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Revision of the EU Ecolabel criteria for detergent products

Preliminary report

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Contents

1. Introduction

The EU Ecolabel is the official voluntary labelling scheme of the EU that promotes the production and consumption of products (goods and services) with a reduced environmental impact over their life cycle, and is aimed at products with a high level of environmental performance. The EU Ecolabel Regulation (EC) 66/2010 ([1]) provides a framework to establish voluntary ecological criteria aiming at reducing the negative impact on the environment, health, climate and natural resources of production and consumption of the defined product group. The setting of EU Ecolabel criteria aims to target the environmentally top 10 to 20% of products on the market within a defined product group or service. Accordingly, the EU Ecolabel enables suppliers to market their products with a simple label that can be used as an accurate, non-deceptive and science-based proof of the excellent environmental performance of their products.

Established in 1992, the EU Ecolabel has become a key policy instrument within the European Commission's Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan (see COM(2008) 397) and the Roadmap for a Resource-Efficient Europe (see COM/2011/0571). It has also links with other policy instruments, such as Green Public Procurement (GPP, see COM(2008) 400), the Eco-Management and Audit Scheme (EMAS) (see Regulation (EC) No 1221/2009 and Regulation (EU) No 2018/2026) and the Ecodesign Directive (see Directive 2009/125/EC). In addition, the EU Ecolabel was mentioned as having an important role in the new Circular Economy Action Plan (CEAP) from March 2020, being regarded as an important tool whose criteria will be developed in synergy with future Ecodesign measures. As a part of the circular economy package, the European Commission submitted a proposal for the Directive on empowering consumers for the green transition (see COM 2022/0092). This Directive, along with the EU Ecolabel, shares the goal of promoting sustainability and empowering consumers to make environmentally conscious choices. The empowering consumers for the green transition Directive is closely linked to the Directive on Green Claims (COM 2023/0085), which promotes reliable claims on the environmental performance of products reducing the risk of greenwashing and with the Ecodesign for Sustainable Products Regulation (COM 2022/0095). .These initiatives in line with the principles of the EU Ecolabel seek to establish a coherent policy framework to help the EU produce sustainable goods, transform consumption patterns in a more sustainable direction, and significantly reduce the environmental footprint of products to contribute to the EU's policy objective of climate neutrality by 2050.

The objective of this project is to revise the existing EU Ecolabel criteria for detergents products:

- Dishwasher detergents, hereinafter DD (Commission Decision 2017/1216/EU) ([2]);
- Industrial and institutional dishwasher detergents, hereinafter IIDD (Commission Decision 2017/1215/EU) ([3]);
- Laundry detergents, hereinafter LD (Commission Decision 2017/1218/EU) ([4]);
- Industrial and institutional laundry detergents, hereinafter IILD (Commission Decision 2017/1219/EU) ([5]);
- Hard surface cleaning products, hereinafter HSC (Commission Decision 2017/1217/EU) ([6];
- Hand dishwashing detergents, hereinafter HDD (Commission Decision 2017/1214/EU) ([7]).

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[1] Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel (OJ L 27, 30.1.2010, p. 1–19). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010R0066

[2] Commission Decision (EU) 2017/1216 of 23 June 2017 establishing the EU Ecolabel criteria for dishwasher detergents (OJ L 180, 12.7.2017, p. 31–44) https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2017%3A180%3ATOC&uri=uriserv%3AOJ.L_.2017.180.01.0031.01.ENG

[3] Commission Decision (EU) 2017/1215 of 23 June 2017 establishing the EU Ecolabel criteria for industrial and institutional dishwasher detergents (OJ L 180, 12.7.2017, p. 16–30) https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2017%3A180%3ATOC&uri=uriserv%3AOJ.L_.2017.180.01.0016.01.ENG

[4] Commission Decision (EU) 2017/1218 of 23 June 2017 establishing the EU Ecolabel criteria for laundry detergents (OJ L 180, 12.7.2017, p. 63–78) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1218&qid=1678703370910

[5] Commission Decision (EU) 2017/1219 of 23 June 2017 establishing the EU Ecolabel criteria for industrial and institutional laundry detergents (OJ L 180, 12.7.2017, p. 79–96). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1219&qid=1678704095676

[6] Commission Decision (EU) 2017/1217 of 23 June 2017, establishing the EU Ecolabel criteria for hard surface cleaning products (OJ L 180, 12.7.2017, p. 45–62) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1217&qid=1678704194237

The Commission Decisions currently in force were adopted on 23 June 2017 and are valid until the 31st December 2026.

The revision process takes the existing criteria and its associated documents as the starting point and seeks to update these, taking into account technological and economic changes in the European market, relevant legislative changes and improved scientific knowledge.

This preliminary report is intended to provide background information for the revision of the existing EU Ecolabel criteria for detergents products. The study has been carried out by the European Commission's Joint Research Centre (JRC), Unit B.5 – Circular Economy and Sustainable Industry, being developed for the European Commission's Directorate General for Environment.

This report addresses the requirements of Annex I to the EU Ecolabel Regulation (EC) 66/2010 ([8]) for technical evidence, which meets requirements of the standard procedure to inform criteria revision.It sets the scene for the discussions planned to take place at the first ad-hoc working group (1st AHWG) meeting planned on the 12 and 13th of March 2024 and that will continue to be relevant throughout the criteria revision process.

The preliminary report acts as a basic reference point to support and complement the technical report (and its successive versions), where scientific-rationales accompanying criteria proposals are discussed in detail. For efficiency and brevity, it analyses the six product group horizontally, while if deemed necessary, focusing on the areas that are specific to each product group. Consequently, the simultaneous revision of the six product groups is looked at holistically, thus enhancing harmonisation of the criteria sets while focusing on the most relevant environmental aspects.

This preliminary report is structured as follows:

— Background information. This chapter sets the scenery for the criteria revision by informing about structure of existing criteria, providing general guidance for their revision based on feedback received from EU Ecolabelling board members and the outcomes of the preliminary stakeholder questionnaire. It also outlines the main legal instruments associated to EU Ecolabel criteria for detergent products.

— Scope and definitions. This chapter focuses on the identification of relevant background information related to scope and definitions. It includes summarised information on products definitions, relevant legislation (current laws and ongoing initiative), stakeholders' (questionnaire) views on scope and definitions, and assessment of other relevant environmental labels schemes.

— Market analysis. This chapter presents an analysis of key market data (e.g. production/consumption; retail market) relating to detergents products, with a special focus on the European market in the last (2017-2022) and the next (2022-2027) years. It also covers the potential emergence of new product types/classifications, relevant trends (innovations, sustainability and/or consumer behaviour) and the EU Ecolabel market penetration.

— Technical analysis. This chapter firstly provides background information on technological processes associated to detergents products manufacturing (ingredients, supply-chain, production processes). Then it assesses available evidences on environmental impacts of detergents products across the entire life cycle, mainly via relevant Life Cycle Assessment (LCA) studies. Those environmental impacts not detected via LCA studies (e.g. chemical pollution/risk, assessment of substitution of hazard substences) are also reviewed and considered. Key aims are the identification of major environmental impacts and the life-cycle stages where they occur ("environmental hotspots") in typical (base-case) and "best-performing" products in the market, so that EU Ecolabel criteria can be, as far as possible, tailored to address them following the identified (environmental) improvement potential.

— Conclusions. This section summarises the main outcomes from *Scope and definitions*, *Market analysis* and *Technical analysis*, providing directions on how to address and improve EU Ecolabel criteria.

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[7] Commission Decision (EU) 2017/1214 of 23 June 2017 establishing the EU Ecolabel criteria for hand dishwashing detergents (OJ L 180, 12.7.2017, p. 1–15) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1214&qid=1678704405604

[8] Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel (OJ L 27, 30.1.2010, p. 1–19). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010R0066

Further information on the revision process and latest announcements can be found on the project website at: https://susproc.jrc.ec.europa.eu/product-bureau/product-groups/411/home

2. Background information

This section presents basic criteria information, as well as information collected before the start of the revision process. In particular, it presents relevant considerations from discussions held in the previous revision and also an overview of the results from a preliminary stakeholder's questionnaire on the validity of current scope and criteria. This section closes presenting main legal instruments (i.e. regulatory and policy frameworks) associated to EU Ecolabel (hereinafter, EUEL) criteria for detergents.

The EUEL criteria represent a holistic approach, which encompass tackling undesired environmental impacts while ensuring proper product usage and performance. Consequently, the aspects covered range from setting requirements, restrictions or limits to the use of hazardous substances, sustainable sourcing of raw materials, recyclability and packaging design, to proper guidance for the product's use and performance testing.

The previous EUEL criteria revision process took place between 2014 and 2017, assessing the validity of the different Commission Decisions established between 2011 and 2012, and aimed at harmonizing, as much as possible, similar requirements within horizontal criteria. On 23 June 2017 the new Commission Decisions for the six detergent product groups (see *1. Introduction* section) were established with a validity until 26 June 2023, subsequently prolonged until 31 December 2026.

The structure of the current EU Ecolabel criteria for the detergent product groups is schematically presented in Table 1, with the color coding emphasizing criteria that cover similar or horizontal issues:

Table 1. Structure of the current EU Ecolabel criteria for the detergent product groups

Criterion	LD	IILD	DD	IIDD	HSC	HDD
1	Dosage requirement	Toxicity to aquatic organisms	Dosage requirement	Toxicity to aquatic organisms	Toxicity to aquatic organisms	Toxicity to aquatic organisms
2	Toxicity to aquatic organisms	Biodegradability	Toxicity to aquatic organisms	Biodegradability	Biodegradability	Biodegradability
3	Biodegradability	Sustainable sourcing of palm oil, etc.	Biodegradability	Sustainable sourcing of palm oil, etc.	Sustainable sourcing of palm oil, etc.	Sustainable sourcing of palm oil, etc.
4	Sustainable sourcing of palm oil, etc.	Restricted substances	Sustainable sourcing of palm oil, etc.	Restricted substances	Restricted substances	Restricted substances
5	Restricted substances	Packaging	Restricted substances	Packaging	Packaging	Packaging
6	Packaging	Fitness for use	Packaging	Fitness for use	Fitness for use	Fitness for use
7	Fitness for use	Automatic dosing systems	Fitness for use	Automatic dosing systems	User information	User information
8	User information	User information	User information	User information	Information on EU Ecolabel	Information on EU Ecolabel
9	Information on EU Ecolabel	Information on EU Ecolabel	Information on EU Ecolabel	Information on EU Ecolabel	n.a.	n.a.

Source: Boyano et al, 2016 ([9]).

[9] European Commission, Joint Research Centre, Boyano, A.; Kaps, R.; Medyna, G.; Wolf, O, 2016. Revision of six EU Ecolabel criteria for detergents and cleaning products. Final Technical Report. Available at https://susproc.jrc.ec.europa.eu/product-

2.1. Inputs from last revision process

The EU Ecolabel Board members requested the following points to be further investigated during the next revision process:

- ban all surfactants that are not aerobically or anaerobically biodegradable;
- state, as a minimum requirement, that the mass balance method is used to confirm the sustainable sourcing of chemicals derived from palm oil and palm kernel oil;
- lower thresholds of isothiazolinones;
- substitute or exclude endocrine disruptors and nanomaterials;
- reinforce criterion on packaging and recyclability of packaging;
- look further into the content of sensitising substances e.g. fragrances and preservatives under 0,010%;
- evaluate the possible non-use of fragrances in HSC professional products and in IILD products;
- reconsider the derogation for the final product classification due to peracetic acid and hydrogen peroxide in the case of IILD.
- Biodegradable micro-plastics;
- Adhesives (water soluble glues and self-adhesive labels) and UV additives and barrier coating in packaging;
- Equivalent test methods for anaerobic biodegradability (AnBUSDiC);
- Clarification for products, which are not explicitly mentioned as being in or out of the scope (e.g. WC gels and blocks in HSC and different kinds of laundry detergents sheet - soluble or not soluble in water).

2.2. Preliminary stakeholders questionnaire

Prior to the start of the revision process, a questionnaire (hereinafter, preliminary questionnaire) was sent to relevant stakeholders in order to collect feedback on the validity of the current EUEL criteria for detergent products and to identify priority areas to be taken as a starting point. A summary of the questionnaire results on Scope & Definitions is presented in the preliminary background report (See *Chapter 3 – Scope and definitions*) while specific and relevant results on particular EUEL criteria are mentioned in the technical report alongside their corresponding scientific rationale. Note that a follow-up stakeholder questionnaire (hereinafter, focused questionnaire) was designed and run (28/11/23 - 12/01/24) to gather evidences on different specific criteria aspects. Relevant observations on it are also mentioned in criteria rationales included in the technical report. On what follows, an outline of the overall validity of current criteria sets is presented, including details of the preliminary questionnaire and respondents' profile.

The preliminary questionnaire survey period ran for three weeks (05/02/2021 – 28/02/2021) and its target audience included EU Ecolabel Competent Bodies, current license holders, industry, technology institutes and trade associations. A total of 113 responses were gathered and are presented according to stakeholder profile in Figure 1.

The majority of respondents (39%) represented ISO Type I Ecolabel license holders, followed by manufacturers (21%), industry supply-chain (14%), the EUEB Member/Competent Body (10%), business association (7%), Government (3%), Consumer Associations (2%), NGO (2%) and test laboratories (1%).

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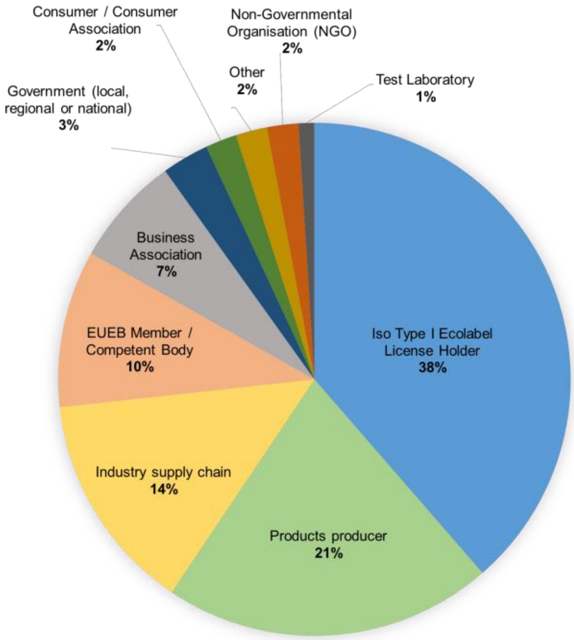
bureau/sites/default/files/contentype/product_group_documents/1581681262/Technical%20background%20report.pdf (Accessed 10/07/23)

Figure 1. Profile of respondents to the questionnaire



Source: La Placa et al.; 2022 ([10])

. Overall, 57 out of 113 survey participants acknowledged the current scopes and criteria's validity, while 45 confirmed the need for revision - 8 of them proposed a shorten procedure to introduce minor changes and/or revise specific limits. The respondents' profiles are diverse in both cases. Those who recognized the validity of the criteria and scope, and therefore indicated no need for revision, included Ecolabel License Holders, EUEB Members/Competent Bodies, product producers, business associations, and industry supply chain representatives. Similarly, those expressing the need for revision included Ecolabel License Holders, EUEB Members/Competent Bodies, NGOs, consumer associations, test laboratories, product producers, business associations, and industry supply chain representatives.

In particular, 39% of respondents highlighted ambiguity of some criteria formulation (mainly due to lack of linguistic clarity), 34% mentioned excessively high ambitious level of some criteria, and 18% thought that there were too many criteria. A minority of respondents suggested to expand on criteria areas and/or to introduce "other" changes. The criteria areas where changes were identified comprise: Scope; Definitions; Toxicity to aquatic organisms; Biodegradability; Excluded and restricted substances (e.g. preservatives; microorganisms) and Fitness for use. Further details are presented in Table 2 and in Figure 2.

Table 2. Outline of stakeholders' suggested modifications to the current EU Ecolabel criteria for detergents product groups

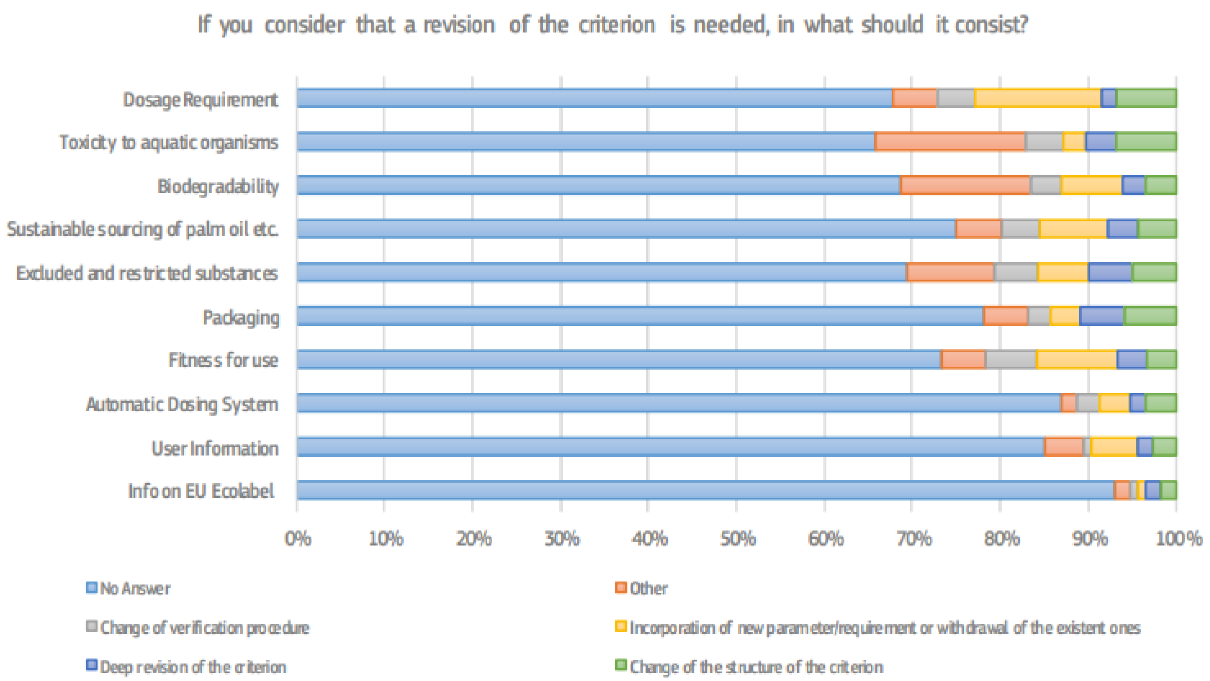
Subject	Proposed changes
Scope (for inclusion)	— Fabric softeners — In-wash stain removers — Ban of Ready-to-Use (RTU) HSC products — Alternative formats (solid; concentrated; sheets) — Products containing microorganisms — HSC including: Outdoor use; Textile flooring; Wash and wax care HSC — Products with biocidal action/function.

[10] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

Definitions	— Updating raw material definitions (Microplastic, Polyacrylate, etc.). — Ingoing substances - More clarity on this definition (including restricted substances) with respect to the by-products and impurities from raw materials, which can be present up to a concentration of 0,010 % by weight in the final formulation.
New criteria	— Introduction of requirement(s) on sustainable and renewable material - (e.g. % w/w)
Assessment and verification	— Specify in more detail the supporting documentation that the companies have to present; — Facilitate verification across the supply chain - difficulty in obtaining requested documentation from the manufacturers; — Better harmonization among procedures applied by national Competent Bodies
Other	— Inclusion of LCA based indicators - Principles of circularity and carbon foot print (or other environmental impact indicators based on LCA) Consider emerging areas of concern (isothiazolinones, EDs, etc.)

Source: La Placa et al.; 2022 [11]

Figure 2. Horizontal outline of the validity of the current criteria across six detergent product groups.



Source: La Placa et al.; 2022 [12]

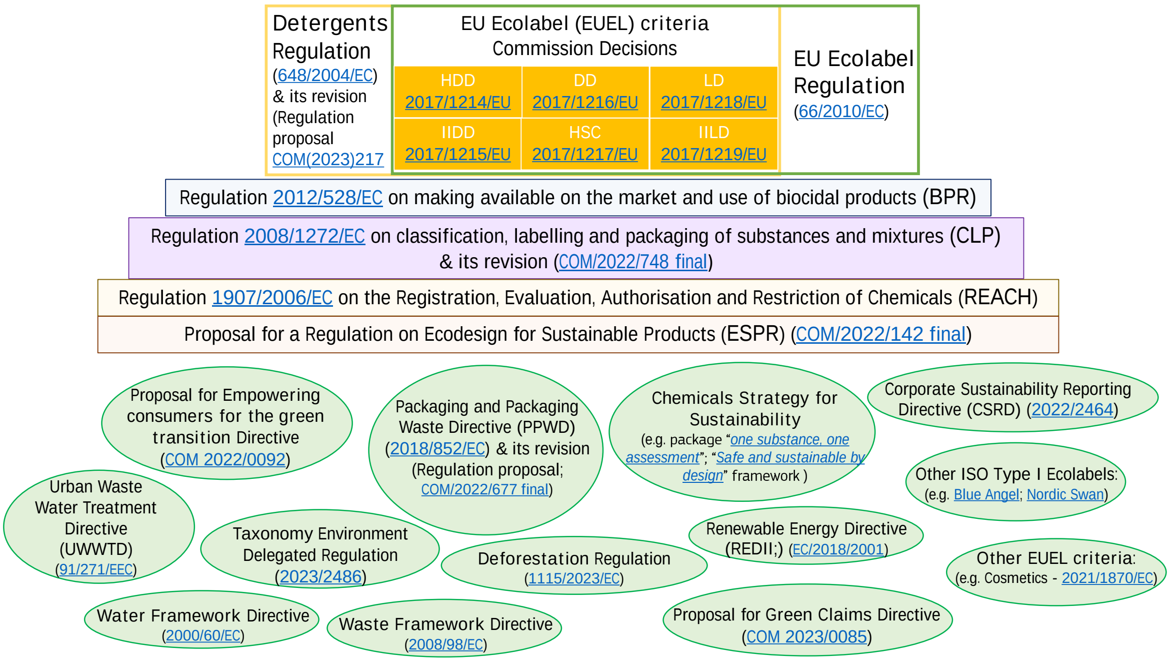
2.3. Legal instruments

Detergents and cleaningproducts, including their ingredients, are subject to sector-specific as well as horizontal (non-specific) EU legislation. Consequently, the requirements on these products are covered by several pieces of EU legislation which are illustratively displayed in Figure 3 and which will be briefly described in this section.

[11] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

[12] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

Figure 3 – Illustration of relevant regulatory and policy context in the European Union to the EU Ecolabel criteria for detergent products



The core legal instrument for the revision of the EU Ecolabel criteria is the EU Ecolabel Regulation 66/2010/EC ([13]). This regulation covers detergent products, as well as other products, and shapes how the criteria are examined, defining the processes and principles by which they must be developed. Article 6 within this Regulation sets out the following general requirements for criteria development:

- It shall cover the most significant environmental impacts, in particular the impact on climate change, the impact on nature and biodiversity, energy and resource consumption, generation of waste, emissions to all environmental media, pollution through physical effects and use, and release of hazardous substances.
- It shall encourage reduction of hazardous substance use by: (1) substitution of hazardous substances by safer substances; (2) use of alternative materials, design or technologies which eliminate the need for hazardous substances, wherever technically feasible.
- The potential to reduce environmental impacts due to durability and reusability of products shall be proved.
- The net environmental balance between the environmental benefits and burdens shall be covered, including health and safety aspects, at the various life stages of the products.
- Where appropriate, social and ethical aspects shall be covered as well, e.g. by referencing to related international conventions and agreements, such as relevant ISO standards and codes of conduct.
- To enhance synergies, criteria established for other environmental labels shall be considered, particularly labels that are officially recognised (nationally or regionally) and ISO 14024 type I ecolabels where they exist for that product group.
- As far as possible, the principle of reducing animal testing shall be addressed.

Some specific requirements within Article 6 are:

[13] Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel. (OJ L 27, 30.1.2010, p. 1–19). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010R0066

— *Article 6(4):* requires the inclusion of EU Ecolabel 'fitness for use' criteria.

— *Articles 6(6)* and *6(7)* limit the substances contained in the product, so that EU Ecolabel is not awarded to products containing the following:

- Substances or preparations/mixtures meeting the criteria for classification as toxic, hazardous to the environment, carcinogenic, mutagenic or toxic for reproduction (*CMR*), in accordance with Regulation (EC) No 1272/2008 ([14]).
- Substances referred to in Article 57 of Regulation (EC) No 1907/2006 ([15]).
- Substances or preparations/mixtures that have been identified according to the procedure described under Article 59 of Regulation (EC) No 1907/2006 ([16]) and which have been subsequently classified as Substances of Very High Concern (*SVHC*).

Article 6(7) allows derogations for substances only if it is not technically feasible to substitute them with safer chemicals, or obviate the need for the substance by using alternative materials or designs, or products which have a significantly higher overall environment performance compared with other goods of the same category. However, no derogation shall be given for substances that:

— meet the criteria of Article 57 of Regulation (EC) No 1907/2006;

— are identified according to the procedure described in Article 59(1) of that Regulation;

— present in mixtures, in an article or in any homogeneous part of a complex article in concentrations higher than 0.1 % (weight by weight).

One of main legal instruments associated to EUEL criteria for detergent products is the Regulation 648/2004/EC ([17]) on detergents (hereinafter referred as the Detergents Regulation). This regulation aims to achieve free movement within the EU of detergents products (including surfactants contained within) whilst maintaining a high degree of environmental protection. Some relevant aspects that it regulates are:

- The biodegradability of surfactants used in detergents, implying that failing to comply impedes entering the EU market;
- The labelling of detergents (minimum information that should appear in the label), especially with regards to fragrance allergens;
- The presence (and concentration) of phosphates and other phosphorus compounds.

The Detergents Regulation was explicitly referenced at the time of defining the scope of detergent product groups falling under the EUEL detergents criteria, thus any change on the scope of this Regulation can potentially affect that of the EUEL criteria.

[14] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. (OJ L 353, 31.12.2008, p. 1–1355). https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32008R1272

[15] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. (OJ L 396, 30.12.2006, p. 1–849) https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32006R1907

[16] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. (OJ L 396, 30.12.2006, p. 1–849) https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32006R1907

[17] Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents. (OJ L 104, 8.4.2004, p. 1–35). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004R0648

The recent revised proposal of the Detergents Regulation ([18]) introduced several novel aspects, being those relevant for the EUEL criteria:

- Expansion of the scope to include digital labelling (Digital Product Passport [DPP])
- Expansion of the scope to include micro-organisms as detergent products ingredients and setting safety requirements on them.
- Approaches for refillable formats, aligned with ongoing policy developments on packaging.

On the one hand, the DPP is presented as a suitable way to achieve harmonised, coherent and efficient labelling, accounting also for digitalisation trends. The DPP is still to be developed under the proposal for a Regulation on Ecodesign for Sustainable Products ([19]). On the other hand, the approaches for refillable detergent formats are aligned with the recent proposal for a Regulation on Packaging and Packaging Waste ([20]), as well considered as part of the current EUEL criteria revision on detergents.

On what follows, the legal instruments mentioned are non-specific (horizontal) to the EUEL criteria on detergents products, meaning that compliance might be required and/or that these horizontal legislation can have influence over the EUEL criteria remit.

The Regulation 2008/1272/EC on classification, labelling and packaging of substances and mixtures (CLP) ([21]) aims to ensure a high level of protection of human health and the environment, as well as the free movement of substances, mixtures and certain specific articles, achieving so by:

— harmonising the criteria for classification of substances and mixture, and the rules on labelling and packaging for hazardous substances and mixtures.

— Setting obligations (e.g. classifying substances and mixtures placed on the market and notifying them to regulators agency) to different actors across the supply chain (e.g. manufactures, importers, producers).

— Establishing at EU level harmonised classifications and labelling elements, as well as an inventory of notified substances at,

This implies that the CLP Regulation allows for the identification of hazardous chemicals and the communication of these hazards to users through labelling. Also, it provides the basis for safety data sheets (SDS) regulated under the REACH Regulation, and sets requirements for the packaging of hazardous chemicals.

The CLP Regulation is relevant for detergent products since it potentially affects the majority of the ingoing substances and mixtures that can be found in detergent products. In addition, the classification of substances or mixtures under certain CLP hazard classes might preclude its use in EU Ecolabelled products. In this sense, a CLP re-classification associated to (i) changes in the CLP classification rules for individual substances or mixtures, or (ii) new toxicological evidence justifying a reclassification of the substance, could result in substances and/or mixtures moving from being "acceptable" for EU Ecolabelled products to not and vice-versa. In this sense, close follow-up on CLP Regulation is necessary, including any update guidance documents

[18] COM(2023)217 - Proposal for a regulation of the European Parliament and of the Council on detergents and surfactants, amending Regulation (EU) 2019/1020 and repealing Regulation (EC) No 648/2004. https://single-market-economy.ec.europa.eu/publications/com2023217-proposal-regulation-detergents-and-surfactants_en

[19] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A0142%3AFIN

[20] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0677

[21] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. (OJ L 353, 31.12.2008, p. 1–1355). https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32008R1272

on how to interpret and implement this Regulation, especially with regards to those environmental aspects of highest relevance to detergent products (eg. Toxicity to aquatic organisms; biodegradability) ([22])

Recently, the European Commission published a Delegated Regulation amending CLP regulation by which new hazard classes and criteria for the classification were incorporated ([23]). These are applicable to all chemical substances and mixtures placed on the EU market under REACH and active substances in biocidal products. These new hazard classes are:

- ED HH in Category 1 and Category 2 (Endocrine disruption for human health)
- ED ENV in Category 1 and Category 2 (Endocrine disruption for the environment)
- PBT (persistent, bioaccumulative, toxic), vPvB (very persistent, very bioaccumulative)
- PMT (persistent, mobile, toxic), vPvM (very persistent, very mobile)

In addition, the revision of the CLP Regulation ([24]) brings , amongst others, updated rules for classifying complex substances, digital labelling and first ever rules for refillable chemicals sold in bulk to households ([25]), which together with the formerly mentioned would require consideration as part of the EUEL criteria on detergents revision process.

The Regulation 2012/528/EC concerning the making available on the market and use of biocidal products ([26]) aims to improve the functioning of the internal market through the harmonisation of the rules on the making available on the market and the use of biocidal products, whilst ensuring a high level of protection of both human and animal health and the environment.

In practical terms, it implies that only active substances either in the process of obtaining approval or after being approved can be used as biocidal products. These biocidal products are authorised according to defined categories or types, being the most relevant for detergents *PT2 Disinfectants and algaecides not intended for direct application to humans or animals* and *PT6 Preservatives for products during storage*. Biocides products within the later type are predominantly used in the EUEL criteria for detergents.

The harmonisation of the classification of biocidal active substances have led to certain substances being re-classified under CLP, with potential restrictive implications on the choice of preservative eligible for use in detergents or cleaners products applying for the EUEL.

The Regulation 1907/2006/EC concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency (REACH) ([27]), places responsibility on industry to manage the risks that chemicals may pose to human health and the environment, as well as to provide safety information that would be passed down the supply chain (e.g. SDS). It also sets the procedures and system for the registration, evaluation, authorisation and restriction of chemicals on the EU market. The companies that do not undertake these procedures will not be able to produce, sell or use their products and would consequently be forced to stop their activity.

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[22] Guidance on the Application of the CLP Criteria. Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures., Version 6.0, Jan 2024; European Chemicals Agency (ECHA), Helsinki, Finland. https://echa.europa.eu/documents/10162/2324906/clp_en.pdf/58b5dc6d-ac2a-4910-9702-e9e1f5051cc5#msdynttrid=6VzQpdWQNbUYUOyKffLLA_6A8rqn_SJlffMmlPZV2_w

[23] https://echa.europa.eu/new-hazard-classes-2023 (Accessed 02/08/23)

[24] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulation (EC) No 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures. COM/2022/748 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0748

[25] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6381 (Accessed 19/01/2024).

[26] Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products. (OJ L 167, 27.6.2012, p. 1–123). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012R0528

[27] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. (OJ L 396, 30.12.2006, p. 1–849) https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32006R1907

The Regulation is complementary to other environmental and safety legislation but does not replace sector-specific legislation (for example, legislation on detergents). Indeed, it sets the underlying regulatory framework for the CLP and BRP regulation. REACH does not allow marketing of a chemical substance if it does not have appropriate registration, which has to be carried out by every legal entity that manufactures or imports from outside the European Union substances on their own, in preparations or in articles in quantities of one tonne or above per year.

In addition to registration, REACH regulates other procedures such as the management of the risk and hazardous properties of the substance, authorisation of substances of very high concern (SVHC) such as those that are carcinogenic, mutagenic and/or toxic for reproduction, persistent, bio-accumulative and toxic or very persistent and very bio-accumulative and the restriction on the manufacturing, placing on the market and use of certain dangerous substances, preparations and articles when an unacceptable risk to human health or the environment exists. Currently, there are 235 substances registered on the SVHC candidate list ([28]) and 59 substances subject to authorisation (EU REACH Annex XIV Authorisation List ([29]).

Besides how chemicals information is shared (SDS), some aspect of REACH specifically of importance to the EUEL criteria revision process are the procedures for SVHC (articles 57 to 59); chemicals that might be subjected to restrictions and conditional authorisations; and (ongoing) amendments to REACH annexes of particular groups of substances (e.g. nanomaterials ([30]), microplastics([31])). This is related to EUEL restrictions on the use of substances classified as SVHC; the access to information aiding in derogation requests for certain hazardous substances in EU Ecolabel products; and the relevance of particular groups of substances, such as nanomaterials and microplastics (synthetic polymer microparticles), that are or could be present in detergent and cleaners products formulations, respectively.

The proposed Regulation on Ecodesign for Sustainable Products (ESPR) ([32]) *establishes a framework to improve the environmental sustainability of products and to ensure free movement in the internal market by setting ecodesign requirements that products shall fulfil to be placed on the market or put into service*. Inspired by the success of Directive 2009/125/EC ([33]), the ESPR extends its scope to all products (including non-energy related), empowering the EU Commission to set mandatory eco-design requirements via delegated acts. These can be product-group specific or horizontal (applicable to various product groups). It classifies products as end-use (e.g. detergents) or intermediate (e.g. steel). In addition, it sets the basis for the creation of the DPP, thus enabling the digitalisation and sharing of information associated to products.

A preliminary study carried by the JRC discusses potential options in terms of new product priorities under ESPR ([34]), including detergents products, which ranked 5th out of the 12th shortlisted end-use products. In principle, eco-design requirements under EUEL criteria should be compatible and complementary to those set under theESPR. In any case, it is relevant for the EUEL criteria revision process to keep track on ESPR developments on the side of DPP implementation, given its impact on labelling as referred by the revised Detergents Regulation, and on the side of eco-design measures specific to detergent products, so as to ensure coherency.

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[28] https://www.echa.europa.eu/candidate-list-table (Accessed 18/01/24)

[29] https://www.echa.europa.eu/authorisation-list (Accessed 18/01/24)

[30] Commission Regulation (EU) 2018/1881 of 3 December 2018 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards Annexes I, III,VI, VII, VIII, IX, X, XI, and XII to address nanoforms of substances (Text with EEA relevance.). (OJ L 308, 4.12.2018, p. 1–20) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.308.01.0001.01.ENG&toc=OJ:L:2018:308:TOC

[31] Commission Regulation (EU) 2023/2055 of 25 September 2023 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles. OJ L 238, 27.9.2023, p. 67–88 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_238_R_0003&qid=1695804976302 (Accessed 03/08/23)

[32] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A0142%3AFIN

[33] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products. (OJ L 285, 31.10.2009, p. 10–35). https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0125

[34] Ecodesign for Sustainable Products Regulation (ESPR) – preliminary study on new product priorities. https://susproc.jrc.ec.europa.eu/product-bureau/product-groups/635/documents

The previous horizontal legal instruments (CLP, BPR, REACH, ESPR) affecting detergents products are directly relevant or highly influential on several aspects related to the revision of EUEL criteria for detergents. Subsequently, several other pieces of legislation are presented, whose relevance to the EUEL criteria revision process is deemed lower since they generally refer to particular aspects (e.g. packaging; palm oil sourcing) affecting different life-cycle stages of detergent and cleaner products.

The Waste Framework Directive (2008/98/EC) ([35]) sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (via the so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive requires that Member States adopt waste management plans and waste prevention programmes. In order to comply with the objectives set by the Directive, Member States shall take the necessary measures designed to achieve the following targets: by 2025, the reuse and the recycling of municipal waste shall be increased to a minimum of 55%, 60% and 65% by weight by 2025, 2030 and 2035 respectively (See consolidated version ([36]).

Recently, a proposal for a targeted revision of the Waste Framework Directive ([37]) was published (05/07/23), targeting specifically textiles and food products. It has as general objectives *reducing environmental and climate impacts, increase environment quality and improve public health associated with textiles waste management in line with the waste hierarchy*, and reducing *the environmental and climate impacts of food systems associated with food waste generation. Preventing food waste would also contribute to food security*.

In general terms, this Directive is not directly relevant with regards to detergents products, since once they are used they become part of waste-waters, which are out of the scope of the Directive. However, it indirectly supports and inform about principles/aspects relevant to the EUEL criteria revision process, such as design-for-recycling; eco-design; use of recycled content, efficient (resource) manufacturing and/or littering prevention (especially in marine environments).

The Directive on Packaging and Packaging Waste (PPWD; 2018/852/EC) ([38]) aims to *harmonise national measures on packaging and the management of packaging waste*; *provide a high level of environmental protection* (by preventing or reducing packaging and packaging waste impacts); and *ensure the good functioning of the internal market*. The latest amendments to this Directive contains updated measures for the prevention of packaging waste production and avoidance of final disposal of packaging waste by promoting reuse, recycle and recovery.

The revision of the PPWD resulted in a proposal for a Regulation published in November 2022 (COM/2022/677 final) ([39]). This proposal follows previous PPWD aims but with a stronger focus on achieving recycling economic viability for all packaging, reducing packaging waste (via reuse & refill) and increasing the use of recycled content in packaging. Amongst others traits, it sets out new recycling and recyclability targets, design for recycling criteria, minimum mandatory recycled content, harmonised labelling of packaging support of refill systems,.

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[35] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. (OJ L 312, 22.11.2008, p. 3–30). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0098

[36] Consolidated text: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02008L0098-20180705

[37] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2008/98/EC on waste. COM(2023) 420 final. https://environment.ec.europa.eu/publications/proposal-targeted-revision-waste-framework-directive_en [38] Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste. (OJ L 150, 14.6.2018, p. 141–154) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L0852

[38] Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste. (OJ L 150, 14.6.2018, p. 141–154) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L0852

[39] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC. COM/2022/677 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0677

The PPWD, including its proposal as a Regulation, have implications for EUEL criteria, in particular for those related to detergents and cleaners packaging. Consequently, it should be considered to ensure proper alignment.

The Water Framework Directive (WFD; 2000/60/EC) ([40]) is the main law for water protection in Europe, of application to surface (inland and coastal) and ground waters, which via an integrated management approach ensures good (healthy) quality waters for natural and human uses. The WFD includes provisions regarding the deadlines to meet its objectives and its accompanying annexes specify details such as monitoring requirements or the criteria for assessing water body status.

The WFD is supported by other legislations, as a directives addressing groundwater quality/quantity (GWD) ([41]) and the environmental quality standards (EQS) in the field of water policy ([42]). The WFD includes in its Annex X the list of priority substances that Member States must monitor in surface waters while the GWD includes a list of pollutants and standards of EU-wide concern in its Annex I, which are revised periodically.

A fitness check carried out on the WFD and associated legislation (i.e. GWD) concluded that there was room for improvement with regards to chemical pollution, thus a proposal was made in 2022 ([43]) to revise the lists of priority substances both in surface and ground waters. In this proposal, several substances were added such as PFAS (a large group of "forever chemicals" used in cookware, clothing and furniture, fire-fighting foams and personal care products), a range of pesticides, bisphenol A and a number of pharmaceuticals (e.g. painkillers, antibiotics).

The WFD and legislation associated to it are relevant to the revision of the EUEL criteria for detergents because they provide notions on which pollutants/chemicals are being emitted and being monitored in water courses, flagging substances whose presence in detergent products should carefully considered. In addition, they also inform about which standards can be used for the detection of these undesired substances.

Another important piece of legislation for the safety and quality of European water courses is the Urban Waste Water Treatment Directive (UWWTD; 91/271/EEC) ([44]), which aims to protect human health and the environment from the effects of untreated urban wastewater. It sets the basis for domestic and industrial wastewater collection, treatment and discharge, including protection from undesired effects of returning treated water to the environment (e.g. eutrophication). As example and in practical terms, this implies setting limits to the levels of nitrogen and phosphorus allowed in treated and discharged wastewaters.

Despite UWWTD being fit for purpose (e.g. reduction or organic matter levels) there is still pollution not properly addressed, including residues from pharmaceuticals and cosmetics that end up in the environment and need to be treated. This and other reasons motivated the proposal for a revised UWWTD ([45]), which proposes introducing micro-pollutants limits progressively in large facilities where there is risk to the environment, a system of producer responsibility for the additional treatment required for these micro-pollutant and new monitoring requirements (e.g. health parameters).

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[40] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. OJ L 327, 22.12.2000, p. 1–73. https://eur-lex.europa.eu/eli/dir/2000/60/o

[41] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. OJ L 372, 27.12.2006, p. 19–31. https://eur-lex.europa.eu/eli/dir/2006/118/oj

[42] Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council. OJ L 348, 24.12.2008, p. 84–97. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0105

[43] COM(2022) 540 final. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2008/105/EC on environmental quality standards in the field of water policy. Brussels, 26.10.2022. https://environment.ec.europa.eu/publications/proposal-amending-water-directives_en

[44] Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment. OJ L 135, 30.5.1991, p. 40–52. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31991L0271

[45] COM(2022) 541 final. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL concerning urban wastewater treatment (recast). https://environment.ec.europa.eu/publications/proposal-revised-urban-wastewater-treatment-directive_en

Similarly to the WFD, the (revised) UWWTD could also inform about the type and quantity of pollutants/chemicals being monitored, treated and/or emitted in wastewaters. These information could be useful in the revision of the EUEL criteria for detergents, especially since the main end-of-life scenario for these products is via wastewaters in the domestic or industrial sphere.

The Renewable Energy Directive (REDII; EC/2018/2001) ([46]) establishes a common framework for the promotion of energy from renewable sources, setting EU binding targets on the share of energy from renewable sources. In order to boost the transition to renewable energies, the REDII was revised in 2023 ([47]), adopting more ambitious targets (32% to 42.5%). Amongst other matter, it also establishes sustainability and greenhouse emission saving criteria for biofuels, bioliquids and biomass fuels, aimed at tackling negative impacts on land use and biodiversity, resource efficiency, competition with food/feed production and social aspects.

This is relevant in the revision of the EUEL criteria for detergents as it can inform about the viability of alternative sources of energy to fossil fuels and about criteria to maximise the sustainability of biomass production. The latter could include directions on how to achieve more sustainable (agricultural) production practices, which could positively impact the environmental footprint of those ingredients derived from biomass and used in the production of detergent/cleaner products.

The Deforestation Regulation (1115/2023/EC) ([48]) aims to minimise the EU contribution to deforestation and forest degradation and reduce its contribution to greenhouse gas emissions and biodiversity loss, thus impacting also at global scale. It sets rules on placing and making available in or out of the EU market of relevant commodities (e.g. oil palm), including information and procedures to set and implement due diligence systems. Overall, this leads to "deforestation-free" products, namely those legally sourced and produced on lands not subjected to deforestation (conversion to agricultural use) after December 2020.

Annex I of this Regulation lists relevant commodities and products under its scope, including oil palm products and its derivatives (e.g. industrial fatty alcohols). These are very relevant raw materials and/or ingredients for surfactants production, which are a key ingredient in detergent and cleaner products (see Chapter 5 – Technical analysis).

This Regulation has implications for the revision of the EUEL criteria for detergents as it is directly related with the criterion on sustainable sourcing of palm oil. In practical terms implies that commodities and products can only be produced not having negative effects associated to land use change. However, it does not set requirements on the management practices of producing such goods (e.g. agricultural practices to cultivate palm oil).

Although still in early days to understand the role and impact with regards to EUEL criteria, the package ***"**one substance, one assessment**"*** ([49]) represents a key deliverable of the Chemicals Strategy for Sustainability ([50]), by which significant tasks will be reallocated between four EU agencies, to ensure coherent and transparent safety assessments of chemicals used in products such as medical devices, toys, food, pesticides and biocides. Under this context, the EU Commission has recently (07/12/23) adopted three

[46] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources. OJ L 328, 21.12.2018, p. 82–209 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018L2001

[47] Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. OJ L, 2023/2413, 31.10.2023. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023L2413&qid=1699364355105

[48] Regulation (EU) 2023/1115 of the European Parliament and of the Council of 31 May 2023 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010. (OJ L 150, 9.6.2023, p. 206–247). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32023R1115&qid=1687867231461

[49] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6413 (Accessed 19/01/24)

[50] https://environment.ec.europa.eu/strategy/chemicals-strategy_en (Accessed 19/01/24)

legislative proposals ([51],[52],[53]) to: streamline assessments of chemicals across EU legislation; strengthen the knowledge base on chemicals; and ensure early detection and action on emerging chemical risks.

Another milestone within the Chemicals Strategy for Sustainability was the adoption of the "*Safe and* ***sustainable by design"*** framework ([54]), aimed at promoting research and innovation for safer and more sustainable chemicals and materials. It aims to develop new chemicals and materials, optimise or redesign production processes and the use of substances currently on the market to improve their safety and sustainability ([55]). In this sense, initiatives applying this framework to detergent and cleaner products could inform about more sustainable alternatives to current raw materials and/or ingredients currently used in the market.

The European Commission indicated in its communication on a EU policy framework on biobased, biodegradable and compostable plastics ([56]) that biobased plastics could be a possible alternative contributing to the reduction of GHG emissions, waste generation, littering and derived pollution from fossil-based and non-biodegradable plastics (currently dominant). Biobased plastics (BBP) and biodegradable and compostable plastics (BDCP) could have potential advantages over fossil-based, non-biodegradable plastics. However, the superior environmental profileof BBP and BDCP compared to conventional plastics needs to be carefully assessed via life-thinking approaches. To achieve this and also aiming to fill possible gaps, this Communication set orientations to be used by EU policies addressing these plastics in the future.

Other ISO Type I labels are relevant references to the EUEL criteria for detergents as they can inform the current revision via shared commonalities – products and/or areas for improvement. Examples of other ecolabelling schemes covering the same products (similar scopes to EUEL criteria detergents) are Nordic Swan ([57]) and Blue Angel ([58]). Examples of other EUEL criteria relevant to EUEL criteria for detergents are cosmetic and animal care products ([59]), which share some product technical commonalities, and absorbent hygiene products and for reusable menstrual cups ([60]), which potentially informs about the latest horizontal aspects applicable to any EUEL criteria (e.g. *Excluded and Restricted Substances* criterion).

[51] COM(2023) 779 final Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND THE COUNCIL establishing a common data platform on chemicals. https://environment.ec.europa.eu/publications/proposal-regulation-establishing-common-data-platform-chemicals_en

[52] COM(2023) 783 final Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND THE COUNCIL amending Regulations (EC) No 178/2002, (EC) No 401/2009, (EU) 2017/745 and (EU) 2019/1021 establishing a common data platform on chemicals, laying down rules to ensure that the data contained in it are findable, accessible, interoperable and reusable and establishing a monitoring and outlook framework for chemicals https://environment.ec.europa.eu/publications/proposal-regulation-re-attribution-scientific-and-technical-tasks-and-improving-cooperation-among_en

[53] COM(2023) 781 final Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND THE COUNCIL amending Directive 2011/65/EU of the European Parliament and of the Council as regards the re-attribution of scientific and technical tasks to the European Chemicals Agency. https://environment.ec.europa.eu/publications/proposal-directive-re-attribution-scientific-and-technical-tasks-european-chemicals-agency_en

[54] Commission Recommendation (EU) 2022/2510 of 8 December 2022 establishing a European assessment framework for 'safe and sustainable by design' chemicals and materials. OJ L 325, 20.12.2022, p. 179–205. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022H2510

[55] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/recommendation-safe-and-sustainable-chemicals-published-2022-12-08_en (Accessed 19/01/2024).

[56] European Commission, 2022. Communication from the EC on EU Policy Framework on biobased, biodegradable and compostable plastics. Available at: https://environment.ec.europa.eu/publications/communication-eu-policy-framework-biobased-biodegradable-and-compostable-plastics_en

[57] https://www.nordic-swan-ecolabel.org/ (Accessed 19/01/2024)

[58] https://www.blauer-engel.de/en (Accessed 19/01/2024)

[59] Commission Decision (EU) 2021/1870 of 22 October 2021 establishing the EU Ecolabel criteria for cosmetic products and animal care products (notified under document C(2021) 7500) (Text with EEA relevance). OJ L 379, 26.10.2021, p. 8–48. https://eur-lex.europa.eu/eli/dec/2021/1870/oj

[60] Commission Decision (EU) 2023/1809 of 14 September 2023 establishing the EU Ecolabel criteria for absorbent hygiene products and for reusable menstrual cups. OJ L 234, 22.9.2023, p. 142–189. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_234_R_0006&qid=1695364426290

3. Scope and definitions

This section of the report starts by providing background to the existing scope and definitions of current EUEL criteria in force, to then compare them against other ecolabel schemes and green initiatives. It also summarises the results of scoping questions included in the preliminary questionnaire, thus incorporating stakeholders' feedback about proposals for scopes and definitions revision. The last section of this chapter describes, assesses and highlights any potential modification to current scope and definitions, doing so based on previous aspects discussed along this chapter, as well as in the light of further legal, policy and technical frameworks (if applicable).

3.1. Definitions

Within the context of existing EU Ecolabel criteria, the understanding on what "*detergent*" means was harmonised with the definition established by Article 2.1 of the Detergents Regulation (EC) No 648/2004 ([61]):

> *""Detergent" means any substance or preparation containing soaps and/or other surfactants intended for washing and cleaning processes. Detergents may be in any form (liquid, powder, paste, bar, cake, moulded piece, shape, etc.) and marketed for or used in household, or institutional or industrial purposes.*
>
> *Other products to be considered as detergents are:*
>
> *- "Auxiliary washing preparation", intended for soaking (pre-washing), rinsing or bleaching clothes, household linen, etc.;*
>
> *- "Laundry fabric-softener", intended to modify the feel of fabrics in processes which are to complement the washing of fabrics;*
>
> *- "Cleaning preparation", intended for domestic all purpose cleaners and/or other cleaning of surfaces (e.g.: materials, products, machinery, mechanical appliances, means of transport and associated equipment, instruments, apparatus, etc.);*
>
> *- "Other cleaning and washing preparations", intended for any other washing and cleaning processes".*

The EU Ecolabel product group categories and their scopes were defined in accordance with this definition from the Detergents Regulation. However, the alignment was not full as some products were excluded after reasoned analyses on their fit to the EU Ecolabel regulation (e.g. fabric softeners; (amongst other reasons) its primary main function is not cleaning). The existing scope for each EUEL detergent product group is presented in Table 3.

Unless otherwise specified, the definitions to describe the products apply horizontally and are harmonised across criteria documents. Current definitions are (*in brackets - the EUEL product group to which the definition applies*):

(*DD, HDD, HSC, IIDD, LD, IILD*)

- <u>ingoing substances</u> *means substances intentionally added, by-products and impurities from raw materials in the final product formulation (including water-soluble foil, where used);*
- <u>primary packaging</u> *means:*
  - *for single doses in a wrapper that is intended to be removed before use, the individual dose wrapping and the packaging conceived so as to constitute the smallest sales unit of distribution to the final user or consumer at the point of purchase, including label where applicable;*
  - *for all other types of products, packaging conceived so as to constitute the smallest sales unit of distribution to the final user or consumer at the point of purchase, including label where applicable;*

[61] Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents (OJ L 104, 8.4.2004, p.1-35) https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32004R0648

— microplastic *means particles with a size of below 5 mm of insoluble macromolecular plastic, obtained through one of the following processes:*

- *a polymerisation process such as poly-addition or poly-condensation or a similar process using monomers or other starting substances;*
- *chemical modification of natural or synthetic macromolecules;*
- *microbial fermentation.*

— nanomaterial *means a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1-100 nm (based on Commission Recommendation 2011/696/EU* ([62]).

