state conditions (at full load 100% and part load 30%, and at 80/60 or 50/30ºC send/return temperature). This efficiency neglects effects of a dynamic heating load as experienced in an average heating season and is therefore not representative for the real-life heating system efficiency. Furthermore the efficiency is limited to boiler output only, and gives not a correct relation between heat demand of a space and energy input needed to meet that heat demand. Some of the energy input to a boiler is needed to overcome losses inherent to operating a hydronic heating system, using piping and emitters.

The Lot 1 study described extensively the real-life energy efficiency of the gas/oil/electric central heating systems. The real-life efficiency is calculated as the total primary energy input needed to realise a certain seasonal heat demand, divided by this heating demand.

For a conventional boiler of 80% (GCV) nominal efficiency the real-life seasonal efficiency was calculated to be some 54%. For the best condensing boilers with 96% GCV nominal efficiency the seasonal efficiency was calculated to be close to 76%.

Table 41 Gas/oil energy consumption (input), heat demand (output) and efficiencies

Gas/oil/electric boilers [55]	Thermal output	(without system losses)	Energy input	Efficiency	
	net heat demand	gross heat demand	fuel consumption	nominal (full load_HT / part load_LT)	real life
	kWh/yr	kWh/yr	kWh/yr	GCV	GCV
M -base case	7.480	8.879	13.247	80%/ 80%	54%
M - condensing	7480	8879	11776	87%/95%	61%
XXL - base case	42.195	48.638	89.492	80%/80%	45%
XXL - condensing	42.195	48.638	65.698	85%/91%	61%

[55] Based on Lot 1: capacity based on Task 5, table 2-3, heat demand based on Task 5, table 2-5, energy consumption from table 3-5

The current proposals for the Ecodesign Regulation aim to allow on the market basic condensing boilers and better. Therefore as basecases for this study the condensing boiler is chosen and not the conventional standard efficiency boiler.

Biomass boilers

As regards biomass boilers the lot 15 study applied a top-down approach where the overall energy consumption was allocated to various solid fuel combustion appliances. The energy consumption was therefore determined without establishment of the corresponding heat demand. An indication of heat demand was provided bij multiplying the nominal efficiency with the energy consumption.

Table 42 Biomass boilers energy consumption (input), heat demand (output) and efficiencies

Biomass boilers[56]	Energy consumption	Power input	Efficiency	Power output	Annual runtime	Thermal output (heat demand)
	GJ/year (kWh/year)	kW	% (nominal)	kW	hr/yr	kWh/yr
small boiler	67 (18.482)	39	75%	29	478	13.862 (a)
medium boiler	322 (89.840)	138	80%	110	651	71.610 (a)

(a) Energy output (or "Heating demand") of biomass boilers is based upon annual runtime multiplied by nominal power output and is not corrected for real-life efficiencies. It is not an adequate description of the average heat demand of buildings heated by biomass boilers.

Note that the nominal efficiency is only a partial indicator of the real life efficiency. For many biomass boilers part load operation is not established, and maybe not even be feasible for manually stoked biomass boilers.

As regards the energy consumption of (solitary) heat pumps and cogeneration boilers: these were not included as such in the final documents of the Lot 1 studies[57] and therefore the energy consumption presented here is established for the purpose of this study only.

Heat pump boilers

In order to calculate the energy consumption of a heat pump, the energy efficiency and heat demand need to be known. The energy efficiency can be calculated on the basis of the SCOP, the Seasonal Coefficient of Performance, which indicates how many units of heating energy can be produced by one unit of electrical energy. The SCOP is based on a seasonal approach, taking into account variable outside climate conditions and constant indoor climate conditions. The SCOP is however not comparable to the overall efficiency as established in Lot 1, since the system effects (distribution, fluctuation and stratification) and certain control effects are not taken into account. Therefore the energy consumption shall be based on a intermediate heat demand, which can be calculated using the 'etas', the seasonal efficiency as defined according the Ecodesign proposals.

A condensing M-class gas boiler requires an fuel energy input of 11.776 kWh (thermal energy = fuel) in order to meet the heating demand of 7.480 kWh. This boiler has a etas of 89% (see example provided in Annex). With the energy input and the etas an intermediate heat demand of 10.449 kWh is calculated. This is the heat as provided to the heating system, without system losses, but also without cycling losses (start/stop, purging, etc.).

[56] Based on Lot 15: Task 3, table 3-25

[57] Lot 1 did describe hybrid solutions where a heat pump is providing a base load and the gas boiler provides additional power

Assuming the heat pump should meet this same intermediate heat demand, and has an etas of 124% (based on SCOP 3.25 and following the Ecodesign method - see example in Annex) an energy consumption of 8.460 kWh (primary) can be calculated (or 3.384 kWh electricity).

For **gas-fired heat pumps** the emission profile will depend on the type of heat pump. It can be expected that the emission profiles are comparable to that of gas-fired condensing boilers (the NOx emissions of certain gas adsorption heat pumps show NOX emissions below that of the average condensing boiler[58]).

Cogeneration boilers

The energy consumption of the cogeneration unit is also calculated on the basis of the energy consumption of the condensing gas boiler (11.776 kWh). However, cogeneration units have a lower thermal efficiency than condensing boilers, so in order to meet the same intermediate heat demand, the total energy consumption must be higher. This is taken into account by correcting the energy consumption by a factor based on the *etason* of the units (is 93.8% for the condensing boiler and 74.3% for the cogeneration unit - see Annex for calculation of example). The energy consumption is therefore assumed to be a factor 1.16 higher: 14.867 kWh. The etas of the cogeneration boiler is 105%, but this includes the electricity consumption. The etas without surplus electricity production is 67.3%. This is corrected for the contribution of the cascading boiler that supplies the remaing heat demand. The final intermediate efficiency is 72% which results in a intermediate heat demand of 10.638 kWh (which is 2% higher than for the normal condensing boiler - a correction is not deemed necessary).

Table 43 Overview of central heating boiler heating demands

Product cases	typical output power	energy input (thermal)	etason (thermal)	etas (intermediate efficiency)	intermediate heat demand
	kW	kWh/year	% GCV	% GCV	kWh/year
gas/oil M	22	11.776	93,8%	89%	10.449
gas/oil XXL	115	89.492	93,8%	88%	78.439
small manual biomass boiler	29	19.803	61,5%	52%	10.300
small automatic biomass boiler	29	17.328	80,0%	73%	12.565
medium automatic biomass boiler	110	84.247	85,0%	78%	65.611
7 kW electric heat pump	7	8.460	130,0%	124%	10.449
cogeneration-boiler	6 + 16	14.867	74,3%	105% incl electricity 67.3% excl. elec, incl cascade	10.638

Consumables

The consumables in the use-phase relate to repair and maintenance activities. As indicated earlier the replacement parts have been added (by default) to the total material input at the manufacturing stage. The visits from service personnel have been accounted for by introducing 100 km of delivery van trips during the ue phase of the product.

Refrigerant leakage (by heat pumps) is considered in the end-of-life phase.

[58] This is based upon the NOx emissions of Robur's GAHP LT which emits 25 ppm according product brochures.

3.1.1.5 End-of-life phase

The end-of-life of the products is calculated according the default scenario's provided for by Ecoreport, which means that 95% of easily recyclable materials as metals and glass is considered to be recycled. The very high metal content of most boilers makes recovery/recycling (through dismantling and/or shredding) a viable economic option

Of the plastics fraction 1% is considered to be recycled at the same level as the original product, 9% is considered to be recycled in lower grade applications and 90% is considered to undergo thermal recovery (incineration with heat recovery). The electronics will be recovered seperately, most often thermal recovery in high temperature ovens, with recovery of precious metals. This scenario is in conformity of the WEEE targets.

As regards emissions of refrigerants used in heat pumps. The refrigerant charge of a 7 kW heat pump is likely to be some 1.7 kg (example Daikin Altherma and General Waterstage LT). Literature sources, also quoted in the Lot 11 study on Airconditioning < 12 kW, indicate an average refrigerant loss of split systems of some 3% per year and an average end-of-life loss of 5%. With a product life of 15 years this accumulates to some 50% of fugitive refrigerant emissions.

The heat pumps usually use refrigerants such as R134A or R410A with a global warming potential of 1300 and 1730 kg CO2 eq. respectively (Ecoreport values).

Assuming that R410A is used, the total GHG contribution by refrigerant leakage then becomes 1470 kgCO2 eg. This is 5% of the total lifecycle GHG emissions of the basecase heat pump, and almost 6% of the GHG emissions of the use-phase only.

3.1.1.6 Life cycle environmental impacts

The table on the next page is a compilation of the environmental impacts of the basecases as presented in the Lot 1 and lot 15 reports.

The heat pump emissions and cogeneration boiler emissions have been added for the purpose of this study. The heat pump emissions are according the Ecoreport environmental indicators for average EU electricity.

The cogeneration boiler are based on that of the condensing gas boiler, with a modified acidification emissions, since the cogeneration boiler is known to emit more Nx than a good condensing gas boiler[59]. Since SOx emissions are not really an issue for gas-fired appliances, the cogeneration acidifying emissions have been raised by a factor 1.7, which is the cogeneration NOX criteria of max. 120 mg/kWh, divided by the gas boiler criteria of 70 mg/kWh. Other emissions remain the same.

The table shows that, apart from GWP, emissions from biomass boilers (on GJ output basis) are significantly higher than for gas/oil/electric (HP) boilers.

The GWP emissions from biomass boilers are nontheless not equal to zero, since GWP includes:

1) Emissions from combustion:
    a) CO2: zero, by political default;
    b) CO: 1.57 kg CO2eq.;
    c) CH4: 21 kg CO2eq.;
2) Emissions from fuel production / distribution (related to fuel consumption only);

[59] This is not described in the Lot 1 study, but a conclusion from the proposed Ecodesign requirements for central heating boilers of March 2011, where the maximum NOx emissions for cogeneration boilers are higher than for normal boilers.

Emissions from electricity consumption during use (limited to appliance only: combustion fans and controls – excluding central heating system circulators etc.) are calculated seperately and not included in combustion emissions indicated above.

The overview shows that even by considering biomass a CO_2 neutral and renewable energy source, with all the associated advantages, the fuel is not a ‘clean’ fuel and may result in significant emissions of polluting substances, especially on a local scale.

[insert landscape]

Table 44 Overview of environmental impacts - base cases "as is" (not normalised)

		materials		GER		water		waste		emissions to air							emissions to water	
		disposed	recycled	total	elec. (as prim.)	process	cooling	non-haz.	haz./incin.	GHG	AP	VOC	POP	HM	PAH	PM	HM	EP
	#	kg	kg	GJ	GJ	m3	m3	kg	kg	tCO2 eq.	kgSOx	kg	mg i-Teq	g Ni	g	kg	g Hg/20	g PO4
gas/oil M	1	6,7	38,5	743,5	41,8	3,2	110,1	5,8	119	41,9	27,3	0,5	1	1,6	0,3	2,4	0,9	13
gas/oil XXL	2	17	204,1	4213,8	246,6	16,9	656,3	356,6	10,5	254,3	222,2	3,6	2,3	5,1	0,8	6	2,2	19,3
small manual biomass boiler	3	21,9	359,0	1213,3	16,9	2,4	28,7	1244,6	2,2	7,9	163,9	9,2	140,2	60,5	309,4	301,5	2,4	76,0
small automatic biomass boiler	4	16,4	303,4	1877,0	20,2	1,5	42,7	825,3	0,7	3,8	168,3	4,4	448,2	102,4	351,5	65,6	1,3	93,0
medium automatic biomass boiler	5	18,2	271,2	6317,0	41,2	3,7	93,4	3301,2	4,0	9,4	600,8	17,0	877,2	298,8	1514,7	278,5	2,4	117,0
7 kW electric heat pump	6	36,8	243,3	637,6	621,2	49,1	1630,3	1336,3	33,1	29,9	169,3	0,4	9,7	16,3	2,6	14,1	11,2	131,5
cogeneration-boiler	7	21	115	552	-375	-32	-1007	-134	6	35	-69	1	1	-3	0	0	0	40

Where:
PER = primary energy demand
Non.haz. waste = mainly ash residu of biomass boilers (mass in g);
GWP = Global Warming Potential of gas emissions (non-renewable CO_2, CO, CH_4, etc.);
AD = Acidification, represented by SOx equivalents (SOx and NOx - included as 1 NOx = 0.7 SOx)
VOC = Volatile organic compounds, emissions of various organic compounds, mostly resulting from suboptimal combustion;
POP = Persistent organic pollutants, especially relevant are emissions of dioxins and furans
HM = heavy metals, these elements can be present in biomass
PAH = Polycyclic aromatic hydrocarbons
PM = Particulate matter, or dust emissions (also referred to as TSP - total suspenced particles, or PM10, PM2.5 etc. indicating particles of certain size).

[end landscape]

3.1.1.7 Comparative analysis

Of course it makes no sense to compare the boilers on the basis of the emissions profile indicated on the previous page: The smaller boiler usually has lower emissions, but this says little on how efficient it is.

In order to allow a fair comparison the emissions need to be harmonised. This is done on the basis of the intermediate heat demand and the average product life.

Each intermediate heat demand of a boiler is multiplied with its product life so that the result is the total thermal intermediate heating demand that one boiler can emit during its product life cyle. These are then divided by 177.634 kWh, which - as it happens- is the life cycle heating demand of the M-class gas condensing boiler. The value is effectively an arbitrary value, only needed to establish usable conversion figures (one could also divide by a different number) since the relative differences between boilers would remain the same.

The outcome is the amount of life cycles heating output, compared to that of the standard condensing boiler. By dividing the life cycle impacts by these numbers, the figures are harmonised to one gas condensing intermediate heat demand.

[insert landscape]

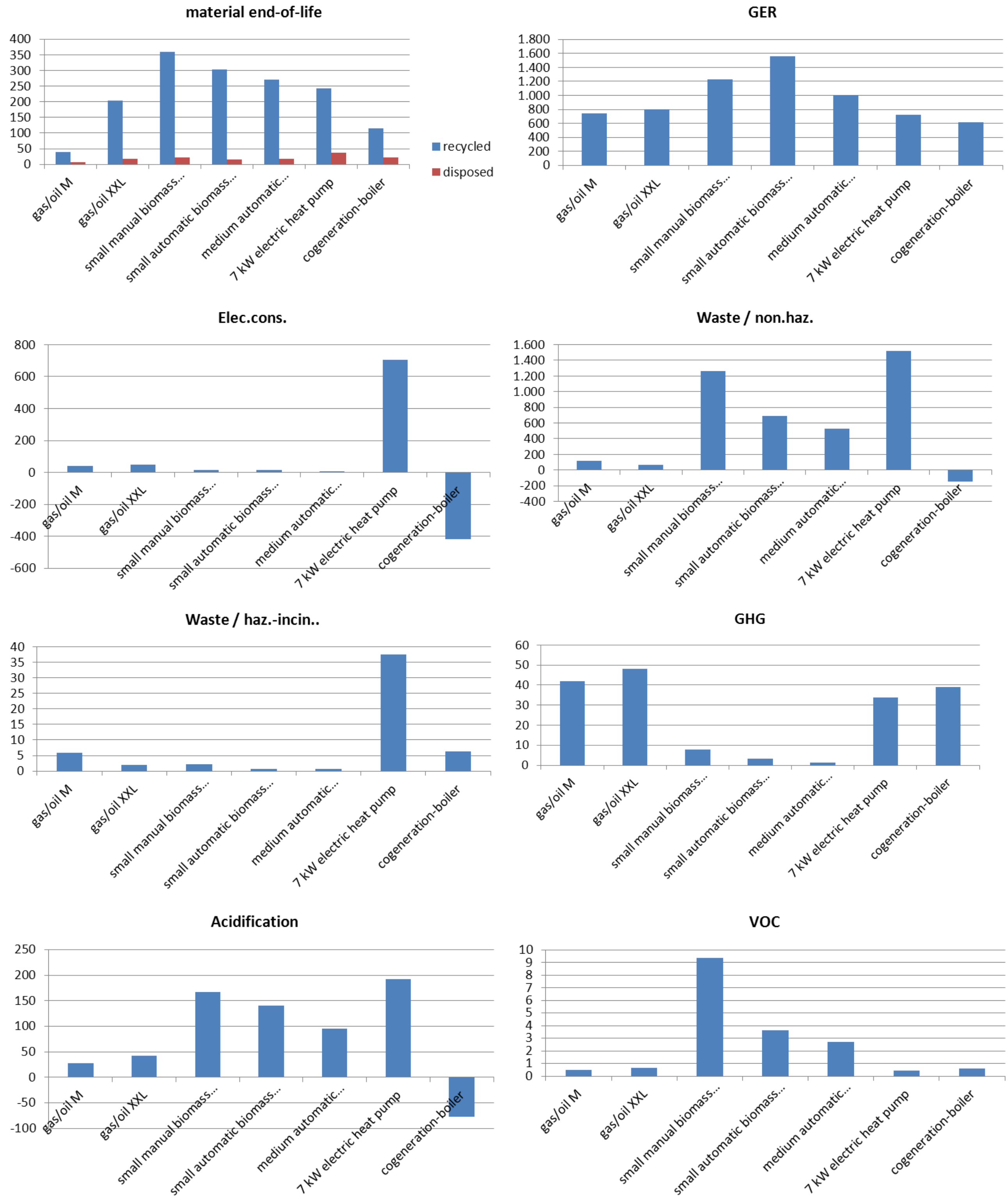
Table 45 Normalised environmental impacts (per 177.634 kWh thermal output)

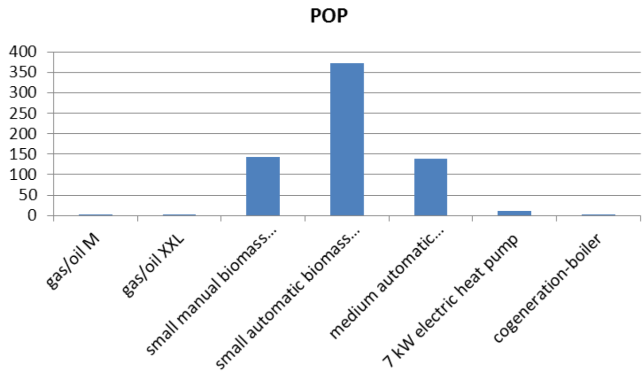
			resource use				emissions to soil										
	materials		GER		water		waste		emissions to air							emissions to water	
	disposed	recycled	GER total	elec. (as prim.)	process	cooling	non-haz.	haz./incin.	GHG	AP	VOC	POP	HM	PAH	PM	HM	Eutr.
	kg	kg	GJ	GJ	m3	m3	kg	kg	tCO2 eq.	kgSOx	kg	mg i-Teq	mg Ni	mg	kg	g Hg/20	g PO4
gas/oil M	6,70	38,50	743,5	41,8	3,20	110,10	5,80	119,00	41,90	27,30	0,50	1,00	1,60	0,30	2,40	0,90	13,00
gas/oil XXL	3,22	38,67	798,3	46,7	3,20	124,34	67,56	1,99	48,18	42,10	0,68	0,44	0,97	0,15	1,14	0,42	3,66
small manual biomass boiler	22,21	364,18	1.230,9	17,1	2,43	29,13	1.262,62	2,28	7,97	166,27	9,37	142,23	61,34	313,86	305,89	2,39	77,10
small automatic biomass boiler	13,65	252,30	1.560,9	16,8	1,28	35,51	686,33	0,58	3,20	140,00	3,64	372,71	85,18	292,29	54,53	1,08	77,34
medium automatic biomass boiler	2,90	43,19	1.006,0	6,6	0,60	14,88	525,74	0,64	1,50	95,68	2,70	139,70	47,59	241,22	44,36	0,38	18,63
7 kW electric heat pump	41,69	275,75	723	704	55,63	1.847,65	1.514,50	37,47	33,90	191,83	0,46	11,04	18,49	2,99	16,00	12,73	148,99
cogeneration-boiler	23,39	128,16	614	418-	35,4-	1.121-	150-	6,3	39,0	76,8-	0,6	0,7	3,4-	0,2-	0,5	0,1	45,0

The next pages show the normalised impacts in graphs, for each impact category.

[end landscape - start graphs]

Figure 11 Overview of normalised environmental impacts




POP
400
350
300
250
200
150
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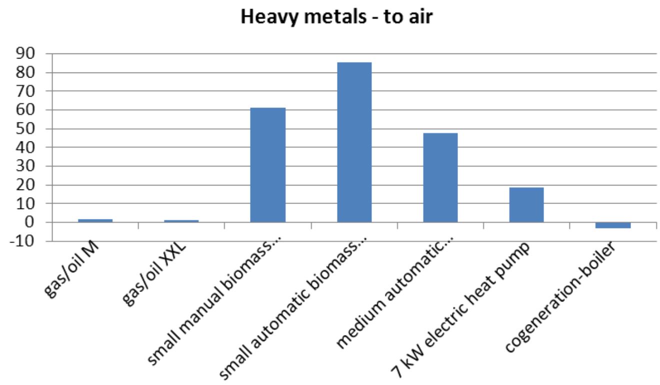
0
gas/oil M
gas/oil XXL
small manual biomass...
small automatic biomass...
medium automatic...
7 kW electric heat pump
cogeneration-boiler


Heavy metals - to air
90
80
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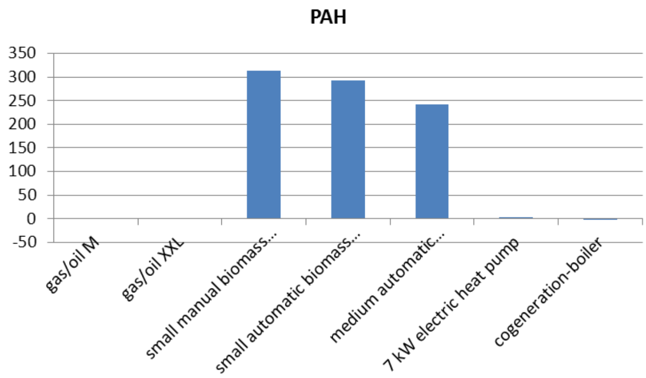
gas/oil M
gas/oil XXL
small manual biomass...
small automatic biomass...
medium automatic...
7 kW electric heat pump
cogeneration-boiler


PAH
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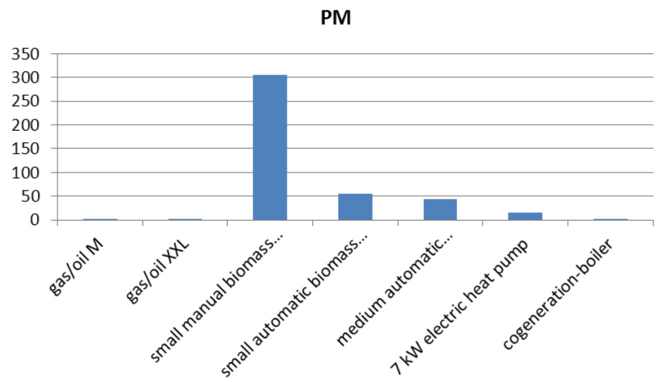
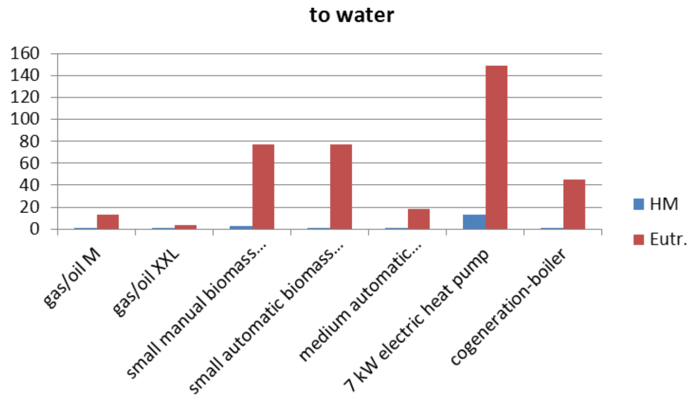
300
250
200
150
100
50
0
-50
gas/oil M
gas/oil XXL
small manual biomass...
small automatic biomass...
medium automatic...
7 kW electric heat pump
cogeneration-boiler


PM
350
300
250
200
150
100
50
0
gas/oil M
gas/oil XXL
small manual biomass...
small automatic biomass...
medium automatic...
7 kW electric heat pump
cogeneration-boiler


to water
160
140
120
100
80
60
40
20
0
gas/oil M
gas/oil XXL
small manual biomass...
small automatic biomass...
medium automatic...
7 kW electric heat pump
cogeneration-boiler
HM
Eutr.

[end graphs]

The table and the graphs shows immediately the major differences between biomass boilers and fossil fuel boilers: Biomass boilers have much lower GHG emissions than other boilers, since the CO2 production of combustion is 'zero' by political default. However, biomass boilers exhibit much higher emissions in all other impact categories. Only electric heat pumps has similar impacts in the categories acidification and non hazardoues waste.

This conclusion mirrors the very well-known fact that biomass combustion is not as 'clean' as good gas or oil combustion - which is accordingly reflected in local and national policies that limit the emissions allowed for biomass boilers (and solid fule boilers in general).

Discussion of impacts, by category:

- GER - The impacts are dominated by small automatic biomass boilers which have the lowest nominal efficiency and also the highest material input. Still, 95-99% of GER of all boilers is related to the use-phase;
- of which electricity - As expected the electricity consumption is highest for the electric heat pump and negative (meaning net electricity production) for the cogeneration boiler;
- Waste / non.hazardous - Most of the impacts stem from ash resulting from biomass combustion. For the electric heat pump the waste is related to EU electricity production (part is coal-based, etc.);
- Waste / hazardous-incinerated - These impacts relate to both hazardous waste (e.g. from electricity production) but also from plastics thermal recycling, which explains the visible contribution from gas condensing boilers and cogeneration boilers;
- GHG - As discussed above the greenhouse gas emissions from biomass boilers are the lowest. The heat pump achieves a reduction of 20% compared to the gas condensing boiler;
- Acidification - Here the NOx and SOx emissions by biomass boilers and EU electricity production appear most significant, the cogeneration boilers achieves a net reduction of acidifying emissions;
- VOC - The manual stoked wood log boiler performs the worst regarding the emissions of VOCs, this relates to both combustion efficiency and type of fuel;
- POP - Here the automatic stoked pellet boiler performs the worst, which is mainly due to the type of fuel (pellets);
- Heavy metals (to air) - Again it is the pellet boiler that performs the worst, but here the electric heat pump has significant emissions as well;
- PAH - The biomass boilers emit the most PAHs but the differences in the group are less outspoken than in other impact categories;
- PM - As regards particle emissions the biomass boilers perform the worst, with the manual stoked wood log boiler as exceptionally high source of emissions;
- emissions to water - As regards the emissions of heavy metals to water and the eutrophication impact the biomass boilers and especially the heat pump are leading. The cogeneration boiler has a significant contribution due to its material composition (relatively large amounts of ferrous and non-ferrous metals).

Conclusions

The life cycle model (effectively a comparison of life cycle impacts of boilers on the basis of the intermediate heat demand) does not indicate an overall winner. Each boiler type has its specific advantages and drawbacks, depending on which impact category is considered.

Despite this, it is obvious that improvements can be made, which reduce the impacts in the various categories:

- For gas/oil boilers the improvements would need to focus on energy efficiency (reduce GHG);
- For biomass boilers the improvements would need to focus especially on reducing harmful emissions from combustion (reduce waste, acidification, VOC, POP, HM, PAH and PM);
- For electric heat pumps improving energy efficiency would be the most effective (reduce GHG and emission related to electricity production, like acidification, (haz.) waste and heavy metals);
- For cogeneration boilers, improving energy efficiency (and material composition) would reduce most impacts.

3.1.2 Aspects not covered by product life cycle

Refrigerants

Although the Lot 1 study did include CO2 emissions from electricity production, no separate analysis was made regarding CO2 emissions (kg equivalents) resulting from refrigerant leakage. This section is dedicated to this aspect currently not covered by the life cycle model.

Most conventional refrigerants are potent greenhouse gases. Refrigerant leakage, occurring unintentionally, since each heat pump is hermetically sealed. However, connections can result in refrigerant leakage, as often is the case in remote refrigeration systems as applied in supermarket.

From Air to water systems, with the evaporator located outside and the compressor unit located inside may be most prone to leakage. Water-tot-water systems and air to water systems with evaporator and condenser in one single package are less prone to leakage.

Therefore split systems have a average refrigerant leakage of 3% per year.

Today's most common refrigerants are potent greenhouse gases with a high global warming potential and their leakage contributes directly to overall greenhouse gas emissions. Indirect greenhouse gas emissions, from electricity consumption, are another source of greenhouse gas emissions (kg CO2 equivalents). In general, direct (refrigerant-related) emissions contribute around 15-20% of the total emissions, depending on heat pump type and characteristics.

Most conventional AC units use high GWP hydro fluorocarbons (HFC) such as R410a and R407C as refrigerant. These substances, when released into the atmosphere, contribute to global warming by retaining infrared radiation from earth's surface. Their level of contribution to this effect can be expressed in kg CO2 equivalents. Since substances may break down in earth's atmosphere, usually the GWP values are related to a given time horizon. In existing legislation a time horizon of 100 years is applied. The scientific community (IPCC) has concluded that if 1 kg of CO2 has a GWP of 1 (100 yrs). For example, the GWP of the most commonly used refrigerants R-407c and R-410a correspond to GWP of 1774 and 2088 respectively. In small capacity appliances (mostly single ducts) also R290 (propane) is used. The GWP of refrigerants already used or which may be commercialised are presented below[60].

Table 46: Characteristics of common refrigerants

refrigerant	R410A HFC	R407C HFC	R1234yfHFO	R290 propane	R744 CO_2 carbon dioxide
kg CO_2 eq.	2088	1774	4	3	1
These GWP values relate to a time horizon of 100 years and are expressed as kg CO2 equivalents.					

The use of certain refrigerants with significant GWP is regulated under the EU F-Gas Regulation 842/2006 and measures focus on containment, recovery, certification and the provision of a technical label. Given the technical characteristics of the products some leakage during use and recovery is unavoidable, especially from split package units. The most common causes are leakages from connections between lines and pipes that carry refrigerants and openings in the system for filling, recharging, measurement of pressure, etc. Annual leakage rates during the use phase are estimated to be 3%/a for split systems and 1%/a for single package and single ducts. In addition, for all units, 5% leakage is assumed due to improper treatment during end-of-life.

Impact of possible direct emissions

The relative share of direct refrigerant emissions in the total (direct and indirect) greenhouse gas emissions depends on various factors such as type of refrigerant and its efficiency, type of air conditioner and its efficiency and the use of the functionalities.

Common heat pumps have a refrigerant charge between 0.2 – 0.3 kg per kW heating capacity. The charge varies according system type (split units generally have higher charge rates) and appliance characteristics (equipment with higher efficiency generally have a higher refrigerant charge).

The annual leakage of single package systems is estimated to be 1% of the initial charge per year. The leakage rate of split systems is estimated to be 3% of the initial charge per year. The leakage during end-of-life, regardless of type, is estimated to be 5% of the total charge (according industry default values of leakage).

The kg CO2 equivalent emissions per kWh of electricity consumed in Europe (average carbon intensity) are estimated to be 0.458 gr/kWh electricity.

Assuming an modest capacity oversizing-factor of 1,5 and a heating demand of some 7500 kWh/a the share of direct emissions ranges from approximately 7% for single package systems, to some 16% for split package systems (of a total of 17.300 kg CO2 eq.).

The base case M-class gas-fired central heating boiler emits some 46.800 kg CO2. In this example the heat pump reduces the emissions by 63% (compared to average base case boiler, when compared to condensing boilers the reductions will be smaller).

60 Technology and Economic Assessment Panel 2010 Progress Report - Volume 1. See also, latest report from TEAP lists refrigerants expected to be used for these appliances. See p. 61-65: http://ozone.unep.org/Assessment_Panels/TEAP/Reports/TEAP_Reports/teap-2010-progress-report-volume1-May2010.pdf

Figure 12 Split package and Single package heat pumps

Split System (5kW ~ 16kW)	Mono System (11kW ~ 16kW)

The most popular and versatile system is the low/medium temperature Split range (Classic). The system consists of 2 parts - an outdoor heat pump and indoor hydro-box reaching temperatures up to 55°C on its own without additional back up heater. Available in 6 capacities single phase and three phase. For heating and hot water there are 3 cylinder sizes available (150/200/300L).	The Mono type system consists of the same components as the Split type system but housed all-in-one outside unit. The Mono system also reaches temperatures up to 55°C on its own. Available in 3 capacities single and three phase. For heating and hot water there are 3 cylinder sizes (150/200/300L).

TEWI

The German Blaue Engel Ecolabel scheme has introduced a TEWI (Total Equivalent Warming Indicator) requirement for electrically driven heat pumps. The calculation takes into account the direct (annual and end-of-life emissions) and indirect (from electricity consumption) emissions from greenhouse gases.

Table 47 TEWI Limits

(the second value - i.e. the value in brackets- will be binding from 1 January 2008)

Type of heat pump	**Thermal output [kW]**	TEWI value (flow temperature 35°C) **[kg CO2]**		TEWI value (flow temperature 45°C) **[kg CO2]**	
Water-to-Water	0 - 20	35,000	(32,500)	37,500	(35,000)
	> 20	70,000	(65,000)	75,000	(70,000)
Brine-to-Water	0 - 20	42,000	(39,000)	45,000	(42,000)
	> 20	84,000	(78,000)	90,000	(84,000)
Air-to-Water	0 - 20	51,500	(48,000)	55,000	(51,500)
	> 20	103,000	(96,000)	110,000	(103,000)
Exhaust air-to-Water	0 - 20	46,000	(43,000)	50,000	(47,000)
	> 20	92,000	(86,000)	100,000	(94,000)

The TEWI value is calculated using the following formula:

TEWI = GWP * (ER * n * m + αV * m) + n * β * Q/SPF

using the following operands:

GWP: Global warming potential [-]
ER: Emission rate [%/a]
n: Life of a system [a]
m: Filling quality of refrigerant [kg]
αv: Disposal loss [%]
β: Conversion factor [kg CO2/kWh]
Qh: Heat demand [kWh/a]

SPF: Seasonal performance factor [-]

Calculation shall be performed using the following parameters:

- annual emission rate of 2 %
- product life of 15 years
- disposal loss of 20 %
- uniform conversion factor: 0.683 kg CO2/kWh
- heat demand for systems up to 20 kW: 15.000 kWh/year
- heat demand for systems over 20 kW: 30.000 kWh/year

The Global Warming Potentials (GWP values) listed in Table 2 shall be used.

The Seasonal Performance Factor is calculated and verified according to paragraph Efficient Energy use.

Table 48 Global Warming Potential of selected refrigerants (list will possibly be extended)

Refrigerant (Code designation)	Refrigerant (Chemical designation)	Global Warming Potential (GWP100)	
R 134a	Tetrafluoroethane	1.300	
R 290	Propane	3	
R 404A	Mixture of trifluoroethane, tetrafluoroethane, pentafluoroethane	3.260	
R 407C	Mixture of difluoromethane, tetrafluoroethane, pentafluoroethane	1.526	
R 410A	Mixture of difluoromethane, pentafluoroethane	1.725	
R 417A	Mixture of butane, tetrafluoroethane, pentafluoroethane	1.965	
R 744	Carbon dioxide	1	
R 1270	Propene (propylene)	3	

The TEWI approach is an alternative for the approach taken by the Ecodesign / Energy labelling regulations to consider both the energy efficiency (through indirect emissions) and refrigerant (through direct emissions).

Noise

Noise emissions from central heating products occur mainly from either combustion air / flue gas transport (combustion boilers) or from air transport over evaporators / compressor noise (vapour compression cycle heat pumps).

In the lot 1 calculation methodology noise emissions were included to determine distribution losses, the rationale being that the noisier the boiler is, the further it is installed from the main living areas, thereby introducing distribution losses.

In the current proposals there is an information requirement for all boilers and a maximum noise emission requirement for heat pumps.

Noise is not quantified in the life cycle method.

3.2 Subtask 3.2 - Analysis of the possibilities of substitution of hazardous substances

This subtask provides a discussion on the use of toxic and/or hazardous substances in heating products and their contribution in the overall environmental impact of these products.

Central heating products can contain small fractions of hazardous substances. These can be:

- Flame retardants: used in cables and plastic parts, including synthetic foamed or expanded thermal insulation;
- Heavy metals: mainly limited to substances found in the electronic components;
- Hardeners: used in foamed thermal insulation.

The ROHS Directive 2002/95/EC already banned various types of flame retardants. RoHS is often referred to as the lead-free directive, but it restricts the use of the following six substances:

1. Lead (Pb)
2. Mercury (Hg)
3. Cadmium (Cd)
4. Hexavalent chromium (Cr6+)
5. Polybrominated biphenyls (PBB)
6. Polybrominated diphenyl ether (PBDE)

Lead used in soldering of electronic components is now phased out following an industry-wide replacement program. Lead is also used as plasticizer of PVC cables – this application is also phased out. PBB and PBDE are flame retardants used in several plastics, a.o. in printed circuit boards.

In February 2011 a further six dangerous chemicals were banned, following an assessment in the context of the REACH program 61. The chemicals involved are a flame retardant (HBCD), a hardener (MDA), various plasticizers and a synthetic fragrance enhancer.

Figure 13 Banned substances (REACH)

Chemical	Use	Products
HBCD (hexabromocyclododecane), a toxic substance that persists and accumulates in biological systems	Flame retardant	Polystyrene plastics, including both extruded and expanded polystyrene insulation
MDA (4,4'-diaminodiphenylmethane), a potent carcinogen	Hardener used in manufacture of 4,4"-methylene diphenyl diisocyanate (MDI), a key constituent of polyurethanes	MDI used in polyisocyanurate and spray polyurethane foam insulation as well as formaldehyde-free particleboards, agrifiber panels, plywoods, and other manufactured wood products
DEHP (bis(2-ethylhexyl)phthalate), a hormone disruptor affecting reproduction	Plasticizer for PVC products	Vinyl flooring, roofing, siding, wall coverings (industry has been phasing out the use of this plasticizer)
BBP (butyl benzyl phthalate), a hormone disruptor affecting reproduction	Plasticizer for PVC products	Used in some vinyl flooring, food conveyor belts, artificial leather
DBP (dibutyl phthalate), a hormone disruptor affecting reproduction	Plasticizer for PVC products	Used in some floor coverings, packaging, adhesives, and paint formulations
Musk xylene (5-ter-butyl-2,4,6-trinito-m-xylene), a toxic substance that persists and accumulates in biological systems, and a possible carcinogen	Fragrance enhancer	Some cleaning products

[61] http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/196&format=HTML&aged=0&language=EN&guiLanguage=en

It is possible that HBCD and MDA are used in thermal insulation used in central heating products (expanded polystyrene may be used as thermal insulation of exposed parts such as valves, pumps, etc., foamed polyurethane may be used as thermal insulating material of heated water storage tanks). It is unknown how many central heating products currently on the market employ these substances.

Plasticizers may be used in PVC sheathing of electrical cables.

Emissions of heavy metals occur mainly during the production phase, stemming both from use of electronics as well use of various other (non)ferro materials such as stainless steel, brass, copper.

The Ecoreport analysis of Lot 1 shows an average mass of boilers of 45 kg, of which only 0.7 kg (1.6%) is related to electronics (refers to boilers of M-class capacity, see also section 1.1.5.1). Some 88% of product weight is however due to use of metallic substances, the production of which also emits heavy metals. The Ecoreport estimates the contribution of electronics at less than 15% of total Heavy Metal emissions (both air and water).

Following Greenpeace's 'Greener Electronics' campaign several electronics manufacturers, such as Apple, HP, Panasonic, Philips, etc. have shown progress in reducing the use of BFR's, PVC and also some other materials such as phthalates (plasticisers), beryllium and antimony. Some of their products are completely free of PVC and BFRs. If these consumer electronics manufacturers can diminish or avoid the use of such substances, then the electronics manufacturers for central heating system could follow suit. However, the pace of improvement in that sector will be much slower, since these products are not in the 'green' spotlight of organisations like Greenpeace.