(*HSC*)

— undiluted product *means a product that should be diluted in water prior to use;*

— ready-to-use (RTU) product *means a product not to be diluted in water before use.*

(*LD*)

— heavy-duty detergents *means detergents used for ordinary washing of white textiles at any temperature*;

— colour-safe detergents *means detergents used for ordinary washing of coloured textiles at any temperature*;

— light-duty detergents *means detergents intended for delicate fabrics*.

The legislative changes that have taken place since the last revision in 2017, being the main ones mentioned in Chapter *Background information*, bring about the urgency to align the definitions with the established (or ongoing) policy. In particular, the consecutive REACH amendments (e.g. microplastics restriction ([63])) and the new proposal for revised Detergents Regulation ([64]), which sets the scene for the update establishing technical standards and requirements in relation to detergents and surfactants while repelling Regulation (EC) No 648/2004, must be dully considered.

The summary of the changes in definitions that might need to be taken into account during the revision process is listed in Table 4. Note that this list is not comprehensive and only considers definitions that are used across the current criteria texts. Nevertheless, the addition of further definitions will need consideration and consultation as part of the current EUEL criteria revision process, including harmonization with other EUEL criteria (e.g. Cosmetics).

[62] Commission Recommendation of 18 October 2011 on the definition of nanomaterial (OJ L 275, 20.10.2011, p. 38) https://eur-lex.europa.eu/eli/reco/2011/696/oj

[63] Commission Regulation (EU) 2023/2055 of 25 September 2023 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles. OJ L 238, 27.9.2023, p. 67–88. http://data.europa.eu/eli/reg/2023/2055/oj

[64] COM(2023)217 - Proposal for a regulation of the European Parliament and of the Council on detergents and surfactants, amending Regulation (EU) 2019/1020 and repealing Regulation (EC) No 648/2004. https://single-market-economy.ec.europa.eu/publications/com2023217-proposal-regulation-detergents-and-surfactants_en (Accessed 10/07/2023)

Table 3. Scope of the current EU Ecolabel criteria for detergents.

	Products included in the scope	Product excluded from the scope
Laundry detergents (LD)	Any laundry detergent or pre-treatment stain remover in the meaning of Regulation (EC) No 648/2004, which is effective at 30 °C or below and is marketed and designed to be used for the washing of textiles principally in household machines, but not excluding its use in public laundrettes and common laundries. Pre-treatment stain removers include stain removers used for direct spot treatment of textiles before washing in the washing machine but do not include stain removers dosed in the washing machine and stain removers dedicated to other uses besides pre-treatment.	fabric softeners, products that are dosed by carriers such as sheets, cloths or other materials or washing auxiliaries used without subsequent washing such as stain removers for carpets and furniture upholstery.
Industrial and institutional laundry detergents (IILD)	Any laundry detergent in the meaning of Regulation (EC) No 648/2004, which is marketed and designed to be used by specialised personnel in industrial and institutional facilities. This product group includes multi-component systems comprised of more than one component used to build up a complete detergent or a laundering programme for an automatic dosing system. Multi-component systems may incorporate a number of products such as fabric softeners, stain removers and rinsing agents, and they shall be tested as a whole.	Products which induce textile attributes such as water repellency, waterproofness or fire retardancy. Products that are dosed by carriers such as sheets, cloths or other materials, or washing auxiliaries used without subsequent washing such as stain removers for carpets and furniture upholstery. Laundry detergents to be used in household washing machines are excluded from the scope of this product group.
Dishwasher detergents (DD)	Any detergent for dishwashers or rinse aid which falls under the scope of Regulation (EC) No 648/2004, and which is marketed and designed to be used exclusively in household dishwashers and in automatic dishwashers for professional use of the same size and usage as that of household dishwashers.	Not specified
Industrial and institutional dishwasher detergents (IIDD)	Any dishwasher detergent, rinse or pre-soak agent in the meaning of Regulation (EC) No 648/2004, which is marketed and designed to be used by specialised personnel in professional dishwashers. This product group includes multi-component systems comprised of more than one component used to build up a complete detergent. Multi-component systems may incorporate a number of products such as pre-soak and rinsing agents, and they shall be tested as a whole.	Dishwasher detergents designed for household dishwashers, Detergents intended to be used in washers of medical devices or in special machines for the food industry. Sprays not dosed via automatic pumps are excluded from this product group.
Hard surface cleaning products (HSC)	Any all-purpose cleaner, kitchen cleaner, window cleaner or sanitary cleaner (in the meaning of Regulation (EC) No 648/2004EC, 2004) for private and professional use, which is sold either in ready-to-use or undiluted form, and marketed and designed to be used as one of the following: *all-purpose cleaners* for the routine indoor cleaning of hard surfaces such as walls, floors and other fixed surfaces; *kitchen cleaners* for the routine cleaning and degreasing of kitchen surfaces (countertops, stovetops, kitchen sinks and kitchen appliance surfaces); *window cleaners* for the routine cleaning of windows, glass and other highly polished surfaces, *sanitary cleaners* for the routine removal, including by scouring, of dirt or deposits in sanitary facilities, such as laundry rooms, toilets, bathrooms and showers.	Products for private use shall not contain micro-organisms that have been deliberately added by the manufacturer
Hand dishwashing detergents (HDD)	Any detergent in the meaning of Regulation (EC) No 648/2004 which is marketed and designed to be used to wash by hand items such as glassware, crockery and kitchen utensils including cutlery, pots, pans and ovenware.	Shall not contain micro-organisms that have been deliberately added by the manufacturer.

Table 4. Summary of definitions that should undergo revision based on in-force or on-going policy and legislative changes. Their applicability is horizontal (across EUEL detergent product group criteria).

Definitions	Revised definition proposal	Justification for the change
Detergent	any of the following: — -a substance, mixture or micro-organism, or two or more such materials in combination, which is intended for cleaning of fabrics, dishes or surfaces; — -a mixture intended for soaking (pre-washing), rinsing or bleaching fabrics or dishes; — -a mixture intended to modify the feel of fabrics in processes which are to complement the washing of fabrics;	Alignment with latest developments in the main and mandatory EU Regulation for detergent products: Regulation on detergents and surfactants, amending Regulation (EU) No 2019/1020 and repealing Regulation (EC) No 648/2004 ([65]) Work in - progress
Microplastic	'microplastic' means polymers that are solid and which fulfil both of the following conditions: a) are contained in particles and constitute at least 1 % by weight of those particles; or build a continuous surface coating on particles; b) at least 1 % by weight of the particles referred to in point (a) fulfil either of the following conditions*: i) all dimensions of the particles are equal to or less than 5 mm; ii) *the length of the particles is equal to or less than 15 mm and their length to diameter ratio is greater than 3.* *Where the concentration of synthetic polymer microparticles covered by this entry cannot be determined by available analytical methods or accompanying documentation, in order to verify the compliance with the concentration limit referred to in paragraph 1, only the particles of at least the following size shall be taken into account: (a) 0,1 μm for any dimension, for particles where all dimensions are equal to or smaller than 5 mm; (b) 0,3 μm in length, for particles that have a length that is equal to or smaller than 15 mm and a length to diameter ratio greater than 3	Amendments of Annex XVII to Regulation (EC) No 1907/2006 that restricts synthetic polymer microparticles ("microplastics")([66]), by which they shall not be placed on the market on their own or, where the synthetic polymer microparticles are present to confer a sought-after characteristic (i.e. intentionally added), in mixtures in a concentration equal to or greater than 0.01% by weight. Entry into force: 5 years after the entry into force (October 2028) for the use of microplastics in detergents/waxes/polishes and air care products, unless already covered by other entries (fragances encapsulation; microbeads) In force
ingoing substances	'ingoing substances' means all substances in the detergent/cleaner product, including additives (e.g. preservatives and stabilisers) in the raw materials. Substances known to be released from ingoing substances (e.g. formaldehyde from preservatives and arylamine from azodyes and azopigments) shall also be regarded as ingoing substances. Residuals, pollutants, contaminants, by-products, etc. from production, incl. production of raw materials, that remain in the raw materials ≥ 1 000 ppm (≥ 0,1000 %w/w ≥ 1 000 mg/kg) are always regarded as ingoing substances, regardless of the concentration in the final product; 'impurities' means unintended constituents (residuals, pollutants, contaminants, by-products, etc.) from production, incl. production of raw materials, that remain in the raw material/ingredient and/or in the in the final product in concentrations less than 100 ppm (0,0100 % w/w, 100 mg/kg) and that were not intentionally	This definition was outdated and required further wording clarity for interpretation, including the incorporation of *'impurities'*. The revised definition proposal was aligned with EU Ecolabel criteria for Cosmetics ([67]) and Nordic Swan detergent criteria (eg laundry & stain removers)[68] In-force

[65] COM(2023)217 - Proposal for a regulation of the European Parliament and of the Council on detergents and surfactants, amending Regulation (EU) 2019/1020 and repealing Regulation (EC) No 648/2004. https://single-market-economy.ec.europa.eu/publications/com2023217-proposal-regulation-detergents-and-surfactants_en (Accessed 10/07/2023)

[66] Commission Regulation (EU) 2023/2055 of 25 September 2023 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards synthetic polymer microparticles. OJ L 238, 27.9.2023, p. 67–88. http://data.europa.eu/eli/reg/2023/2055/oj

[67] Commission Decision (EU) 2021/1870 of 22 October 2021 establishing the EU Ecolabel criteria for cosmetic products and animal care products (notified under document C(2021) 7500) (OJ L 379, 26.10.2021, p. 8–48) https://eur-lex.europa.eu/eli/dec/2021/1870/oj

[68] 006 Laundry Detergents and Stain Removers, version 8.7, 24 October 2023. https://www.nordic-swan-ecolabel.org/4ac25f/contentassets/70445c77678f46db9a850528cb7398d5/criteria-document_006_laundry-detergents-and-stain-removers-006_english.pdf

	added.	
Primary packaging	‘packaging’ means items of any materials that are intended to be used for the containment, protection, handling, delivery or presentation of products and that can be differentiated into packaging formats based on their function, material and design, including: (a) items that are necessary to contain, support or preserve the product throughout its lifetime without being an integral part of the product which is intended to be used, consumed or disposed of together with the product; In the context and for compliance with this EU Ecolabel criteria, items potentially falling under clause (a) definition that are part of a single dose unit (product and wrappers/films (or equivalent)), that are water-soluble and and that are not removed prior to the product use for washing/cleaning purposes, shall not be regarded as packaging but rather as part of the product formulation. Conversely, items potentially falling under clause (a) definition that are part of a single dose unit (product and wrappers/films (or equivalent)), that are water-insoluble and that are removed prior to the product use for washing/cleaning purposes, shall be regarded as packaging but not as part of the product formulation (b) components of, and ancillary elements to, an item referred to in point (a) that are integrated into the item; (c) ancillary elements to an item referred to in point (a) that are hung directly on, or attached to, the product and that perform a packaging function without being an integral part of the product which is intended to be used, consumed or disposed of together with the product; etc; (d) items designed and intended to be filled at the point of sale, provided that they perform a packaging function; (e) disposable items sold, filled or designed and intended to be filled at the point of sale, provided that they perform a packaging function; ‘sales packaging’ also known as ‘primary packaging’, means: packaging conceived so as to constitute the smallest sales unit of products and packaging to the final user or consumer at the point of sale.	COMMISSION DECISION This definition was updated and others were proposed to provide clarity in criteria interpretation and also to align with the revised Packaging and Packaging Waste Directive (PPWD) ([69]), which set the basis for packaging-related terminology. The terms *“packaging”* and “*sales packaging*” that are fully/partially adopted. Work in-progress The term "*primary packaging*" is fully adopted from Blue Angel ([70]). Also, *“sales packaging”* definition inspired how to modify that of PPWD for EU Ecolabel purposes. In-force
Nanomaterials	means a natural, incidental or manufactured material consisting of solid particles that are present, either on their own or as identifiable constituent particles in aggregates or agglomerates, and where 50 % or more of these particles in the number-based size distribution fulfil at least one of the following conditions: (a) one or more external dimensions of the particle are in the size range 1 nm to 100 nm; (b) the particle has an elongated shape, such as a rod, fibre or tube, where two external dimensions are smaller than 1 nm and the other dimension is larger than 100 nm; (c) the particle has a plate-like shape, where one external dimension is smaller than 1 nm and the other dimensions are larger than 100 nm. In the determination of the particle number-based size distribution, particles with at least two orthogonal external dimensions larger than 100 μm need not be considered. However, a material with a specific surface area by volume of < 6 m^2/cm^3 shall not be considered a nanomaterial.	Alignment with the latest EU Commission Recommendation on the definition of nanomaterial (2022/C 229/01) ([71]) that updated Recommendation 2011/696/EU In-force

[69] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC. COM/2022/677 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0677

[70] DE-UZ 202. Laundry detergents. Basic Award. V1.1 September 2023. . https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20202-202201-en%20criteria-V1.1.pdf

[71] Commission Recommendation of 10 June 2022 on the definition of nanomaterial (OJ C 229, 14.6.2022, p. 1–5) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022H0614(01).

3.2. Review of relevant ISO type I ecolabelling schemes and other sustainability standards for detergents

This section addresses scope and products categorization across main ecolabel schemes and other sustainability standards addressing detergent and cleaner products. It firstly identifies and presents brief descriptions of their main traits, to then provide some closing statements on how these relate to existing EUEL criteria.

The International Organization for Standardisation (ISO) identified three types of voluntary labels:

- Type I: voluntary, multiple-criteria-based, third-party programme that awards a licence that authorises the use of environmental labels on products indicating overall environmental preference for a product within a particular product category based on life-cycle considerations. EUEL criteria fall under this category. ISO 14024 lists the guiding principles for Type I Ecolabels.
- Type II: self-declared environmental claim, i.e. environmental claim that is made, without independent third-party certification, by manufacturers, importers, distributors, retailers or anyone else likely to benefit from such a claim, in line with ISO 14021.
- Type III: voluntary programmes that provide the quantified environmental data of a product, under pre-set categories of parameters set by a qualified third party and based on life-cycle assessment, and verified by that or another qualified third party in line with ISO 14025

On the European market, the Nordic Swan ([72]) and Blue Angel ([73]) are also ISO 14024 type I ecolabels and are taken as a key point of reference due to the broad correspondence with EU Ecolabel. These schemes developed criteria for detergents product group categories and their scopes largely reflect that of the EUEL correlative product groups, as shown in Table 5.

Nordic Swan and Blue Angel ecolabel schemes have been chosen as key points of reference due to their well-established reputation and high uptake in the European market. The Nordic Swan Ecolabel, established in 1989, is supported by all Nordic governments and is the most recognized environmental label in the region, with over 25,000 products and services being sold in the Nordic countries. It is also a founding member of the international network for ISO 14024 Type 1 ecolabels, the Global Ecolabelling network (GEN). Similarly, the Blue Angel, established in 1978, has been the ecolabel of the German federal government for more than 45 years and has awarded over 30,000 products and services from more than 1,600 companies. Both ecolabels are ISO type I, like the EU Ecolabel, and are well-established and highly recognized in the European market. Their long-standing presence and widespread use make them suitable for comparison with the EU Ecolabel.

Table 5. Scope of relevant ISO Type I ecolabel schemes (Nordic Swan and Blue Angel), including differences with the scope of the EUEL criteria for detergents.

Type I Ecolabel	Scope	Major differences (referring to the EUEL scope)
	Laundry detergents (LD)	
Nordic Ecolabelling for Laundry detergent and stain removers, v.8.6 ([74])	Laundry detergents and stain removers in powder, tablets, liquids, gel or any other form, used for washing of textiles, and are intended to be used in household machines, but not excluding the use in launderettes and common laundries. Excluded from the scope: — Products that are exclusively used for handwashing or products that are dosed via carriers such as sheets, cloths or other materials. — Fabric softeners or multiple function detergents such as "2 in 1" products with both detergent and fabric softening effects/claims.	EU Ecolabel only covers pre-treatment stain removers and requires effective washing temperature at or below 30°C Nordic Swan excludes products to be used exclusively for hand washing.

[72] https://www.nordic-swan-ecolabel.org/ (Accessed 19/01/2024)
[73] https://www.blauer-engel.de/en (Accessed 19/01/2024)
[74] https://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=006. (Accessed 19/01/2024)

Type I Ecolabel	Scope	Major differences (referring to the EUEL scope)
	— Products for professional laundries	
Bluea Angel for Laundry detegrents DE-UZ 202, v.1 ([75])	All laundry detergents, laundry detergent boosters and pre-treatment stain removers in powder, liquid or other form that are marketed and used for the washing of textiles principally in standard household washing machines but not excluding their use in launderettes and their additional use as a hand washing laundry detergent. Pre-treatment stain removers are stain removers for the direct spot treatment of textiles (before washing in the machine) but not including stain removers dosed in the washing machine or stain removers dedicated to other uses besides pre-treatment. Laundry detergent boosters are laundry detergent additives containing bleach that are added alongside the laundry detergent to improve the performance of the main washing cycle in the washing machine. Excluded from the scope of these Basic Award Criteria are: — Portioned laundry detergent in water-soluble films — Stain removers combined with carriers such as sheets, cloths or other materials — Stain removers for use without subsequent washing e.g. for carpets and upholstered furniture — Products containing microorganisms that have been intentionally added by the manufacturer	Laundry detergent boosters are not covered by the EUEL. Products containing microorganisms are specifically excluded. The EUEL does not specifically mention the inclusion of handwashing laundry detergent
Industrial and institutional laundry detergents (IILD)		
Nordic Ecolabelling for Laundry detergent for professional Use, v.3.12 ([76])	Products intended for washing fabrics in water, and that are intended for use by large-scale consumers and professional users. The criteria apply to both complete powders and complete liquid laundry detergents, and multi-component systems (where rinsing agent and stain remover may also be included). Fabric softeners and stain removing agents may also be Nordic Swan Ecolabelled when they are constituents of a multi-component system. Only products that are primarily intended for washing in soft water (0-6 °dH) may be awarded the Nordic Swan Ecolabel. Multi-component systems are detergent systems based on the use of various components to form a complete detergent, a stock solution, or a wash programme for automatic dosing. This type of system may include several products, such as pre-wash agent, main detergent, wash booster, bleaching agent, fabric conditioner disinfectants, neutralizing agents and detergent for delicate fabrics. In cases where the ingredients/raw materials are mixed in an automated process in direct connection to the washing machine, the ingredients/raw materials are considered as subcomponents in a multi-component system. The criteria apply to all products that come into contact with the laundry during washing, but do not apply to special impregnating agents that have, for example, a water-repelling or flame-retardant function. Dyes for colouring textiles are not covered by this product group. Products with specifically added microorganisms are also not included in the product group definition.	Only products primarily intended for washing in soft water (0-6°dH).
Dishwasher detergents (DD)		

75 https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20202-202201-en%20criteria-V1.1.pdf (Accessed 19/01/2024)
76 https://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=093 (Accessed 19/01/2024)

Type I Ecolabel	Scope	Major differences (referring to the EUEL scope)
Nordic Ecolabelling for Dishwasher detergents and rinse aids v.7.3 ([77])	Dishwasher detergents and rinse aids for household machines. The rinse aid may be integrated into the product or it may be a separate product. <u>Dishwasher detergents for professional use cannot be labelled</u> under these criteria. Cleaning agents for dishwashers cannot be labelled under these criteria.	Professional use is explicitly excluded whereas EUEL allows the DD for household dishwashers and automatic dishwashers for professional use of the same size and usage as that of household dishwashers.
Blue Angel for dishwasher detergents DE-UZ 201 ([78])	Detergents for dishes (monofunctional, multifunctional and rise aids) that are exclusively designed for use in automatic household dishwashers and/or for automatic dishwashers designed for commercial use that are comparable in terms of their size and use to household dishwashers.	Largely reflects the EUEL's scope
	Industrial and institutional dishwasher detergents (IIDD)	
Nordic Ecolabelling for dishwasher detergents for professional use, v.3.3 ([79]).	Complete dishwasher detergents, multi-component systems, rinse aids and soaking agents for professional use in <u>institutional and large-scale kitchens, for instrument cleaning in healthcare</u> (products for washer disinfectors and disinfection machines). Professional products are defined as products used in machines that have a wash cycle of maximum 20 minutes, which also includes products intended for hybrid/ semi-professional machines. Products used for instrument cleaning in healthcare may be used in machines that have a wash cycle of maximum 30 minutes. There is no maximum time for soaking agents.	Largely harmonised except for detergents used in washers of medical devices or in special machines for the food industry, which are specifically excluded from the EUEL scope.
	Hard surface cleaning products (HSC)	

77 https://www.nordic-swan-ecolabel.org/criteria/dishwasher-detergents-and-rinse-aids-017/
https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20201-202201-en%20criteria-V3.pdf (Accessed 19/01/2024)
78 https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20201-202201-en%20criteria-V3.1.pdf (Accessed 19/01/2024)
79 https://www.nordic-swan-ecolabel.org/criteria/dishwasher-detergents-for-professional-use-080/ (Accessed 19/01/2024)

Type I Ecolabel	Scope	Major differences (referring to the EUEL scope)
Hand Dishwashing Detergents and Hard Surface DE UZ 194 v.5 (80)	a) All-purpose cleaner; b) Glass cleaner; c) Sanitary cleaner; d) Kitchen cleaner; e) Hand dishwashing detergent; f) Products from the product categories listed above that are designed for commercial/industrial maintenance and cleaning. g) Descaler for coffee machines, fully automatic coffee machines, tea makers, kettles and comparable devices for preparing hot drinks. Excluded from the scope: a) Products that consist exclusively of water. b) Products containing microorganisms, c) All-purpose cleaners sold as ready-to-use (RTU) products. d) Cleaning agents designed for special cleaning purposes or are exclusively suitable for special materials. e) Products designed for special cleaning purposes include e.g. disinfectant cleaners, drain cleaners, polishing agents, basic cleaners, intensive cleaners, floor care products without a cleaning effect (e.g. floor wax), oven cleaners or grill cleaners, descalers, additives for toilet cisterns, toilet tabs, toilet blocks or toilet rim hangers. e) All cleaning agents exclusively suitable for textile surfaces (e.g. carpet cleaners, cleaners for upholstered furniture). f) Exterior cleaning of buildings or vehicles g) Sprays that contain propellant gas. h) Biocidal products	Unlike the EUEL, HSC and HDD are bundled into one criteria document. For HSC the product categories included are largely harmonised with the EUEL. However, Blue Angel exclude all-purpose cleaners that are sold as ready-to-use (RTU).
Nordic Ecolabelling for Cleaning Products, v.6.11 (81)	Products for the professional and domestic market: a) All-purpose cleaners (concentrated and ready-to-use (RTU)) b) Kitchen cleaner c) Sanitary cleaner d) Windows cleaner e) Textile flooring cleaner f) Wash polish/wash-and-wax product g) Facade and patio/terrace cleaner h) Concentrated products containing microorganisms for indoor professional use Products count as products for the professional market if > 80% of sales are to the professional market.	Exterior (e.g. patio cleaners), textile flooring, and wash-polish/wash-and wax products are not addressed by the EUEL scope.
Hand dishwashing detergents (HDD)		

80 https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20194-201807-en%20Kriterien_V5_20-06-22.pdf (Accessed 19/01/2024)

81 https://www.nordic-swan-ecolabel.org/criteria/cleaning-products-026/ (Accessed 19/01/2024)

Type I Ecolabel	Scope	Major differences (referring to the EUEL scope)
Hand Dishwashing Detergents and Hard Surface DE UZ 194 v.5Cleaners DE-UZ 194([82])	Hand dishwashing detergents - a cleaning agent that is designed for washing dishes, drinking glasses, earthenware, cutlery, pots, pans and other kitchen utensils.	Unlike the EUEL, HSC and HDD are bundled into one criteria document.. The individual scope for HDD is largely harmonised with the EUEL.
Nordic Ecolabelling for Hand dishwashing detergents, v.6.6.([83]).	Liquid hand dishwashing detergents for consumer use or for professional use are eligible for the Nordic Swan Ecolabel along with hand dishwashing tablets that are diluted at least 10 times by the user to form the finished product. (The diluted solution is mainly used directly onto dishes.) The main function of the product must be as a hand dishwashing detergent. Ready-to-use products, pre-soaks or products that are intended to disinfect or prevent the growth of microorganisms (e.g. bacteria) are not covered by the product group. Products count as products for the professional market if > 80% of sales are to the professional market.	Largely harmonised EUEL does not specify form (liquid/solid) or format (RTU/Concentrated).

On what follows, an enumeration of other voluntary schemes that were identified as relevant to the existing EUEL criteria is presented, including others beyond the European market:

— Green Seal ([84])

The Green Seal was founded in 1989 and encourages market transformation away from products made with toxic ingredients and resource-intensive practices and toward safer, greener products supported by safer, greener supply chains. Green Seal's cleaning product standards set horizontal foundational criteria (e.g. formula disclosure requirements, concentrated products packaging or chemical requirements, among others) though some unique exceptions may be included for each standard. The detergents products of relevance are distributed across six product categories, which are indicated below.

GS-8 Cleaning products for household use ([85]) - establishes requirements for products that are sold for routine cleaning functions including general purpose, floor, restroom, toilet, glass and carpet cleaning with or without enzymes and microorganisms, more specifically: general-purpose, bathroom, glass, and carpet cleaners marketed specifically for use in households or similar residential settings.

GS-37 Cleaning products for industrial and institutional use ([86]) – establishes requirements for industrial and institutional general-purpose, restroom, glass, and carpet cleaners, includes general-purpose, bathroom, glass and carpet cleaning products that contain enzymes or microorganisms. Industrial and institutional cleaners are those cleaners intended for routine cleaning of offices, institutions, warehouses, and industrial facilities, including consideration of vulnerable populations in institutional settings such as schools, day-care facilities, nursing homes, and other facilities. Includes undiluted and RTU products.

The standard does not include cleaners for household use, air fresheners, or products which make claims as sterilizers, disinfectants, or sanitizers. Floor care products such as waxes are addressed under GS -40 (Floor-care products for industrial and institutional use)

GS-48 Laundry care products for household use ([87])- products that are used to clean, remove stains, and/or otherwise treat the softness, static, or wrinkle characteristics of laundry. The scope is limited to products designed for household use, including laundry detergent products, fine washable laundry

[82] https://produktinfo.blauer-engel.de/uploads/criteriafile/en/DE-UZ%20194-201807-en%20Kriterien_V5_20-06-22.pdf (Accessed 19/01/2024)
[83] https://www.nordic-swan-ecolabel.org/criteria/hand-dishwashing-detergents-025/ (Accessed 19/01/2024)
[84] https://greenseal.org/ (Accessed 19/01/2024)
[85] https://greenseal.org/wp-content/uploads/GS-8_Standard_Ed-5.7_04.2023.pdf (Accessed 19/01/2024)
[86] https://greenseal.org/wp-content/uploads/GS-37_Standard_Ed-7.8_04.2023.pdf (Accessed 19/01/2024)
[87] https://greenseal.org/wp-content/uploads/GS-48_Standard_Ed-1.7_04.2023.pdf (Accessed 19/01/2024)

detergent products (for delicates), stain and spot removing products (pre-treatment and stand-alone), laundry additives (bleaching and softening products), fabric softener (liquids and sheets), anti-static products (liquid and sheets), fabric refresher products, anti-wrinkle products, laundry prewash products, laundry starch/sizing/fabric finish products, and combination products that may serve several of these functions.

It includes fabric protectant products but excludes impregnating products with flame retardant or waterproofing properties, carpet or upholstery cleaning and maintenance products, footwear or leather care products.

GS-51 Laundry care products for industrial and institutional use ([88])- products that are used to clean, remove stains, and/or otherwise treat the softness, static, or wrinkle characteristics of laundry. The scope is limited to laundry detergent products (home-style detergent, complete detergent, or multi-component system) for industrial and institutional use, as well as pre-treatment stain and spot removing products, softening products (liquids and sheets), laundry additives (bleaching, softening, sour, antichlor, and alkali booster products), anti-static products (liquid and sheets), fabric refresher products, anti-wrinkle products, laundry prewash products, and laundry starch/sizing/fabric finish products.

Excluded from the scope are: the facility where laundry care occurs, such as a dry cleaner or commercial laundry, as well as any equipment used (e.g., ozone generation/use). The solvent used at a dry cleaner is considered part of the process; therefore, it is also excluded. Products that contain enzymes and are sold in, or designed for use in, spray packaging are excluded from the scope. The fabric protectant products are included except for impregnating products with flame retardant or waterproofing properties. Carpet or upholstery cleaning and maintenance products or footwear or leather care products are neither addressed.

GS-52 Specialty cleaning products for household use ([89]) - specialty cleaning products intended for household use, which might contain enzymes or microorganisms, including (but is not limiting to): boat cleaning products; boat wax, polish, sealant, or glaze products; deck, siding, and outdoor furniture cleaning products; dish cleaning products (automatic and hand); furniture polish products; graffiti remover products; holding tank treatment products; metal cleaning products; motor vehicle cleaning products; motor vehicle wax, polish, sealant, or glaze products; motor vehicle dressing products; waterless motor vehicle cleaning products; tire and wheel cleaning products; motor vehicle windshield washing fluid; odour remover products; optical lens cleaning products; oven cleaning products; drain additive/cleaning products; recreational vehicle tank treatment products; septic tank treatment products; chewing gum remover; upholstery cleaning products; antimicrobial pesticide products, and other household cleaning products sold for specialty uses.

Excluded from the scope are products that contain enzymes and are sold in, or designed for use in, spray packaging and those intended for industrial and institutional use, printing press cleaning products, laundry care products, air fresheners, or products that serve as sporicides, sterilizers, or used to sterilize critical and semi critical medical devices and equipment are also excluded.

GS-53 Specialty cleaning products for industrial and institutional use ([90])– speciality cleaning products intended for industrial and institutional use, which might contain enzymes or microorganisms, including (but is not limiting to): boat cleaning products; boat wax, polish, sealant or glaze products; deck, siding, and outdoor furniture cleaning products; dish cleaning products(automatic and hand);furniture polish products; graffiti remover products; holding tank treatment products; metal cleaning products; motor vehicle cleaning products; motor vehicle wax, polish, sealant, or glaze products; motor vehicle dressing products; waterless motorvehicle cleaning products; tire and wheel cleaning products; motor vehicle windshield washing fluid; odour remover products; optical lens cleaning products; oven cleaning products; drain additive/cleaning products; recreational vehicle tank treatment products; septic tank treatment products; upholstery cleaning products; printing press cleaning products; chewing gum remover products; adhesive remover products; rust stain remover products; dishwasher cleaning products; electronic cleaning products; leather cleaning products; pressurized gas duster products; dusting aid products; antimicrobial pesticide products, and other industrial and institutional use products sold for specialty uses.

This standard does not include products that contain enzymes and are sold in, or designed for use in, spray packaging and does not apply to products intended for household use, laundry care products, air fresheners, or products that serve as sporicides, sterilizers, or used to sterilize critical and semi-critical medical devices and equipment.

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[88] https://greenseal.org/wp-content/uploads/GS-51-Standard-Ed.1.8-07.2022.pdf (Accessed 19/01/2024)

[89] https://greenseal.org/wp-content/uploads/GS-52_Standard_Ed-2.7_04.2023.pdf (Accessed 19/01/2024)

[90] https://greenseal.org/wp-content/uploads/GS-53_Standard_Ed-2.8_04.2023.pdf (Accessed 19/01/2024)

The standards generally include products with or without enzymes and microorganisms and exclude products that contain enzymes and are sold in, or designed for use in, spray packaging. The Standards GS-8 and GS-37 (routine cleaning products) neither includes antimicrobial pesticide products such as those requiring registration with the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide Fungicide and Rodenticide Act, such as those making claims as sterilizers, disinfectants, or sanitizers ([91]) . By contrast GS-48 and GS- 51 (laundry care), and GS-52 and GS-53 (specialty cleaning) include products, which may include antimicrobial pesticide products (e.g., products covered by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)), but excludes products that serve as sporicides, sterilizers, or used to sterilize critical and semi-critical medical devices and equipment.

— Eco Choice Aotearoa (formerly, Environmental Choice New Zealand) ([92])

Eco Choice Aotearoa (formerly Environmental Choice New Zealand - ECNZ) is the official ISO 14024 type I ecolabel of New Zealand. The ECNZ programme started in 1992 and is owned and endorsed by the Ministry for the Environment of the New Zealand Government.

As of September 2022, revision of detergents and cleaning products criteria EC-58-19 ([93]) accommodated all detergents categories under one common product group. The grouping of detergent products is based on intended function, which is allocated to 8 sub-categories, as follows:

1. Hand-dishwashing detergents: All liquid hand dishwashing detergent in which the main function is washing up by hand.;
2. Laundry detergents: All laundry detergents, soaps, bleaches; in powder, liquid or any other form; for washing textiles; which are intended to be used principally in household machines, but not excluding the use in launderettes and common laundries.
3. Machine dishwashing detergents : All detergents intended for use exclusively in automatic domestic dishwashers and all detergents intended for use in automatic dishwashers operated by professional users but similar to automatic domestic dishwashers in terms of machine size and usage.
4. General purpose cleaning products: All general purpose and spray and wipe cleaning products for household use. It includes:
   (a) Glass/window cleaning products, floor cleaning products, carpet cleaning products, bathroom cleaning products and degreasers.
   (b) Deodorisers for eliminating malodour, this does not include air fresheners that work by masking malodour.
5. Commercial and institutional dishwashing detergents: Automatically dosed dishwasher detergents, drying agents and pre-soaking liquid for professional use within institutional and catering facilities.
6. Floor care products: Products that apply (or remove) a film of polymers or wax to floors to ease maintenance and protect the floor. It includes base coat polish, floor polish, wash polish, wash-and-wax care products, polish removers and wax removers.
7. Commercial and institutional cleaning products: Any cleaning product sold for use by the commercial cleaning and property maintenance industry during the routine cleaning of offices, institutions, warehouses and industrial facilities. It includes:
   (a) Glass/window cleaning products, floor cleaning products, carpet cleaning products, bathroom cleaning products and degreasers.
   (b) Deodorisers for eliminating malodour, this does not include air fresheners that work by masking malodour.
   (c) Microbial and biological cleaners for floors, drains and hard to reach areas, and not intended for human contact surfaces.

[91] Antimicrobial pesticide products such as EPA-registered products are included in the Green Seal Standard for Specialty Cleaning Products for Household Use, GS-52.
[92] https://www.ecochoiceaotearoa.org.nz/ (Accessed 19/01/2024)
[93] https://www.ecochoiceaotearoa.org.nz/assets/Specifications/EC-58-19-Detergents-and-Cleaning-Products-.pdf (Accessed 19/01/2024).

8. Commercial and institutional laundry detergents: Products intended for laundering textiles in water by professional or commercial users like institutional/industrial users and other large-scale consumers. The product group covers complete powders and complete liquid detergents as well as a multi-component system. Softeners, rinsing agents and stain removers are also covered by these criteria.

The following products are excluded from this product category:

- Products with the purpose of disinfecting or limiting growth of micro-organisms (e.g. bacteria). This includes deodorisers intended to kill microbes, and act as a disinfectant.
- Products for specialised equipment (e.g. used in food production, dairies, or medical facilities), and products used to clean industrial or production equipment.
- Tablet toilet bowl cleaning products and urinal blocks.
- Floor sealers, spray buffing products, or products designed to remove floor wax solely through abrasion.
- Special impregnating agents for textiles, with a water-repelling or flame retarding function

The main differences from the EU Ecolabel are inclusion of stand-alone softeners (under sub-category commercial and institutional laundry) and product categorisation e.g. general purpose cleaning products vs hard surface cleaners.

— GECA ([94])

GECA is an ISO type I ecolabel and a certification trade mark giving the public assurance that certified goods or services meet a particular standard. The standard developed for cleaning products (CPv3.0-2022) ([95]) applies to the following detergents categories:

- General Purpose Cleaners: includes cleaners for use on tables, benches, tiles, windows, walls, floors and other fixed surfaces, including kitchens;
- Sanitary Cleaners: includes cleaners for use on toilets, bathrooms and other wet areas;
- Laundry Cleaning Agents: includes household laundry detergents including liquids and powders for washing machine or hand clothes washing use;
- Hand Dishwashing Detergents: includes cleaners for manually washing dishes;
- Machine Dishwashing Detergents: includes detergents (liquid and powder) and rinse aids intended for use in automatic dishwashers;
- Fabric Softeners or Multi-Component Detergents: such as stain removers and rinsing agents.

Hong Kong Green Label Scheme ([96])

The Hong Kong Green Label Scheme (HKGLS) is an independent and voluntary ISO 14024 Type 1 label the certification of environmentally preferable products. The HKGLS was first launched in 2000 by the Green Council to promote more sustainable pattern of consumption, encourage manufacturers to supply products with good environmental performance and provide a convenient means for consumers to recognise products that are more environmentally responsible. The detergents product categories (denominated by HKGLS as common cleaning products – group 003) are allocated into seven sub-categories, as follows:

GL-003-001 Laundry Detergent ([97]) - applies to all detergents (powder, liquid or other forms), intended for washing with textiles in washing machines and by hand. The document does not cover separate detergent components (e.g. softeners, whiteners etc) and specific products for carpet washing and/or commercial, industrial washing of textiles;

[94] https://geca.eco/about-us/our-labels/ (Accessed 19/01/2024)
[95] https://geca.eco/standards/cleaning-products-cpv3-0-2022/ (Accessed 19/01/2024)
[96] https://www.greencouncil.org/hkgls (Accessed 19/01/2024).
[97] http://greencouncil.net/hkgls/GL003001_rev2.pdf (Accessed 19/01/2024).

GL-003-002 Detergent for Sanitary Facilities ([98]) - all liquid and solid multifunctional products designed for sanitary facilities including water closets, kitchens, laundry rooms, bathrooms, and showers. The document applies to products for use both by consumers and by professional cleaners. The products may be either disinfecting or non-disinfecting.

GL-003-003 Machine Dishwashing Detergent ([99]) - all machine-wash dishwashing detergents. Rinsing agents are not covered.

GL-003-004 Hand Dishwashing Detergent ([100]) - all hand-wash dishwashing detergents. Rinsing agents are not covered.

GL-003-005 All Purpose Cleaner ([101]) – "all purpose cleaners" in powdered, liquid or other forms.

GL-003-006 Industrial Cleaner ([102]) – all industrial cleaners

GL-003-007 Disinfectant/Disinfectant-Cleaner ([103]) - all disinfectants and disinfectant-cleaners

The criteria for Laundry detergents include detergents for hand washing and, similarly to EU Ecolabel criteria, softeners and specific products for carpet washing are excluded. Furthermore the products with disinfection function are included in the scope.

Good Environmental Choice (Bra Miljöva) ([104])

Good Environmental Choice is an independent eco-label launched in 1990 by the Swedish Society for Nature Conservation (SSNC) and is an example of so-called Type-I labelling: a third-party certification independent of the partners involved. The Good Environmental Choice label for chemical products (Criteria 2018:1) ([105]) is one of the tools used by the SSNC to promote the development of a sustainable society. The aim of the ecolabel is to reduce the use of substances that are hazardous to the environment or human health and encourage the substitution to better alternatives. SSNC´s policy for environmental pollutants has been the basis for the design of the criteria, which can be applied to most chemical products. The criteria impose requirements on all ingredients. In addition, requirements are set on the product's packaging, as well as dosage and user information. The product groups that are subject to product-specific requirements are listed below:

All-purpose cleaners: Products that are used for routine cleaning of floors, walls, interiors, kitchens, stairs, etc.

Bathroom and sanitary cleaners: Products that are used for routine cleaning of toilet seats, sanitary ware, bathroom tiles, shower cubicles, etc.

Bleaching agents: Products that remove stains or discolouration by bleaching.

Dishwasher detergents: Products that are used in dishwashers. Drying agents used in the dishwasher are not included in the definition.

Fabric softeners: Products that are added to textiles to make these softer and to reduce any static properties.

Heavy-duty cleaning agents: Products that are used to clean heavily soiled surfaces. Products specifically intended for the food industry, restaurant kitchens and similar areas of use are not included in the definition.

Laundry detergents: Products that are used for hand washing and machine washing of textiles.

Microorganism-based products: Products with intentionally added microorganisms.

Soft soaps: Products based on saponified vegetable oils.

Stain removers: Products that remove stains or discolouration from textiles.

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[98] http://greencouncil.net/hkgls/GL003002_rev3.pdf (Accessed 19/01/2024).
[99] http://greencouncil.net/hkgls/GL003003_rev2.pdf (Accessed 19/01/2024).
[100] http://greencouncil.net/hkgls/GL003004_rev2.pdf (Accessed 19/01/2024).
[101] http://greencouncil.net/hkgls/GL003005_rev2.pdf (Accessed 19/01/2024).
[102] http://greencouncil.net/hkgls/GL003006_rev2.pdf (Accessed 19/01/2024).
[103] http://greencouncil.net/hkgls/GL003007_rev0.pdf (Accessed 19/01/2024).
[104] https://www.bramiljoval.se/artiklar/about-good-environmental-choice/ (Accessed 19/01/2024).
[105] https://cdn.naturskyddsforeningen.se/uploads/2021/06/16192811/Criteria_Bra_Miljoval_Chemical_Products_2018-1_20181125_0.pdf (Accessed 19/01/2024).

Textile and leather impregnation: Spray products used to protect products of textiles or leather from dirt and grease.

Washing-up liquids: Products that are used for hand washing porcelain, glass, kitchen utensils and similar

Singapore Green Label ([106])

The Singapore Green Label is a type I ecolabel, which was launched by the Ministry of the Environment in 1992. Since 1995 the scheme has been run by the Singapore Environment Council, which is an independently managed non-profit and non-governmental organisation. The green label considers overall product environmental impacts such as raw materials, manufacturing process, health impacts and disposal. The label covers a wide range of products, but does not cover services and processes. In addition there are five levels of certification: basic, bronze, silver, gold and platinum. Products are scored across all five criteria categories and the overall certification level is equal to the lowest score in any category.

Ecocert ([107])

Ecocert is an inspection and certification body founded in France in 1991, accredited by the French Accreditation Committee (Cofrac). Its focus is on sustainable development and organic agricultural products and develops internationally recognised standards for products, systems and services. The product categories include natural cleaning products, paintings and coatings from natural origin and inputs eligible for use in organic farming. The basic principle of the label is to protect our planet and its resources, to protect and inform the consumer and to reduce unnecessary waste and discharges. In specific, Ecocert natural cleaning products ([108]) guarantees: environmentally friendly production and processing processes; promotion of the use of natural or organic ingredients; responsible management of natural resources; and the prohibition of most of petrochemical ingredients

US EPA Safer Choice ([109])

Safer Choice is an initiative, which helps consumers, businesses, and purchasers to find cleaning products that perform and contain ingredients that are safer for human health and the environment. Safer Choice is an EPA Pollution Prevention (P2) program, which includes practices that reduce, eliminate, or prevent pollution at its source, such as using safer ingredients in products. EPA's Safer Choice label collects information on chemicals that are safer alternatives under Safer Chemical Ingredients list ([110]). The chemicals included in the list are categorised by their functional-use class and grouped (colour coding) based on their chemical safety, which had been assessed against Criteria for Safer Chemical Ingredients ([111]). All in all, chemicals are grouped into following functional groups:

- Antimicrobial Actives;
- Chelating Agents;
- Colorants;
- Defoamers;
- Emollients;
- Enzymes and Enzyme Stabilizers;
- Fragrances;
- Oxidants and Oxidant Stabilizers;

[106] https://sgls.sec.org.sg/ (Accessed 19/01/2024)
[107] https://www.ecocert.com/en/home (Accessed 19/01/2024)
[108] https://www.ecocert.com/en/certification-detail/ecological-household-products-natdet (Accessed 19/01/2024)
[109] https://www.epa.gov/saferchoice (Accessed 19/01/2024)
[110] https://www.epa.gov/saferchoice/safer-ingredients#searchList (Accessed 19/01/2024).
[111] https://www.epa.gov/saferchoice/standard#tab-2 (Accessed 19/01/2024).

- Polymers;
- Preservatives and Antioxidants;
- Processing Aids and Additives;
- Skin Conditioning Agents;
- Solvents;
- Specialized Industrial Chemicals;
- Surfactants;
- Uncategorized;

In addition to the product and ingredient criteria in the Safer Choice Standard, supplemental requirements are necessary to ensure that certain classes of products achieve best-in-class status and qualify to carry the Safer Choice label. Some of the changes proposed under current Safer choice revision ([112]) actually imply further product-level requirements, as the addition of *Special product classes* (like *Microorganism-based products)* and *Special product classifications* (like *Direct release products*; e.g. boat cleaners), both of which require tailored assessment ([113],[114]). Another relevant change proposed is the addition of a *Safer Choice cleaning service* standard.

AISE Charter for Sustainable Cleaning ([115])

The Charter for Sustainable Cleaning ([116]) is a voluntary initiative launched in 2005 and managed by the European Soap, Detergent, and Maintenance products industry (A.I.S.E) ([117]). It is an ISO 14025 standard for Type III environmental labels and declarations (LCA based framework) aims to encourage the whole industry to undertake continual improvement in terms of sustainability and also to encourage consumers to adopt more sustainable ways of doing their washing, cleaning and household maintenance. The annual reporting obligation subscribed by all participating members is independently verified and since its introduction the measured key performance indicators (KPIs) have shown the trends on the environmental impact associated with cleaning and maintenance products. Amongst others, these KPIs include information about participating companies (e.g. number, sites), energy consumption and CO_2 emitted, water consumption, waste, packaging (e.g. ratios on plastic and recycled plastic content) and number of products containing the *Advance Sustainability Profiles* (ASPs) logo ([118]). Regarding ASPs, they are set for major product categories and are used to define a set of criteria and thresholds that a product must meet to improve the environmental performance, being these derived from life cycle assessments identifying the most relevant impacts per product category (Golsteijn et al., 2015) ([119])

The Charter for Sustainability Cleaning is aligned with EU circular economy and plastics policy, climate change priorities and with global policy expectations. According to its latest report ([120]), 184 184 companies signed up to the Charter and during 2006-2022 the 193 manufacturing sites have cut energy use by 42% and carbon emissions by 42% per tonne produced, and (amongst others) have decreased overall packaging mass with respect to consumer units delivered and increased the share of recycled plastic packaging (21.4% in 2022).

[112] https://www.epa.gov/saferchoice/standard#changes (Accessed 19/01/2024)
[113] https://www.epa.gov/saferchoice/safer-choice-criteria-formulations-containing-microorganisms (Accessed 19/01/2024).
[114] https://www.epa.gov/saferchoice/standard#directrelease
[115] https://www.aise.eu/our-activities/sustainable-cleaning-78/charter-for-sustainable-cleaning-2874.aspx (Accessed 19/01/2024).
[116] https://www.aise.eu/our-activities/sustainable-cleaning-78/charter-for-sustainable-cleaning-2874.aspx (Accessed 19/01/24)
[117] https://www.aise.eu/about-aise/who-we-are.aspx (Accessed 19/01/2024).
[118] Products which meet the requirements of these ASPs may then use a differentiated 'ASP' logo on pack which signifies not only that the manufacturer is committed to certain sustainability processes at the manufacturing level (the Charter Company Standards), but also that the product itself meets certain advanced sustainability criteria. ASPs are specific to A.I.S.E. product categories, whether in the household or in the professional cleaning & health sector, and companies are verified on their use of the ASP logo on a random basis by A.I.S.E., similarly to the KPI verification.
[119] Golsteijn, L., R. Menkveld, H. King, C. Schneider, D. Schowanek, and S. Nissen, 'A Compilation of Life Cycle Studies for Six Household Detergent Product Categories in Europe: The Basis for Product-Specific A.I.S.E. Charter Advanced Sustainability Profiles', Environmental Sciences Europe, Vol. 27, No. 1, December 2015, p. 23. DOI 10.1186/s12302-015-0055-4
[120] https://www.aise.eu/cust/documentrequest.aspx?UID=531f4fcc-401f-4eec-bc61-92ca2897d41b (Accessed 19/01/2024).

EWG VERIFIED™ ([121])

Since 1993, the Environmental Working Group has tracked product chemical safety including cleaning products. EWG's Guide to Healthy Cleaning ([122]) includes a list of EWG's licensing criteria ([123]) that must be met, such as no ingredients form the EWG's "Unacceptable" list, EWG's standards for ingredient disclosure on the label, provide full transparency to EWG, including fragrance ingredients. Product manufacturers must develop and follow current good manufacturing practices to further ensure the safety of their products. The EWG VERIFIED: For Your Health™ discloses more about product formulations and manufacturing processes, and ingredients that are seldom listed on product labels.

3.2.1. Summary of ISO Type I Ecolabelling Schemes and Sustainability Standards Review

In general, the detergents categorisation across selected schemes relies on product intended function and largely reflects EU Ecolabel segmentation into laundry and dishwasher detergent for professional or commercial (so called industrial and institutional use) or domestic use (household use), and all-purpose cleaners. The products and services provided by the industrial and institutional market cater for specialist cleaning and hygiene needs, where not only is the customer base vastly different but so are the needs required from the products, compared to the market for domestic products. For example, for the IILD users, more care and attention is given to the dosage rates, and often automatic dosing systems are used. This not only cuts down on product wastage and therefore cost but also impacts on the environmental performance of textile washing.

In contrast, users of household detergents are more likely to over-dose with laundry detergent. As a consequence, more stringent user information and dosage requirements are needed for the Ecolabel criteria for domestic compared to industrial and institutional use (Kaps et al.; 2015) ([124]).

Some schemes establish separated product groups for specific end-use products (e.g. floor care products), whereas EU Ecolabel accommodates them under a generic product group hard surface cleaners, which is then further segmented into four product sub-categories. The US Green seal considers use of detergents products which might contain enzymes or microorganisms for domestic and industrial/institutional use and establishes the specific sub-category for special cleaning products (outdoor and indoor) which is allocated under the analysed schemes and is not considered by EU Ecolabel. The GECA Ecolabel and Bra Miljöva introduces the specific category of fabric softeners, which, by contrast are excluded as a stand-alone products from Nordic Ecolabelling and EU Ecolabel (only accepted as constituents of a multi-component system).

No ecolabels were identified which have separate criteria for professional and domestic HDDs. In some cases one criteria document covers both automatic and hand dishwashing detergents, for example the US Green Seal labelling scheme HDDs (automatic and hand dish cleaning products) are included as part of a large product group named 'speciality cleaning product's. For laundry detergents, the US Green Seal Ecolabel covers all categories and types of laundry care products and so, in defining the scope, takes a different approach to the EU Ecolabel. The New Zealand Environmental Choice label for LD also has a wider product scope. For laundry detergents a better comparison are Nordic Ecolabelling and Blue Angel. The main difference in product scope is that the Nordic Swan covers stain removers in any form, whereas EU Ecolabel only covers pre-wash stain removers. For IILD the EU Ecolabel has a similar product group definition to both the Nordic Swan and the Environmental Choice ecolabels. The definitions used in the other ecolabels are more detailed which is likely to help avoid confusion over which products are covered.

On the whole, the information collected confirms the validity and representativeness of the six EUEL detergent products groups, and also corroborate the current product group names. The products included in the scope of different ecolabels vary, with some covering all cleaning products (e.g. US Green Seal)

[121] https://www.ewg.org/ewgverified/about-the-mark.php (Accessed 19/01/2024).

[122] https://www.ewg.org/ewgverified/what-is-ewg-verified-cleaning.php (Accessed 19/01/2024).

[123] https://static.ewg.org/ewgverified/docs/EWGV_LicensingCriteria_Cleaners-23_C03.pdf?_gl=1*1xm74c*_gcl_au*OTI5MDMxNTA3LjE2ODYwNjQ3NjY.*_ga*NjU3MzY5MDM4LjE2ODYwNjQ3NjU.*_ga_CS21GC49KT*MTY4NjA2NDc2Ni4xLjEuMTY4NjA2NTQwNC4wLjAuMA..&_ga=2.165587064.610467078.1686064766-657369038.1686064765 (Accessed 19/01/2024).

[124] European Commission, Joint Research Centre, Kaps, R., Boyano, A., Sims, E., et al., Revision of the European ecolabel criteria for laundry detergents and industrial and institutional laundry detergents : preliminary report, Publications Office, 2015, https://data.europa.eu/doi/10.2791/0171

and others - such as the current EU Ecolabel and Nordic Swan - adopting a more selective approach. There is a large range of cleaning products, and therefore a degree of variation in the scopes of different ecolabels is to be expected. However, some key differences observed lied in the inclusion or exclusion of singular product types, accommodation of microorganism-based detergents, and/or inclusion of softeners (as a separate category).

3.3. Feedback from preliminary stakeholders questionnaire on the scope and definition

This section presents in greater detail the results of the preliminary stakeholders' questionnaire (See chapter 2.2.) on *Scope and Definitions* of existing EUEL criteria. Overall, the stakeholders' survey confirmed the validity of the currents scope and definitions, yet highlight particular aspects within particular product groups for consideration during the revision.

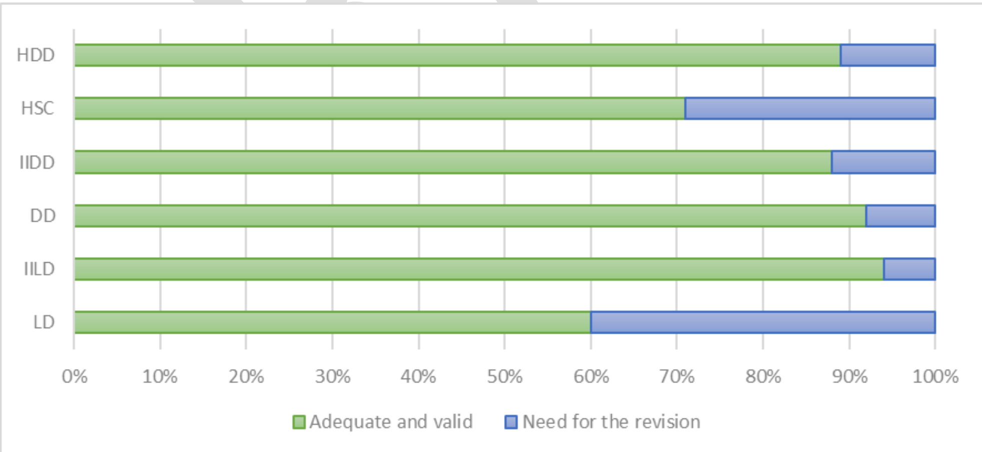
The scope and definitions were considered adequate in most of the product groups (IILD, DD, IIDD, and HDD), as less than 12% of respondents highlighted the need to revise them (See Figure 4). In contrast, revision could be needed for LD and HSC, with 40% and 29%, respectively. Stakeholders suggested:

— LD - inclusion of: fabric softeners, in-wash stain removers, hand washing detergents and alternative product formats (solid, concentrated, dosed by carriers, etc).

— HSC - scope extension to outdoor and vehicle cleaning detergents, toilet blocks, solid products, concentrated products, biocidal and other special cleaning products. Also, possible differentiation between professional and consumer HSC products, and exclusion of the ready-to-use (RTU) products in all purpose cleaner sub-category, in line with other EU Ecolabelling schemes of relevance.

Complementary definitions could also require attention according to 12% of the respondents, with 34% of them having no opinion. The few suggestions for changes in the complementary definitions corroborated information collected beforehand (See Chapter 2 *Background information*), such as the need for updating definitions for nanomaterials, microplastics, impurities and in-going substances.

Figure 4. The validity of the current scope and definitions across the six detergent product groups – based on stakeholders' feedback



Source: Source: La Placa et al.; 2022 ([125])

[125] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

More detailed information on stakeholders' feedback for each product group and definitions is presented below.

Laundry Detergents (LD)

60% of respondents agreed with the accuracy of the existing scope, whereas 40% supported its revision. The respondents asked for an expansion of product categories to satisfy market needs. 24 respondents highlighted the appropriateness to include fabric softener, mainly to provide a consumer with the "greener" option. Seven respondents suggested that in-wash stain removers should be included within the scope and one specified that all stain removers shall be considered. Additional comments concerning the scope of the laundry detergents product group addressed inclusion of:

- Hand washing detergents;
- Solid soaps;
- Bleaching agent;
- Concentrated products that need to be diluted to refill RTU products
- Multicomponent products: laundry detergent/softeners and laundry detergent /stain removers;
- Products dosed by carriers (sheets and balls);
- A new category covering dry cleaning action should be consider to include stain removers for carpets and furniture upholstery.
- Reduce temperature for the laundry efficiency, i.e. "*As the AISE advice to make laundry products efficient at 20°C (at least for liquid laundry), Ecolabel shall ask for 20°C as well (for liquid laundry and maybe for pods also*)".

Industrial and Institutional laundry Detergents (IILD)

The vast majority of respondents (94%) confirmed the validity of the current IILD scope and definition. Similarly to the LD product group, some comments highlighted the relevance to include stand-alone (not part of the multi-component system) fabric softeners and stain removers in the scope.

Dishwasher Detergents (DD)

The vast majority of respondents (92%) confirmed the validity of the current IILD scope and definition. One respondent suggested distinguishing tests intended for domestic machines from machines for industrial use, even if of the same size.

Industrial and Institutional Dishwasher Detergents (IIDD)

The majority of respondents (88%) confirmed the validity of the current IIDD scope and definition. Two respondents called for the editorial improvement (add the clarity to the scope) and for more precise definition of the multi-components system. Only few respondents suggested to include: disinfecting detergents, spray products and a disclaimer about biocide or similar application.

Hard Surface Cleaner Products (HSC)

71% of the respondents agreed with the existing scope for HSC products, whereas. 29% called scope extension and inclusion of the following products (or products categories).

- Floor polish as industrial and institutional products;
- Products for outdoor cleaning such as garden furniture, walls, terraces, roofs;
- Products for ceramic plates;
- Cleaning wipes;
- Drain de-blockers;

- Toilet refreshing blocks;
- Oven cleaner, odour remover, griddle cleaner, ink remover;
- Vehicle cleaning products;
- Solid products;
- Biocidal products;
- Consumer products that contain micro-organism;
- Concentrated formats that need to be diluted at home to create/refill RTU products (e.g. sprays)

A respondent suggests to exclude the RTU product from the all-purpose cleaners category. Others proposed the differentiation between professional and consumer products in line with the Nordic Swan ecolabel and the inclusion of industrial cleaning products.

Hand Dishwasher Detergents (HDD)

The vast majority of respondents (89%) confirmed the validity of the current HDD scope and definition. A few stakeholders who suggested changes in the scope indicated the inclusion of the following products:

- Cleaners for stainless steel pots and pans;
- De-greasers for grills and BBQs;
- Soaking products before cleaning;
- Biocidal products;
- Products with actively working microorganisms;
- Products contain Enzyme for better performance;
- Solid products;
- Concentrated products that need to be diluted to create/refill RTU HDD;

Complementary definitions

A minority (12%) of respondents proposed changes in the existing complementary definitions:

- Definition micro-plastics of nanomaterials need to be updated;
- The micro-plastics definition should be adjusted to the latest definition from ECHA;
- Definition of impurities/ingoing substances need to be updated;
- Any transport aspect should be more clearly excluded from the definition on primary packaging;
- It is not clear if in Heavy-duty detergents only white clothes are considered;
- The RTU definition may need expansion to include products that can be used by consumers to create/refill
- RTU products at home;
- Are the heavy-duty detergents considered only for a white clothes? The definition of heavy-duty detergents is not clear in this point of view;
- Specified the case of tablet which are always put in water: RTU or refill;

Only 8% of respondents considered that additional complementary definitions should be included:

- For HSC, clarify the definition of barrier coating as oppose to mono material packaging.
- For HSC, clarification on VOC and their chemical properties. It must be clearly defined that it is necessary to consider the boiling point of the substances and not of the mixture.

3.4. Conclusive remarks and preliminary scope analysis

3.4.1. Conclusive remarks

This chapter firstly outlines the key findings from previous chapters (3.1, 3.2 and 3.3) to provide perspective and as the basis for the preliminary scope analysis. Then, directions where further research is needed to conclude about whether changes to current EUEL criteria scope should be proposed are provided in the preliminary scope analysis. Note that the full analysis, including conclusions and any potential scope proposals, might be presented in the technical report accompanying the 1st draft criteria proposals.

Directions for potential changes to the EUEL criteria scope and definitions are defined via the collated information on policy background (See chapter 2.3), type I ecolabels and other sustainability standards (See chapter 3.2) and preliminary stakeholders' feedback (See chapter 3.3). The latter were considered as a "call for changes" indicator on how the scope and definitions should be revised, which were carefully analysed and screened against the former aspects (legislation; technical requirements, other ecolabels).

Definitions update must be considered in order to ensure accuracy and appropriateness of criteria implementation and also coherence, primarily with the current legislation but also with other relevant schemes. The definitions identified and proposed for update at this stage are: *Microplastic; Ingoing substance; Impurities; Primary packaging and Nanomaterials*. In addition, the updated definition of detergents in the revised Detergent Regulation is considered and a proposal is made to include as part of the product group names the terminology *Professional* for products used in industrial and institutional contexts.

Despite the EU Ecolabel detergent products segmentation is largely mirrored in other ecolabelling schemes relies, relying on the combination of their intended function and end-user (e.g. LD in domestic or professional premises), still there are differences in the range (or type) of products included (or excluded) from their scope. Some examples mentioned in this report are:

- *In-wash stain removers (LD)* -> in Nordic Ecolabelling scope; out of EUEL and Blue Angel criteria. Also in the Green Seal scope within its category "laundry care products" (laundry detergents, pre-treatment stain removers, softening products, laundry additives, fabric refreshers, or anti-static products).
- Laundry detergent booster (LD) -> in Blue Angel scope (a laundry detergent additive containing bleach that is added alongside the laundry detergent to improve the performance of the main washing cycle in the washing machine
- *Softeners (LD)* -> in Good Environmental Choice (Bra Miljöva) and in Green Seal scope within its category "laundry care products" (laundry detergents, pre-treatment stain removers, softening products, laundry additives, fabric refreshers, or anti-static products).
- *Outdoor/Textile flooring/Wash*-and-wax (*HSC*) -> within the scope of Nordic Ecolabelling, Bra Miljöva and US Green Seal. The latter establish a specific sub-category for special cleaning products (outdoor and indoor).
- *Instrument cleaning in healthcare (IIDD)* -> in Nordic Swan and US Green Seal scope; out of EUEL criteria.
- *Ready-to-use (RTU) products (HSC)* -> all-purpose cleaners are out of Blue Angel scope; in for EUEL and Nordic Ecolabelling, which also include concentrated (undiluted) products.
- *Microorganisms containing products (HSC)*-> Whilst all EUEL, Bra Miljöva and US Green Seal accommodates microorganism-based products, EUEL restricts their use to professional hard surface cleaning products (HSC) while the latter two allow different product categories for domestic and industrial/institutional use (excluding spray packaging products that contain enzymes).

Overall, the main requests for scope expansion from respondents focused in LD and HSC detergent product groups, along the previous lines but also asking for additional formats inclusion (e.g. solid, concentrated, dosed by carriers, etc).

Given the former comments and bearing in mind the focus on assessing proposals for change horizontally to the extent possible, the following thematic areas have been identified as relevant to the preliminary scope analysis:

- *Inclusion of fabric softeners*

- *Inclusion of in-wash stain removers*
- *Temperature of laundry efficiency*
- *Use of detergents that contain microorganisms*
- *The exclusion of the RTU products*

These reflect the directions provided by all inputs analysed so far and depict a prioritisation of the research efforts required to conclude about scope expansion suitability. In what follows, a brief description and analysis of the main aspects for consideration and, whenever feasible by evidences gathered, a conclusion on a course for action is presented. However, in the absence of conclusive evidences (e.g. further stakeholders' inputs are required) the discussion will be continued and concluded in the technical report containing the scientific rationales accompanying the draft criteria proposals.

Whilst the subsequent general observations might indicate the need to revise and enlarge the scope (e.g. inclusion of new products in the market), the feasibility of doing so should be subject to further technical investigation and consultation with stakeholders. This is an integral part of the EUEL criteria revision process, which also should dictate the inclusion or non-inclusion of singular product types (e.g. carpet cleaners or softeners) under corresponding detergent categories.

3.4.2. Preliminary scope analysis

Inclusion of fabric softeners

Fabric softeners, also known as fabric conditioners, come in various forms (e.g. liquid, sheets, pods) and they are added to the washing cycle to reduce the harshness of clothes. Since softeners are added at the end of the washing process, they can be considered as post-washing laundry aids. Unlike detergents, the purpose of fabric softeners is to condition and protect the fabric instead of cleaning it. This conditioning function is achieved through softeners chemical formulation, which amongst others includes compounds like cationic surfactants, which prevent the build-up of electrostatic charge on the fabric surface and reduce fibres friction during the wash, resulting in a softer or fluffier textile surface after washing. A very important class of cation surfactants are the quaternary ammonium cations (quats).

In the market, various quad technologies have emerged consecutively. The chronological order of these technologies includes dihydrogenated tallow dimethyl ammonium quats, imidazoline quats, diamidoamine quats, and ester quats, which gained prominence in the nineties. This progression has been driven by cost considerations and the biodegradability of these molecules, as highlighted by Murphy (2015) ([126]) and the Mishra study of 2007 ([127]). According to the environmental risk assessment report of the HERA project ([128]), the majority of fabric conditioners marketed in Europe consist of three Esterquat groups: TEAQ (triethanol amine quat), DEEDMAC (diethyloxyester dimethylammonium chloride), and HEQ ((Z)-2-hydroxy-3-[(1-oxo-9-octadecenyl)oxy]propyltrimethylammonium chloride). Ester quats have become the dominant form of quat active in the market due to their affordability and excellent biodegradability. The Murphy review of 2015 states that there is currently no foreseeable replacement for ester quats as the main active ingredient in domestic fabric softener products.

Recently, research efforts have shifted towards reducing the concentration of surfactants in softener formulations to mitigate their environmental impact. Studies have demonstrated the possibility of halving the concentration of cationic surfactants, such as esterquats, while maintaining the overall physicochemical properties and performance of the formulations. This has been achieved through the addition of hydrophilic biopolymers derived from the seeds of cyamopsis tetragonalobus (guar gum), a legume polysaccharide, through chemical modification with cationic or hydroxylpropyl groups ([129])([130]). Furthermore, other studies

[126] Murphy, D.S., 'Fabric Softener Technology: A Review', Journal of Surfactants and Detergents, Vol. 18, No. 2, March 2015, pp. 199–204. DOI 10.1007/s11743-014-1658-2,

[127] Mishra, S., and V.K. Tyagi, 'Ester Quats: The Novel Class of Cationic Fabric Softeners', Journal of Oleo Science, Vol. 56, No. 6, 2007, pp. 269–276. DOI10.5650/jos.56.269

[128] https://heraproject.com/ExecutiveSummary.cfm?ID=274 (Accessed 10/06/23)

[129] Oikonomou, E.K.; Berret, J.-F. Advanced Eco-Friendly Formulations of Guar Biopolymer-Based Textile Conditioners. *Materials* 2021, *14*, 5749. https://doi.org/10.3390/ma14195749

have reported the use of silicones ([131]) and some patents reported the use of polysaccharides ([132])([133]), or unsaturated fatty acids ([134]) in softener formulations.

Article 2 of the ongoing revision of the Detergents Regulation acknowledges mixtures intended to modify the feel of fabrics as detergent products that complement the washing process (See Table 4). However, in GECA Ecolabel or US Green Seal fabric softeners are categorized under a specific sub-category while Nordic Swan and EU Ecolabel specifically exclude this product type from the LD scope, allowing fabric softeners only within a multi-component system for IILD.

In the context of the EUEL criteria for detergents, the inclusion of softeners had already been discussed in previous revision processes, adducing that this product is covered by the Detergents Regulation and that, due to its high market share, a significant environmental positive impact could be achieved by having environmentally friendlier softerner products. However, arguments against its inclusion include not having a washing function, the implications of this additional chemical load on human (skin) and environmental toxicity ([135]) and how to differentiate environmentally "best-in-class" softeners, as formulations might be very similar with main product differentiation arising from the fragrances used.

Given the former, there are various crucial aspects that require further analysis and information from key stakeholders. It is important to understand the level of market adoption and penetration of the new softener technologies. Additionally, acquiring information about the diverse fabric softeners formulation currently available in the market. These information holds particular significance for the EU Ecolabel, which aims to identify products that tend to be in the 10-20% of the most environmentally friendly within their category. However, at present, we lack sufficient data to make such assessment.

Regardless of the added benefits of fabric softeners and based on the outcome of previously mentioned aspect for further assessments, the authors wish to verify with stakeholders whether stand-alone softeners are truly necessary for cleaning efficiency and if auxiliary cleaning products with mainly aesthetic functions should or should not be included in the scope of laundry detergents.

Inclusion of in-wash stain removers

In-wash stain removers are a type of detergent designed for soaking (pre-washing), rinsing, or bleaching fabrics or dishes, as defined by the revised Detergents Regulation (Art 2(1)). The current scope of the laundry detergents under the EUEL only includes pre-treatment stain removers. However, the scope of industrial and institutional laundry detergent (IILD) encompasses various products like fabric softeners, stain removers, and rinsing agents, which are tested as a whole, as reported in Table 3.

Different ecolabeling organizations have varying approaches to stain removers. For instance, the Nordic Ecolabel includes all types of stain removers in domestic and institutional laundry detergent categories, while Eco Choice Aotearoa includes them in the scope of commercial and institutional laundry detergents. Blue Angel defines laundry detergent boosters and pre-treatment stain removers primarily for standard household washing machines, but they can also be used for hand washing. Good Environmental Choice (Bra Miljöva) has a specific product category for stain removers (products that removes stain and discolouration from textile).

The active ingredients in stain removers, like laundry detergents, consist of emulsifiers and surfactants, such as anionic surfactants, with additional solvents (to dissolve stain e.g. alcohol). Stain removers generally contain also enzymes, bleach, preservatives, colorants, and fragrances, depending on their type and usage.

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[130] Oikonomou EK, Christov N, Cristobal G, Bourgaux C, Heux L, Boucenna I, Berret JF. Design of eco-friendly fabric softeners: Structure, rheology and interaction with cellulose nanocrystals. J Colloid Interface Sci. 2018 Sep 1;525:206-215. doi: 10.1016/j.jcis.2018.04.081.

[131] Kumar, A.; Trambitas, A.; Peggau, J.; Dahl, V.; Venzmer, J.; Gambaryan-Roisman, T.; Kleinen, J. Charge and size matters—How to formulate organomodified silicones for textile applications. Colloids Surf. A 2019, 560, 180–188

[132] Zhang, H.Z.; Jin, D.W.; Christov, N.; Cristobal, G. Compositions Comprising Quat and Polysaccharides. International Patent Application No. WO 2017/101798 A1, 22 June 2017

[133] Zhang, H.Z.; Christov, N.; Jin, D.W. Composition Comprising a Quaternary Ammonium Compound, a Cationic Polysaccharide and a Nonionic Polysaccharide. International Patent Application No. WO 2015/192971 A1, 23 December 2015

[134] Hsu, F.; Killinger, D.L.; Raders, S.M.; Sabelko, J.J.; Ming, Y.; Zhu, Y.; Brijmohan, S. Esterquat Free Liquid Fabric Softener Compositions Containing Unsaturated Fatty Acid Soap. International Patent Application No. PCT/US2018/057671 WO/2019/084375, 5 February 2019 https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2019084375

[135] Gonçalves, R.A., K. Holmberg, and B. Lindman, 'VIP Cationic Surfactants: A Review', Journal of Molecular Liquids, Vol. 375, April 2023, p. 121335. DOI 10.1016/j.molliq.2023.121335

Considering the inclusion of in-wash stain removers in washing machines, it is essential to assess the impact of introducing additional and potentially unwanted chemicals into the washing process. Pre-treatment stain removers are applied in limited doses directly to difficult stains, making their contribution to the overall chemical load relatively minor whilst maximixing cleaning performance.

Furthermore, in-wash stain removers are auxiliary products that are generally not considered strictly necessary to achieve clean laundry under normal and routine conditions. Hence, the justification for their additional chemical load and environmental impact should be subject to further examination.

To include in-wash stain removers under the revised laundry detergent product group scope, a comprehensive assessment should focus primarily on the dosage and chemical composition of these auxiliary products. Gathering additional information during stakeholders' consultations and meetings will be crucial for making well-informed decisions.

Temperature of laundry efficiency

In existing EUEL criteria for detergents, water temperature is considered mainly via the criteria *Fitness for use* (temperature at which detergent products performance is tested) and *User information* (a text in the primary packaging indicates the importance of the correct dosage and the lowest recommended temperature to minimise resource conssumption). The EU Ecolabel scheme cannot influence the choice of energy source used for water heating (nor the device consuming such energy), but can influence the water temperature at which products are effective during the usage phase, always within the technical constraints imposed by devices used (if applicable). All detergents products (thus groups) do not have the same requirements with regards to water temperature - Some might claim to work effectively with cold water (e.g. LD) while others require high temperatures (e.g. IILD).

In general terms, there is a trend in developing products that work at lower temperatures, but this doesn't guarantee a lower washing temperature as it majorly depends on user behaviour, an aspect difficult to influence. Nevetherless, producers could ensure that their products are effective at lower temperatures and inform about the environmental impacts of such products to build user confidence. Even if user behaviour is favourable and ensures appropriate use of these type of products, there might still be trade-offs between benefits on decreasing energy usage versus changes in the chemical formulation profile to ensure performance at such lower temperature.

In the existing EUEL criteria, the temperature at which LD have to be efficient is 30 °C or below and the intention is to understand the suitability of proposing its reduction to 20 °C, considering for this trade-offs identified. This proposal needs to be verified against and requires further information about market performance (availability), life cycle considerations (energy saving potential) and formulation profile of products effective at low temperature.

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Use of detergents that contains microorganisms

The products containing microorganism (MBCPs) replace chemical-based active ingredient by various strains of microorganisms (e.g. several *Bacillus* species) while achieving the same performance, which indeed might be an interesting alternative to reduce environmental impact of detergent and cleaning products. However, routinely using MBCPs as domestic products also means higher likelihood human exposure to the micro-organisms contained within. Microbiological hazards may arise from: the possible presence of unwanted microbes and/or pathogens ([136]); their sensitisation properties ([137]); or due to the potential for frequent, high and direct exposure to microorganisms ([138]). Microorganisms may cause intoxication as some species produce toxins or harmful metabolites, which are able under certain condition to damage host tissues and disable the

[136] These effects may be either symptomatic or asymptomatic. Asymptomatically infected persons have no symptoms, but they can spread a microbiological hazard among a population. Symptomatic effects may be local or systemic. Local effects of exposure to a microorganism may include irritation and sensitisation; potential systemic effects may include infections and intoxications.

[137] The hazard can be caused to some extent by microbial enzymes and/or other components of microbial cells and spores.

[138] Boyano A., Kaps R., Medyna G., Wolf O. (2016): JRC Technical Reports – Revision of six EU Ecolabel Criteria for detergents and cleaning products, Final Technical Report, European Commission. Available at: http://susproc.jrc.ec.europa.eu/detergents/docs/Technical%20background%20report.pdf

immune system. The production of these toxins can occur not only in the product itself, but also after uncontrolled disposal to the environment. Some microorganisms may carry antimicrobial resistance genes that are mobile and can be transmitted among species, thus rendering them potentially hazardous ([139]). This is why the use of MBCPs in detergent products must be ahead of all a subject of product biological safety and safety precautions that must be taken during the use phase. The EU in-place applicable legislation (REACH, CLP, BPR) does not provide clear rules to address risk management of microorganisms in detergents and the ongoing legislative development with regards to initiative "*one substance, onse assessment*"([140]) might impact on which entities would be responsible for such safety assessment instead of the current EU Scientific committes (e.g. SCHER; SCCS).

So far, cleaning products have been the main niche with regards to MCPs. Indeed, the growing market distribution of these products within the HSC category shows consumer interests in the MBCPs products (Spok and Klaude, 2009) ([141]). Common claims associated with these products in supermarkets and online are "environmentally-friendly", "biodegradable", "non-toxic" and "green cleaning products". Arvanitakis et al. (2017) ([142]) based on searches of publicly available information sources, surveyed and categorised the currently known types of MBCPs, their uses, and the microorganisms that are their active ingredients.

The current EU Ecolabel criteria for the HSC includes taxonomic designation, scientific validation, labelling/user information, and efficacy for MBCPs used. Good Environmental Choice (Bra Miljöva) includes MBCPs products in the scope of detergents designating specific sub-category for the microorganism-based products. The Green Seal allocates MBCPs products across cleaning products categories and requires that all biologically-based cleaning and degreasing products be manufactured in a facility that has a documented quality control/quality assurance system. Nordic Ecolabelling specifically excludes products that contains microorganism from the HSC scope.

There are two reasons that could support the inclusion of MPCs also as part of the EUEL LD product group. On the one hand. the revised Detergents Regulation includes microorganisms as an ingredient in its "Detergents" definition (Art 2 (1), thus microbial MBCPs are indirectly within its scope. On the other hand, technological innovations points toward the potential feasibility of using microorganisms (bacteria) during the laundry washing process to break-down organic matter and remove/detach stains from fabrics, which could potentially imply not only lower chemical load (associated with detergent formulation) but also lower load for treatment at the wastewater treatment plants (already part of the organic matter degradation happened). At this moment evidences consulted can't support the inclusion of microorganism within LD product group but it certainly appears as an innovation trail whose upscaling should not be precluded. In order to conclude in any of the previous two regards and given the sensitivity associated with innovations, further stakeholder's consultation, especially with industry, are required

The exclusion of the RTU products

EU Ecolabel, Nordic ecolabelling and US Green Seal accommodate RTU and concentrated products, whereas Blue Angel excludes the use of all-purpose cleaners sold as ready-to-use products. The exclusion of the RTU products from the scope and so focusing on the concentrated products must be carefully checked against the chemical requirements of EU Ecolabel Regulation, more precisely Art 6(6) and 6(7).

The consumer market, especially for all-purpose cleaners, sanitary cleaners, toilet cleaners, and kitchen cleaners, is highly represented by RTU products. Thus, the exclusion of ready-to-use (RTU) products from the EU Ecolabel may significantly reduce the number of eligible products and would lead to the exclusion of a

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[139] VKM, Elisabeth Henie Madslien, Nana Asare, Øivind Bergh, Erik Joner, Pål Trosvik, Siamak Yazdankhah, Ole Martin Eklo, Kaare Magne Nielsen, Bjørnar Ytrehus, Yngvild Wasteson (2019). Current knowledge of the health and environmental risks of microbial based cleaning products. Scientific opinion of the Panel on Microbial Ecology of the Norwegian Scientific Committee for Food and Environment. VKM report 2019:09, ISBN: 978- 82-8259-325-0, ISSN: 2535-4019. Norwegian Scientific Committee for Food and Environment (VKM), Oslo, Norway

[140] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6413 (Accessed 19/01/24)

[141] Spök, A., Klade, M., 2009. Environmental, health and legal aspects of cleaners containing living microbes as active ingredients", results and conclusions of a study commissioned by the Austrian Federal Ministry of Agriculture, Forestry, Environment andWater Management. http://www.ifz.at/Media/Dateien/Downloads-IFZ/Publikationen/Electronic-Working-Papers/IFZ-EWP-3-2010 viewed 21 April 2

[142] Arvanitakis, G. Temmerman, R. Spök, A. 2017. Development and use of microbial-based cleaning products (MBCPs): Current issues and knowledge gaps. Food and Chemical Toxicology 116, Part A 3-9, doi.org/10.1016/j.fct.2017.12.032

large portion of the market, reducing the environmental benefits achieved through the criteria for this particular products category.

When evaluating these products, it is important to consider their advantages and disadvantages. RTU products offer the main advantage of providing users with ready-to-use solutions that require no further dilution before application, eliminating the need for measuring or mixing. They are designed to be user-friendly, requiring minimal effort or knowledge for effective use, which helps mitigate the issue of detergent overdosing and potential chemical releases. However, the main disadvantage of RTU products is related to their transport and in particular, the higher water transport compared to undiluted products, affecting their overall environmental footprint. Another concern relates specifically to RTU spray products and their health implications, as exposure to sprays differs from diluting concentrated products. To address these disadvantages, potential solutions include selling concentrated refills alongside RTU products, allowing multiple dilutions, reducing transportation, and packaging waste. Additionally, specific provisions can be implemented in the criteria to address aerosol reduction mechanisms for spray products. Conducting technical investigations and engaging with stakeholders would be necessary to assess the environmental impacts of RTU products throughout their life cycle compared to undiluted products. Furthermore, gathering information on their formulations and evaluating their effects on criteria such as toxicity to aquatic organisms and in particular CDV (critical dilution volume), organic substance content and biodegradability, phosphorus content, and VOC content would be crucial. Additionally, evaluating the feasibility of implementing new provisions, as suggested above, should be considered within the criteria revision.

4. Market analysis

4.1. Introduction

The aim of the market analysis is to understand the market maturity and segmentation, to then identify any significant changes or development that need to be reflected in the EU Ecolabel criteria to match the 10-20 % best environmentally performing products, outlining the necessary market knowledge to do so.

This chapter focuses on the detergents products under the scope of any of the following six different EU Ecolabel (EUEL) criteria related to detergents:

— Dishwasher detergents (Commission Decision 2017/1216/EU) ([143]);

— Industrial and institutional dishwasher detergents (Commission Decision 2017/1215/EU) ([144]);

— Laundry detergents (Commission Decision 2017/1218/EU) ([145]);

— Industrial and institutional laundry detergents (Commission Decision 2017/1219/EU) ([146]);

— Hard surface cleaning products (Commission Decision 2017/1217/EU) ([147]);

— Hand dishwashing detergents (Commission Decision 2017/1214/EU) ([148]).

This chapter analyses the market associated to these six detergents product groups, aiming at characterizing, quantitatively and qualitatively, the market data and information associated with each detergent product groups under EUEL scope. In order to facilitate independent and coherent reading, it is structured in sections and analysed according to following product grouping:

— LD Laundry Detergents (including Industrial and Institutional Laundry Detergents).

— DD Dishwasher Detergents (including Industrial and Institutional Dishwasher Detergents).

— HDD Hand Dishwashing Detergents.

— HSC Hard surface Cleaning Products.

Within this chapter on market analysis, each section is structured and provides information about:

- *Production and trade*: figures on imports/exports; production; apparent consumption; showing economic relevance, especially at European level;
- *Market structure and sales*: outline of market segmentation and analysis of the retails sale figures split by relevant sectors/ product types;
- *Key players*: manufacturers; brands; supply-chain structure;
- *Trends:* relevant trends on innovative products, consumer behaviour and EU Ecolabel statistics (licenses, products);
- *Summary*: capturing the main highlights of the product group section.

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[143] Commission Decision (EU) 2017/1216 of 23 June 2017 establishing the EU Ecolabel criteria for dishwasher detergents (OJ L 180, 12.7.2017, p. 31–44) https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2017%3A180%3ATOC&uri=uriserv%3AOJ.L_.2017.180.01.0031.01.ENG

[144] Commission Decision (EU) 2017/1215 of 23 June 2017 establishing the EU Ecolabel criteria for industrial and institutional dishwasher detergents (OJ L 180, 12.7.2017, p. 16–30) https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2017%3A180%3ATOC&uri=uriserv%3AOJ.L_.2017.180.01.0016.01.ENG

[145] Commission Decision (EU) 2017/1218 of 23 June 2017 establishing the EU Ecolabel criteria for laundry detergents (OJ L 180, 12.7.2017, p. 63–78) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1218&qid=1678703370910

[146] Commission Decision (EU) 2017/1219 of 23 June 2017 establishing the EU Ecolabel criteria for industrial and institutional laundry detergents (OJ L 180, 12.7.2017, p. 79–96). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1219&qid=1678704095676

[147] Commission Decision (EU) 2017/1217 of 23 June 2017, establishing the EU Ecolabel criteria for hard surface cleaning products (OJ L 180, 12.7.2017, p. 45–62) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1217&qid=1678704194237

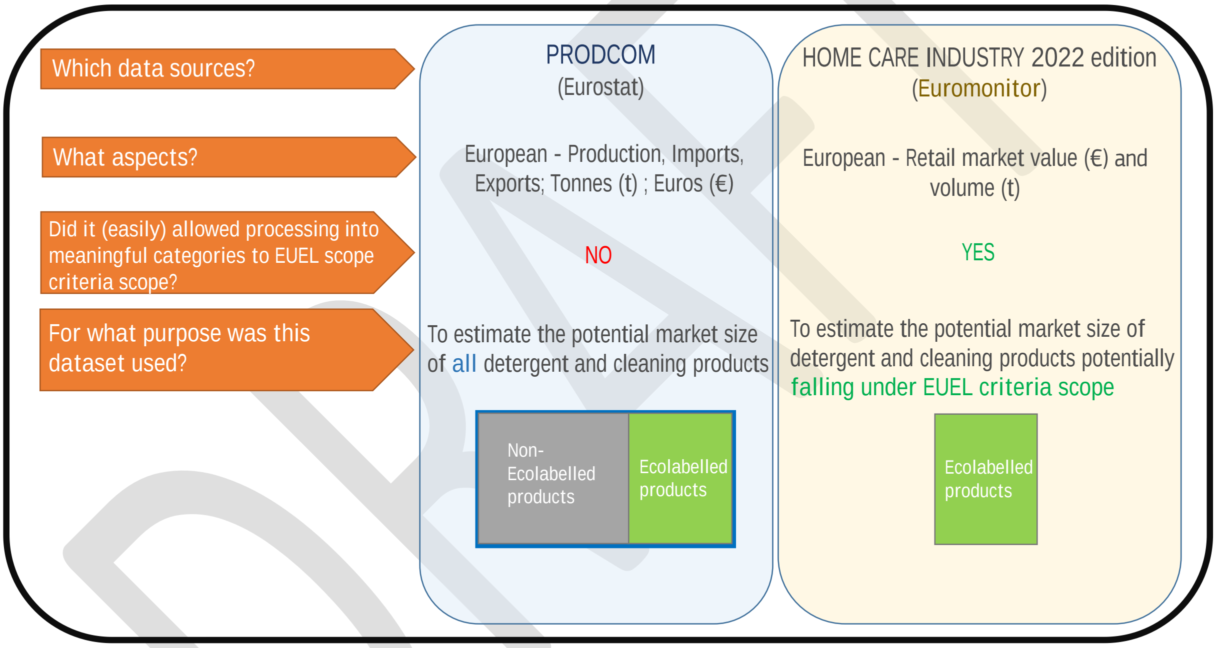
[148] Commission Decision (EU) 2017/1214 of 23 June 2017 establishing the EU Ecolabel criteria for hand dishwashing detergents (OJ L 180, 12.7.2017, p. 1–15) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1214&qid=1678704405604

The methodology used is fundamentally desktop study, sourcing data and information from a variety of literature and statistical databases. In particular, data used to characterize the European ([149]) production/trade and retail market are sourced from PRODCOM and Euromonitor International, Home Care, 2022, respectively. The periods considered for the market data analysis are the last 5 years (historic; 2018-2022) and the next 5 years (forecasting; 2023 -2027).

Note that PRODCOM categorisation mostly stands on products composition and/or form but not on other aspects such as functionality or end-user, thus not being closely aligned with EU ecolabel products scope. In contrast, the scope of Euromonitor's Home Care retail market data available in their Home Care industry edition, 2022, ([150]) considers how and for what the products are used, therefore being this categorisation closer to EU Ecolabel products scope. Consequently, PRODCOM data is used to characterise the overall market for detergent and cleaning products whereas Euromonitor data is used to estimate the market attributable to detergent and cleaning products potentially falling under the EU Ecolabel scope, including relevant sub-groups (segmentation). Box 1 aims to provide clarity on this particular aspects related to market size estimation.

Finally, any further clarification on the methodology or the approach followed that is specific to one of the four product groups, is described and discussed within its corresponding product group section.

Box 1 – Outline of methodological aspects related to market size estimation.



4.2. Laundry detergents (LD)

4.2.1. Production and trade figures (LD)

Data derived from PRODCOM categories do not directly match EU Ecolabel scope but they are useful as estimates of the overall detergent and cleaning products market in Europe (see section 4.1), which includes all

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[149] PRODCOM data: EU27 ->Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.
Euromonitor data: EU28 -> Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. NB: Croatia, Cyprus, Estonia, Latvia, Luxembourg, Malta, Slovenia are modelled countries.

[150] While every attempt has been made to ensure accuracy and reliability, Euromonitor International cannot be held responsible for omissions or errors of historic figures or analyses.

laundry detergents [LD], as well as other washing and cleaning preparations and other detergents and soaps covered by the PRODCOM categories shown in Table 6. Production, Imports and Exports figures derived from these PRODCOM categories, broken down by Member State, are shown in Table 7. Finally, production data at EU 27 of the last 5 years (2017-2022) is summarised via apparent consumption ([151]) in Figure 5.

Table 6- PRODCOM cleaning product categories

Code(s)	Description
20.41.20.20	Anionic surface-active agents (excluding soap)
20.41.20.30	Cationic surface-active agents (excluding soap)
20.41.20.50	Non-ionic surface-active agents (excluding soap)
20.41.20.90	Organic surface-active agents (excluding soap, anionic, cationic, non-ionic)
20.41.31.20	Soap and organic surface-active products in bars, etc., n.e.c.
20.41.31.50	Soap in the form of flakes, wafers, granules or powders
20.41.31.80	Soap in forms excluding bars, cakes or moulded shapes, paper, wadding, felt and non-wovens impregnated or coated with soap/detergent, flakes, granules or powders
20.41.32.40	Surface-active preparations, whether or not containing soap, p.r.s. (excluding those for use as soap)
20.41.32.50	Washing preparations and cleaning preparations, with or without soap, p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations
20.41.32.60	Surface-active preparations, whether or not containing soap, n.p.r.s. (excluding those for use as soap)
20.41.32.70	Washing preparations and cleaning preparations, with or without soap, n.p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120 custom 5648310]

[151] Apparent consumption = EU domestic production + imports - exports

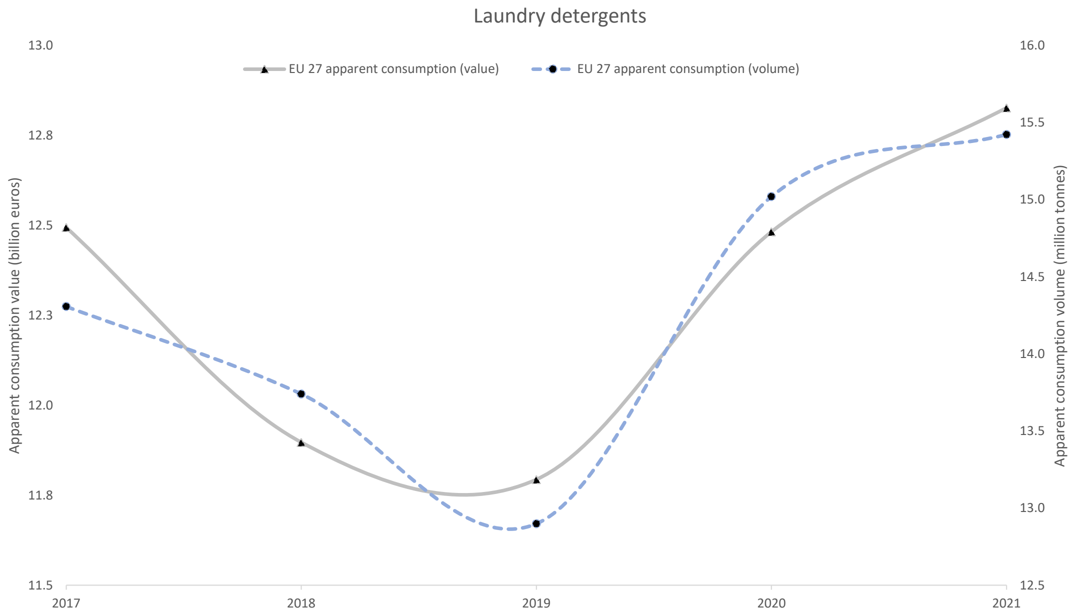
Table 7 - Exports, imports and production of detergent and cleaning products falling under the categories displayed in Table 6 for EU-27 during 2021.

Country	Exports quantity (tonnes)	Exports value (million EUR)	Imports quantity (tonnes)	Imports value (million EUR)	Production quantity (tonnes)	Production value (million EUR)
Austria	299558	423.3	325888	493.0	9040	23.8
Belgium	1578170	2359.7	945909	1343.7	869825	1023.4
Bulgaria	66085	67.7	93700	124.7	8298	7.1
Croatia	41276	46.4	80807	117.9	91671	93.3
Cyprus	383	0.8	29504	41.9	0	0.0
Denmark	231790	400.2	180528	245.8	357575	605.6
Estonia	31858	26.0	24663	61.1	47181	31.8
Finland	11808	27.0	101124	159.0	28330	55.0
France	955883	1847.0	1229925	1711.6	104109	0.0
Germany	1770963	3808.4	1420703	2343.9	1960706	4423.6
Greece	194625	168.9	152175	220.5	329119	145.6
Hungary	344718	420.6	237429	348.1	82056	20.0
Ireland	12672	40.2	133923	245.6	2717	16.9
Italy	1277959	1616.1	540845	933.7	2843749	2481.1
Latvia	8593	17.8	40824	65.0	1871	4.6
Lithuania	24327	45.7	57223	110.7	20055	26.5
Luxembourg	48893	91.2	25490	65.5	0	0.0
Malta	28	0.1	14448	17.5	0	0.0
Netherlands	932931	1771.5	672780	1177.1	355532	243.6
Norway	Data Not Available:					
Poland	1144714	1431.5	557150	836.9	300550	266.0
Portugal	121942	116.3	270361	321.7	181630	109.1
Romania	216508	254.2	372945	407.4	97112	65.8
Slovakia	62388	106.9	138837	190.3	24315	7.2
Slovenia	45039	61.5	74177	123.8	0	0
Spain	946150	1205.6	502599	828.9	2144396	1795.7
Sweden	161756	387.5	246500	378.7	41496	52.4
EU27TOTALS_2020	3068488	5819.1	1096863	2121.3	17395013	16524.5

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120 custom 5648310]

The total EU-27 production in 2021 was 17.4 million tonnes with an associated value of 16.5 billion € (See Table 7). Italy was the key producer (2.84 million tonnes valued 2.48 billion €), followed by Spain (2.14 million tonnes valued 1.8 billion €), and Germany (1.96 million tonnes valued 4.42 billion €). As of 2021, Germany, Italy and Spain represent 40% and 53% of the production volume and value in the EU-27, respectively.

Figure 5 – Apparent consumption ([152]) for EU-27 during the period 2017-2021.



Source: EUROSTAT ([153])

The apparent consumption volume and value from 2017 to 2021 were 14.3 – 15.4 million tonnes (7.8% growth) and 12.5-12.8 billion € (2.7% growth), respectively. During this period, the total production value and volume changed from 15.6 to 16.5 billion € and from 16.0 to 17.4 million tonnes, respectively, which corresponds to an increase of 5.7% in value and 8.6% in volume. The averaged exports volume was 2.88 million tonnes, valued at 5.3 billion €, which exceeded imports.

4.2.2. Market structure and sales (LD)

4.2.2.1. Market segmentation outline

In 2021 the Asia-Pacific region was the top household cleaning products market, valued at 235.8 billion USD, with laundry detergents accounting 53.7% of the total share ([154]). In 2020, the laundry products market in Western Europe ([155]) ranked third globally by sales ([156]).

The European cleanliness and hygiene market, which includes laundry products, can be split into household and professional (institutional and industrial; I&I) use. The household care sector was valued in 2021 at 32.4 billion € and it is comprised by: laundry care (15 billion €); surface care (7.4 billion €); dishwashing (5.2 billion €); maintenance products (4.1 billion €); and bleaches (0.7 billion €) ([157]).

In 2021, the total value of the laundry care market across Europe (EU-27 + CH + NO) was 15.4 billion €, with household laundry possessing 97.4% of the market share ([158]) (AISE, 2022). Professional laundry care had

[152] Apparent consumption = EU domestic production + imports - exports

[153] Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]; 5 year growth (%) = ((2021 – 2017)/2017)*100

[154] Household Cleaning Products Market Size & Report [2029] (fortunebusinessinsights.com) (Accessed on 22/05/2023)

[155] Austria, Belgium, Germany, France, Italy, UK, Spain, Turkey, Netherlands, Switzerland, Greece, Portugal, Sweden, Norway, Denmark, Ireland, Finland

[156] Laundry Care in Western Europe | Market Research Report | Euromonitor International, Home Care, 2022 (As on 22/05/2023)

[157] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[158] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

the remaining market share (2.6%), valued at 0.4 billion € ([159]). This is in line with actual and projected global trends, where the largest share of the market value corresponds to the household segment[160].

Laundry care can be segmented as “Laundry detergents”, “Laundry conditioners” and “Laundry aids/Others” with laundry detergents having the highest (63.4%) market share (See Table 8).

Table 8 – Laundry care sub-categories and associated market value during 2021

	Market value (billion €)	Laundry care share (%)
Laundry Detergents ([1161])	9.5	63.3
Fabric conditioners	2.7	18.0
Laundry aids; Other	2.8	18.7

Source: Euromonitor (EU 27 + UK + CH + NO) via A.I.S.E. Activity and Sustainability Report 2021-2022 ([162])

Laundry products generally used in conjunction with laundry detergents include:

— Fabric conditioner

— Fabric freshener

— Stain removers and other additives

“Laundry detergents” can be broadly categorised into ([163]):

— Powder detergents

— Liquid detergents

— Detergent tablets (powder or liquid/gels)

— Other detergents (such as hand wash or fine fabric)

Another relevant segmentation for laundry detergent is *by Cleaning method*, which provides information about the market share of those products used for laundry wash in washing machines (*Automatic detergents)* versus those used for hand-wash (*Other detergents*).

Amongst the many different categorisations possible for laundry detergents for washing machines *(Automatic detergents*), in this chapter we have focused on the *type* (Powder/Liquid/Tablets) and the *form* (Standard/Concentrated/Tablets), since it facilitates the understanding on market penetration and potential phase-out of these formats.

The split *by type* is the typical segmentation used to categorise laundry detergents and informs about the most common products type historically in the market. The segmentation *by cleaning* method and *by form* allow to understand the market penetration of alternative laundry detergents formats such as hand-washing and/or concentrated products as opposed to conventional ones such as automatic detergents or detergents of standard strength.

[159] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[160] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed on 23/05/23)

[161] Laundry detergents calculated as the aggregation of liquid, powder and tablets detergents

[162] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[163] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for: Laundry detergents and industrial and institutional laundry detergents; EUR 27380 EN; doi:10.2791/0171

4.2.2.2. Analysis of retail market

Euromonitor retail market data is used to estimate the potential market attributable to EU Ecolabel products falling under EU Ecolabel scope (see section 4.1), including relevant products segmentation. To improve the analysis, retail sales data from Euromonitor ([164]) (See Table 9) were processed into "best matching categories" to EU ecolabel scope (See Table 10). In particular, the category *Laundry detergents EUEL"* was calculated as an aggregation of the categories *"Pre-Wash Spot and Stain Removers*" (See Table 9) and "*Automatic Detergents"* (See Table 10) and contains data on products under EU Ecolabel laundry detergents scope.

Note that in this section, any reference to actual or projected (forecasted) data refers to products potentially falling under EU Ecolabel scope, in this case laundry detergents, but do not directly refer to measured/recorded sells or turnover of ecolabelled product.

[164] Source: Euromonitor International's dedicated Home Care industry edition, 2022

Table 9 – Euromonitor categories correspondent to EU Ecolabel scope for laundry detergents

EU Ecolabel Laundry Detergents scope (as in Commission Decision (EU) 2017/1218 of 23 June 2017)	Euromonitor Passport (sub-) category	Description
The product group 'laundry detergents' shall comprise any laundry detergent or pretreatment stain remover falling under the scope of Regulation (EC) No 648/2004 of the European Parliament and of the Council[165] which is effective at 30 °C or below and is marketed and designed to be used for the washing of textiles principally in household machines, but not excluding its use in public laundrettes and common laundries. Pre-treatment stain removers include stain removers used for direct spot treatment of textiles before washing in the washing machine but do not include stain removers dosed in the washing machine and stain removers dedicated to other uses besides pre-treatment. This product group shall not comprise fabric softeners, products that are dosed by carriers such as sheets, cloths or other materials or washing auxiliaries used without subsequent washing such as stain removers for carpets and furniture upholstery.	*Pre-Wash Spot and Stain Removers*	This is the combination of pre-treaters and others.
	Standard Powder Detergents	Conventional detergents in powdered form for machine washing. Multi-purpose products combining several functions such as detergent and softener or detergent and colour protection are treated as washing detergents and are therefore also included, as long as they are of regular strength and in powder form.
	Concentrated Powder Detergents	Includes all strengths of concentrated textile cleaning powders for machine washing. By definition, a smaller amount of concentrated detergent is needed to produce the same cleaning effect as standard powders. Therefore, packaging is usually more compact. Multipurpose products in concentrated powder form are also included.
	Detergent Tablets	Includes detergents sold in tablet format for machine washing. These could either be in compressed powder or liquid form.
	Standard Liquid Detergents	Conventional liquid detergents for machine washing. Multi-purpose products combining several functions such as detergent and softener or detergent and colour protection are treated as washing detergents and are therefore also included, as long as they are of regular strength
	Concentrated Liquid Detergents	Includes all strengths of concentrated textile cleaning liquids for machine washing. By definition, a smaller amount of concentrated detergent is needed to produce the same cleaning effect as standard liquids. Packaging is also usually more compact than for standard liquids. Multi-purpose products in concentrated liquid form are also included.
	Other Detergents	This is the aggregation of bar, hand wash and fine fabric detergents.

Sources: EC 2017 ([166]); Euromonitor ([167])

[165] Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents (OJ L 104, 8.4.2004, p. 1). https://eur-lex.europa.eu/legal-content/EN/AUTO/?uri=OJ:L:2004:104:TOC

[166] EC 2017 ->Commission Decision (EU) 2017/1218 of 23 June 2017 establishing the EU Ecolabel criteria for laundry detergents (notified under document C(2017) 4243) (OJ L 180, 12.7.2017, p. 63–78) https://eur-lex.europa.eu/eli/dec/2017/1218/oj

[167] Euromonitor International, Home Care, 2022 -> Passport Category definitions

Table 10 – Euromonitor Passport data categories being processed into categories "best matching" EU Ecolabel laundry detergents scope, the latter used for EU Ecolabel Laundry detergents retail market analysis.

Category ("best matching" EU ecolabel scope)	Euromonitor data categories (being processed)
Concentrated Detergent	Concentrated powder detergents + Concentrated liquid detergents
Standard Detergent	Standard powder detergents + Standard liquid detergents
Liquid Detergents	Standard liquid detergents + Concentrated liquid detergents.
Powder Detergents	Standard powder detergents + Concentrated powder detergents.
Automatic Detergents	Powder detergents + Liquid detergents + Detergent Tablets
Laundry Detergents	Automatic detergents + Other detergents
Laundry Detergents EUEL	Laundry Detergents + Pre-Wash Spot and Stain Removers.

Source: Euromonitor ([168])

During 2021, the total EU28 sales retail volume for *Laundry detergents EUEL* was 2.37 million tonnes with an associated value of 8.91 billion €. Germany had the highest sales retail volume (0.50 million tonnes), followed by France (0.39 million tonnes) and Italy (0.36 million tonnes). France had the highest production value (1.86 billion €), followed by Germany (1.48 billion €) and Italy (1.16 billion €). Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Poland) represented 70.7% and 67.6% of the total EU28 retail sales volume and value.