3.3 Subtask 3.3 - Improvement potential

[to complete - the text below are the first entries, but the more LCC information and improvement options needs to be added]

In this subtask a description of the environmental improvement potential as identified using the least life cycle cost (LLCC) method is provided. An assessment of basic assumptions in the calculation will be made (how are the life cycle costs defined, is a harmonization of energy costs necessary, is a harmonization or categorization of heat demand necessary). A sensitivity analysis for the main parameters will be performed.

Energy saving options

Bot the lot 1 (gas/oil/electric boilers) and the lot 15 study (biomass boilers) present possible improvement options. These options range from gradual (incremental) improvements of the existing product up to improvements that involve a fuel change and/or configurations with supplementary equipment. Examples of the latter are:

- boilers (fossil fuel, biomass and/or electric, incl. heat pumps) combined with solar thermal collectors;
- combustion boilers (fossil fuel and/or biomass) combined with heat pumps (gas and/or electric).

The information below describes the identification of LCC and BAT (best available technology) options as defined in the Lot 1 study for fossil fuel and electric boilers. The information will be complemented later on.

Table 49: Performance of Average, BAT and BNAT central heating systems (based on fossil fuel boiler options)

	average	BAT (good condensing boiler)	BNAT + solar (ideal condensing boiler + 5m2 vacutube)
net heat demand	7480	7608 (+2%)	7608
system loss	2752	1364 (-50%)	1294
boiler loss	3595	763 (-79%)	292
renewable contribution			- 1551 (17% of total)
boiler energy input	13827	9735 (-30%)	7642 (-45%)

Table 50: Net Heating Efficiency for Base case-, LLCC- and BAT-levels

Size-Class	Pnom [kW]	Net heat load kWh/a	Net Heating Efficiency[1] BASECASE-LEVEL	Net Heating Efficiency LLCC-LEVEL	Net Heating Efficiency BAT-LEVEL	Explanation BAT
XXS	10	2.350	53%	77%	160 - 170 %	Apartments connected to a collective water/water heat pump
XS	14	3.700	54%	77%	160 - 170 %	Apartments connected to a collective water/water heat pump
S	19	4.850	52%	79%	160 - 170 %	Apartments connected to a collective water/water heat pump
M	22	7.480	54%	78 – 80%	130 - 140 %	House with brine/water heat pump
L	29	10.515	55%	78%	130 - 140 %	House with brine/water heat pump
XL	60	20.000	44%	77%	125 - 135 %	Apartments connected to a collective water/water heat pump
XXL	115	42.195	45%	101%	125 - 135 % *	Apartments connected to a collective water/water heat pump with an increased output
3XL	250	106.738	43%	98%	110 - 120 % *	Apartments connected to a collective water/water heat pump with an increased output
4XL	750	320.215	43%	99%	110 - 120 % *	Apartments connected to a collective water/water heat pump with an increased output

* BAT-levels can be further increased by combining a collective hp with state-of-the-art individual boilers

Table 51: Energy Savings LLCC level versus Base case level

Size-Class	Net heat load kWh/a	Base Case Net heating efficiency[1]	Energy consumption kWh/unit/a	LLCC Efficiency level	Energy consumption kWh/unit/a	Savings versus Base case
XXS	2.350	53,1%	4.422	77%	3052	31%
XS	3.700	54,0%	6.852	77%	4805	30%
S	4.850	51,8%	9.368	79%	6139	34%
M	7.480	54,1%	13.827	78%	9590	31%
L	10.515	55,1%	19.095	78%	13481	29%
XL	20.284	44,1%	45.965	77%	26343	43%

XXL	42.195	45,2%	93.407	101%	41777	55%
3XL	106.738	42,8%	249.392	98%	108916	56%
4XL	320.215	43,3%	739.894	99%	323449	56%
*1 . Calculated with Ecoboiler Integrated model version 5a						

Table 52: Energy Savings BAT level versus Base case level

Size-Class	**Net heat load kWh/a**	**BaseCase Net heating efficiency[1]**	**Energy consumption kWh/unit/a**	**BAT Efficiency level**	**Energy consumption kWh/unit/a**	**Savings versus Basecase**
XXS	2.350	53,1%	4.422	165%	1424	68%
XS	3.700	54,0%	6.852	165%	2242	67%
S	4.850	51,8%	9.368	165%	2939	69%
M	7.480	54,1%	13.827	135%	5541	60%
L	10.515	55,1%	19.095	135%	7789	59%
XL	20.284	44,1%	45.965	130%	15603	66%
XXL	42.195	45,2%	93.407	130%	32458	65%
3XL	106.738	42,8%	249.392	115%	92816	63%
4XL	320.215	43,3%	739.894	115%	278448	62%
*1 . Calculated with Ecoboiler Integrated model version 5a						

The BAT (Best Available Technology) or BNAT (Best Not yet Available Technology) levels are mostly based on heat pump technology sometimes with an add-on benefit from solar installations, which would have several drawbacks for application in mandatory measures.

- Heat pumps cannot be universally applied. Especially 'geothermal' or 'vertical' ground-source heat pumps require special permissions from the waterworks and/or the commune, etc..
- Specialist installers and special equipment are necessary and (as yet) not abundant
- The efficiency of the heat pump is highly dependent on the lay-out and installation.
- Often a heat pump is a base-load device, which means that a hybrid device (e.g. with a conventional boiler) may often be an economical solution to capture both base and peak loads
- The energetic benefits are highly dependent on the climate, especially with air-based heat pumps and of course with solar energy.
- As a result of the above, the pay-back time will vary widely per country and circumstance.
- The current heat pumps are mostly electric, which means that a hypothetical full EU heat pump strategy would lead to increased emissions of everything else besides CO2: more acidification, more VOCs, more heavy metals, etc.
- Most heat pumps are reversible, which means that they can supply both cooling an heating. If they are attached to a central heating-system the cooling options will be limited (only top-cooling), but still this could lead to a summer operation that would be detrimental to the saving and mitigation effort.

All in all, the heat pump technologies represent an interesting option with a large saving potential and should be promoted whenever and wherever possible (with emphasis on possible). As such they should therefore have their place in the highest ranks in an endorsement scheme. However, the uncertainties (and the costs) of the option should be taken into account.

Regarding the solar-assisted space heating our technical and economical analysis indicates that yields are often higher than expected (usually solar heating is seen as typically for water heating only). However, the economical benefits are too small to make them qualify as LLCC-target, although in larger installations and at mass volume collector prices they can be competitive.

Table 53 : Lifecycle costs and savings LLCC- and BAT- levels versus Base case level

Size-Class	**BaseCase lifecycle costs**	**LLCC lifecycle costs**	**BAT lifecycle costs**	**LLCC** savings	**LLCC saving in %**	**BAT saving**	**BAT Savings in %**
XXS	€ 9.085	€ 8.716	€ 10.943	€ 369	4%	-€ 1.858	-20%
S	€ 14.172	€ 12.313	€ 13.352	€ 1.859	13%	€ 820	6%
M	€ 18.750	€ 15.797	€ 16.859	€ 2.953	16%	€ 1.891	10%
L	€ 24.119	€ 20.259	€ 21.262	€ 3.860	16%	€ 2.857	12%
XL	€ 57.697	€ 37.851	€ 38.668	€ 19.846	34%	€ 19.029	33%
XXL	€ 108.111	€ 65.623	€ 73.738	€ 42.488	39%	€ 34.373	32%
3XL	€ 272.770	€ 164.057	€ 190.187	€ 107.943	40%	€ 81.813	30%
4XL	€ 904.288	€ 487.237	€ 495.964	€ 417.051	46%	€ 408.324	45%
*1 . Calculated with Ecoboiler Integrated model version 5a							

The table below gives the Life Cycle Costs at LLCC and BAT levels. It shows savings at LLCC level of up to 16% for the smaller size classes (up to L) and 30-46% for the largest sizes. The savings at BAT level indicate that, apart from the smallest XXS level, the BAT-solutions do not save as much as LLCC-solutions but are still more economical than the Base Case.

Table 54 : Overview of index classes for central heating-boiler systems

Class		**%**	**Examples**
A+++	market share	**<1%**	**vertical ground-source heat pumps (GSHP)**
	sys-eff	**>132%**	best horizontal GSHP
	net eff.	**>120%**	
A++	market share	**<1%**	**gas-fired heat pump**
	sys-eff	**>116%**	best air-based electric heat pump
	net eff.	**>104%**	average horizontal GSHP
			low-end vertical GSHP
A+	market share	**2,0%**	**best condensing+ solar**
	sys-eff	**>100%**	good air-based heat pump
	net eff.	**>88%**	low-end horizontal ground source el. heat pump
			low-end gas-fired heat pump

A	market share	8,0%	**best condensing**
	sys-eff	>92%	average air-based heat pump
	net eff.	>80%	average condensing + solar
B	market share	10,0%	**average condensing**
	sys-eff	>84%	low-end air-based heat pump
	net eff.	>72%	best LT + solar
C	market share	12,0%	**best LT**
	sys-eff	>76%	low-end condensing
	net eff.	>64%	average LT + solar
D	market share	15,0%	**average LT**
	sys-eff	>68%	best atmospheric + solar
	net eff.	>56%	low-end LT + solar
E	market share	30,0%	**low-end LT** **BASE CASE**
	sys-eff	>60%	best atmospheric
	net eff.	>48%	average atmospheric + solar
F	market share	15,0%	**average atmospheric**
	sys-eff	>52%	electric resistance central heating-boiler-systems + solar
	net eff.	>40%	low-end atmospheric + solar
G	market share	6,0%	**low-end atmospheric**
	sys-eff	<52%	electric resistance central heating-boiler-systems
	net eff.	<40%	

The table below shows the calculated consumption at LLC target level 9net heating efficiency).

Table 55 : Calculation of annual primary energy consumption Base Case (avg. EU-25, sold in 2005)

A. Total sales EU-25 in '000 units in the year 2005											
in '000 units	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	**3XL**	**4XL**	**Total**	
Boiler	150	500	1000	3400	650	650	170	40	40	6600	
Total	150	500	1000	3400	650	650	170	40	40	**6600**	
B. Net load in GWh/a											
Net load kWh/a.unit	*2350*	*3700*	*4850*	*7480*	*10515*	*20000*	*42195*	*106738*	*320215*		
total net load in GWh/a	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	**3XL**	**4XL**	**Total GWh/a**	**Average kWh/a**
Boiler space heating	353	1.850	4.850	25.432	6.835	13.000	7.173	4.270	12.809	76.571	11602
Total GWh/a	353	1.850	4.850	25.432	6.835	13.000	7.173	4.270	12.809	**76.571**	**11602**

C. Efficiency in % (primary energy, Gross Calorific Value)											
in %	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	**3XL**	**4XL**	**weight avg.***	
Boiler space heating	53%	54%	52%	54%	55%	44%	45%	43%	43%	48%	
D. Energy consumption in GWh/a (net load efficiency)											
Sales	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	**3XL**	**4XL**	**Total**	
Boiler space heating	665	3.426	9.327	47.096	12.427	30.233	15.940	9.929	31.240	160.284	
Total	**665**	**3.426**	**9.327**	**47.096**	**12.427**	**30.233**	**15.940**	**9.929**	**31.240**	**160.284**	
Efficiency aggreg.	53%	54%	52%	54%	55%	44%	45%	43%	43%	48%	
**=weighted for total net load in GWh/a, so taking into account both sales and load*											
E. Energy consumption at LLCC targets (in MWh/a)											
target	76%	76%	76%	76%	76%	76%	96%	96%	96%	**81%**	
energy in GWh/a	464	2.434	6.382	33.463	8.993	17.105	7.472	4.447	13.342	**94.103**	

However, even larger reductions are possible by adding complementing equipment: thermostats with better response can improve the central heating efficiency by optimizing the boiler heat output to the (expected) heat demand, heat pumps using ambient heat and/or solar thermal systems reduce the fossil fuel or electric energy input. The model was extended to incorporate these technologies as well (cogeneration and passive flue heat recovery devices were added after the finalization of the Lot 1 study).

3.3.1 Discussion

As regards biomass boilers, the Lot 15, Task 1 report mentions:

Lot 15 products fuelled by biomass are especially topical, as the Proposal for a Directive on the promotion of the use of energy from renewable sources, published the 23rd of January 2008, aims to establish an overall binding target of a 20% share of renewable energy sources in energy consumption and binding national targets by 2020 in line with the overall EU target. This Directive, together with the oil and gas scarcity, is expected to encourage the use of biomass solid fuels. Hence, the stock of such Solid fuel Small Combustion Installations (SCIs) is likely to increase in the coming years.

However, Clean Air for Europe (CAFE) programme[2] has identified domestic combustion installations burning coal and wood as a major source of local air pollution and concludes that tackling particulate matter (PM) emissions from these sources need to be given high priority. The CAFE initiative has led to a thematic strategy[3] setting health and environmental objectives and emission reduction targets for the main pollutants, including fine particulate matter.

Recently, Carbosol research programme[4] has further highlighted the fact that biomass burning (wood fires in homes, and burning of agricultural and garden waste) causes between 50 and 70% of particulate carbon pollution in winter in Europe. Assessments at Member States level confirm the important contribution of small-scale combustion of solid fuels to the air emissions.

In order to ensure the sustainability of the EU renewable energy policy, it is therefore crucial to address the air emissions from the small scale-solid fuel combustion installations. This wider policy context underlines the importance of considering energy efficiency along with direct air emissions of SCIs in this study.

4 Task 4: Policy analysis [to complete]

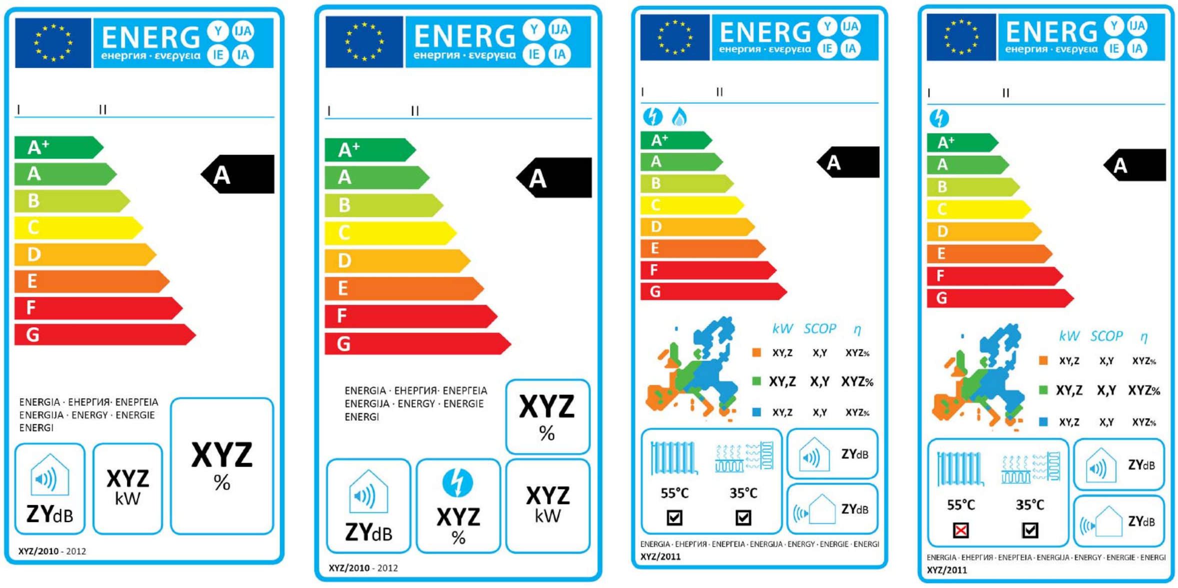
This task comprises an impact analysis of various policy options. The impacts shall cover both the technical aspects of products as well as the environmental impacts of applying policy measures.

[this section is not complete and will be finalised after the first stakeholder meeting. The text below is just to provide an introduction of the possible harmonisation of the EU proposed Ecodesign method to establish a key environmental parameter of boilers: energy efficiency].

The following figure presents the proposed layout of the Energy label.

Figure 14 Energy labelling (proposal March 2011)

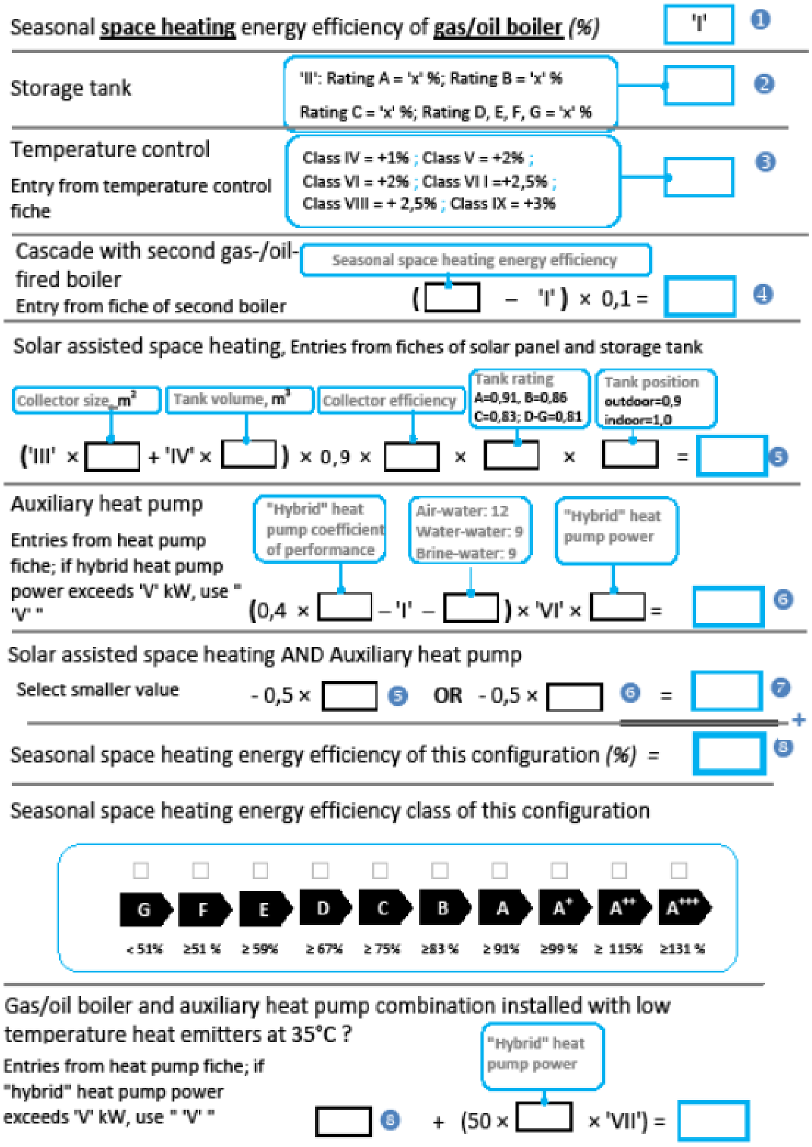
fossil fuel boilers | **cogeneration boilers** | **heat pumps (other than LT)** | **LT heat pumps**



The figure below is an example of the lay-out of product sheet 2, which presents the elements and the calculation of a configured product. The calculations are kept as simple as possible, requiring only input of a few main parameters from test results (Ecodesign product information or supplied by manufacturer) and sometimes only the indication of the type. The parameters have been identified on the basis of the elaborate approach resulting from the lot 1 study. Of course this approach introduces simplifications (some quite drastic, others only involving a slight change), but these were needed to gather enough support for the proposal and allow suppliers to produce this information.

The figure below presents an example of the product fiche “sheet 2” for fossil fuel boilers.

Figure 15 Sheet 2 for fossil fuel boilers



The values ‘III’, ‘IV’ etc. in the figure above are results of simple calculations, as provided in the Energy label Regulation text (Annex III, item 2) or related Commission Communication. Entries related to solar collectors (ie. collector efficiency), temperature controls and storage tanks shall be provided by the supplier of these parts in the corresponding fiches (see also Article 3, item 2 of the Energy label Regulation text).

Summarizing, the new elements in the current proposal are:

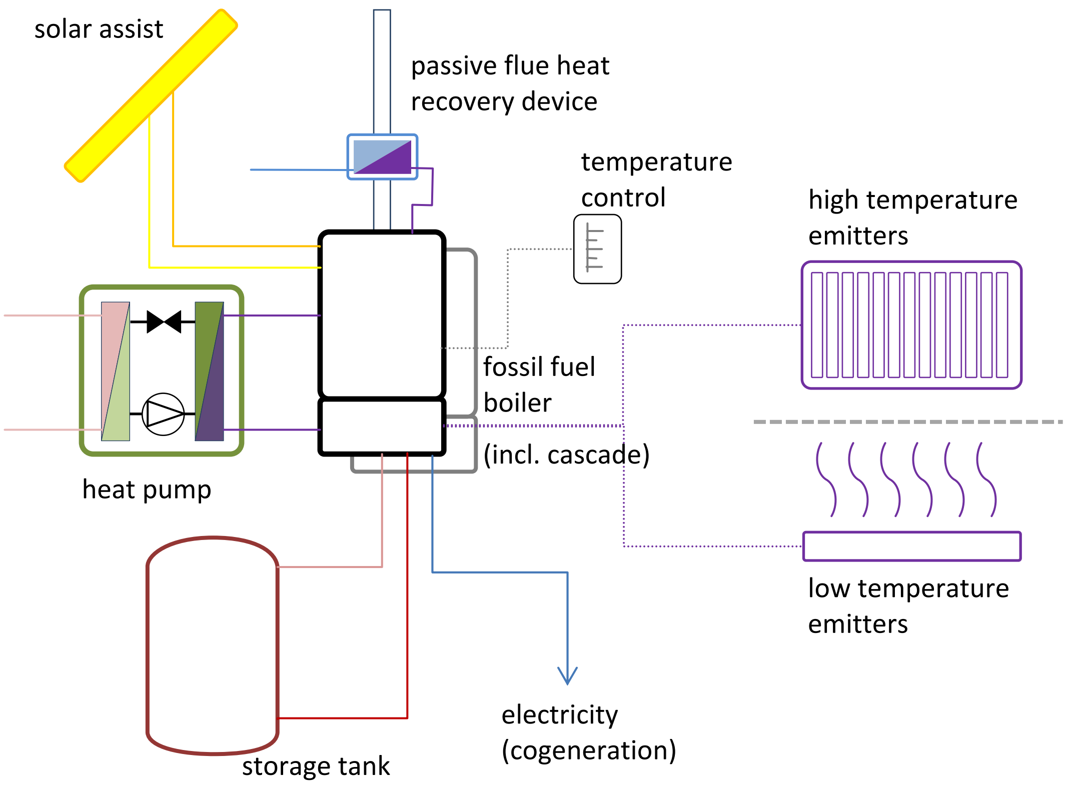
- The treatment of ‘system losses’ is different. Distribution losses are no longer part of the integral calculation, whereas Stratification and Fluctuation losses are now partly considered through the consideration of system temperature (LT products) and of temperature control aspects that affect Stratification and Fluctuation losses. Therefore the inclusion of LT and temperature control in sheet 2 addresses these losses, however not to the same extent as was done according the Lot 1 calculation methodology.

- The introduction of 'low temperature' heat pumps. These are heat pumps that do not have to supply water at elevated temperatures in order to feed radiators, but instead are developed for use with extremely low temperature emitters only (floor heating etc.). The average efficiency of such heat pumps is higher than that of heat pumps intended to be used in connection with radiators.

Common benchmarking methodology

Both approaches (the former 'lot 1 based approach' and the new 'sheet 2 - configuration seasonal space heating efficiency of the configuration') allow calculation of the space heating energy efficiency of not only the primary heat generator (the boiler or heat pump) but also of various other central heating product configurations. Therefore both methods are suitable to benchmark various configurations central heating products, from very simple to complex space heating products, regardless of heat/fuel source or working principle. The figure below shows the products that can be considered.

Figure 16 Overview of central heating products covered by benchmarking methodology



Note that solid fuel and boilers specifically designed for biomass are not included in this method.

The 'sheet 2' method (the 'product fiche - sheet 2') fulfills the requirement of setting of a common methodology for the various central heating products on offer on the market.

The proposed approach, when applied to the same base case central heating product as the example in section 1.1.3.1 renders an efficiency of 68% instead of 54% (the difference is the 20% distribution losses: 54%/80% = 68%).

5 Task 5: Elaboration of draft criteria and technical reports

[to complete - This section is not complete yet. The ultimate goal of this section is to present draft environmental criteria which can be fulfilled by only a select share of products on the market. However, at this stage of the study only the identification of which environmental parameters to cover by such criteria is presented]

5.1 Proposal for criteria (draft)

Ecolabels and GPP aim to identify those products with the least environmental impact. They do so

The selection of environmental parameters is based upon information from Task 3 (Technical analysis), environmental labels, ecodesign / energy label preparatory studies and implementing measures, GPP preparatory studies and criteria (heat pumps, boilers, CHP) and other available information (e.g. LCA studies in literature).

5.1.1 Ecodesign criteria

The table below shows which aspects are regulated by the Ecodesign and Energy labeling measures.

Table 56: Overview of scope and aspects regulated by Ecodesign and Energy labelling

Product	Ecodesign	Energy labelling		
	Annex I: Ecodesign requirements	Annex II: Label	Annex III: Product fiche - sheet 1	Annex III: Product fiche - sheet 2
Scope	boilers of 4-400 kW rated input	4-70 kW boilers, incl. controls and passive flue heat recovery devices		
Excluded	excluded are: biomass boilers, solid fuel boilers, IED boilers[62], equipment for district heating, components or sub-assemblies, dedicated water heaters, air-based heating, cogeneration exceeding 50 kW			
Requirements				
Fossil fuel boilers (gas/liquid) and cogeneration boilers	1 - minimum seasonal efficiency - 4-70 kW (2nd tier: 4-15 kW and 15-70 kW) - 70-400 kW 2 - NOx emissions for fossil fuel and cogeneration + detailed product information requirements	- seasonal efficiency (arrow and % value) - capacity (kW) - noise level (dB) - cogeneration: electricity generation (%)	general information technical information as supplied on label - added: Energy consumption (kWh/year)	1 - seasonal efficiency 2 - storage tank 3 - temp. control 4 - boiler cascade 5 - solar assist 6 - auxiliary heat pump 7 - solar assist AND heat pump 8 - overall configuration efficiency (plus class) 9 - if for LT emitter (6, 7 and 9 do not apply to cogeneration boilers)

[62] IED refers to the Industrial Emissions Directive 2010/75/EU, combining the former IPPC Directive 2008/1/EC, LCP Directive 2001/80/EC, waste Directive 200/76/EC, VOC Directive 1999/13/EC and three 'titanium dioxide' Directives.

Heat pump (electric and/or fossil fuel fired)	1 - minimum seasonal efficiency - 'normal' - low temperature - 'bonus' for low GWP 2 - max. sound power + detailed product information requirements	- seasonal efficiency (arrow) - capacity / SCOP / efficiency (kW,-,%)) - noise level indoor/outdoor (dB/dB) - emitter system temp. (HT/LT)	general information technical information as supplied on label - added: Energy consumption (kWh/year) (for LT HP: 35°C) - added: variation of efficiency and capacity for warmer/colder climate - added: hybrid coefficient of performance and capacity	1 - seasonal efficiency 2 - storage tank 3 - temp. control 4 - solar assist 5 - auxiliary fossil fuel boiler 6 - overall configuration efficiency (plus class) 7 - if for LT emitter 8 - efficiency in warmer climate 9 - efficiency in colder climate (7 does not apply to LT heat pumps)
Sanitary water heating (fossil fuel and cogeneration boiler)	- minimum water heating efficiency	- water heating efficiency - in accordance with water heater label		1 - water heating efficiency 2 - solar assist 3 - passive flue heat recovery device 4 - efficiency of configuration 5 - variation if in warmer/colder climate
Solar thermal	n.a.	n.a.	included in product fiche for configurations	
Temperature controls	n.a.	n.a.	included in product fiche for configurations and separate product fiche with generic information and effect on space heating efficiency (%)	
Passive flue heat recovery device	n.a.	n.a.	included in product fiche for configurations and separate product fiche with generic information and effect on water heating efficiency (%)	

5.1.2 GPP criteria

Overview of Technical Specifications for Green Public Procurement:

Core criteria are those suitable for use by any contracting authority across the Member states and address the key environmental impacts. They are designed to be used with minimal additional verifications effort or cost increase.

Comprehensive criteria are for those who wish to purchase the best environmental products available on the market. These may require additional verification effort or a slight increase in cost compared to other products with the same functionality

Boilers

Table 57 GPP Boiler Core Criteria

1. Energy efficiency	**Criteria**			**Standards**
Gas condensing boilers (<70 kW)	For 10 kW	Nominal utilisation ratio must not fall below 100% at temp 75/60°	Nominal utilisation ratio must not fall below 103% at temperatures 40/30°	DIN 4702
	For 70kW	Nominal utilisation ratio must not fall below 101% at temp 75/60°	Nominal utilisation ratio must not fall below 104% at temp 75/60°	DIN 4702

Gas boilers and oil boilers (<120 kW)	Y=(1/60)z +b, Where b is Fuel B Measurement at nominal effect Measurement at low effect Liquid 91,77 89,77 Gas 85,83 93,83	CEN 303 and 204
Solid fuel biomass boilers (<300 kW)	Manual feed: nk = 73 + 6log Qn, at full load Automatic feed: nk = 75 + 6log Qn, at full load and part load	
2. Emissions to air	**Criteria**	**standards**
gas condensing boilers (<70 kW)	Parameter mg/kWh Nitrogen oxides (NOx)60 Carbon monoxide (CO) 50 Emissions during operational phase must not exceed	DIN EN 267
Non-condensing gas boilers (<120 kW)	Parameter mg/kWh Nitrogen oxides (NOx)70 Carbon monoxide (CO) 20 Emissions during operational phase must not exceed	EN 303
Liquid Fuel boilers (<120 kW)	Emissions during operational phase must not exceed Parameter mg/kWh ingoing fuel Nitrogen oxides (NOx)70 Hydrocarbons (HC) 10 Carbon monoxide (CO) 20 Soot values 0.5	EN 267, CEN 303 and EN 304
Solid biomass boilers(Nominal thermal output < 300 kW)	Emissions must not exceed the following limit values Automatic feed boiler Manual feed boiler (mg/m^3 dry gas at 10% O_2) X ≤ 300 kW X ≤ 100 kW 100 < X ≤ 300 kW OGC 25 70 50 CO 400 2000 1000 NO_2 340 340 340 particles 40 70 70	EN 303-5
3. The boiler must be correctly designed and sized for the use specified by the contracting authority. It should take into account any other heating sources e.g. solar that may contribut towards overall heating demand.		

Table 58 GPP Boiler Comprehensive criteria

4	Plastic components weighing more than 50g must be marked according to ISO 11469 or equivalent
5	Cadmium (Cd), Lead (Pb), Mercury (Hg) or their compounds must not be intentionally added to plastic parts for gass and liquid fuel burners/boilers.

6	Only phthalates that at the time of purchase have been risk assessed and have not been classified with the phrases: R20, R61, R62, R50, R51, R52, R53, R50/53, R51/53, R52/53. In accordance with Directive 67/548/EEC, may be used in the product. DNOP, DINP and DIDP are not permitted in the product.
7	Halogenated flame retardants must not be added to plastic materials for gas and liquid fuel burners/boilers combinations and solid biomass boilers. Halogenated flame retardants may be accepted if can be documented that they are necessary for safety in accordance with the Low Voltage Directive 72/23/ EEC Flame retardants with following risk phrases, classified according to Directive 1999/45/EC and 67/548/CEE must never be used. (*Substances or preparations that are classified according to Directive 1999/45/EC and 67/548/CEE as carcinogenic (R40, R45, R49), harmful to the reproductive system (R60, R61, R62, R63), mutagenic (R46, R68), toxic (R23, R24, R25, R26, R27, R28, R51), allergenic when inhaled (R42) or harmful to the environment (R50, R50/53, R51/53, R52, R52/53, R53), cause heritable genetic damage (R46), danger of serious damage to health by prolonged exposure (R48), possible risks of irreversible effects (R68) shall not be used.)* Printed circuits and plastic parts weighing less that 25g in electronic parts are completely exempted from these flame retardant requirements
8	Paint coatings for boilers should not contain the following: heavy metals or their compounds shall not be used as an ingredient of the product or tins: Cadmium, lead, chromium VI, arsenic, barium, selenium, antimony.
9	Metals used in oil/gas boilers must not plated with chromium, nickel or their compounds. In exceptional cases, small screws and other smaller parts may be plated with the aforementioned heavy metals. Parts plated with the heavy metals must be capable of recycling.
10	Degreasing agents used in oil/gas boilers must not contain halogenated solvents
11	Foaming agents for thermal insulation material used in oil/gas boilers must not give rise to a greenhouse effect, measured a GWP in excess of 5

Combined Heat and Power

Table 59 GPP CHP Core Criteria

1	To ensure efficient conversion of energy into heat or electricity, the contracting authority shall ensure that the unit has a minimum overall efficiency of 75% or 80% depending on the type of CHP plant, where Annex II of the Cogeneration Directive is used, or alternative criteria that Member States have agreed under Article 12 (2) of the Cogeneration Directive.	Cogeneration Directive 2004/8/EC)
2	The CHP plant shall meet the requirements of high efficiency CHP as defined in the Cogeneration Directive (2004/8/EC) and outlined as follows: - CHP units with an installed capacity of below 1MWe must demonstrate positive energy savings compared to the separate production of heat and electricity using harmonised reference values - CHP units with an installed capacity of above 1MWe must demonstrate primary energy savings of at least 10 % compared to the separate production of heat and electricity using harmonised reference values	Cogeneration Directive (2004/8/EC)

Comprehensive criteria

Additional award criteria apply (extra points if performance exceeds criteria)

Heat Pumps

Table 60 GPP Heat Pump Core criteria

	Criteria	Standards
	Fitters, dealers and service personnel shall be suitably trained and be familiar with the CCU purchased. Training should comprise the following elements: • General information and familiarity with the product • Installation • Measurement methods with practical exercises • Adjustment of the equipment and environmentally friendly settings • Trouble shooting • Service	
1	Heat pumps should have a minimum heating CoP and/or cooling EER of Type Electric driven CoP (heating EER (cooling) Gas driven Cop (heating EER (cooling) Air/water 3.10 2.20 1.36 0.97 Brine/water 4.30 3.00 1.89 1.32 Water/water 5.10 3.20 2.24 1.14	EU Ecolabel criteria for heat pumps, Commision decision 2007/742/EC
2	Any refrigerants used must not have a GWP of more than 2000 when measured over a 100-year period. If the refrigerant has a GWP of less than 150 then the minimum requirements of the coefficient of performance (COP) and primary energy ratio (PER) in heating mode and the energy efficiency ratio (EER) in cooling mode shall be reduced by 15 %. Here the PER for cooling is 3 because the unit is producing 3kW of useful cooling for 1kW of electrical input. If the unit is in heating mode then the PER is 4	
3	The devices will be returned free of charge to a designated collection facility. Whilst end users cannot do this, it is the responsibility of both the end user the contractor/installer to ensure end-of-life products are disposed of correctly at the appropriate facilities.	WEEE Directive
4	The setting instructions shall include clear and concise information for proper adjustment of the system by skilled personnel while the operating instructions shall include information on handling and maintenance as well as on the disposal of material used	

Table 61 GPP Heat Pump Comprehensive criteria

5	The following apply to the materials used (unless a fundamental constituent of another material): • Cadmium, lead, mercury, chromium 6+ or the flame retardants as listed in Article 4 of Directive 2002/95/EC of the European Parliament and Council may not be used in the air conditioner / heat pump or in its system, taking into account the tolerances specified in Commission Decision 2005/618/EC amending Directive 2002/95/EC, poly-brominated biphenyl (PBB), polybrominated diphenyl ether (PBDE) and deca-BDE. • The product shall not contain any substances or preparations that are classified according to Directive 1999/45/EC and 67/548/CEE as carcinogenic (R40, R45, R49), harmful to the reproductive system (R60, R61, R62, R63), mutagenic (R46, R68), toxic (R23, R24, R25, R26, R27, R28, R51),	

	allergenic when inhaled (R42) or harmful to the environment (R50, R50/53, R51/53, R52, R52/53, R53), cause heritable genetic damage (R46), danger of serious damage to health by prolonged exposure (R48), possible risks of irreversible effects (R68).	

5.1.3 Ecolabels applicable in the EU

5.1.3.1 Blaue Engel

http://www.blauer-engel.de/en/products_brands/vergabegrundlage.php?id=141

Criteria documents for:

- Wood Pellet boilers (RAL-UZ 112)
- Solar Collectors (RAL-UZ 73)
- Electric heat pumps (RAL-UZ 121)
- Gas fired heat pumps (RAL - UZ 118)
- Heated water storage tanks (RAL - UZ 124)
- Gas condensing boilers (RAL - UZ 61)

Wood Pellet boilers (RAL-UZ 112)

Scope
These Basic Award Criteria apply to wood-pellet boilers according to DIN EN 303-5 with a rated thermal output of up to and including 50 kW which are exclusively designed for the use of wood pellet fuel, preferably according to DINplus or according to ÖNORM M 7135 or DIN 51731, respectively.[63]

General Requirements
In addition to the herein-below described energetic and emission requirements applicants for award of the Blue Angel must prove compliance with the requirements under DIN EN 303-5 with respect to structural engineering and safety behaviour (avoidance of critical operation modes during normal and faulty operation, limitation of the surface temperature, automatic cut-off, electrical safety).

Table 62 Blue Angel Requirements for Wood Pellet Heating Systems valid till 31.12.2010

Pellet boiler (RAL-UZ 112)

Scope	Efficiency		Power demand	Emissions						Remaining Requirements
				NO_x (mg/Nm)	CO (mg/Nm^3)		PM (mg/m^3)	C_{ges} (mg/Nm^3)		
	Nominal load	Part load	Nominal load			Part load	Nominal load		Part load	
Capacity till 50	≥ 90%	≥ 88%	≤ 1% of the design heat	150	90	200	20	5	5	Dust content in flue gas in part load

---

[63] On the strength of legal bases further co-effective EU-Regulations must be observed for the marketing of wood pellet boilers, such as for example, the EMV Directive (Council Directive 89/336/EWG on the approximation of the laws of the member states relating to electromagnetic compatibility).

kW			capacity							conditions
Automatic fuse, heat exchange cleaning, capacity- and burning control										Power demand in part load and stand-by mode
Just for wood pellets										Electrical power decrease significant part of the systems
Water resistance										
Operating and tuning manual										
Overview of services										

Requirements for an Efficient Energy Use

Efficiencies are to be determined at rated load pursuant to DIN EN 303-5 (rated thermal output) as well as at partial load (lowest available power, 30% of the rated thermal output at the most). Efficiency according to DIN 18 894 or DIN EN 14784 must not fall below 90% when operating at rated load or partial load.

Auxiliary Power Demand

The auxiliary power demand of the systems is to be determined in accordance with Annex 2 to the Basic Criteria. It must not exceed 1% of the produced thermal output at rated thermal output. The auxiliary power demand shall be determined at partial-load operation (lowest available power, 30% of the rated thermal output at the most), in the sleep mode (standby without heat generation) as well as for the ignition process. All data shall be indicated in the test report. The electric power consumption of the integrated power-consuming devices of the boiler mentioned in Annex 2 (if existing) shall be given in watts and separately listed in the test report. The water-side flow resistance shall be determined in accordance with DIN EN 303-5 and included in the test report.

Emission Requirements

The emission limits hereunder - related to dry exhaust gas in a standard condition (0°C, 1013 mbar) with an oxygen volumetric content of 13% - must be observed. The 5/10 UZ 112 - Edition March 2007 measuring unit mg/Nm³ is to be understood as mg of pollutant per standard cubic meter of exhaust gas (mass concentration). Testing shall be done according to the measuring methods listed in paragraph 4. The emission values are to be determined at rated load as well as at partial load (lowest available power, 30% of the rated thermal output at the most).

Nitrogen Oxides (NOx)

At rated load, the nitrogen monoxide content and the nitrogen dioxide content of the exhaust gas must not exceed 150 mg/Nm³, given as nitrogen dioxide.

Carbon Monoxide (CO)

The carbon monoxide content of the exhaust gas must not exceed 90 mg/Nm³ and 200mg/Nm3 as partial load.

Organic Substances

The organic substance content of the exhaust gas given as total carbon (total C) must not exceed 5mg/Nm³ at rated and at partial load.

Dust

The dust content of the exhaust gas must not exceed 20 mg/Nm³ at rated load. The dust content of the exhaust gas at partial load shall be indicated.

Setting and Operating Instructions
The Setting Instructions must include clear and concise information for proper adjustment of the wood-pellet firing by skilled personnel. Setting according to the Setting Instructions must enable the operator to meet the requirements under paragraphs 3.2, 3.3 and 3.4 during operation. The Setting Instructions must further include detailed information on how to adapt the wood-pellet firing to the exhaust-gas unit as well as on the combination with a puffer storage.

The Operating Instructions must include clear and understandable information on the environmentally acceptable - i.e. efficient and low-emission - operation of the system by the user as well as information on regular maintenance and cleaning of the plant by a qualified service company. The documents must at least comply with the requirements of DIN 18894. Compliance with DIN EN 62079 "Preparation of instructions. Structuring, content and presentation" is recommended.

Compliance Verifications
To prove compliance with the requirements under paragraphs 3.1-3.5 the applicant shall submit the following documents:
- Test report on the testing of the system in accordance with Annex 1 to the Basic Criteria RAL-ZU 112 confirming compliance with the requirements under paragraph. 3.1. - 3.5 in connection with paragraph 4 indicating the respective test methods/instruments and the measurement inaccuracies.
- Setting and Operating Instructions providing the information pursuant to paragraph 3.5. as well as the Attachment to the Operating Instructions according to Annex 3 to the Basic Award Criteria including the corresponding page/percentage indication. (If due to the design of the heating system paragraphs 3 and 4 of the attachment text require changes for the purpose of an energy-efficient and low-emission operation, applicant may suggest such changes).

Testing
Testing Institutes
Testing shall be done by an independent testing institute approved for the test field „Solid-Fuel Boilers" according to DIN EN 45 001 or DIN EN ISO 17 025 or by a testing institute acknowledged by Deutsches Institut für Bautechnik (German Institute for Building and Civil Engineering Technology) for the testing of solid-fuel firings. Testing comprises the complete compliance verifications under paragraphs 3.1 to 3.5.

Test Methods
Measurements are to be taken at rated load (rated thermal output) and at partial load (Lowest available power, 30% of the rated thermal output at the most). The tests, especially those for checking compliance with the efficiency and emission requirements under paragraphs 3.2 and 3.4 shall be conducted in accordance with DIN EN 303-5.
Testing of the pollution output shall be done with wood pellets preferably according to DINplus or according to ÖNORM M 7135 or DIN 51731, respectively. The pellets must be subjected beforehand to an elementary analysis with calorific value determination.

Calibration Gases and Measuring Instruments
Certified calibration gases shall be used for calibrating the measurement equipment. Calibration gas generators must not be used. Measuring instruments are to be used in accordance with DIN EN 303-5. The measurement of the nitrogen oxide content and the carbon content shall be based on test results obtained during heating.

Table 63 Blue Angel pellet boiler required test results

Efficiency				
	Unit	Requirement	Determined	
Efficiency at rated load (rated thermal output)	%	≥ 90	at ... kW[x]	....
Efficiency at partial load (lowest available power)	%	≥ 88	at ... kW[x]	....
x) Please enter the values determined during testing for reaching the rated thermal output/ range of thermal output pursuant to manufacturer's specifications				
Auxiliary Power Demand				
	Unit	Requirement	Determined	
Operating Mode				
Average electrical power consumption (measuring period ≥ 6 h) at			at…kW*	....
-rated load	W	□1 % of the	measuring	corres-ponds
(rated thermal output)		generated thermal power	period …. min	to…. %
-partial load		-	at…kW*	....
(lowest available power)	W		measuring	corres-
			period	ponds to
			…. min	…. %
Sleep Mode Average electrical power consumption (Measuring period ≥ 10 min)	W	-	Measuring period .... min	….
Ignition Process Electrical work	Wh	-	Ignition period .... min	….
Electrical Power Consumption of Central Consumers (if existing) -Fan engine(s) -Engine(s) driving the heat exchanger cleaning -Engine(s) driving the ash removal device -Engine(s) driving the fuel feed screw conveyor(s) -Engine(s) driving the fuel space discharge device	W W W W W	-----	----	…. …. …. …. ....
Heating-Water Circulating Pump (if existing)	-	-	Setting range	…. %
Type of pump control (automatically			or	
controllable or multi-stage)			Number of power levels	….
mininmum power consumption				
maximum power consumption	W W	--		…. ….

Emissions						
			Unit	Requirement	Determined	
NOx	-at rated	load	mg/Nm3	□150	at…. kW*	….
CO ---	at rated load at partial load with a rated thermal output < 15 kW at partial load with a rated thermal output □15 kW □50 kW		mg/Nm3 mg/Nm3 mg/Nm3	□100 □300 □250	at…. kW* at…. kW* at…. kW*	…. … ….
Organic substances -at rated load -at rated load			mg/Nm3 mg/Nm3	□5 □5	at…. kW* at…. kW*	…. …
Dust	-at rated -at rated	load load	mg/Nm3 mg/Nm3	□30 -	at…. kW* at…. kW*	…. …

Solar Collectors (RAL-UZ 73)

Scope
These Basic Criteria apply to solar collectors according to DIN EN 12975 (Thermal solar systems and components - Solar collectors)

Requirements and Compliance Verifications
Solar collectors as specified under paragraph 2 may be marked with the Environmental Label shown on page 1, provided that they comply with the following requirements:

The annual collector output (annual energy supply) Qkol related to a solar cover portion of 40% must be at least 525 kWh/m².

Compliance Verification
The applicant shall present a Collector Output Certificate in accordance with the "Empfehlung betr. Nachweis eines Kollektormindestertrags" (Information on how to prove the minimum collector output) (Appendix to these Basic Criteria according to RAL UZ-73) as a prerequisite for award of federal funds in accordance with the Guidelines for Promotion of the Use of Renewable Sources of Energy, dated January 1996, and indicate the collector output QKol. Such certificate shall be prepared 4/6 UZ 73 - Edition March 2009 by a testing institute authorized by DIN - Deutsches Institut für Normung (German Institute for Standardization) or by an accredited test institute according to EN ISO/IEC 17025.

No halogenated hydrocarbons may be used as heat transfer medium of the collectors. In addition, the heat transfer medium must not include any substances which are classified as hazardous according to a legal regulation based on Section 14, Chemikaliengesetz (Chemicals Act),
which the "Regulation of Water-Endangering Substances"[64], as amended, lists in Category 2 or 3 of Water-Endangering Substances (WGK 2 or WGK 3),
which according to the "Gefahrstoffverordnung" (Ordinance on Hazardous Substances), as amended, require marking (on the basis of the definition of "hazardous substances/hazardous preparations" in Section 3a, Chemicals Act),
which according to the EC Directive in force must be marked "dangerous to the environment"[65]

Compliance Verification
The applicant shall declare compliance with the requirement and present a Safety Data Sheet of the heat transfer medium according to Directive 91/155/EEC.

The materials used for the insulation of the collectors must not be manufactured with the help of halogenated hydrocarbons. Apart from that, the insulating materials must not contain any substances the exhalation of which at stagnation temperature according to EN 12975-1
- is classified as hazardous according to a legal regulation based on Section 14, Chemicals Act,

[64] Allgemeine Verwaltungsvorschrift zum Wasserhaushaltsgesetz (Administrative Regulation relating to the Water Supply Act on the Classification of Water-Endangering Substances dated 17.5.1999 (Federal Legal Gazette 29.5.1999 No.98a)
[65] Directive in force: Commission Directive, dated April 27, 1993, for the 18th adaptation to technological progress of the Council Directive 67/548/EEC for the harmonization of legal and administrative provisions relating to classification, packaging and marking of hazardous substances.

- requires marking according to the "Gefahrstoffverordnung" (Ordinance on Hazardous Substances), as amended, (based on the definition of "hazardous substances/ hazardous preparations", as specified in Section 3a, Chemicals Act),
- requires marking "dangerous to the environment" in accordance with the EC Directive in force.

Compliance Verification
The applicant shall declare compliance with the requirement. 5/6 UZ 73 - Edition March 2009

3.4 The collectors and the materials used for their manufacture must meet the safety and durability requirements as specified in the relevant standard DIN EN 12975.

Compliance Verification
The applicant shall submit the Typ-prüfungsprotokoll (Type Approval Test Report) according to DIN EN 12975 from accredited test institute according to EN ISO/IEC 17025.

The applicant shall undertake to accept return of used products marked with the Environmental Label and the materials used for their manufacture and to forward them to proper recycling. Information on this obligation shall be included in the Operating Instructions.

Compliance Verification
The applicant shall declare compliance with the requirement and submit the Operating Instructions. The Operating Instructions supplied along with the solar collector shall include a Safety Data Sheet according to Directive 91/155/EEC on the heat transfer medium to be used.

Heat Pumps
Energy-Efficient Heat Pumps using an Electrically Powered Compressor RAL-UZ 121

Scope
These Award Criteria apply to heat pumps using an electrically powered compressor according to DIN EN 255/EN 14511 taking into account VDI Directive 4650[66], Sheet 1, "Berechnung von Wärmepumpen; Kurzverfahren zur Berechnung der Jahresaufwandszahlen von Wärmepumpenanlagen; Elektro-Wärmepumpen zur Raumheizung" (Assessment of heat pumps - Short-cut method for the calculation of the annual effort figure of heat pumps - Electrically powered heat pumps for room heating) with a total thermal output of up to 100 kW at a flow temperature of 45°C meeting the requirements under paragraph 3. These Award Criteria refer to factory manufactured compact units for room heating purposes.

TEWI Limits
The climate-changing emissions from heat pumps are evaluated by using the TEWI value as system parameter. TEWI describes the climate effect of a system via a CO_2-equivalent. Fixing TEWI limits instead of seasonal performance factor limits of the heat pump system or the GWP of refrigerants allows to compensate emissions from refrigerants with a high global warming potential for very low energy-related emissions (highly efficient systems) and vice versa.
The applicant shall demonstrate that the TEWI value of a heat pump system does not exceed the limits specified in Table 1.
Lower TEWI values will have to be observed from 1 January 2008. Compliance with these values can be achieved by

- using refrigerants with a low GWP in energy-efficient products (state of the art) or

[66] The directive does not refer to direct expansion coils.

- further increasing the efficiency of products using refrigerants with a high GWP.

Table 64 TEWI Limits

(the second value - i.e. the value in brackets- will be binding from 1 January 2008)

Type of heat pump	**Thermal output [kW]**	TEWI value (flow temperature 35°C) **[kg CO2]**		TEWI value (flow temperature 45°C) **[kg CO2]**	
Water-to-Water	0 - 20	35,000	(32,500)	37,500	(35,000)
	> 20	70,000	(65,000)	75,000	(70,000)
Brine-to-Water	0 - 20	42,000	(39,000)	45,000	(42,000)
	> 20	84,000	(78,000)	90,000	(84,000)
Air-to-Water	0 - 20	51,500	(48,000)	55,000	(51,500)
	> 20	103,000	(96,000)	110,000	(103,000)
Exhaust air-to-Water	0 - 20	46,000	(43,000)	50,000	(47,000)
	> 20	92,000	(86,000)	100,000	(94,000)

The TEWI value is calculated using the following formula:

TEWI = GWP * (ER * n * m + αV * m) + n * β * Q/SPF

using the following operands:

GWP: Global warming potential [-]
ER: Emission rate [%/a]
n: Life of a system [a]
m: Filling quality of refrigerant [kg]
αv: Disposal loss [%]
β: Conversion factor [kg CO2/kWh]
Qh: Heat demand [kWh/a]
SPF: Seasonal performance factor [-]

Calculation shall be performed using the following parameters:

- annual emission rate of 2 %
- product life of 15 years
- disposal loss of 20 %
- uniform conversion factor: 0.683 kg CO2/kWh
- heat demand for systems up to 20 kW: 15.000 kWh/year
- heat demand for systems over 20 kW: 30.000 kWh/year

The Global Warming Potentials (GWP values) listed in Table 2 shall be used.
The Seasonal Performance Factor is calculated and verified according to paragraph Efficient Energy use.

Table 65 Global Warming Potential of selected refrigerants (list will possibly be extended)

Refrigerant (Code designation)	**Refrigerant (Chemical designation)**	**Global Warming Potential (GWP100)**

R 134a	Tetrafluoroethane	1.300	
R 290	Propane	3	
R 404A	Mixture of trifluoroethane, tetrafluoroethane, pentafluoroethane	3.260	
R 407C	Mixture of difluoromethane, tetrafluoroethane, pentafluoroethane	1.526	
R 410A	Mixture of difluoromethane, pentafluoroethane	1.725	
R 417A	Mixture of butane, tetrafluoroethane, pentafluoroethane	1.965	
R 744	Carbon dioxide	1	
R 1270	Propene (propylene)	3	

Efficient energy use

Performance measurement is done in accordance with standards EN 255 / EN 14511 for different types of heat pumps.

Table 66 Measurement points for performance measurement:

Measurement	W10/W35	W15/W35	W10/W50	W15/W50
points				
water-to-water				

Measurement	B-5/W35	B0/W35	B5/W35	B-5/W50	B0/W50	B5/W50
points						
brine-to-water						

Measurement	A-7/W35	A2/W35	A7/W35	A10/W35	A20/W35
points	75% r.F.	93% r.F.	89% r.F.	78% r.F.	40% r.F.
air-to-water					
	A-7/W50	A2/W50	A7/W50	A15/W50	A20/W50
	75% r.F.	93% r.F.	89% r.F.	71% r.F.	40% r.F.

Requirements for the Heat Pump System

The heat pump system comprises all energetic components which according to VDI 4650, Sheet 1, must be taken into account for determining the seasonal performance factor. The entire system is to be set for a maximum flow temperature of 45°C. This maximum temperature applies to the heating operation. Additional heating which may be added depending on the design of the system (direct electric heating system) must not exceed 5% of the annual heating energy demand.

Energy-Efficient Heat Pumps using Absorption and Adsorption Technology or operating by use of Combustion Engine-Driven Compressors RAL-UZ 118

Scope
These Award Criteria shall apply to:

- gas-fired absorption and adsorption heat pump systems according to DIN EN 12309, Part 1 and 2
- gas-fired adsorption heat pumps according to DVGW VP 120 (see edition of 8/03)
- ready-to-connect absorption heat pumps according to DIN 33830, Part 1 to 4
- ready-to-connect heat pumps with internal combustion-engine-driven compressors according to DIN 33831, Part 1 and 2
- other compressors driven by primary fuels or using internal or external combustion Technology with a rated thermal output of up to 70 kW at a flow temperature of 40°C. These Award Criteria apply to factory-manufactured compact units for space heating.

Requirements for the Refrigerants
The refrigerants used must meet a limit of GWP15 (Global Warming Potential related to a 100-year period). The following table shows, by way of example, some refrigerants that may be used.

Table 67 Global Warming Potentials of Selected Refrigerants for Adsorption and Absorption:

Refrigerant (Code Designation)	Refrigerant (Chemical Name)	Global Warming Potential (GWP100)
R 717	Ammonia	0
R 290	Propane	3
	Water	0
R 744	Carbon dioxide	1
R 1270	Propylene	3

Emission Requirements
The NO_x and CO emission data - related to dry exhaust gas - are to be determined as standard emission factors according to DIN 4702, Part 8. As regards the performance of the measurements the Award Criteria RAL-UZ 61, RAL-UZ 108 and RAL-UZ109 shall be taken into account depending on the type of the heat pump. The following values shall be met without making use of a measuring tolerance and an error tolerance of the calibrating gases:

- Gas-fired heat pumps (O_2 content 0%) The content of nitrogen monoxide and nitrogen dioxide in the exhaust gas must not exceed 60 mg/kWh, expressed as nitrogen dioxide. The carbon monoxide content in the exhaust gas must not exceed 50 mg/kWh.
- Gas engine-driven heat pumps (O_2content 5%) The content of nitrogen monoxide and nitrogen dioxide in the exhaust gas must not exceed 250 mg/Nm^3, expressed as nitrogen dioxide. The carbon monoxide content in the exhaust gas must not exceed 300 mg/Nm^3.
- Other combustion engine-driven heat pumps (O2 content according to specifications in the 1st BImSchV – 1st Ordinance on the Implementation of the German Federal Immission Control Act) The content of nitrogen monoxide and nitrogen dioxide in the exhaust gas must not exceed 2500 mg/Nm^3, expressed as nitrogen dioxide. The carbon monoxide content in the exhaust gas must not exceed 300 mg/Nm^3. The total dust content in the exhaust gas must not exceed 150 mg/Nm^3.

- Heat pumps fired by other fuels (O2 content according to specifications in the 1st BImSchV – 1st Ordinance on the Implementation of the Federal Immission Control Act) The content of nitrogen monoxide and nitrogen dioxide in the exhaust gas must not exceed 250 mg/kWh, expressed as nitrogen dioxide. The carbon monoxide content in the exhaust gas must not exceed 300 mg/kWh.

Efficient Energy Use
Without using a measuring tolerance the standard energy efficiency ratio must not fall below 120 %.
The standard energy efficiency ratio shall be determined at temperatures of 40 and 30 °C in accordance with DIN 4702 T8. In supplementation to DIN 4702 T8, source temperatures must be assigned to the measurement points. The temperatures of the heat transfer medium are hereinafter defined at the inlet to the evaporator (or, alternatively, at the appliance connection point):
-Water-water heat pumps: 10 °C
-Brine-water heat pumps: 0 °C
-Air-water heat pumps: see the Table below

Table 68 Measurement points for perormance measurement

Measurement point	Q / Q_N (% of the rated thermal output)	Flow temperature in ºC	Return temperature in ºC	Ambient temperature in ºC	Temperature of the heat source in ºC
1	0.13	23	21	16.9	14.9
2	0.30	26	23	12.6	10.6
3	0.39	28	24	9.5	7.5
4	0.48	30	25	6.2	4.2
5	0.63	33	26	1.0	-1.0

Auxiliary Power Demand
In stationary mode, the electric power consumption must not exceed 30 Wel / kWH,N related to the rated thermal power. In this calculation, the output of the heating circulating pump for the heat distribution system shall not be taken into account.

Hot water storage
Energy-Efficient Hot-Water Storage Tanks RAL-UZ 124

Scope
These Basic Award Criteria apply to hot-water storage tanks as defined in DIN ENV 12977 – 3 (edition of 2001) and DIN 4753, part 1 (edition of 1988) with nominal volumes from 50 to 3.000 litres.

Requirements for Efficient Energy Use

Heat loss from hot-water storage tanks shall be low. It shall meet a heat loss limit that is to be calculated in dependence on the storage volume using the following formula:
Heat loss rate (W/K) = 0,135 (W/K)/($l^{0,5}$) * actual or effective storage volume (in l)^{0,5}.

Data Sheet
The applicant shall be liable to present a data sheet indicating the following:

- type of storage tank (drinking water tank, buffer storage tank, combined storage tank, others),
- actual or effective storage volume (l),
- drinking water volume (l), if applicable,
- standby volume (l),
- maximum storage temperature (°C),
- tank wall material,
- wall material of the drinking water storage tank (for combined storage tanks),
- insulating material, including thickness (mm) and thermal conductivity group,
- type of corrosion protection (external current anode, sacrificial anode, others),
- overall weight, empty,
- overall weight, filled,
- standby heat loss rate (W/K) according to DIN ENV 12977-3
- maximum permissible container pressure (bar),
- diameter with and without heat insulation,
- transportation dimensions (w, l, h) in mm,
- tilting dimension for installation purposes in mm.

Condensing boilers
Low-emission and Energy-saving Gas-fired Calorific-Value Heating Devices RAL-UZ 61

Scope
These Basic Criteria apply to gas-fired calorific-value appliances:
a) according to DIN 4702, Part 6, with a nominal thermal output of up to and including 70 kW designed for the use of natural gas the exhaust gases of which are discharged via an over-roof exhaust-gas system according to DIN 18160 approved by the building inspection authorities.
b) according to DIN 3368, Parts 7 and 8, with a nominal thermal output of up to and including 70kW designed for the use of natural gas the exhaust gases of which are discharged via an over-roof exhaust-gas system approved by the building inspection authorities or via an exhaust-gas pipe tested together with the appliance.
c) according to DIN EN 677 with a nominal heat load of up to and including 70kW designed for the use of natural gas the exhaust gases of which are discharged via an over-roof exhaust-gas system approved by the building inspection authorities or via an exhaust-gas pipe tested together with the appliance.

Emission Requirements
The emission values listed below - related to dry exhaust gas containing 0% of O_2 - must not be exceeded within the entire setting range without making use of a measuring tolerance under paragraph 6.5 of DIN EN 267 and the error tolerance of the calibrating gases. The pollutant emissions of appliances with modulating or multi-stage firing systems shall be tested in accordance with DIN 4702, Part 8. The measuring unit of the emission values (mg/kWh) is to be understood as mg of pollutant per kWh of heat generating material.

Continuous Operation (Steady State)
Nitrogen Oxides (NO_x)
The content of nitrogen monoxide and nitrogen dioxide in the exhaust gas must not exceed 60 mg/kWh (34 ppm) given as nitrogen dioxide.
Carbon Monoxide (CO)
The content of carbon monoxide in the exhaust gas must not exceed 50 mg/kWh (46 ppm).

Efficient Energy Utilization
Without making use of a measuring tolerance the nominal utilization ratio according to DIN 4702, Part 8, must not fall below 100% for 10kW and 101% for 70kW at temperatures of 75/60 C°. At temperatures of 40/30°C the nominal utilization ratio must not fall below 103% for 10 kW and 104% for 70kW. Output values between the above limits shall be linearly interpolated according to the formula:
"y = (1/60) x + 99.83" or "y = (1/60) x + 102.83", resp.

Auxiliary Power Demand
Electric Power Consumption / Current Consumption
The following electric power consumption values must be adhered to:
In the SLEEP Mode: 15 watts
During (normal) operation: 80 watts with fan-aided burner
200 watts with forced-drought burner according to DIN EN 676

Heating-Water-Side Resistance
With a temperature difference of 10 Kelvin the heating-water-side resistance according to DIN EN 303 must not exceed 800 mbar. The requirement shall also be considered fulfilled for products with a heating-unit content of 5 litres at the most (heat exchanger, among other things) and hence
greater temperature differences in heating water in practice if - with a temperature difference of 20 Kelvin - the heating-water-side resistance falls below 400 mbar. In such case, the heating circulation pump which may either be integrated or form part of the heating device may be on only during heating operation (burner operation) and during a follow-up operation of the pump of 5 minutes at the most. This condition must be fulfilled by the standard setting of the heating device control.

Table 69 Gas condensing boiler measurement requirements

	Unit	Requirement
Sleep mode (Electric power consumption)	W	≤ 15 Measurement time ≥ 10 minutes
Operation (Average electric power consumption)	W	≤ 80/200 Measurement time ≥ 10 minutes
Heating-Water-Side Resistance With a		
Temperature differenct of 10 Kelvin	mbar	≤ 800
Temperature differenct of 20 Kelvin	mbar	-
or		
with a heating unit content	litre	≤ 5
temperature difference of 20 Kelvin	mbar	≤ 400
and a follow-up operation of the pump	min	≤ 5
Heating Circulation Pump		
Type of Pump Control(pump management)	-	Controllable 60-100% or at least 3 levels

Minimum power consumption	W	-
Maximum power consumption	W	-

5.1.3.2 Nordic Swann

Nordic Swan
http://www.nordic-ecolabel.org/
http://www.svanen.se/eng/

Heat Pumps

Class I Single heat pump units
The electricity consumption of a single heat pump unit is calculated independent of the house in which it is installed. However, climatic data for the climate zone in question is used.
The unit is considered to augment another heat source. The definition does not cover other heat sources that contribute to the total heat requirement.
Units that are used solely for cooling cannot be labelled.
In practice, this means that Class I includes the following types of unit:
a) heat pump that directly heats the air in the area to be heated.
b) exhaust air heat pumps.
c) heat pumps for sanitary hot water production only.

Class II Heat pump systems
The electricity requirement of a heat pump system is calculated for model houses of varying size and with climatic data for the relevant climate zone. The electricity consumption shall also include the electricity required by circulation pumps, fans and other auxiliary equipment.
The heat pump system is judged to support the whole heat and sanitary water demand in a house. It is however possible to define the system including or excluding sanitary water.
The system may include a complementary solar collector/cell or other type of supplement that is not detrimental to the environment, such as heat recovery.
During installation, the system shall be optimised to the house or building.
In practice, this means that Class II includes the following types of unit:
a) ground-source, geothermal and air heat pumps with a heat distribution through water or brine.
b) air heat pumps with a heat distribution through air ducts.

Sales in other Nordic countries
Registering a licence in another Nordic country allows the Nordic Ecolabel to be used on a larger market. The following must be submitted to Nordic Ecolabelling:
l Form for sales in the country in question.
l Relevant sections of the installation manual and operation and maintenance instructions must be translated into the applicable language.
Registration is free of charge but an annual fee shall be paid in accordance with the national regulations.

Operation of the Nordic Ecolabelled heat pump
The heat pump must be tested for efficiency and noise. European standards are used for measurement. The test results shall be submitted to Nordic Ecolabelling.

The efficiency of the heat pump is to be tested in accordance with EN 14 511 for both heating and cooling (if relevant) including cases where carbon dioxide is used as the coolant. CEN/TS 14 825 is used for testing of different loads.
Noise is tested as per ENV-12 102.

The laboratory must produce a comprehensive test report containing information on:

- Selected testing method.
- Results from all tests.
- Clear definition of the heat pump.
- That the test has been conducted as per the indicated method, with the exception of any non-conformance that is specified.
- Assessment of the manufacturer's calculation program complies with the program specified by Nordic Ecolabelling.
- That the laboratory fulfils the requirements specified in Section 2.1.
- An assessment showing that the heat pump meets the requirements in the Nordic Ecolabel criteria.

Sample products shall be chosen at random from the factory's warehouse or from the open market. The following material must accompany the product submitted to the testing body:

- Drawings including dimensions.
- Description of materials.
- Installation manual.
- Operating and maintenance instructions.
- Photograph of the product.
- Proposed labelling solution.

Versions of the same heat pump may be assessed based on the results from previous measurements of a product of the same type. Differences between the products must not influence the results of the actual tests. An assessment of this type must be made by a laboratory that complies with the requirements in Section 2.1[67]. The applicant is responsible for all test costs.

Requirement levels

Noise

The noise level must be tested and reported to Nordic Ecolabelling.
Information on measured noise levels must be present in the installation manual. For units that are designed as split units, information must be included for both outdoor and indoor values.

Annual average heat production efficiency

The annual average heat factor shall at least reach the values stated below, calculated as the produced useful heat per electricity consumption in kWh, as an average over a defined period of time, mainly during a year.
If the heat pump is equipped with a cooling function, the heat pump shall be tested during use for all defined test temperatures in the standard. The heat pump shall provide an A level as defined by the energy label for air-to-air heat pumps.

Class I: The annual average efficiency for heat production shall at least reach 1.75 in the relevant climate zone.

[67] When testing the heat pump, the applicant can select from laboratories that comply to the general requirements in the SS EN ISO/IEC 17 025 standard or have official GLP approval. The laboratory must be accredited for testing in accordance with current the EN standard for heat pumps.
If the country of origin lacks an accredited laboratory, a competent, independent laboratory shall be chosen. Such a laboratory shall fulfil the requirements of EN ISO/IEC 170 25 or have official GLP status.

If the refrigerant in the heat pump unit is a HFC refrigerant, the annual average efficiency for heat production shall at least reach 2.5.

Class II: The annual average efficiency for heat production shall at least reach 2.0 in the relevant climate zone.
If the refrigerant in the heat pump unit is a HFC refrigerant, the annual average efficiency for heat production shall at least reach:
GWP < 1000 2.25
GWP < 2000 2.30

Annual average efficiency = EPROD / ELCON
where ELCON annual electricity consumption in kWh
EPROD annual produced useful heat in kWh

The heat pump shall be classified for use in one or more climate zones. Climate zones are defined according to the following temperature ranges (map of climate zones included in Appendix 9):
Climate zone 1: annual average temperature below and up to 5ºC
Climate zone 2: between 6 -10ºC
Climate zone 3: between 11-15ºCNordic Ecolabelling of Heat pumps 2.2 12 (16)
The calculation of the annual average efficiency factor shall relate to the relevant climate zone. Hourly climatic data must be used for the relevant region in the climate zone in question. The manufacturer may use a custom calculation program. In such a case, an independent laboratory must verify that the calculation program complies with the requirements set in this document and the specified program.
The test results from all test points are to be used for each climate zone. If the pump can handle low loads, these are to be included.

Class I: Calculations shall be made for the separate unit.
Class II: Calculations shall be made for the entire system including the supply of hot sanitary water. For temperatures where the heat pump is not in use, the relevant electricity consumption shall be included.

If circulation pumps and/or fans are used, electricity consumption for their operation shall be included. If solar collectors or solar cells are used in the heating system, the heat generated from these units shall be included. If heat recovery is made from external refrigerating machines, this must be regarded as a supplemental part of the system.

Test methods
Testing encompasses:

- Examination of product drawings, description of materials, installation manual, and operating and maintenance instructions. Materials must comply with R10 to R15.
- Declaration of product compliance with R21 - R23.
- Comprehensive test reports.
- Verification of manufacturer’s calculation program.

Noise measurements must be conducted by an independent laboratory in accordance with ENV-12 102.
The heat pump must be tested in accordance with EN 14 511 for heat production and for cooling (if applicable). The test method is also used for testing with a carbon dioxide refrigerant. CEN/TS 14 825 is used for testing partial loads.

Heat pump testing must cover all the items specified in the standard. If the heat pump shuts down under certain operating conditions, this must be clearly documented in the test report. If the heat pump can be used for several loads, the heat pump shall be tested at these loads.
In cases where the heat pump has been fitted with a cooling function, the pump must be tested for the specified test points in the standard.

Solid biofuel boilers

A boiler is classified as a primary heat source when one boiler provides the majority of heat, including hot water, in one building.
The product group comprises combined solid biofuel boilers/burners with an output of up to 300 kW. Solid biofuel refers to split logs, briquettes, pellets and chips as defined by EN 303-5. Straw is also a solid biofuel. The fuel can be fed manually or automatically.
A solarcell may be included in the heating system.
Normally separate burners cannot be awarded the Nordic Ecolabel. However, if a burner is tested together with a defined boiler, the burner may be Nordic Ecolabelled if it is sold together with the defined boiler.
Single-room heat sources such as stoves, slow heat release fireplaces and open fireplaces are covered by a separate criteria document. These are covered by other criteria.

Operation of the Nordic Ecolabelled boiler
The boiler must be tested for flue gas emissions. The results of these tests must be submitted to Nordic Ecolabelling.
The test laboratory shall produce a comprehensive test report that contains information on the following.
1 Selected test method.
2 Results from all tests.
3 A clear description of the boiler.
4 Confirmation that the test has been performed in accordance with the method specified, except where stated otherwise.
5 Specification of the test fuel.
6 That the laboratory fulfils the specified requirements.
7 An evaluation of whether the boiler fulfils the requirements in the criteria.

Products for testing are chosen randomly from the factory's warehouse or from the open market. The following material must be submitted to the testing body together with the product:

- lDrawings including dimensions.
- lDescription of materials.
- lInstallation manual.
- lOperating and maintenance instructions.
- lPhotograph of the product.
- lProposed labelling solution.

Variations of the same boiler may be assessed on the basis of results from an earlier measurement of a product of the same variant. The difference between the boilers must not affect the results of the testing itself. The assessment must be made by a laboratory that fulfils the requirements stipulated in Section 2.1.

Such an evaluation must place emphasis on the boiler's environmental and safety characteristics. Design factors that strongly influence these properties:

- Dimension and volume of the combustion chamber.
- Air valves and air channels.
- Gas flues.
- Radiation protection and convection system.

The applicant is liable for the cost of testing.

2.1 Choosing a laboratory
For flue gas tests, the applicant may choose any laboratory that fulfils the general requirements of EN ISO/IEC 17 025 or which has official GLP status. The laboratory must be accredited for testing to a valid EN standard.

An alternative laboratory may be acceptable if the laboratory has applied for accreditation according to the valid EN method but has not yet been granted approval. The laboratory must be able to show that it is independent and qualified.

If the country of origin lacks an accredited laboratory, a competent, independent laboratory shall be chosen. Such a laboratory shall fulfil the requirements of EN/ISO/IEC 170 25 or have official GLP status.

2.2 Limit values
Air emissions
The limit values specified in the table below, must not be exceeded.
Particle and NOx (nitrogen oxides) emissions are only tested at nominal load.
The limit values for OGC (organic carbon) and CO (carbon mono oxide) are tested under the following conditions:
1 Nominal load for manual feed boilers equipped with a hot-water tank.
2 Nominal load and low load for automatic feed boilers. An average is calculated from the results of the three low loads. The various loads are defined in Section 2.3.
The requirements are applicable to manual and automatic feed boilers as well.
Limit values for air emissions

Table 70 Nordic Swann biomass boiler ELV

Automatic feed boiler		Manual feed boiler	
(mg/m^3 dry gas at 10% O_2)	X ≤ 300 kW	X ≤ 100 kW	100 < X ≤ 300 kW
OGC	25	70	50
CO	400	2000	1000
NO_2	340	340	
particles	40	70	

Efficiency
Boiler efficiency: ηk must at least be:

Manual feed boiler: ηk = 73 + 6 log QN
where QN is the nominal output of the boiler.
Automatic feed boiler: ηk = 75 + 6 log QN,
and ηx ≥ 86%; ηx = (η20 + η40 + η60)/3
where η20, η40 ,η60 stand for the measured efficiency at 20, 40 and 60% load.

Comprehensive test report with laboratory certification that the boiler meets the requirements.

2.3 Test methods
Testing encompasses:
1 Examination of product drawings, description of materials, installation manual, and operating and maintenance instructions.
2 Declaration that the product.
3 Full test reports.
Boilers must be tested fully equipped.
Boilers shall be tested according to EN 303-5 at nominal load. Nominal load is defined by the manufacturer.
Low load testing shall comply with EN 303-5 but at 20, 40 and 60% of the nominal load, and with the transitions specified by the SP test method for P-labelling. Emission levels shall be tested at a steady state at the predefined low loads. Readings shall not be taken during the transition between loads.

Nordic Ecolabelling adopted, version 2 of the criteria for Solid biofuel boilers on 14 March 2007. The criteria are valid until 30 June 2011.
On 21 June 2010 the Nordic Ecolabelling Board decided to prolong the criteria until 31 March 2013. The new version is called 2.1.
An Ecolabel licence is valid providing the criteria are fulfilled and until the criteria expire. The validity period of the criteria may be extended or adjusted, in which case the licence is automatically extended and the licensee informed.
Revised criteria shall be published at least one year prior to the expiry of the present criteria. The licensee is then offered the opportunity to renew their licence.

New criteria
The following test methods will be evaluated in future criteria. The intention is to investigate whether the lighting phase should be included in testing.
Current technology will also be assessed, in particular to determine whether technical advances mean that manual feed boilers without a hot-water tank fulfil the requirements. If such is the case, it should also be possible to Ecolabel such boilers.
An evaluation of whether test laboratories should be engaged in round-robin testing.
An evaluation of whether the pellet grade used for testing of emissions should be defined.
An evaluation of whether service life requirements on catalytic converters should be introduced in those cases a catalytic converter is used.
An evaluation if requirements of an average annual efficiency shall be included.

5.1.3.3 Österreichisches Umweltzeichen UZ37

Österreichisches Umweltzeichen
- Wood fired (pellets, briquette) boilers
- Solar collectors and solar systems

Guideline UZ 37

Wood fired (pellets, briquette) boilers

Scope
This guideline is valid for automatic or manual fed space heaters as well as boilers. These must be suitable for the firing of the natural fuel wood, wood chips or pressed wood (briquette, pellets) and may have a maximum fuel thermal output of 400 KW.

To reach an even emission distribution in the enterprise as possible only quality-examined fuels are to be used. Depending on the heating, data must be given by the applicant to its technical characteristics the permissible fuel, as well as a reference following sets of rules.

- Wood: Data to wood, size of, water content
- Compressed wood (briquette, pellets): Quality and supply in accordance with requirements of the Austrian ones Symbol for environmental protection guideline UZ 38[68] or in accordance with ÖNORM M 7135[69] in Connection with ÖNORM M 7136[70]
- Wood chips: Requirement in accordance with ÖNORM M 7133[71]

Table 71 UZ 37 Automatic feed heaters, emissions in (mg/MJ)

Parameter	Boiler	Space heating
CO Full load		
Pellets	60	120
Woodchips	150	
CO Part load (30% of full load respectively the smallest capacity)		
Pellets	135	265
Woodchips	300	
NO_x Full load		
Pellets	100	100
Woodchips	120	
C_{org} Full load		

[68] Österreichische Umweltzeichen - Richtlinie UZ 38, Brennstoffe aus Biomasse, Briketts, Pellets, Ausgabe vom 1. Jänner 2005
[69] ÖNORM M 7135, Presslinge aus naturbelassenem Holz oder naturbelassener Rinde, Pellets und Briketts; Anforderungen und Prüfbestimmungen, vom 1. November 2000
[70] ÖNORM M 7136 Presslinge aus naturbelassenem Holz - Holzpellets - Qualitätssicherung in der Transport- und Lagerlogistik, vom 1. Juni 2002
[71] ÖNORM M 7133 Holzhackgut für energetische Zwecke; Anforderungen und Prüfbestimmungen, 1. Februar 1998

Pellets	3	6
Woodchips	5	
C_{org} Part load		
Pellets	3	10
Woodchips	10	
Dust (PM) Full load		
Pellets	15	20
Woodchips	30	

Emissions of manual fed wood burning boiler must be equipped with an achievement and a firing regulation. During the type testing following emissions may not be exceeded.

Table 72 UZ 37 manual feed, emissions in [mg/MJ]

Parameter	Boiler	Space heating
CO Full load	250	700
CO Part load (50% of full load)	750	---
NO_x	120	120
C_{org} Full load	30	50
Dust (PM) Full load	30	30

With boiler the radiation losses must be minimized over the surface, following values may not be exceeded.

Table 73 UZ 37 Maximum radiation losses during nominal heat output

Boiler-nominal heat capacity (kW)	Maximum radiation loss (%)
till 100	2,5
100 till 400	1,5

Table 74 UZ 37 Standards to be used

Boiler	ÖNORM EN 303-5
Space heating (manual feed)	ÖNORM EN 13240
Space heating (pellets)	ÖNORM EN 14785
Stove	ÖNORM B 8303
Central heating stove	ÖNORM EN 12815
Chimney insert	ÖNORM EN 13229

Solar collectors and solar systems

Scope

Thermal solar collectors (panel collectors or Vacuum collectors) as well as solar systems, which produce warmth with o.a. collectors.

The solar collector has to be tested according to ÖNORM EN 12975 part 1[72] and 2[73].

Table 75Minimum returns for environmental protection collectors

Collector type	Panel collector	Vacuum collector
Annual heat production	≥ 350 kWh/m^2	≥ 400 kWh/m^2

Solar systems must correspond to the requirements of the ÖNORM EN 12976 and exhibit in dependence of their use the following dimensions.

Table 76 UZ 37 Solar collector dimensioning

Application	Surface area	Storage volume
Water heating	6 m^2	400 liter
Vacuum collector water heating	12 m^2	1.000 liter
Panel collector water heating	15 m^2	1.000 liter

Energetic decrease of the collectors

The portion of not renewable primary energy contents (PEI) for the production of, all materials used to the building, collectors may amount to maximally 80% of the annual utilizable heat produce of the collector. The power requirement for the assembly of the collector is not along-balanced thereby. As data source to the determination of the PEI per know kg material in the inspection report aforementioned „energetic characteristic numbers ", to be consulted.