Laundry detergents actual (2008-2022) and projected (2023-2027) EU Ecolabel retail market trends (EU28; top European countries) are shown in Figure 6. These countries were chosen as indicators of the European market since a change in these countries will have larger impact on the overall retails sales and would help to understand the overall (EU28) trend.

The total retail sales value of the EU28 market steadily increased during the period 2008 -2022, from 7.5 to approximately 9.6 billion € , with forecasting indicating an even stepper increase during the years (2023 - 2027), reaching a maximum of 12.3 billion € (Figure 6 – A).

France, Germany and Poland showed a steady increase during (2008 -2022), with Italy and Spain showing little or no increase (Figure 6 – B). The retails sales value of all these countries is foreseen to increase according to data projections (2023-2027).

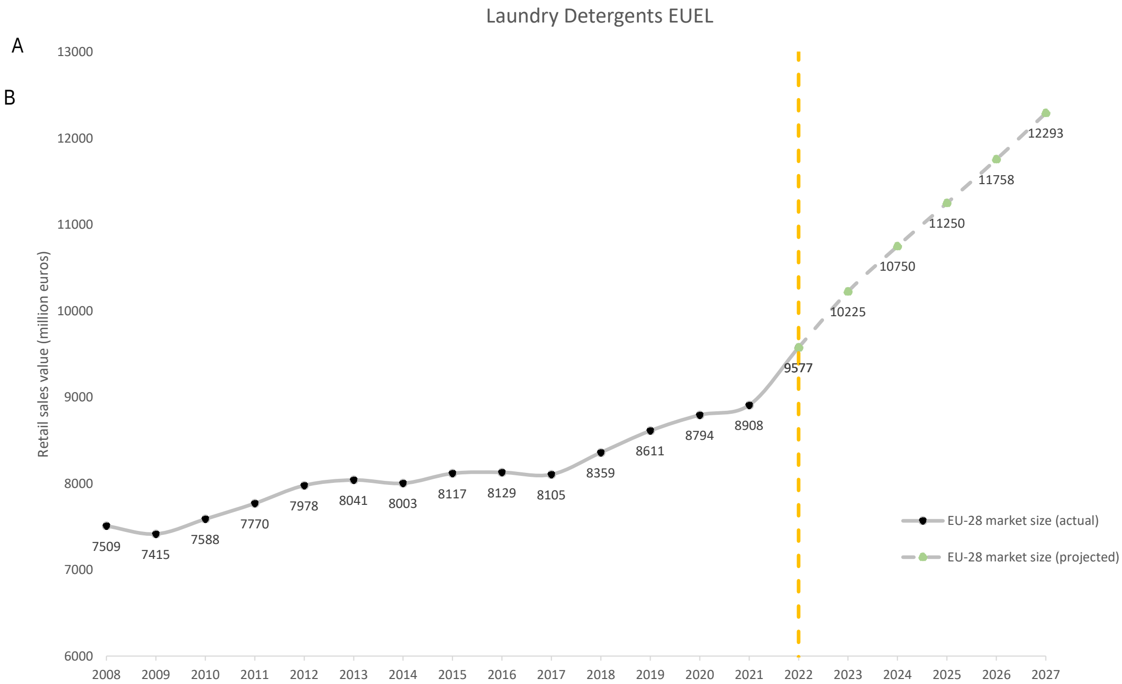
The total retail sales volume of the EU28 market decreased during the period 2008 -2018, from 2.96 million tonnes to approximately 2.37 million tonnes, then remaining stable up to 2022. Forecasting (2023 -2027) predicted reaching 2.51 million tonnes (Figure 6 – C).

By retail sales volume Poland steady increased during (2008 -2022), while France, Italy and Spain decreased (Figure 6 – D). Data projections indicated a continuation of Poland's increasing trend, joined by France.

The contrasting trends on total (EU28) retail sales value versus volume suggest a decoupling of value (on the rise) from volume (stable or decreased).

[168] Euromonitor International, Home Care, 2022 -> Category definitions

Figure 6 – Laundry Detergents EUEL actual (2008 - 2022) and projected (2023 - 2027)market trends for products potentially falling under EU Ecolabel LD scope. This figure presents the retail sales value (A-B) and volume (C-D) for the EU28 (A-C) and for the top five European countries by market share (B-D).



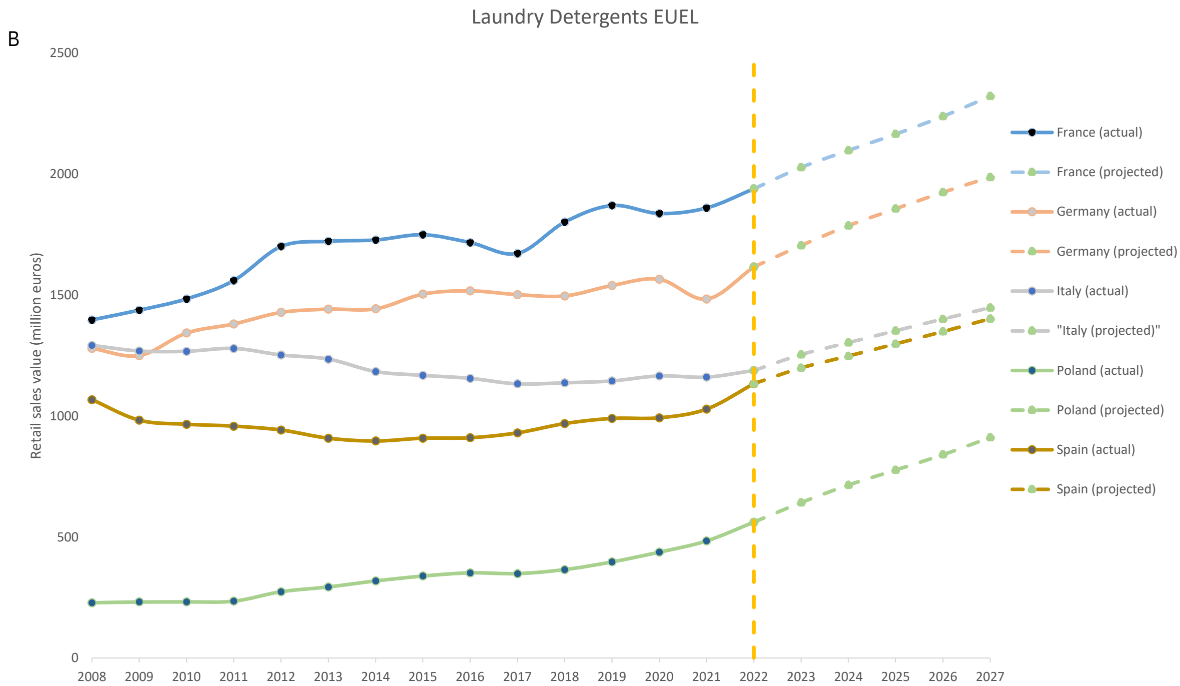
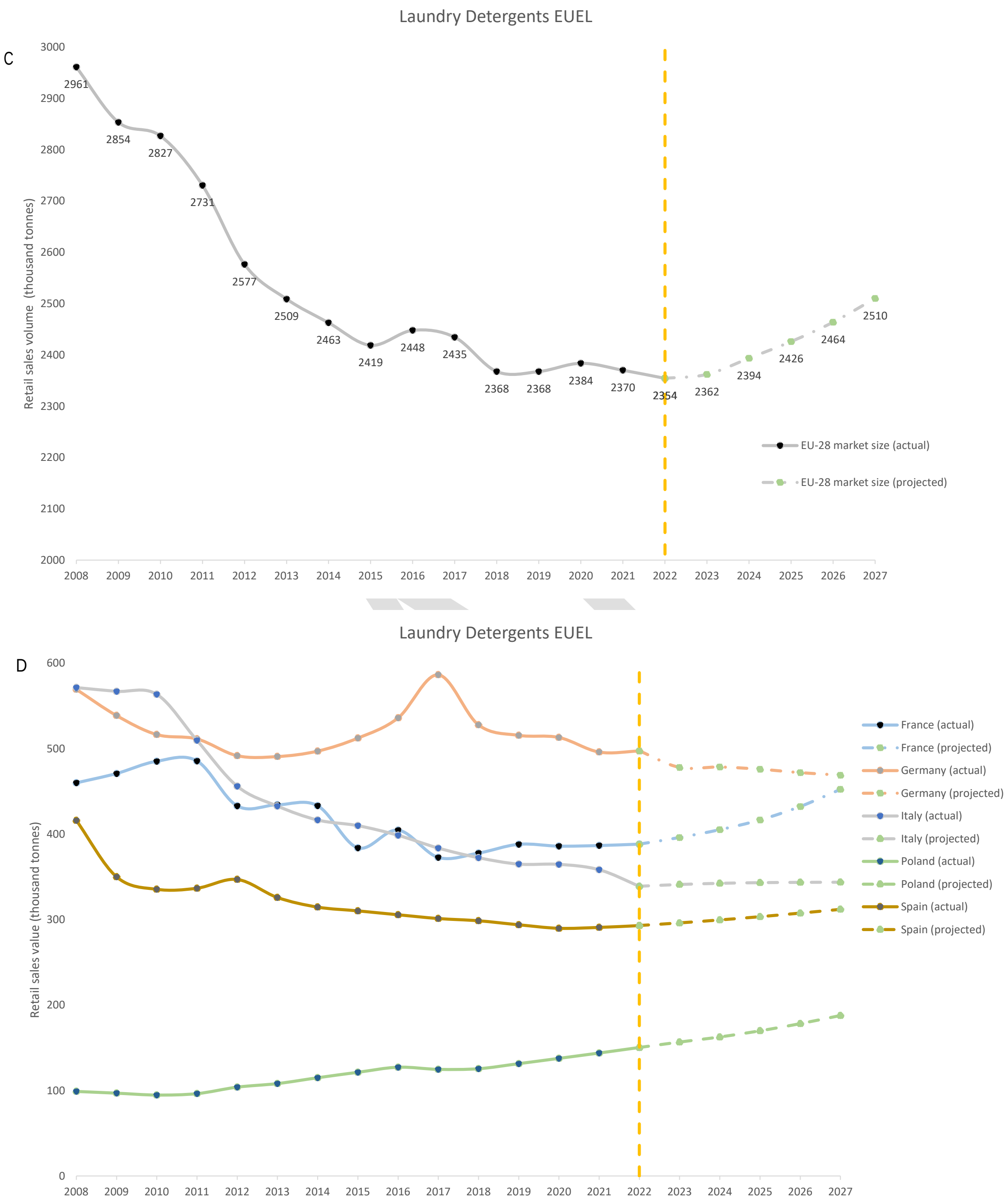


Figure 6 - Continuation



Source: Euromonitor

The next section explores the segmentation of laundry detergents products *by cleaning method* (Automatic Detergents/Other Detergents).

Then, the following two sections focus on detergents for laundry wash (namely, automatic detergents), grouping them:

- *By type* Liquid detergents / Powder detergents / Detergents tablets
- *By form* Standard detergents / Concentrated detergents/ Detergents tablets

4.2.2.2.1. Laundry detergents *by cleaning method* (Automatic/Other Detergents)

"Laundry Detergents*"* was calculated as the aggregation of the Euromonitor categories "*Other Detergents (See Table 9)* and *Automatic detergents* (See Table 10), which are detergents used for washing laundry by hand or in washing machines, respectively.

During 2021, the total EU28 retail sales volume of "*Laundry Detergents*" was 2.33 million tonnes with an associated value of 8.64 billion € (See Figure 7). "*Automatic detergents"* clearly dominated the market, with 2.09 million tonnes valued at 7.91 billion €. Conversely, "*Other Detergents"* had lower market share, with 10.5% and 8.2% of the total "*Laundry detergents*" retail sales volume and value, respectively.

In 2021, Germany had the highest retail sales volume of "*Automatic Detergents"* with 0.49 million tonnes (valued at 1.41 billion €), followed by France with 0.38 million tonnes (valued at 1.80 billion €) and Italy with 0.35 million tonnes (valued at 1.13 billion € (See Figure 7). Together with Poland and Spain, these countries represent 70.5% and 67.49% of the total (EU28; "*Automatic Detergents")* retail sales volume and value, respectively. These countries were also the highest by retail sales volume and value of *Other Detergents*, ranging from 0.014 to 0.069 million tonnes and from 0. 48 to 1.81 billion €, respectively.

Laundry detergents, split *by cleaning method* as "*Automatic detergents"* and *"Other detergents",* actual (2008-2022) and projected (2023-2027) EU Ecolabel retail market trends (EU28; top European countries) are shown in Figure 8. These countries were chosen as indicators of the European market since a change in these countries will have larger impact on the overall retails sales and would help to understand the overall (EU28) trend.

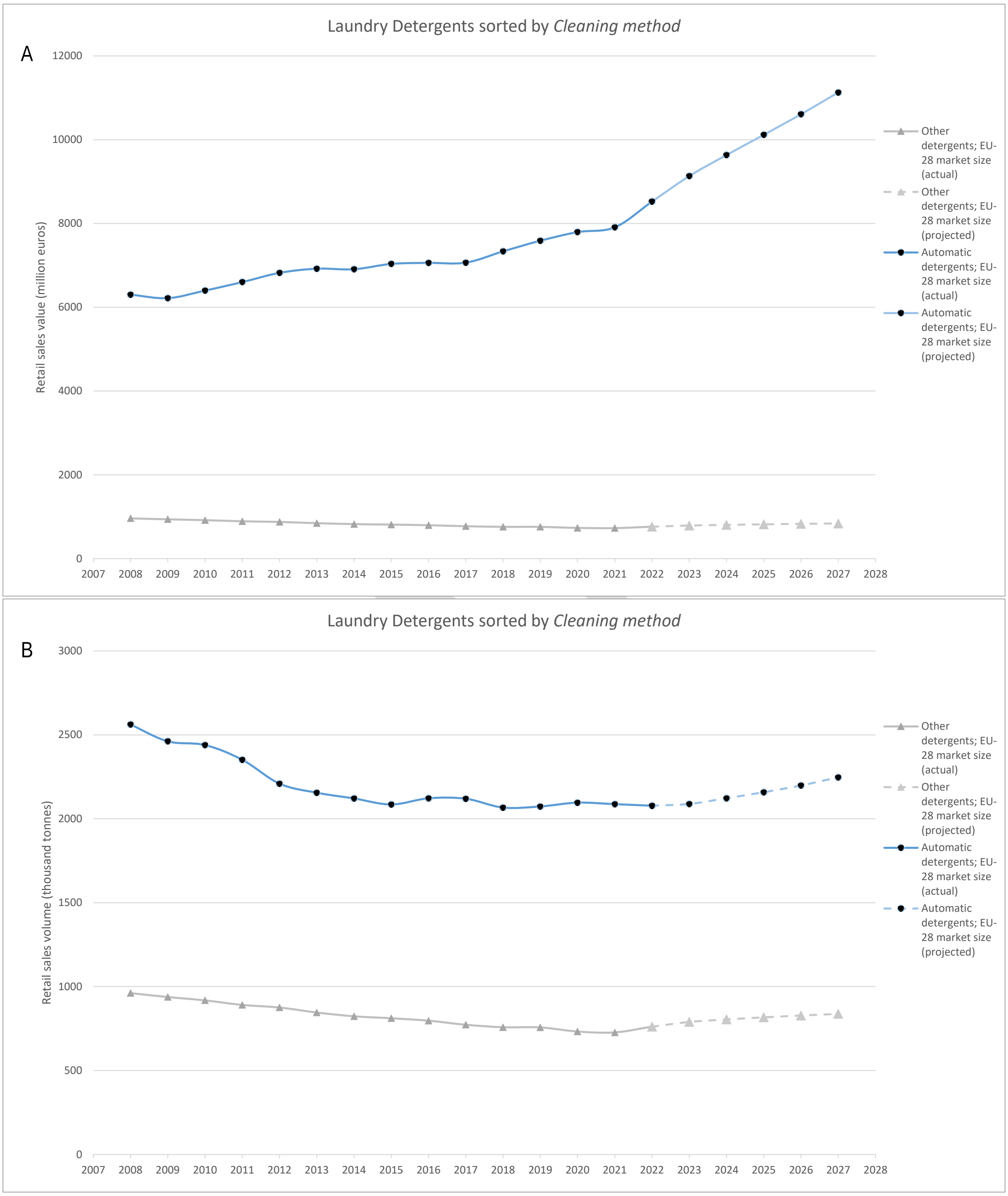
"*Other detergents"* total (EU28) retail sales volume and value decreased slightly during the period 2008-2022, from 0.36 to 0.24 million tonnes and from 0.96 to 0.76 billion €, respectively. Forecasting (2023-2027) predicted a decrease of retail sales volume of 4.8%, reaching 0.23 million tonnes, and an increase of retail sales value of 5.7%, reaching 0.84 billion €.

"*Automatic Detergents*" total (EU28) retail sales volume decreased during the period 2008 -2015, from 2.56 to 2.09 million tonnes, remaining then relatively stable up to 2022, when forecasting (2023 -2027) predicted the start of an increasing trend reaching 2.25 million tonnes. In contrast, by retail sales value it increased steadily (2008 -2022), from 6.3 to approximately 8.5 billion €, with forecasting (2023 -2027) predicting an even stepper increase reaching 11.1 billion €.

Figure 7 – Laundry detergents split by cleaning method retail sales volume (A) and value (B)

Source: Euromonitor

Figure 8 – Laundry detergents actual (2008 - 2022) and projected (2023 - 2027) market trends of retail sales volume (A) and value (B) at EU 28 level.



Source: Euromonitor

4.2.2.2.2. Automatic laundry detergents split *by type* (Powder/Liquid/Tablets).

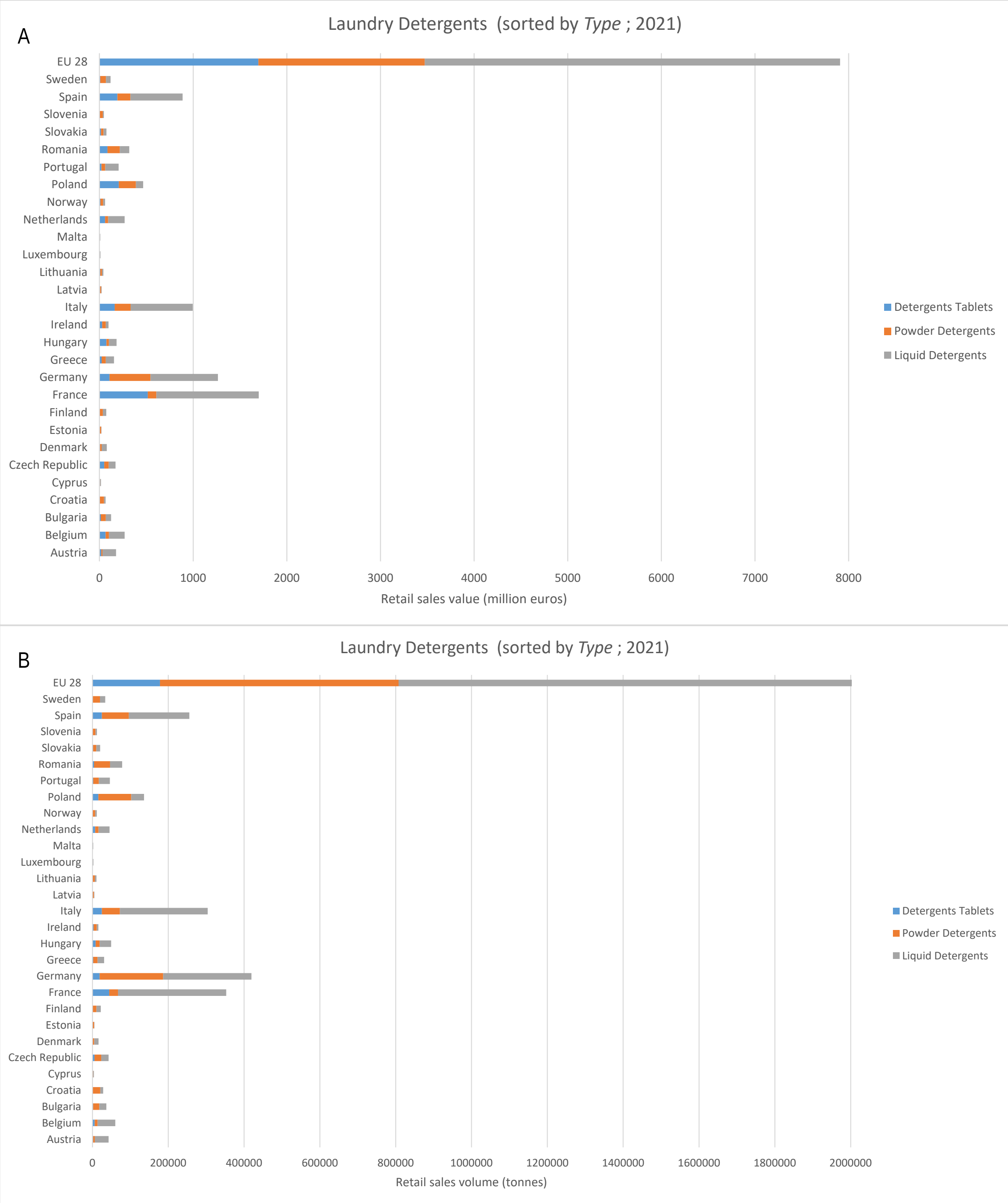
"*Automatic Detergents"* was calculated as the aggregation of the Euromonitor categories "*Detergent Tablets"* (see Table 9), "*Liquid Detergents"* and *"Powder Detergents" (*see Table 10). These categories provide information on the type of automatic laundry detergent products that have been historically more widely used: liquid detergents, powder detergents and detergent tablets.

During 2021, the total EU28 retail sales volume of “*Automatic Detergents*” was 2.09 million tonnes with an associated value of 7.91 billion € (See Figure 9). Germany had the highest automatic detergents sales retail volume with 0.42 million tonnes (valued at 1.26 billion €), followed by France with 0.35 million tonnes (valued at 1.70 billion €) and Italy with 0.30 million tonnes (valued at 0.99 billion €). Together with Spain and Poland, these five countries were the top by retail sales volume and value and had 70.4% and 67.2% of the total (EU28) market, respectively.

Overall (EU28), “*Liquid detergents”* clearly dominated the laundry automatic detergents market, both by retail sales volume (61.3%) and value (56.1%), followed by *“powder detergents”* (30.1% and 22.5%, respectively). In Germany, France, Italy and Spain the share of “*Liquid Detergents*” was over 55% by both retail market volume and value. Only Poland’s market was dominated by other types: powder detergent (63.5%) by retail volume and Detergents Tablets (44.1%) by retail sales value.

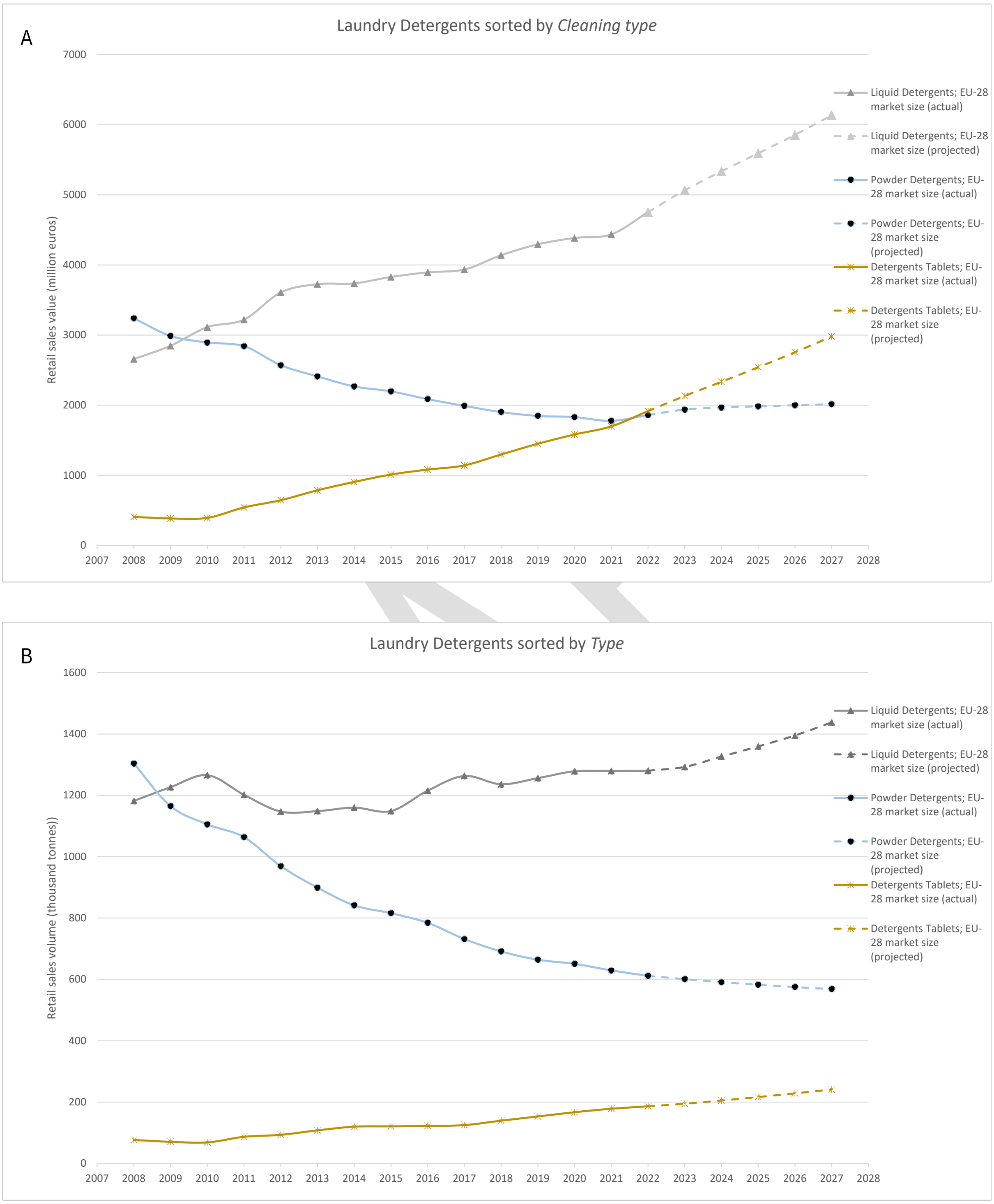
The total retail sales value of *“Liquid detergents* EU28 market has almost doubled during the period 2008 - 2022, from 2.66 to 4.75 billion €, with forecasting (2023 -2027) predicting reaching 6.14 billion €. Similarly, the total retail sales of *“Detergents tablets”* EU28 market increased, from 1.01 to 1.92 billion €, with forecasting predicting reaching a maximum of 2.98 billion €. In contrast, the total retail sales of *“Powder Detergents*” EU28 market decreased, from 3.24 to approximately 1.86 billion €, with forecasting predicting a stabilisation at around 2.0 billion €. The trends observed for the total (EU28) retail sales by volume were very similar to those described for retail sales by value. These data suggested a decrease in the purchase/use of powder detergents, potentially being replaced by liquid and/or Detergent Tablets.

Figure 9 – Laundry automatic detergents split *by type* retail market sales volume (A) and value (B)



Source: Euromonitor

Figure 10 – Laundry automatic detergents actual (2008 - 2022) and projected (2023 - 2027) market trends of retail sales volume (A) and value (B) at EU 28 level.



Source: Euromonitor

4.2.2.2.3. Automatic laundry detergents split *by form* (Standard/Concentrated/Tablets).

An alternative way to group automatic laundry detergents is by the strength claimed by the product, either as standard or concentrated. Detergents tablets are presented alongside standard and concentrated detergents for clarity and complementarity of the analysis. The aggregation of "*Standard detergents*", "*Concentrated detergents*" and "*Detergent tablets*" categories conforms the "*Automatic Detergents*" category (See Tables 9 and 10). Note that any comparison made amongst these three categories is constrained by data gaps on *"Standard detergents"*. Progressively with time, several of the 28 European countries ceased having EUROMONITOR data available on "*Standard Detergents"* (13 countries after 2021 for retail sales value ([169]); 16 countries after 2018 for retail sales volume[171]). Therefore, results are interpreted in the light of this, not making direct quantitative comparisons with the group *"Standard detergents"*. Irrespective of former, this section provides information on how new formats of automatic laundry detergent products are consumed (eg concentrated products).

During 2021, concentrated products were preferred to standard strength ones (See Figure 11). "*Standard Detergents"* had 1.3% and 1.5% of the total (EU28) market share of "*Automatic detergents"* by retail sales volume and value while "*Concentrated detergents"* had 77% and 89%, respectively. Note that "*Standard Detergents*" data for several of the 28 European countries by retail sales value ([170]) and volume ([171]) was missing. Where available, data indicated a market share generally under 10%, by both retail sales value and volume, being exceptions Slovenia (80.5% & 87.4%), Estonia (23.5% & 29.0%) and Lithuania (15.6% & 21.4%).

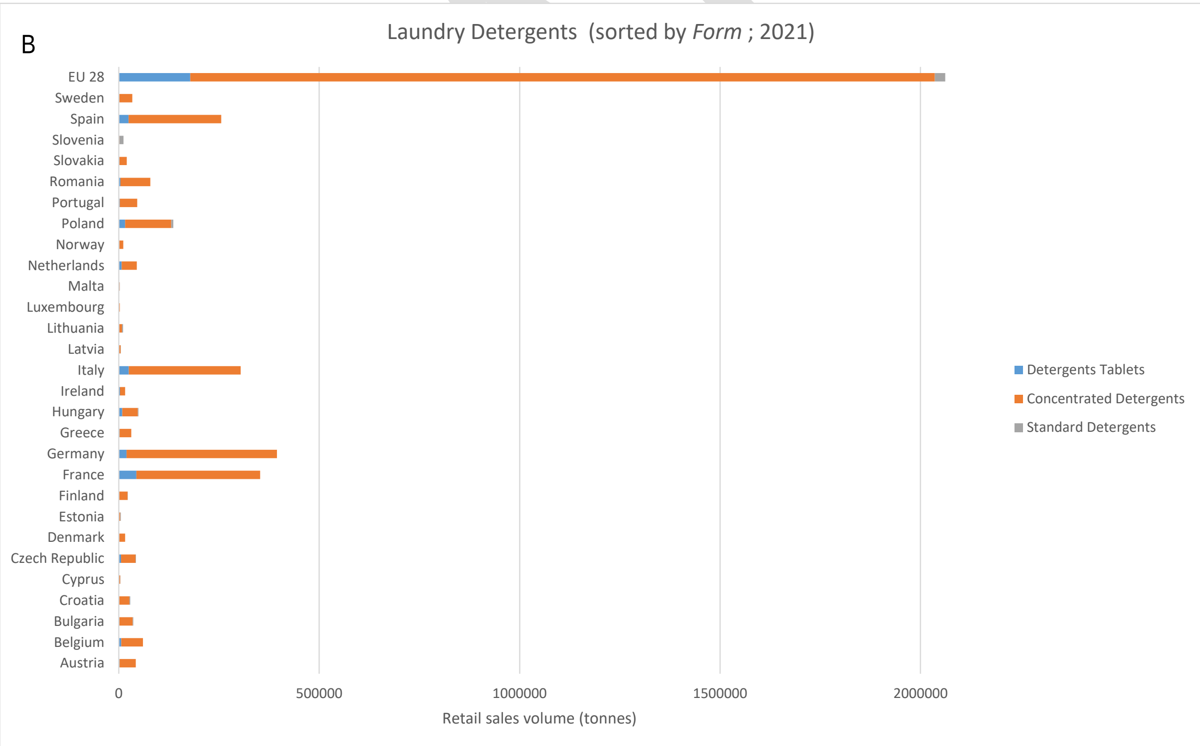
The total retail sales value of the EU28 "*Concentrated Detergents"* market increased during the period 2008 to 2013, to then remain stable at approximately 6 billion € (See Figure 12) and with forecasting (2023 - 2027) predicting reaching 8 billion €. In contrast, the total retail sales value of "*Standard Detergents"* decreased during the period 2008 -2014, from 3.69 to less than 0.1 billion €, including forecasting (2023 - 2027) prevision. Total retail sales volume trends of EU28 market were very similar to those observed for retails sales value (See Figure 12). These data suggested a phase-out of standard detergents (decrease of purchase/use), potentially being replaced by other formats (eg concentrated).

[169] Austria, Belgium, Denmark, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Romania, Spain and Sweden

[170] Austria, Belgium, Denmark, France, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Romania, Spain and Sweden

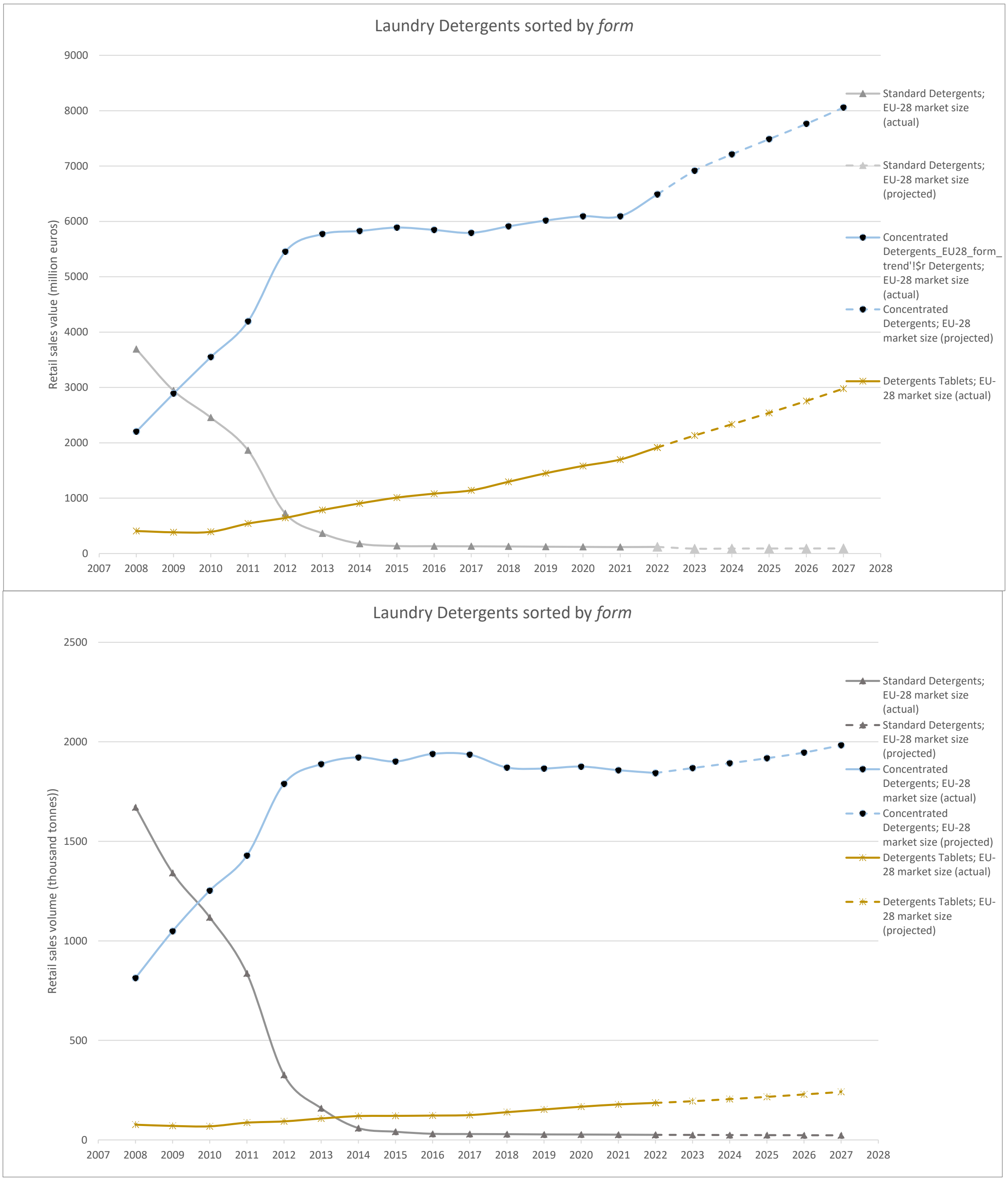
[171] Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Romania, Slovakia, Spain and Sweden

Figure 11 – Laundry automatic detergents split by form retail sales volume (A) and value (B)



Source: Euromonitor.

Figure 12 – Laundry automatic detergents actual (2008 - 2022) and projected (2023 - 2027) market trends of retail sales volume (A) and value (B) at EU 28 level.



Source: *Euromonitor.*

4.2.3. Key players (LD)

The following can be considered a representation of the European key players for cleaning (thus detergents) market: The Procter & Gamble Co, Henkel AG & Co. KGaA, Unilever PLC, Reckitt Benckiser Group PLC, Colgate-Palmolive Co, The Clorox Company, and Dropps ([172]).

Similarly, the laundry care (thus detergents) market across Europe is heavily dominated by a few well-known and globally recognised organisations and brands, with the top five players accounting for two thirds of the laundry care sales value ([173]). In 2013, the top manufacturers by retail sales value were (in this order): Procter & Gamble Co (26%)> Henkel AG & Co KGaA (18%)> Unilever Group (14%)> Reckitt Benckiser Plc (8%) ([174]). In the recent years there has not been changes among the top region's leading brands ([175]), thus it is expected similar dynamic at European level.

The global market of chemicals for detergents is fairly fragmented, its size has been estimated at 50.14 billion USD in 2020 and has a projected CAGR for 2021-2028 of 4.2%, reaching a maximum of 71.26 billion USD ([176]). In terms of ingredients suppliers, they can be grouped by the type of chemical they supply:

- *Inorganic* suppliers responsible for supplying fillers, builders and bleaches.
- *Organic* suppliers responsible for supplying surfactants, polymers and antifoams.
- *Enzyme* suppliers responsible for supplying enzymes targeting specific type of stains.

In 2020 builders and fillers was the segment in the specialty ingredients market with the highest share (39.2%) followed by surfactants, with enzymes being the fastest-growing segment ([177]). Currently, anionic and non-ionic surfactants account for 95% of the market, zwitterionics around 1% and the remaining (less than 5%) to cationics, valued at approximately 2 billion USD ([178]).

Some relevant companies active in the European market for detergent speciality ingredients include Clariant, Croda, Solvay, Novozymes, Evonik, Croda, DuPont Alco Chemical and BASF. The availability, thus the price (and related market fluctuation), of raw materials and/or ingredients for detergents production is susceptible to changes.

4.2.4. Trends (LD)

4.2.4.1. Product innovation (sustainability). The growing awareness of consumers on detrimental effects on the environment has led to several sustainability trends and innovations within the laundry products market, like:

- *Ingredients substitution* – detergents formulation change to incorporate substances that deliver equivalent or better functionality at similar production costs whilst being a more sustainable alternative. Examples could be products produced excluding Alkylbenze Sulfonate (LAS) ([179]) and/or incorporating biosurfactants (eg Rhamnolipids in Unilever's Quix ([180])).

[172] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for: Laundry detergents and industrial and institutional laundry detergents; EUR 27380 EN; doi:10.2791/0171

[173] Laundry Care in Western Europe | Market Research Report | Source: Euromonitor International, Home Care, 2021 (Accessed on 22/05/2023).

[174] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for: Laundry detergents and industrial and institutional laundry detergents; EUR 27380 EN; doi:10.2791/0171

[175] Laundry Care in Western Europe | Market Research Report | Source: Euromonitor International, Home Care, 2021 (Accessed on 22/05/2023).

[176] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[177] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[178] Gonçalves, R.A., K. Holmberg, and B. Lindman, 'Cationic Surfactants: A Review', Journal of Molecular Liquids, Vol. 375, April 2023, p. 121335. 10.1016/j.molliq.2023.121335

[179] Laundry Detergents | Nopa Nordic (Accessed 23/05/23)

[180] Nature and science combine to create a cleaning world-first | Unilever (Accessed 23/05/23)

- *Efficient manufacturing* – which encompass resource efficiency improvement (e.g. energy-efficient running of equipment), minimization of waste and use of renewable energy sources. An example is the brand Cascade by Procter & Gamble ([181]) or the ARM & HAMMER brand ([182]).
- *Concentrated products* – which deliver the same function with lower mass of product used. This in turn, consume fewer resources across the production-consumption life cycle (less packaging; less resources consumption associated with transport). An example on tablet detergents could be Persil non-bio washing tablets/pods from Unilever ([183],[184]). Examples on laundry detergent sheets are ECOS ([185]) and Natulim ([186]).
- *Biobased products* – sourcing raw materials for detergents production more sustainably, which might also enhance the biodegradability of the product. An example is Unilever with its brand Quix which incorporated surfactants of microbial origin (Rhamnolipids) ([187]).
- *Refill systems* – allowing less single-use packaging waste thanks to an alternative format/business model. An example is the Fill Refill Co ([188]).
- *Enzymes* – which enhance the efficiency of the cleaning process, for example by allowing achieving the same cleaning performance at lower washing temperatures ([189]).
- *Microbial cleaning products* – which take advantage of the biological action of microorganisms to contribute to the cleaning process, increasing the efficiency (via enzymes, for example) and/or by substituting substances with negative environmental footprint ([190]). An example could be EM・1™ product from EMRO, containing different groups of microorganisms (including lactic acid bacteria, yeast and phototrophic bacteria), with claims related to enhanced cleaning (dirt/sebum from clothes) and environmental care (aid in natural water purification) ([191]).
- *"Cold wash"* – which ensures achieving same cleaning efficiency at lower washing temperatures than commonly historically, thus decreasing the energy use during washing. An example are PG's brands *Tide* and *Ariel ([192]).*

Focusing on laundry detergent products, innovation is one of the main drivers supporting their demand (i.e. concentrated products; liquid tablets) ([193]). In this regard, sustainability is an important aspect owing to consumers growing awareness on environmental implications associated to products consumption ([194]). Generally, several of these innovation trends co-exist together within a particular product (eg concentrated and biobased products).

Concentrated products and liquid detergents have experienced continuous growth historically (see sections 4.2.2.2.2 and 4.2.2.2.3). In particular, tablet and concentrated detergents in liquid form are expected to continue being widely used in Western Europe (period 2020-2025), especially in France as the biggest market, owing their ease of use and to consumers' environmental consciousness (avoid overdosing risk; more efficient manufacturing) ([195]). During the period 1997-2017, the compaction ([196]) of laundry detergents has enabled

[181] Sustainable Manufacturing Commitment | Cascade Detergent (cascadeclean.com) (Accessed 03/05/23)
[182] What is Eco-Friendly & Sustainable Detergent | ARM & HAMMER™ Laundry (armandhammer.com) (Accessed 23/05/23)
[183] Persil Non-bio Washing Tablets | Persil (Accessed 23/05/23)
[184] https://www.persil.com/uk/laundry/detergent/products/non-bio-3in1-washing-capsules.html (Accessed 19/01/24)
[185] Eco-Conscious Laundry Sheets, Our Hypoallergenic Detergent Without Added Scents - ECOS® (Accessed 23/05/23)
[186] Natulim - 11Onze Comunitat Fintech (Accessed 23/05/23)
[187] Nature and science combine to create a cleaning world-first | Unilever (Accessed 23/05/23)
[188] About - Fill Refill Co - Refillable Eco Household & Personal Care Products (Accessed 23/05/23)
[189] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23).
[190] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032
[191] Personal Use | EMRO (emrojapan.com) (Accessed 23/05/23)
[192] Washing Your Clothes on Cold with Tide and Ariel Does a World of Good (pg.com) (Accessed 13/06/2023)
[193] Laundry Care in Western Europe | Market Research Report | Source: Euromonitor International, Home Care, 2021 (Accessed on 22/05/2023).
[194] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449
[195] Laundry Care in Western Europe | Market Research Report | Source: Euromonitor International, Home Care, 2021 (Accessed on 22/05/2023).
[196] Higher active ingredients concentration, lower total mass, equivalent or improved functionality, enhanced manufacturing efficiency.

significant environmental savings in Europe, being estimated the CO_2 savings (excluding the use phase) at 1.4 million tonnes ([197]). Additionally, it has also led to alternative product formats, such as detergents sheets ([198]).

Ingredients substitution aims to improve the environmental profile of laundry products, by exerting the same function with an alternative more sustainable substance produced at competitive market costs. Some producers claim formulations based on plant-based ingredients (100% naturally sourced) with comparable cleaning power but without needing being combined with synthetic additives neither being ethoxylated ([199]), thus potentially reducing environmental impacts ([200]). Other business models encompass production lines that, amongst other aspects, consider ingredients substitution or exclusion (e.g. LAS) ([201]).

Bio-based products trend is linked with ingredients substitution, since there is a demand for natural raw materials exerting the same function but with lower environmental impacts (eg enhanced biodegradability) ([202]). Note that using raw materials of biological origin does not automatically guaranty greater sustainability ([203]), and is dependent on the particular case being evaluated. Nevertheless, there are evidences that support that certain environmental issues (eg ecotoxicity) could be reduced as a results of the use of biobased ingredients, for example, in the surfactants case. The shift towards biobased surfactants use is a relevant trend to consider given that surfactants are major components in laundry detergents (15-40%) with environmental concerns associated to those of synthetic origin ([204]). In addition to those biosurfactants derived from plants, we find those of microbial origin (bacteria, yeasts, and fungi), being the most reported types in laundry detergents rhamnolipid, glycolipids, sophorolipid and lipopeptides ([205]). Several major market players have tapped into incorporating natural raw materials into their products, such as biosurfactants seeking further market aperture and greater sustainability ([206]), such Unilever with its brand Quix which incorporated Rhamnolipids ([207]).

Enzymes such as amylase or protease can improve the cleaning efficiency in laundry detergents products, being the ingredient segment experiencing the fastest market growth ([208]). Enzymes can remove stains effectively under mild conditions (low temperatures, gentle mechanical action aiding in keeping household clothing fit for longer and in removing difficult stains under professional conditions (eg. Blood in hospital linens) ([209]). In addition, their efficiency could be boosted by surfactants of microbial origin ([210]), creating a synergistic effect amongst biobased ingredients, microbial cleaning products and enzymes.

Microbial cleaning products (MCP) are characterized by containing strains of microorganism as active ingredients, being an alternative to the wide-spread detergents forms with purely chemical-based active ingredients. The market for MCP represents a growing share within the "green cleaning products" market being projected to increase more in Europe than in United States ([211]). In 2017 projections estimated a maximum of $US9.32 billion, approximately equivalent to 6% of global household cleaning products market

[197] 20190410111600-aise_factsheet-2019_compaction_def.pdf (Accessed on 22/05/2023).
[198] Eco-Conscious Laundry Sheets. Our Hypoallergenic Detergent Without Added Scents - ECOS® (Accessed 23/05/23)
[199] Ethoxylation is a common organic synthesis process in surfactants by which synthetically sourced ethylene oxide is added to plant or petrochemical-sourced raw materials in order to make them more effective and compatible with water.
[200] Innovative formulas from our ecological detergents an soaps | BIOBEL (Accessed 23/05/23)
[201] Laundry Detergents | Nopa Nordic (Accessed 23/05/23)
[202] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com).
[203] In line with the Communication from the European Commission on EU Policy Framework on biobased, biodegradable and compostable plastics. COM/2022/682 final. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0682&qid=1680246180511 (Accessed 23/05/23).
[204] El-Khordagui, L., S.E. Badawey, and L.A. Heikal, 'Application of Biosurfactants in the Production of Personal Care Products, and Household Detergents and Industrial and Institutional Cleaners', In: Green Sustainable Process for Chemical and Environmental Engineering and Science, Elsevier, 2021, pp. 49–96. ISBN 978-0-12-823380-1
[205] El-Khordagui, L., S.E. Badawey, and L.A. Heikal, 'Application of Biosurfactants in the Production of Personal Care Products, and Household Detergents and Industrial and Institutional Cleaners', In: Green Sustainable Process for Chemical and Environmental Engineering and Science, Elsevier, 2021, pp. 49–96. ISBN 978-0-12-823380-1
[206] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com)(Accessed 23/05/23)
[207] Nature and science combine to create a cleaning world-first | Unilever (Accessed 23/05/23)
[208] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed on 22/05/2023).
[209] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23).
[210] El-Khordagui, L., S.E. Badawey, and L.A. Heikal, 'Application of Biosurfactants in the Production of Personal Care Products, and Household Detergents and Industrial and Institutional Cleaners', In: Green Sustainable Process for Chemical and Environmental Engineering and Science, Elsevier, 2021, pp. 49–96. ISBN 978-0-12-823380-1
[211] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032

value (totalling $US147 billion) ([212]). In addition, the recent inclusion of microorganism within the scope of the revised Detergent Regulation provides regulatory guidance on the use of this type of ingredients/products, thus being reasonable to expect a boost in this market because of a harmonised regulatory framework. Nevertheless, some of the issues identified relate to potential for pathogenicity, taxonomic identification of the microorganisms used, quality assurance and control, labelling and exposure upon use ([213]).

"Cold wash", or cleaning with lower temperature than commonly used tackles one of the main environmental hotspots associated with laundry detergents during the use phase: the energy use to heat the water during washing ([214]). The temperature for laundry wash within European households is typically equal or higher than 40 degrees Celsius, but several initiatives are advocating for the use of lower temperature, such as AISE's "*I prefer 30 (*"[215]). In Europe the average wash temperature has moved from 49°C to 42.6°C over the period 1997 – 2017 ([216]). By decreasing washing temperature, the energy consumption is directly decreased, which also impacts indirectly on fossil fuel depletion and global warming potential ([217]). Decreasing washing temperature could have positive side-effects, such as favouring fabric care but they also could be negative, such as enhancing pathogenic infection risks in household laundry practices ([218]). In this last regard, risk would only be meaningful in households with ill or immuno-depressed individuals while under common circumstances ("healthy households) "cold wash" (eg 14.4°C) in combination with a quality laundry detergent would suffice to decrease infection risks from washed clothes ([219]).

4.2.4.2. Consumer behaviour.

Cleanliness and hygiene are both the main function (cleaning) and the primary reason that drives consumers' behaviour. In a study by Insites Consulting for A.I.S.E ([220]), the majority (>88%) of the respondents indicated that "*Cleaning and hygiene in my home is important because it helps me and/or the people I live with avoid becoming unwell or getting and infectious disease",* also indicating that it was *"important for the health of people around me"*. Once consumers see this primary condition met, then additional factors are considered, such as price (affordability), ease of use/convenience and/or the effect on the environment ("green"; "eco-product").

Laundry wash respond to the reality of the region where is carried out but a raise in environmental consciousness is a common pattern, which have led in the last 10 years to an increase of energy and resource efficiency ([221]). Laundry can be washed by hand but it is generally done using washing machines, with European households having very high possession rates (over 90% for most EU countries in 2013) ([222]). Consequently, in Europe product innovation and other market trends are important to capture consumers attention and gain market share.

The increase in consumers' environmental awareness has led to the rise of the demand for more environmentally friendly dishwashing detergents products. Surveys on consumer behaviour indicated a strong

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[212] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032

[213] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032

[214] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for: Laundry detergents and industrial and institutional laundry detergents; EUR 27380 EN; doi:10.2791/0171

[215] AISE_print_flowchart_EN (Accessed 13/06/23)

[216] 20190410111600-aise_factsheet-2019_compaction_def.pdf (Accessed 13/06/2023)

[217] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for: Laundry detergents and industrial and institutional laundry detergents; EUR 27380 EN; doi:10.2791/0171

[218] Reynolds, K.A., M.P. Verhougstraete, K.D. Mena, S.A. Sattar, E.A. Scott, and C.P. Gerba, 'Quantifying Pathogen Infection Risks from Household Laundry Practices', Journal of Applied Microbiology, Vol. 132, No. 2, February 2022, pp. 1435–1448. DOI 10.1111/jam.15273

[219] Reynolds, K.A., M.P. Verhougstraete, K.D. Mena, S.A. Sattar, E.A. Scott, and C.P. Gerba, 'Quantifying Pathogen Infection Risks from Household Laundry Practices', Journal of Applied Microbiology, Vol. 132, No. 2, February 2022, pp. 1435–1448. DOI 10.1111/jam.15273

[220] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[221] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575.DOI 10.3139/113.110449

[222] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for: Laundry detergents and industrial and institutional laundry detergents; EUR 27380 EN; doi:10.2791/0171

preference towards the use of eco-friendly products ([223]). Some of these type of products in the market present "eco-claims" such as: fragrance free, clear of dyes and brighteners, without artificial fragrance, colors or preservatives, biodegradable, ozone safe, free of phosphate, chlorine, ammonia, petroleum solvents, alcohol, butyl, glycol ether, sodium lauryl sulfate (SLS) ([224]).