The annual utilizable heat transfer the collector and/or the system can do is with the simulator routine f-chart[74] with the following descriptive basic conditions of a simulation plant to be computed. The necessary collector surface is to be selected with the fact in such a way that a solar yearly covering degree is reached to the warm water production of 60% (± 1%).

Weather:	A-8010 Graz
Height over Mediterranean:	353 m
Reference area aperture:	m ²
Conversion factor (h):	of testing centre
A1 determines:	of testing centre
Determines Collector inclination:	45°
Collector adjustment:	0°
Collector throughput:	40 l/m ² *h and/or manufacturer data
Heat exchanger achievement:	50 W/m ² *K
Memory contents:	500 l
Warm water need:	200 l/Tag
Chilled water temperature:	12°C
Memory withdrawal temperature:	45°C
System losses:	0%
Plant quality:	on the average

[72] ÖNORM EN 12975-1, Thermische Solaranlagen und ihre Bauteile – Kollektoren - Teil 1: Allgemeine Anforderungen, 1. Februar 2001
[73] ÖNORM EN 12975-2, Thermische Solaranlagen und ihre Bauteile – Kollektoren - Teil 2: Prüfverfahren (EN 12975-2: 2001 + AC: 2002), 1. Dezember 2002
[74] Simulationsprogramm Version 7.00, IST Energietechnik GmbH D-79400 Kandern, http://www.ist-datentechnik.de/

5.1.3.4 Flamme Verte

'Flamme Verte' label
http://www.flammeverte.org/
http://www.focus-creation.com/#/fireplace-flamme-verte

The Green Flame applies minimum energetic efficiency requirements for heating boilers apliances using wood of ≥ 80%.

Table 77 Evolution of the performance of the Flamme Verte label

Boilers		Efficiency		CO emissions (ppm)		VOC (ppm)		Dust (mg/m^3)	
		2008	2009/2010	2008	2009/2010	2008	2009/2010	2008	2009/2010
Manual	Pn ≤ 50 kW	≥ 70	≥ 80	8.000	5.000	225	150	165	150
	50 < Pn ≤ 70 kW			5.000	2.500	150	100		
Automatic	Pn ≤ 50 kW	≥ 75	≥ 85	4.000	3.000	150	100	165	150
	50 < Pn ≤ 70 kW			3.500	2.500	115	80		

Table 78 Evolution of the performances of self-contained equipment label Flamme Verte

	2004	2005	2006	2007	2008	2009
Efficiency	60%	65%	65%	70%	70%	70%
CO emissions (ppm)	1%	0,8%	0,6%	0,6%	0,5%	0,3%

Adhesion with the charter “FLAME GREEN” engages the signatories, at least, with the respect of the performances of the table hereafter for the apparatuses concerned with the European standards:

Table 79 Flamme Verte ELV and standards

Boiler type	Thresholds	Norm
Fireplaces and insers	Efficiency: ≥ 70%	EN 13229
	CO Emissions: ≤ 0,3%	
Stove with pellets	Efficiency: ≥ 85%	EN 14785
	CO Emissions: ≤ 0,04%	
Stove with logs	Efficiency: ≥ 70%	EN 13240
	CO Emissions: ≤ 0,3%	
Stoves with slow accumulation of heat	Efficiency: ≥ 75%	EN 15250
	CO Emissions: ≤ 0,3%	
Fireplace boilers	Efficiency: ≥ 70%	EN 12809
	CO Emissions: ≤ 0,3%	
Space heater	Efficiency: ≥ 70%	EN 12815 and NFD 32301
	CO Emissions: ≤ 0,3%	
Power	No minimum threshold. Indication provided by the manufacturer will carry the power to nominal level.	In accordance with EN standards

5.1.3.5 HETAS Certification

Solid biomass fired boilers (up to 50kW)
Heat pumps

HETAS certification
http://www.hetas.co.uk/installer/microgeneration-certification
http://www.microgenerationcertification.org/installers/installers

Scope
For the purposes of this Microgeneration Installation Standard, solid biofuel heating systems are defined as: Biofuel appliances designed to burn only solid renewable Biofuels[75] as specified by the manufacture with an output up to 45 kW_{th} also including their fuel supply system. The biofuel appliance need to meet and continue the following requirements:

BS EN 13240:2001+A2:2004 - Room heaters fired by solid fuel. Requirements and test methods
Or
· BS EN 14785:2006 - Residential space heating appliances fired by wood pellets. Requirements and test methods. This can be used for boilers and roomheaters in and out of living space.
Or
· BS EN 12809:2001+A1:2004 - Residential independent boilers fired by solid fuel. Nominal heat output up to 50 kW Requirements and test methods
Or
· BS EN 303-5:1999 Heating boilers - Part 5: Heating boilers for solid fuels, hand and automatically fired, nominal heat output of up to 300kW. Terminology, requirements, testing and marking.
And
· The performance and emission criteria detailed in Clause 7

If the solid biomass fired heating appliance is to be installed within a smoke control area (www.uksmokecontrolareas.co.uk) it must be exempt under section 21 of the Clean Air Act 1993. The listing of a solid fuel appliance within the MCS does NOT confer exempt appliances status.

PERFORMANCE CRITERIA

For compliance with this scheme, biomass systems must be optimised for heating and must achieve the following minimum efficiency and emissions when tested by an independent test body (please refer to document MCS 011) and in accordance with the appropriate British Standards (see section 5):

Efficiency
Solid biomass fired boilers (up to 50kW)

[75] Solid biofuel as defined in the "DD CEN/TS 14588:2004 Solid Biofuels. Terminology, definitions and descriptions" and excluded from the Waste Incineration Directive. Biomass, defined as all material of biological origin excluding material embedded in geological formations and transformed to fossil fuel. As well as solid biofuels produced directly or indirectly from biomass.

Solid biomass fired boilers when tested according to BS EN 12809:2001+A1:2004 shall achieve an efficiency in accordance with Figure 1, of that standard, relative to its nominal heat output (i.e. from 65% at 5kW up to 70% at 50kW net efficiency) or when tested according to BS EN 303-5:1999 (for boilers operating on sealed systems) shall achieve an efficiency in accordance to class 2 in figure 1, of that standard, (i.e. 57 + 6 log Nominal Heat Output).

Emissions

Solid biomass fired boilers (up to 50kW)

Shall achieve at least the Class 3 emissions standard of BS EN 303-5:1999 when tested with an appropriate fuel, with visible smoke not exceeding Ringlemann 2. When tested in accordance to BS EN12809:2001+A1:2004 the mean CO concentration calculated for 13% Oxygen content in the flue gas shall be less than or equal to the manufacturer's declared value or shall not exceed 1.0%. Also see section 2 for installations within Smoke Controlled Areas.

Heat pumps

Scope

Micro generation Heat Pump systems utilise different primary heat sources (ground-, air and water-sources), each of which requires different design and installation considerations. This Microgeneration Installation Standard includes the requirements for Microgeneration Heat Pump systems for heating or for heating and cooling. Cooling only systems and direct expansion (DX) ground-loop systems are excluded from this Standard.

For the purposes of this Microgeneration Installation Standard, Microgeneration Heat Pump systems are defined as those having a design output that does not exceed 45kW thermal.

No specific requirements found, just MSC 001 Installer certification scheme requirements document but that is in general for all subjects available for labelling.

- Solar domestic hot water
- Solar PV
- Micro Wind
- Micro Hydro
- Biomass
- Heat Pumps
- Micro CHP
- Renewable CHP
- Fuel cells

5.1.4 *Overview of criteria parameters*

The table below is the summary of the environmental aspects covered by criteria as described in the previous sections.

Table 80 Overview of environemntal aspects in legislation, labels etc.

Product	Source	Environmental aspect							
		thermal efficiency	elec. aux.power	thermal standby power	various other env.aspects	NOx	CO	OGC	dust
Electric resistance boilers	Ecodesign	will not meet requirements				-	-	-	-
Gas/oil boilers	Ecodesign	fl + pl	(indirect)	(indirect)	(protocol, indirect)	incl.	-	-	-
	GPP	incl.	-	-	-	incl.	incl.	incl. (oil)	incl. (oil)
	Blaue Engel	incl.	incl.		int. resistance, pump	incl.	incl.		
Biomass boilers	GPP	-	-	-	-	incl.	incl.	-	-
Biomass boilers-pellets	Blaue Engel	fl + pl	incl.	-	-	incl.	incl.	incl.	incl.
Solid fuel boilers	Nordic Swan	fl + pl (autom.)	-	-	-	incl.	incl.	incl.	incl.
Biomass boilers (pellets/wood)	UZ 37	-	-	incl.	-	incl.	incl.	incl.	incl.
Biomass boilers	Flamme Verte	incl.	-	-	-	incl.	incl.	incl.	incl.
Biomass boilers	HETAS	incl.	-	-	-		incl.	incl.	incl.
Heat pump boilers	Ecodesign	SCOP	(indirect)	-	GWP bonus	incl. (if gas-fired)	-	-	-
	GPP	COP/PER	-	-	GWP bonus	-	-	-	-
	Blaue Engel - elec.	TEWI			info requirements				
	Blaue Engel - gas	PER	incl.		GWP max	incl	incl.		incl.
	Nordic Swan	SPF	-	-	GWP bonus, noise info	-	-	-	-
Cogeneration boilers	Ecodesign	fl + pl	incl.			incl.			
	GPP	efficiency	-	-	-	-	-	-	-
	CHP Directive	energy efficiency	-	-	-	-	-	-	-
Supplementary equipment									
Solar thermal collectors	Blaue Engel	collector efficiency, at 40% solar coverage							
	UZ 37	collector efficiency, at 60% solar coverage							
	Ecodesign	can be included in CH boiler configuration							
Thermal storage	Ecodesign	can be included in CH boiler configuration							
	Blaue Engel	heat loss requirements							

Passive flue heat recovery	Ecodesign	can be included in CH boiler configuration
Circulators	Ecodesign	Energy efficiency requirement
Temp.control	Ecodesign	can be included in CH boiler configuration
Emitters	-	[to discuss]

[to expand with discussion]

Annex I - Generic economic data

The following tables present production, import and export data of various central heating products, as extracted from the Eurostat Prodcom database of 2010 (values of 2009 are most recent).Based upon these figures the MSP value of an “average” central heating boiler produced in the EU27 is 679 euro (2009).

Table 81: Production of central heating boilers

Production	25.21.12.00 Boilers for central heating (other than HS8402)							
	in 1.000 units				in million Euro			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	55	53	52	56	99	96	175	223
Belgium	141	100	52		80	50	32	
Bulgaria			2,2	2,5			1,7	1,7
Cyprus								
Czech Rep.			102	145				100
Denmark	13	16	17	0,7	24	31	43	28
Estonia								
Finland			20	9,1	20	18	30	25
France	65	995	1.011[1]	719	63	728	791	610
Germany	787	664	1.047	1.194	996	774	849	799
Greece	17	17	23	10	10	8	11	6
Hungary			11	18		20	6,8	19
Ireland		67	97			18	34	
Italy	1.031	2.094	2.985	1.992	463	1.027	1.499	1.101
Latvia			1,9	1,6			2,0	3,4
Lithuania		4,8	9,6	9,1		2,5	5,7	6,4
Luxemburg								
Malta								
Netherlands	256	432		594	233	380	449	543
Poland			355	420			149	197
Portugal	1,2		137	180	0,8		46	64
Romania			25	15			5,4	9,7
Slovakia		30		164				100
Slovenia								
Spain	54	124	86	53	41	102	66	51
Sweden		36			0,03	50		
UK	903	945	1.210	1.178	439	644	856	689
EU27			7.067	6.944			5.302	4.715

1Suspicious value: the value in PRODCOM 2009 is 1.011 but manually adjusted to 1.011.000

Table 82: Production of solid fuel equipment

Production	27.52.12.70 Iron or steel solid fuel domestic appliances, including heaters, grates, fires and braziers (excluding cooking appliances and plate warmers)							
	in 1.000 units				in million Euro			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	38	50	48	43	26	40	52	74
Belgium	62	84	73		27	40	60	
Bulgaria			74,0	127			8,6	17
Cyprus								
Czech Rep.			182	125			51	61
Denmark	73	90	133	96,0	41	59	76	76
Estonia				23			3,0	1,8
Finland	60	80	90	90,0	9,8	11	19	22
France			192	160			104	166
Germany	65	60	45	55	31	48	49	75
Greece	9,8	10	4,5	1,7	1,3	1,0[1]	1,0	0,5
Hungary			334	261			86	81
Ireland	47							
Italy	30	91	188	165	9,1	56	144	163
Latvia								
Lithuania		0,4	33	1,0			0,8	0,6
Luxemburg								
Malta								
Netherlands				11	14	16	26	19
Poland				64			5,1	13
Portugal		13	15	3,8		4,6	6,3	2,9
Romania								
Slovakia		16	31	28			10	19
Slovenia								
Spain	35	182	132	111	10	22	39	44
Sweden		16				18		
UK	38	30	59	167	9,3	15	28	52
EU27			1.820	1.696			840	1.041

Table 83: Production of heat pumps (units, euros)

Production	28.25.13.80 Heat pumps other than air conditioning machines of HS 8415							
	in 1.000 units				in million Euro			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria								
Belgium								
Bulgaria			0,6	0,05				
Cyprus								
Czech Rep.								
Denmark				23	0,02	0,006	2,2	40
Estonia								
Finland		0,7	0,9	1,6		4,8	9,4	14
France	1,8	309	337		5,5	479	493	458
Germany	11		12	109	19		95	392
Greece								
Hungary			1,2	44			2,7	40
Ireland								
Italy	20	92	75	53	14	98	207	116
Latvia								
Lithuania		0,02		0,004				0,01
Luxemburg								
Malta								
Netherlands		19	23		16	14	20	14
Poland							2,4	
Portugal		3,6	6,6	19		2,6	4,2	16
Romania								
Slovakia								
Slovenia								
Spain	79	109	37	20	48	88	132	54
Sweden		16	2,2	73		54	11	185
UK		1.868	2.110	14	25	53	50	27
EU27			2.630	559			1.350	1.521

Table 84: Production of thermostatic radiator valves (units, euros)

Production	28141253 - Central heating radiator thermostatic valves							
	in kg				in million Euro			
	1995	2000	2005	2009	1995	2000	2005	2009
Finland			1,2					
Germany	5.373	5.895	6.587		95	101	86	
Italy	453	2.128	3.790	3.154	6,8	42	50	65
Romania		194				0,2		
Spain		1.250		421		12		12
Sweden		9.180				4,9		
UK						21		
EU27			15.903	11.514			227	212

(No more data available in Prodcom for the other countries)

Table 85: Production of other radiator valves (units, euros)

Production	28141255 - Central heating radiator valves, other							
	in kg				in million Euro			
	1995	2000	2005	2009	1995	2000	2005	2009
Denmark				122				
Finland						0,1		
Germany	15.851	16.186	16.141	6.881	139	79	108	80
Sweden		222				3,8		
UK					14			
EU27			37.138	31.427			398	401

(No more data available in Prodcom for the other countries)

EU25 Trade

Data are only available in mln. € and not in physical units and relate to PRODCOM category 25.21.12.00, central heating boilers other than those of HS 84.02.

Table 86: EU trade (import/export) of central heating boilers

25211200 - Boilers for central heating other than those of HS 84.02								
	EU27 central heating BOILER EXPORTS				EU27 central heating BOILER IMPORTS			
	in mln. €				in mln. €			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	32	49	147	259	49	63	90	87
Belgium	60	41	18	44	64	70	120	189
Bulgaria			0,4	0,2			10	7,1
Cyprus								
Czech Rep.			76	77			33	50
Denmark	13	16	26	21	7	16	39	42
Estonia		0,4	0,4	0,4			4,3	1,7
Finland	8	6	9,6	5,8	0,8	0,8	0,9	4,3
France	224	237	200	163	100	171	220	227
Germany	491	734	923	945	135	208	309	361
Greece	1	3	3	0,8	11	20	30	23
Hungary			24	9,9			61	40
Ireland		16	26	35		27	33	20
Italy	238	512	629	480	120	126	221	219
Latvia			11	7,7			16	8,2
Lithuania		0,5	3,4	8,2		4,6	8,8	10
Luxemburg		1,6	1,9	0,9			9,4	8,9
Malta							0,06	0,05
Netherlands	31	150	203	266	76	34	76	82
Poland			77	136			80	98
Portugal	0	26	36	22	8,3		28	16
Romania		2,9	14	12		34	106	75
Slovakia		17	79	139		9,5	31	33
Slovenia			6,1	4,6			14	15
Spain	9	42	51	33	111	165	201	171
Sweden	8,61	12	22	16	6,14	6	20	17
UK	20	28	61	33	99	277	354	217
EU27			565	687			152	193

Table 87: EU trade (import/export) of solid fuel equipment

27521270 - Iron or steel solid fuel domestic appliances, including heaters, grates, fires and braziers (excluding cooking appliances and plate warmers)								
	EU27 EXPORTS				EU27 IMPORTS			
	in mln. €				in mln. €			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	13	23	37	77	8,1	15	32	52
Belgium	15	25	35	57	9,8	9,6	17	35
Bulgaria			5,1	17			2,4	1,2
Cyprus								
Czech Rep.			47	62			9,6	17
Denmark	34	51	67	61	1,1	1,7	5,8	16
Estonia		0,2	2,1	1,8		1,1	3,9	2,3
Finland	0,7	1,9	5,2	7,8	1,0	2,6	3,9	4,1
France	30	58	69	59	9,8	14	34	85
Germany	12	25	51	87	59	86	128	164
Greece	0,1	0,05	0,2	0,2	0,8	1,0	2,8	4,5
Hungary			76	73			2,7	4,9
Ireland	0,06	0,01	0,7	0,3	0,3	1,0	4,7	1,8
Italy	7,3	14	35	121	12	25	28	29
Latvia			1,0	1,8			3,2	1,8
Lithuania		0,2	0,9	0,7		1,4	3,8	2,7
Luxemburg		0,04	0,3	4,3		1,0	1,8	7,7
Malta							0,2	0,2
Netherlands	10	11	11	12	2,9	8,3	7,7	14
Poland			11	16			26	31
Portugal	0,9	0,2	0,7	2,6	6,3	12	11	13
Romania		0,1	0,7	0,2		0,2	1,7	4,1
Slovakia		9,1	19	30		1,4	3,5	6,3
Slovenia			2,4	4,8			2,9	3,7
Spain	2,2	6,0	9,1	16	5,3	8,3	11	16
Sweden	1,6	3,3	26	21	3,0	5,2	17	8,7
UK	1,4	0,7	2,6	3,8	4,4	7,2	16	33
EU27			87	90			65	106

Table 88: EU trade (import/export) of heat pumps

28251380 - Heat pumps other than air conditioning machines of HS 8415								
	EU27 EXPORTS				EU27 IMPORTS			
	in mln. €				in mln. €			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	6,4	5,4	14	38	14	23	28	31
Belgium	9,7	7,2	10	14	27	36	37	37
Bulgaria			0,3	0,1			4,8	5,8
Cyprus								
Czech Rep.			5,5	7,1			25	21
Denmark	2,5	1,6	7,2	41	6,5	34	67	18
Estonia		0,2	0,3	0,2		1,5	1,3	1,9
Finland	1,8	4,7	7,8	2,3	8,3	17	22	31
France	263	492	627	336	73	96	94	139
Germany	93	137	207	235	91	135	183	86
Greece	0,6	1,6	1,2	3,4	6,6	15,0	16	16
Hungary			1,3	0,7				6,1
Ireland	199	222	235	143	11	2,2	3,3	3,7
Italy	67	136	187	124	31	60	63	39
Latvia			0,2	0,4			3,1	1,7
Lithuania		0,2	5,5	2,1		1,9	7,1	5,4
Luxemburg			0,2	0,2		0,9	2,0	2,4
Malta			0,2				0,3	0,2
Netherlands	15	16	25	14	45	40	43	31
Poland			6,1	3,1			38	26
Portugal	0,5	1,1	3,2	0,6	5,4	11	8,3	17
Romania		0,1	0,8	0,1		8,3	12	3,9
Slovakia		6,2	10	13		3,0	2,6	3,1
Slovenia			3,1	1,8			5,9	5,4
Spain	20	44	29	26	22	47	80	27
Sweden	39	10	27	106	11	12	17	31
UK	32	104	96	3,6	50	95	133	80
EU27			449	281			146	73

Table 89: EU trade (import/export) of thermostatic radiator valves

28141253 - Central heating radiator thermostatic valves								
	EU27 EXPORTS				EU27 IMPORTS			
	in mln. €				in mln. €			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	0,2	3,6	2,7	0,7	3,9	6,9	5,7	3,5
Belgium	1,7	3,0	2,4	3,4	8,4	8,2	8,2	9,6
Bulgaria			0,5	1,6				1,0
Cyprus								
Czech Rep.			2,1	7,9			4,6	5,1
Denmark					1,4	0,8	4,0	4,2
Estonia						0,3	0,5	0,3
Finland	0,4	0,4	0,08	0,3	3,3	3,3	1,4	0,7
France	13	52	51	20	22	27	17	21
Germany	45	44	42	51	32	30	18	17
Greece			0,08	0,2	0,4	1,1	0,5	0,7
Hungary			0,08	0,2			2,4	2,2
Ireland	0,3	3,4	8,6	4,3	2,2	1,6	0,9	2,0
Italy	3,6	4,8	9,3	11	1,5	2,3	6,5	7,2
Latvia			1,2	0,1			2,1	0,5
Lithuania		0,05	0,06	0,5		0,3	0,8	0,7
Luxemburg		0,4	0,3	0,2		1,3	0,9	0,8
Malta								
Netherlands	0,2	0,3	0,1	0,5	12	13	12	21
Poland			5,5	6,2			8,8	17,0
Portugal		0,03	0,2	0,5	1,6	0,9	1,2	1,0
Romania		0,02	0,7	0,8		1,1	6,0	1,8
Slovakia		0,1	0,2	4,1		2,1	3,5	2,4
Slovenia			0,4	0,3			1,0	1,0
Spain	0,3	1,4	0,9	0,5	0,04	0,9	1,3	1,8
Sweden	4,5	16	22	9,4	3,0	2,1	4,3	4,4
UK	2,2	12	9,7	8,2	20	26	15	16
EU27			19	22			11	17

Table 90: EU trade (import/export) of other radiator valves

28141255 - Central heating radiator valves, other								
	EU27 EXPORTS				EU27 IMPORTS			
	in mln. €				in mln. €			
	1995	2000	2005	2009	1995	2000	2005	2009
Austria	0,9	1,0	2,7	1,3	5,6	7,1	8,3	7,5
Belgium	14	9,4	2,2	2,7	17	19	11	15
Bulgaria			0,2	0,04			1,3	1,4
Cyprus								
Czech Rep.			1,2	3,5			6,2	5,3
Denmark	0,8	0,3	6,5	12	1,6	11	7,4	11
Estonia			0,02				0,03	0,02
Finland	4,0	0,09	0,4	0,03	1,2	0,9	2,2	3,1
France	3,6	2,6	1,8	5,2	6,6	11	8,3	12
Germany	16	23	50	68	30	32	39	28
Greece	0,5	2,6	5,1	1,8	2,6	2,3	1,9	1,5
Hungary			1,9	0,2			3,6	4,3
Ireland	4,3	8,3	6,3	4,6	0,8	2,7	3,3	1,8
Italy	17	32	55	134	1,4	2,7	4,4	10
Latvia							0,03	0,01
Lithuania		0,02	0,3	0,4		0,4	0,6	0,6
Luxemburg						0,2	0,4	0,5
Malta								
Netherlands	0,05	0,9	5,5	23	6,7	4,2	6,4	12
Poland			3,8	16			10	11
Portugal		0,2	0,4	0,3	0,3	1,4	2,1	1,4
Romania			0,03	1,3		1,4	1,9	3,7
Slovakia		0,5	0,7	1,6		1,4	0,9	2,5
Slovenia			5,5	5,9			1,1	2,6
Spain	0,7	1,0	0,6	1,4	2,0	2,0	1,2	6,3
Sweden	0,3	23	3,5	7,2	0,6	0,5	1,3	4,4
UK	1,1	2,7	8,2	5,1	4,0	14	28	37
EU27			54	87			19	29

Apparent consumption

Apparent consumption is calculated as: Apparent Consumption = Production + import - export

Table 91: EU Apparent consumption of central heating boilers

Consumption: Boilers for central heating other than HS 8402				
	in mln. €			
	1995	2000	2005	2009
Austria	116	110	118	51
Belgium	84	79	134	145
Bulgaria	0	0	11,3	8,6
Cyprus	0	0	0	0
Czech Rep.	0	0	-43	73
Denmark	18	31	56	49
Estonia	0	-0,4	3,9	1,3
Finland	12,8	12,8	21,3	23,5
France	-61	662	811	674
Germany	640	248	235	215
Greece	20	25	38	28,2
Hungary	0	20	43,8	49,1
Ireland	0	29	41	-15
Italy	345	641	1091	840
Latvia	0	0	7	3,9
Lithuania	0	6,6	11,1	8,2
Luxemburg	0	-1,6	7,5	8
Malta	0	0	0,06	0,05
Netherlands	278	264	322	359
Poland	0	0	152	159
Portugal	9,1	-26	38	58
Romania	0	31,1	97,4	72,7
Slovakia	0	-7,5	-48	-6
Slovenia	0	0	7,9	10,4
Spain	143	225	216	189
Sweden	-2,44	44	-2	1
UK	518	893	1.149	873
EU27	0	0	4.889	4.221

Annex II - Boiler market segmentation

Table 92 : EU 2004 Boiler Market, segmented by sector, application, boiler type and capacity
(VHK analysis on the basis of BRGC data 2006)

SECTOR	RESIDENTIAL (incl. boilers shared with small non-residential)											NON-RESIDENTIAL			TOTAL
APPLICATION	INDIVIDUAL							COLLECTIVE			TOTAL			TOTAL	
TYPE	gas wh				gas fs	oil jet	total Indiv.	gas fs	oil jet	total Coll.		gas fs	oil jet		
Output in kW	8-15	16-25	26+	tot wh	< 35	< 30		> 35	> 30			> 35	>.30		
Austria	*4*	*23*	*17*	44	4	9	57	1	2	3	59	1	2	8	67
Belgium	*8*	*61*	*36*	105	17	22	144	4	9	13	157	5	11	13	170
CzechRep.	*12*	*12*	*61*	85	8	0	93	2	0	2	95	2	1	1	96
Denmark	*17*	*2*	*2*	21	0	5	25	0	0	1	26	0	0	0	26
Estonia	–	–	–	2	0	1	3	0	0	0	3	0	0	0	3
Finland	–	–	–			12	12	0	0	0	12	0	0	9	21
France	–	*430*	*107*	537	64	153	754	7	16	23	777	9	19	38	815
Germany	*72*	*359*	*64*	495	46	117	658	16	38	54	711	19	47	47	758
Greece	*0*	*8*	*3*	12	1	27	39	0	18	18	57	0	22	29	86
Hungary	*9*	*69*	*8*	86	8	1	95	5	0	5	101	6	0	0	101
Ireland	*20*	*35*	*3*	58	2	35	96	0	5	5	101	0	6	10	111
Italy	*1*	*1084*	*145*	1230	59	21	1310	3	12	14	1324	3	14	14	1338
Latvia	–	–	–	6	1	1	7	0	0	0	7	0	0	0	7
Lithuania	–	–	–	8	3	1	12	0	0	0	12	0	0	3	15
Netherlands	*210*	*153*	*44*	408	2	0	410	3	0	3	413	3	0	6	419
Poland	*2*	*114*	*11*	126	8	7	141	4	5	9	150	5	6	6	157
Portugal	–	*30*	*3*	33	0	4	37	0	5	6	43	1	7	10	53
Slovakia	*2*	*6*	*18*	26	13	0	39	2	0	2	42	3	0	0	42
Slovenia	*1*	*6*	*1*	8	1	10	18	0	0	0	18	0	0	4	22
Spain	*3*	*371*	*64*	438	1	24	463	3	34	37	500	4	42	42	542
Sweden	*0*	*1*	–	1	0	0	1	0	1	1	3	0	1	6	9
UK (>44 kW)	*203*	*1044*	*318*	1565	59	92	1715	4	6	10	1726	5	8	75	1801
EU	***564***	***3810***	***904***	**5295**	**296**	**541**	**6132**	**51**	**152**	**203**	**6335**	**67**	**186**	**253**	**6588**
avg. kW	*12*	*22*	*29*	22,1	22	22	22,1	120	93	100	25	120	93	100	27
mln. kW	*6,8*	*83,8*	*26,2*	116,8	6,5	11,9	135,2	6,1	14,2	20,2	155	8,0	17,3	25,3	181

Annex III - Collective / commercial boiler market

Table 93: EU Collective & Commercial Boiler Market 2004

	Floor Standing Atmospheric Gas Boilers				Jet Burner Boilers			Total
Austria	31-60 kW	61-350 kW	>350 kW		31-60 kW	61-350 kW	>350 kW	
	1,0	0,3	0,1		3,4	0,5	0,3	5,6
Belgium	35-70 kW	>70-150 kW	>150-500 kW	>500 kW	35-60 kW	>60 kW		
	7,0	1,3	1,1	0,0	15,0	4,5		28,9
CzechRep.	30-49 kW	50-60 kW			31-60 kW	61-350 kW	>350 kW	
	2,4	1,2			0,1	0,6	0,3	4,6
Denmark	30-<70 kW				35-70 kW	>70 kW		
	0,4				0,5	0,4		1,3
Estonia								
Finland								
France	31-70 kW	>70-<180 kW	180+ kW		31-70 kW	>70-<180 kW	180+ kW	
	11,8	3,1	0,8		23,5	5,9	5,7	50,8
Germany	26-50 kW	>50 kW			26-50 kW	>50-120 kW	>120 kW	
	18,9	15,6			57,5	11,2	15,9	119,1
Greece					31-70 kW	>70-180 kW	>180 kW	
					23,1	11,8	5,2	40,1
Hungary	26+ kW				26-49 kW	50-<120 kW	120+ kW	
	7,9				7,9	8,3	1,1	25,2
Ireland	>24 kW				>27 kW			
	0,1				11,8			
Italy	>35-50 kW	>50 kW			>35-50 kW	>50-110 kW	>110 kW	
	2,4	3,6			6,0	8,1	11,5	31,6
Latvia								
Lithuania								
Netherlands	>30-60 kW	>60-120 kW	>120-250 kW	>250 kW	>60-120 kW	>120-250 kW	>250 kW	
	1,2	0,9	1,5	2,5	0,3	0,4	0,1	6,9
Poland	35->150 kW	>150 kW			<50 kW	50-200 kW	>200 kW	
	5,3	0,3			13,6	2,6	0,8	22,6
Portugal	30-70 kW	>70 kW			30-70 kW	>70-180 kW	>180 kW	
	0,5	0,5			10,8	1,0	0,3	13,1

Slovakia		>30-60 kW	>60-350 kW	>350 kW							
		3,6	1,6	0,2							
Slovenia											
Spain		>25-<50 kW	50+ kW				>25-50 kW	>50-120 kW	>120 kW		
		3,8	3,0				69,6	4,0	2,1		82,5
Sweden		>50 kW					30-50 kW	>50 kW			
		0,5					1,7	1,0			3,2
UK		>44 kW					>44 kW				
		9,0					13,0				22,0
TOTAL EU22*											457,5
NB: does not include Cyprus, Luxembourg and Malta											

The sales figures presented include boilers that are applied in collective or commercial settings. Separating these collective residential boilers and non-residential boilers from boilers applied in individual dwellings is difficult, and made more so by the variety of definitions and thresholds adopted by different countries. BRGC estimates that less than 0.5 million boilers at least overlap with commercial/collective categories.

In terms of consistency with the stock data presented in the previous paragraph, this figures makes sense. At a product life of 30 years the 6 mln. stock of collective residential boilers would result in replacement sales of around 200 000 units. The 8 mln boilers in the non-residential sector would result in replacement sales of around 260 000 units.

Annex IV - Boiler sales and stock, per country, by segment

Table 94: Boiler Sales, by country, by type (in '000 units)

	Gas Wall Hung non condensing		Gas Wall Hung condensing		Gas Floor Standing,non condensing		Gas Floor Standing, condensing		Jet Burner (oil and gas)		Solid Fuel		Electric		Heat Pumps		TOTAL		% of EU22	
	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004
Austria	29	26	1	18,2	11,6	3,1	0,4	2,2	33	12,9	21	17,5	0	0	1	3,78	97	84	*1,4%*	*1,2%*
Belgium	26	78,2	0	27	29	25,4	0	1,2	51	41,7	1	1	0	0	0	0,425	107	175	*1,5%*	*2,5%*
Czech	7	76,5	0	8	25	10,3	0	1,7	0,5	1,12	28	39,3	2	10,8	0	0	62,5	148	*0,9%*	*2,1%*
Denmark	9	6,6	0	16,65	0,7	0,65	0	0	6,5	5,8	1,1	4,5		0	0	0,2	17,3	34	*0,2%*	*0,5%*
Estonia	0,4	2	0	0,27	0,1	0,43	0	0	0,1	0,675	0,1	1,9	0	0,2	0	0	0,7	5	*0,0%*	*0,1%*
Finland	0	0	0	0	0	0	0	0	9,6	12,4	2	2,1	0,7	0,2	0	4,5	12,3	19	*0,2%*	*0,3%*
France	318	505	14	32,3	62	68,8	0	0	130	198,7	17	7,5	0	0	0	21,495	541	834	*7,7%*	*11,9%*
Germany	292	155	8	340	212	62	3	18	294	202	19	20	0	0	0	12,65	828	810	*11,8%*	*11,6%*
Greece	0,7	11,5	0	0,2	0	0,35	0	0,3	58	67	3	0,7	0	0	0	0	61,7	80	*0,9%*	*1,1%*
Hungary	43	84	0	2,05	65	18	0	2	1	1	18	3,6	0	0	0	0	127	111	*1,8%*	*1,6%*
Ireland	12	55,3	0	2,7	1,25	2,4	0	0	26	47	6	3,8	0,9	1,4	0	0	45,925	113	*0,7%*	*1,6%*
Italy	848	1171,3	0	59,1	160	59,9	0	5	99	46,4	5	4,9	0	0	2	13,378	1114	1360	*15,9%*	*19,5%*
Latvia	0	5	0	0,5	0,1	1	0	0	0,6	0,5	2,6	6	0	0	0	0	3,3	13	*0,0%*	*0,2%*
Lithuania	0	7,6	0	0,45	1	3,2	0	0	0	0,49	4	10,5	0	0	0	0	5	22	*0,1%*	*0,3%*
Netherlands	196	44	43	364	44	4,2	3	3,7	1	0,8	5	1	0	0	0	2,072	292	420	*4,2%*	*6,0%*
Poland	15	115	0	11,4	15	16,7	0	1,2	7	17	100	75,2	0	0	0	0	137	237	*2,0%*	*3,4%*
Portugal	1,8	33	0	0	0,3	1,3	0	0	0,5	16	1,9	0,1	0	0	0	0	4,5	50	*0,1%*	*0,7%*
Slovakia	1	20,5	0	5,8	12	16,9	0	1	0	0,39	14	14,6	0	0,4	0	0	27	60	*0,4%*	*0,9%*
Slovenia	0,5	6,45	0	1,45	0,2	0,8	0	0	12	9,6	7	8,3	0	0,13	0	0	19,7	27	*0,3%*	*0,4%*
Spain	160	437	0	1	4	7,6	0	0	90	100	6	0,1	0	0	0	0,1	260	546	*3,7%*	*7,8%*
Sweden	0	0,25	0	0,9	0,5	0,3	0	0,2	12,5	3	12	9	22,5	7,5	20,05	60,2	67,55	81	*1,0%*	*1,2%*
UK	543	1144,8	1	403,97	297	67,8	0	16,027	70	106	14	5	10	18	0	0,32	935	1762	*13,4%*	*25,2%*
EU22	2502	3985	67	1296	941	371	6	53	902	890	288	237	36	39	23	119	4765	6989	100,0%	100,0%

The data is excluding Malta, Cyprus, Luxembourg, Romania and Bulgaria. Correction by a factor 1.06 would approximate the EU27 values

Stock of central heating boilers

Table 95: Stock of central heating boiler types, by country, in ' 000 dwellings (source: BRG Consult, 2006)

	INDIVIDUAL WET CENTRAL HEATING (excl. solid fuel boilers)															
	Gas wall-hung				Gas floorstanding		Gas jet burner		Oil jet burner		Electric boiler		Heat pump		Total (excl. solid fuel)	
	non-condens		condensing													
	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004
Austria	264	340	1	175	201	134	67	83	260	343	0	0	46	58	839	1,134
Belgium	318	692	0	84	386	475	51	65	790	919	0	0	0	0	1,546	2,236
Czech R.	86	742	0	25	90	376	1	2	1	2	16	11	0	0	194	1,158
Denmark	124	227	0	59	10	17	5	5	602	369	0	0	0	13	742	690
Estonia	1	13	0	0	1	3	0	0	19	21	1	3	0	0	22	40
Finland	0	0	0	0	0	0	0	0	391	455	5	6	5	40	402	501
France	3,45	6,697	120	184	1,735	2,026	0	0	3,58	4,361	0	0	0	86	8,885	13,354
Germany	1,602	4,15	32	1,243	2,054	3,577	1,223	2,04	4,781	6,467	0	0	0	66	9,691	17,542
Greece	4	30	0	0	0	1	10	47	1,48	1,63	0	0	0	0	1,493	1,709
Hungary	324	768	0	7	169	477	2	9	1	4	0	0	0	0	495	1,266
Ireland	75	435	0	6	16	29	0	0	170	460	29	37	0	0	289	967
Italy	4,667	12,022	0	223	1,072	1,683	211	266	3,43	884	0	0	2	89	9,382	15,166
Latvia	0	25	0	1	9	5	1	2	0	1	0	0	0	0	10	34
Lithuania	0	55	0	1	1	24	0	2	6	8	0	0	0	0	6	89
Netherlands	3,513	1,548	193	3,31	155	180	0	0	0	0	0	0	0	9	3,861	5,048
Poland	236	856	0	26	58	214	27	102	70	145	0	0	0	0	392	1,343
Portugal	3	179	0	0	1	7	1	3	1	34	0	0	0	0	7	223
Slovakia	16	136	0	14	163	251	0	0	0	0	0	0	0	0	179	401
Slovenia	1	41	0	3	0	10	1	8	189	221	0	0	0	0	191	284
Spain	715	4,094	0	3	32	69	10	6	403	1,548	0	0	0	0	1,159	5,72
Sweden	5	15	0	0	0	0	0	0	396	390	459	472	77	566	938	1,443
United K.	6,381	13,143	1	1,15	6,79	5,412	0	0	937	1,1	427	587	0	0	14,536	21,392
Total EU22	21785	46207	346	6514	12943	14971	1608	2642	17510	19361	937	1115	129	928	55259	91,739
% of total	12,1	22,2	0,2	3,1	7,2	7,2	0,9	1,3	9,7	9,3	0,5	0,5	0,1	0,4	35,7	47,1

Annex V - EU Dwelling characteristics

Table 96 :EU Housing Characteristics 2003

(source: VHK compilation of ‘Housing Statistics of the European Union 2004’, Boverket 2005)

	Parameter	***unit***	EU-25	A	B	CY	CZ	DK	EST	FIN	F	D	GR	H	IRL	IT	LT	LIT	LUX	MT	NL	PL	P	SK	SLO	E	S	UK
1.	Dwelling stock**	k#	**204663**	3280	4820	299	4366	2561	624	2574	29495	38925	5465	4134	1554	26526	967	1292	176	127	6811	11764	5318	1885	785	20947	4351	25617
2	Primary (= ca. # households)	k#	**184166**	3280	4325	239	4216	2481	566	2378	24525	38944	3674	3863	1382	22004	915	1346	171	129	6996	13337	3651	2072	685	14187	4454	24346
3	Secondary	k#	**20497**	0	495	60	150	80	58	196	4970	-19	1791	271	172	4522	52	-54	5	-2	-185	-1573	1667	-187	100	6760	-103	1271
4	Secondary, in dwelling stock*			WSV	WSC VN	WS CV	SVN	V	na	SVN	WSH MV	S	WSV	WSV	WSm VN	WSV	WV	CN	CHM	WSN	V-	SCH MVN	WS VN	V	WSV	WS VN	CV	WSV
5	Vacant dwellings	k#	**18083**		na	72	537	128	68	237	2006	*3192*	514	347	182	5199	58	*48*	*4*	na	150	623	564	219	79	2912	74	871
6	One/two family dwellings	%	**54**	48	75	na	44	61	32	42	57	46	59	66	91	25	29	39	71	na	69	37	77	49	72	53	48	81
7	Multi-family dwellings	%	**46**	52	25	na	57	39	68	58	43	54	41	34	9	75	71	61	29	na	31	63	23	52	28	48	52	19
8	of which high-rise (> 4 storeys),	%	**16**	na	4	na	34	10	na	na	16	6	na	23	na	23	na	na	16	na	7	39	22	38	12	31	na	2
9	New built 2003 (completed)	k#	**2174**	42	41	6	27	24	2	28	334	268	128	*22*	69	*178*	1	5	2	na	60	163	82	14	7	459	24	190
10	New built 1990 (completed)	k#	**2169**	42	43	8	45	27	8	65	336	319	120	44	20	176	13	22	3	na	101	134	66	25	8	281	58	205
11	Demolished/removed	k#	**133**	16	2	0	2	*8*	1	3	21	*22*	na	5	11	na	3	0	na	na	18	5	1	1	0	16	2	15
12	Year of built <1919 *[VHK 1880]*	%	**15**	19	15	na	11	20	9	2	20	15	3	14	10	19	11	6	12	15	7	10	6	3	15	9	12	21
13	Year of built 1919–1945	%	**12**	8	17	7	15	17	14	9	13	13	7	13	8	11	14	23	15	11	13	13	9	7	8	4	20	18
14	Year of built 1946–1970	%	**32**	27	29	17	26	28	30	31	18	47	32	26	16	41	28	33	27	29	31	27	23	35	28	34	33	21
15	Year of built 1971–1980	%	**20**	16	15	21	23	18	22	23	26	11	25	22	18	20	23	18	15	17	19	18	18	26	24	24	17	22
16	Year of built >1980	%	**22**	12	9	27	16	10	20	20	10	15	19	18	16	10	21	14	12	16	30	19	44	21	16	14	10	19
17	of which, year of built >1990	%	**13**	18	15	|	8	7	5	14	12	|	14	7	32	|	4	6	17	12	|	13	|	7	9	16	7	|
18	Avg. age dwellings *[VHK est.]*	yr	**49**	49	50	28	46	57	45	33	52	53	35	48	35	56	46	47	45	48	40	43	33	36	47	39	52	56
19	Floor area/dwelling (stock)	m²	**87**	94	86	*145*	76	109	60	77	90	90	83	75	104	90	55	61	125	106	98	68	83	56	75	90	92	87
20	Floor area/dwelling (new 2003)	m²	**103**	101	119	198	105	112	89	90	113	114	125	94	105	82	194	106	120	*106*	116	99	89	118	114	96	128	83
21	Floor area/person (stock)	m²	**35**	38	36	*48*	29	51	28	36	38	40	*30*	28	35	*35*	24	23	*50*	34	41	22	*30*	26	30	*31*	44	44
22	Number of rooms (stock)	#	**4,0**	4,1	4,3	5,4	2,9	3,8	3,6	3,6	4	4,4	3,8	na	5,6	4,1	2,4	2,5	5,5	na	4,2	3,7	4,3	3,2	2,8	5	4,2	4,7
23	Number of rooms (new built)	#	**4,5**	3,5	5,8	6,1	3,9	3,4	4	3,8	3,9	5,1	3,1	4	5,6	3,8	4,3	3,5	5,2	na	3,9	4,2	4,9	3,1	3,4	5,4	4,2	4,5
24	persons/household (stock)	#	**2,5**	2,4	2,4	3	2,4	2,2	2,4	2,2	2,4	2,1	2,8	2,6	2,9	2,6	2,5	2,6	2,5	3	2,3	2,8	2,8	2,6	2,8	2,9	1,9	2,4
25	Central heating (wet & dry)	%	**79**	90	73	27	82	92	59	92	91	91	64	53	59	79	65	72	92	3	90	78	4	74	79	42	100	94
26	Bath/shower (hot water)	%	**78**	98	96	99	96	95	67	99	98		98	87	94	99	67	70	94	100	100	87	66	93	92	99	100	99
27	solar sys.penetration, % dwell.***	%	**2,5**	11,8	0,5	66,9	0,3	2,6	0,0	0,1	0,4	3,4	22,3	25,4	0,2	0,6	0,1	0,0	1,5	6,0	1,5	0,2	1,2	0,7	2,6	0,8	1,0	0,3
28	solar collector stock***	000m²	**15573**	2318	68	500	66	337	1	14	396	6554	3047	5250	11	516	3	2	13	19	304	138	161	64	102	527	208	197
29	estimated collect area/hh	m²	**3**	6	3	2,5	5	5	5	5	3	5	2,5	5	3	3	5	5	5	2,5	3	5	2,5	5	5	3	5	3

30	total solar collector sales 2005	000m²	**2073**	240	28	50	19	21	0	2	164	980	221	1	4	72	1	1	2	4	39	28	16	7	5	107	35	28
31	of which glazed collector sales	%	**89**	97	73	100	70	99	100	100	93	87	100	100	100	96	100	100	100	100	48	85	97	88	94	95	49	64
32	unglazed coll. sales	%	**4**	3	27		17				4	3									52	0						
33	vacuum tube sales	%	**6**	1			13	1			3	10				4						15	3	12	6	5	16	36

* = W=Winter or summer habitation; S=Second homes; C=Collective homes; H=Hotels; M=Trailers & ships; m=Trailers; V=Vacant homes; N=Non-permanent habitation; na= no data available; | = data included in line above; **= dwelling stock data year CY: 2002; FI: 2001; FR: 2002; GR:2001; HU: 2001; LU: 2002; MT: 1983; PL: 2002. PT: 1999 most recent, 2003 is estimate; In other lines, italic font indicate older reference years
***= solar sales and stock data from ESTIF (www.estif.org). Collector area per household estimated by VHK on the basis of general recommendations by authorities for 4-person household.

Table 97 :EU Residential Heat Load Assessment (VHK 2006)

	Parameter	*unit*	EU-25	AT	BE	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	SK	SI	ES	SE	UK
	Base data 2003																											
1	Energy/hh 2003	kWh	17370	24805	26277	13952	16519	20004	18832	25242	17653	20326	15720	16495	22911	13497	15591	11913	36288	7092	17179	14599	9627	11637	21238	10736	20979	19647
2	Households 2003	mln.	191,4	3,3	4,3	0,2	4,0	2,5	0,6	2,4	26,5	37,7	3,8	4,3	1,4	25,1	0,9	1,4	0,2	0,2	7,1	14,2	3,7	2,6	0,7	14,4	4,2	26,3
3	Persons/hh 2003	#	2,5	2,4	2,4	3	2,4	2,2	2,4	2,2	2,4	2,1	2,8	2,6	2,9	2,6	2,5	2,6	2,5	3	2,3	2,8	2,8	2,6	2,8	2,9	1,9	2,4
4	Floor area/dw. 2003	m²	87	94	86	*145*	76	109	60	77	90	90	83	75	104	90	55	61	125	106	98	68	83	56	75	90	92	87
	Water Heater energy (from previous table)																											
5	Energy cons. WH	kWh	2048	2719	2706	2240	1240	3115	717	3670	2180	1632	2090	2392	2550	2374	788	808	4698	2240	2641	1365	3067	1266	1971	2624	3281	2112
6	of which electric	kWh	725	1327	944	1526	474	1278	473	2192	911	717	1424	941	638	847	571	521	1639	1526	398	729	322	724	1125	649	750	420
7	TOTAL Net Energy Demand per hh. (PRIMES 2006)																											
8	electric	kWh	4305	5746	6978	6976	3940	4626	3531	9548	4997	3984	4881	2808	6581	2963	1559	1702	4948	4728	3758	1909	3869	1976	5562	4308	10454	5076
9	fossil & biomass	kWh	11523	16760	19225	4186	8563	7377	5885	7455	12597	13802	10425	11792	16331	10535	7795	4619	29690	2364	13063	7856	5669	6477	13147	6406	3391	14571
10	heat	kWh	1493	2011	74	0	4016	8002	9416	8240	0	2437	83	1895	0	0	6236	5592	1649	0	313	4834	0	3184	2528	0	7134	0
11	renewable	kWh	49	287	0	2790	0	0	0	0	59	103	331	0	0	0	0	0	0	0	45	0	90	0	0	22	0	0
12	Total	kWh	17370	24805	26277	13952	16519	20004	18832	25242	17653	20326	15720	16495	22911	13497	15591	11913	36288	7092	17179	14599	9627	11637	21238	10736	20979	19647
	ELECTRICITY																											
13	Electric WH	kWh	725	1327	944	1526	474	1278	473	2192	911	717	1424	941	638	847	571	521	1639	1526	398	729	322	724	1125	649	750	420
14	Non-heat electric	kWh	2123	3000	2600	2000	2100	2900	1000	3300	2500	2500	2602	1684	2500	1700	900	919	3000	2000	3000	1100	2600	1200	3165	2200	3300	2800
15	Electric cooking	kWh	267	300	300	100	50	300	50	500	300	300	300	100	300	150	50	50	300	150	300	50	200	50	50	200	400	500
16	Total non space heat	kWh	3115	4627	3844	3626	2624	4478	1523	5992	3711	3517	4326	2725	3438	2697	1521	1490	4939	3676	3698	1879	3122	1974	4340	3049	4450	3720

	FOSSIL																											
17	Fossil WH	kWh	1323	1392	1762	714	766	1837	244	1478	1269	915	666	1451	1912	1528	217	287	3060	714	2243	636	2745	542	846	1975	2532	1692
18	Fossil cooking	kWh	260	200	200	400	450	200	450	0	200	200	200	400	200	350	450	450	200	350	200	450	300	450	450	300	100	0
19	Total non-space heat	kWh	1583	1592	1962	1114	1216	2037	694	1478	1469	1115	866	1851	2112	1878	667	737	3260	1064	2443	1086	3045	992	1296	2275	2632	1692
20	SOLAR	kWh	49	287	0	2790	0	0	0	0	59	103	331	0	0	0	0	0	0	0	45	0	90	0	0	22	0	0
	SPACE HEATING Energy demand (incl. losses)																											
21	electric	kWh	1190	1120	3134	3350	1316	148	2008	3556	1287	468	555	83	3143	266	38	211	10	1052	60	30	747	2	1222	1259	6004	1356
22	fossil & biomass	kWh	9940	15168	17263	3072	7347	5339	5191	5977	11128	12687	9559	9941	14218	8657	7128	3883	26430	1300	10620	6770	2624	5485	11851	4131	759	12879
23	heat	kWh	1493	2011	74	0	4016	8002	9416	8240	0	2437	83	1895	0	0	6236	5592	1649	0	313	4834	0	3184	2528	0	7134	0
24	Total space heating	kWh	12622	18299	20471	6422	12679	13489	16615	17772	12414	15591	10197	11919	17361	8923	13403	9686	28089	2353	10993	11634	3371	8671	15601	5390	13898	14235
	SPACE HEATING Heat load dwelling																											
25	electric (90%)	kWh	1071	1008	2820	3015	1185	133	1807	3200	1158	421	500	75	2828	240	34	190	9	947	54	27	672	2	1100	1133	5404	1221
26	fossil & biomass(54%)	kWh	5368	8191	9322	1659	3967	2883	2803	3227	6009	6851	5162	5368	7678	4675	3849	2097	14272	702	5735	3656	1417	2962	6399	2231	410	6955
27	heat (70%)	kWh	1045	1408	52	0	2811	5601	6591	5768	0	1706	58	1327	0	0	4365	3914	1155	0	219	3384	0	2229	1770	0	4994	0
28	Heat load/dwelling		7483	10606	12194	4674	7963	8618	11201	12195	7167	8977	5719	6769	10506	4915	8249	6201	15436	1649	6008	7067	2089	5193	9269	3364	10808	8175
29	Heat load kWh/m²	kWh	86	113	141	32	104	79	186	158	80	100	69	90	101	54	149	102	123	16	61	104	25	93	124	37	118	94

Annex VI - Housing statistics Bulgaria-Romania

From 'Housing Statistics in the European Union 2010' by the OTB Research Institute, Delft University of Technology, The Netherlands, September 2010.

Figure 17 Dwelling amenities

2.3 Bath/shower, hot running water and central heating in total dwelling stock (as % of dwelling stock)

	Year	Bath/shower	Year	Hot running water	Year	Central heating
Austria [1]	2009	99.2	-	na	2009	92.0
Belgium	2009	96.8	2009		2009	83.1
Bulgaria						
Cyprus [2]	2001	99.0	-	na	2001	27.3
Czech Republic [2]	2001	95.5	2001	95.1	2001	81.7
Denmark	2009	96.0	-	na	2009	98.0
Estonia	2002	67.1	-	68.0	2002	59.0
Finland	2009	99.1	2009	97.1	2009	93.4
France	2006	98.5	2006	98.5	2006	93.0
Germany	-	na	-	na	2006	92.3 [3]
Greece [2]	2001	97.8	-	na	2001	62.0
Hungary	2005	91.3	2005	91.5	2005	56.7
Ireland	2002	94.0	-	na	2002	59.0
Italy	2008	99.4	2004	99.6	2004	94.7
Latvia	2008	60.3	2008	61.6	2008	61.2
Lithuania	2008	71.1	2008	61.6	2008	73.5
Luxembourg	2008	99.0	2008	99.7	2008	72.8
Malta [2]	2005	98.2	2005	97.1 [4]	2005	1.2 [5]
Netherlands	2009	100.0	2009	100.0	2009	94.0 [3]
Poland [2]	2008	86.9	2002	83.0	2008	78.0
Portugal	2001	65.6	-	na	2001	3.8
Romania	2008	58.9	2008	57.2	2008	51.9
Slovak Republic [2]	2001	92.8	2001	90.5	2001	74.3
Slovenia	2004	92.3	-	na	2004	79.1
Spain	2008	na	2008	99.5	2008	63.8
Sweden	2008	100.0	2008	100.0	2008	100.0
United Kingdom [6]	2001	99.0	2001	100.0	2001	94.0

See "equipment of dwellings" in Appendix 1

1 Main residences
2 (Permanently) occupied dwellings
3 Can include categories like district heating, central/zone heating and self-contained central heating
4 Availability of water heater or solar water heater
5 Excluding air conditioning stand alone units
6 The figures refer to England, not the UK

Source: National statistical institutes
CZ and SK Population and Housing Census 2001
DK Housing Census 2009
FR Enquête logement 2006, INSEE
GR 2001 Housing Census
LU Housing Observatory - Ministry of Housing; estimation from EU-SILC 08
RO 2002 Housing Census, 2008 Family Budget Survey
ES EPF

This 2010 Housing Statistics edition is the first one since the 2005/2006-version. One reason for not publishing the data too frequently is that housing stock and demographic characteristics generally change slowly over time. The Global Financial Crisis has however had an impact on housing market data like price developments, new construction and transactions of existing dwellings. Another reason to update the housing statistics is that an overview of EU Housing data is not complete without the new member states Bulgaria and Romania.

BU and RO make up some 5.8% of the EU27 population. The number of (private) households however is smaller than that, caused by a relatively large average household size in Romania (2.9 persons per household) and estimated to be 5%. Share of central heating is partly known: for Romania this is 52%, or 3,8 million dwellings with central heating. If the same share of central heating is applied for Bulgaria, this would add another 1.6 million dwellings with central heating.

Some ..% of dwellings are flats, in which central heating is more often present than in (semi)detached. Assuming that some 40% of dwellings use a collective central heating system, the total number of systems would be around 3.4 million systems.

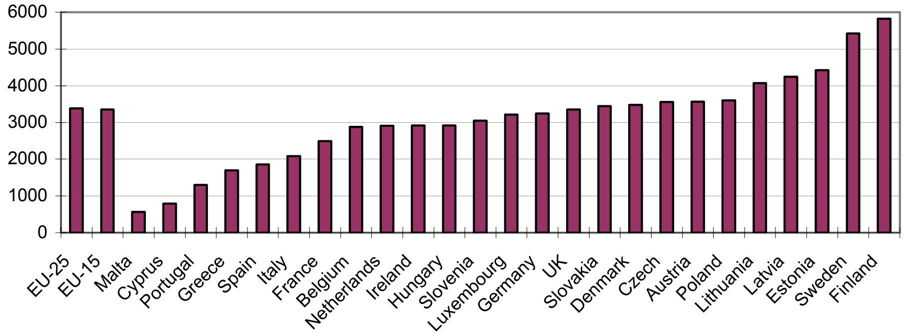
The Lot 1 study assumed a total of 208 million central heating systems (Task 3, table 5.2). Adding the 3.4 million dwellings with central heating in BU/RO would increase the total to 211 million systems, an increase of 1.6%. As visible in many other eastern European countries a significant share of systems will be fuelled by solid fuels.

However, the housing statistics also say that some 40% of Romanians do not have a bath or shower (highest in Europe, followed by Bulgaria/Latvia and Lithuania with 16% living in dwellings without bath or shower).The 3.4 million systems calculated above may therefore be too optimistic.

Annex VII - Heat Balance model

Heating degree days (long term average 1998-2004).

Figure 18 EU Heating degree days (long term average)



For Romania and Bulgaria the degree days for 2007/2008 are respectively 2750/2776 and 2357/2430 (source: Eurostat), comparable to the range found for Italy/France/Belgium/The Netherlands.

Energy consumption at set temperature, includes consideration of average dwelling characteristics (room size, volume, heat loss areas), building characteristics (U-value of walls, windows, doors, ceilings, floors, etc. plus adjacent spaces), ventilation and infiltration rate (heat loss from air exchange), solar heat gain and internal heat gain. And the consideration of various temperatures in different zones (living room: 50% of area at 21ºC, bedrooms 40% of area at 18ºC and bathrooms 10% of area at 22ºC)

- Thermal mass effects, include calculation of energy retained during coo down, steady state conditions and heat up and depends on thermal mass (of building and space heating systems), use of night setback, emitter capacity, etc.
- Internal heat transfer, between different zones of the building
- Fluctuation losses, depend on system temperature and temperature control (operative room temperature i.e. people are more sensitive to 'too cold' instead of 'too warm'). In Heat Balance model fluctuation losses are limited to including flow rate control (i.e. thermostatic radiator valves) only.
- Stratification losses, depends on system temperature and room/emitter characteristics
- Distribution losses, depends on system temperature and building characteristics

Heat demand, as calculated with Heat Balance model and according statistics

Table 98 : Selected outputs (week 20/19/22) and comparison to statistics

EU-25/ AVERAGE EXISTING/ WEEK 20/19/22 /Zone1								Net heat load	
	TOTAL	(Net heat load=) Tset	Tmass	Tintr ans	Tfluct	Tstrat	Distr. losses	according to statistics	according to model (Tset-20%)
EU-25	13.550	9.296	1.365	488	272	566	1.563	7.483	7.437
AT	18.188	13.289	1.364	575	465	700	1.795	10.606	10.631
BE	20.480	14.661	1.706	527	652	890	2.045	12.194	11.729

CY	9.507	5.387	1.966	412	407	729	605	4.674	4.310
CZ	14.472	10.570	1.004	473	247	507	1.671	7.963	8.456
DK	18.224	13.052	1.374	705	407	726	1.959	8.618	10.442
EE	16.851	13.029	795	427	278	484	1.838	11.201	10.423
FI	16.941	13.098	714	554	273	458	1.845	12.195	10.478
FR	13.535	9.183	1.413	508	275	580	1.576	7.167	7.346
DE	16.093	11.676	1.220	553	334	601	1.710	8.977	9.341
GR	11.132	6.934	1.688	392	287	603	1.228	5.719	5.548
HU	12.917	9.372	999	424	217	461	1.444	6.769	7.498
EI	20.177	13.928	1.932	655	631	940	2.090	10.506	11.142
IT	8.990	5.345	1.466	406	179	493	1.101	4.915	4.276
LT	13.350	10.077	689	383	169	382	1.651	8.249	8.061
LI	12.022	8.951	652	406	132	346	1.536	6.201	7.161
LU	27.350	19.670	2.100	758	1.158	1.251	2.414	15.436	15.736
MT	5.380	2.715	1.288	258	102	411	605	1.649	2.172
NL	12.912	8.741	1.292	567	227	520	1.565	6.008	6.992
PL	14.235	10.592	876	444	220	456	1.647	7.067	8.474
PO	5.642	2.774	1.296	303	86	382	801	2.089	2.219
SK	9.910	7.082	745	339	114	326	1.304	5.193	5.666
SI	15.913	11.665	1.214	444	369	605	1.617	9.269	9.332
ES	8.194	5.148	1.203	394	128	395	926	3.364	4.119
SE	16.231	12.106	875	632	277	500	1.840	10.808	9.685
UK	15.735	10.754	1.553	525	369	690	1.844	8.175	8.603

Annex VIII - Background Ecoboiler model

The following text is a copy of the 'Background Ecoboiler model' text, as it is made available on www.ecoboiler.org. It explains the background of the ECOBOILER calculation models and gives more insight in the choices the authors had to make and which sources they have used.

MEMO: BACKGROUND ECOBOILER MODEL v5

The ECOBOILER and ECOHOTWATER models were developed in the preparatory studies for the 2005/32/EC directives Lot 1 and 2, where we have tried to find the common denominator in EPBD standards.

This means principally the prEN 15316 series, esp. parts 2 and 4 for distribution and heat generators. For the dwelling/ load part we used mainly EN 832. Apart from these European (pre)-standards we also looked at unique features and emphasis in the national EPBD standards.

In the RT 2005 we found inspiration in the unique way that the indoor temperature was treated (day- and night setback, temperature fluctuations and stratification, influence of thermal mass). Of course many of the required equations can come from the EN 832, but most other countries just set a fixed temperature or give a minor correction through a look-up table (e.g. SAP). In fact the RT 2005 and the discussions leading up to this French standard, made us choose the subdivision not just in months, but also dividing up the each average month-day in the heating season (max. 9 months) into 5 parts (morning, midday, evening, late evening and night). This gave us 45 (9 x 5) time periods in which we could—in a basic way—take into account most of the indoor temperature aspects that were realized or aspired in the RT 2005.

The German (EnEV, DIN V 4701-10, DIN 18599) and the UK (SAP, Part L, etc.) regulations were the inspiration (on the building side) for the way to handle the subject of internal heat transfer, which is different in both countries and we had to try to reconcile these two approaches into one coherent set of equations, which are derived from the less popular part of EN 832. Basically, the biggest difference between the UK and German approach is not in the basic physical equations, but in the presentation (UK uses lookup tables; Germany equations) and the input values (UK: assumes a large share of air infiltration and exchange between the rooms. DE: assumes basically closed doors without much ventilation slits, probably because large part the current German ventilation requirements are based on opening windows and not as in UK on mechanical ventilation).

For the fossil-fuel fired heat generator side, we also principally used default values and approaches from both the UK and German standards mentioned above and—with the watchful eye of the boiler industry experts in our project—tried to incorporate both, together with elements of the Boiler Cycling method in prEN 15316-4-1, in the ECOBOILER model. Apart from the steady state efficiency and a dynamic calculation of off and on-modes, this also led to a calculation of cycle times, cool down and heat up periods, etc. in conjunction with the boiler- and room temperature controllers.

In fact, the controller-part was one of the most difficult to model. It is on the interface between current EPBD dwelling and EPBD installation standards and, although both will give some empirical lookup tables, the subject is not really treated in-depth. Here we have made an extra effort, using basic engineering thermodynamics and know-how of boiler-design, to make a model of the cycling-behavior and thereby the heat-loss in the off-periods, the effect of thermal mass, etc.. If you like, this is one of the more original subjects in the model, but we have always tried to reproduce similar outcomes to the ones given in the lookup tables of prEN, national standards/

regulations in UK, Germany, Italy, etc. and the outcomes of a test-house by controller-manufacturers (e.g. Danfoss, Honeywell) during the ECOBOILER project. Also we looked at German (OPTIMUS project) and UK experience, telling us the importance of the controllers for good boiler-operation. E.g. the OPTIMUS-project found differences of on average 13% efficiency (!) between the nominal and real-life behavior of condensing boilers, caused to a considerable part by the suboptimal controls and lay-out.

From the Dutch (NEN 5128), some Scandinavian standards and prEN ventilation standards we adopted the concept of “summer comfort”, which is relevant for the credits for waste heat recovery from e.g. storage tanks, boilers and piping. Traditionally these losses were seen in the older standards (and also in prEN 15316) as something to be rewarded during the heating season or not, depending on whether the waste heat source was in the heated area. However, in holistic approach it also has to be taken into account that in the summer months certain waste heat source e.g. from hot water also contribute to the cooling load (negative impact). In the Dutch approach it is assumed that this surplus heat in the summer months has to be cooled away by a (real or virtual) cooling device with a COP of 3. Thus, the total waste heat recovered is a some of positive contributions in the winter (7 months), no contribution in the transition period (May, Sept) and a negative load in the winter (June-Aug.).

What we also took from the Dutch (and the German) standards is the subdivision of dwellings in temperature Zones. But we did not make the zones a variable (as in the NL, DE standards), but chose fixed zones (Day zone=living room + kitchen 50%, Night zone: bedrooms 40%, Bath zone: 10%), which is more in line with the British and French approach. The Bath zone is relatively new in this, but it is important to consider also a Zone that requires the highest temperatures, because in the morning and late evening this can be a determining factor for the boiler temperature.

For the distribution losses (piping) we extracted from the 5-6 different Annexes in the prEN standard a single methodology (the prEN annexes mainly differ in presentation but not in outcome). As standard inputs we first used DIN V 4701-10 defaults, but—after review by prof. Oschatz—we decided to switch to known and generally accepted German defaults for distribution losses for existing buildings of various types and sizes.

For the heat pumps (combined or stand-alone with electric backup), we used the BIN method and lookup-tables from prEN 15316-4-2, but—because we already calculate the load in 45 “BINS”—we did not have to copy the BINs in the same way. Furthermore, for reasons of compact programming we converted the lookup-tables for COP and Output at different source/sink temperatures and the part load tables into equations with approximately the same result. We have not checked the correctness of the values in the prEN in-depth, but we know of the IEA Annex 28 research+ field tests and we do know of course that the NEN 5128 defaults come from extended tests at the TNO Heat Pump center.

The thermal solar installations have cost us considerable head-aches, because in general we found the values in all national standards (including the new Spanish and Portuguese) too optimistic, especially on the point of the waste heat recovery from the solar storage tank. Even in the prEN 15316-4-3 we found that waste heat recovery was 100% (not 85% like for other tanks, piping and boilers) in the whole heating season and there is no penalty to the cooling load of a dwelling. Therefore, we adjusted the prEN 15316-4-3 on this point and brought it in line with prEN 15316-4-1, prEN 15316-4-2, etc. and the “summer comfort” principle. We did not use most default parameter-values in the main text of prEN 15316-4-3, because this would have yielded very low or even negative values, which is too pessimistic. Instead, we used the values in the Annexes of the prEN, which come from Dutch(TNO) calculations.

Conclusion

All in all, we ended up with a spreadsheet type of model where we think the common denominator of existing EPBD standards are incorporated or at least the parameters can be adjusted in such a way that each of the frontrunner countries (UK, DE, FR, IT, NL, DK, ES) as to reproduce its very own national building standard. In order to further facilitate this check, we have supplied the model with the outdoor temperature and global solar irradiance data for all EU-25 capitals (source JRC Ispra, from which also these data can be extracted for every possible location in Europe in 15 minute intervals).

The principal application of the ECOBOILER model is the adjustment of (steady-state) outcomes from EN product test standards (e.g. EN 303 etc.), also based on assessments of system, controller and other characteristics. The concept is that the boiler-manufacturer will hopefully no longer restrict its CE-marking to a single boiler (burner + body), but also other heat generator components (hybrids or stand-alones with solar and heat pumps), the complete control chain (boiler temperature controller, room thermostats, valve controllers) and even a service contract whereby the manufacturer (not necessarily the installer) guarantees hydraulic balancing of the system and correct initial controller settings.

VHK, René Kemna,4 July 2007

Annex IX - Working documents Ecodesign/Energy labelling

Overview of Ecodesign / Energy labelling requirements

In the latest working documents of the Commission significant changes have occurred as regards the approach taken in the lot 1 study and previous working documents: not only in the way how the energy efficiency of the central heating product is calculated, but also regarding what aspects of the central heating product are regulated.

What remains is that the scope of the measures not only address gas and oil fired boilers, but also competing technologies (such as heat pumps), complementing technologies (such as cascading boilers, storage tanks, temperature controls and solar thermal systems) and combined functions (water heating and also cogeneration) and combinations of the aforementioned products. The calculation model developed in Lot 1 took these market trends into account, except for solid fuel boilers and boilers specifically designed for biomass fuel which are subject to separate preparatory studies.

The former working documents calculated the overall central heating efficiency on the total configuration of the products as supplied to the market. This gave manufacturers freedom of choice in how to meet the requirements: A manufacturer could opt to meet the minimum Ecodesign requirements by either improving the boiler itself, but also by adding other energy-saving technologies like solar assist or better temperature controls to the package. The CE marking and therefore entry to the EU market involved an assessment of the efficiency of the complete configuration.

The current proposals for Ecodesign requirements and Energy labelling apply a different method.

The Ecodesign requirements are now based upon the ‘seasonal space heating efficiency’ as determined for the central heating product only, without consideration of (unavoidable) system losses (from distribution, fluctuation and stratification), complementary equipment (cascade of boilers, storage tanks, solar thermal assist and temperature controls), the combined operation of fossil fuel boilers and heat pumps (so-called ‘hybrid’ systems) or cogeneration boilers. The requirements for the Ecodesign product information fiche does require more information on product test results and product characteristics but do not address the other aspects.

The Energy labelling requirements are currently quite elaborate and offer a diverging range of options for product information and here the other aspects (complementary equipment and/or combined operation) is included in some way:

- The main energy label (Annex II of the proposed Regulation) considers the seasonal space heating energy efficiency as determined without the effects of complementary equipment, similar to the Ecodesign requirements, and some other information on key product characteristics;
- The product fiche - sheet 1 adds to the information provided on the label, information on annual energy consumption and the efficiency/capacity of heat pumps in other climates;
- The product fiche - sheet 2 resembles the original approach of the Lot 1 study the best. Here the combined effects of various equipment (a configuration) is calculated and presented. The overall ‘configuration space heating efficiency’ takes into account the benefits of combining the product with storage tanks, solar heating, type of temperature control[76], boiler cascading, solar thermal assist, heat pump (assist), low temperature

[76] This is not the same as the control protocol' as included in the calculation of the product space heating efficiency. The control protocol is an inherent characteristic of the boiler, whereas the temperature control (the room thermostat if you will) can be a

emitters and (for heat pumps) the effects of operating in a colder and warmer climate. The result is a ‘seasonal space heating efficiency’ of the complete configuration, however still without consideration of system losses.

It is believed that the main Energy label information will be compiled by the manufacturer (or other person responsible for placing on the market), since this requires information produced by testing according technical standards. The product fiches (sheet 1 and 2) can be compiled by the ‘supplier’ which is not necessarily the manufacturer. This opens up possibilities for retailers, including installers, to bring to the market configurations of products (possibly from different manufacturers) and calculate by themselves the space heating efficiency of that configuration. This adapts to the current market trend of offering combined sets of central heating boilers supplied with a thermostat, solar thermal systems, storage tanks and/or ‘hybrid’ systems that employ a boiler and a heat pump.

Transitional method for calculating seasonal space heating efficiency

The following text is a copy of the ‘ Working document for a Commission communication in the framework of the implementation of Commission Regulation (EC) No …/… implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for central heating equipment, and of the implementation of Commission Delegated Regulation (EU) No …/… implementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labeling of central heating equipment’.

The Commission Communication is intended to explain in more detail how the product parameters relevant for the Ecodesign requirements and Energy Labeling, should be calculated. The calculation is based upon test results from current technical standards and elaborated with calculations developed by a working group to enable the calculation of seasonal space heating efficiency etcetera.

etas= etason - ΣF(i),

where

- etason is the seasonal steady-state thermal efficiency in on-mode calculated

according to point 2(4),

- F(i) are corrections calculated according to point 2(5).

The seasonal steady-state thermal efficiency in on-mode is calculated as

etason = 0,85•eta1 + 0,15•eta4

(eta1 = 30% rated input and low temperature regime)

(eta4 = 100% of rated input and high temperature regime)

(1) The correction F(1) accounts for the turndown ratio td as set out in Table 2.

Table 2: values for F(1)

td	1,00≤*td*< 0,80	0,80≤*td*< 0,66	0,66≤*td*< 0,50	0,50≤*td*< 0,30	*td*≤0,30
F(1)	0,07	0,04	0,02	0,01	0

separately supplied product, from a different manufacturer. Of course if the boiler offers the 'open protocol' it may allow a better communication with certain types of temperature controls.

(2) The correction F(2) accounts for controls. For boilers which are compatible with an open communication protocol F(2)=0,025. For boilers which are not compatible with an open communication protocol F(2)=0,03.

(3) The correction F(3) accounts for auxiliary electricity consumption and is given as follows:

F(3)=2,5*(0,15•elmax+0,85•elmin+3,3•fossb)/Pfos4; OR a default value as set out in EN 15316-4-1 may be applied.

(4) The correction F(4) accounts for stand-by heat loss and is given as

F(4)= 0,5•Pstby/Pfos4; OR a default value as set out in EN 15316-4-1 may be applied.

(5) The correction F(5) accounts for pilot flame energy consumption and is given as

F(5) = Pign/Pfos4.

(6) The correction F(6) accounts for the seasonal electric efficiency. For fossil fuel boilers F(6)=0. For cogeneration boilers F(6) is given as follows.

[NB: negative, to result in an overall positive contribution]

F(6)=-2,5•(0,57•chp1+0,09•chp2+0,34•chp4).

Alternative suggestion of EHI received just before sending out working documents: The seasonal steady-state thermal efficiency in on-mode of cogeneration boilers is calculated as

etason = eta1 • (1+x+x2+x3),

EN 6 EN

with x = 2,5 • chp1.

Also defined are the calculation for heat pumps, controls, passive flue heat recovery devices and storage tanks.

Example calculation of space heating efficiency

Fossil fuel boilers (including cogeneration boilers)

In the earliest proposals for rating of central heating boilers, the energy efficiency was based on a calculation of the ‘performance’ of the boiler (the useful heat output) In the latest Working Documents (March 2011) the boiler efficiency is no longer calculated on the basis of a ‘heating demand’ and the total energy input required to fulfil this heat demand. Instead the seasonal space heating energy efficiency is calculated on the basis of two test points (at 30% load and low return temperature and full load at high return temperature) and including a correction based on 5 parameters.

The corrections are reductions on the seasonal steady-state efficiency.

etason = 0.85 * eta1 + 0.15*eta4

With eta1 is 0.99 and eta4 is 0.87, etason becomes:

etason = 0.85 * 0.99 + 0.15 * 0.87 = 0.972 or 97.2%

Correction parameters:

1) the **turndown ratio** addresses the fact that if the boiler is able to run at very low capacity, significant start-stop losses are avoided. The boiler can run continuously at part load for an extended time, often making optimal use of low return temperatures.

The corrections are:

td	1.00 ≤ td < 0.80	0.80 ≤ td < 0.66	0.66 ≤ td < 0.50	0.50 ≤ td < 0.30	0.30 ≤ td	1.00 ≤ td < 0.80
F(1)	0.07	0.04	0.02	0.01	0	

If the boiler maximum output is 24 kW and the minimum output is 4 kW, the turndown ratio td is 4/24 = 0.17. The correction is zero.

If the boiler maximum output is 24 kW and the minimum output is 12 kW, the turndown ratio is 12/24 = 0.50 and the correction (reduction of seasonal steady-state efficiency) is 0.01 (or 1%). If the boiler offers no turndown (td = 1.00) then the reduction is 7 percentage points (0.07 or 7%).

2) the **control correction** addresses the way the room thermostat and the boiler communicate. An 'open communication protocol' allows the thermostat to convey information regarding actual room temperature and set temperature on the basis of which the boiler control can decide to operate at lower or higher part load (or full load).

If the boiler is compatible with 'open communication protocol' controls, the reduction is 0.025, if the boiler is not compatible the reduction is 0.03.

3) Almost every boiler consumes some **auxiliary electricity** in order to operate. This electricity consumption reduces the seasonal efficiency. The following parameters are included in the correction:

elmax = the electric power consumption (kW) at full load (100% rated input)

elmin = the electric power consumption (kW) at part load (30% rated input)

fossb = the electric standby power consumption (kW)

Pfos4 = the nominal output (kW) at 100% rated input

F(3) = 2.5 * (0.15*elmax + 0.85 * elmin + 3.3 * fossb) / Pfos4

If for an average 24 kW combi boiler the elmax is 0.145 kW (total 145 W, of which 45 W for combustion fan, 90 W for circulator and 10 W for boiler controls), the elmin is 0.050 kW (total 50 W, of which 15 W for combustion fan, 25 W for circulator and 10 W for boiler controls), the fossb is 0.010 kW and the Pfos4 is 22 kW, the F(3) becomes:

F(3)=2,5*(((0,15*0,145) + (0,58*0,05) + (3,3* 0,01))/22) = 0.01

One can also apply the default value as defined in EN 15316-4-1.

4) Correction F(4) corrects for **standby heat loss**. Each boiler cools down after providing heat. This is called standby heat loss. manufacturers may improve upon this value by providing better thermal insulation in the boiler, minimising heat loss. A flue draught preventer (preventing

escape of accumulated heat, by venting this to the chimney/flue pipe) is also a often applied measure.

Suppose the boiler example above has a standby loss of 0.2 kW (200 W), the formula calculates a correction as follows:

F(4) = 0.5 * Pstby/Pfos4

F(4) = 0.5 * 0.2/22 = 0.004

5) Correction F(5) corrects for **pilot flame** energy consumption. Suppose the equipment has a pilot flame with a capacity of (approximate value) 0.02 kW, the correction (with Pfos4 is 22 kW) is calculated as:

F(5) = Pign/Pfos4

F(4) = 0.02/22 = 0.001

Modern boilers all use electronic ignition and therefore have zero pilot flame consumption.

6) Correction F(6) accounts for the seasonal electric efficiency, generated during the heating process and is therefore dedicated to (small scale) cogeneration boilers. For heat-only boilers F(6) is zero by default. For cogeneration boilers F(6) is calculated as:

F(6) = -2.5 * (0.57*chp1 + 0.09*chp2 + 0.34*chp4).

Assuming a cogeneration boiler with following characteristics

	eta		chp	15%
30%, low temp	eta1	0,99	chp1	0,15
100%, low temp	eta2	0,94	chp2	0,15
100%, high temp	eta4	0,87	chp4	0,15

The correction then becomes:

F(6) = -2,5*((0,57*0.15)+(0,09*0.15)+(0,34*0.15)) = -0.375

EHI has provided an alternative calculation, but details are not known yet.

For the calculation example we assume that the boiler is not a cogeneration unit (otherwise the eta 1 and eta4 would be very different, as well as elmax and elmin).

The overall seasonal space heating energy efficiency 'etas' for the example boiler is then:

etas = etason - sumF(1-6) = 93.6%

etas	etason	F(1)	F(2)	F(3)	F(4)	F(5)	F(6)
seasonal space heating energy efficiency	seasonal steady state thermal efficiency	correction for:					
		turndown ratio	control protocol	auxiliary electricity	standby heat loss	pilot flame	cogeneration
etas =	0.972	0	0.025	0.01	0.004	0	0
etas =	97.2%		2.5%	1%	0.4%		
etas =	93.2%						

Heat pumps (electric and gas fired)

For heat pumps the general principle is the same: a seasonal thermal efficiency, corrected for control and other losses. The corrections are limited with respect to fossil fuel boilers since the thermal efficiency may already include turndown losses and auxiliary electricity (if the heat pump is electric) and that standby heat losses, pilot flame losses and cogeneration surplus energy are not relevant (for current state-of-play).