Laundry wash at lower temperatures (*Cold-wash*) have given rise to an increase in the detergent formats with highest solubility and performance at these temperatures, as some liquid and/or powder detergents.

4.2.4.3. Labelling - EU Ecolabel.

Market penetration

Considering the licences awarded up to September 2023 to all EU Ecolabel products, the majority are held by Italy (18%), Germany (15%) and France (15%). Similarly, the majority of products are awarded in, Italy (16%), Spain (15%) and France (13%).

As on September 23, the total number of licenses and products awarded to EU Ecolabel laundry products (household + professional) were 149 and 1869, respectively. These, accounted for 4.1 % and 1.6% of the total licenses and products awarded so far. The EU ecolabel laundry products split in laundry detergents and industrial and institutional laundry detergents, the former having higher number of licenses (107 vs 42) and products (1010 vs 657) than the latter.

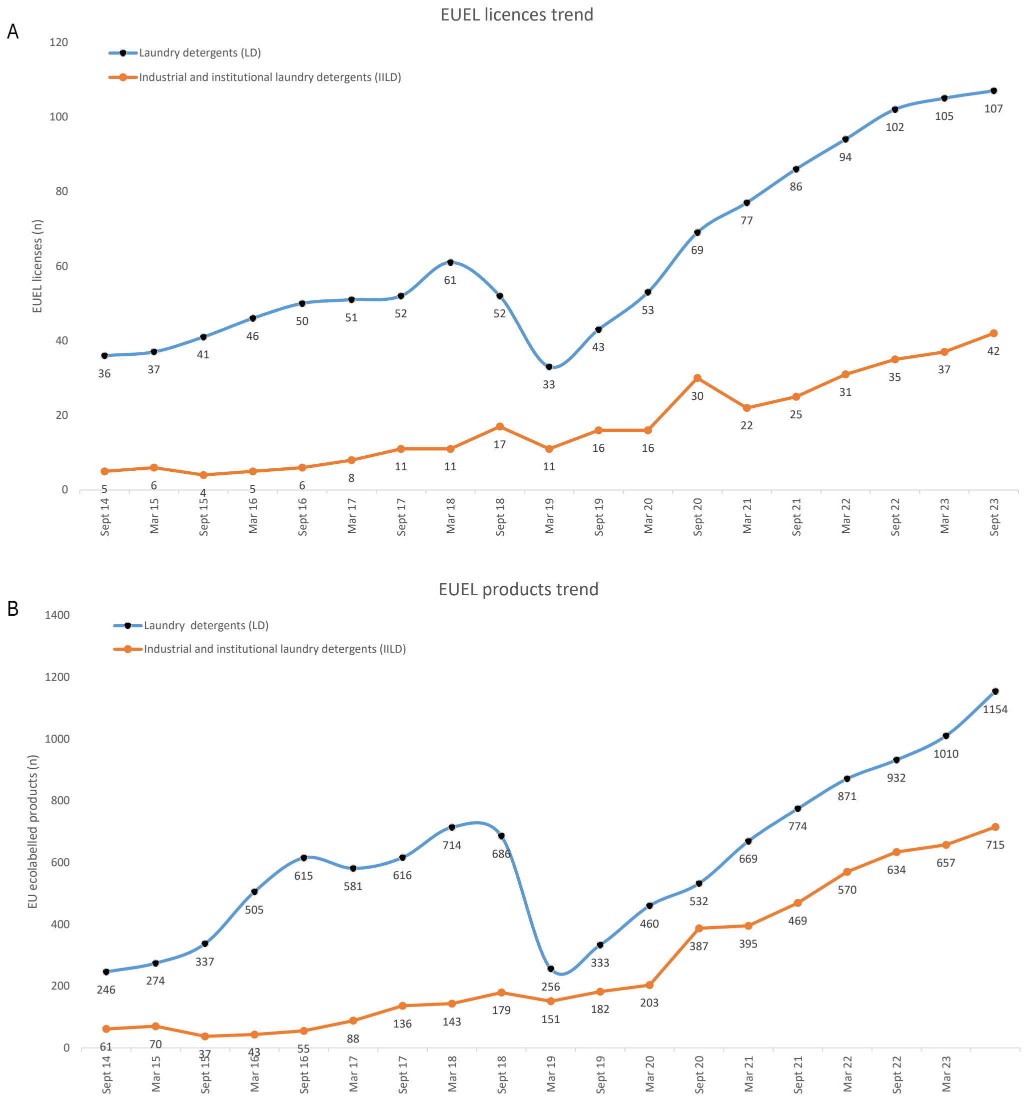
The number of licences for both LD and IILD has increased from 2019 to 2023, which indicates a steady update of the EU ecolabel.

The number of EU Ecolabel awarded licenses and ecolabelled products, arranged by EU member state, are displayed in Figures 13 and 14. Spain, Germany and Italy were top countries by number of EU Ecolabel laundry detergents licenses, accounting for 54% and 74% of the total market share for household (LD) and professional (IIDD) products, respectively. By number of EU Ecolabelled products, Estonia, Spain and Belgium were top countries for LD EU (60% share) while Belgium, Germany and Italy were top countries for IILD (71% share).

[223] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575.DOI 10.3139/113.110449

[224] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575.DOI 10.3139/113.110449

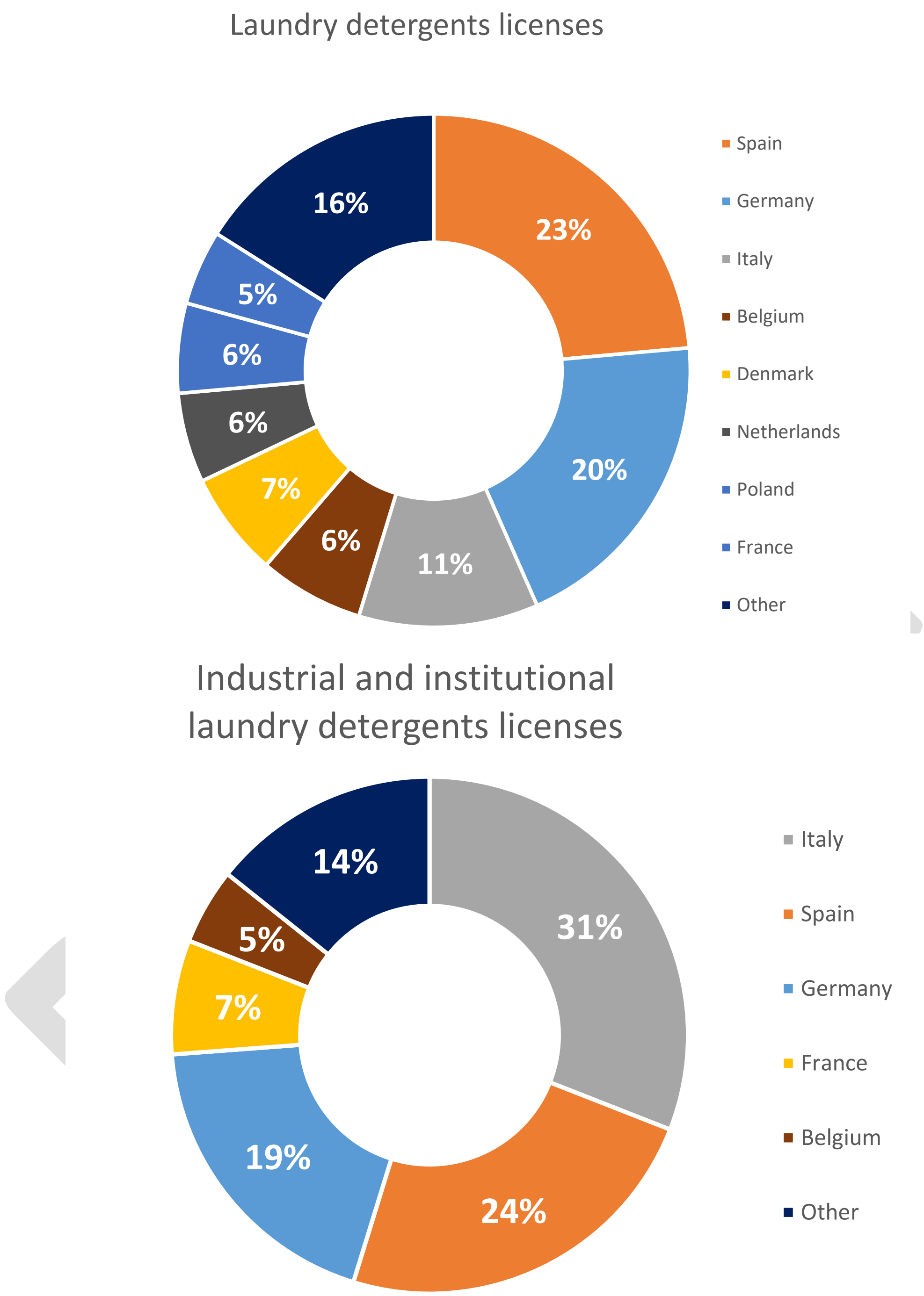
Figure 13 - Evolution of the number of EU Ecolabel licences (A) and products (B) for the product groups "Laundry detergents" and "Industrial and institutional laundry detergents"



Source: EU Ecolabel Statistics – European Commission ([225])

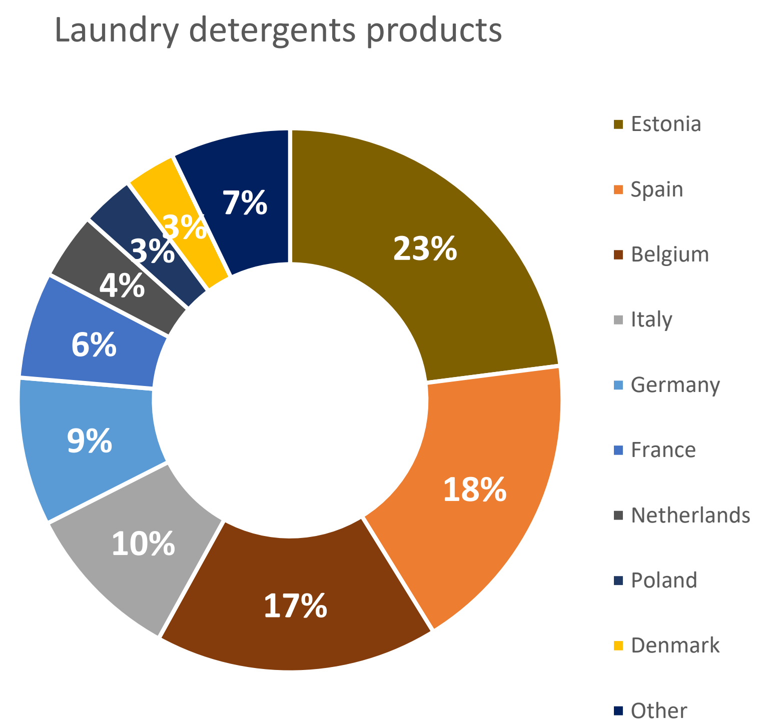
[225] https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/business/ecolabel-facts-and-figures_en (Accessed 04/05/23)

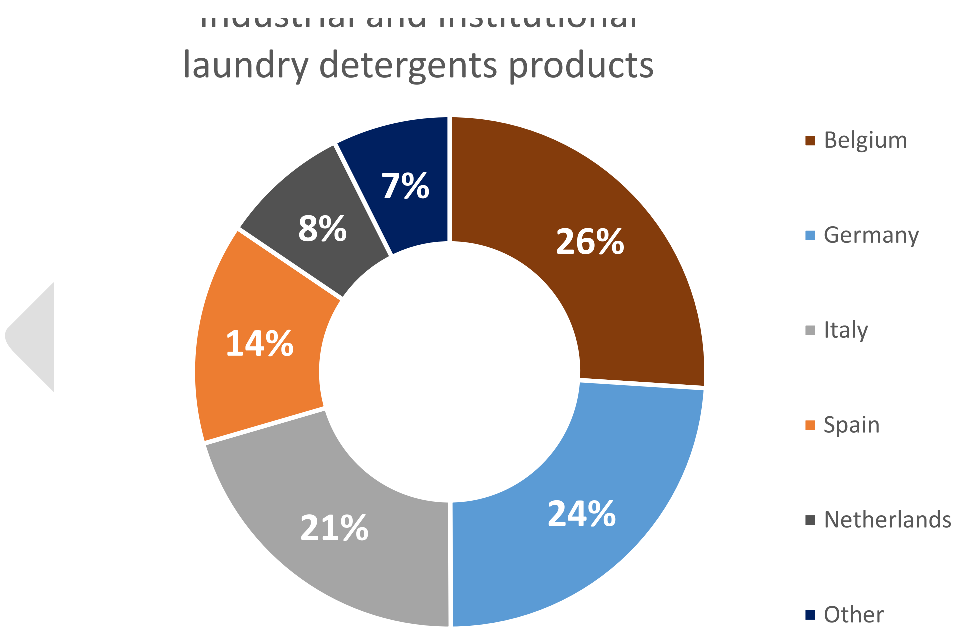
Figure 14 - Number of EU Ecolabel licences arranged by EU Member State for the product groups "Laundry detergents" and "Industrial and institutional laundry detergents" as on September 23.



Source: EU Ecolabel Statistics – European Commission

Figure 15 - Number of EU Ecolabel products arranged by EU Member State for the product groups "Laundry detergents" and "Industrial and institutional laundry detergents" as on September 23





Source: EU Ecolabel Statistics – European Commission

The previous evidences support that:

- For both household (LD) and professional (IIDD) laundry detergents product groups, Italy, Spain and Germany are the top 3 countries by number of licences.
- For both household (LD) and professional (IIDD) laundry detergents product groups, Italy and Germany are within the top 3 countries by number of ecolabelled products. The top country for LD was Estonia while for IILD it was Belgium.

- The number of licenses and products have steadily grow, being higher for laundry detergents, and there is expectance for this trend to be maintained.

Market challenges

The Assessment of the current criteria ([226]) summarises the following key market challenges for the product environmental labelling:

- Availability of raw materials in compliance with the EU Ecolabel criteria at reasonable costs (conventional ones commonly cheaper).
- Find the right balance in the formula: greenest raw materials (eg enhanced biodegradability) in synergy with optimal performance, also at reasonable costs.
- Finding suitable packaging for RTU products and/or the right bottle/label combination.

Indeed, the current lack of market stability due to .e.g. military conflict in Ukraine, might cause further global economic turbulences, and hence increase in a product's shelf price. Due to the global increase of the household goods costs, it might be expected that the consumer will, behind cleaning efficiency, look for the competitive - price or discount products.

4.2.5. Summary (LD)

The market analysis presented here allows for some key conclusions about laundry products, especially those potentially falling under EU ecolabel scope. On what follows, the summary refers to Laundry Detergents (including Industrial and Institutional Laundry Detergents).

Production and Trade

The nature of the data available in terms of imports/exports (PRODCOM) did not allowed for a direct match with EU Ecolabel laundry detergents products but it is useful as estimate of the overall detergent and cleaning products market in Europe, with main highlights being:

- In 2021, the total (EU27) production was 17.4 million tonnes valued at 16.5 billion €, with exports reaching an average of 2.88 million tonnes and 5.3 billion €, which almost tripled imports volume and value.
- Germany, Spain and Italy were the top producing countries, representing 40% and 53% of the total (EU27) production volume and value.

Market structure and sales

A market value of 15.4 billion € can be attributed to the European laundry care market, with the segmentation into household (LD) and professional (IILD) indicating dominant share for household (97.4%).

In 2021, the total (EU28) sales retail volume of laundry detergents products under EU Ecolabel scope (*"Laundry detergents EUEL"*) was 2.37 million tonnes and it was valued at 8.91 billion €. This is majorly composed by laundry detergents, with pre-wash spot removers having 0.04 million tonnes valued at 0.27 billion.

Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Poland) represented 70.7% and 67.6% of the total *"Laundry detergents EUEL"* retail sales market. Both actual and projected (2022-2027) data shown a clear increasing trend in the retail market by value but no so much by volume, thus suggesting an average increase in the price per unit.

Laundry detergents market was segmented by cleaning method, meaning whether clothes are washed in washing machines (*"Automatic detergents")* or by hand (*"Other detergents"*). *"Automatic detergents"* dominated the market with over 85% of the total sales retail market, by both volume (2.09 million tonnes) and value (7.91 billion €), with forecasting (2022 -2027) predicting a significant increase by value and minor increase by volume.

[226] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

Given its market relevance, *"Automatic detergents"* market was segmented by type (liquid/powder/ tablets) and by form (standard/concentrated/tablets), aiming to provide insights on the market trends of typical and innovative product formats. By type, *"Liquid detergents"* dominated the market by both retail sales volume (61.3%) and value (56.1%). By form, *"Concentrated detergents"* were preferred, having 77% by volume and 89% by value of the retail sales market. Both liquid and concentrated formats are projected (2022-2027) to further increase.

Key players

The manufacturing market is dominated by a few manufacturing global brands/groups, like Procter & Gamble Co, Henkel AG & Co KGaA, Unilever Group and Reckitt Benckiser Plc.

The European detergents specialty market, dominated by the surfactants and builders/fillers segments, includes key companies like Clariant, Croda, Solvay, Novozymes, Evonik, Croda and BASF.

Trends

The main driver for consumers' behaviour is functionality, understanding as such primarily cleaning but also contribution to hygiene. Then, under similar price per product (cost as modulator), there is a clear push for more environmentally friendly products ("eco"-products).

Amongst the main innovations observed in the detergents field, some impactful for laundry detergents are: "cold wash" (same cleaning efficiency at lower temperatures), ingredients substitution (eg alternatives to LAS), concentrated products (eg liquid/tablets); biobased products (eg biosurfactants as rhamnolipids), enzymes (enabling efficient cold wash) and microbial cleaning products.

As on September 2023, the EU Ecolabel for laundry detergent products splits into 42 licenses and 715 products for industrial and institutional laundry detergents and 107 licenses and 1154 products for laundry detergents. The EU Ecolabel licences and products increased in the last 4 years, trend that is aligned observed increase in retail value and the enhanced interest in "Eco"- products.

4.3. Dishwasher detergents (DD)

4.3.1. Production and trade figures (DD)

Data derived from PRODCOM categories do not directly match EU Ecolabel scope but they are useful as estimates of the overall detergents and cleaning products market in Europe (see section 4.1), which includes all dishwasher detergents [DD], as well as other washing and cleaning preparations and other detergents and soaps covered by the PRODCOM categories ([227]) shown in Table 11. Production, Imports and Exports figures derived from these PRODCOM categories, broken down by Member State, are shown in Table 12. Finally, production data at EU 27 of the last 5 years (2017-2022) is summarised via apparent consumption ([228]) in Figure 16.

Table 11 - PRODCOM cleaning product categories

Code(s)	Description
20.41.20.20	Anionic surface-active agents (excluding soap)
20.41.20.30	Cationic surface-active agents (excluding soap)
20.41.20.50	Non-ionic surface-active agents (excluding soap)
20.41.20.90	Organic surface-active agents (excluding soap, anionic, cationic, non-ionic)
20.41.31.20	Soap and organic surface-active products in bars, etc., n.e.c.
20.41.31.50	Soap in the form of flakes, wafers, granules or powders
20.41.31.80	Soap in forms excluding bars, cakes or moulded shapes, paper, wadding, felt and non-wovens impregnated or coated with soap/detergent, flakes, granules or powders
20.41.32.40	Surface-active preparations, whether or not containing soap, p.r.s. (excluding those for use as soap)
20.41.32.50	Washing preparations and cleaning preparations, with or without soap, p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations
20.41.32.60	Surface-active preparations, whether or not containing soap, n.p.r.s. (excluding those for use as soap)
20.41.32.70	Washing preparations and cleaning preparations, with or without soap, n.p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]

[227] PRODCOM list is a classification of industrial products derived from activities listed in sections B, C and E in the Statistical Classification of Economic Activities in the European Community (NACE) Eurostat - EU Vocabularies - Publications Office of the EU (europa.eu)

[228] Apparent consumption = EU domestic production + imports - exports

Table 12 - Exports, imports and production of detergent and cleaning products falling under the categories displayed in Table 11 for EU-27 during 2021.

Country	Exports quantity (tonnes)	Exports value (million EUR)	Imports quantity (tonnes)	Imports value (million EUR)	Production quantity (tonnes)	Production value (million EUR)
Austria	299558	423	325888	493	9040	23.8
Belgium	1578170	2360	945909	1343.7	869825	1023.4
Bulgaria	66085	68	93700	124.7	8298	7.1
Croatia	41276	46	80807	117.9	91671	93.3
Cyprus	383	1	29504	41.9	0	0.0
Denmark	231790	400	180528	245.8	357575	605.6
Estonia	31858	26	24663	61	47181	32
Finland	11808	27	101124	159	28330	55
France	955883	1847	1229925	1712	104109	0
Germany	1770963	3808	1420703	2344	1960706	4424
Greece	194625	169	152175	220	329119	146
Hungary	344718	421	237429	348	82056	20
Ireland	12672	40	133923	246	2717	17
Italy	1277959	1616	540845	934	2843749	2481
Latvia	8593	18	40824	65	1871	5
Lithuania	24327	46	57223	111	20055	26
Luxembourg	48893	91	25490	65	0	0
Malta	28	0	14448	17	0	0
Netherlands	932931	1772	672780	1177	355532	244
Norway	Data Not Available:					
Poland	1144714	1432	557150	837	300550	266
Portugal	121942	116	270361	322	181630	109
Romania	216508	254	372945	407	97112	66
Slovakia	62388	107	138837	190	24315	7
Slovenia	45039	62	74177	124	0	0
Spain	946150	1206	502599	829	2144396	1796
Sweden	161756	387	246500	379	41496	52
EU27TOTALS_2020	3068488	5819	1096863	2121	17395013	16524

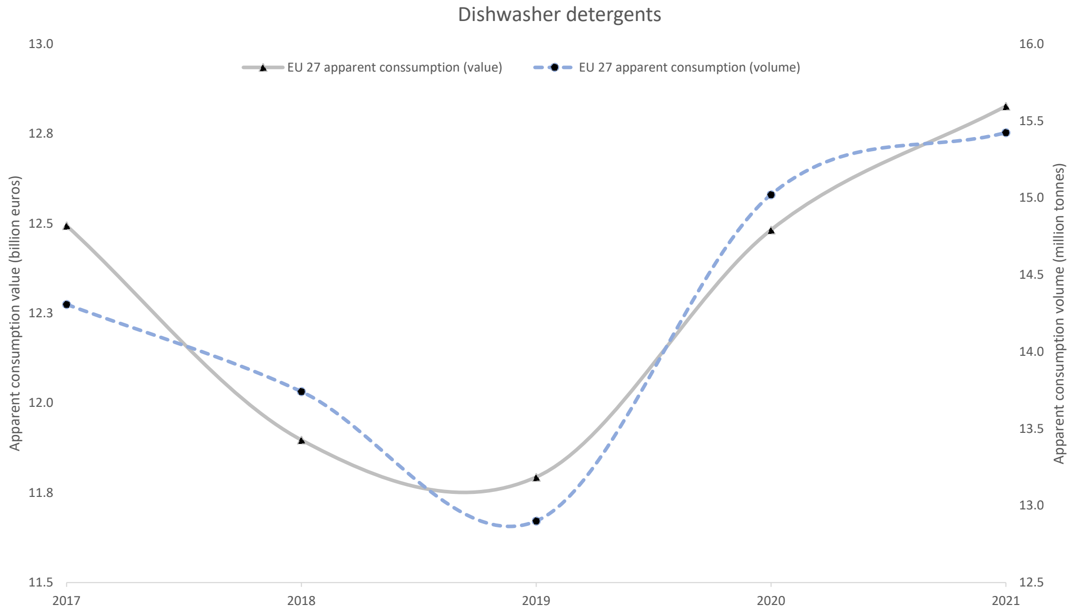
Source: EUROSTAT[229]

The total EU-27 production in 2021 was 17.4 million tonnes with an associated value of 16.5 billion € (See Table 12). Italy was the key producer (2.84 million tonnes valued 2.48 billion €), followed by Spain (2.14 million tonnes valued 1.8 billion €), and Germany (1.96 million tonnes valued 4.42 billion €). As of 2021,

[229] EUROSTAT Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]

Germany, Italy and Spain represent 40% and 53% of the production volume and value in the EU-27, respectively.

Figure 16 – Apparent consumption ([230]) for EU-27 during the period 2017-2021.



Source: EUROSTAT[231]

The apparent consumption volume and value from 2017 to 2021 were 14.3 – 15.4 million tonnes (7.8% growth) and 12.5-12.8 billion € (2.7% growth), respectively. During this period, the total production value and volume changed from 15.6 to 16.5 billion € and from 16.0 to 17.4 million tonnes, respectively, which corresponds to an increase of 5.7% in value and 8.6% in volume. The averaged exports volume was 2.88 million tonnes, valued at 5.3 billion €, which exceeded imports.

4.3.2. Market structure and sales (DD)

4.3.2.1. Market segmentation outline

Worldwide, Australasia is the top dishwashing market per capita spending ([232]). During the period 2018-2022, the registered compound annual growth rate (CAGR) for automatic dishwashing products global market was 4.2%, with expectations to reach 4.9% CAGR by 2033 ([233]). Dishwashing products market in Western Europe ([234]) ranked second globally in 2019 per capita spending, with prospects to remain in this position ([235]).

The European cleanliness and hygiene market, which includes dishwashing products, can be split into household and professional (institutional and industrial; I&I) use. The household care sector was valued in 2021 at 32.4 billion € and it is comprised by: laundry care (15 billion €); surface care (7.4 billion €); dishwashing care (5.2 billion €); maintenance products (4.1 billion €); and bleaches (0.7 billion €) ([236]).

[230] Apparent consumption = EU domestic production + imports - exports

[231] Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]; 5 year growth (%) = ((2021 – 2017)/2017)*100

[232] Dishwashing in Western Europe | Market Research Report | Euromonitor (Accessed 27/04/23)

[233] Automatic Dishwashing Products Market Size & Forecast by 2033 (futuremarketinsights.com) (Accessed 27/04/23)

[234] Austria, Belgium, Germany, France, Italy, UK, Spain, Turkey, Netherlands, Switzerland, Greece, Portugal, Sweden, Norway, Denmark, Ireland, Finland

[235] Dishwashing in Western Europe | Market Research Report | Euromonitor (Accessed 27/04/23)

[236] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

In 2021, the total value of the dishwashing care market across Europe (EU-27 + CH + NO) was 6.6 billion €, with household dishwashing possessing 78.8% of the market share ([237]). Professional dishwashing care had the remaining market share (21.2%), valued at 1.4 billion €. Note that *Kitchen & catering* data ([238]) are used as proxy of professional dishwashing products, yet it is unknown what proportion of these data relates only to dishwasher detergents.

Dishwashing products market can be segmented as "automatic dishwashing" and "hand-dishwashing", the former having higher market share (See Table 13). In broad terms, "automatic dishwashing" can present four different product types ([239]):

— 1. Dishwasher detergents, consisting of:
  - *Powdered detergents* – made up of free flowing granules which are poured into the dishwasher dispenser. They are very stable but might have tendency to clump owing to humidity.
  - *Gel/liquid detergents* – to be poured into the dishwasher dispenser.
  - *Tablet detergents* – a compact amount of detergent in a premeasured tablet. These are most commonly in powdered form, but gel tablets are becoming more widely seen. They are typically pre-wrapped to avoid environmental factors (e.g. moisture).

— 2. Other dishwasher additives – including water hardness regulators.

— 3. Rinse aids – used to improve cleaning (particularly for reducing smearing on glasses) and to aid drying.

— 4. Combined products – for example dishwasher detergents combined with rinse aids or other dishwasher additives. Often, these products come in tablet form.

All the previous product types are used in both household and professional segments.

Table 13 – Dishwashing sub-categories and associated market value during 2021

	Market value (billion €)	Dishwashing share (%)
Automatic dishwashing	3.3	63.5
Hand-dishwashing	1.9	36.5

Source: Euromonitor (EU 27 + UK + CH + NO) via A.I.S.E. Activity and Sustainability Report 2021-2022 ([240])

4.3.2.2. *Analysis of retail markets*

Euromonitor retail market data is used to estimate the potential market attributable to EU Ecolabel products falling under EU Ecolabel scope (see section 4.1), including relevant segmentations (eg products sub-groups; product form). To improve the analysis, retail sales data from Euromonitor ([241]) were processed into "best matching categories" to EU Ecolabel scope. In particular, "*Dishwasher Detergents"* was calculated as the

[237] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[238] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[239] G. Medina, A. Boyano, R. Kaps, J. Arendorf, K. Bojczuk, E. Sims, R.Menkveld, L.Golsteijn, A. Gaasbeek; Revision of the European Ecolabel Criteria for dishwasher detergents and industrial and institutional dishwasher detergents. https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/contentype/product_group_documents/1581681262/DD%20Preliminary%20Report.pdf

[240] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[241] Source: Euromonitor International's dedicated Home Care industry edition, 2022

difference between data from the Euromonitor categories "*Dishwashing*" and "*Hand-dishwashing*" (See Table 14). This newly formed category contains data on dishwashing detergents ([242]) and additives ([243]) products.

Note that in this section, any reference to actual or projected (forecasted) data refers to products potentially falling under EU Ecolabel scope, in this case dishwasher detergents, but do not directly refer to measured/recorded sells or turnover of ecolabelled product.

Table 14 – Euromonitor categories correspondent to EU Ecolabel scope for dishwasher detergents

EU Ecolabel dishwasher detergents scope (as in Commission Decision (EU) 2017/1216 of 23 June 2017)	Euromonitor (sub-) category	Description
The product group 'dishwasher detergents' shall comprise any detergent for dishwashers or rinse aid falling under the scope of Regulation (EC) No 648/2004 of the European Parliament and of the Council[244] which is marketed and designed to be used exclusively in household dishwashers and in automatic dishwashers for professional use of the same size and usage as that of household dishwashers.	*Dishwashing*	This is the aggregation of hand and automatic dishwashing products and dishwashing additives.
	Hand Dishwashing	Includes all detergents used to clean crockery and cutlery by hand. All formats (bar, liquid, gel, foam or wipes) are included

Sources: EC 2017 ([245]) , Euromonitor ([246])

During 2021, the total EU28 sales retail volume of "*Dishwasher detergents*" was 0.486 million tonnes with and associated value of 2.79 billion €. Germany had the highest sales retail volume , followed by France and Italy. Likewise, Germany had the highest production value (0.64 billion €), followed by France (0.54 billion €) and Italy (0.4 billion €). Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Netherlands) represent 77.1% and 71.1% of the total EU28 retail sales volume and value.

Dishwasher detergents actual (2008 - 2022) and projected (2023 - 2027) EU Ecolabel retail market trends (EU 28; top European countries) are shown in Figure 17. These countries were chosen as indicators of the European market, since a change in these countries will have larger impact on the overall retail sales and would help to understand the overall (EU28) trend.

The total retail sales value of the EU28 market steadily increased during the period 2008 -2022, from 1.78 to approximately 2.93 billion €, with forecasting indicating an even stepper increase during the years 2023 - 2027, reaching a maximum of 3.59 billion € (Figure 17-A).

Germany and France showed a steady increase during 2008 -2019, with Spain and Netherlands showing little or no increase (Figure 17-B). Except for Italy, the retail sales value of all these countries is foreseen to increase according to data projections (2023-2027).

[242] *Automatic dishwashing products* (Euromonitor category) -> Includes all detergents used in automatic dishwashers.

[243] *Dishwashing additives* (Euromonitor category) -> Includes all rinsing agents, salts, water softeners, and deodorisers used in dishwashing machines in addition to dishwashing detergents. Also includes products that clean the inside of dishwashers and remove limescale.

[244] Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents (OJ L 104, 8.4.2004, p. 1). https://eur-lex.europa.eu/legal-content/EN/AUTO/?uri=OJ:L:2004:104:TOC

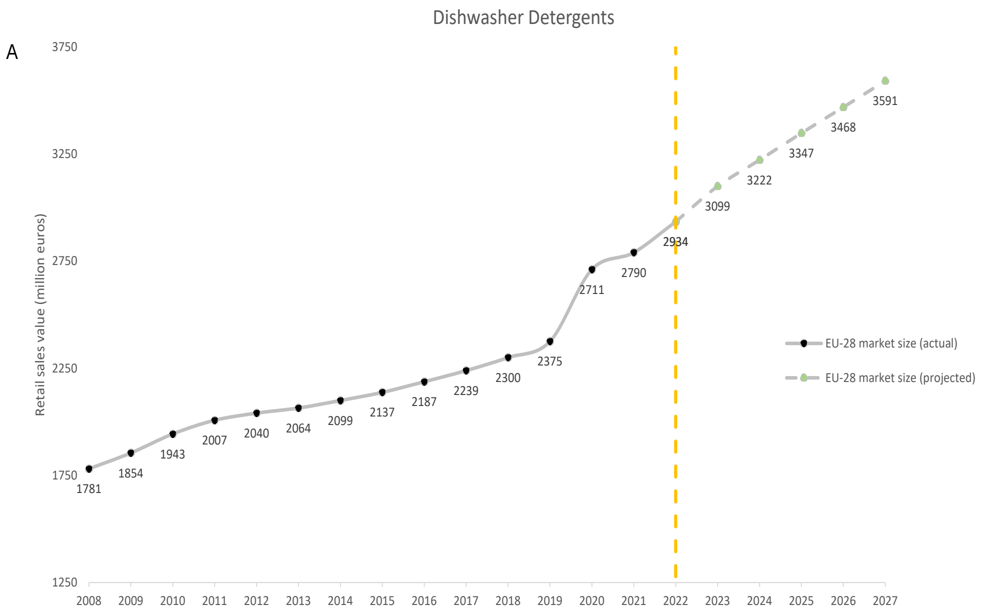
[245] Commission Decision (EU) 2017/1216 of 23 June 2017 establishing the EU Ecolabel criteria for dishwasher detergents (OJ L 180, 12.7.2017, p. 31–44) https://eur-lex.europa.eu/eli/dec/2017/1216/oj

[246] Euromonitor International, Home Care, 2022-> Category definitions

The total retail sales volume of the EU28 market also increased during the period 2008 -2022, from 0.399 million tonnes to 0.471 million tonnes, with forecasting (2023-2027) predicting reaching 0.487 million tonnes (Figure 17-C).

Germany increased (2008-2016) and decreased (2017-2022), returning to the starting level at approximately 0.140 million tonnes. During the period 2008 -2022, France's volume steadily increased, reaching 0.092 million tonnes, while Spain’s decreased by 7187 tonnes (12.5%). Data projections indicated that Germany will decrease; France and Netherland will slightly increase; and Netherland & Spain will reach a plateau at approximately 54.000 tonnes (Figure 17–D).

Figure 17 – Dishwasher detergents actual (2008 - 2022) and projected (2023 - 2027) market trends for products potentially falling under EU Ecolabel DD scope. This figure presents the retail sales value (A-B) and volume (C-D) for the EU28 (A-C) and for the top five European countries by market share (B-D).



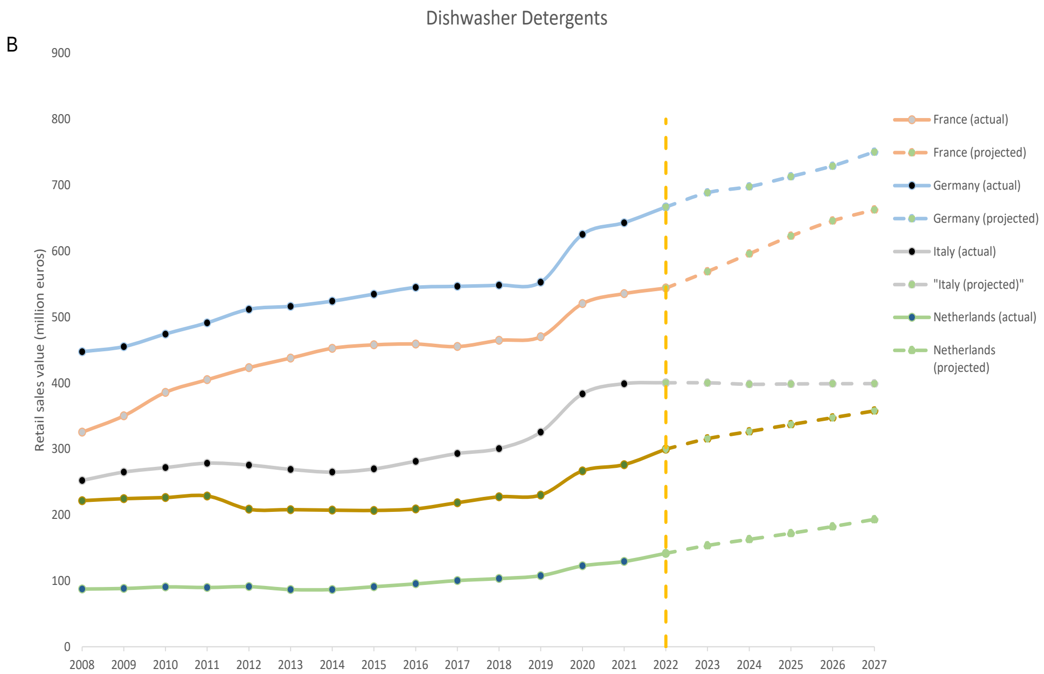
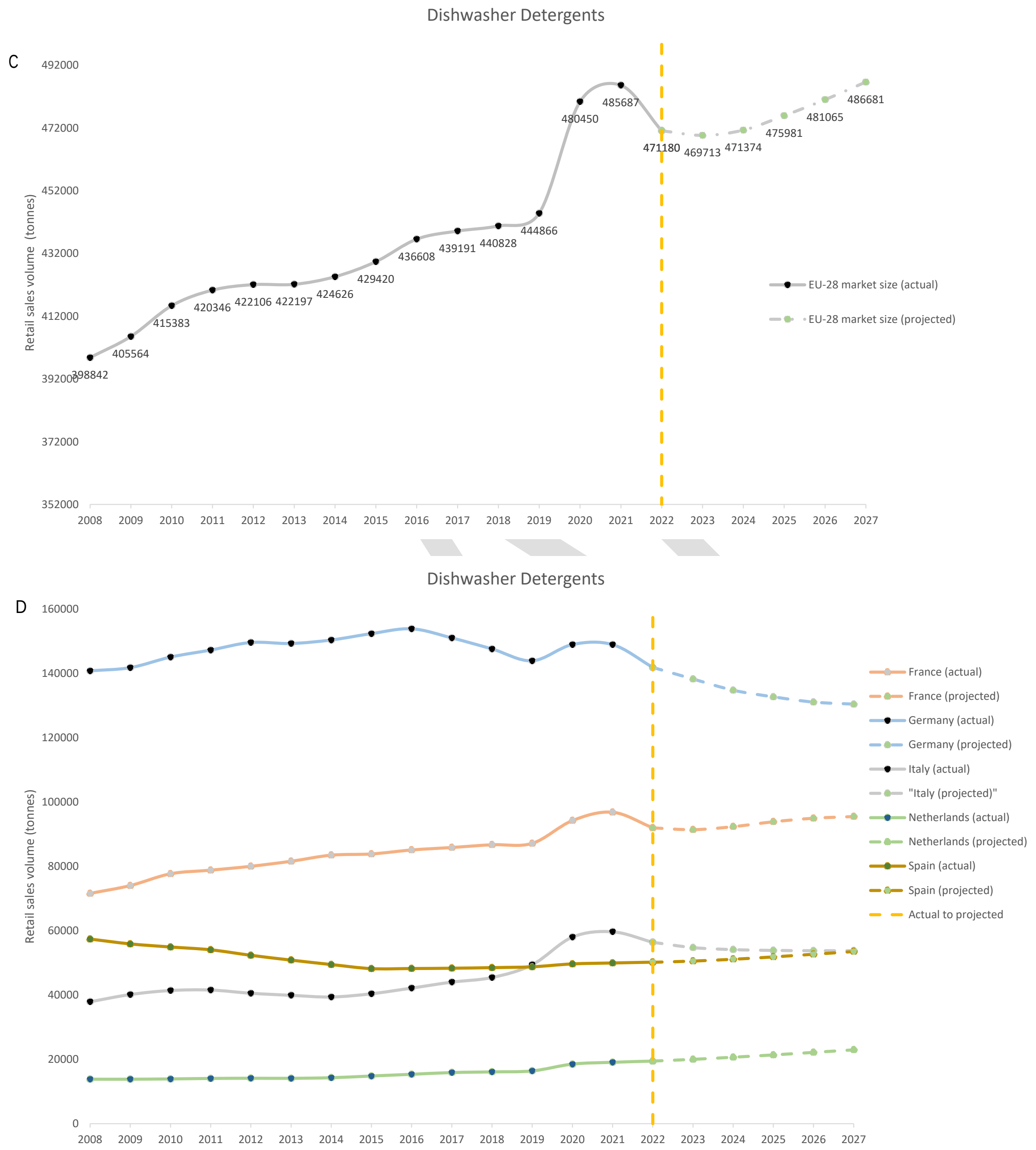


Figure 17 – continuation.



Source: Euromonitor. ([247]).

[247] Euromonitor International, Home Care, 2022

Dishwasher Detergents retail sales data accommodates two products' sub-groups: *Automatic dishwashing detergents* (e.g. powder/liquid/tablets) and *Dishwashing additives* (e.g. Rinse aids). Out of these, more than 70%[248] of the market value is attributed to dishwashing detergents ([249]). Consumers' preferences seem to target convenient/ease of use products, as detergent tablets[250]. Amongst the three main product forms (liquid, powder and tablets), in 2012 the range of dishwashing tablets was superior to the other forms, ranging from 52% to 92% depending on the country[16]. Despite, data constraints did not allow for carrying out a detailed retail market analysis segmented by product form (liquid, powder and tablets), it is reasonable to assume based on previous evidences that dishwashing detergents tablets is the preferred form of product used.

4.3.3. Key players (DD)

The following can be considered a representation of the global key players for cleaning/detergents market: Reckitt Benckiser Group PLC, The Procter & Gamble Company, Unilever PLC, Johnson & Johnson, Kao Corporation, Colgate-Palmolive Company, The Clorox Company, Henked AG & Co. KGaA and Dropps[Error! Bookmark not defined.].

Similarly, the dishwashing detergents market across Europe is heavily dominated by a few well-know and globally recognised organisations and brands. In 2013, the top manufacturer's by retail sales value were (in this order): Reckitt Benckiser Plc (23%)> Procter & Gamble Co (14%)> Henkel AG & Co KGaA (13%)>Unilever Group (11%)> Colgate-Palmolive Co (4%) ([249]). In 2019, big brands remained consumer's preferred choice, with Reckitt Benckiser retaining its leading position with its product line "*Finish*" ([235]).

In addition, the impact of COVID pandemic in 2020 with the associated strict lock downs disrupted trading fluidity of the global supply chain. This also affected the dishwashing detergents market that avoided negative growth in the sales revenue of consumer goods by deviating to e-commerce platforms ([251]).

Retail distribution channel for dishwashing detergents in Western Europe remain very fragmented, with discounters holding large share in Germany, hypermarkets being preferred in France and supermarkets in Netherlands ([235]).

The global market size attributable to chemicals was estimated at 50.14 billion USD in 2020, with a projected CAGR for 2021-2028 of 4.2%, reaching a maximum of 71.26 billion USD ([252]). In terms of ingredients suppliers, they be grouped by the type of chemical they supply:

- *Inorganic* suppliers responsible for supplying fillers, builders and bleaches.
- *Organic* suppliers responsible for supplying surfactants, polymers and antifoams.
- *Enzyme* suppliers responsible for supplying enzymes targeting specific type of stains.

Builders and fillers is the segment with the highest market share (39.2%) in 2020, with enzymes being the fastest-growing segment in the market ([253]). Currently, anionic and non-ionic surfactants account for 95% of the market, zwitterionics around 1% and the remaining (less than 5%) to cationics, valued at approximately 2 billion USD ([254]).

Companies active in the European market for detergent speciality ingredients include Clariant, Rhodia, Solvay, Rohm & Hass, Cognis, Croda, Dow Corning, Elementis, Alco Chemical and BASF amongst others. The availability, thus the price (and related market fluctuation), of raw materials and/or ingredients for detergents production is susceptible to changes.

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[248] On average of those countries used as indicators like France, Germany, Italy and Poland

[249] Revision of the EU Ecolabel criteria for dishwasher detergents and industrial and institutional dishwasher detergents. (Accessed 27/04/23) https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/contentype/product_group_documents/1581681262/DD%20Preliminary%20Report.pdf

[250] US-10346718-B2 - Tablet Dishwashing Detergent and Methods for Making and Using the Same | Unified Patents (Accessed 27/04/23)

[251] https://www.fortunebusinessinsights.com/dishwashing-detergent-market-106546 (Accessed 27/04/23)

[252] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[253] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com)

[254] Gonçalves, R.A., K. Holmberg, and B. Lindman, 'Cationic Surfactants: A Review', Journal of Molecular Liquids, Vol. 375, April 2023, p. 121335. DOI 10.1016/j.molliq.2023.121335

4.3.4. Trends (DD)

4.3.4.1. Product innovation (sustainability).

The growing awareness of consumers on detrimental effects on the environment has led to several sustainability trends and innovations within the detergents products market, like:

- *Ingredients substitution* – detergents formulation change to incorporate substances that deliver equivalent or better functionality at similar production costs whilst being a more sustainable alternative. An example is the Fairy Platinum from Procter and Gamble, substituting phosphates with methyl glycine diacetic acid ([255]).
- *Efficient manufacturing* – which encompass resource efficiency improvement (e.g. energy-efficient running of equipment), minimization of waste and use of renewable energy sources. An example is the brand *Cascade* by Procter & Gamble ([256]).
- *Concentrated products* – which deliver the same function with lower mass of product used. This in turn, consume fewer resources across the production-consumption life cycle (less packaging; less resources consumption associated with transport). An example could be *Persil non-bio washing tablets* from Unilever ([257]).
- *Biobased products* – sourcing raw materials for detergents production more sustainably, which might also enhance the biodegradability of the product. For example, Pectins can serve as functional substitutes for non-degradable polymer detergents ([258]).
- *Refill systems* – allowing less single-use packaging waste thanks to an alternative format/business model. An example is the Fill Refill Co ([259]).
- *Enzymes* – which enhance the efficiency of the cleaning process, for example by allowing achieving the same cleaning performance at lower washing temperatures ([260]).
- *Microbial cleaning products* – which take advantage of the biological action of microorganisms to contribute to the cleaning process, increasing the efficiency (via enzymes, for example) and/or by substituting substances with negative environmental footprint ([261]) (Arvanitakis, Temmerman, and Spök, 2018).
- *"Cold wash"* – which ensures achieving same cleaning efficiency at lower washing temperatures than commonly historically, thus decreasing the energy use during washing. An example are PG's brands *Tide* and *Ariel* ([262]).

Focusing on dishwashing detergent products, innovation is one of the main drivers supporting premium products demand, adding features desirable usage traits (i.e. all-in-one tablets)[235]. In this regard, sustainability is an important aspect owing to consumers growing awareness on environmental implications associated to products consumption ([263]).

Ingredients substitution aims to improve the environmental profile of dishwashing products, by exerting the same function with an alternative more sustainable substance produced at competitive market costs. The

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[255] Van Hoof, G., M. Fan, and A. Lievens, 'Use of Product and Ingredient Tools to Assess the Environmental Profile of Automatic Dishwashing Detergents', Journal of Cleaner Production, Vol. 142, January 2017, pp. 3536–3543. DOI 10.1016/j.jclepro.2016.10.114

[256] Sustainable Manufacturing Commitment | Cascade Detergent (cascadeclean.com) (Accessed 03/05/23)

[257] Persil Non-bio Washing Tablets | Persil (Accessed 04/05/23)

[258] https://innovationorigins.com/en/beet-pulp-as-an-alternative-to-chemicals-in-dishwasher-detergents-and-the-leather-industry/ (Accessed 03/05/23)

[259] About - Fill Refill Co - Refillable Eco Household & Personal Care Products (Accessed 03/05/23)

[260] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23)

[261] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOi 10.1016/j.fct.2017.12.032

[262] Washing Your Clothes on Cold with Tide and Ariel Does a World of Good (pg.com) (Accessed 13/06/2023)

[263] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOi 10.3139/113.110449

substitution of phosphates by other builders, such as methyl glycine diacetic acid (MGDA), allow for decreased P-emissions whilst maintaining the ability to bind water hardness ions (Ca and Mg), so surfactants efficiency is maintained ([264]).

Enzymes in dishwashing products can remove food soils effectively with mild mechanical action required, which implies reduced water consumption and less time required per wash cycle, also aiding in the maintenance of recirculated (sump) water within industrial use contexts ([265]).

Microbial cleaning products (MCP) are characterized by containing strains of microorganism as active ingredients, being an alternative to the wide-spread detergent forms with purely chemical-based active ingredients. The market for MCP represents a growing share within the “green cleaning products” market being projected to increase more in Europe than in United States ([266]). In 2017 projections estimated a maximum of $US9.32 billion, approximately equivalent to 6% of global household cleaning products market value (totalling $US147 billion) ([267]). In addition, the recent inclusion of microorganism within the scope of the revised Detergent Regulation[268] provides regulatory guidance on the use of this type of ingredients/products, thus being reasonable to expect a boost in this market because of a harmonised regulatory framework. Nevertheless, some of the issues identified relate to potential for pathogenicity, taxonomic identification of the microorganisms used, quality assurance and control, labelling and exposure upon use ([269]). Given these issues and the potential exposure via ingestion of dish washed goods, it is necessary a thorough understanding of the risks associated, which will be discussed in further detail in the technical report.

“Cold wash”, or cleaning with lower temperature than commonly used tackles one of the main environmental hotspots associated with dishwashing detergents during the use phase: the energy use to heat the water during washing ([270]). The washing temperature is conditioned by dishwashers’ configuration, which responds to manufacturer’s recommendations, being normally operated 40 - 60 C ([271]) (Hook, Schmitz, and Stamminger, 2018). By decreasing washing temperature, the energy consumption is directly decreased, which also impacts indirectly on fossil fuel depletion and global warming potential ([272]). However, decreasing the temperature could impact upon dishwasher cleaning performance, especially on heavily soiled load items and of fatty soilings on plastic surfaces ([273]).

4.3.4.2. Consumer behaviour.

Cleanliness and hygiene are both the main function (cleaning) and the primary reason that drives consumers’ behaviour. In a study by Insites Consulting for A.I.S.E ([274]), the majority (>88%) of the respondents indicated that “*Cleaning and hygiene in my home is important because it helps me and/or the people I live with avoid becoming unwell or getting and infectious disease”,* also indicating that it was *“important for the health of*

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[264] Van Hoof, G., M. Fan, and A. Lievens, ‘Use of Product and Ingredient Tools to Assess the Environmental Profile of Automatic Dishwashing Detergents’, Journal of Cleaner Production, Vol. 142, January 2017, pp. 3536–3543. DOI 10.1016/j.jclepro.2016.10.114

[265] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23).