Therefore the seasonal steady state thermal efficiency is based on the establishment of the reference SCOP. The reference SCOP of a heat pump can be calculated for a specific heating season (the reference heating season) and taking into account certain boundary conditions (for instance at what outdoor temperature a backup heater is assumed to take over the heating capacity, etc.).

Since the seasonal space heating energy efficiency is given in primary energy units, the efficiency of the electric heat pump is converted to primary efficiency by a value of 2.5. seasonal space heating energy efficiency thus becomes:

etas = (1/prim)*referenceSCOP - sumF(1-2)

where prim = primary energy factor. For electric equipment the value is 2.5, for equipment using primary fuels (gas-fired heat pumps) the value is 1.0.

referenceSCOP is established on the basis of the reference heating season

F(1-2) are correction factors F(1) and F(2)

1) F(1) is a correction for control operation similar to that of fossil fuel boilers: the correction involves the way the room thermostat and the boiler communicate.

If the heat pump is compatible with ‘open communication protocol’ controls, the reduction is 0.025, if the boiler is not compatible the reduction is 0.03.

An ‘open communication protocol’ allows the thermostat to convey information regarding actual room temperature and set temperature on the basis of which the boiler control can decide to operate at lower or higher part load (or full load).

2) Correction F(2) accounts for auxiliary electricity consumption (e.g. by a fan, or pump) in active heating mode and is zero for electric heat pumps (assumed included in referenceSCOP) and is calculated for heat pumps using fossil fuels as follows:

F(2) = (prim - auxrecov) * 0.5 * hpaux/DC4

where:

prim is the primary energy factor (is 2.5 for electrical equipment)

auxrecov is the amount of heat from electric equipment that can be recovered (is useful heat) and is by default 0.55

hpaux is the electric power input, in kW, during active heating mode at testpoint A (standard rating condition). This value can be for instance some 900-1000 W for gas heat pumps providing 35-40 kW of heating capacity.

DC4 is the heat pump capacity at standard rating condition, eg. 35 kW.

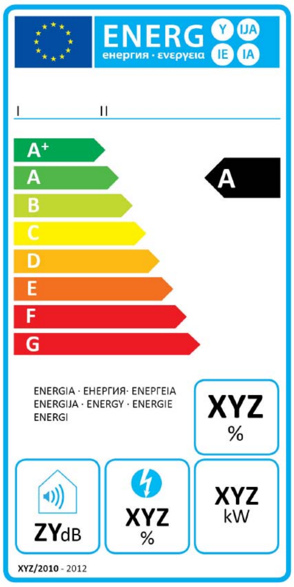
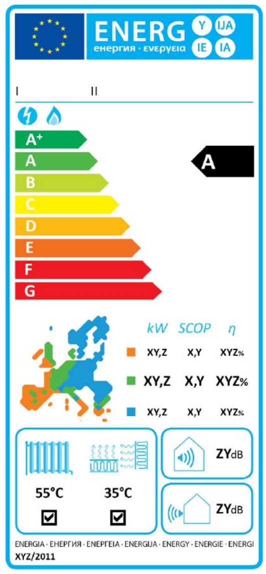
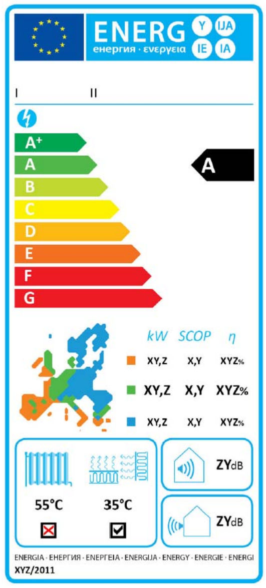
For a readily available gas fired heat pump the F(2) is therefore:

F(2) = (2.5 - 0.55) * 0.5 * 0.95/35 = 0.026

COP stands for coefficient of performance and is a measure of how much units of heat can be produced per unit of electrical energy. A COP of 4 means that 4 units of heat are produced with 1 unit of electrical energy. The heat pump method requires establishment of COP values for the whole heating season, the combined and weighted average is then called SCOP - for Seasonal coefficient of performance.

Annex X - Energy labelling of boilers

Label design

fossil fuel boilers	cogeneration boilers	heat pumps (other than LT)	LT heat pumps
			

Not shown (to add) are the labels for sanitary water production (for combination boilers)

Seasonal space heating efficiency classes for boilers, cogeneration and normal heat pumps:

Seasonal space heating energy efficiency class	Seasonal space heating energy efficiency
A+++	$\eta > 130$
A++	$130 \leq \eta < 114$
A+	$114 \leq \eta < 98$
A	$98 \leq \eta < 90$
B	$90 \leq \eta < 82$
C	$82 \leq \eta < 75$
D	$75 \leq \eta < 67$
E	$67 \leq \eta < 59$
F	$59 \leq \eta < 45$
G	$\eta < 45$

Seasonal space heating efficiency classes for LT heat pumps:

Seasonal space heating energy efficiency class	Seasonal space heating energy efficiency
A+++	$\eta > 155$
A++	$155 \leq \eta < 139$
A+	$139 \leq \eta < 123$
A	$123 \leq \eta < 115$
B	$115 \leq \eta < 107$
C	$107 \leq \eta < 100$
D	$100 \leq \eta < 92$
E	$92 \leq \eta < 84$
F	$84 \leq \eta < 70$
G	$\eta < 70$

Water heating efficiency classes (to align with Dedicated Water Heaters Labeling):

Table 3: Water heating energy efficiency classes *[NB: possibly to be adapted to final version of water heating regulation]*

	XXS	XS	S	M	L	XL	XXL	3XL	4XL
A+++	$\eta > 62$	$\eta > 69$	$\eta > 90$	$\eta > 96$	$\eta > 107$	$\eta > 112$	$\eta > 124$	$\eta > 140$	$\eta > 150$
A++	$53 \leq \eta < 62$	$61 \leq \eta < 69$	$72 \leq \eta < 90$	$79 \leq \eta <96$	$90 \leq \eta < 107$	$92 \leq \eta < 112$	$104 \leq \eta < 124$	$110 \leq \eta < 140$	$120 \leq \eta < 150$
A+	$44 \leq \eta < 53$	$53 \leq \eta < 61$	$55 \leq \eta < 72$	$62 \leq \eta <-79$	$73 \leq \eta < 90$	$76 \leq \eta < 92$	$84 \leq \eta < 104$	$96 \leq \eta < 110$	$96 \leq \eta < 120$
A	$35 \leq \eta < 44$	$38 \leq \eta < 53$	$38 \leq \eta < 55$	$45 \leq \eta < 62$	$56 \leq \eta < 73$	$62 \leq \eta < 76$	$72 \leq \eta < 84$	$80 \leq \eta < 96$	$86 \leq \eta < 96$
B	$32 \leq \eta < 35$	$35 \leq \eta < 38$	$35 \leq \eta < 38$	$39 \leq \eta < 45$	$46 \leq \eta < 56$	$50 \leq \eta < 62$	$60 \leq \eta < 72$	$64 \leq \eta < 80$	$64 \leq \eta < 86$
C	$29 \leq \eta < 32$	$32 \leq \eta < 35$	$32 \leq \eta < 35$	$36 \leq \eta < 39$	$37 \leq \eta < 46$	$38 \leq \eta < 50$	$40 \leq \eta < 60$	$40 \leq \eta < 64$	$40 \leq \eta < 64$
D	$26 \leq \eta < 29$	$29 \leq \eta < 32$	$29 \leq \eta < 32$	$33 \leq \eta < 36$	$34 \leq \eta < 37$	$34 \leq \eta < 38$	$36 \leq \eta < 40$	$36 \leq \eta < 40$	$36 \leq \eta < 40$
E	$23 \leq \eta < 26$	$26 \leq \eta < 29$	$26 \leq \eta < 29$	$30 \leq \eta < 33$	$30 \leq \eta < 34$	$30 \leq \eta < 34$	$32 \leq \eta < 36$	$32 \leq \eta < 36$	$32 \leq \eta < 36$
F	$20 \leq \eta < 23$	$23 \leq \eta < 26$	$23 \leq \eta < 26$	$27 \leq \eta < 30$	$27 \leq \eta < 30$	$27 \leq \eta < 30$	$28 \leq \eta < 32$	$28 \leq \eta < 32$	$28 \leq \eta < 32$
G	$\eta <20$	$\eta < 23$	$\eta <23$	$\eta <27$	H <27	$\eta <27$	$\eta <28$	$\eta <28$	$\eta <28$

Product fiche - sheet 2 ("installer labels")

Figure 19 Gas/oil boiler fiche

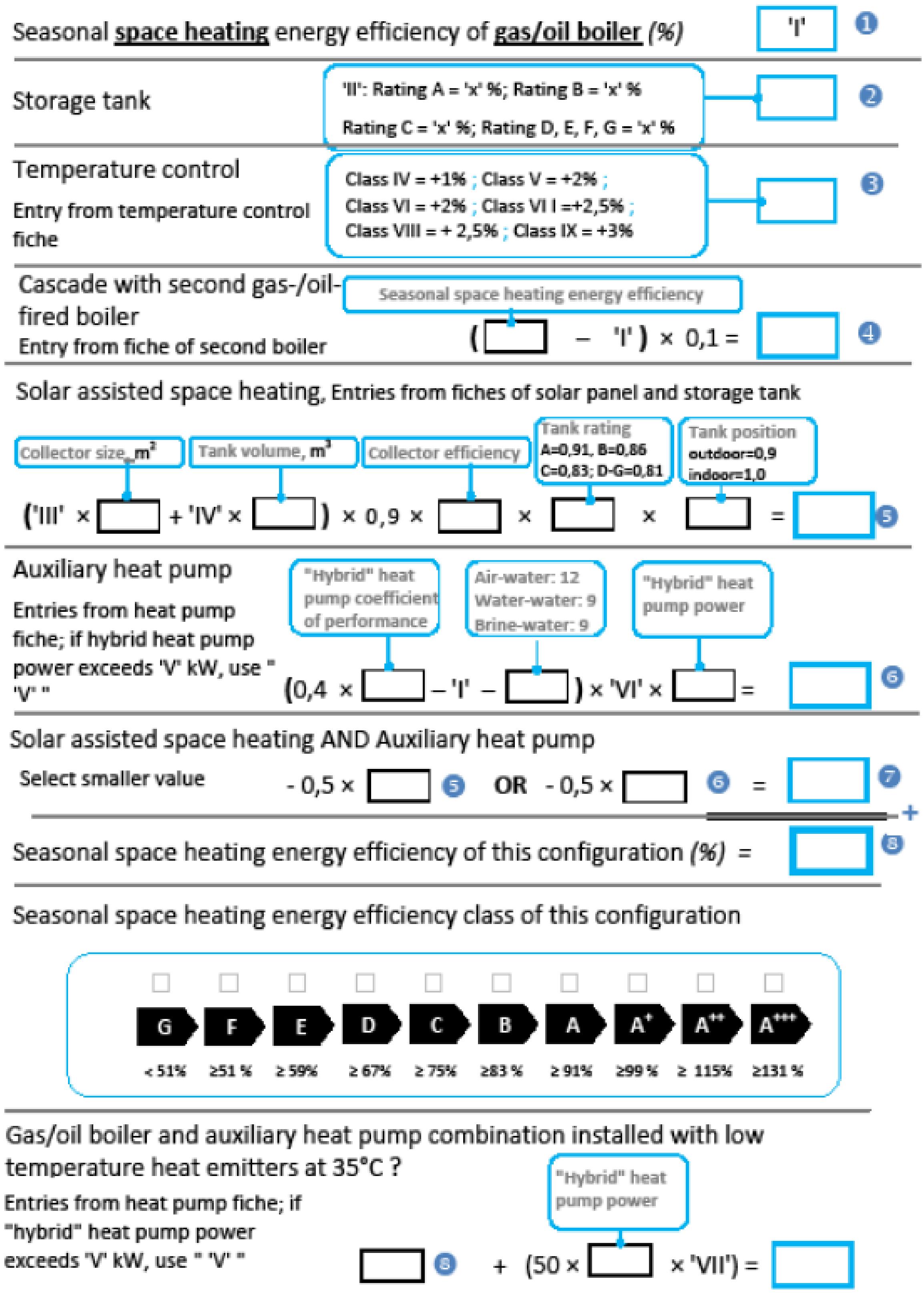


Figure 20 Cogeneration boiler fiche

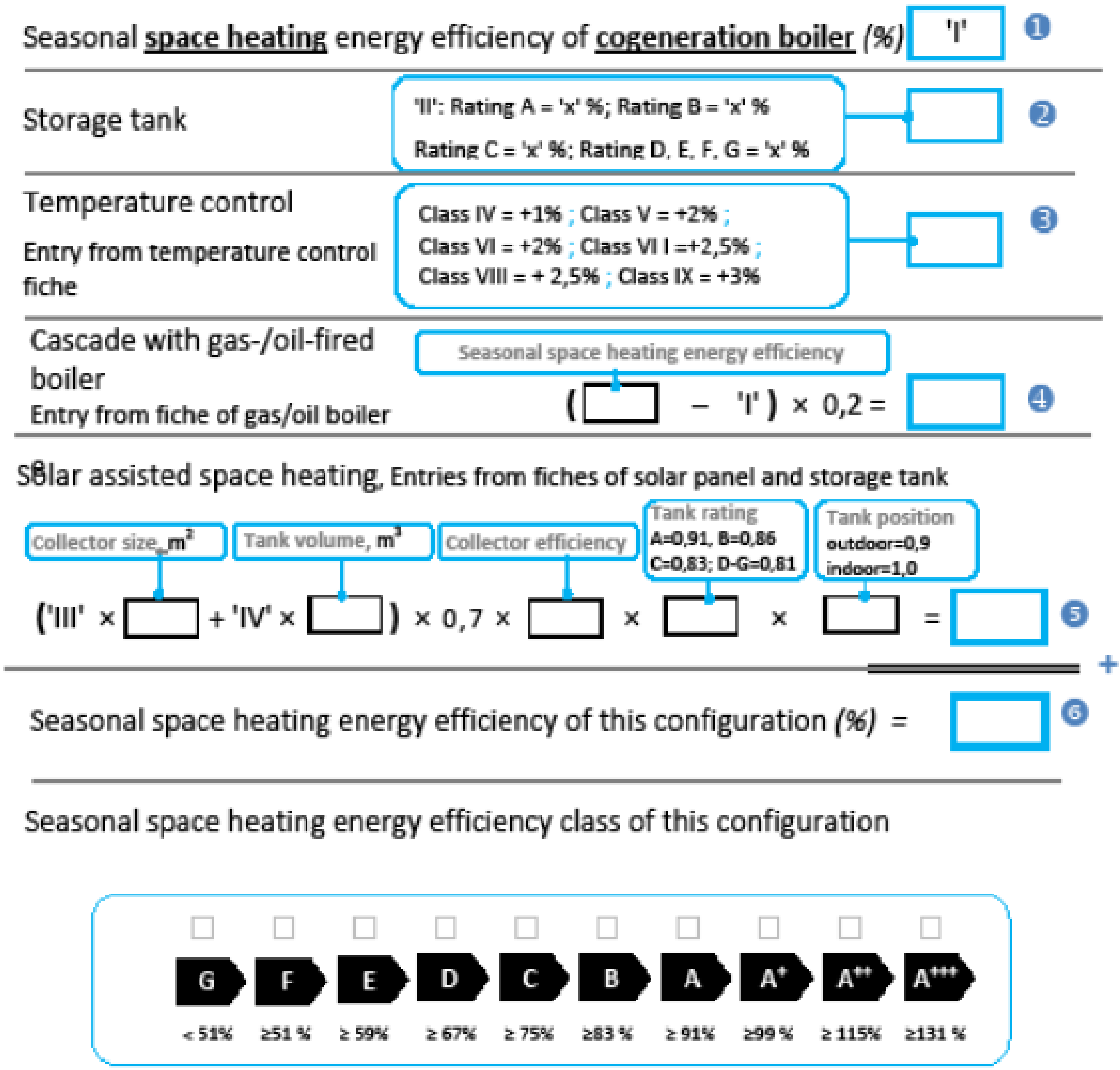


Figure 21 Heat pump boiler fiche

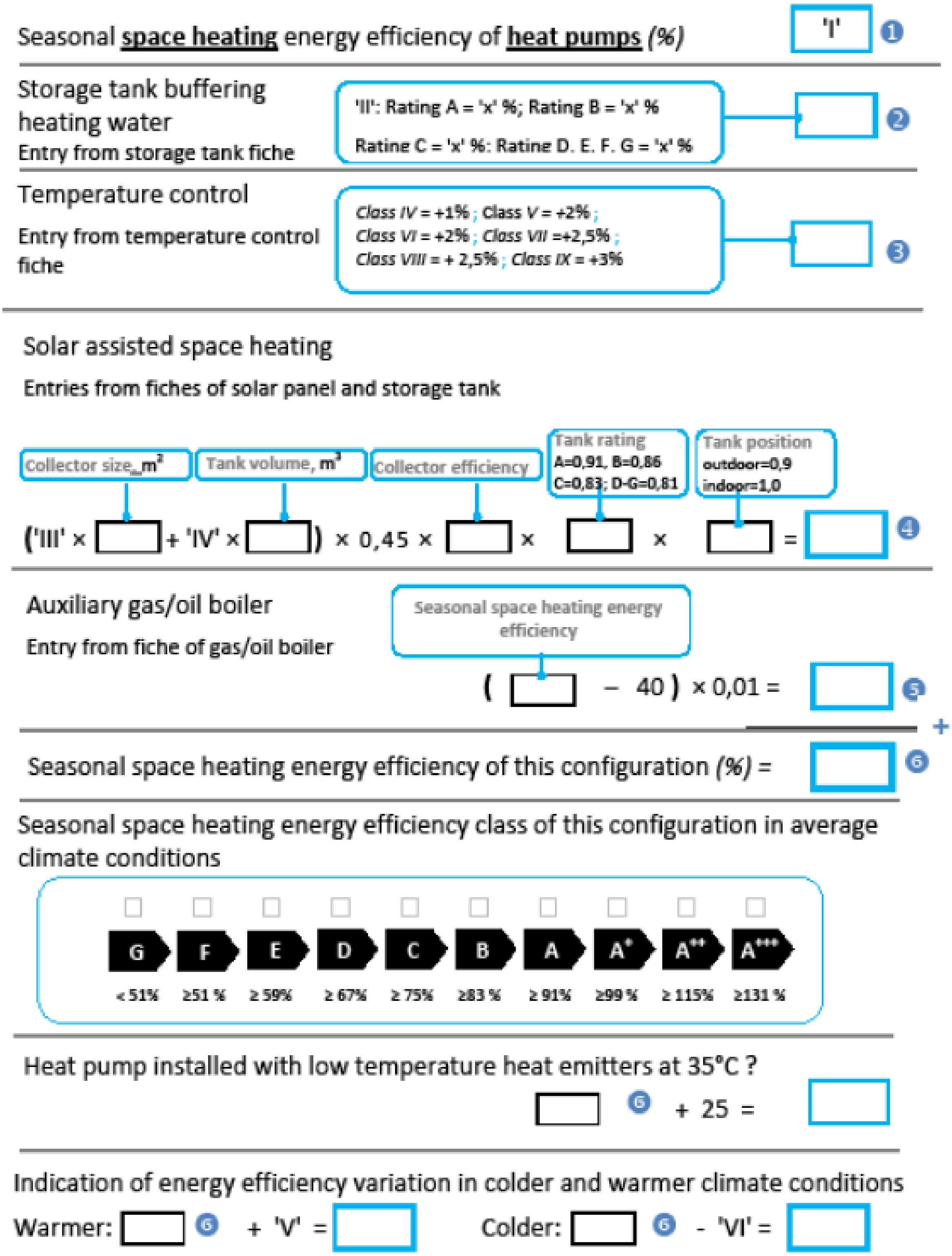


Figure 22 Low Temperature heat pump boiler fiche

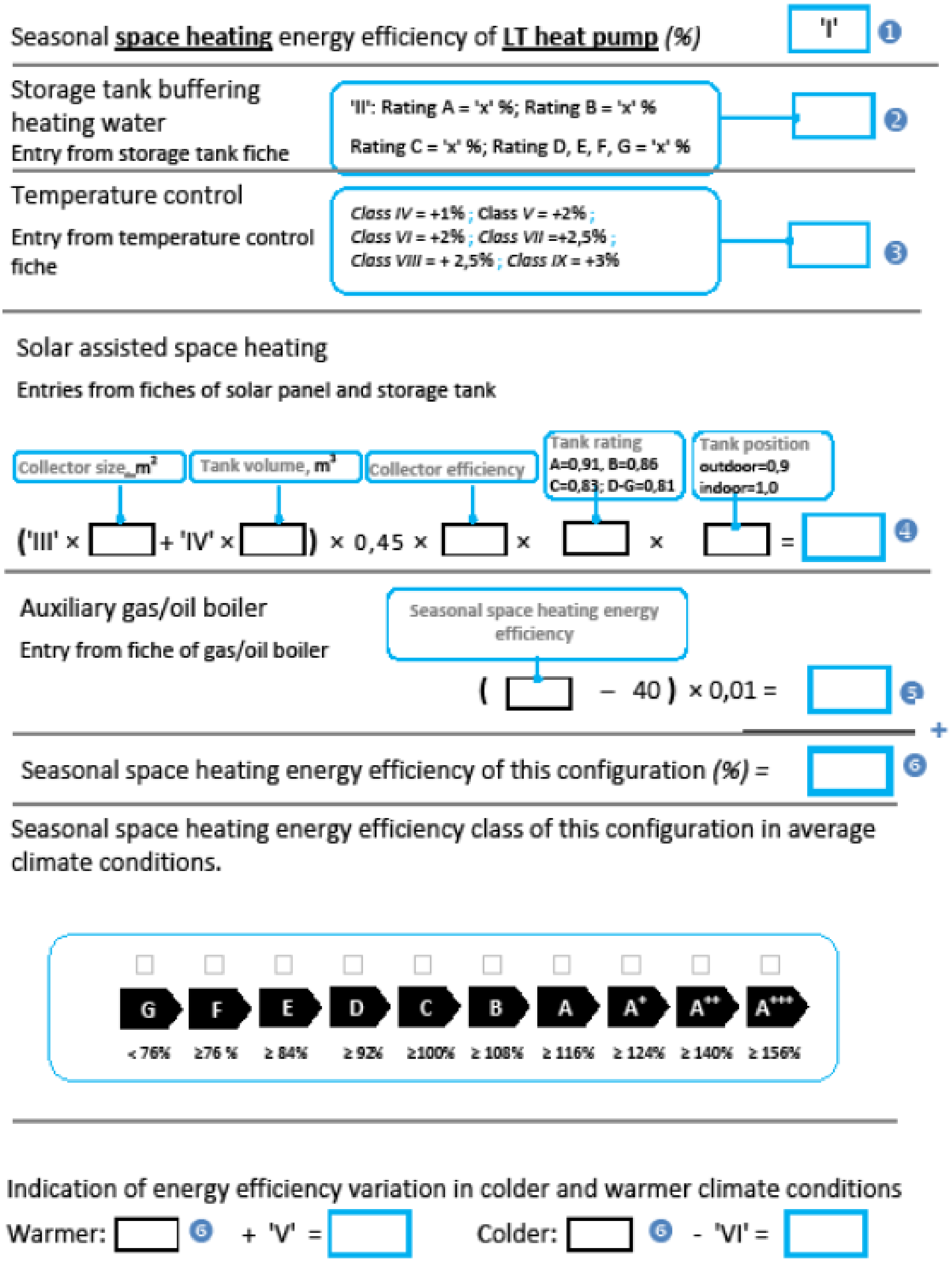


Figure 23 Sanitary water heating fiche

Water heating energy efficiency of gas/oil combination boiler *(%)* 'I' ❶

Solar contribution to water heating

Entries from fiches of solar panel and storage tank

$$\frac{220 \times 'II' \times 'III'}{220 \times 'II' + \square - \square} - 'I' = \square \quad ❷$$

(Storage tank energy losses) (Solar contribution to water heating)

PFHRD = Take value from PFHRD-fiche or –website for Model Xyz, "L" → ❸

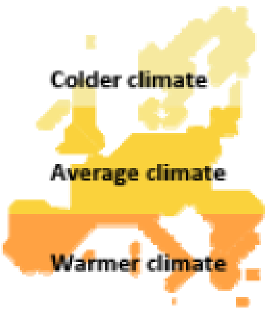
\+

Water heating energy efficiency in Average climate *(%)* ❹

Load profile of combination boiler and water heating energy efficiency class of this configuration in average climate

	G	F	E	D	C	B	A	A+	A++	A+++
S	0	23	26	29	32	35	38	55	72	90
M	0	27	30	33	36	39	45	62	79	96
L	0	27	30	34	37	46	56	73	90	107
XL	0	27	30	34	38	50	62	76	92	112
XXL	0	28	32	36	40	60	72	84	104	124
3XL	0	28	32	36	40	64	80	96	110	140
4XL	0	28	32	36	40	64	86	96	120	150

Indication of variation of solar assisted water heating energy efficiency by climate



❹ – 0,2 x ❷ = ☐

❹

❹ + 0,4 x ❷ = ☐

Annex XI - Lot 1 Methodology

Methodology

Before proceeding to the life cycle model, an explanation of the how the energy consumption in the use phase is calculated is appropriate, since this energy consumption will constitute the majority of the environmental impacts (as will be shown later on). The section below gives a short overview of the development of describing the average energy consumption of central heating appliances.

Up to today, product brochures and commercial documents regarding central heating boilers (including heat pumps) express energy efficiency of boilers in terms of steady state efficiency: the ratio of heat output and energy input for a given test condition. Furthermore the value may be given in lower calorific value, thus ignoring the fact that the water vapour formed during combustion can also provide useful heat.

Of course this 'brochure' efficiency value has little in common with the energy efficiency experienced in the real world over a whole heating season, where the heat load may change per hour (or even less), where thermostatic radiator valves open and close automatically, where central heating piping runs through inhabited areas, where a share of the heat emitted by radiators is not perceived by the people in a room, where a room thermostat is not 'aware' of the actual presence of people in the rooms, etc. etc.

Besides the discrepancy between 'brochure' efficiency and 'real world' efficiency, there are also trends visible that aim to increase the efficiency of heat generation, but the benefits of which are not properly conveyed to consumers. Many manufacturers nowadays offer fossil fuel fired boilers in combination with a solar thermal system. Manufacturers have introduced boilers that incorporate small (air-to-water) heat pumps that offer better efficiency during part load conditions: Some of these heat pumps may use ventilation air as heat source, thereby recuperating a large share of the heat contained in ventilation air, others combine the boiler with an outdoor heat pump unit, using ambient heat as additional heat source. And then there are products that combine a heating function with an electricity generating device, so-called (micro) combined heat and power. The performance of such 'combined' products is currently not expressed in a way that allows easy comparison between options.

Back in 2006, when VHK was awarded the preparatory study for central heating boilers - lot 1 (and water heaters, lot 2) the situation described above prompted VHK to develop a methodology to assess energy efficiency of central heating boilers that takes these developments into account. In 2007 the study was finalized, resulting in a proposal for better assessment of central heating efficiency which takes into account 'real world' effects and the possible combination of straightforward boilers with 'alternative' technologies like solar thermal heating, heat pumps, micro CHP and other products that influence final energy consumption by boilers. This proposal can still be downloaded from the lot 1 website, although it is currently outdated, since during the course of the policy process that followed several simplifications and trade-offs have been negotiated in order to gather support for a possible measure.

The methodology proposal is as follows:

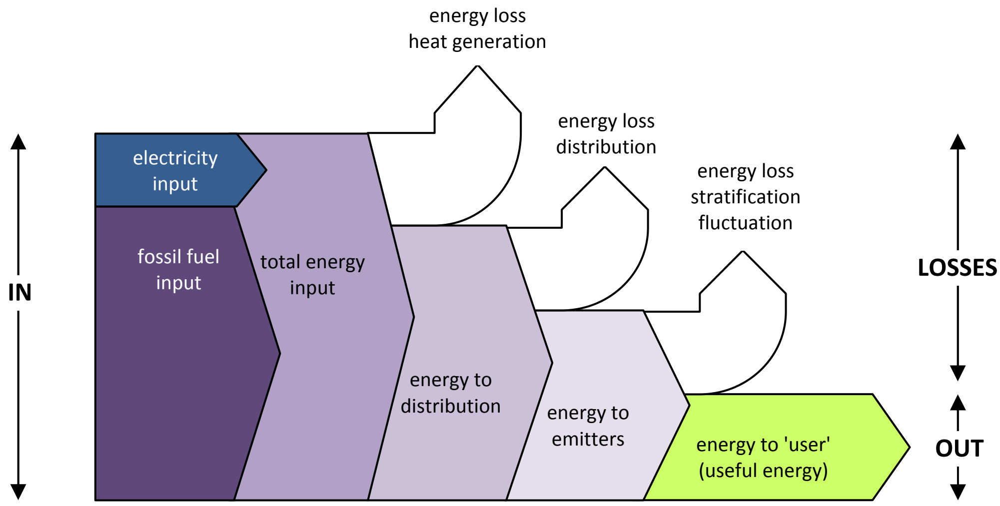
A basis 'seasonal heat demand' is defined. The heat demand describes the amount of heat needed to keep living areas, sleeping areas and bathroom area of a given average room size at a given average room temperature at a given time of day, with average heat losses due to transmission (m2 windows, facade wall, of certain insulating value, etc.), air exchange losses and standard seasonal outdoor temperatures.

The heat input needed to establish and maintain this room temperature is somewhat higher than a straightforward physics calculation predicts, since the average heat emitter (the 'radiator') provides only a smaller fraction of heat by direct radiation and a larger fraction by heating air (convection). Some of this convected heat is trapped below the ceiling, not contribution sufficiently to room temperature levels perceived by persons. These 'stratification-losses' as they are called, are added to the required heat input. Also the heat is not always supplied at the right temperature at the right time. The (room or radiator) thermostat reacts with a certain delay and tolerance, which introduces some 'hysteresis' (temperature lag and temperature overshoot) which causes 'fluctuation-losses' - or unnecessary heat up of the room. These emitter and control losses are added to the required heat input.

Then the central heating piping introduce heating losses, by spending some of the heat transported in areas/spaces that are not populated. These 'distribution-losses' are added to the required heat input.

Then the heat generator itself causes energetic losses: At each boiler start some heat may be lost through purging (cleaning of the combustion chamber with cold fresh air), some fuel may be spent by suboptimal combustion processes, especially during boiler start. Some heat is lost through the repeated warming-up and cooling-down of the thermal mass of the boiler. This effect is even more pronounced if the boiler is located outside the heated zone and if the heat generator (boiler) is over dimensioned (larger than it actually needs to be) and has a relatively small turndown ratio (the heat generator is less capable of providing heat at lower capacities). Some over dimensioning is unavoidable, since the heat generator must have enough capacity to heat up a cold room after a 'cold start' (this requires more energy than just maintaining the room temperature). The heat exchange between hot combustion gases and the circulated water through the primary heat exchanger also introduces losses, indicated as 'chimney losses'. And then the electric components require energy, of which only a small fraction is transferred to useful heat (the thermal dissipation of the energy consumed by the circulator is transferred to the central heating water, for most other electronic components this is not the case).

Figure 24 Energy losses central heating



All these losses have been thoroughly documented in the Task 4 report of the lot 1 Ecoboiler study (over .. pages).

The figure above does not correctly depict the relative significance of the losses. The correct order of magnitude is as follows:

Table 99: Energy losses

Energy losses
Energy in: 100%
heat generation: -15% of total
distribution: -6% of total
stratification/fluctuation: -3%
remaining useful energy: 76%

In the lot 1 study and the first version of the European Commission Working Document the heating season energy demand was classified into separate categories: from XXS to 4XL. Note that the heat demand does not assume a fixed relation with building size: A seasonal heating demand could just as well relate to an average sized space with average heat losses as well as an above average sized space (which would lead to higher heat demands) with lower heat losses (the extra heat demand due to larger space size is compensated by better insulation, the overall heat demand is the same). Concluding: the classes represent a certain amount of heat demand, not a certain building size, since the heat demand is also governed by heat losses (insulation levels, etc.).

The seasonal heating efficiency was calculated by defining the heat load (the required heating capacity) for some 45 'bins' (a bin is a time period for which a certain temperature difference between indoor and outdoor exists). For each bin the required heat input was calculated, taking into account heat up times after a night setback etc.

Taking into account the emitter (stratification), control (fluctuation) and distribution losses the momentary required heat output of the boiler could be calculated. Based upon efficiencies of the boiler assessed at several test points, the actual efficiency of the boiler for that specific bin could be calculated (inter- and extrapolation of test results). A main parameter of the calculation is the calculation of the system return temperature, since this determines to a large extent if the energy of the hot water vapour can be recuperated. Ultimately the method allowed calculation of energy input (fuel, but also electricity for auxiliary components) for each bin, the summation of which is the annual energy consumption.

For heat pumps the basic method of calculation is the same (energy consumption calculated per bin, overall efficiency calculated over the heating season, based on the prEN14825) but then adapted to heat pump characteristics. The model assumed preferential use of heat pumps (the boiler kicks in as back-up heater, if the efficiency of the heat pump drops below a given set point - often related to outdoor temperature).

Solar thermal systems were also included in this method, whereby their contribution was calculated on the basis of certain solar thermal characteristics (like efficiency of collectors, heat loss of storage, etc.). The model assumed a preferential use of solar thermal systems: If the solar system did not provide enough heat, the system boiler (possibly including a heat pump) functions as back up.

At a later stage also micro-CHP was added (the boiler model allowed calculation of running hours - which were used to calculate electricity output - the calculation was made in close cooperation of one of the largest manufacturers of micro-CHP boilers and gave results close to real-life test results).

The model included a correction for combined boilers that provide central heating and heated sanitary water: There are some benefits in the combined operation since residual heat of sanitary water production, may be used for central heating and vice versa. At a later stage also a correction for 'passive flue heat recovery devices' (these are sanitary water pre-heaters, that extract heat from the flue gasses and transfer this to cold sanitary water) was introduced.

The overall methodology may have been 'complex' but all formulas and calculations were taken from, or based upon, calculations in EN standards and not 'new' to the industry involved. In fact, the methodology summarized several tens of years of boiler testing and contained the same amount of information as in twenty or so technical standards (also because much of the information in such standards is repeating other standards).

EN 12170	**Heating systems in buildings - Procedure for the preparation of documents for operation, maintenance and use - Heating systems requiring a trained operator**	**2002**
EN 12171	Heating systems in buildings - Procedure for the preparation of documents for operation, maintenance and use - Heating systems not requiring a trained operator	2002
EN 12828	Heating systems in buildings - Design for water-based heating systems	2003
EN 12831	Heating systems in buildings - Method for calculation of the design heat load	2003
EN 14336	Heating Systems in buildings - Installation and commissioning of the water based heating systems	2004
EN 15217	Energy performance of buildings - Methods of expressing energy performance and for energy certification of buildings	2007
EN 15240	Ventilation for Buildings - Energy performance of buildings : Guidelines for the inspection of air-conditioning systems	2007
EN 15243	Ventilation for Buildings - Calculation of room temperatures and of load and energy for buildings with room conditioning systems	2007
EN 15316-1	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 1: General	2007
	This European Standard specifies the structure for calculation of energy use for space heating systems and domestic hot water systems in buildings. It standardises the required inputs and outputs for the calculations, in order to achieve a common European calculation method. The calculation method facilitates the energy analysis of the different sub-systems of the heating system, including control.	

EN 15316-2-1	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies : Part 2.1: Space heating emission systems	2007
	Energy performance may be assessed either by values of the heat emission system performance factor or by values of the heat emission system losses due to inefficiencies. Method is based on an analysis of the following characteristics of a space heat emission system including control: - non-uniform space temperature distribution; - emitters embedded in the building structure; - control of the indoor temperature	
EN 15316-2-3	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-3: Space heating distribution systems	2007
	This standard provides a methodology to calculate/estimate the heat emission of water based distribution systems for heating and the auxiliary demand as well as the recoverable heat emission and auxiliary demand	
EN 15316-3-1	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 3: Domestic hot water systems	2007
	Calculation of energy requirements for domestic hot water heating systems including control, for all building types. In three parts: Part 3-1 Characterisation of needs (tapping patterns) Part 3-2 Distribution Part 3-3 Storage and generation	
EN 15316-3-2	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 3-2: Domestic hot water systems, distribution	2007
	This European Standard is part of a set of standards covering methods for calculation of system energy requirements and system efficiencies of heating systems in buildings. In particular this European Standard is one of a number of standards dealing with domestic hot water systems. The scope of this specific part is to standardise the methods for calculation of: - thermal losses from the domestic hot	
EN 15316-3-3	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 3-3: Domestic hot water systems, generation	2007
	This European Standard is part of a set of standards covering the methods for calculation of system energy requirements and system efficiencies of heating systems in buildings. In particular this standard is one of a number of standards dealing with domestic hot water systems. The scope of this specific part is to standardise the methods for calculation of: - thermal loss es from the domestic hot water.	
EN 15316-4-1	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating generation systems, combustion systems (boilers)	2008

	This European Standard is part of a series of standards on the method for calculation of system energy requirements and system efficiencies of space heating systems and domestic hot water systems. The scope of this specific part is to standardise the: - required inputs; - calculation method; - resulting outputs; for space heating generation by combustion sub-systems (boilers), including control. This European Standard is the general standard on generation by combustion sub-systems (boilers) If a combustion generation sub-system is within the scope of another specific part of the EN 15316 series (i.e. part 4.x), the latter shall be used. EXAMPLE Biomass combustion generation	
EN 15316-4-2	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-2: Space heating generation systems, heat pump systems	2008
	This European Standard covers heat pumps for space heating, heat pump water heaters (HPWH) and heat pumps with combined space heating and domestic hot water production in alternate or simultaneous operation, where the same heat pump delivers the heat to cover the space heating and domestic hot water heat requirement. The scope of this part is to standardise the: - required inputs, - calculation methods, - resulting outputs, for heat generation by the following heat pump systems, including control, for space heating and domestic hot water production: - electrically-driven vapour compression cycle (VCC) heat pumps, - combustion engine-driven vapour compression cycle heat pumps, - thermally-driven vapour absorption cycle (VAC) heat pumps, using combinations of heat source and heat distribution as listed in Table 1.	
EN 15316-4-3	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-3: Heat generation systems, thermal solar systems;	2007
	This European Standard is part of a series of standards on the method for calculation of system energy requirements and system efficiencies. The framework for the calculation is described in prEN 15603. The scope of this specific part is to standardise the: - required inputs, - calculation method, required outputs, for thermal solar systems (including control) for space heating, domestic hot water production and the combination of both. The following typical thermal solar systems are considered: - domestic hot water systems characterized by EN 12976 (factory made) or ENV 12977 (custom built); - combisystems (for domestic hot water and space heating) characterized by ENV 12977 or the Direct Characterisation method developed in Task 26 'Solar Combisystems' of the IEA Solar Heating and Cooling programme; - space heating systems characterized by ENV 12977	
EN 15316-4-4	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-4: Heat generation systems, building-integrated cogeneration systems	2007
	This European Standard defines a method for calculation of the energy requirements, electricity production, thermal output and recoverable losses of building-integrated cogeneration units forming part of a heat	

	generation system (space heating and domestic hot water) in a building. Such units are commonly known as micro- or small scale cogeneration, or micro- or small scale CHP.	
EN 15316-4-5	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-5: Space heating generation systems, the performance and quality of district heating and large volume systems	2007
	This European Standard is part of a set of standards on the method for calculation of system energy requirements and system efficiencies. The scope of this specific part is to standardise the method of assessing the energy performance of district heating and cooling systems and to define: - system borders; - required inputs; - calculation method; - resulting outputs.	
EN 15316-4-6	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-6: Heat generation systems, photovoltaic systems	2007
	This European Standard is part of a set of standards on the method for calculation of system energy requirements and system efficiencies. The scope of this specific part is to standardise for photovoltaic systems: - required inputs; - calculation method; - resulting outputs. The calculation method applies only to building integrated photovoltaic systems.	
EN 15316-4-7	Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-7: Space heating generation systems, biomass combustion systems	2008
	The standard provides calculation methods for the energy performance of heat generation of biomass combustion systems with respect to: › type of stocking device (automatic or by hand); › type of biomass fuel (pellets, chipped wood or log wood); › including control. This standard is part of the EN 15316 series (see figure 1) for calculation of heating system energy requirements and efficiency. The required heat output, according to the distribution part EN-15316-2-3, must be available as an input for this standard. The domestic hot water generation sub-system is treated in the standard EN 15316-3-3, although EN 15316-4-7 may be used to assess the heat generation for hot water production, when an indirectly heated storage system used heating boilers as a heat source. In this case, the required heat output for domestic hot water distribution (or storage) is taken into account as an input.	
EN 15377-1	Heating systems in buildings - Design of embedded water based surface heating and cooling systems - Part 1: Determination of the design heating and cooling capacity	2008
EN 15377-	Heating systems in buildings - Design of embedded water based surface	2008

2	heating and cooling systems - Part 2: Design, dimensioning and installation	
EN 15377-3	Design of embedded water based surface heating and cooling systems	2007
EN 15378	Energy performance of buildings : Inspection of boilers and heating systems	2007
EN 15459	Energy performance of buildings - Economic evaluation procedure for energy systems in buildings	2007
EN ISO 13790	energy use for space heating (ISO 13790:2004) No 89/106/EEC EN ISO 13790:2008 Energy performance of buildings - Calculation of energy use for space heating and cooling	2008
	ISO 13790:2008 gives calculation methods for assessment of the annual energy use for space heating and cooling of a residential or a non-residential building, or a part of it, referred to as "the building". This method includes the calculation of: the heat transfer by transmission and ventilation of the building zone when heated or cooled to constant internal temperature; the contribution of internal and solar heat gains to the building heat balance; the annual energy needs for heating and cooling, to maintain the specified set-point temperatures in the building – latent heat not included; the annual energy use for heating and cooling of the building, using input from the relevant system standards referred to in ISO 13790:2008 and specified in Annex A. ISO 13790:2008 also gives an alternative simple hourly method, using hourly user schedules (such as temperature set-points, ventilation modes or operation schedules of movable solar shading).	
EN 15603	Energy performance of buildings - Overall energy use and definition of energy ratings	2008
	The purpose of the standard is to: a) collate results from other standards that calculate energy use for specific services within a building; b) account for energy generated in the building, some of which may be exported for use elsewhere; c) present a summary of the overall energy use of the building in tabular form; d) provide energy ratings based on primary energy, carbon dioxide emission or other parameters defined by national energy policy; e) establish general principles for the calculation of primary energy factors and carbon emission coefficients. This standard defines the energy services to be taken into account for setting energy	

	performance ratings for planned and existing buildings, and provides for this: f) method to compute the standard calculated energy rating, a standard energy use that does not depend on occupant behaviour, actual weather and other actual (environment or indoor) conditions; g) method to assess the measured energy rating, based on the delivered and exported energy; h) methodology to improve confidence in the building calculation model by comparison with actual energy use; i) method to assess the energy effectiveness of possible improvements. This European standard is applicable to a part of a building (e.g. flat), a whole building, or several buildings. It is up to national bodies to define under which conditions, for which purposes and for which types of buildings the various ratings apply. This standard handles the energy performance of a building as a whole. The assessment of the energy performance of specific technical building systems is handled in the appropriate part of EN 15241, EN 15243 and EN 15316 series	

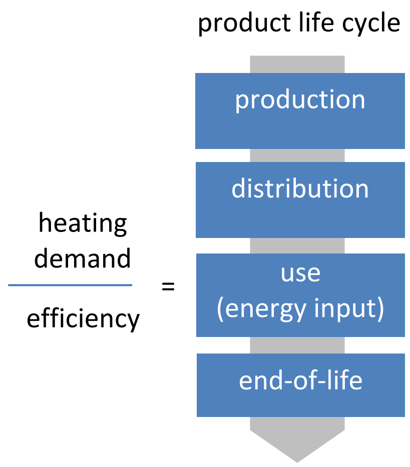
Introduction

The goal of the life cycle model is to allow a comparison of environmental aspects and impacts of various central heating products (electric, gas and/or oil-fired boilers, including solar heating, heat pumps and micro-CHP/cogeneration).