[266] Arvanitakis, G., R. Temmerman, and A. Spök, ‘Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps’, Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOi 10.1016/j.fct.2017.12.032

[267] Arvanitakis, G., R. Temmerman, and A. Spök, ‘Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps’, Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOi 10.1016/j.fct.2017.12.032

[268] COM(2023)217 - Proposal for a regulation of the European Parliament and of the Council on detergents and surfactants, amending Regulation (EU) 2019/1020 and repealing Regulation (EC) No 648/2004 COM(2023)217 - Proposal for a regulation on detergents and surfactants (europa.eu) (Accessed 04/05/23).

[269] Arvanitakis, G., R. Temmerman, and A. Spök, ‘Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps’, Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOi 10.1016/j.fct.2017.12.032

[270] Josephine Arendorf, Katherine Bojczuk, Edward Sims, Rimousky Menkveld, Laura Golsteijn, Anne Gaasbeek, Alicia Boyano, Galyna Medyna, Renata Kaps. Revision of the EU Ecolabel criteria for dishwasher detergents and industrial and institutional dishwasher detergents. (Accessed 27/04/23) https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/contentype/product_group_documents/1581681262/DD%20Preliminary%20Report.pdf

[271] Hook, I., A. Schmitz, and R. Stamminger, ‘Dishwashing Behaviour of European Consumers with Regard to the Acceptance of Long Programme Cycles’, Energy Efficiency, Vol. 11, No. 7, October 2018, pp. 1627–1640. DOI 10.1007/s12053-017-9539-y

[272] Revision of the EU Ecolabel criteria for dishwasher detergents and industrial and institutional dishwasher detergents. (Accessed 27/04/23) https://susproc.jrc.ec.europa.eu/product-bureau/sites/default/files/contentype/product_group_documents/1581681262/DD%20Preliminary%20Report.pdf

[273] Gorny, S., S. Bichler, M. Seifert, A. Kessler, R. Stamminger, and N. Wrubbel, ‘Potentials and Impacts of Low Temperature Electric Household Dishwashing’, Tenside Surfactants Detergents, Vol. 53, No. 5, September 15, 2016, pp. 470–477. DOi 10.3139/113.110454

[274] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

people around me". Once consumers see this primary condition met, then additional factors are considered, such as price (affordability), ease of use/convenience and/or the effect on the environment ("green"; "eco-product").

Amongst the factors explaining dishwashing detergent product consumption, there is an inherent relationship with dishwashers owned, both total number in the market and their characteristics. On the one hand, the higher is the ownership of dishwashers, the higher can be expected the demand of dishwashing detergents products. On the other hand, dishwashing detergent products are designed to work effectively under the most common operational conditions for dishwasher machines, thus dishwashing detergent product design and usage is constrained by dishwashers configuration. The increase in the use of household dishwasher relates to its benefits achieved in terms of health & safety, resources saving (e.g. water, time), and personal convenience ([275]). Further increases in the demand for dishwashing products could be reasonably expected.

The increase in consumers' environmental awareness has led to the rise of the demand for more environmentally friendly dishwashing detergent products. Surveys on consumer behaviour indicated a strong preference towards the use of eco-friendly products ([276]). Some of these types of product in the market present "eco-claims" such as: fragrance free, no dyes and brighteners, without artificial fragrance, colors or preservatives, biodegradable, ozone safe, free of phosphate, chlorine, ammonia, petroleum solvents, alcohol, butyl, glycol ether, sodium lauryl sulfate (SLS) ([277]).

4.3.4.3. Labelling - EU Ecolabel.

Market penetration

Considering the licences awarded up to September 2023 to all EU Ecolabel products, the majority are held by Italy (18%), Germany (15%) and France (15%). Similarly, the majority of products are awarded in, Italy (16%), Spain (15%) and France (13%).

As on September 23, the total number of licenses and products awarded to EU Ecolabel dishwasher products (household + professional) were 173 and 1757, respectively. These, accounted for 6.7% and 1.9% of the total licenses and products awarded so far. The EUEL dishwasher products splits into 99 licenses and 1376 products for industrial and institutional dishwasher detergents; and 74 licenses and 381 products for dishwasher detergents.

The number of licences for both DD and IDD has increased from 2019 to 2023, which indicates a steady update of the EU ecolabel (See Figure 18). Similarly, the number of ecolabelled products has also increased during this period but at a faster pace for IIDD (381 versus 1376, respectively). Note that the dip observed in license and products number correspond with a transition from the old criteria to the new one approved during June 2017.

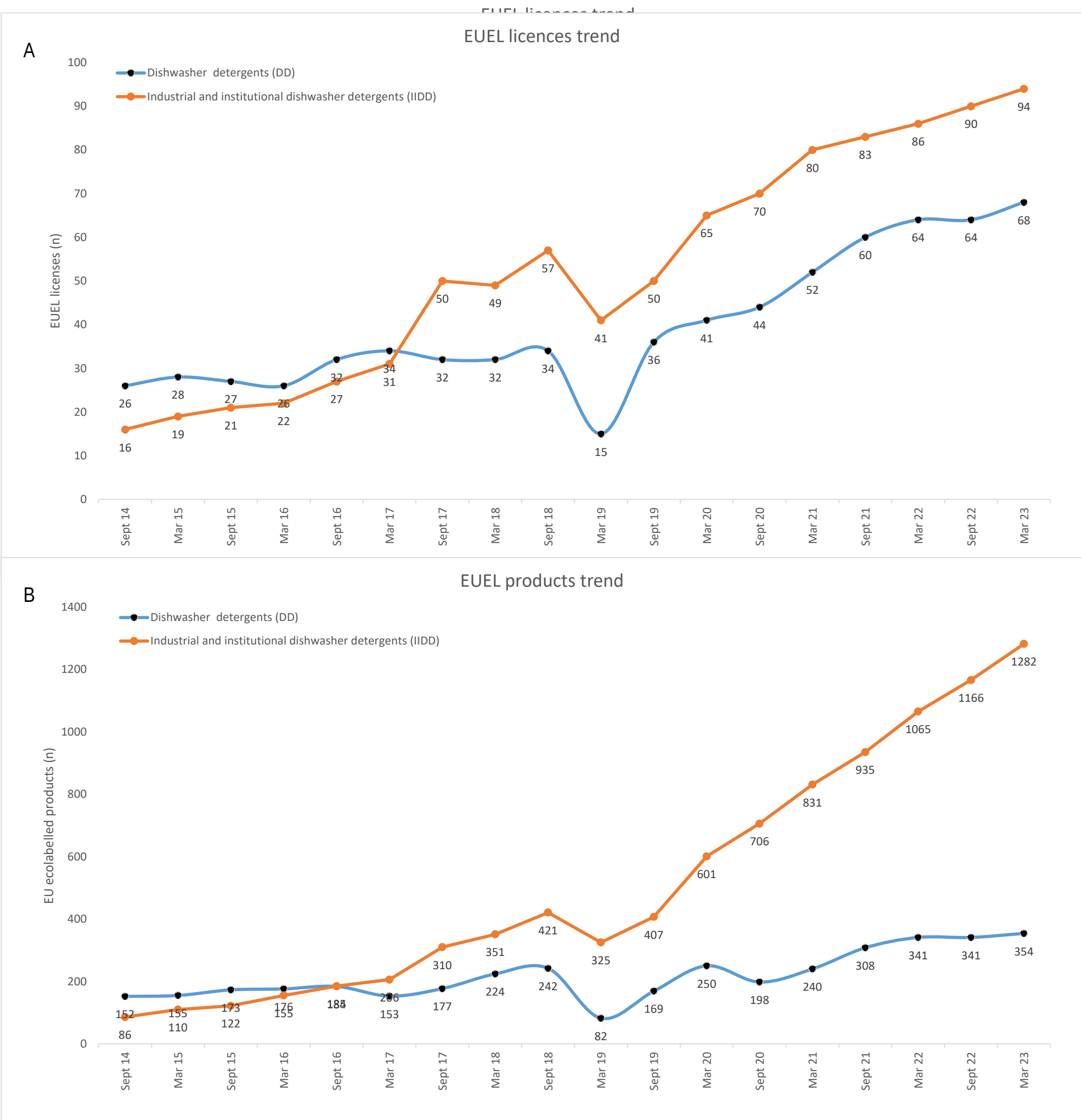
The number of licenses and products awarded to EUEL dishwasher products arranged by EU member state are displayed in Figures 19 and 20. The top country by number of dishwasher detergents licenses is Germany while by number of ecolabelled products is Netherlands. The rest of countries in the top 4, both by licenses and products, are Spain, Italy, Denmark and France. The two top countries by number of industrial and institutional licenses and ecolabelled products are Italy followed by Spain, accounting for more than 65% of the total share.

[275] Venkatesh, G., 'Dishwashers: Literature Review to Summarise the Multi-Dimensionality of Sustainable Production and Consumption', Sustainability, Vol. 14, No. 16, August 18, 2022, p. 10302. DOi 10.3390/su141610302

[276] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449

[277] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449

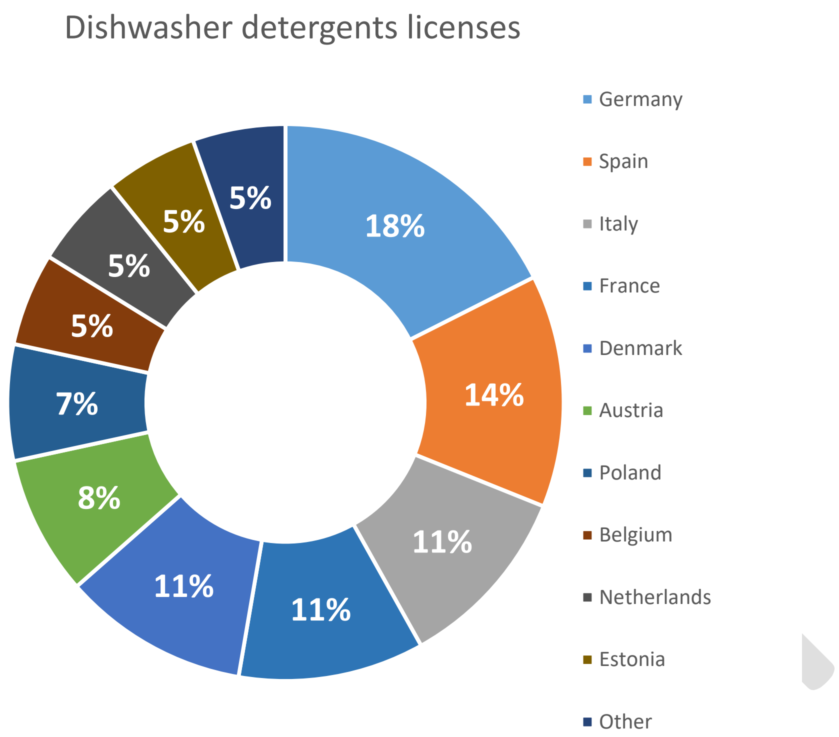
Figure 18 - Evolution of the number of EU Ecolabel licences (A) and products (B) for the product groups "Dishwasher detergents" and "Industrial and institutional dishwasher detergents"

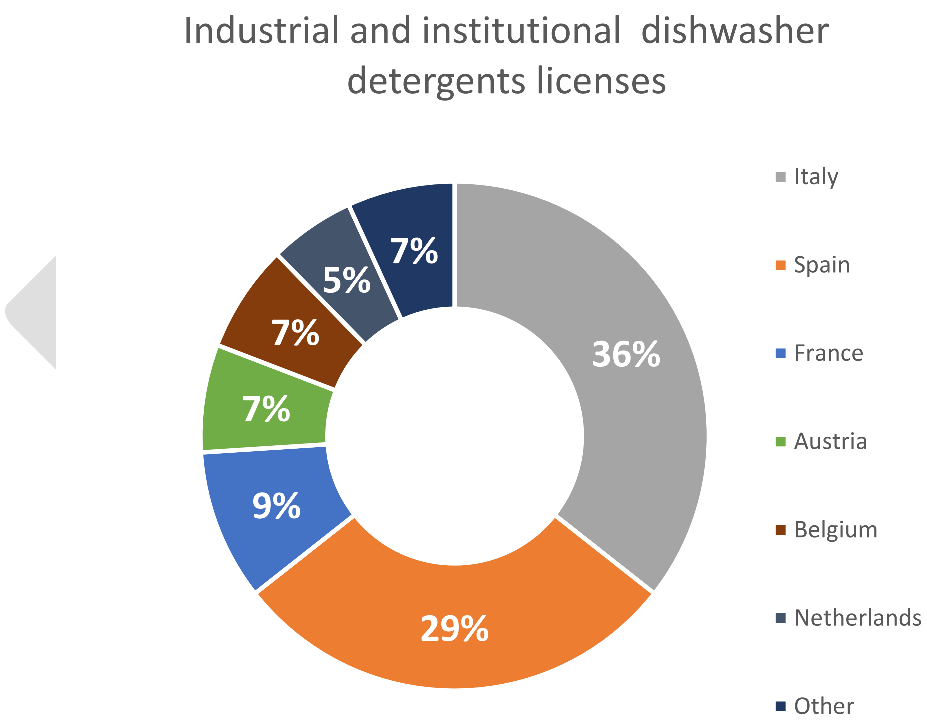


Source: EU Ecolabel Statistics – European Commission ([278])

278 https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/business/ecolabel-facts-and-figures_en (Accessed 04/05/23)

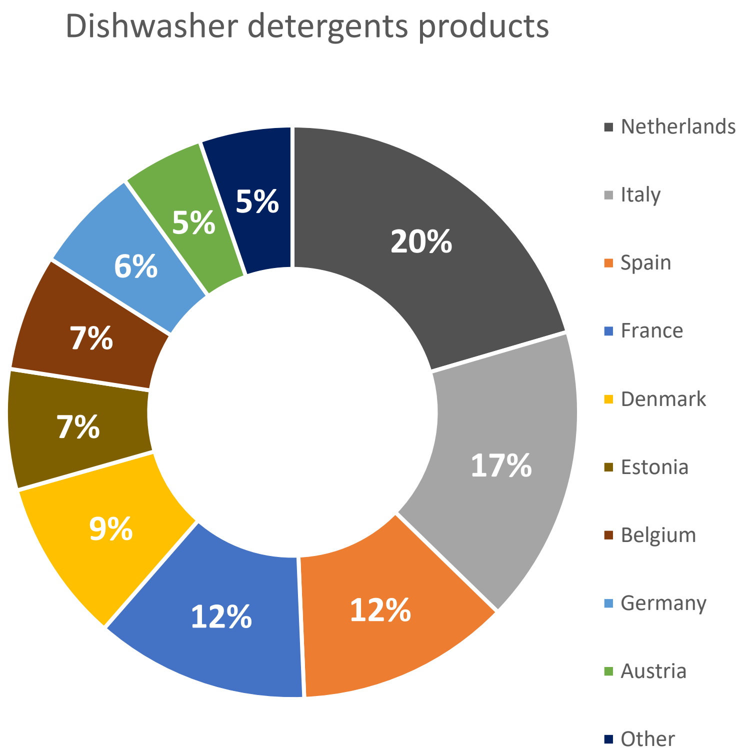
Figure 19 - Number of EU Ecolabel licences arranged by EU Member State for the product groups "Dishwasher detergents" and "Industrial and institutional dishwasher detergents" as on September 23.

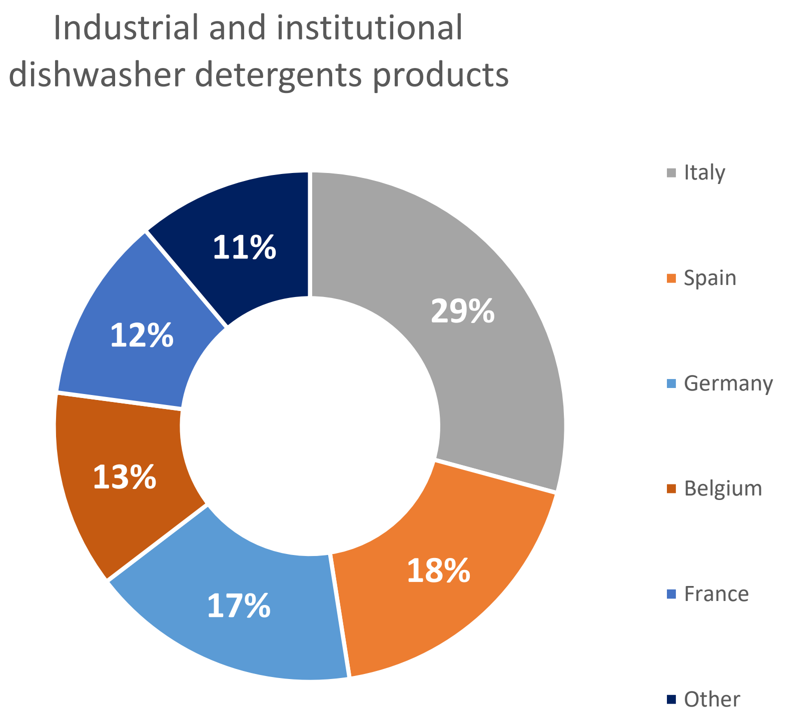




Source: EU Ecolabel Statistics – European Commission

Figure 20 - Number of EU Ecolabel products arranged by EU Member State for the product groups "Dishwasher detergents" and "Industrial and institutional dishwasher detergents" as on September 23.





Source: EU Ecolabel Statistics – European Commission

The previous evidences support that:

- The top countries by total number of EU Ecolabel licenses and products, not only for hand dishwashing detergents but also for the rest of EU ecolabel product groups are France, Germany, Italy and Spain. These match with those showing highest retail market share by value and volume.

- The number of licenses and products have steadily grow and there is expectance for this trend to be maintained. Comparatively with household (DD), professional dishwasher detergents are superior in terms of ecolabelled products but present the same increasing trend in the number of licenses awarded.

Market challenges

The Assessment of the current criteria ([279]) summarises the following key market challenges for the product environmental labelling:

- Availability of raw materials in compliance with the EU Ecolabel criteria at reasonable costs (conventional ones commonly cheaper).
- Find the right balance in the formula: greenest raw materials (eg enhanced biodegradability) in synergy with optimal performance, also at reasonable costs.
- Finding suitable packaging for RTU products and/or the right bottle/label combination.

Indeed, the current lack of market stability due to .e.g. military conflict in Ukraine, might cause further global economic turbulences, and hence increase in a product's shelf price. Due to the global increase of the household goods costs, it might be expected that the consumer will, behind cleaning efficiency, look for the competitive - price or discount products.

4.3.5. Summary (DD)

The market analysis presented here allows for some key conclusions about the dishwasher products, especially those potentially falling under EU Ecolabel scope. On what follows, the summary refers to Dishwasher Detergents (including Industrial and Institutional Dishwasher Detergents).

Production and Trade

The nature of the data available in terms of imports/exports (PRODCOM) did not allow for a direct match with EU Ecolabel laundry detergents products but it is useful as estimate of the overall detergent and cleaning products market in Europe, with main highlights being:

- In 2021, the total (EU27) production was 17.4 million tonnes valued at 16.5 billion €, with exports reaching an average of 2.88 million tonnes and 5.3 billion €, which almost tripled imports volume and value.
- Germany, Spain and Italy were the top producing countries, representing 40% and 53% of the total (EU27) production volume and value.

Market structure and sales

A market value of 6.6 billion € can be attributed to the European dishwashing market, with the segmentation into household (DD) and professional (IIDD) indicating dominant share for household (78.8%).

In 2021, the total (EU28) sales retail volume of "Dishwasher detergents" under EU Ecolabel scope was 0.486 million tonne, valued at 2.79 billion €. Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Netherlands) represented 77.1% and 71.1% of the total retail sales market.

The historical plus forecasted trends show a clear increase in the retail market value of dishwasher detergent products potentially falling under EU Ecolabel scope with an associated moderate increase in retail market volume, thus suggesting an average increase in the price per unit.

[279] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

This product group is also segmented into liquid, powder and tablets dishwasher detergents. Best estimates indicated that the highest share (>50%) of the market belonged to dishwasher detergents tablets.

Key players

The market is dominated by a few manufacturing global brands/groups, like Reckitt Benckiser Plc, Procter & Gamble Co, Henkel AG & Co KGaA, Unilever Group and Colgate-Palmolive).

The European detergents specialty market, dominated by the surfactants and builders/fillers segments, includes key companies like Clariant, Croda, Solvay, Novozymes, Evonik, Croda and BASF.

Trends

The main driver for consumers' behaviour is functionality, understanding as such primarily cleaning but also contribution to hygiene. Then, under similar price per product (cost as modulator), there is a clear push for more environmentally friendly products ("eco"-products).

Amongst the main innovations observed in the detergents field, some impactful for dishwasher detergents are: "cold wash" (same cleaning efficiency at lower temperatures), ingredients substitution, refill systems and the use of enzymes. Most innovations are conditioned to lesser or greater extend by the design of the dishwasher in which detergents products will be used, thus dishwasher ownership and representative technical profile (reference machine) appear as important elements.

As on September 2023, the EU Ecolabel for dishwasher products splits into 99 licenses and 1376 products for industrial and institutional dishwasher detergents and 74 licenses and 381 products for dishwasher detergents. The EU Ecolabel licences and products increased in the last 4 years, trend that is aligned observed increase in retail value and the enhanced interest in "Eco"- products.

4.4. Hand-dishwashing detergents (HDD)

4.4.1. Production and trade figures (HDD)

Data derived from PRODCOM categories do not directly match EU Ecolabel scope but they are useful as estimates of the overall detergent and cleaning products market in Europe (see section 4.1), which includes all hand-dishwashing detergents [HDD], as well as other washing and cleaning preparations and other detergents and soaps covered by the PRODCOM categories shown in Table 15. Production, Imports and Exports figures derived from these PRODCOM categories, broken down by Member State, are shown in Table 16. Finally, production data at EU 27 of the last 5 years (2017-2022) is summarised via apparent consumption ([280]) in Figure 21.

Table 15 - PRODCOM cleaning product categories

Code(s)	Description
20.20.14.30	Disinfectants based on quaternary ammonium salts put up in forms or packing for retail sale or as preparations or articles
20.20.14.50	Disinfectants based on halogenated compounds put up in forms or packing for retail sale or as preparations
20.20.14.90	Disinfectants put up in forms or packing for retail sale or as preparations or articles (excluding those based on quaternary ammonium salts, those based on halogenated compounds)
20.41.20.20	Anionic surface-active agents (excluding soap)
20.41.20.30	Cationic surface-active agents (excluding soap)
20.41.20.50	Non-ionic surface-active agents (excluding soap)
20.41.20.90	Organic surface-active agents (excluding soap, anionic, cationic, non-ionic)
20.41.31.20	Soap and organic surface-active products in bars, etc., n.e.c.
20.41.31.50	Soap in the form of flakes, wafers, granules or powders
20.41.31.80	Soap in forms excluding bars, cakes or moulded shapes, paper, wadding, felt and non-wovens impregnated or coated with soap/detergent, flakes, granules or powders
20.41.32.40	Surface-active preparations, whether or not containing soap, p.r.s. (excluding those for use as soap)
20.41.32.50	Washing preparations and cleaning preparations, with or without soap, p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations
20.41.32.60	Surface-active preparations, whether or not containing soap, n.p.r.s. (excluding those for use as soap)
20.41.32.70	Washing preparations and cleaning preparations, with or without soap, n.p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]

[280] Apparent consumption = EU domestic production + imports - exports

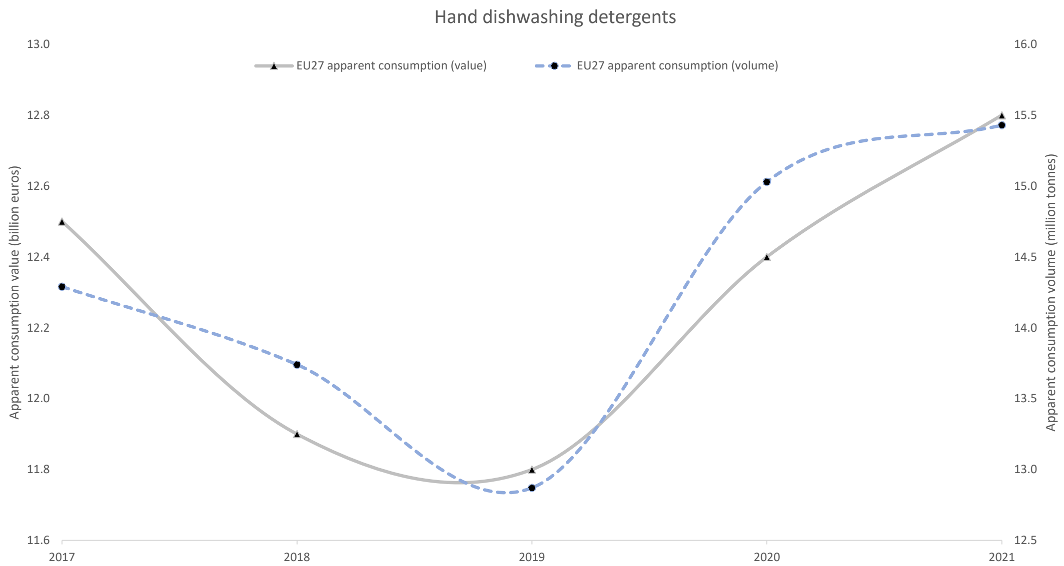
Table 16 - Exports, imports and production of detergent and cleaning products falling under the categories displayed in Table 15 for EU-27 during 2021.

Country	Exports quantity (tonnes)	Exports value (million EUR)	Imports quantity (tonnes)	Imports value (million EUR)	Production quantity (tonnes)	Production value (million EUR)
Austria	299558	472	325888	555	9571	26
Belgium	1578170	2627	945909	1514	906076	1098
Bulgaria	66085	71	93700	129	11253	16
Croatia	41276	49	80807	129	92454	97
Cyprus	383	1	29504	45	0	0
Denmark	231790	438	180528	280	366932	639
Estonia	31858	36	24663	64	50642	45
Finland	11808	30	101124	176	29974	62
France	955883	1981	1229925	1889	104109	0
Germany	1770963	4234	1420703	2604	2040625	5132
Greece	194625	173	152175	242	334463	152
Hungary	344718	427	237429	370	82227	21
Ireland	12672	94	133923	280	2865	17
Italy	1277959	1656	540845	999	2871011	2549
Latvia	8593	19	40824	71	1871	5
Lithuania	24327	50	57223	122	20351	28
Luxembourg	48893	92	25490	72	0	0
Malta	28	0	14448	19	0	0
Netherlands	932931	1945	672780	1327	355532	244
Norway						Data Not Available:
Poland	1144714	1483	557150	901	300550	271
Portugal	121942	122	270361	349	183378	112
Romania	216508	258	372945	440	97337	68
Slovakia	62388	123	138837	212	24315	7
Slovenia	45039	71	74177	134	0	14
Spain	946150	1352	502599	891	2206533	1937
Sweden	161756	409	246500	407	41496	52
EU27TOTALS_2020	3068488	6317	1096863	2421	18078169	18127

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]

The total EU-27 production in 2021 was 18.1 million tonnes with an associated value of 18.1 billion € (See Table 16). Italy was the key producer (2.84 million tonnes valued 2.55 billion €), followed by Spain (2.21 million tonnes valued 1.94 billion €), and Germany (2.04 million tonnes valued 5.13 billion €). As of 2021, Germany, Italy and Spain represented 39% and 53% of the production volume and value in the EU-27, respectively.

Figure 21 – Apparent consumption ([281]) for EU-27 during the period 2017-2021.



Source: EUROSTAT ([282])

The apparent consumption volume and value from 2017 to 2021 were 14.7 – 16.1 million tonnes (9.6% growth) and 13.4-14.2 billion € (6.3% growth), respectively. During this period, the total production value and volume changed from 16.7 to 18.1 billion € and from 16.4 to 18.1 million tonnes, respectively, which corresponds to an increase of 8.2% in value and 10.2% in volume. The averaged exports volume was 2.88 million tonnes, valued at 5.73 billion €, which exceeded imports.

4.4.2. Market structure and sales (HDD)

4.4.2.1. Market segmentation outline

Worldwide, Australasia is the top dishwashing market per capita spending ([283]). The market for global dishwashing liquid (including automatic and hand-dishwashing) increased during the period 2018-2022, reaching 20 billion USD ([284]). During this period, the registered compound annual growth rate (CAGR) for automatic dishwashing products global market was 4.2%, with expectations to reach 4.9% CAGR by 2033 ([285]). Dishwashing products market in Western Europe ([286]) ranked second globally in 2019 per capita spending, with prospects to remain in this position ([287]).

The European cleanliness and hygiene market, which includes dishwashing products, can be split into household and professional (institutional and industrial; I&I) use. The household care sector was valued in 2021 at 32.4 billion € and it is comprised by: laundry care (15 billion €); surface care (7.4 billion €); dishwashing care (5.2 billion €); maintenance products (4.1 billion €); and bleaches (0.7 billion €) ([288]).

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[281] Apparent consumption = EU domestic production + imports - exports

[282] Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310; 5 year growth (%) = ((2021 – 2017)/2017)*100

[283] Dishwashing in Western Europe | Market Research Report | Euromonitor (Accessed 27/04/23)

[284] Dishwashing Liquid Market Share | Opportunities Forecast, 2023 To 2030 (businessresearchinsights.com) (Accessed 13/06/2023)

[285] Automatic Dishwashing Products Market Size & Forecast by 2033 (futuremarketinsights.com) (Accessed 27/04/23)

[286] Austria, Belgium, Germany, France, Italy, UK, Spain, Turkey, Netherlands, Switzerland, Greece, Portugal, Sweden, Norway, Denmark, Ireland, Finland

[287] Dishwashing in Western Europe | Market Research Report | Euromonitor (Accessed 27/04/23)

[288] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

In 2021, the total value of the dishwashing care market across Europe (EU-27 + CH + NO) was 6.6 billion €, with household dishwashing possessing 78.8% of the market share ([289]). Professional dishwashing care had the remaining market share (21.2%), valued at 1.4 billion €. Note that *Kitchen & catering* data ([290]) are used as proxy of professional dishwashing products, yet it is unknown what proportion of these data relates only to hand-dishwashing detergents.

Dishwashing products market can be segmented as "automatic dishwashing" and "hand-dishwashing", the former having higher market share (See Table 17).

Table 17 – Dishwashing sub-categories and associated market value during 2021

	Market value (billion €)	Dishwashing share (%)
Automatic dishwashing	3.3	63.5
Hand-dishwashing	1.9	36.5

Source: Euromonitor (EU 27 + UK + CH + NO) via A.I.S.E. Activity and Sustainability Report 2021-2022 ([291])

4.4.2.2. *Analysis of retail markets*

To study the household dishwashing care sector falling under the scope of the hand-dishwashing detergents EU criteria in force, retail sales data (volume and value) were sourced from Euromonitor ([292]). Those categories best aligned with the EUEL dishwasher detergents scope were selected (See Table 18). Data from the category *Hand Dishwashing* were used to understand the overall European retail sales value and volume (EU28) attributed to hand-dishwashing detergents products under EUEL scope.

Euromonitor retail market data is used to estimate the potential market attributable to EU Ecolabel products falling under EU Ecolabel scope (see section 4.1), including relevant segmentations (eg products sub-groups; product form). In particular, retail sales data of the category *"Hand-dishwashing"* from the Euromonitor International's Home Care, 2022 (See Table 18).

Note that in this section, any reference to actual or projected (forecasted) data refers to products potentially falling under EU Ecolabel scope, in this case hand-dishwashing detergents, but do not directly refer to measured/recorded sells or turnover of ecolabelled product.

During 2021, the total EU28 sales retail volume of hand-dishwashing detergents was 0.85 million tonnes with and associated value of 1.65 billion €. Germany had the highest sales retail volume, followed by France and Italy. France had the highest production value (0.33 billion €), followed by Germany (0.26 billion €) and Italy (0.22 billion €). Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Netherlands) represented 69.6% and 74.2% of the retail sales volume and value in EU28, respectively.

Hand dishwashing detergents actual (2008 - 2022) and projected (2023 - 2027) EU Ecolabel retail market trends (EU 28; top European countries) are shown in Figure 22. These countries were chosen as indicators of the European market, since a change in these countries will have larger impact on the overall retail sales and would help to understand the overall (EU28) trend.

The total retail sales value of the EU28 market ranged from 1.46 to 1.52 billion € during the period 2008 - 2019, then increasing up to 1.71 billion € by 2022. Data projections (2023-2027) indicated a continuation of this increasing trend, reaching a maximum of 1.91 billion € (Figure 22-A).

[289] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[290] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[291] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[292] Source: Euromonitor International's dedicated Home Care industry edition, 2022

Table 18 – Euromonitor Passport categories representing EU Ecolabel dishwasher detergents scope

EU Ecolabel dishwasher detergents scope (as in Commission Decision (EU) 2017/1216 of 23 June 2017)	Euromonitor (sub-) category	Description
The product group 'hand dishwashing detergents' shall comprise any detergent falling under the scope of Regulation (EC) No 648/2004 of the European Parliament and of the Council[293] on detergents which is marketed and designed to be used to wash by hand items such as glassware, crockery and kitchen utensils including cutlery, pots, pans and ovenware. The product group shall comprise products for both private and professional use. The products shall be a mixture of chemical substances and shall not contain micro-organisms that have been deliberately added by the manufacturer.	*Dishwashing*	This is the aggregation of hand and automatic dishwashing products and dishwashing additives.
	Hand Dishwashing	Includes all detergents used to clean crockery and cutlery by hand. All formats (bar, liquid, gel, foam or wipes) are included

Sources: EC 2017 (294); Euromonitor (295)

During 2008-2011 the top country by retail sales value was Italy, followed by France during 2012-2022, ranging from approximately 280 to 320 million € (Figure 22-B). Germany and Spain retail sales value remained relatively stable during the period 2008 -2019, then switching to an increasing trend (2020-2022). According to data projections (2023 – 2027), the retail sales value of Germany, Spain and Poland will increase while that of France and Italy will decrease.

The total retail sales volume of the EU28 market decreased during the period 2008 -2019, from 0.890 million tonnes to 0.814 million tonnes, then peaking in 2020 at 0.861 million tonnes, with forecasting (2023-2027) predicting a stabilisation at approximately 0.822 million tonnes (Figure 22-C).

Italy was the top country by retail sales volume during the period 2008 -2019 yet, then (2020-2022) having little difference with Germany and France (Figure 22 –D). Data projections (2023 - 2027) indicated that, from these three countries, only France is expected to increase according to forecasted data (2023-2027).

[293] Regulation (EC) No 648/2004 of the European Parliament and of the Council of 31 March 2004 on detergents (OJ L 104, 8.4.2004, p. 1). https://eur-lex.europa.eu/legal-content/EN/AUTO/?uri=OJ:L:2004:104:TOC

[294] Commission Decision (EU) 2017/1214 of 23 June 2017 establishing the EU Ecolabel criteria for hand dishwashing detergents (OJ L 180, 12.7.2017, p. 1–15) https://eur-lex.europa.eu/eli/dec/2017/1214/oj

[295] Euromonitor International, Home Care, 2022->Category definitions

Figure 22 – Hand dishwashing detergents actual (2008 - 2022) and projected (2023 - 2027) market trends for products potentially falling under EU Ecolabel HDD scope. This figure presents the retail sales value (A-B) and volume (C-D) for the EU28 (A-C) and for the top five European countries by market share (B-D).

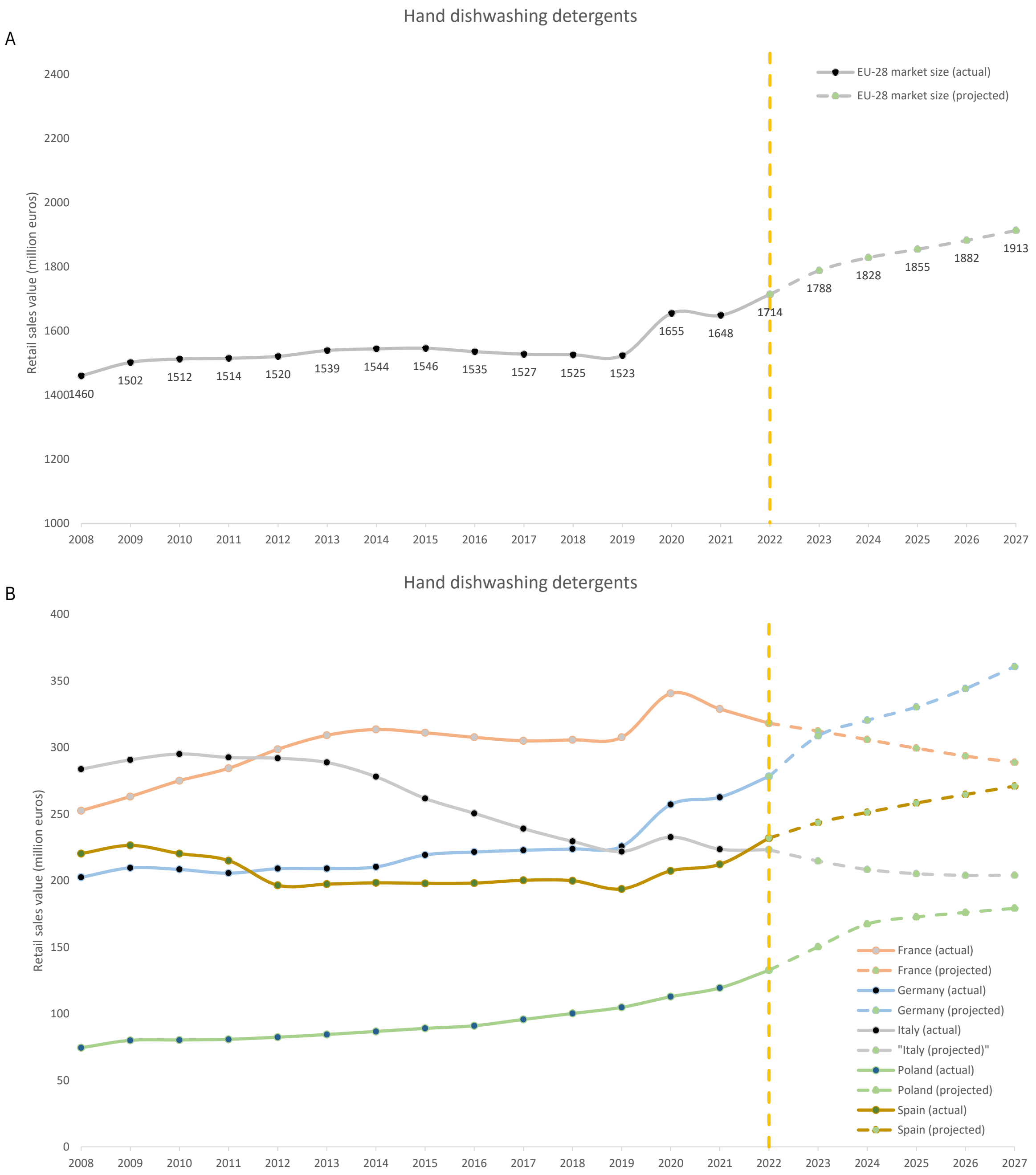
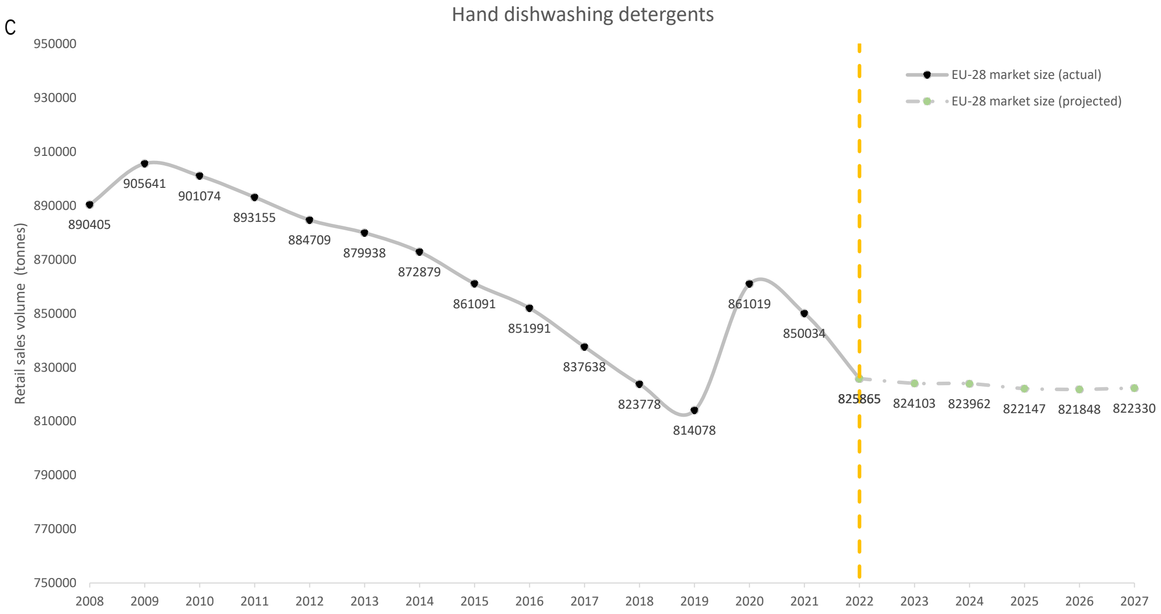
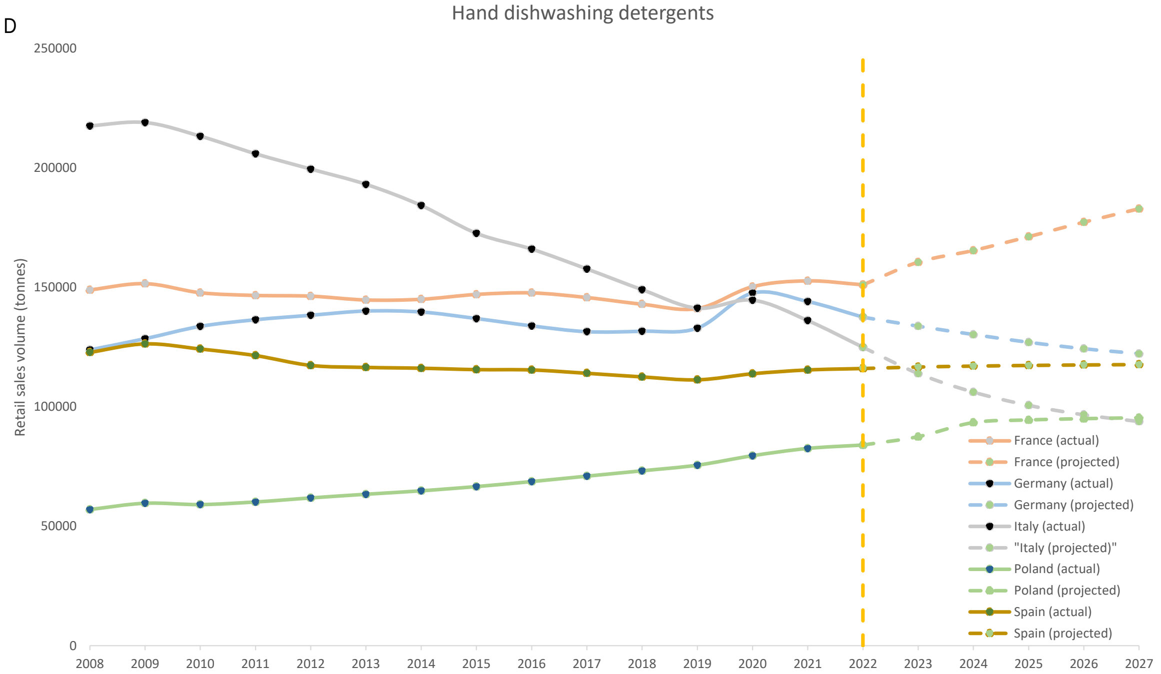


Figure 22 - Continuation





Source: Euromonitor ([296])

4.4.3. Key players (HDD)

The following can be considered a representation of the global key players for cleaning/detergents market: Reckitt Benckiser Group PLC, The Procter & Gamble Company, Unilever PLC, Johnson & Johnson, Kao Corporation, Colgate-Palmolive Company, The Clorox Company, Henkel AG & Co. KGaA and Dropps[Error! Bookmark not defined.].

[296] Euromonitor International, Home Care, 2022

Similarly, the dishwashing detergents market across Europe is heavily dominated by a few well-know and globally recognised organisations and brands. In 2013, the top manufacturer's by retail sales value were (in this order): Reckitt Benckiser Plc (23%)> Procter & Gamble Co (14%)> Henkel AG & Co KGaA (13%)>Unilever Group (11%)> Colgate-Palmolive Co (4%) ([249297]). In 2019, big brands remained consumer's preferred choice, with Reckitt Benckiser retaining its leading position with its product line "*Finish*" ([298]).

In addition, the impact of COVID pandemic in 2020 with the associated strict lock downs disrupted trading fluidity of the global supply chain. This also affected the dishwashing detergents market that avoided negative growth in the sales revenue of consumer goods by deviating to e-commerce platforms ([299]).

Retail distribution channel for dishwashing detergents in Western Europe remain very fragmented, with discounters holding large share in Germany, hypermarkets being preferred in France and supermarkets in Netherlands ([300]).

The global market size attributable to chemicals was estimated at 50.14 billion USD in 2020, with a projected CAGR for 2021-2028 of 4.2%, reaching a maximum of 71.26 billion USD ([301]). In terms of ingredients suppliers, they be grouped by the type of chemical they supply:

- *Inorganic* suppliers responsible for supplying fillers, builders and bleaches.
- *Organic* suppliers responsible for supplying surfactants, polymers and antifoams.
- *Enzyme* suppliers responsible for supplying enzymes targeting specific type of stains.

Builders and fillers is the segment with the highest market share (39.2%) in 2020, with enzymes being the fastest-growing segment in the market ([302]). Currently, anionic and non-ionic surfactants account for 95% of the market, zwitterionics around 1% and the remaining (less than 5%) to cationics, valued at approximately 2 billion USD ([303]) .

Companies active in the European market for detergent speciality ingredients include Clariant, Rhodia, Solvay, Rohm & Hass, Cognis, Croda, Dow Corning, Elementis, Alco Chemical and BASF amongst others. The availability, thus the price (and related market fluctuation), of raw materials and/or ingredients for detergents production is susceptible to changes.

4.4.4. Trends (HDD)

4.4.4.1. Product innovation (sustainability).

The growing awareness of consumers on detrimental effects on the environment has led to several sustainability trends and innovations within the detergents products market, like:

- Ingredients substitution – detergents formulation change to incorporate substances that deliver equivalent or better functionality at similar production costs whilst being a more sustainable alternative. An example is the Fairy Platinum with P from Procter and Gamble, substituting phosphates with methyl glycine diacetic acid ([304]).

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[297] European Commission, Joint Research Centre, Kaps, R., Arendorf, J., Skinner, D., et al., *Revision of the European ecolabel criteria for hand dishwashing detergents : preliminary report*, Publications Office, 2015, https://data.europa.eu/doi/10.2791/756629

[298] Dishwashing in Western Europe | Market Research Report | Euromonitor (Accessed 23/05/23)

[299] https://www.fortunebusinessinsights.com/dishwashing-detergent-market-106546 (Accessed 27/04/23)

[300] Dishwashing in Western Europe | Market Research Report | Euromonitor (Accessed 23/05/23)

[301] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[302] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[303] Gonçalves, R.A., K. Holmberg, and B. Lindman, 'Cationic Surfactants: A Review', Journal of Molecular Liquids, Vol. 375, April 2023, p. 121335. DOI 10.1016/j.molliq.2023.121335

[304] Van Hoof, G., M. Fan, and A. Lievens, 'Use of Product and Ingredient Tools to Assess the Environmental Profile of Automatic Dishwashing Detergents', Journal of Cleaner Production, Vol. 142, January 2017, pp. 3536–3543. DOI 10.1016/j.jclepro.2016.10.114

- Efficient manufacturing – which encompass resource efficiency improvement (e.g. energy-efficient running of equipment), minimization of waste and use of renewable energy sources. An example is the brand Cascade by Procter & Gamble ([305]).
- Concentrated products – which deliver the same function with lower mass of product used. This in turn, consume fewer resources across the production-consumption life cycle (less packaging; less resources consumption associated with transport). An example is the brand SURE ® from Diversey, a concentrated hand-dishwashing detergent ([306]).
- Biobased products – sourcing raw materials for detergents production more sustainably, which might also enhance the biodegradability of the product. An example could be Unilever's Seventh Generation dishwashing products ([307]).
- Refill systems – allowing less single-use packaging waste thanks to an alternative format/business model. An example is the Fill Refill Co ([308]).
- Enzymes – which enhance the efficiency of the cleaning process, for example by allowing achieving the same cleaning performance at lower washing temperatures or, in the case of hand-diswashing, by requiring less mechanical action (scrubs) ([309]). An example is the Novozymes' Intensa ® Core ([310]).
- Microbial cleaning products – which take advantage of the biological action of microorganisms to contribute to the cleaning process, increasing the efficiency (via enzymes, for example) and/or by substituting substances with negative environmental footprint ([311]).
- *"Cold wash"* – which ensures achieving same cleaning efficiency at lower washing temperatures than commonly historically, thus decreasing the energy use during washing. An example are PG's brands *Tide* and *Ariel* ([312]).

Focusing on hand-diswashing detergent products, innovation is one of the main drivers supporting premium products demand. In this regard, sustainability is an important aspect owing to consumers growing awareness on environmental implications associated to products consumption ([313]).

Ingredients substitution aims to improve the environmental profile of dishwashing products, by exerting the same function with an alternative more sustainable substance produced at competitive market costs. An example are Clariant's Glucamides, bio-based sugar surfactants with superior cleaning performance to other sugar based sufactants and comparable one to traditional surfactants ([314])

Enzymes in dishwashing products can remove food soils effectively with mild mechanical action required ([315]). For enzymes to be effective, they have to be in contact for some time with food soil, which could restrict enzymes in hand-dishwashing in the absence of soaking time. However, recommendations ([316]) some studies points towards soaking as being standard practice, in which case enzymes could help on cutting down scrubbing and enhance performance (including environmentally-wise) ([317])

Microbial cleaning products (MCP) are characterized by containing strains of microorganism as active ingredients, being an alternative to the wide-spread detergents forms with purely chemical-based active ingredients. The market for MCP represents a growing share within the "green cleaning products" market

[305] Sustainable Manufacturing Commitment | Cascade Detergent (cascadeclean.com) (Accessed 03/05/23)
[306] Hand dishwash, SURE® | VWR (Accessed 05/06/23)
[307] Dish Soap - Free & Clear | Seventh Generation (accessed 05/06/23)
[308] About - Fill Refill Co - Refillable Eco Household & Personal Care Products (Accessed 03/05/23)
[309] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23)
[310] Intensa® Core 220 L | Novozymes (Accessed 05/06/23)
[311] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032
[312] Washing Your Clothes on Cold with Tide and Ariel Does a World of Good (pg.com) (Accessed 13/06/2023)
[313] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449
[314] Sugar surfactants home care (clariant.com) (Accessed 05/06/23)
[315] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23)
[316] Dishwashing Made Easy | The American Cleaning Institute (ACI) (Accessed 05/06/23)
[317] Enzymes for hand dishwashing liquids | Novozymes (Accessed 05/06/23)

being projected to increase more in Europe than in United States ([318]). In 2017 projections estimated a maximum of $US9.32 billion, approximately equivalent to 6% of global household cleaning products market value (totalling $US147 billion) ([319]). In addition, the recent inclusion of microorganism within the scope of the revised Detergent Regulation provides regulatory guidance on the use of this type of ingredients/products, thus being reasonable to expect a boost in this market because of a harmonised regulatory framework. Nevertheless, some of the issues identified relate to potential for pathogenicity, taxonomic identification of the microorganisms used, quality assurance and control, labelling and exposure upon use ([320]) (Arvanitakis, Temmerman, and Spök, 2018). Given these issues and the potential exposure via ingestion of dish washed goods, it is necessary a thorough understanding of the risks associated, which will be discussed in further detail in the technical report.

4.4.4.2. Consumer behaviour.

Cleanliness and hygiene are both the main function (cleaning) and the primary reason that drives consumers' behaviour. In a study by Insites Consulting for A.I.S.E ([321]), the majority (>88%) of the respondents indicated that "*Cleaning and hygiene in my home is important because it helps me and/or the people I live with avoid becoming unwell or getting and infectious disease",* also indicating that it was *"important for the health of people around me"*. Once consumers see this primary condition met, then additional factors are considered, such as price (affordability), ease of use/convenience and/or the effect on the environment ("green"; "eco-product").

Generally, washing dishes by hand could be either done by diluting the hand-dishwashing detergent in a container (eg sink) filled with water or by applying it directly onto a sponge or the dirty surface, to then remove dirt through combined mechanical and chemical action, being dosing equally important in both cases ([322]).

There are different product strategies aimed at responding and/or driving consumer behaviour, like ([323]) incorporating into to the product additional traits (eg via fragances), functionalities (eg cleaning and removing odours) or benefits (eg compatible with washing edibles); boost performance (eg reducing soaking time); or protect consumers (eg skin protection, mild on hands). The latter aspect is relevant since hand-dishwashing imply significant exposure via skin, on average estimated to happen close to once per day, lasting for 10 – 20 min per wash and with 5.5 – 7.0 grams of dishwashing liquid used ([324]).

The increase in consumers' environmental awareness has led to the rise of the demand for more environmentally friendly dishwashing detergents products. Surveys on consumer behaviour indicated a strong preference towards the use of eco-friendly products ([325]). Some of these type of products in the market present "eco-claims" such as: fragrance free, clear of dyes and brighteners, without artificial fragrance, colors or preservatives, biodegradable, ozone safe, free of phosphate, chlorine, ammonia, petroleum solvents, alcohol, butyl, glycol ether, sodium lauryl sulfate (SLS) ([326]).

4.4.4.3. Labelling - EU Ecolabel.

<u>Market penetration</u>

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[318] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032

[319] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032

[320] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032

[321] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[322] Dishwashing Made Easy | The American Cleaning Institute (ACI) (Accessed 13/06/23)

[323] European Commission, Joint Research Centre, Kaps, R., Arendorf, J., Skinner, D., et al., *Revision of the European ecolabel criteria for hand dishwashing detergents : preliminary report*, Publications Office, 2015, https://data.europa.eu/doi/10.2791/756629

[324] Schneider, K., S. Recke, E. Kaiser, S. Götte, H. Berkefeld, J. Lässig, T. Rüdiger, O. Lindtner, and J. Oltmanns, 'Consumer Behaviour Survey for Assessing Exposure from Consumer Products: A Feasibility Study', Journal of Exposure Science & Environmental Epidemiology, Vol. 29, No. 1, January 2019, pp. 83–94. DOI 10.1038/s41370-018-0040-2

[325] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449

[326] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449

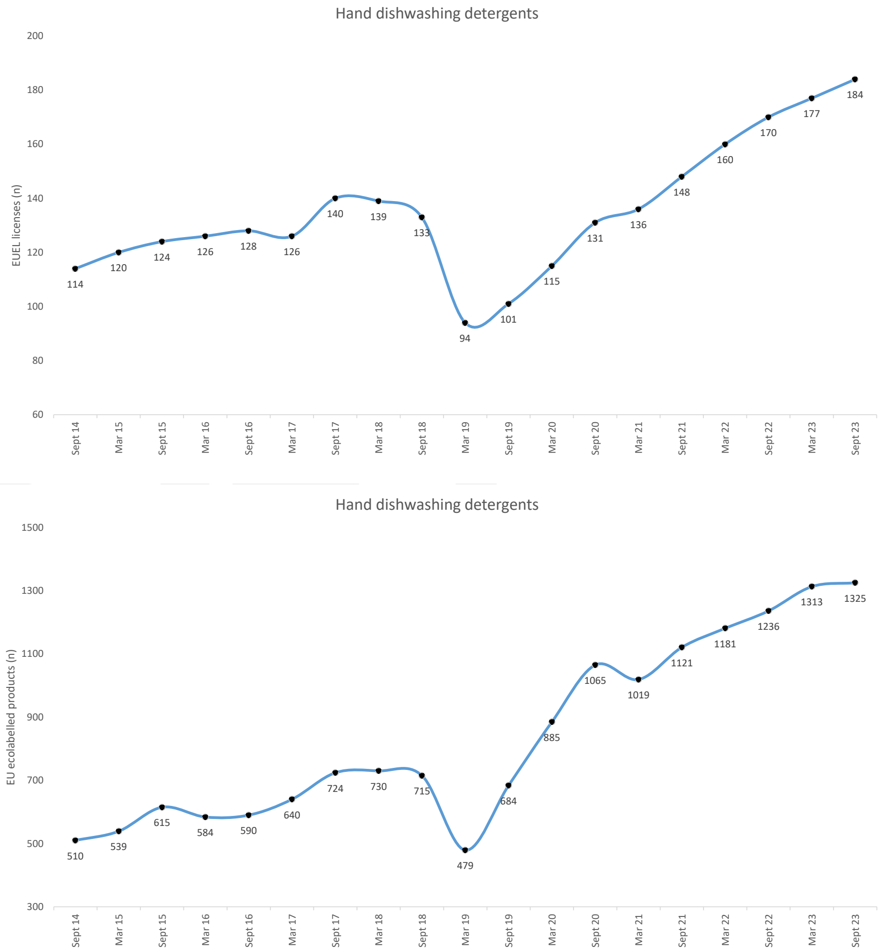
Considering the licences awarded up to September 2023 to all EU Ecolabel products, the majority are held by Italy (18%), Germany (15%) and France (15%). Similarly, the majority of products are awarded in, Italy (16%), Spain (15%) and France (13%).

As on September 23, the total number of licenses and products awarded to EU Ecolabel hand dishwashing detergents were 184 and 1325, respectively. These, accounted for 7.1% and 1.5% of the total licenses and products awarded so far.

The number of licences and ecolabelled hand dishwashing products has increased from 2019 to 2023, which indicates a steady update of the EU ecolabel (See Figure 23).

The number of licenses and products awarded to EU Ecolabel dishwashing detergents arranged by EU member state are displayed in the Figure 24. The top country by number of dishwasher detergents licenses is Spain followed by Italy, Germany and France, accounting for 61% of the total share. By number of ecolabelled products Italy is the top producer, followed by Spain, Germany, France and Belgium, accounting for 75.8% of the total share.

Figure 23 - Evolution of the number of EU Ecolabel licences (A) and products (B) for the product group "”Hand dishwashing detergents"

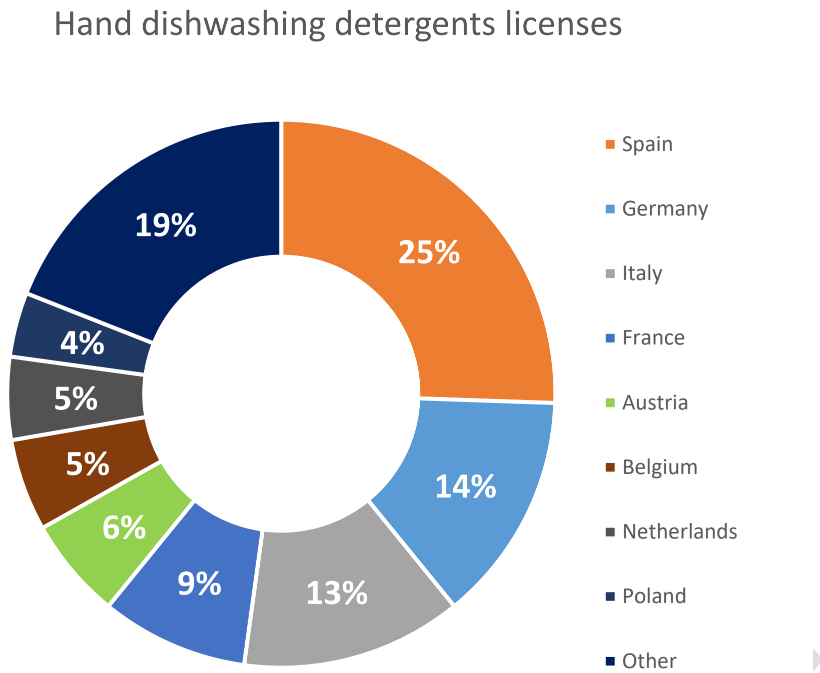


Source: EU Ecolabel Statistics – European Commission ([327])

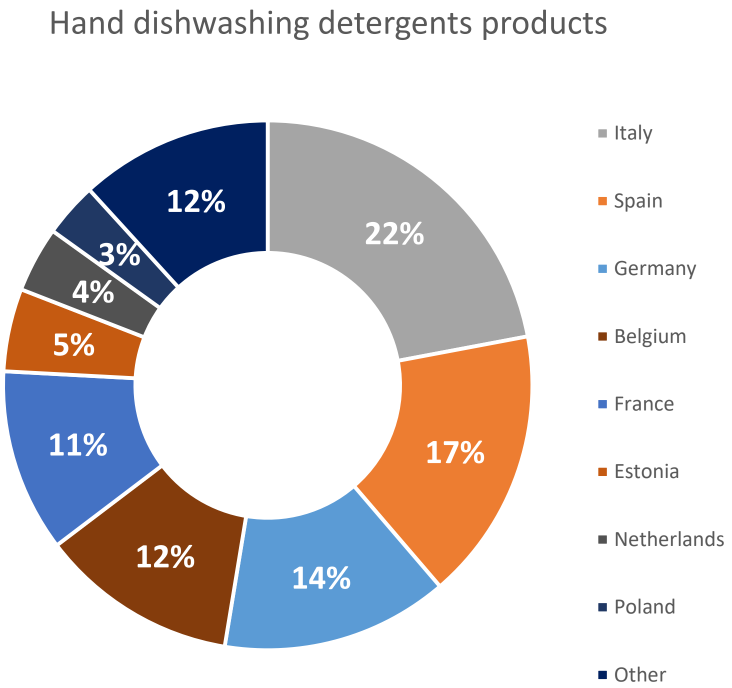
[327] https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/business/ecolabel-facts-and-figures_en (Accessed 04/05/23)

Figure 24 – Hand dishwashing detergents number of EU Ecolabel licenses (A) and products (B) arranged by EU Member State as on September 23.

A



B



Source: EU Ecolabel Statistics – European Commission

The previous evidences support that:

- The top countries by total number of EU Ecolabel licenses and products, not only for hand dishwashing detergents but also for the rest of EU ecolabel product groups are France, Germany, Italy and Spain. These match with those showing highest retail market share by value and volume.

- The number of licenses and products have steadily grow and there is expectance for this trend to be maintained.

Market challenges

The Assessment of the current criteria ([328]) summarises the following key market challenges for the product environmental labelling:

- Availability of raw materials in compliance with the EU Ecolabel criteria at reasonable costs (conventional ones commonly cheaper).
- Find the right balance in the formula: greenest raw materials (eg enhanced biodegradability) in synergy with optimal performance, also at reasonable costs.
- Finding suitable packaging for RTU products and/or the right bottle/label combination.

Indeed, the current lack of market stability due to .e.g. military conflict in Ukraine, might cause further global economic turbulences, and hence increase in a product's shelf price. Due to the global increase of the household goods costs, it might be expected that the consumer will, behind cleaning efficiency, look for the competitive - price or discount products.

4.4.5. Summary (HDD)

The market analysis presented here allows for some key conclusions about the hand dishwashing, especially those potentially falling under EU Ecolabel scope.

Production and Trade

The nature of the data available in terms of imports/exports (PRODCOM) did not allowed for a direct match with EU Ecolabel hand dishwashing detergents products but it is useful as estimate of the overall detergent and cleaning products market in Europe, with main highlights being:

- In 2021, the total (EU27) production was 18.1 million tonnes valued at 18.1 billion €, with exports reaching an average of 2.88 million tonnes and 5.73 billion €, which almost tripled imports volume and value.
- Germany, Spain and Italy were the top producing countries, representing 40% and 53% of the total (EU27) production volume and value.

Market structure and sales

A market value of 6.6 billion € can be attributed to the European dishwashing market, with the segmentation into household (DD) and professional (IIDD) indicating dominant share for household (78.8%).

In 2021, the total (EU28) sales retail volume of "Hand dishwashing detergents" under EU Ecolabel scope was 0.85 million tonne, valued at 1.65 billion €. Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Netherlands) represented 69.6% and 74.1% of the total retail sales market.

European retail market data (by value) on dishwasher detergent products potentially falling under EU Ecolabel scopeshowed a relatively stable size during the period 2008-2019 (approximately 1.48 – 1.52 billion €). From then and including data projections (2022 – 2027), the retail market value is expected to increase. By retail market value, actual data showed the opposite trend, with data projections (2022 – 2027) suggesting a stabilisation of the market size by volume at approximately 0.82 million tonnes. This suggested an expected average increase in the price per unit in the forthcoming years.

Key players

The market is dominated by a few manufacturing global brands/groups, like Reckitt Benckiser Plc, Procter & Gamble Co, Henkel AG & Co KGaA, Unilever Group and Colgate-Palmolive).

[328] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

The European detergents specialty market, dominated by the surfactants and builders/fillers segments, includes key companies like Clariant, Croda, Solvay, Novozymes, Evonik, Croda and BASF.

<u>Trends</u>

The main driver for consumers' behaviour is functionality, understanding as such primarily cleaning but also contribution to hygiene. Then, under similar price per product (cost as modulator), there is a clear push for more environmentally friendly products ("eco"-products).

Amongst the main innovations observed in the detergents field, some impactful for hand-dishwashing detergents are ingredients substitution, concentration (compaction), refill systems and the use of enzymes.

As on September 2023, the EU Ecolabel for hand dishwashing products had 184 licenses and 1325 products. The EU Ecolabel licences and products increased in the last 4 years, trend that is aligned with the observed increase in retail value and the enhanced interest in "Eco"- products. Amongst others, more environmentally friendly formulations are identified as a market challenge/barrier and a likely factor increasing the cost of ingredients, thus potentially of the product.

4.5. Hard surface cleaning products (HSC)

4.5.1. Production and trade figures (HSC)

Data derived from PRODCOM categories do not directly match EU Ecolabel scope but they are useful as estimates of the overall detergent and cleaning products market in Europe (see section 4.1), which includes all hard surface cleaning [HSC], as well as other washing and cleaning preparations and other detergents and soaps covered by the PRODCOM categories shown in Table 19. Production, Imports and Exports figures derived from these PRODCOM categories, broken down by Member State, are shown in Table 20. Finally, production data at EU 27 of the last 5 years (2017-2022) is summarised via apparent consumption ([329]) in Figure 25.

Table 19 - PRODCOM cleaning product categories

Code(s)	Description
20.20.14.30	Disinfectants based on quaternary ammonium salts put up in forms or packing for retail sale or as preparations or articles
20.20.14.50	Disinfectants based on halogenated compounds put up in forms or packing for retail sale or as preparations
20.20.14.90	Disinfectants put up in forms or packing for retail sale or as preparations or articles (excluding those based on quaternary ammonium salts, those based on halogenated compounds)
20.41.20.20	Anionic surface-active agents (excluding soap)
20.41.20.30	Cationic surface-active agents (excluding soap)
20.41.20.50	Non-ionic surface-active agents (excluding soap)
20.41.20.90	Organic surface-active agents (excluding soap, anionic, cationic, non-ionic)
20.41.31.20	Soap and organic surface-active products in bars, etc., n.e.c.
20.41.31.50	Soap in the form of flakes, wafers, granules or powders
20.41.31.80	Soap in forms excluding bars, cakes or moulded shapes, paper, wadding, felt and non-wovens impregnated or coated with soap/detergent, flakes, granules or powders
20.41.32.40	Surface-active preparations, whether or not containing soap, p.r.s. (excluding those for use as soap)
20.41.32.50	Washing preparations and cleaning preparations, with or without soap, p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations
20.41.32.60	Surface-active preparations, whether or not containing soap, n.p.r.s. (excluding those for use as soap)
20.41.32.70	Washing preparations and cleaning preparations, with or without soap, n.p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]

[329] Apparent consumption = EU domestic production + imports - exports

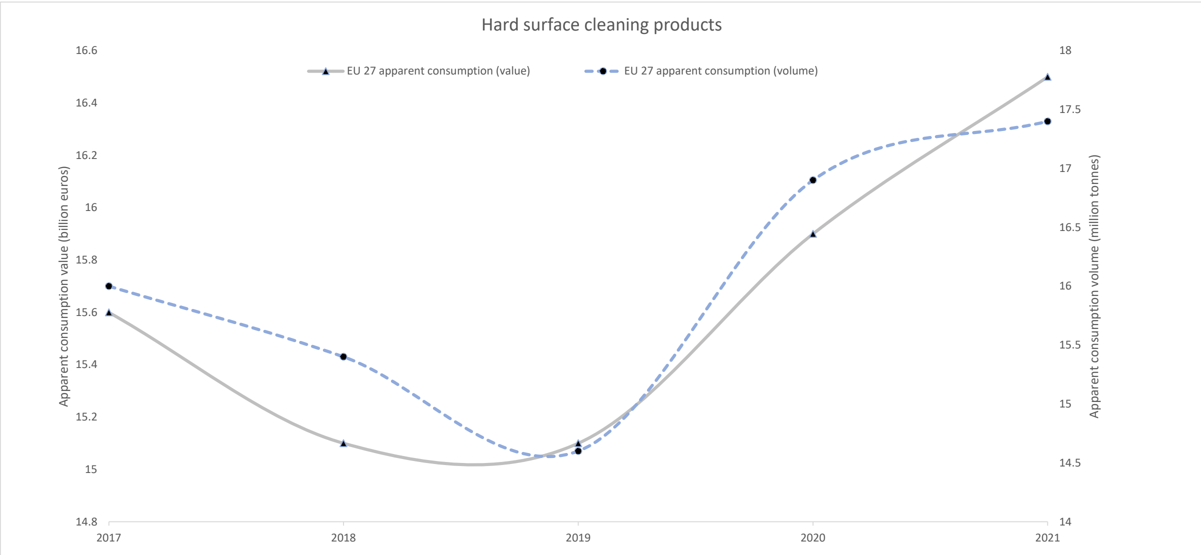
Table 20 - Exports, imports and production of detergent and cleaning products falling under the categories displayed in Table 19 for EU-27 during 2021.

Country	Exports quantity (tonnes)	Exports value (million EUR)	Imports quantity (tonnes)	Imports value (million EUR)	Production quantity (tonnes)	Production value (million EUR)
Austria	299558	472	325888	555	9571	26
Belgium	1578170	2627	945909	1514	906076	1098
Bulgaria	66085	71	93700	129	11253	16
Croatia	41276	49	80807	129	92454	97
Cyprus	383	1	29504	45	0	0
Denmark	231790	438	180528	280	366932	639
Estonia	31858	36	24663	64	50642	45
Finland	11808	30	101124	176	29974	62
France	955883	1981	1229925	1889	104109	0
Germany	1770963	4234	1420703	2604	2040625	5132
Greece	194625	173	152175	242	334463	152
Hungary	344718	427	237429	370	82227	21
Ireland	12672	94	133923	280	2865	17
Italy	1277959	1656	540845	999	2871011	2549
Latvia	8593	19	40824	71	1871	5
Lithuania	24327	50	57223	122	20351	28
Luxembourg	48893	92	25490	72	0	0
Malta	28	0	14448	19	0	0
Netherlands	932931	1945	672780	1327	355532	244
Norway	Data Not Available:					
Poland	1144714	1483	557150	901	300550	271
Portugal	121942	122	270361	349	183378	112
Romania	216508	258	372945	440	97337	68
Slovakia	62388	123	138837	212	24315	7
Slovenia	45039	71	74177	134	0	14
Spain	946150	1352	502599	891	2206533	1937
Sweden	161756	409	246500	407	41496	52
EU27TOTALS_2020	3068488	6317	1096863	2421	18078169	18127

Source: Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310]

The total EU-27 production in 2021 was 18.1 million tonnes with an associated value of 18.1 billion € (See Table 20). Italy was the key producer (2.84 million tonnes valued 2.55 billion €), followed by Spain (2.21 million tonnes valued 1.94 billion €), and Germany (2.04 million tonnes valued 5.13 billion €). As of 2021, Germany, Italy and Spain represented 39% and 53% of the production volume and value in the EU-27, respectively.

Figure 25 – Apparent consumption ([330]) for EU-27 during the period 2017-2021.



Source: EUROSTAT ([331])

The apparent consumption volume and value from 2017 to 2021 were 14.7 – 16.1 million tonnes (9.6% growth) and 13.4-14.2 billion € (6.3% growth), respectively. During this period, the total production value and volume changed from 16.7 to 18.1 billion € and from 16.4 to 18.1 million tonnes, respectively, which corresponds to an increase of 8.2% in value and 10.2% in volume. The averaged exports volume was 2.88 million tonnes, valued at 5.73 billion €, which exceeded imports.

4.5.2. Market structure and sales (HSC)

4.5.2.1. Market segmentation outline

Worldwide, the market value of commercial cleaning products in 2021 was estimated at 19 billion USD, being surface cleaners a product segment having the largest share (44%) in the previous year ([332]). Focusing on hard surface care market, in 2021 the retail sales value was 7.78 billion USD with a compound annual growth rate of 2.9% over the period 2019-2022 ([333]). Western Europe is expected to lose the second place in terms of surface care products sales over the period 2021-2026 ([334]).

The European cleanliness and hygiene market, which includes hard surface cleaning products, can be split into household and professional (institutional and industrial; I&I) use. The household care sector was valued in 2021 at 32.4 billion € and it is comprised by: laundry care (15 billion €); surface care (7.4 billion €); dishwashing care (5.2 billion €); maintenance products (4.1 billion €); and bleaches (0.7 billion €) ([335]).

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330 Apparent consumption = EU domestic production + imports - exports

331 Database - Prodcom - statistics by product - Eurostat (europa.eu); Dataset: Sold production, exports and imports [DS-056120__custom_5648310; 5 year growth (%) = ((2021 – 2017)/2017)*100

332 Commercial Cleaning Products Market Size, Share & Trends Analysis Report by Product (Surface Cleaners, Metal Surface Cleaners, Glass Cleaners Fabric Cleaners), by Distribution Channel, by Region, and Segment Forecasts, 2021-2028 (researchandmarkets.com) (Accessed 15/06/2023)

333 Mintel via Dow ® Hard Surface Care Kit presentation (Accessed 15/06/2023)

334 Surface Care in Western Europe | Market Research Report | Euromonitor (Accessed 27/04/23)

335 AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

In 2021, the total value of the surface care market across Europe (EU-27 + CH + NO) was 7.4 billion €, with household products possessing 89% of the market share ([336]). Professional surface care had the remaining market share (11%), valued at 0.9 billion €. Note that *Building care* data ([337]) are used as proxy of professional products, yet it is unknown what proportion of these data relates only to hard surface cleaning products. Furthermore, household products may in some instances be used also within professional contexts.

Surface care represents the overall European market for hard surface cleaning products and is broken-down into the sub-categories *Surface care* and *Toilet* care and (Table 21).

Table 21 – Surface care sub-categories and associated market value during 2021

	Market value (billion €)	Surface care share (%)
Surface Care	5.2	70.3
Toilet Care	2.2	29.7

Source: Euromonitor (EU 27 + UK + CH + NO) via A.I.S.E. Activity and Sustainability Report 2021-2022 ([338])

An alternative segmentation for surface care is by the type of surface and/or space that the product is designed to clean:

- All purpose cleaners
- Kitchen cleaners
- Window cleaners
- Sanitary cleaners

This categorisation is followed by the EU Ecolabel (See Table 22).

4.5.2.2. Analysis of retail markets

Euromonitor retail market data is used to estimate the potential market attributable to EU Ecolabel products falling under the EU Ecolabel scope (see section 4.1), including relevant segmentations (eg products sub-groups; product form). To improve the analysis, retail sales data from Euromonitor ([339]) were processed into "best matching categories" to EU ecolabel scope. In particular, "*Hard surface cleaning EUEL"* was calculated as the aggregation of the following Euromonitor International's Home Care, 2022 categories (See Table 22): "*Bathroom cleaners" + "Standard floor cleaners*" + "*Kitchen cleaners*" + "*Multi-purpose cleaners*" + "*Window/Glass cleaners*". This newly formed category contains data on hard surface cleaning products under the EU Ecolabel criteria scope.

Note that in this section, any reference to actual or projected (forecasted) data refers to products potentially falling under EU Ecolabel scope, in this case hard surface cleaning products, but do not directly refer to measured/recorded sells or turnover of ecolabelled product.

During 2021, the total EU28 sales retail volume of "*Hard surface cleaning EUEL"* was 1.13 million tonnes with and associated value of 2.52 billion €. Spain had the highest retail sales volume (0.25 million tonnes), closely followed by Italy (0.22 million tonnes). Germany had the highest retail sales value (0.44 billion €), followed by Italy (0.41 billion €) and Spain (3.9 billion €) Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Poland) represented 76.6% and 67.4% of the retail sales volume and value in EU28, respectively.

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[336] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[337] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[338] AISE 2022. International Association for Soaps, Detergents and Maintenance Products (AISE) Activity & Sustainability report 2021-22. https://www.aise.eu/cust/documentrequest.aspx?UID=5783b16f-3bc7-4f65-98df-7f910337c371 (Accessed 22/05/2023)

[339] Source: Euromonitor International's dedicated Home Care industry edition, 2022

"*Hard surface cleaning EUEL*" actual (2008 - 2022) and projected (2023 - 2027) EU Ecolabel retail market trends (EU 28; top European countries) are shown in Figure 26. These countries were chosen as indicators of the European market, since a change in these countries will have larger impact on the overall retail sales and would help to understand the overall (EU28) trend.

The total retail sales value of the EU28 market increased by 163 million € from 2008 -2019 and by 457 million €. from 2019-2022, with forecasting indicating a continuation of the growth observed during the years 2023 - 2027, reaching a maximum of 3.17 billion € (Figure 26–A).

Italy was the top country by retail sales value until 2020, when it was surpassed by Germany, an increasing trend foreseen to continue during the years 2023 -2027, reaching 0.185 million € (Figure 26-B). Indeed, all five countries projected data showed an increase.

The total retail sales volume of the EU28 market remained stable at approximately 1 million tonnes during the period 2008 -2018, then increasing up to 1.13 million tonnes by 2022 and with data projections (2023-2027) reaching a maximum of 1.19 million tonnes (Figure 26–C).

During 2008 - 2019, three different groups were observed by retail sales volume: Italy & Spain (approximately 0.22 million tonnes); France & Germany (ranging from 0.125-0.135 million tonnes); and Poland (0.06-0.07 million tonnes). According to data projections (2023 – 2027) Spain and then Italy would remain in the top, reaching 0.271 and 0.207 million tonnes, respectively.

<u>Hard surface cleaning products segmentation (by type)</u>

Hard surface cleaning products accommodates many potential sub-groups but the analysis of those best matching EU Ecolabel scope ("*Multi-Purpose Cleaners; Bathroom Cleaners; Standard Floor Cleaner; Window/Glass Cleaners; Kitchen Cleaners*") is subsequently presented. Note that *"Floor Cleaners"* and *"Multi-Purpose Cleaners"* fall under the category of the EU Ecolabel scope "All-purpose cleaners" (See Table 22) but were not merged into a single category to allow for further granularity in the analysis.

The European retail market shares (value and volume) of hard surface cleaning products, split by product type, at total (EU28) and country level is shown in Figure 27.

At EU28 level, *Multi-purpose cleaners* was by far the top product, with 1.39 billion € and 1.13 million tonnes, respectively. The second highest by retail sales value was *Bathroom cleaners* (0.4 million €) and by retail volume *Standard floor cleaners* (0.18 million tonnes). The corresponding market share for *All purpose cleaners (*the combination of *Multi-purpose cleaners* and *Standard floor cleaners)* was 66.8 % by retail sales value and 70.1% by retail sales volume. *Window/Glass cleaners* and *Kitchen cleaners* accounted for 10% or less of the retail sales value and volume market share.

By country, m*ulti-purpose cleaners* was the preferred product type in all European countries by both retail value and volume (on average, 57.7% and 63%, respectively). The exception was Portugal, where *standard floor cleaners* was the top one (44.8% and 64.3%, respectively). On average, *standard floor cleaners* had 9.6% of the market share by retail value and 11.3% by retail volume.

The actual (2008 - 2022) and projected (2023 - 2027) European (EU28) retail market trends of hard surface cleaning products under EU Ecolabel scope, split by type of product, is shown in Figure 28.

*Multi-purpose cleaner*s was, by far, the most commonly used product type by both retail sales value and volume. During 2010 -2019, this product type increased by 162 million € (16%) and 49.4 thousand tonnes (9%). Then, from 2019 to 2022, a steeper growth was observed, increasing by 294 million € (25%) and 73.9 thousand tonnes (12%). Forecasting predicted a continuation of this increasing trend, potentially reaching over 1.8 billion € and 0.7 million tonnes. The rest of the hard surface cleaning type of products had approximately, 5 times less retail sales value and volume, showing similar increasing trend from 2019 onwards (actual and projected), except for window/glass cleaners.

Table 22 –Euromonitor categories representing EU Ecolabel hard surface cleaning scope

EU Ecolabel Laundry Detergents scope (as in Commission Decision (EU) 2017/1218 of 23 June 2017)	Euromonitor (sub-) category	Description
"The product group 'hard surface cleaning products' shall comprise any all-purpose cleaner, kitchen cleaner, window cleaner or sanitary cleaner falling under the scope of Regulation (EC) No 648/2004 of the European Parliament and of the Council (FN) which is marketed and designed to be used as one of the following: all-purpose cleaners, which shall include detergent products intended for the routine indoor cleaning of hard surfaces such as walls, floors and other fixed surfaces, kitchen cleaners, which shall include detergent products intended for the routine cleaning and degreasing of kitchen surfaces such as countertops, stovetops, kitchen sinks and kitchen appliance surfaces, window cleaners, which shall include detergent products intended for the routine cleaning of windows, glass and other highly polished surfaces, sanitary cleaners, which shall include detergent products intended for the routine removal, including by scouring, of dirt or deposits in sanitary facilities, such as laundry rooms, toilets, bathrooms and showers. The product group shall cover products for both private and professional use and sold either in ready-to-use or undiluted form. Products shall be mixtures of chemical substances. Products for private use shall not contain micro-organisms that have been deliberately added by the manufacturer."	*Bathroom Cleaners*	Products specifically marketed as bathroom cleaners are included. However, products designed specifically for toilet cleaning, as well as descalers intended for the removal of limescale are excluded. Products that contain added bleach are also included although conventional bleaches and disinfectants are excluded. Also included are innovative device-like products, featuring a handle, to which disposable wipes/pads can be attached. Initially sold as starter kits, with refill wipes/pads available as refills.
	Standard Floor Cleaners	Covers all strengths and formats of products designed primarily for cleaning floors. Wood and modern floor cleaners are to be included. Combination wash & wax floor cleaners are excluded. Some floor cleaners have disinfecting/germ killing properties and may contain bleach - these should be included if they are specifically marketed as floor cleaners despite the inclusion of disinfectants or bleach.
	Kitchen Cleaners	Include products that are specifically marketed as kitchen cleaners. All product formats and strengths are included.
	Multi-Purpose Cleaners	Products that are designed for general household cleaning and have multi-purpose uses e.g. for cleaning floor surfaces, kitchen, bathroom and other household surfaces. Includes all product formats (eg liquids, powders, foam, granules, gel, mousse etc) and all strengths (standard, concentrated). Multi-purpose cleaners with antibacterial properties such as Dettox, and those with added bleach for extra effectiveness and/or germ elimination, are also included - the defining factor in both cases is that the products are primarily marketed as multi-purpose surface cleaners. Products marketed for a specific room use as well as conventional bleaches and antiseptics/disinfectants are excluded.
	Window/Glass Cleaners	All products whose primary usage specifically states that the product is designed for use on windows and other glass surfaces (eg mirrors). Includes all product formats such as liquid or cream preparations in trigger sprays or regular bottles. Exclude multi-purpose glass cleaners that can be used on tiles, ceramic, formica, chrome etc.

Sources: (EC 2017[340]; Euromonitor[341])

[340] Commission Decision (EU) 2017/1217 of 23 June 2017, establishing the EU Ecolabel criteria for hard surface cleaning products (OJ L 180, 12.7.2017, p. 45–62) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D1217&qid=1678704194237

[341] Euromonitor International, Home Care, 2022 ->Category definitions

Figure 26 – Hard surface cleaning EUEL actual (2008 - 2022) and projected (2023 - 2027) market trends for products potentially falling under EU Ecolabel LD scope. This figure presents the retail sales value (A-B) and volume (C-D) for the EU28 (A-C) and for the top five European countries by market share (B-D).

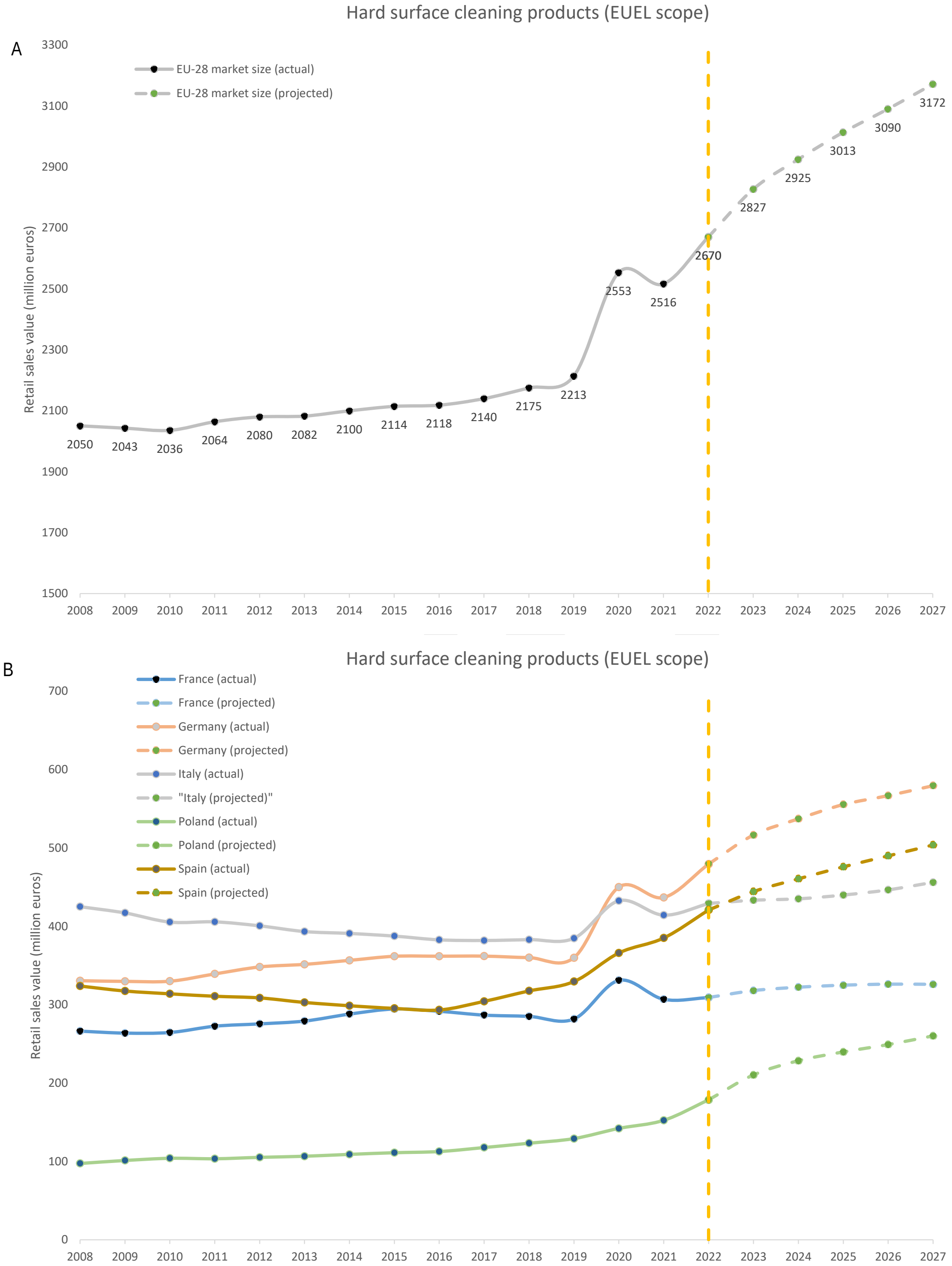
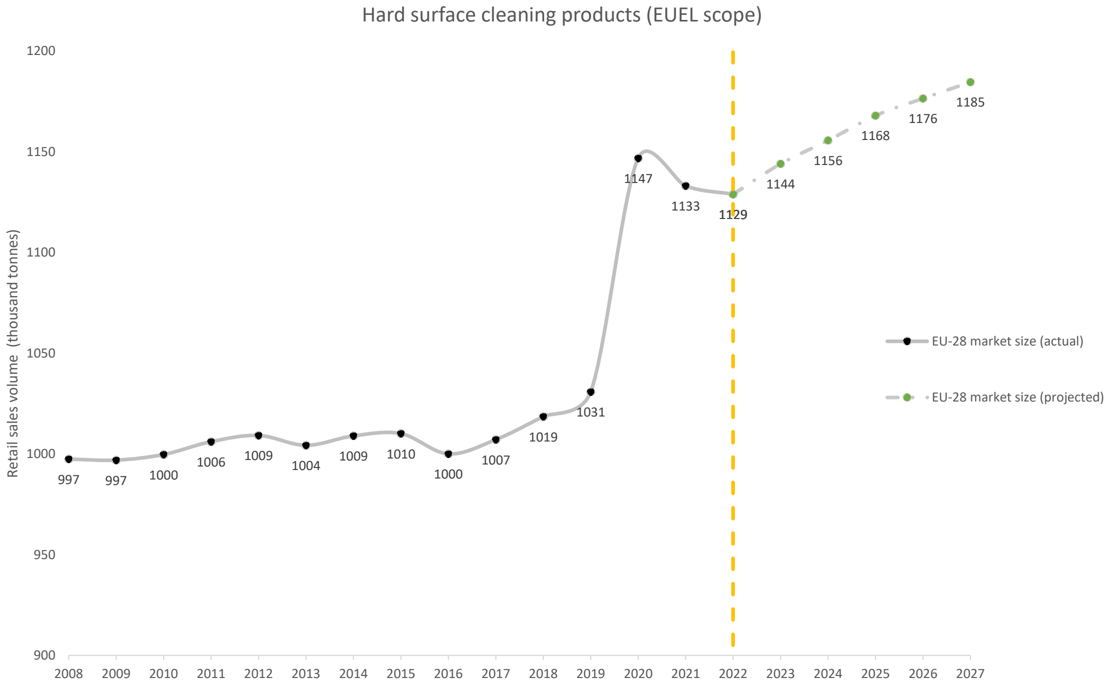
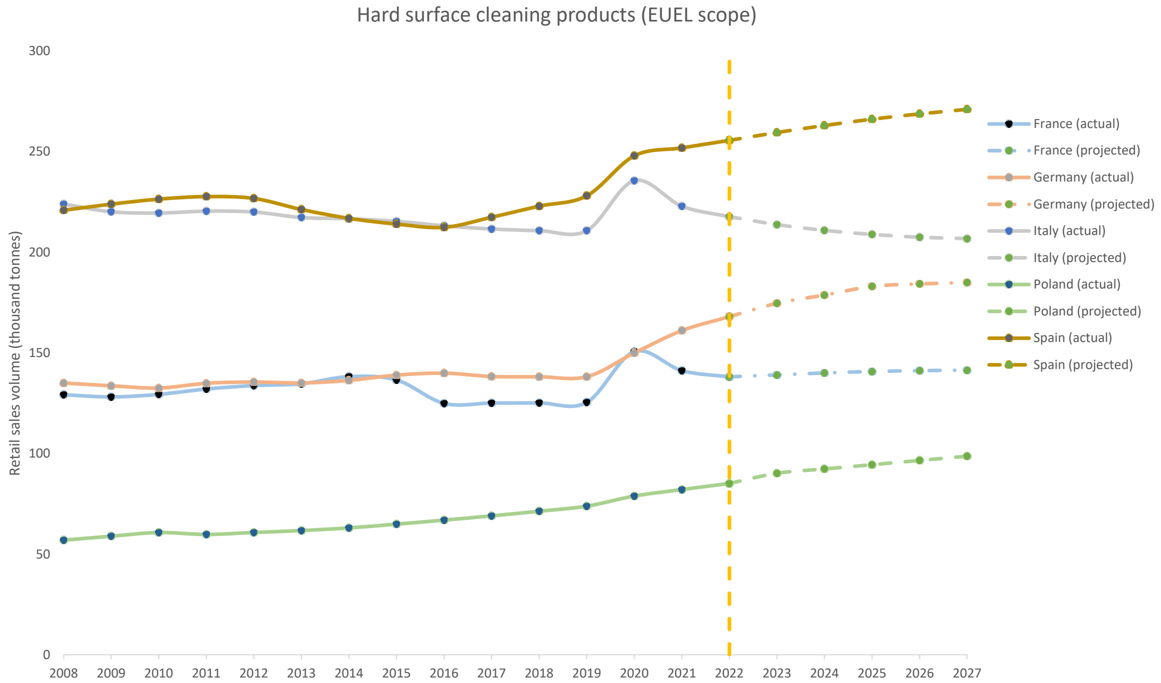


Figure 26 – Continuation

C

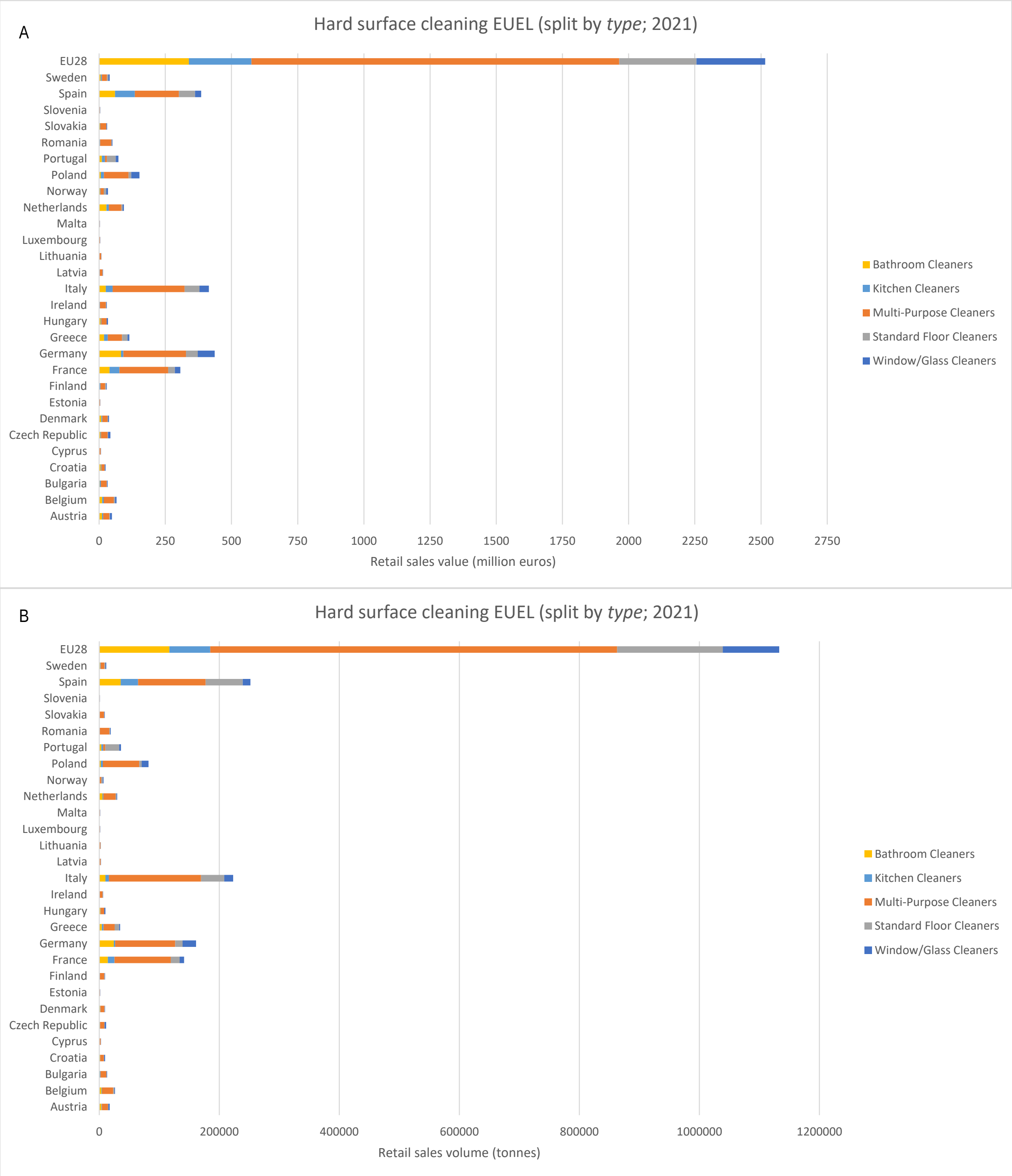


D



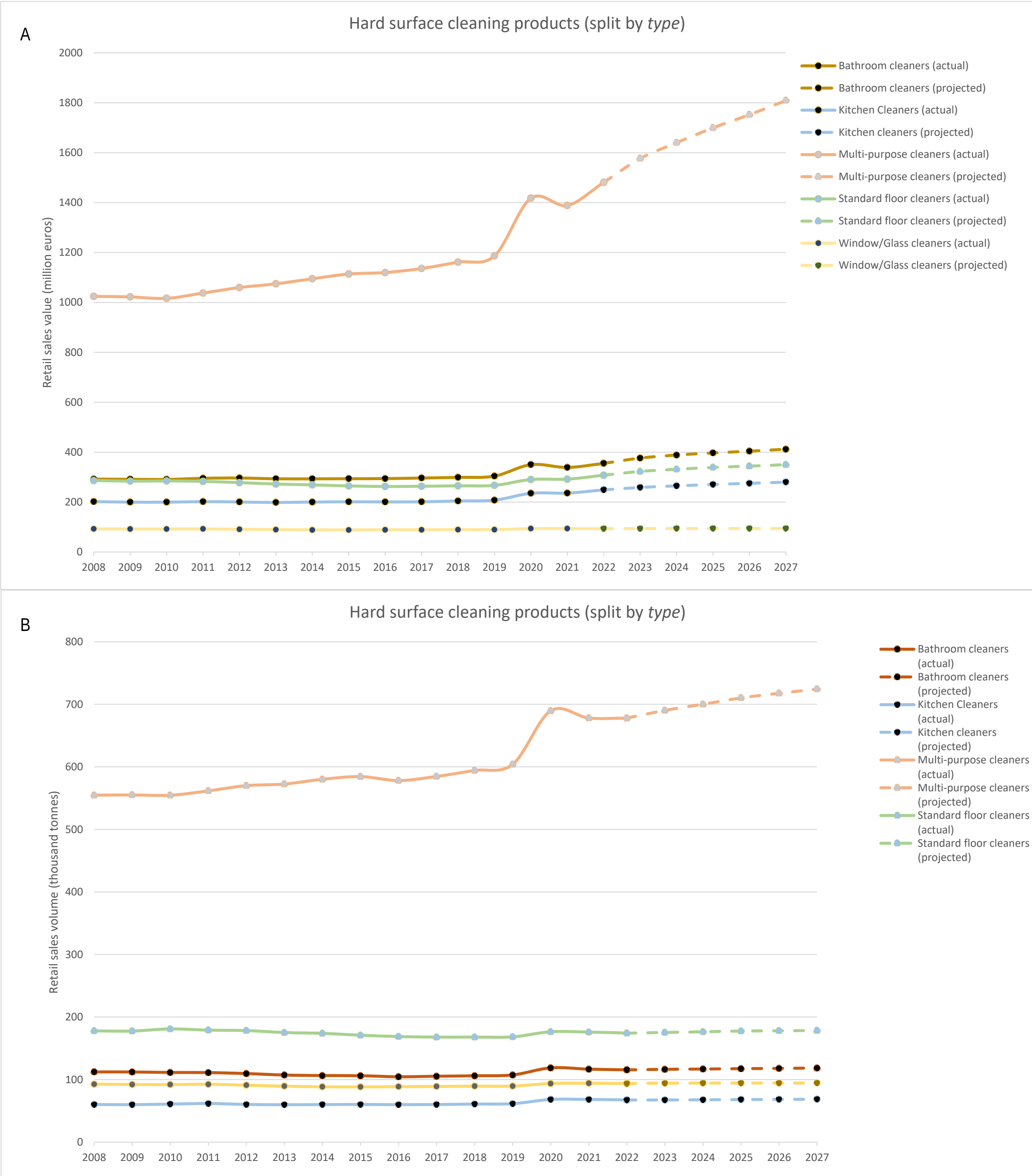
Source: Euromonitor

Figure 27 – Hard surface cleaning EUEL, split by sub-categories, retail market sales volume (A) and value (B)



Source: Euromonitor

Figure 28– Hard surface cleaning EUEL actual (2008 - 2022) and projected (2023 - 2027) market trends by retail sales volume (A) and value (B) at EU 28 level split by type of product.



Source: Euromonitor

4.5.3. Key players (HSC)

The surface care (thus hard surface cleaning products) market across Europe is heavily dominated by a few well-know and globally recognised organisations and brands, with the top five players accounting for 40% or more of the total sales ([342]). The following can be considered a representation of the European key players for

[342] Surface Care in Western Europe | Market Research Report | Euromonitor International, Home Care, 2021 (Accessed 14/06/2023)

cleaning (also for surface care) market: The Procter & Gamble Co, Henkel AG & Co. KGaA, Unilever PLC, Reckitt Benckiser Group PLC, Colgate-Palmolive Co,IWP International Plc; Bolton Group ([343]).

After the impact of COVID pandemic in 2020, with strict lock downs disrupting trading of the global supply chain, the surface products demand is still significant (especially multi-purpose cleaner) with e-commerce platforms consolidating as sales channels ([344]).

The global market of chemicals for detergents is fairly fragmented, its size has been estimated at 50.14 billion USD in 2020 and has a projected CAGR for 2021-2028 of 4.2%, reaching a maximum of 71.26 billion USD ([345]). In terms of ingredients suppliers, they can be grouped by the type of chemical they supply:

- *Inorganic* suppliers responsible for supplying fillers, builders and bleaches.
- *Organic* suppliers responsible for supplying surfactants, polymers and antifoams.
- *Enzyme* suppliers responsible for supplying enzymes targeting specific type of stains.

In 2020 builders and fillers was the segment in the specialty ingredients market with the highest share (39.2%) followed by surfactants, with enzymes being the fastest-growing segment ([346]). Currently, anionic and non-ionic surfactants account for 95% of the market, zwitterionics around 1% and the remaining (less than 5%) to cationics, valued at approximately 2 billion USD ([347]).

Some relevant companies active in the European market for detergent speciality ingredients include Clariant, Dow, Croda, Solvay, Novozymes, Evonik, Croda, DuPont Alco Chemical and BASF. The availability, thus the price (and related market fluctuation), of raw materials and/or ingredients for detergents production is susceptible to changes.

4.5.4. Trends (HSC)

4.5.4.1. Product innovation (sustainability).

The growing awareness of consumers on detrimental effects on the environment has led to several sustainability trends and innovations within the detergents products market, like:

- *Ingredients substitution* – detergents formulation change to incorporate substances that deliver equivalent or better functionality at similar production costs whilst being a more sustainable alternative. An example is the Fairy Platinum with P from Procter and Gamble, substituting phosphates with methyl glycine diacetic acid ([348]).
- *Efficient manufacturing* – which encompass resource efficiency improvement (e.g. energy-efficient running of equipment), minimization of waste and use of renewable energy sources. An example is the brand Cascade by Procter & Gamble ([349]).
- *Concentrated products* – which deliver the same function with lower mass of product used. This in turn, consume fewer resources across the production-consumption life cycle (less packaging; less resources consumption associated with transport). An example could be Persil non-bio washing tablets from Unilever ([350]).