The impacts are determined by all phases of the product life cycle, but most importantly (for central heating products) the energy consumption during the use phase. For this reason, the discussion of the life cycle model starts with an elaborate explanation of how the energy consumption of central heating products is determined: starting with the heating demand, the energy efficiency of systems and ending with the calculation of energy consumption during use. This is then followed by described impacts from other life cycle phases.

The figure below indicates the place of heating demand and efficiency in the life cycle model.

Figure 25 Representation of product life cycle



For average central heating products the energy consumption can be calculated as the heating demand (= the heating output of the central heating systems) divided by the efficiency (therefore ‘efficiency’ is the relation between the heating output / total energy input).

Therefore this section will start by describing the average heating demand of central heating products. It will then discuss the method of establishing the energy efficiency of the central heating product.

Finally it will describe the energy consumption of the central heating products, which will then be combined with environmental inputs during the other phases of the product life cycle.

Space heating demand

The space heating demand is the yardstick for the 'performance' of the central heating system - it is the quantification of how much 'heat' (in kWh) the central heating product is assumed to deliver during a heating season (useful heat, excluding losses).

The lot 1 preparatory study did an extensive study on the average heat demand of buildings, for both the domestic sector as the non-domestic sector (industrial and tertiary buildings) .

Domestic heat demand

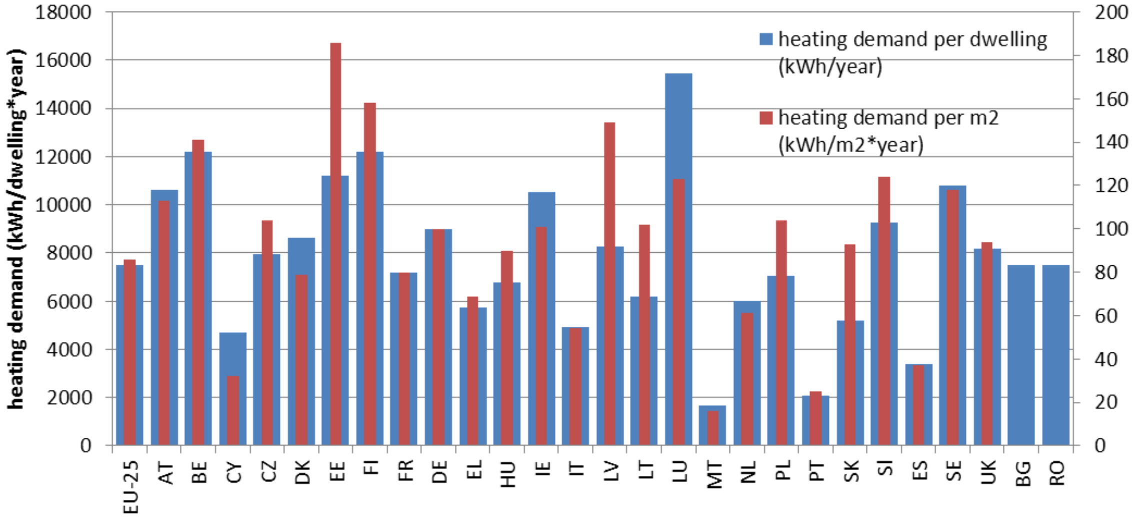
For households the heat demand was established by first assessing the average heat loss for a given indoor temperature, which takes into account average floor space and height of European dwellings, the average internal heat gain (from persons, equipment and lighting), the average external heat gain (depending on solar energy, average window size, characteristics and positioning), the average heat loss through transmission (depending on indoor/outdoor temperature difference, average insulation values, including that of windows and doors and their respective heat loss surfaces, etc.) and the average air exchange rate. See also Annex V and VI fro more information on the EU building stock.

Combined with a consideration of system losses (due to distribution, temperature control and emitter losses) the calculation method was called the 'Heat Balance Model' in the Lot 1 study (described in Task 3) - see also Annex VII for a more detailed review.

The analysis resulted in an average EU25 heat demand (required heat output of the system, excluding the energy losses of the system) of some 7500 kWh per dwelling per year. The differences across Member States are however quite large, as can be seen from the figure below[77.]

[77] Bulgaria and Romania have been added to the end of the graph, the demand is estimated to be comparable to that of Greece.

Figure 26 Heating demand per EU dwelling



The differences between Member States can partly be explained by differences in:

- climate (Malta, Cyprus, Spain and Portugal have relatively warm climates);
- building standards / level of insulation (this would explain the relative differences between The Netherlands, Belgium and Luxembourg, which share a similar climate, but show large differences in heating demand);
- other housing characteristics (the average dwelling size differs per country: a dwelling in Luxembourg is average 125 m2, Germany and France are average 90m2 and Slovakia and Latvia are average 55-56 m2).

In 2007 two new Member States joined the EU: Romania and Bulgaria. Unfortunately there is little to no information available regarding housing statistics in these countries to enable a full screening of average heating demand. However, when looking at data from neighboring countries like Hungary (6800 kWh/year), Greece (5700 kWh/year), possibly Slovakia as well (5200 kWh/year) it is safe to say that the average dwelling (with central heating) in Romania and Bulgaria will not significantly change the EU25 average heating demand (see also Annex VI).

Concluding, the average heat demand of dwellings remains approximately is 7500 kWh/year.

Industrial and tertiary sector heat demand

The Lot 1 study also assessed the heating demand of industrial and tertiary buildings. The approach was different because of the absolute scarcity of data and included various sources of top-down analysis of energy consumption and anecdotal data for tertiary and industrial sectors.

Summarizing the lot 1 analysis of 2007 shows a total of 36 billion m3 heated volume in the tertiary sector and 24 billion m3 in the industrial sector. The heat demand for these sectors was estimated to be some 23 kWh/m3 for the tertiary sector and 17 kWh/m3 for the Industrial sector.

Figure 27 Tertiary sector

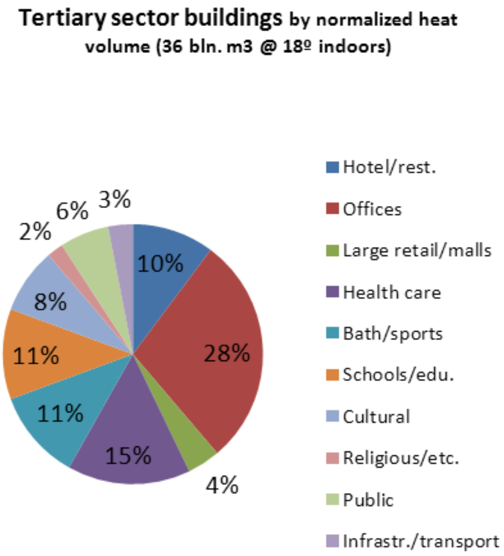
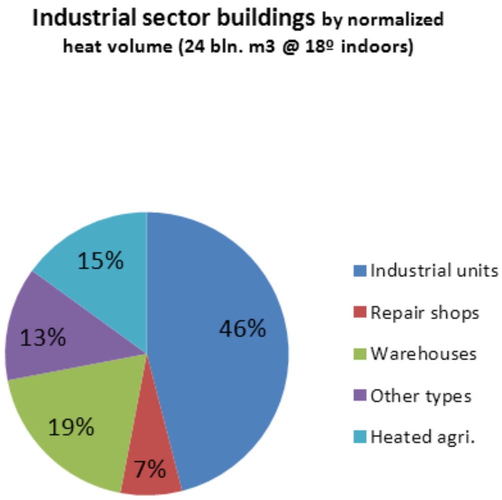


Figure 28 Industrial sector



This heating demand (expressed in heated indoor volume of buildings) was combined with an assessment of average sales of boilers to the industrial and tertiary sectors. In the end the analysis shifted towards identifying a heating demand per boiler class, instead of trying to establish a heat demand per building type, since the boiler sales data were believed to deliver more accurate data than the assessment of building types could deliver.

Average heating demand per boiler

taking into account the difficulty in establishing the average heating demand of tertiary and/or industrial buildings (given the diversity encountered in these sectors) it appeared better to define a heating demand per boiler. For this purpose the Lot 1 study defined nine base case classes of central heating boilers, each representing a suitable heating demand.

The base case classes can be characterized by input power (taking into account average boiler oversizing), minimum required out power and finally typical heating demands.

Table 100: Minimum output power, average input power and average heating demand per boiler capacity class

		Minimum required output power	**est. input power Base Case (incl. eff + oversize)**	**Heating demand**
Class	**Indicative application**	**kW**	kW	**kWh/year**
XXS	apartment new	**3,6**	10	**2354**
XS	average new	**5,1**	14	**3699**
S	apartment existing*	**6,9**	19	**4850**
M	average existing	**7,7**	22	**7480**

L	house existing	**10,5**	29	**10515**
XL	new building (8 apartments)	**30,6**	60	**20284**
XXL	existing building (8 ap.)	**46,4**	115	**42195**
3XL	*high rise apt. (20 exist apt's)*	*117*	*250*	*106738*
4XL	*3 high-rise apt. (60 exist. apt's)*	*350*	*750*	*320215*

The table below shows the characteristics of these boiler capacity classes.

Table 101: Overview of capacity classes, market share in EU- stock and typical examples of application.

Size-Class	Indicative Range for Pnom	Market share	Nr of units in stock *mln.	Avg. Net heat load kWh/a	Examples of application
XXS	< 10 kW	2,3 %	2,4	2.350	- **Apartment new** - Passive new house - Professional practice (part of house) - Small shop- / office-space new
XS	10-15 kW	7,6 %	8,0	3.700	- **Average dwelling new** - Terraced or low-E house new - Large apartment new - Medium shop / office space new
S	16-20 kW	15,2 %	16,0	4.850	- **Apartment existing** - House new / fully renovated - Penthouse new - Small shop / office space existing
M	21-25 kW	51,5 %	54,1	7.480	- **Average existing** - House partially renovated - Large apartment existing - Medium shop / office space existing
L	26-32 kW	9,9 %	10,4	10.515	- **House existing** - Small low-rise apt. Building (4 apts) existing - Two family house new - Small office/ shop building new
XL	33-70 kW	9,9 %	10,4	20.000	- **New avg. apt. building (8 apts.)** - Small low-rise apt. building (4 apts) existing - Villa, large house, 2 family house existing - Medium shop/office building new
XXL	70-150 kW	2,6 %	2,7	42.195	- **Existing avg. apt. building (8 apts.)** - High-rise apt. building (12 – 20 apts) new - Medium shop/office building existing - Large low-rise shop/office building new
3XL	150-350 kW	0,6 %	0,6	106.738	- **High-rise apt. building (16-24 apt.) existing** - Large low-rise shop/office building existing - Medium high-rise office building new - In cascade: larger high rise building
4XL	>350 kW	0,6 %	0,6	320.215	- **Block heating 3 high-rise buildings** (60 apt.) - Large high-rise office building - In cascades: Hospital, shopping mall, small airport, district heating substations.
		100 %	105		

The overall average heating demand per boiler (sales weighted) is 11.602 kWh/year (heating season).

Table 102: Total heating demand EU25, year 2005

		XXS	XS	S	M	L	XL	XXL	3XL	4XL	Total
Boiler sales	*in '000 units*	150	500	1000	3400	650	650	170	40	40	6600
Heating demand per boiler	*kWh/a. unit*	*2350*	*3700*	*4850*	*7480*	*10515*	*20284*	*42195*	*106738*	*320215*	
TOTAL Heating demand	GWh/a	353	1.850	4.850	25.432	6.835	13.000	7.173	4.270	12.809	76.571
Average	kWh/a					11602					

For scenario modeling it is assumed that the heating demand has reduced and will continue to reduce for the following reasons (estimate 2020-2025):

- The heat load will increase by 7-8% because of a bigger average floor area (from 87 m² today to 94-95 m²/dwelling in 2020);
- The heat load will decrease because of better insulation and less ventilation heat losses. Even taking into account the continuously growing floor area per dwelling the SAVE study –building on a 1960-2005 historical data—predicted a decrease of 900 kWh (12%). Given the negative effect of the enlargement of the floor area this means that insulation and ventilation measures would yield a 20% improvement';
- The effective heat load will increase by 8% because the comfort level (the average indoor temperatures) in Southern and Eastern EU Member States will increase;
- Combining the three points above VHK expects a decrease in the effective space heat load of the average existing dwelling by 4-5% in 2020-2025.

The average heating demand also changed from 1990 towards 2020, since the average building in which a boiler is places is gradually becoming more energy efficient (there are other effects as well, but this is the main one). Between 2005 and 2010 an average decline of 9% is expected.

Efficiency of central heating products

The energy efficiency of the central heating product is the product characteristic that describes the relation between the total energy input to the product and the required heating output (space heating demand).

The efficiency therefore gives the measure of how much losses there have been in the conversion from energy inputs to useful heating (100% - efficiency % = loss %).

Between 2006 and 2007 VHK conducted the Lot 1 preparatory study on central heating boilers, in which a lot of time and effort was devoted to modeling of the real-life energy efficiency of central heating boilers. The model developed in this study was used to produce the first working documents for Ecodesign Requirements and Energy labeling of central heating boilers.

However, the most recent proposals by the Commission for the Ecodesign Requirements and Energy labeling of central heating boilers apply a simplified approach. Both methods and the differences are explained in the following two sections.

Efficiency according 'Lot 1'

Heating demand

The starting point of the calculation of central heating efficiency in Lot 1 was a required indoor temperature per zone in the building en per time period. On the basis of calculated heat losses due to transmission (losses through walls, windows, floors, ceilings etc.) and losses through air exchange (ventilation rate and infiltration rate) in combination with an outdoor temperature / global irradiance that changes throughout the heating season, the average heat demand could be established. The energy needed to achieve this 'set' temperature in the given conditions is called **Tset**.

In the heat demand also thermal mass effects were considered, since - after a night setback or a weekend away - the building may have cooled down and needs to be reheated. The heat is not supplied 'instantly' when people enter the room, nor is it 'gone' when people leave the room. This thermal mass effect is also taken into account. This energy is called **Tmass**.

A third element of the building net heating demand is the internal heat transfer, since not all the spaces in the buildings will have the same temperature and some energy transfer will happen. This energy transfer is referred to as **Tintrans**.

Together these three (Tset, Tmass and Tintrans) make up the 'net heating demand' which can be calculated for each zone, day-period and day of the heating season (the Heat Balance model - Annex VII). For each moment the load (the heating power) needed to fulfill the demand can be calculated and this load is what should be delivered through the heating system to the space. All other energy needed to fulfill this heating demand can be regarded as an energetic loss. These losses occur due to the characteristics of the central heating system (system losses) and of course in the heat generator itself (boiler losses).

Distribution (and emitter) losses

Most heating systems have a feedback systems based on thermostats that sense the room temperature. Since each control type will have some 'hysteresis' (temperature overshoot and undershoot) and especially temperature undershoot causes thermal discomfort, the set temperature is somewhat higher to overcome the perceived discomfort from temperature undershoot. The extra increase of temperature due to control characteristics is referred to as fluctuation losses (**Tfluct**).

The heat is transferred to the space mostly by means of radiators (>80% of boilers will be connected to a radiator heating system, only > 10% applies (under)floor heating). This introduces the stratification losses (**Tstrat**) where much of the heat accumulates just below the ceiling, whereas the heat is actually needed at the height level of average persons.

The piping that transfers the heated system water to and from the boiler also introduces thermal losses, since some energy transfer inevitably occurs in places where it does not contribute to the performance of the boiler (heating of the occupied space). These losses are referred to as distribution losses (**Tdistr**).

Boiler losses

The remaining losses occur in the boiler itself: First there are steady state losses which effectively describe the efficiency of the heat exchange process between the hot flue gases from combustion and the system water. The larger the heat exchange surface and the lower the return temperature, the more energy can be extracted from the flue gases. Condensing boilers can extract even the energy of the water vapour that forms during combustion. Energy (heat) not transferred to system water is lost either through the flue gas pipe and/or the boiler casing. The electricity consumption of various boiler parts is not part of this efficiency (treated separately).

For the base cases a steady state efficiency of 80% was assumed (based on an 80/60 temperature regime).

A second boiler loss are start/stop losses: These losses are related to purging of the combustion chamber with clean (cold) air, thereby removing flue gases but also some residual heat. Furthermore, during the first instances of the boiler start the combustion process is not optimal and some fuel may be lost as well.

A third boiler loss are standby losses, when the boiler cools down after a boiler stop (the boiler represents a significant thermal mass that heats up and cools down during each boiler cycle. If not listed separately the energy consumption of a pilot flame can be added to standby losses, but most if not all boilers have electronic starters instead of pilot flames.

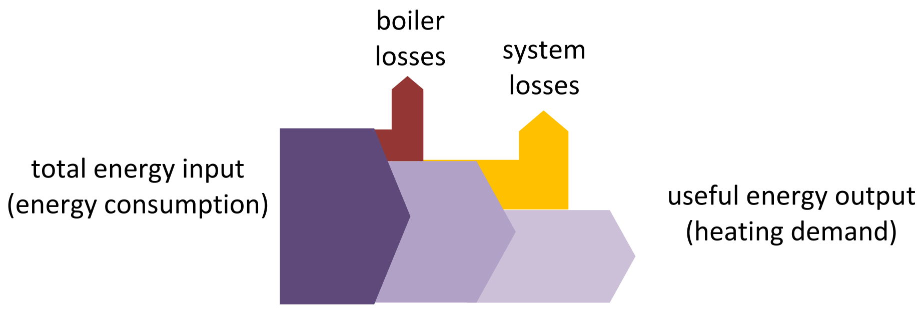
A fourth loss factor is the electricity consumption. Some of the consumption is emitted as heat and is transferred to the system water (e.g. the system water effectively 'cools' the circulator that pumps the fluid around, and therefore this heat is not entirely lost). Most of the electricity consumption is however lost to the environment.

This electricity consumption includes the electricity consumption of the central heating circulator. In most cases (especially regarding the smaller boilers, up to size XL) the circulator is an integral part of the boiler. For larger boilers, the circulator is often installed externally from the boiler, as a separate component. The circulator operating time is in most cases determined by the boiler control (activated just before boiler start, during firing and also after boiler stop) but for many larger systems the circulator may run continuously throughout the season, sometimes the whole year. For the average boiler, the runtime multiplied by the average power consumption gives the total electricity consumption.

In the lot 1 study all these loss factors have been computed for boilers of various capacity classes. Assuming an average boiler efficiency and an average system design, the 'net heating demand' represents some 54% of the total required energy input, the 'system losses' represent some 20% of the required input and the 'boiler losses' the remaining 26%.

The figure below shows the losses that occur from the energy input side (fuel or electric power consumption) to the output side (the heating demand that is met by the system).

Figure 29 Losses in the central heating system



The table below gives a quantification of these losses for an average boiler (M-class capacity). It shows that the system losses are approximately 20% of the total and the boiler losses some 26% of the total energy input. Concluding, the efficiency of this central heating systems is some 54%. Note that this is the base case M-class boiler of average steady state efficiency (not a condensing boiler).

Table 103: Energetic losses for a central heating system of M-class capacity

	per item		grouped			grouped and excluding system losses	
	kWh/year	% of total		kWh/year	% of total	kWh/year	% of total
Tset	6056	44%	net heating demand	7480	54%	7480	68%
Tmass	1106	8%					
Tintrans	318	2%					
Tfluct losses (controls)	992	7%	'system' losses	2752	20%	0	0%
Tstrat losses (emitters)	629	5%					
Tdistr losses (distribution)	1131	8%					
Steady state losses	2633	19%	'boiler' losses	3595	26%	3595	32%
Start/stop losses	44	0%					
Standby heat losses	338	2%					
Electricity consumption	580	4%					
TOTAL	13827	100%		13827	100%	10515	

Average efficiencies

The average efficiency cy of a new boiler can be determined by weighing of the average boiler efficiency per capacity class and the relative share of that capacity class in the total sales.

Table 104: Boiler efficiency per capacity class (in % primary energy, Gross Calorific Value)

	XXS	XS	S	M	L	XL	XXL	3XL	4XL	weight avg.*
Boiler space heating efficiency **(%)**	53%	54%	52%	54%	55%	44%	45%	43%	43%	48%

By estimating the average boiler efficiency in recent and coming years the stock efficiency can be calculated.

Table 105: Average boiler efficiency of the stock - projections (in % primary energy, Gross Calorific Value)

	1990	1995	2000	2005	2010	2015	2020
average stock boiler efficiency	42%	44%	46%	48%	52%	53%	54%

Note that these efficiencies are 'net heating' efficiencies, i.e. they are a direct relation between the heating demand and the total energy consumption.

Annex XII - Emissions from combustion

Table 106 Emissions gas fired boilers (source Pfeiffer, 1)

Gas fired appliance	Ref.	CO [mg/MJ]		CH_4 [mg/MJ]		TOC [mgC/MJ]	
		Steady state	*Cycling**	*Steady state*	*Cycling**	*Steady state*	*Cycling**
Boiler with premix burner	H1-G1	2,2	32	0,42	19	0,59	16
Premix condensing, flat burner	G2	0,43	21	0,49	36	0,68	31
Premix condensing, flat burner	G3	3,9	10	2,6	33	2,0	28
Instantaneous boiler, flat burner	G7	14	16	0,89	16	0,99	14
Instantaneous boiler, flat burner	G8	6,5	15	0,45	23	0,99	19
Average		***5***	***19***	***0,97***	***25,4***	***1,05***	***21,6***

* Cycling operation based on relative boiler load acc. DIN 4702 / Part 8

Table 107 Emissions oil fired boilers (source: Pfeiffer, 1)

Oil fired boiler	Ref.	CO [mg/MJ]		CH_4 [mg/MJ]		TOC [mgC/MJ]	
		Steady state	*Cycling**	*Steady state*	*Cycling**	*Steady state*	*Cycling**
Boiler 1 with jet burner 1	H1-B1	< 0,33	2,3	< 0,40	0,49	< 0,56	1,5
Boiler 1 with jet burner 2	H1-B2	< 0,35	1,9	< 0,43	0,48	< 0,60	1,0
Boiler 1 with jet burner 3	H1-B3	< 0,34	3,7	< 0,41	0,45	< 0,58	1,2
Boiler 1 with jet burner 4	H1-B4	0,34	2,4	< 0,41	0,44	< 0,58	1,6
Boiler 2 with jet burner 5	H2-B5	1,2	43	< 0,42	1,5	< 0,59	17
Boiler 3 with jet burner 6	H3-B6	4,0	7,3	< 0,40	2,0	< 0,56	6,9
Boiler 3 with jet burner 3	H3-B3	5,4	7,8	< 0,41	0,61	< 0,57	1,9
Boiler 3 with jet burner 7	H3-B7	4,3	3,3	< 0,38	0,74	< 0,53	2,4
Average		*2*	*9*	*0,4*	*0,84*	*0,57*	*4,18*

* Cycling operation based on relative boiler load acc. DIN 4702 / Part 8

In terms of actual mass, the numbers are small. In our calculation of the methane combustion we will use a value of 100-120 mg/MJ: CO 24, CH4 26, NOx 25-30 mg/MJ + TOC 23 mg C/MJ (say 30 mg hydrocarbons). At 39,8 MJ/m³ for methane this comes down to a total 4-5 gram. This mass does not come on top of the emissions, but replaces a minute part of the other combustion products.

Emissions of air pollutants from the combustion process in gas- and oil-fired CH boilers are carbon dioxide (CO_2), nitrogen oxides (NO_x), carbon monoxide (CO) and methane (CH4). In oil-fired boilers you have these emissions plus sulphur oxides (SO_x), Volatile Organic Compounds (C_xH_y) and "soot" (Particulate Matter, PM).

When looking at the combustion emissions from the angle of their relative environmental impact. there are a number of categories.

Global Warming Potential (GWP). These include CO2, CO and CH4 emissions. Legal basis is the Kyoto protocol and the weighting factors for the GWP-100 are prescribed by the Intergovernmental Panel on Climate Change (IPCC). The unit of GWP-100 is CO2-equivalent (CO2=1). Carbon monoxide has –per weight unit— a CO2-equivalent of 1,57. Methane (CH4) has a significantly higher GWP at CH4=21.

Acidification Potential (AP). These include SOx and NOx emissions. The policy framework for regulating acidification consists of several European Community directives and the so-called Gothenburg Protocol . This protocol considers SO2 to be 50% more harmful in terms of acidifaction than NOx (weighting factor 1 versus 0,7 respectively. This relationship is also reflected in the emission limit values of the 1999/30/EC daughter directive of the Ambient Air Quality Directive (AAQD) . The AAQD is an interesting framework directive, because the collection of –so far— 4 daughter directives show the relative importance that the legislator gives to very different types of emissions, which are all assessed in a similar (grid-based) method.

From this comparison (see table 3) it is clear that the legislator thinks NOx some 50 times more harmful than CO-emissions from the viewpoint of ambient air quality. This is very significant, because up till now the boiler sector has mostly treated the emission limits for CO as equivalent to NOx (see Task 1 report). This is not in line with EU environmental policy. If the sector —and the governments in Member States—have treated CO equally stringent this must be due to other reasons, e.g. historical safety reasons when boilers were not room sealed and CO-poisoning was a real danger with open (not room-sealed) units.

Volatile Organic Compounds (VOC). These include the C_xH_y emissions from oil-fired boilers. Strictly also methane (CH_4) is part of VOCs, but because the effect on the environment is different it is excluded. For this reason VOCs are often called NMVOCs (non-methane VOCs).

VOCs appear in Directive 2002/3/EC of 12 Feb. 2002 due to their role in (ground level) ozone and in Directive 1999/13/EC dealing with organic solvents. Furthermore, the European IMPEL network is monitoring fugitive NMVOCs, amongst others from combustion processes. There are no weighting factors mentioned and the MEEUP study proposes to simply make an inventory on a weight basis.

Formation of VOCs in commercial and industrial boilers primarily result from poor or incomplete combustion due to improper burner set-up and adjustment. To control VOC emissions from commercial and industrial boilers, no auxiliary equipment is needed; properly maintaining the burner/boiler package will keep VOC emissions at a minimum. Proper maintenance includes keeping the air/fuel ratio at the manufacturer's specified setting, having the proper air and fuel pressures at the burner, and maintaining the atomizing air pressure on oil burners at the correct levels. An improperly maintained boiler/burner package can result in VOC levels over 100 times the normal levels. Furthermore, as VOC emissions mainly occur at start-up and the end of a burning cycle, a very important measure is a reduction of the number of cycles.

Heavy Metals (Toxicity). Although not a Heavy Metal, the MEEUP classifies CO as a toxic agent, albeit –as an outdoor emission—with a very low weighting factor. Carbon monoxide is a pollutant that is readily absorbed in the body and can impair the oxygen-carrying capacity of the hemoglobin. Impairment of the body's hemoglobin results in less oxygen to the brain, heart, and tissues. Even short-term over exposure to carbon monoxide can be critical, or fatal, to people with heart and lung diseases. It may also cause headaches and dizziness in healthy people.

Particulate Matter (PM). This refers to 'soot' from oil-fired boilers. Emission limit values are mentioned in Directive 1999/30/EC, which indicate that the European legislator takes PM 10-emissions very serious indeed (see table 4). In fact, the emission limits on a weight basis are 4 times more stringent than the ones for NO_x.

PM emissions are primarily dependent on the grade of fuel fired in the boiler. Generally, PM levels from natural gas are significantly lower than those of oils. Distillate oils result in much lower particulate emissions than residual oils.

When burning heavy oils, particulate levels mainly depend on four fuel constituents: sulfur, ash, carbon residue, and asphalenes. These constituents exist in fuel oils, particularly residual oils, and have a major effect on particulate emissions. By knowing the fuel constituent levels, the particulate emissions for the oil can be estimated.

Methods of particulate control vary for different types and sizes of boilers. For utility boilers, electrostatic precipitators, scrubbers, and baghouses are commonly utilized. For industrial and commercial boilers, the most effective method is to utilize clean fuels. The emission levels of particulate matter can be lowered by switching from a residual to a distillate oil or by switching from a distillate oil to a natural gas. Additionally, through proper burner set-up, adjustment and maintenance, particulate emissions can be minimized, but not to the extent accomplished by switching fuels.

The above refers to emissions to air. To complete the picture it must be mentioned that in some regions of the EU there are strict regulations regarding the emissions to water, which –when using heating oil with a higher sulphur content—can apply to affluent of condensate to the sewer.

Taking the angle of their origin, the emissions from gas-and oil-fired boilers can be split into four groups:

Unavoidable products from the combustion reaction. As already explained in the previous chapter water vapour and carbon dioxide (CO_2) are the main combustion products from the reaction between a hydrocarbon and oxygen. The CO_2 production is completely linked with a) the specific fuel and b) the energy efficiency of combustion. Regarding the fuel the CO_2 emissions per MJ gas are 20-30% lower[78] than with oil. Regarding the efficiency, it depends very much on the design. At best the oil-fired boilers in the top-end of the market can keep up (but not surpass) the best gas-fired boilers.

Pollutants that are unavoidable because they are already contained in the fuel. This is the case with SO_x production from sulphur. In principle, without end-of-pipe measures, the sulphur emissions are independent of the design of the combustion process. If we use heavy fuel oil with 3% sulphur, this amount will also result from the combustion process. If we use low-sulphur (<50 ppm) gas heating oil the corresponding lower amount will result. The only design-measure that a boiler designer can take is to make sure that the boiler (also) works with low-sulphur oil, but it is the user —or the regulations on the sulphur content of heating oil in a particular country— that will determine the outcome.

[78] Eurogas mentions a figure of 24%, citing the International Gas Union. The MEEUP table shows even higher differences (>30%) for comparable boilers.

Emissions that are a consequence of incomplete combustion. Basically, these are all other carbon-containing compounds, besides CO_2: Carbon monoxide (CO), Methane (CH_4), hydrocarbons (C_xH_y) and soot (PM). The carbon in these compounds comes from the fuel and is an indicator of how much fuel was subject to incomplete combustion. The most well known cause of this is the lack of sufficient air/oxygen. But there may be other causes, such as the temperature of the fuel is too low to permit oxidation (combustion) to occur. It can occur as a result of flame impingement (flame in contact with metal) because parts of the flame are cooled—quenched—below the burn temperature of the fuel. For instance, on a gas range burner, flame impingement always occurs when a pot is on a burner. As the pot becomes hotter, the carbon monoxide production decreases because the flame is not cooled as much by the impingement. This makes measurement of carbon monoxide difficult; as impingement surfaces change temperature, the carbon monoxide emissions change. Quenching of a flame can also occur if air blows across a flame rapidly enough to cool it to below its burn temperature. A rule of thumb is that –in order to keep the CO-emissions low—the combustion temperature should be well above 900°C. Finally, the most obvious cause of non-CO_2 carbon emissions is during start- and stop of combustion, i.e. when unburned fuel remains in the combustion chamber. This causes of course a considerable amount of unburned fuel emissions (CH_4 or C_xH_y), but also gives peaks in CO-emissions as the circumstances at start-up (cold heat exchanger) are so favourable for CO-formation. As mentioned in chapter 2, 80-90% of the non-CO_2 carbon emissions occur not during steady-state but during start-up and stop.

Emissions that do not involve the fuel, but are chemical reactions between air molecules triggered by the specific combustion conditions. This relates to emissions of nitrogen oxides (NO_x), NO and NO_2, from the reaction between the oxygen and nitrogen molecules in the air. This occurs only when there is enough air around (excess air, e.g. air factor > 1,4), when the temperature is high enough (above 1200°C) and when there is enough time for the reaction to take place at this high temperature (the so-called 'residence time' should be long enough).

Basically the above is about all there is to tell about the amount of CO_2 and SO_x emissions (point 1 and 2). Once the fuel is chosen[79], the amount of SO_x and CO_2 emissions follow directly from the fuel input per functional unit.

Low NOx

The term low NO_x technology used in the industry has a broad range in terms of the NO_x emission level achieved. In some instances, an emission of 70 - 80 ppm at 0% O_2 on dry basis is regarded as "low". In other instances, it may be down to 10 - 15 ppm or less. In the EU the threshold level of <40 ppm (70 mg/kWh) seems the most appropriate, being used in the German Blue Angel labelling scheme and the Dutch 'Low- NO_x' label and it is the lowest class limit (class 5) in the European Standard prEN 267.

Conversions:
Europe: 1 ppm (at 3% O_2) = 1,83 mg/kWh = 0,508 mg/MJ = 0,508 ng/J.
US: 100 ppm (at 3% O_2) = 0,118 lb/MMBtU (1 lb= 0,4535 kg; 1 Btu= 1,0546 kJ) = 183 mg/kWh.
ppm (at 3% O_2) = (21-3)/(21 – O_2 actual) ppm actual.
1 ppm (at 3% O_2) = 18/21= 0,857 ppm (at 0% O2).

[79] And a minute amount is subtracted for unburned fuel (<1,5%, see Chapter 2)

What effect does NOx control technology ultimately have on a boiler's performance? Certain NOx controls can worsen boiler performance while other controls can appreciably improve performance. Aspects of the boiler performance that could be affected include turndown, capacity, efficiency, excess air, and CO emissions.

Failure to take into account all of the boiler operating parameters can lead to increased operating and maintenance costs, loss of efficiency, elevated CO levels, and shortening of the boiler's life.

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Table 108 Overview of environmental performance aspects of central heating boilers

Boiler	sub-division	NOx levels (mg/kWh GCV)			CO			OGC			dust/PM			seasonal efficiency		
		'average'	'good'	'BAT'	'average'	'good'	'BAT'	'average'	'good'	'BAT'	'average'	'good'	'BAT'	'average'	'good'	'BAT'
gas-fired	heating only	< 105	< 70	< 35												
	cogeneration	nd	< 120	nd												
oil-fired	heating only	<250	<120	< 70												
	cogeneration	nd	< 200	nd												
biomass (a)	manual DD (log)	109 mg/m3 69g/GJ (d) 150 mg/MJ			200 mg/m3 @13%O2		100	10 mg/m3 @13% O2		10	50 mg/m3 @13% O2		40	58% NCV	66% NCV (test 88%) and 450 kWh_e	test 90% + 108 kWh_e
	automatic (pellet)	69g/GJ (d) or			350 mg/m3 @13%O2		59	50 mg/m3 @13% O2		18	50 mg/m3 @13% O2		15	59% NCV	69% NCV (test 88%) and 540 kWh_e	test 93% + 67 kWh_e
heat pump (b)	electric															
	gas-fired		< 60 (c)													

1 mg/MJ = 0.278 mg/kWh
(a) no cogeneration biomass boiler identified, instead sub-division based on type of boiler
(b) no cogeneration heat pump boiler identified, instead sub-division based on energy input
(c) ROBUR "GAHP-A LT" gas-fired adsorption heat pump: NOx 25 ppm (class 5), CO 36 ppm
(d) From EN 303-5

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OGC is total organically bound carbon, ie. all carbon that exits in organic form in flue gases

	Light Fuel Oil EL	
CO	1 ppm = 1.110 mg/kWh 1 mg/m³ = 0.889 mg/kWh	1 mg/kWh = 0.900 ppm 1 mg/kWh = 1.125 mg/m³
NO_x	1 ppm = 1.822 mg/kWh 1 mg/m³ = 0.889 mg/kWh	1 mg/kWh = 0.549 ppm 1 mg/kWh = 1.125 mg/m³

	Natural Gas H (G20)	
CO	1 ppm = 1.074 mg/kWh 1 mg/m³ = 0.859 mg/kWh	1 mg/kWh = 0.931 ppm 1 mg/kWh = 1.164 mg/m³
NO_x	1 ppm = 1.759 mg/kWh 1 mg/m³ = 0.859 mg/kWh	1 mg/kWh = 0.569 ppm 1 mg/kWh = 1.164 mg/m³

Table 4-22 *Emissions factors (mg/MJ) for wood and other solid biofuels in stoves, small boilers and small commercial installations [De Wilde, 2006]*

Pollutants	Build environment	Stoves in household	Biolers in household < 50 kW_{th}	Boilers 50 kW_{th} – 1 MW_{th}	Biolers 1 MW_{th}- 50 MW_{th}	Small commercial installations
NOx	80	50	150	150	150	150
SO_2	20	10	50	50	30	40
NH_3	No data	No data	No data	No data	No data	No data
NMVOS	No data	No data	No data	No data	No data	No data
Dust	800	900	500	250	50	200
PM10	700	800	440	220	40	180
PM2,5	700	800	440	220	40	180

Annex XIII - Fossil fuel boilers life cycle data

Energy consumption of fossil fuel boilers

The space heating energy consumption can be calculated on the basis of the heating demand and the space heating efficiency, being either the 'net heating efficiency' (from the Lot 1 study) or the 'seasonal space heating efficiency' (from latest Commission proposals) including a correction for unavoidable system losses (distribution, stratification and fluctuation).

New sales energy consumption

Based on the 'net heating efficiency' of the boiler sales the average boiler consumes some 20.000 kWh/year (based on XL capacity class).

Table 109: Calculation of energy consumption of average new boiler per capacity class

Class	Indicative application	Minimum required output power	est. input power Base Case (incl. eff + oversize)	Heating demand	net heating efficiency	Energy consumption
		kW	kW	kWh/year	%	kWh/year primary
XXS	apartment new	3,6	10	2354	53	4422
XS	average new	5,1	14	3699	54	6873
S	apartment existing*	6,9	19	4850	52	9368
M	average existing	7,7	22	7480	54	13827
L	house existing	10,5	29	10515	55	19095
XL	new building (8 apartments)	30,6	60	20284	44	45965
XXL	existing building (8 ap.)	46,4	115	42195	45	93407
3XL	*high rise apt. (20 exist apt's)*	*117*	*250*	*106738*	*43*	*246159*
4XL	*3 high-rise apt. (60 exist. apt's)*	*350*	*750*	*320215*	*43*	*739894*

The energy consumption can be split up into fuel-related consumption and electricity consumption, as shown in the table below (note: electric energy is presented in primary kWh, to convert to electric kWh divide by 2.5).

Table 110: Energy consumption of central heating boilers

	XXS	XS	S	M	L	XL	XXL	3XL	4XL
net heat demand	2354	3699	4850	7480	10515	20284	42195	106738	320215
net heating efficiency	53%	54%	52%	54%	55%	44%	45%	43%	43%
prim.energy	4422	6873	9368	13827	19095	45965	93407	246159	739894
- as fuel	4100	6470	8814	13247	18490	43118	89492	236126	710017
- as electricity	322	403	555	580	605	2848	3915	10033	29877

Table 111: Share of energy consumption per size class (in % of total)

Size-Class	Pnom [kW]	Net heat load kWh/a	Base Case Net heating efficiency[1]	Energy consumption kWh/unit/a	Market share in number of boilers	Nr of units in stock *mln.	Total energy consumption per class [TWh/a]	Share of total energy consumption
XXS	10	2.350	53,1%	4.422	2,3%	2,4	10.679	0,4%
XS	14	3.700	54,0%	6.852	7,6%	8,0	54.678	2,2%
S	19	4.850	51,8%	9.368	15,2%	16,0	149.513	5,9%
M	22	7.480	54,1%	13.827	51,5%	54,1	747.695	29,7%
L	29	10.515	55,1%	19.095	9,9%	10,4	198.493	7,9%
						90,8	1.161.058	46,1%
XL	60	20.284	44,1%	45.965	9,9%	10,4	477.806	19,0%
XXL	115	42.195	45,2%	93.407	2,6%	2,7	255.001	10,1%
3XL	250	106.738	42,8%	249.392	0,6%	0,6	157.117	6,2%
4XL	750	320.215	43,3%	739.894	0,6%	0,6	466.133	18,5%
						14,4	1.356.057	53,9%
					100%	105	2.517.115	100%

*1 . Calculated with Ecoboiler Integrated model version 5a

Stock energy consumption

In the central heating stock model these effects are calculated throughout the whole period (1990-2020) in the following ways:

- The load effect (more comfort, more floor area, more insulation) is controlled by a load factor ("LoadCor"), which is set at 1,8% annually. The pivot-point for this load factor is the "net load" value for the base year 2005 [see worksheet STOCK 1YR in model].
- The efficiency effect is given in Table 3.2, which is equivalent to worksheet STOCK 5YR. These values are used as anchor points for the respective years in the STOCK 1YR worksheet. The values are based on the base year 2005 , where it is derived from the Base Case values as shown in Table 3.1 [from worksheet BASE CASE in spread sheet] and estimates for pre-2005 and post-2005 as shown in Table 3.2. Especially for post-2005 the BRG prediction of 48% (low-cost) condensing boilers in 2010 was taken into account.
- The growth effect of increasing number of households and ownership comes from the unit sales projections by BRG Consult in Task 2. But we did calibrate the "ProductLife" parameter and individual sales slightly to match sales and park data. Graph 3.1 gives the unit sales projections (from Task 2).

Table 112: Calculation of annual primary energy consumption Base Case (avg. EU-25, sold in 2005)

Sales EU-25 in '000 units in the year 2005											
	XXS	XS	S	M	L	XL	XXL	3XL	4XL	Total	
Boiler sales	150	500	1000	3400	650	650	170	40	40	6600	*in '000 units*
Net load per unit	*2350*	*3700*	*4850*	*7480*	*10515*	*20000*	*42195*	*106738*	*320215*		*kWh/year.unit*
Total net load of sales										Total	average
Total	353	1.850	4.850	25.432	6.835	13.000	7.173	4.270	12.809	76.571	11602

GWh/a											kWh/year
Efficiency in % (primary energy, Gross Calorific Value)											
in %	XXS	XS	S	M	L	XL	XXL	3XL	4XL	weight avg.*	
Boiler space heating	53%	54%	52%	54%	55%	44%	45%	43%	43%	48%	
Energy consumption in GWh/a (net load efficiency)											
Sales	XXS	XS	S	M	L	XL	XXL	3XL	4XL	Total	average per boiler
Boiler space heating	665	3.426	9.327	47.096	12.427	30.233	15.940	9.929	31.240	160.284	24.171 kWh/year
Total	665	3.426	9.327	47.096	12.427	30.233	15.940	9.929	31.240	160.284	
Efficiency aggreg.	53%	54%	52%	54%	55%	44%	45%	43%	43%	48%	
**=weighted for total net load in GWh/a, so taking into account both sales and load*											
Energy consumption at LLCC targets (in MWh/a)											
target	76%	76%	76%	76%	76%	76%	96%	96%	96%	81%	
energy in GWh/a	464	2.434	6.382	33.463	8.993	17.105	7.472	4.447	13.342	94.103	

Product life cycle

The product life cycle covers all environmental aspects of central heating boilers over their whole product life, from production, distribution, use to end-of-life.

Figure 30 Generic product life cycle phases
(picture: http://www.nist.gov)

The purpose of the life cycle model will be to differentiate between various central heating products. Therefore the product specific inputs relate to new products ('new sales').

The life cycle model can in principle also be used to describe the environmental impacts of the stock of heating systems: In this case an important parameter is the energy consumption of the existing stock of appliances. As production inputs the average existing appliance should be used (between 7 and 8 years old), but given that the appliance material composition hasn't changed much over the last eight years, it is possible to use the same inputs as for new sales products.

Production

The environmental impact during the production phase of central heating boilers is described by the 'bill-of-materials' (aka BOM): This bill lists all the materials used to manufacturer a boiler in order to place it on the market.

The Lot 1 study describes these materials, using material categories as defined by the Ecoreport life cycle analysis tool.

Table 113: Bills of Materials for Base Case (avg. new boiler) categories

Row	Mat/process		1	2	3	4	5	6	7	8	9
nr		unit	**XXS**	**XS**	**S**	**M**	**L**	**XL**	**XXL**	***3XL***	***4XL***
4	PP (Plastics)	g	3.650	3.650	3.650	3.650	3.650	3.200	3.564	*10.463*	*32.195*
5	PS (Misc.)	g	350	350	350	350	350	100	84	*247*	*760*
10	ABS (Plastics ABS)	g	0	0	0	0	0	0	0	*0*	*0*
15	Rigid PUR	g	800	800	800	800	800	800	2.844	*8.350*	*25.693*
21	St sheet galv.	g	19.726	19.726	19.726	28.180	32.407	50.754	69.100	*202.868*	*624.224*
23	Cast iron	g	1.170	1.170	1.170	1.170	1.170	71.465	141.760	*416.188*	*1.280.579*
25	Stainless 18/8 coil	g	1.862	1.862	1.862	2.660	3.059	1.728	1.728	*5.073*	*15.610*
27	Al diecast	g	1.379	1.379	1.379	1.970	2.265	0	0	*0*	*0*
30	Cu tube/sheet	g	2.982	2.982	2.982	4.260	4.899	700	888	*2.607*	*8.022*
31	CuZn38 cast	g	1.650	1.650	1.650	1.650	1.650	500	564	*1.656*	*5.096*
98	avg. controller board	g	690	690	690	690	690	750	876	*1.752*	*5.256*
54	glass	9	0	0	0	0	0	0	0	*0*	*0*
		kg	**34,3**	**34,3**	**34,3**	**45,4**	**50,9**	**123.0**	**221,4**	*650,0*	*2000,0*

Linked to the materials used to manufacture the boiler are processing inputs: these are processes like metal casting, metal shaping and an assessment of scrap metal. Also the impacts of producing a certain amount of electronics are included.

Table 114: Manufacturing inputs for Base Cases

Row	Mat/process		1	2	3	4	5	6	7	8	9
nr		unit	XXS	XS	S	M	L	XL	XXL	*3XL*	*4XL*
34	foundries Fe/Cu/Zn	g	2820	2820	2820	2820	2820	71965	142324	*417844*	*1285675*
35	foundries Al	g	1379	1379	1379	1970	2265	0	0	*0*	*0*
36	sheet metal plant	g	19726	19726	19726	28180	32407	50754	69100	*202868*	*624224*
37	sheet metal scrap	g	4932	4932	4932	7045	8102	12688	17275	*50717*	*156056*
53	PWB assembly	g	690	690	690	690	690	750	876	*1.752*	*5.256*
At a last minute request size-classes 3XL and 4XL were added; figures are indicative.											

For the calculation of impacts of improvement options, also the bill-of-materials for solar collectors and heat pumps were described.

Table 115: Manufacturing inputs for Heat pumps and solar systems

	Solar systems (per m2)			Heat pumps (correct for power pNom)			
	glazed	unglazed	evac-tube	Air source HP		Ground source HP	
Mat.process	1m2	1m2	1m2	80L / 300W	120L / 300W	7kW	>20kW
1-LDPE		5183		1186	1279		
2-HDPE							
3-LLDPE							
4-PP						3920	7840
5-PS							
6-EPS	208	208	208				
8-PVC	42	42	42	158	209		
10-ABS	200	200	713				
11-PA 6							
11-PA 6							
12-PC							
14-Epoxy							
15-Rigid PUR	1950		417	2615	2404	5880	11760
16-flex PUR							
19-Aramid fibre							
21-St sheet galv.	329	329	329	42728	50271	154000	308000
22-St tube/profile							
23-cast iron	429	429	429				
24-Ferrite							
25-Stainless 18/8 coil	71	71	71	124	165		
26-AL sheet extr.	2604			360	479		
27-Al diecast	96	96	96				
29-Cu wire	221	221	221				
30-Cu tube/sheet	9896	4375	12063	2560	4686	26040	52080
31-CuZn38 cast	654	654	1279	900	1197	28000	56000
39-powder coating				1305	1657		
42-LCD per m2 scrn							
44-big caps & coils							
45-slots / ext. ports							
46-IC's avg.,5%Si,Au							
47-IC's avg., 1% Si							
48-SMD/ LED's avg.							
49-PWB ½ lay 3.75kg/m2							
52-Solder SnAg4Cu0.5							
98-controller board	113	113	113	141	51	15120	30240
52 - glass	6779		7458				

56-Cardboard							
57-Office paper							
not specified	38	38	38	2387	2545	47040	94080
TOTAL	23629	11958	23475	54463	64943	280000	560000

For cogeneration no bill-of-materials could be found: The technology is still in very early development stage and manufacturers do not want to disclose information on the actual product design.

One of the first micro-CHP solutions to enter the market is the Remeha Evita. This boiler has comparable central heating capacity as the average M-class boiler, however weighs approximately 85 kg more (130 kg versus 45 kg). The extra material will be stainless steel (for the Stirling engine and extra piping), construction steel (for the suspension/frame) and the electronics section will be larger.

Therefore the production-related emissions will be around 2.5 or 3 times as much as those of an average M-class boiler. The energy-related emissions (after correction for electricity production) will be lower than average.

Distribution (and storage)

The EcoReport estimates transportation and warehouse impacts based on product volume. Other than that, there are two fixed impacts (multiplier=1)

Table 116: Distribution inputs for Base Cases

Row	Mat/process		1	2	3	4	5	6	7	*8*	*9*
nr		unit	XXS	XS	S	M	L	XL	XXL	*3XL*	*4XL*
60	per m³ appliances	m³	0,08	0,1	0,12	0,15	0,15	0,5	1	*2*	*6*
61	per product	#	1	1	1	1	1	1	1	*1*	*1*
63	per m³ installed product	m³	0,08	0,1	0,12	0,15	0,15	0,5	1	*2*	*6*
At a last minute request size-classes 3XL and 4XL were added; figures are indicative.											

Use phase

This phase is extensively discussed in the preceding sections.

The use phase has shown to be the most significant phase in the life cycle of heating products such as central heating. The inputs in this phase are energy for heating, but also some consumables such as spare parts (for product servicing and maintenance). These spare parts are by default included in the calculation of the material inputs during the production phase (default value of 1% of total material inputs for manufacturing - no reason has been found to change this default value).

Servicing also requires inputs related to transportation (the visits from the service mechanic/installer). For the latter Lot 1 assumes a total travelled distance of 100 km of the product life of 17 years.

But the most important aspect is of course the energy consumption of the central heating-boiler. This energy consumption is determined by assumptions regarding the energy demand (“how much heat is needed?”) and energy conversion (“how well does the central heating system turn energy -like oil or gas - into heat required?”).

The lot 1 study applied the following methodology - Note that the methodology was developed to allow comparison of products on energy efficiency, and not to describe the actual energy consumption of each individual building in the EU27

The basis for the design features is the ECOBOILER Integrated Model, where we have defined design-settings for each category/ load profile that come as close as possible to the technical market segmentation as found in Chapter 3 of the Task 2 report.

An overview of these settings for XXS to 4XL boiler categories is given in the Table on the next page. Please note that the Base Case assessment relates to new boilers.

The variation of design features is limited between the categories, which is fairly close to real-life. Basically, the differences can be found between typical individual boilers (XXS to L) on one hand and collective/commercial boilers (XL, XXL) on the other hand. We therefore anticipate that in Task 6 we will concentrate on just two categories—M and XXL—and extrapolate these results for the other categories.

The M and XXL Base Cases use the following settings:

- Inputs power as indicated. On average 22 kW for individual boilers (M), 100 kW for the collective boiler (XXL),
- Combustion air intake is room-sealed (type C)
- Turndown ratio: 33% (smallest power as a fraction of nominal)
- Steady State Efficiencies on Gross Calorific Value: 80/80/80/80% for 60/80°C regime at full power, 30/50 regime at full power, 60/80 regime at minimum power, 30/50 regime at minimum power. The collective boiler starts from 76% steady state efficiency.
- Standby heat energy losses: 1% of Pnom.
- No pilot flame (electronic ignition)
- Pump 45 W, fan 9-40 W each, CPU power 10/12 W for standby/"on", power of gas valve etc. 10/10 W for standby/"on". No night setback for pump. Pump stops 10 minutes after "burner-off". Prepurge time 25 seconds.
- Consequently the electricity consumption in standby (in W electric) is 20 W, at maximum (nominal) load 112 W and at minimum load 110 W. The primary energy factor for power plant losses and distribution is 2,5 (1 kWh electric= 2,5 kWh primary).
- On/off room thermostat for individual boilers, with timer-control (regime 19/18/21 for Zone 1/2/3) but without electronic optimiser (reheat power 100%). Fixed boiler thermostat (70°C average) for collective boilers.
- For individual boilers: Valve controllers: TRVs 2K (thermostatic radiator valves with a 2K bandwidth and a 20 minute delay) in bed- and bathroom. No valves in reference room (living room and kitchen), because this is controlled by the room thermostat. The system is not hydraulically not optimised and has a bypass-mix of 30% (mix between return and feed flows).
- For collective boilers: TRVs 2K in all rooms.
- Pump set at fixed flow 1000 ltrs./h.
- The air-fuel mixer of the heat generator is pneumatic with an air factor of 1,4 . Consequently, the fuel loss factor is set at 1,5% (at 14.000 cycles equivalent) and the corrected dewpoint for the default fuel (gas) is set at 50°C.

The boiler mass, water content, envelope volume will be indicated per Base Case. An average value is 60 kg boiler mass and an average water content of 4 ltr. for an individual boiler. The envelope will then be smaller than 0,15 m³. The default noise level is 45 dBA.

Table 117: Losses for an average central heating system (M-class capacity, base case efficiency)

	per item		grouped			grouped and excluding system losses	
	kWh/year	% of total		kWh/year	% of total	kWh/year	% of total
Tset	6056	44%	net heating demand	7480	54%	7480	68%
Tmass	1106	8%					
Tintrans	318	2%					
Tfluct losses (controls)	992	7%	'system' losses	2752	20%	0	0%
Tstrat losses (emitters)	629	5%					
Distr.losses	1131	8%					
Steady state losses	2633	19%	'boiler' losses	3595	26%	3595	32%
Start/stop losses	44	0%					
Standby heat losses	338	2%					
Electricity cons.	580	4%					
TOTAL	13827	100%		13827	100%	10515	

Table 118: Summary Use Phase inputs

Row	Mat/process		1	2	3	4	5	6	7	8	9
nr		unit	XXS	XS	S	M	L	XL	XXL	3XL	4XL
65	Electricity	kWhe/a	129	161	222	232	242	1.139	1.566	4.013	11.950
	Fuel	kWh/a	4.422	6.873	9.368	13.827	19.095	45.965	93.407	246.159	739.894
86	Mini-van diesel	km	100	100	100	100	100	100	100	100	100

Table 119: Annual Energy Consumption Base Cases

DESIGN INPUT BASECASE	1	2	3	4	5	6	7	8	9
INPUTS CH									
CH-power class	1 -XXS (XX Small)	2 -XS (Xtra Small)	3 -S (Small)	4 -M (Medium)	5 -L (Large)	6 -XL (Xtra Large)	7 -XXL (XX Large)	8 -3XL	9 -4XL
	6 -apartment new	*2 -average new*	*5 -apartment existing*	*1 -average existing*	*3 -house existing*	*8 -new building (8 ap)*	*7 -exist. building (8 ap)*	*9 -high-rise avg. (20 ap)*	*10 -block avg. (60 ap)*

MAIN ENERGY OUTPUTS	1	2	3	4	5	6	7	8	9
Net heating efficiency	53%	54%	52%	54%	55%	44%	45%	43%	43%
Primary energy consumption	4422 kWh/a	6873 kWh/a	9368 kWh/a	13827 kWh/a	19095 kWh/a	45965 kWh/a	93407 kWh/a	246159 kWh/a	739894 kWh/a
-of which fuel (primary kWh GCV)	4100 kWh/a	6470 kWh/a	8814 kWh/a	13247 kWh/a	18490 kWh/a	43118 kWh/a	89492 kWh/a	236126 kWh/a	710017 kWh/a
-of which electricity (primary kWh)	322 kWh/a	403 kWh/a	555 kWh/a	580 kWh/a	605 kWh/a	2.848 kWh/a	3.915 kWh/a	10.033 kWh/a	29.877 kWh/a

ANNUAL SPACE HEAT ENERGY breakdown

		1		2		3		4		5		6		7		8		9	
TOTAL	kWh/a	4422	100%	6873	100%	9368	100%	13827	100%	19095	100%	45965	100%	93407	100%	246159	100%	739894	100%
Tset	kWh/a	1653	37%	2680	39%	3799	41%	6056	44%	8660	45%	19949	43%	41924	45%	105759	43%	317277	43%
Tmass	kWh/a	423	10%	681	10%	788	8%	1106	8%	1454	8%	335	1%	271	0%	979	0%	2938	0%
Tintrans	kWh/a	277	6%	339	5%	263	3%	318	2%	401	2%	0	0%	0	0%	0	0%	0	0%
Tfluct (cntrl)	kWh/a	383	9%	604	9%	642	7%	992	7%	1359	7%	3109	7%	5262	6%	13968	6%	41905	6%
Tstrat(emit)	kWh/a	241	5%	367	5%	415	4%	629	5%	918	5%	2507	5%	3888	4%	10188	4%	30565	4%
Distr. loss	kWh/a	394	9%	601	9%	846	9%	1131	8%	1474	8%	6514	14%	14289	15%	43148	18%	129442	17%
Steady st.	kWh/a	628	14%	1009	15%	1752	19%	2633	19%	3674	19%	8450	18%	17584	19%	46393	19%	139556	19%
Start/stop	kWh/a	21	0%	32	0%	43	0%	44	0%	51	0%	216	0%	604	1%	1512	1%	4543	1%
Stby heat	kWh/a	79	2%	157	2%	265	3%	338	2%	499	3%	2037	4%	5669	6%	14179	6%	43791	6%
Electric	kWh/a	322	7%	403	6%	555	6%	580	4%	605	3%	2848	6%	3915	4%	10033	4%	29877	4%
Credit solar	kWh/a	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Credit HP	kWh/a	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

		1	2	3	4	5	6	7	8	9
Net heating efficiency	%	53%	54%	52%	54%	55%	44%	45%	43%	43%
gross heat load	kWh/a	2.965	4.508	6.052	8.929	12.292	23.766	48.638	124.389	371.657
net heat load	kWh/a	2.354	3.699	4.850	7.480	10.515	20.284	42.195	106.738	320.215
net load per unit floor area	kWh/m2	56	68	141	160	180	73	175	145	146
CH syst. Efficiency	%	61%	62%	60%	62%	63%	51%	52%	50%	50%

Table 120: Calculation of impacts of options - Option 7-8 are heat pumps, option 9 is solar

DESIGN OPTIONS	1 BaseCase	2	3	4	5	6	7	8	9
INPUTS CH									
CH-power class	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**	**4 -M (Medium)**
	1 -average existing	*1 -average existing*	*1 -average existing*	*1 -average existing*	*1 -average existing*	*1 -average existing*	*1 -average existing*	*1 -average existing*	*1 -average existing*
boiler characteristics									
power input in kW*	22 kW	22 kW	22 kW	22 kW	22 kW	22 kW	22 kW	22 kW	22 kW
turndown ratio	33%	33%	33%	33%	20%	10%	10%	10%	10%
standby heat loss (% of Pnom)	1,0%	1,0%	1,0%	1,0%	0,5%	0,5%	0,5%	0,5%	0,5%
steady st. efficiency %	5 -80/80/80/80	2 -87/87/95/95	1 -89/89/97/97	1 -89/89/97/97	1 -89/89/97/97	9 -ideal 96/96/97/97	9 -ideal 96/96/97/97	9 -ideal 96/96/97/97	9 -ideal 96/96/97/97
fuel (dewpoint)	1-gas	1-gas	1-gas	1-gas	1-gas	1-gas	1-gas	1-gas	1-gas
air-fuel mix control	2 -pneumatic	2 -pneumatic	2 -pneumatic	2 -pneumatic	2 -pneumatic	3 -ionisation	3 -ionisation	3 -ionisation	3 -ionisation
circ. pump power	6 -95W	6 -95W	6 -95W	3 -25..(45)..65 W	3 -25..(45)..65 W	1 -5..(15)..25W + sb	1 -5..(15)..25W + sb	1 -5..(15)..25W + sb	1 -5..(15)..25W + sb
fan power	3 -P=9..40W	3 -P=9..40W	3 -P=9..40W	3 -P=9..40W	1 -P=3..18W	1 -P=3..18W	1 -P=3..18W	1 -P=3..18W	1 -P=3..18W
CPU power sb/on	4 -P=10/12W	4 -P=10/12W	4 -P=10/12W	4 -P=10/12W	1 -P=2/3W	1 -P=2/3W	1 -P=2/3W	1 -P=2/3W	1 -P=2/3W
controls power sb/on	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W	1 -P=0/10W
comb. air intake	1 -room sealed	1 -room sealed	1 -room sealed	1 -room sealed	1 -room sealed	1 -room sealed	1 -room sealed	1 -room sealed	1 -room sealed
boiler mass (empty), kg	45 kg	45 kg	45 kg	45 kg	45 kg	45 kg	45 kg	45 kg	45 kg
water content in kg	4,0 kg	4,0 kg	4,0 kg	4,0 kg	4,0 kg	4,0 kg	4,0 kg	4,0 kg	4,0 kg
envelope volume in m3	0,15 m3	0,15 m3	0,15 m3	0,15 m3	0,15 m3	0,15 m3	0,15 m3	0,15 m3	0,15 m3
noise level in dB-A	43 dB-A	43 dB-A	43 dB-A	43 dB-A	43 dB-A	43 dB-A	43 dB-A	43 dB-A	43 dB-A
controllers									
auto-timer control	yes	yes	yes	yes	yes	yes	yes	yes	yes
valve control	2 -RTV 2K	2 -RTV 2K	2 -RTV 2K	2 -RTV 2K	3 -RTV 1K	3 -RTV 1K	3 -RTV 1K	3 -RTV 1K	3 -RTV 1K
boiler temp control	6 -on/off RT	6 -on/off RT	7 -modulating RT	7 -modulating RT	7 -modulating RT	7 -modulating RT	7 -modulating RT	7 -modulating RT	7 -modulating RT
electronic optimiser	no	no	yes	yes	yes	yes	yes	yes	yes
autoset weather control	N/A	N/A	no	N/A	N/A	N/A	no	no	no
solar (for combi only)									
collector type	N/A	1 -glazed	3 -vacutube	3 -vacutube	3 -vacutube	3 -vacutube	3 -vacutube	3 -vacutube	3 -vacutube
collector surface m2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,0
tank position	N/A	1 -indoors	1 -indoors	1 -indoors	1 -indoors	1 -indoors	1 -indoors	1 -indoors	1 -indoors
CH-fraction served	0%	100%	0%	0%	0%	0%	0%	0%	100%
El. back-up heater CH?	no	no	no	no	no	no	no	no	no
heat pump (HP)									
Reference type	1 -El. brine/ water 0/5	3 -El. air/ water 7/5(	3 -El. air/ water 7/50	3 -El. air/ water 7/5(	3 -El. air/ water 7/5(	3 -El. air/ water 7/50	3 -El. air/ water 7/50	1 -El. brine/ water 0/50	2 -El. water/ water 10/5(
Power nominal in kW	0,0 kW	0,0 kW	0,0 kW	0,0 kW	0,0 kW	0,0 kW	2,0 kW	2,0 kW	0,0 kW
COP nominal 0/50	0,00	0,00	0,00	2,50	0,00	3,50	2,50	3,10	3,80
Ratio CH : DHW	100%	80%	80%	80%	80%	80%	80%	80%	80%
CH-fraction served	100%	0%	100%	100%	100%	50%	100%	100%	0%
El. back-up heater CH?	no	no	no	no	no	no	no	no	no
MAIN ENERGY OUTPUTS									
Net heating efficiency	54%	61%	69%	74%	78%	82%	103%	136%	100%
Primary energy consumption	13827 kWh/a	12352 kWh/a	10987 kWh/a	10300 kWh/a	9735 kWh/a	9251 kWh/a	7368 kWh/a	5591 kWh/a	7642 kWh/a
-of which fuel (primary kWh GCV)	13247 kWh/a	11776 kWh/a	9890 kWh/a	9890 kWh/a	9454 kWh/a	9166 kWh/a	2154 kWh/a	1397 kWh/a	7520 kWh/a
-of which electricity (primary kWh)	580 kWh/a	576 kWh/a	1.097 kWh/a	410 kWh/a	281 kWh/a	85 kWh/a	5.214 kWh/a	4.195 kWh/a	123 kWh/a
MAIN LCC OUTPUTS									
Purchase (incl. installation)	€ 2.724	€ 3.194	€ 3.383	€ 3.480	€ 3.737	€ 4.123	€ 7.173	€ 9.323	€ 7.723
Lifetime Running costs (NPV)	€ 16.025	€ 14.584	€ 13.185	€ 12.597	€ 12.060	€ 11.609	€ 9.150	€ 7.536	€ 10.032
Life Cycle Costs LCC	€ 18.750	€ 17.777	€ 16.569	€ 16.076	€ 15.797	€ 15.732	€ 16.323	€ 16.859	€ 17.755
Simple Payback Period PBB	reference yrs	6,6 yrs	5,0 yrs	4,4 yrs	5,1 yrs	6,2 yrs	17,4 yrs	18,7 yrs	16,5 yrs

End-of-life

The mass of central heating boilers varies from some 35 kg for small capacity boilers to over several hundreds of kg for large capacity boilers (up to 400 kW). The majority of this mass, some 88% for an M-size boiler, is made up of metals with significant economic value, especially stainless steel and copper alloys.

Therefore most, if not all, boilers enter the scrap metal recycling processes after their useful life. Modern day scrap metal recycling allows recovery of over 95% of metals present in the boiler. The plastics fraction is in most cases sent to energy recovery (incineration with energy recovery). The electronics ore usually scrapped separately (these also contain small but valuable shares of precious metals).

For the End-of-Life in the product Life Cycle the EcoReport default scenario is used (please note that most new products are offered for end-of-life treatment some 15 tot 20 years from now - the current recovery/recycling rates used below, will have increased by then):

Table 121: Default EOL scenario

Landfill (not recovered)	**5% of total weight * [row 89]**
Incinerated	(plastics & PWB fraction -(re-used + recycled)) * [row 91]
Cost of plastics recycling	(re-used + recycled fraction) * [row 92]
Plastics: Re-used (closed loop)	1% of plastics fraction
Plastics: Materials recycling	9% of plastics fraction
Plastics: Thermal recycling	90% of plastics fraction
Electronics easy to assembly	YES: electronics fraction & manuf. [=row 98] * 20%
Metals & Misc.	95% recycled (value already incorporated)

As a consequence, the following inputs are used for the EOL:

Table 122: EOL Inputs Base Cases

Row	**Mat/process**		1	2	3	4	5	6	7	8	9
nr		unit	XXS	XS	S	M	L	XL	XXL	*3XL*	*4XL*
93	Metals recycled	g	27331	27331	27331	37896	43178	118889	203338	*596972*	*1836854*
94	Plastics, Thermal recycling: credit is 75% of feedstock energy & GWP of plastics used (displaces oil)										
95					Re-used plastics credits						
4	PP	g	35	35	35	35	35	30	34	*100*	*309*
5	PS	g	3	3	3	3	3	1	1	*2*	*7*
15	PUR	g	8	8	8	8	8	8	27	*80*	*246*
96	Plastics, Recycling: credit is 27 MJ (displaces wood) + 50% of feedstock energy & GWP of plastics (less chance heat recovery)										
4	PP	g	312	312	312	312	312	274	305	*894*	*2753*
5	PS	g	30	30	30	30	30	9	7	*21*	*65*
15	PUR	g	68	68	68	68	68	68	243	*714*	*2197*
97	Electronics: if designed for easy separate shredding credit is 20% of production impact components and materials										
98		g	131	131	131	131	131	143	166	*332*	*998*

	Default EOL scenario				Materials balance EOL						
	disposal	g	6145	6145	6145	6701	6979	10362	17037	*50885*	*156571*
	recyc/re-use	g	27918	27918	27918	38483	43765	119421	204121	*599115*	*1843429*
	total	g	34062	34062	34062	45183	50743	129783	221158	*650000*	*2000000*

Life cycle impacts

Based on the assumptions and calculations presented in the previous sections the following calculations of total life cycle impacted were calculated.

Table 123: Environmental impacts Base Cases

BASECASES		1		2		3		4		5		6		7		8		9	
		1 -XXS (XX Small)		2 -XS (Xtra Small)		3 -S (Small)		4 -M (Medium)		5 -L (Large)		6 -XL (Xtra Large)		7 -XXL (XX Large)		8 -3XL		9 -4XL	
ENVIRONMENTAL IMPACT PER UNIT OVER LIFE																			
MATERIALS		**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE	**TOTAL**	USE
TOTAL	kg	**34,1**		**34,1**		**34,1**		**45,2**		**50,7**		**129,8**		**221,2**		**649,4**		**1997,9**	
of which																			
Disposal	kg	**6,1**		**6,1**		**6,1**		**6,7**		**7,0**		**10,4**		**17,0**		**49,6**		**152,6**	
Recycled	kg	**27,9**		**27,9**		**27,9**		**38,5**		**43,8**		**119,4**		**204,1**		**599,8**		**1845,3**	
OTHER RESOURCES																			
Total Energy (GER)	GJ	**269,4**	266,7	**416,0**	413,3	**566,0**	563,3	**831,8**	828,4	**1145,3**	1141,6	**2832,8**	2827,2	**5689,3**	5680,7	**14843,3**	14819,8	**46177,2**	46105,5
of which, electric(in primary)	GJ	**23,6**	23,0	**29,4**	28,8	**40,2**	39,6	**42,2**	41,4	**44,0**	43,2	**204,5**	203,3	**281,1**	279,5	**720,5**	716,3	**2145,8**	2133,2
Water (process)	m3	**2,0**	1,5	**2,4**	1,9	**3,1**	2,6	**3,3**	2,8	**3,4**	2,9	**14,1**	13,6	**19,4**	18,6	**49,5**	47,8	**147,6**	142,2
Water (cooling)	m3	**61,7**	61,3	**77,1**	76,7	**106,0**	105,6	**110,9**	110,4	**115,7**	115,2	**543,0**	542,2	**746,6**	745,5	**1913,6**	1910,3	**5698,9**	5688,6
Waste, non-haz./ landfill	kg	**5,3**	0,5	**5,5**	0,7	**5,7**	0,9	**5,8**	1,0	**5,8**	1,0	**9,0**	4,7	**12,9**	6,4	**34,6**	16,5	**104,8**	49,2
Waste, hazardous/ incinerated	kg	**98,0**	26,7	**104,7**	33,3	**117,3**	45,9	**146,9**	48,0	**162,7**	50,1	**369,1**	235,8	**521,2**	324,1	**1407,6**	830,6	**4248,3**	2473,3
EMISSIONS TO AIR																			
GHG in GWP100	tCO2	**15,1**	14,9	**23,4**	23,2	**31,8**	31,6	**47,0**	46,8	**64,9**	64,6	**176,0**	175,6	**344,4**	343,7	**859,7**	857,9	**3095,7**	3090,2
AP Acidification	kgSOx	**12,4**	11,4	**17,1**	16,0	**23,0**	22,0	**29,6**	28,3	**37,2**	35,8	**181,4**	179,9	**289,2**	286,9	**593,3**	587,2	**3527,8**	3508,9
VOC Volatile Organic Comp.	kg	**0,2**	0,2	**0,3**	0,3	**0,4**	0,4	**0,6**	0,6	**0,8**	0,8	**2,6**	2,6	**4,9**	4,8	**11,5**	11,4	**49,1**	48,6
POP Persist.Organic Poll.	mg i-Teq	**0,9**	0,2	**0,9**	0,2	**1,0**	0,3	**1,3**	0,3	**1,4**	0,3	**3,3**	1,3	**4,8**	1,8	**13,4**	4,7	**40,8**	14,0
HMa Heavy Metals	mg Ni	**1,3**	0,4	**1,4**	0,5	**1,6**	0,7	**1,8**	0,8	**2,0**	0,8	**4,7**	3,5	**6,5**	4,8	**17,2**	12,3	**51,6**	36,6
PAHs	mg	**0,2**	0,1	**0,3**	0,1	**0,3**	0,1	**0,3**	0,2	**0,3**	0,2	**0,6**	0,5	**0,9**	0,7	**2,1**	1,8	**6,2**	5,4
PM Particulate Matter	kg	**2,1**	1,1	**2,2**	1,2	**2,4**	1,3	**2,7**	1,4	**2,9**	1,5	**8,0**	4,2	**13,3**	6,1	**29,6**	11,7	**117,3**	62,7
EMISSIONS TO WATER																			
HMw Heavy Metals	g Hg/20	**0,7**	0,1	**0,8**	0,2	**0,8**	0,3	**1,0**	0,3	**1,1**	0,3	**2,0**	1,3	**2,7**	1,8	**7,0**	4,6	**21,1**	13,8
EP Eutrophication	g PO4	**12,4**	0,7	**12,6**	0,9	**12,9**	1,2	**15,7**	1,3	**17,1**	1,3	**23,2**	6,3	**31,5**	8,6	**85,5**	22,0	**260,3**	65,6

In the table on the previous page the use-phase impacts have been singled-out to show their relative importance by impact category.

Annex XIV - High efficiency CHP

The CHP Directive introduced the concept of high efficiency CHP, where the combined generation of heat and power shows an overall higher efficiency than separate generation. Whether this occurs depends on the share of electricity production. Average nominal efficiencies of CHP systems (above micro) are between 75% to 85% (best available is approximately 90-95%). Depending on the type of power generator the electricity production efficiency may be 10-25%. The rest of the 90% GCV concerns the heat generation with an efficiency of 65-80%.

Separate production has a nominal power generation efficiency of 40% (GCV) and a heat generation efficiency of maximum 99% (GCV) for the best condensing boilers or close to 140% for good heat pumps. When comparing separate to combined heat and power generation, the need for a high electricity share becomes apparent, as presented in the figure below where a 10% electricity share does not lead to significant savings. A 25% electricity share does lead to savings. An 15% electricity share does not lead to savings when compared to separate production with a good heat pump.

In the table below the basis is an influx of 100 'units' of energy to an imaginary cogeneration boiler, calculatiing the outputs and then matching these outputs with outputs of separate generation and calculating back to its energy inputs.

Total energy in 'CHP'	**nominal efficiency GCV**	**energy form**	**output**	**separate production**	**nominal efficiency GCV**	**Energy input needed to match output**	**Total energy in 'separate'**
Average CHP				cond. Boiler / el.grid			
100	80%	as heat	70	heat	95%	74	99
		as electricity	10	power	40%	25	
very good CHP				cond. Boiler / el.grid			
100	95%	as heat	70	heat	95%	74	137
		as electricity	25	power	40%	62.5	
Good CHP				heat pump / el.grid			
100	90%	as heat	75	heat	140%	54	92
		as electricity	15	power	40%	37.5	

Table 1: TEWI Limits

(the second value - i.e. the value in brackets- will be binding from 1 January 2008)

Type of heat

pump

Thermal

output [kW]

TEWI value

(flow temperature 35°C)

[kg CO2]

TEWI value

(flow temperature 45°C)

[kg CO2]

Water-to-Water 0 - 20 35,000 (32,500) 37,500 (35,000)

> 20 70,000 (65,000) 75,000 (70,000)

Brine-to-Water 0 - 20 42,000 (39,000) 45,000 (42,000)

> 20 84,000 (78,000) 90,000 (84,000)

Air-to-Water 0 - 20 51,500 (48,000) 55,000 (51,500)

> 20 103,000 (96,000) 110,000 (103,000)

Exhaust air-to-Water 0 - 20 46,000 (43,000) 50,000 (47,000)

> 20 92,000 (86,000) 100,000 (94,000)

The TEWI value is calculated using the following formula:

TEWI = GWP * (ER * n * m + α_v * m) + n * β * Q/SPF

using the following operands:

GWP: Global warming potential [-]

ER: Emission rate [%/a]

n: Life of a system [a]

m: Filling quality of refrigerant [kg]

α_v: Disposal loss [%]

β: Conversion factor [kg CO_2/kWh]

Q_h: Heat demand [kWh/a]

SPF: Seasonal performance factor [-]

Calculation shall be performed using the following parameters:

- • annual emission rate of 2 %
- • product life of 15 years

- • disposal loss of 20 %
- uniform conversion factor: 0.683 kg CO_2/kWh
- heat demand for systems up to 20 kW: 15.000 kWh/year
- heat demand for systems over 20 kW: 30.000 kWh/year