[343] European Commission, Joint Research Centre, Gaasbeek, A., Golsteijn, L., Bojczuk, K., et al., Revision of the European ecolabel criteria for all-purpose cleaners, sanitary cleaners and window cleaners : preliminary report, Publications Office, 2015, https://data.europa.eu/doi/10.2791/923

[344] Surface Care in Western Europe | Market Research Report | Euromonitor International, Home Care, 2021 (Accessed 14/06/2023)

[345] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[346] Detergent Chemicals Market Size, Share & Growth by 2028 (fortunebusinessinsights.com) (Accessed 23/05/23)

[347] Gonçalves, R.A., K. Holmberg, and B. Lindman, 'Cationic Surfactants: A Review', Journal of Molecular Liquids, Vol. 375, April 2023, p. 121335. DOI 10.1016/j.molliq.2023.121335

[348] Van Hoof, G., M. Fan, and A. Lievens, 'Use of Product and Ingredient Tools to Assess the Environmental Profile of Automatic Dishwashing Detergents', Journal of Cleaner Production, Vol. 142, January 2017, pp. 3536–3543. DOI 10.1016/j.jclepro.2016.10.114

[349] Sustainable Manufacturing Commitment | Cascade Detergent (cascadeclean.com) (Accessed 03/05/23)

[350] Persil Non-bio Washing Tablets | Persil (Accessed 04/05/23)

- *Biobased products* – sourcing raw materials for detergents production more sustainably, which might also enhance the biodegradability of the product. For example, Pectins can serve as functional substitutes for non-degradable polymer detergents ([351]).
- *Refill systems* – allowing less single-use packaging waste thanks to an alternative format/business model. An example is the Fill Refill Co ([352]).
- *Enzymes* – which enhance the efficiency of the cleaning process, for example by allowing achieving the same cleaning performance at lower washing temperatures ([353]).
- *Microbial cleaning products* – which take advantage of the biological action of microorganisms to contribute to the cleaning process, increasing the efficiency (via enzymes, for example) and/or by substituting substances with negative environmental footprint ([354]).
- *"Cold wash"* – which ensures achieving same cleaning efficiency at lower washing temperatures than commonly historically, thus decreasing the energy use during washing. An example are PG's brands *Tide* and *Ariel* (*[355]).*

Focusing on hard-surface cleaning products, innovation is one of the main drivers supporting premium products demand. In this regard, sustainability is an important aspect owing to consumers growing awareness on environmental implications associated to products consumption ([356]). Indeed, amongst the most relevant trends identified for hard surface care, we can find *"Refill and monodose innovations"* and "*Natural and sustainable cleaning products with ingredients transparency* (*[357]*). These are related to the previously mentioned trends *refill systems*, *concentrated products*, *ingredients substitution* and/or *biobased* products.

Another trend is the use of biological agents within cleaning products, namely microbial cleaning products (MCP). The MCP are characterized by containing strains of microorganism as active ingredients, being an alternative to the wide-spread detergents forms with purely chemical-based active ingredients. The market for MCP represents a growing share within the "green cleaning products" market being projected to increase more in Europe than in United States ([358]). In 2017 projections estimated a maximum of $US9.32 billion, approximately equivalent to 6% of global household cleaning products market value (totalling $US147 billion) ([359]). In addition, the recent inclusion of microorganism within the scope of the revised Detergent Regulation provides regulatory guidance on the use of this type of ingredients/products, thus being reasonable to expect a boost in this market because of a harmonised regulatory framework. Nevertheless, some of the issues identified relate to potential for pathogenicity, taxonomic identification of the microorganisms used, quality assurance and control, labelling and exposure upon use ([360]) (La Maestra et al., 2021). Weighting pros and cons under different exposure scenarios is necessary in order to better understand the risk, for example of microorganisms contained in MCP which behave like opportunistic pathogens could infect the general population, especially vulnerable groups ([361]) (La Maestra et al., 2021).

[351] Hand dishwash, SURE® | VWR (Accessed 05/06/23)
[352] About - Fill Refill Co - Refillable Eco Household & Personal Care Products (Accessed 03/05/23)
[353] Enzymes-factsheet.pdf (cleaninginstitute.org) (Accessed 03/05/23)
[354] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032
[355] Washing Your Clothes on Cold with Tide and Ariel Does a World of Good (pg.com) (Accessed 13/06/2023)
[356] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449
[357] PowerPoint Presentation (ulprospector.com)
[358] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032
[359] Arvanitakis, G., R. Temmerman, and A. Spök, 'Development and Use of Microbial-Based Cleaning Products (MBCPs): Current Issues and Knowledge Gaps', Food and Chemical Toxicology, Vol. 116, June 2018, pp. 3–9. DOI 10.1016/j.fct.2017.12.032
[360] La Maestra, S., F. D'Agostini, M. Geretto, and R.T. Micale, 'Microbial-Based Cleaning Products as a Potential Risk to Human Health: A Review', Toxicology Letters, Vol. 353, December 2021, pp. 60–70. DOI 10.1016/j.toxlet.2021.09.013
[361] La Maestra, S., F. D'Agostini, M. Geretto, and R.T. Micale, 'Microbial-Based Cleaning Products as a Potential Risk to Human Health: A Review', Toxicology Letters, Vol. 353, December 2021, pp. 60–70. DOI 10.1016/j.toxlet.2021.09.013

4.5.4.2. Consumer behaviour.

Cleanliness and hygiene are both the main function (cleaning) and the primary reason that drives consumers' behaviour. In a study by Insites Consulting for A.I.S.E (AISE, 2022), the majority (>88%) of the respondents indicated that *"Cleaning and hygiene in my home is important because it helps me and/or the people I live with avoid becoming unwell or getting and infectious disease",* also indicating that it was *"important for the health of people around me"*. Once consumers see this primary condition met, then additional factors are considered, such as price (affordability), ease of use/convenience and/or the effect on the environment ("green"; "eco-product").

The increase in consumers' environmental awareness has led to the rise of the demand for more environmentally friendly dishwashing detergents products. Surveys on consumer behaviour indicated a strong preference towards the use of eco-friendly products ([362]) (Geetha and Tyagi, 2016). Some of these type of products in the market present "eco-claims" such as: fragrance free, clear of dyes and brighteners, without artificial fragrance, colors or preservatives, biodegradable, ozone safe, free of phosphate, chlorine, ammonia, petroleum solvents, alcohol, butyl, glycol ether, sodium lauryl sulfate (SLS) ([363]) (Geetha and Tyagi, 2016).

Hard surface care product launches by claim showed a clear interest from consumers on more sustainable products, being the highest number of claims corresponding to the categories (in this order) *Ethical & Environmental* > *Convenience* > *Functional* > *Natural* (*[364]).*

4.5.4.3. Labelling - EU Ecolabel.

<u>Market penetration</u>

Considering the licences awarded up to September 2023 to all EU Ecolabel products, the majority are held by Italy (18%), Germany (15%) and France (15%). Similarly, the majority of products are awarded in, Italy (16%), Spain (15%) and France (13%).

As on September 23, the total number of licenses and products awarded to EU Ecolabel hard surface cleaning products were 376 and 7012, respectively. These, accounted for 14.6% and 7.9% of the total licenses and products awarded so far.

The number of licences and ecolabelled hand dishwashing products has increased from 2019 to 2023, which indicates a steady update of the EU ecolabel (See Figure 29).

The number of licenses and products awarded to EU Ecolabel dishwashing detergents arranged by EU member state are displayed in the Figure 30. The top country by number of hard surface cleaning products licenses is Spain followed by Germany and Italy, accounting for 59% of the total share. By number of ecolabelled products Italy is the top producer, followed by Spain, Germany, France and Belgium, accounting for 78.4% of the total share.

The previous evidences support that:

- The top three countries by total number of EU Ecolabel licenses and products, not only for hard surface cleaning products but also for the rest of EU ecolabel product groups are Germany, Italy and Spain. These match with those showing highest retail market share by value and volume.
- The number of licenses and products have steadily grow and there is expectance for this trend to be maintained.

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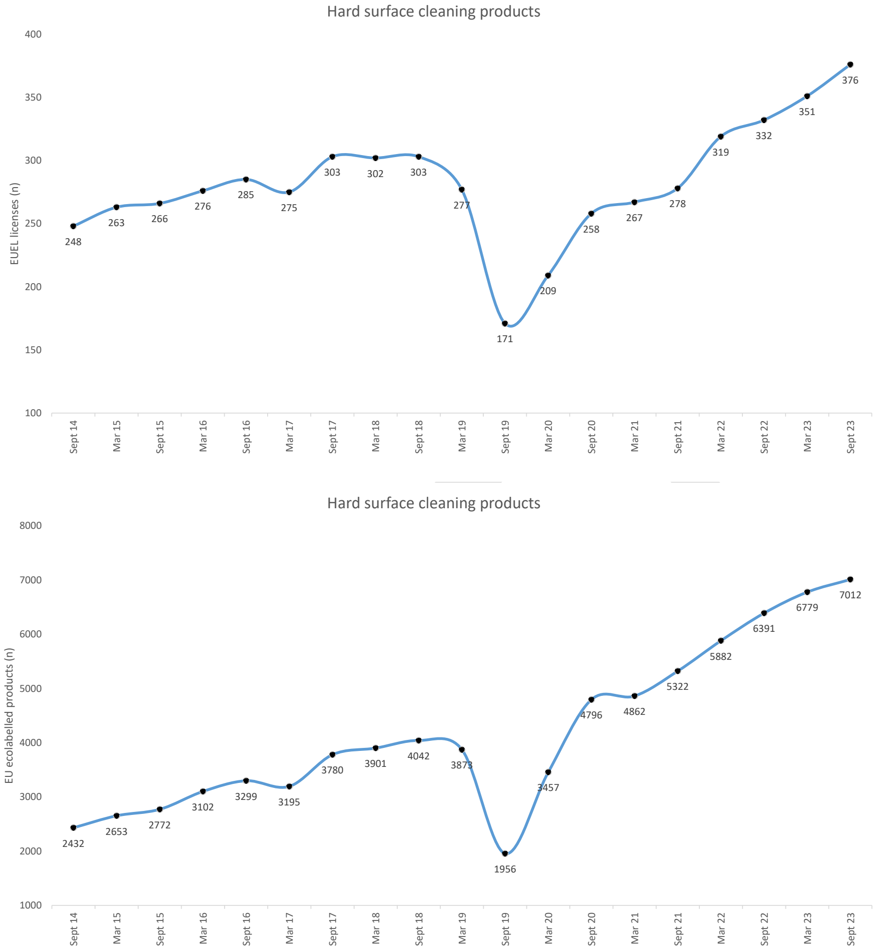
[362] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449

[363] Geetha, D., and R. Tyagi, 'Consumer Behavior and Fascinating Challenges on Household Laundry and Dishwashing', Tenside Surfactants Detergents, Vol. 53, No. 6, November 15, 2016, pp. 568–575. DOI 10.3139/113.110449

[364] Mintel via Dow ® <u>Hard Surface Care Kit presentation</u> (Accessed 15/06/2023)

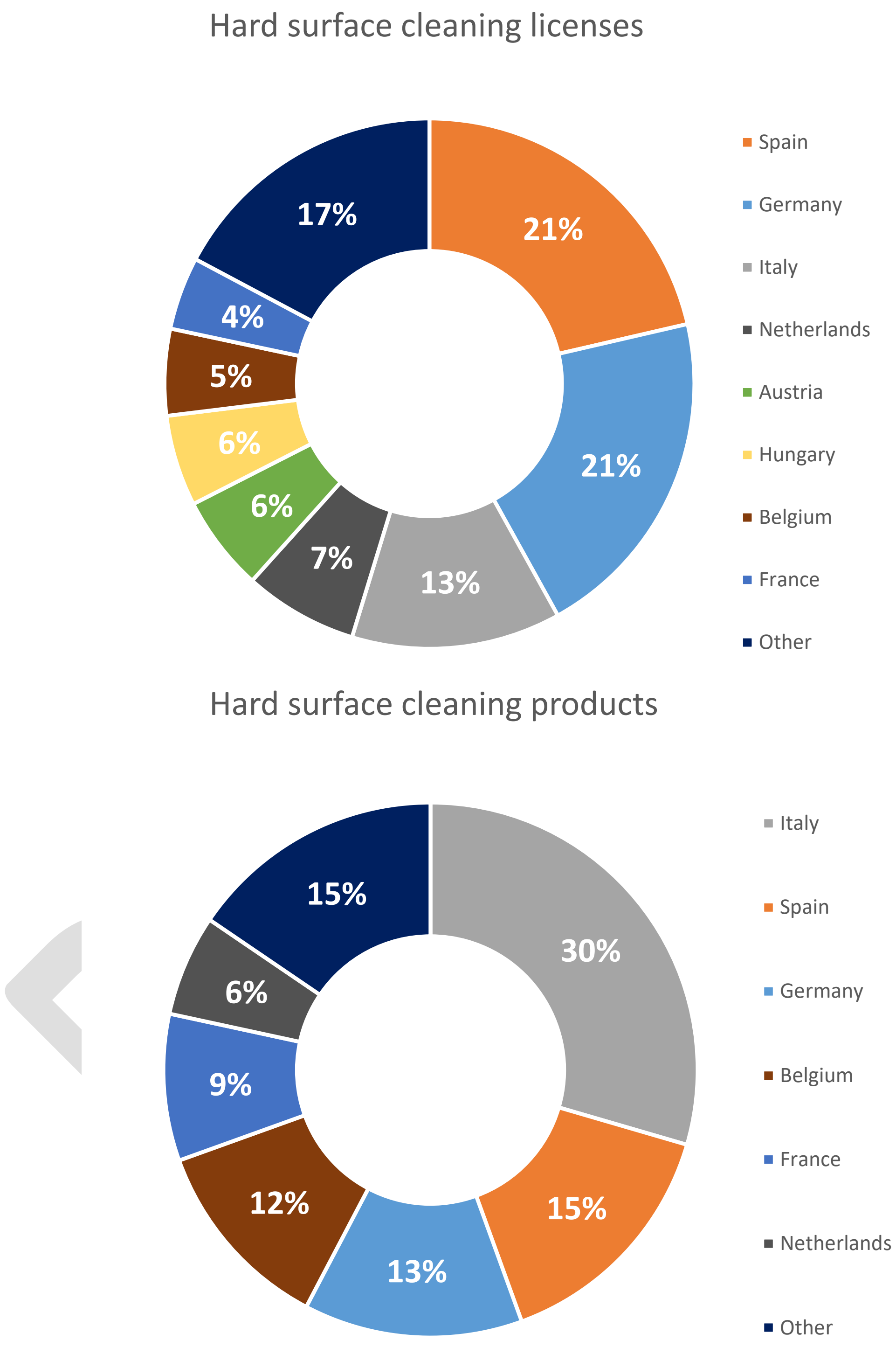
Figures 29 - Evolution of the number of EU Ecolabel licences (A) and products (B) for the product group "Hard surface cleaning products".



Source: EU Ecolabel Statistics – European Commission ([365])

[365] https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home/business/ecolabel-facts-and-figures_en (Accessed 04/05/23)

Figure 30 - Number of EU Ecolabel licences arranged by EU Member State for the product groups "Hard surface cleaning products" as on September 23.



Source: EU Ecolabel Statistics – European Commission

Market challenges

The Assessment of the current criteria ([366]) summarises the following key market challenges for the product environmental labelling:

- Availability of raw materials in compliance with the EU Ecolabel criteria at reasonable costs (conventional ones commonly cheaper).
- Find the right balance in the formula: greenest raw materials (eg enhanced biodegradability) in synergy with optimal performance, also at reasonable costs.
- Finding suitable packaging for RTU products and/or the right bottle/label combination.

Indeed, the current lack of market stability due to .e.g. military conflict in Ukraine, might cause further global economic turbulences, and hence increase in a product's shelf price. Due to the global increase of the household goods costs, it might be expected that the consumer will, behind cleaning efficiency, look for the competitive - price or discount products.

[366] European Commission, Joint Research Centre, La Placa, M.G.; Vidal Abarca Garrido, C.; Wolf, O, 2022. Assessment of the EU Ecolabel criteria for six Detergent Product Groups. Internal. Document prepared for the European Union Ecolabelling Board (EUEB)

4.5.5. Summary (HSC)

The market analysis presented here allows for some key conclusions about the hard surface cleaning products, especially those potentially falling under EU Ecolabel scope.

Production and Trade

The nature of the data available in terms of imports/exports (PRODCOM) did not allowed for a direct match with EU Ecolabel hard surface cleaning products but it is useful as estimate of the overall detergent and cleaning products market in Europe, with main highlights being:

- In 2021, the total (EU27) production was 18.1 million tonnes valued at 18.1 billion €, with exports reaching an average of 2.88 million tonnes and 5.73 billion €, which almost tripled imports volume and value.
- Germany, Spain and Italy were the top producing countries, representing 40% and 53% of the total (EU27) production volume and value.

Market structure and sales

A market value of 6.6 billion € can be attributed to the European surface care market, with the segmentation into household (DD) and professional (IIDD) indicating dominant share for household (89%).

In 2021, the total (EU28) retail sales volume of hard surface cleaning products potentially falling under EU Ecolabel scope was 1.13 million tonnes, valued at 2.52 billion €. Together, the top five countries by retail sales volume and value (Germany, France, Italy, Spain and Poland) represented 76.6% and 67.4% of the total retail sales market.

EU28 data pointed to *multipurpose cleaner* as the most successful group amongst hard surface cleaning products. In 2021, the market volume and value for this product was 1.13 million tonnes and 1.39 billion €, corresponding to an average market size of 63% and 57.7%, respectively. The second position by value was for *Bathroom cleaners* (0.4 million €) and by retail volume for *Standard floor cleaners* (0.18 million tonnes).

Forecasting (2023-2027) suggested a steep increase of the total EU28 retail market (both by volume and value), mainly driven by the corresponding projected increase of *multipurpose cleaners.*

Key players

The market is dominated by a few manufacturing global brands/groups, like Reckitt Benckiser Plc, Procter & Gamble Co, Henkel AG & Co KGaA, Unilever Group and Colgate-Palmolive).

The European detergents specialty market, dominated by the surfactants and builders/fillers segments, includes key companies like Clariant, Dow, Croda, Solvay, Novozymes, Evonik, Croda and BASF.

Trends

The main driver for consumers' behaviour is functionality, understanding as such primarily cleaning but also contribution to hygiene. Then, under similar price per product (cost as modulator), there is a clear push for more environmentally friendly products ("eco"-products).

Amongst the main innovations observed in the hard surface cleaning products field, some impactful for hard surface cleaning products are ingredients substitution, concentration (compaction), refill systems and biobased products.

As on September 2023, the EU Ecolabel for hand dishwashing products had 376 and licenses and 7012 products. The EU Ecolabel licences and products increased in the last 4 years, trend that is aligned with the observed increase in retail value and the enhanced interest in "Eco"- products. Amongst others, more environmentally friendly formulations are identified as a market challenge/barrier and a likely factor increasing the cost of ingredients, thus potentially of the product.

4.6. Conclusions

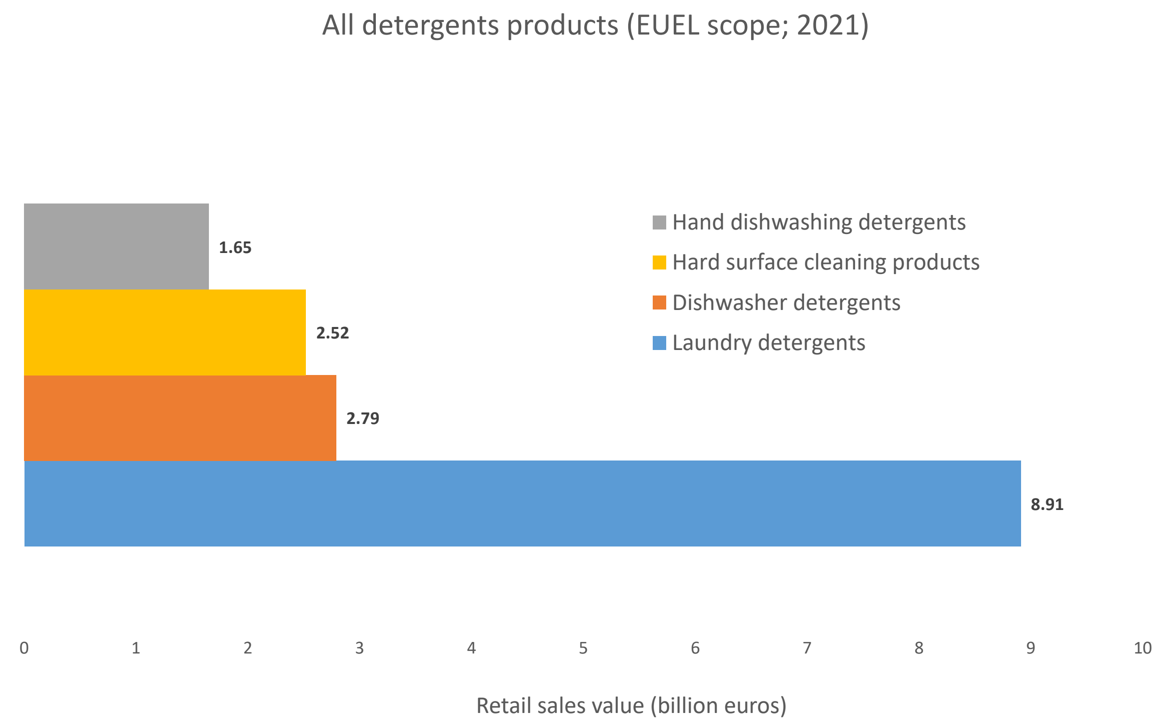
This section compares the EU ecolabel product groups within the scope of this market analysis for particular aspects in order to understand better their market significance and provide key conclusions.

Market data have been collected primarily from Euromonitor International but complementary market data, as well as data on other aspects (such as trends) have been obtained from the best available resources. Irrespective of this, the information provided is sufficiently robust to be used as a basis for discussing the market associated to detergents product groups under the scope of the EU Ecolabel.

<u>Laundry detergents holds the majority of the market share potentially attributable to products falling under the EU Ecolabel scope.</u>

The total (all product groups) market size of products potentially falling under EU Ecolabel scope by retail sales value was 15.9 billion euros in 2021, with laundry detergents accounting 8.91 billion euros (See Figure 31). This corresponded to a 56% share followed by dishwashing detergents (18%) and hard surface cleaning products (16%) (See Figure 32).

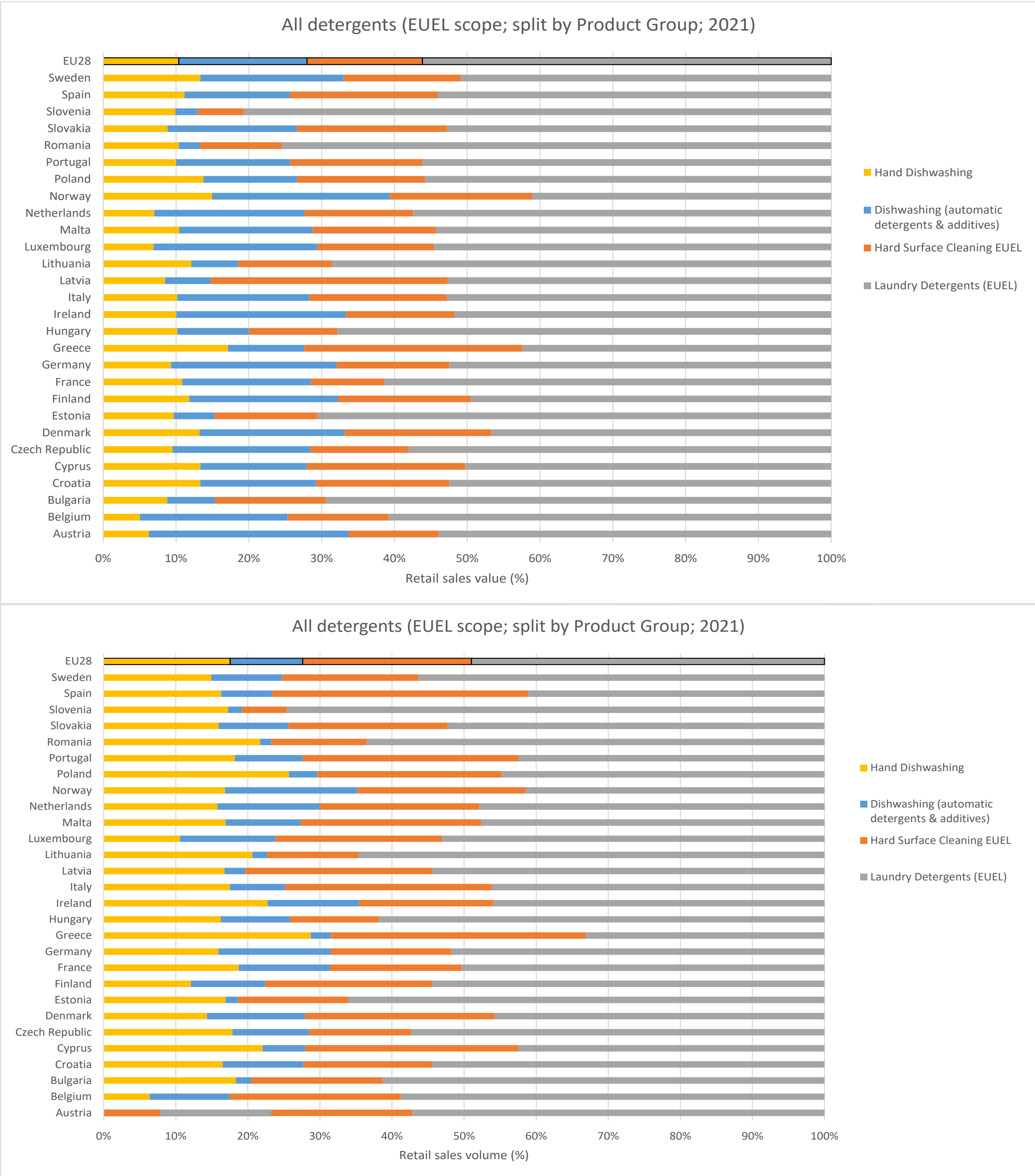
Figure 31 –European (EU28) market size estimation of the EU Ecolabel product groups in 2021.



Source: Euromonitor

Laundry detergents is also the product group amongst EUEL detergents with the highest market share by volume (49%) at EU28 level, followed by hard surface cleaning (23%) and hand-dishwashing (See Figure 32).

Figure 32 – All EUEL detergents, split by product group, retail market shares (%) value (A) and volume (B)



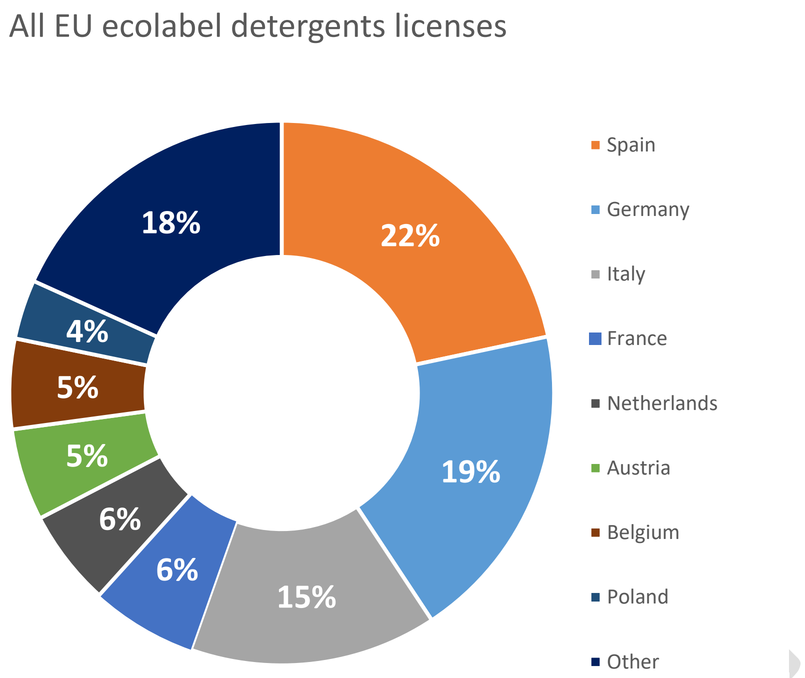
Source: Euromonitor

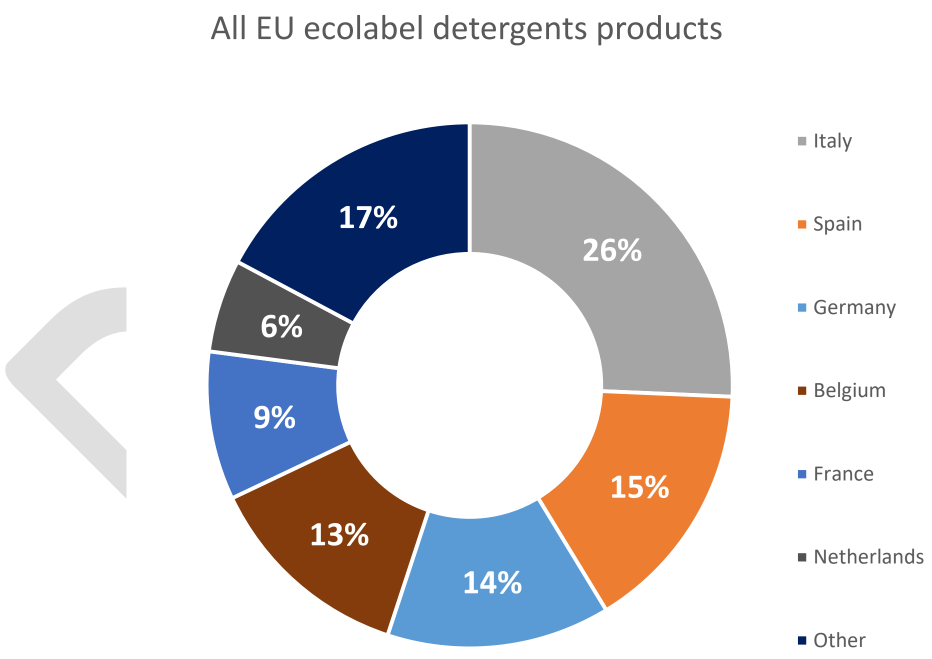
<u>EU Ecolabelling - Hard surface cleaning products the most successful; Germany, Italy and Spain top 3 countries.</u>

Since September 2014, a quite stable evolution of the number of EU Ecolabel licenses and ecolabelled products has been registered for all detergents product groups, as shown in Figures *13, 18, 23 and 29*. Over the last 6 months (March 23 – September 23), the number of license holders and ecolabel awarded products have generally increased in all product groups. Focusing on detergent product groups, HSC was the most successful product group by number of licenses (+25) and ecolabelled products (+233), comparatively having the greatest increase.

The Member States with the highest share of awarded licences and ecolabelled products for detergents product groups are Spain, Italy, Germany, Belgium and France, as displayed by Figure 33.

Figure 33 - Share of EU Ecolabel detergents licenses (A) and products (B) arranged by EU Member State as on September 23 (Total number of licenses = 2584; Total number of ecolabelled products = 88921).

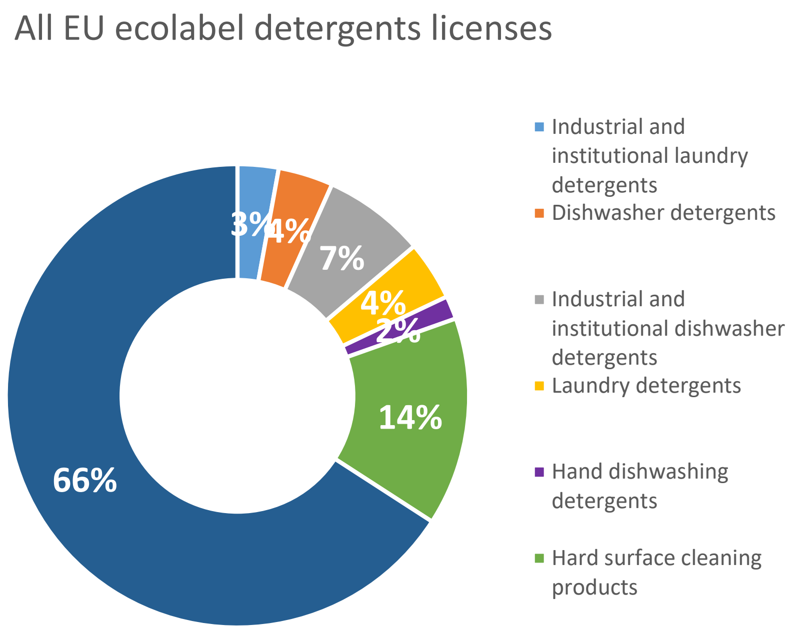


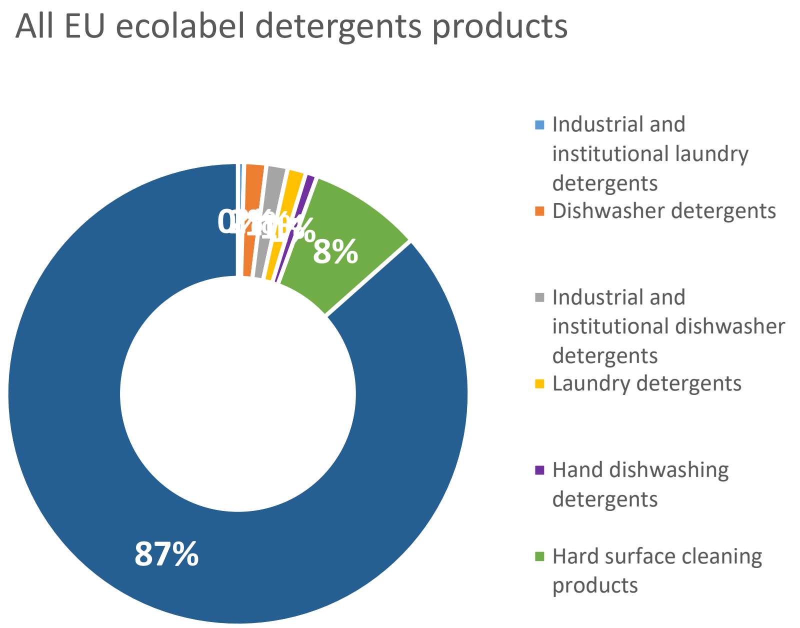


Source: EU Ecolabel Statistics – European Commission

All EU detergents product groups pooled together represents 34.1% of the total number of licenses and 13.5% of the total number of ecolabelled products, as shown by Figure 34. Hard surface cleaning products is the most successful product group both by number of awarded licenses (14.6%) and ecolabelled products (7.9%), followed by hand dishwashing detergents (7.1% and 1.5%, respectively).

Figure 34 - Share of EU Ecolabel detergents licenses (A) and products (B) over the total as on September 23





Source: EU Ecolabel Statistics – European Commission

5. Technical analysis

A technical analysis of the environmental performance of detergents has been carried out and is presented in this chapter. The main objective is to provide specific information on environmental, health and technical aspects related to the products considered in the scope (See chapter 3) in order to revise the existing EU Ecolabel criteria on detergents.

This analysis incorporates an overview of technological aspects associated with detergent products (section 5.1), the presence of chemicals of potential concern in terms of environmental and human hazards (section 5.2), and innovation and/or best practice (section 5.3). It also includes environmental information on detergent products throughout their life-cycle, sourced from a literature review of available life cycle assessments (LCA) studies (section 5.4.1) and from in-house screening LCA studies produced as part of this project (section 5.4.3). This chapter concludes by presenting a summary on improvement potentials for the environmental impacts of detergent products, also informing on the relevant areas of the current criteria that should be taken into account for the revision (section 5.4.4.).

5.1. Technological aspects

5.1.1. Ingredients

Detergents and cleaners, either for household or professional use, are formulated products of varying degrees of complexity that are capable of providing the features that consumers expect ([367]). Their ingredients typically need to meet multiple selection criteria such as cost, sustainability, human health, environmental safety and performance ([368]).

Table 23 provides an overview on the types of ingredients that can be found in detergent product groups, except for the relatively novel category of microorganisms ([369]).

The different product groups (and sub-groups) under study present different formulations, thus different types and proportions of these ingredients, which respond to the intended function (cleaning), the targeted materials and the conditions of use under which each product is used. A brief summary of the presence, role and context under which detergent and cleaner product ingredients are used per product group is subsequently presented:

<u>Laundry detergents</u>

They are used to removed stains (single or complex) from clothing, primarily using a washing machine which operates by subjecting soiled clothing to sequential wash (at different temperature), rinse and centrifugation cycles inside a rotating drum with holes. Laundry detergent formulations are determined by desired cleaning performance, targeted textile type and washing machine operational traits and context of use (professional, household). In this last regard, professional laundry cleaning differs from household in having larger textile laundry volumes, with higher and more specific soiling and that operates under shorter and more automatized washing programmes, which could imply the use of special bleaches and stain-removal processes ([370]).

Laundry detergent formulations are complex, with many different types of ingredients that can be generally categorised as surfactants, builders, bleaching agents and auxiliary agents. Surfactants are the most important ingredient for laundry detergents, generally consisting in a mixture of, primarily, anionic (eg LAS, AES, AS) and non-ionic (eg AE, APG) surfactants. Builders (eg polycarboxylates, ether polycarboxylates, fatty acids and salts of polyacetic acids) account for a significant share (>20%), if not the highest, by weight of

[367] Taifouris, M., M. Martín, A. Martínez, and N. Esquejo, 'On the Effect of the Selection of Suppliers on the Design of Formulated Products', Computers & Chemical Engineering, Vol. 141, October 2020, p. 106980. DOI 10.1016/j.compchemeng.2020.106980

[368] Taifouris, M., M. Martín, A. Martínez, and N. Esquejo, 'On the Effect of the Selection of Suppliers on the Design of Formulated Products', Computers & Chemical Engineering, Vol. 141, October 2020, p. 106980. DOI 10.1016/j.compchemeng.2020.106980

[369] The American Cleaning Institute. https://www.cleaninginstitute.org/understanding-products/about-cleaning-product-ingredients (Accessed 26/03/23)

[370] Smulders, E., and E. Sung, 'Laundry Detergents, 2. Ingredients and Products', in Wiley-VCH Verlag GmbH & Co. KGaA (ed.), Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2011, p. o15_o13. DOI 10.1002/14356007.o15_o13

laundry detergent composition and they play a central role in washing, by supporting detergent action and by softening water ([371]). Bleaching agents (eg sodium perborate, sodium percarbonate) are used to remove coloured stains (eg coffee, wine), primarily via peroxide bleaching, which may include bleach activators (eg TAED) to ensure proper function below optimal temperature (60C<) ([372]) (Smulders and Sung, 2011). Auxiliary agents are used in small quantities only, each with its own specific purpose. As examples, enzymes, anti-foaming agents, anti-corrosion or dye transfer inhibitors which facilitate food break-down (mainly proteins), avoid foaming issues, protect machine parts or avoid dye transfer on other textiles, respectively.

Dishwasher detergents

They are used to remove food soils (single or complex/recalcitrant) from dishes using dishwashers, which operate by subjecting soiled dishware to sequential wash and rinse cycles at varying temperatures inside a closed washing chamber ([373]). Ingredients in dishwasher detergents are expected to maintain cleaning efficiency whilst protecting dishwashers and improving washware conditions.

The major components in dishwasher detergents are builders and alkalis ([374]). Builders serve for water softening and buffering purposes (eg tripolyphoshates, sodium citrate). Alkalis adjust the pH of the water to the optimum level for the other components to work (eg sodium carbonate; sodium metasilicate). Surfactants, commonly non-ionic (eg alcohol ethoxylates, alkane sulfonates and alkyl polyglycosides), are present in small amounts, aiding with wetting, removing and emulsifying fats. Bleaching agents (eg perborates) are used to remove stains such as coffee and tea. Auxiliary agents are used in small quantities only, each with its own specific purpose. For example enzymes, anti-foaming agents or corrosion inhibitors which facilitate food break-down (mainly proteins, polysaccharides), avoid foaming issues and protect dishware and machine parts (eg sodium silicate), respectively.

Hand-dishwashing detergents

They are used to remove food soils (single or complex/recalcitrant) from dishes by hand (scrubbing), using incremental amounts of water (none, some, soaking) at different temperatures (cold, hot) ([375]).

Hand dishwashing detergents are primarily a mixture of surfactants dispersed in water, with builders and solubility enhancers as secondary groups by weight percentage ([376]). Anionic surfactants with carboxylate, sulfate, sulfonate and phosphate polar head groups (eg LAS, SAS) dominate, followed by non-ionic (eg APG) and lastly by cationic surfactants. Other minor ingredients that hand-dishwashing detergents may include are preservatives, fragrances, dyes and enzymes.

Hard surface cleaning products

Typically, the chemistry of a household cleaner is determined primarily considering the cleaning task: soil removal without damaging the target surface/s to be cleaned. Packaging is another aspect to be considered, aiming to ensure compatibility of the formulation with the packaging material and how the product will be applied/used ([377]). Finally, the type of end user could also affect the formulation, yet some ingredients might

[371] Smulders, E., and E. Sung, 'Laundry Detergents, 2. Ingredients and Products', in Wiley-VCH Verlag GmbH & Co. KGaA (ed.), Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2011, p. o15_o13. DOI 10.1002/14356007.o15_o13

[372] Smulders, E., and E. Sung, 'Laundry Detergents, 2. Ingredients and Products', in Wiley-VCH Verlag GmbH & Co. KGaA (ed.), Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2011, p. o15_o13. DOI 10.1002/14356007.o15_o13

[373] Tomlinson, A., and J. Carnali, 'A Review of Key Ingredients Used in Past and Present Auto-Dishwashing Formulations and the Physico-Chemical Processes They Facilitate', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 197–255. DOI 10.1016/B978-044451664-0/50006-1

[374] von Rybinski, W., 'Physical Aspects of Cleaning Processes', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 1–55. DOI 10.1016/B978-044451664-0/50002-4

[375] Szewczyk, G., and K. Wisniewski, 'Dish and Household Cleaning', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 125–195. DOI 10.1016/B978-044451664-0/50005-X

[376] Szewczyk, G., and K. Wisniewski, 'Dish and Household Cleaning', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 125–195. DOI 10.1016/B978-044451664-0/50005-X

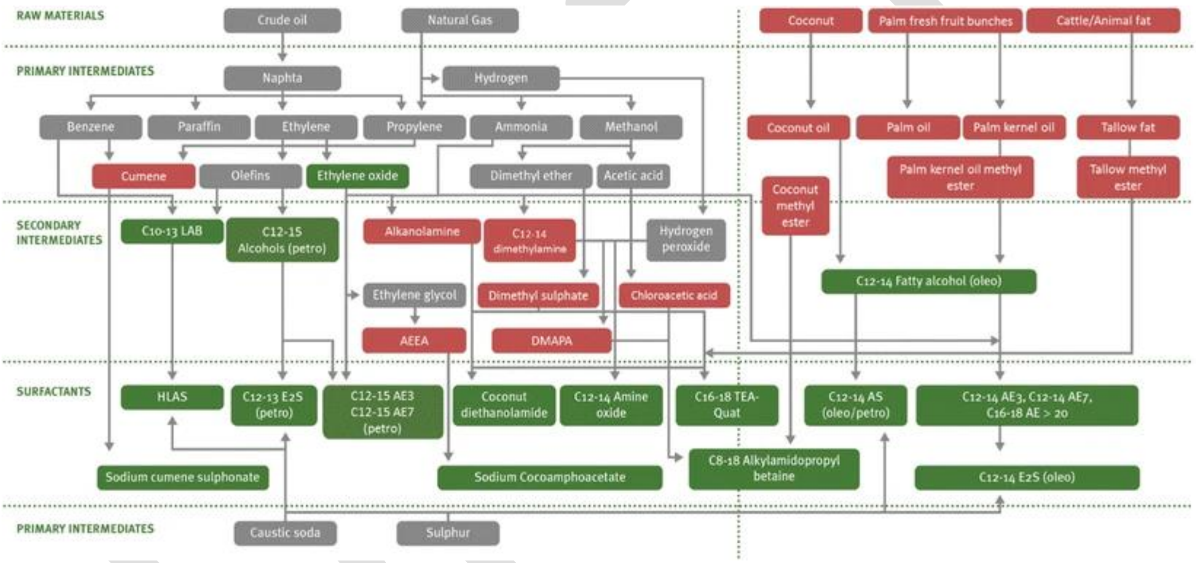
[377] Szewczyk, G., and K. Wisniewski, 'Dish and Household Cleaning', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 125–195. DOI 10.1016/B978-044451664-0/50005-X

be equally used for the production of both household or professional products ([378]). Hence, this results in many different potential types of products.

The major ingredient groups for hard surface cleaners are surfactants, builders, solvents and preservatives/biocides ([379]) (von Rybinski, 2007). Surfactants moisten the surface and remove and keep in solution soil/stains, finding any type except cationic ones. Builders ensure surfactant cleaning efficiency while solvents aid dissolving soil and boost the drying of cleaned surfaces. Preservatives keep the product shelf-life and also aid in disinfecting surfaces. Abrasives, fragrances, bleach, dyes, thickeners or solubility enhancers are examples of other type of ingredients that hard surface cleaners may include and whose use depends on the type of product considered (eg kitchen/toilet/window/all-purpose cleaners).

The raw materials used for the production of detergent and cleaner ingredients are classified according to their origin as oleochemical or petrochemical sources. Oleochemical (or renewable) raw materials derived from animal fats and plants, including coconut oil, tallow, palm kernel oil and palm oil. Petrochemical (or synthetic) raw materials are derived from crude oil or natural gas. The complexity of the production of surfactants from petrochemical or oleochemical sources is illustrated in Figure 35.

Figure 35 – Overview of substances included in the production of commercially major surfactants and their main precursors/intermediates based on current surfactant production technology (reference year 2011).



Source: (Schowanek et al., 2018) ([380])

[378] Gerster, F.M., D. Vernez, P.P. Wild, and N.B. Hopf, 'Hazardous Substances in Frequently Used Professional Cleaning Products', International Journal of Occupational and Environmental Health, Vol. 20, No. 1, January 2014, pp. 46–60. DOI 10.1179/2049396713Y.0000000052

[379] von Rybinski, W., 'Physical Aspects of Cleaning Processes', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 1–55. DOI 10.1016/B978-044451664-0/50002-4

[380] Schowanek, D., T. Borsboom-Patel, A. Bouvy, J. Colling, J.A. de Ferrer, D. Eggers, K. Groenke, et al., 'VIP New and Updated Life Cycle Inventories for Surfactants Used in European Detergents: Summary of the ERASM Surfactant Life Cycle and Ecofootprinting Project', The International Journal of Life Cycle Assessment, Vol. 23, No. 4, April 2018, pp. 867–886.DOI 10.1007/s11367-017-1384-x

Table 23 – General overview of the type of ingredients commonly used in detergent and cleaner formulations. *"Product group"* shows likely presence of the ingredient type within one or more of following product groups: laundry detergents [LD], dishwasher detergents [DD], hand-dishwashing detergents [HDD] and/or hard surface cleaning products [HSC].

Ingredient type	Product groups	Description	Commonly used groups/examples
Surfactants (surface active agents)	LD DD HDD HSC	The active cleaning ingredients found in detergent products, which remove soil from surfaces and keep it in suspension. Surfactants change the surface tension of water, thus assisting with cleansing, wetting surfaces, foaming and emulsifying. Main groups are anionic, cationic, amphoteric and non-ionic. In terms of production and usage, non-ionic and anionic are used in similar amounts, whereas cationic or amphoteric usage is approximately x10 lower	*Anionic*: linear alkylbenzene sulfonates (LAS), alcohol ether sulfates (AES), secondary alkane sulfonates (SAS) and alcohol sulfates (AS). *Non-ionic:* Alcohol ethoxylates (AE) primarily; alcohol alkoxylates (EO/PO adducts), fatty acid alkanolamides, alkylamine oxides and alkyl polyglucosides (APG). *Cationic:* di-tallow dimethyl ammonium chloride (DTDMAC); esterquats. *Amphoteric* (for cleaners): alkyl betaines, alkyl amido propyl betaines and alkyl amphodiacetates.
Preservatives/ Biocides	LD DD HDD HSC	They prevent the product from spoiling during storage by inhibiting microorganisms' growth and are especially key for liquid detergent products. They are a broad spectrum of chemical types (approx. 30 groups/sub-groups), being mainly regulated by the Biocidal Product Regulation ([381]).	Those technically compatible with detergency industry and current biocidal regulations are: Methylisothiazolinone (MIT); Benzisothiazolinone (BIT); Mixture of chloromethylisothiazolinone (CMIT)/MIT); Bronopol; Phenoxyethanol
Enzymes	LD DD HDD	An enzyme is a catalyst that can speed up biological processes. They work under mild temperature and pH conditions and are grouped based on the reaction catalysed (eg breakdown of protein, starch or fat stains).	Cellulase, amylase, lipase, protease
Builders	LD DD HSC	Builders maintain a desirable level of alkalinity for cleaning. They prevent hard water ion (eg Ca, Mg) interference with the functioning of other ingredients. Ion exchangers do so by adsorbing these ions, while complexing agents immobilise them.	*Complexing/chelating agents:* phosphates (eg tri(poly)phosphate), citrate, ethylenediaminetetraacetic acid (EDTA), nitrilotriacetate (NTA), glutamic acid N,N-diacetic acid (GLDA), methylglycinediacetic acid (MGDA) *Ion exchangers:* polycarboxylic acids, zeolites.
Dyes	LD DD HDD HSC	Dyes give detergent formulations colour, normally for non-functional purposes (eg marketing). They can be grouped as organic/inorganic, natural/synthetic, by chemical makeup and by dyeing method.	It is a heterogeneous group of chemicals. As example, commercial azo dyes as Disperse Blue 165 (CAS No.41642-51-7)
Bleaching agents	LD DD HSC	They are mainly used for the dissolution, decolourization and oxidisation of organic deposits (eg stains), but they can have a biocidal effect for some applications. Two main groups based on the presence of chlorine (active chlorine) or its absence (oxygen bleaches).	*Chlorine:* chlorinated trisodium phosphate or chlorinated isocyanurates; *Oxygen bleaches:* persalts (peroxides, sodium perborate, sodium percarbonate); peracids (eg phthalimidoperhexanoic acid [PAP]) and bleach activators (eg tetraacetyl ethylene diamine [TAED]).
Fragrances	LD HDD HSC	They aim at providing a pleasant smell and/or neutralize unpleasant ones (eg other detergent ingredients). Generally are used in trace amounts and its classification is based on origin (natural/synthetic) and/or molecular structure.	*Natural musk*: mixture of various, dominantly cyclic substances, partly with nitrogen-containing aromatic moieties (pyridines). *Synthetic musk:* significant different molecular structure, grouped as nitro, polyciclic and macro-cyclic musk.
Solvents	LD HSC	Organic solvents are used in detergent formulations to aid in dissolving hydrophobic substances in water.	Alcohols (eg ethanol, isopropanol, ethylene glycol), acetone, some glycol ethers, aliphatic and aromatic hydrocarbons (eg terpenes, pine/citrus oils)
Optical brighteners	LD	Optical brighteners make fabrics appear whiter and brighter, doing so by absorbing UV light and re-emitting it by fluorescence (blue region).	Mainly anionic diamino stilbene (DAS) or distyryl biphenyl (DSBP) derivatives. Include aminotriazines, coumarins and stilbenes.
Anti-corrosion agents	DD	They prevent the corrosion of glass by other detergent ingredients.	Zinc salts and sodium silicates

[381] Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products. OJ L 167, 27.6.2012, p. 1–123. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012R0528

Ingredient type	Product groups	Description	Commonly used groups/examples
Anti-foaming agents	DD	They reduce the foam formation during the wash process, thus avoiding reduced washing effectiveness due to foaming.	Silicon fluids (polydimethyl siloxanes, PDMS) and paraffins
Solubility enhancers	HDD	Hydrotopes increase the solubility of all active ingredients and give a clear and homogenous product, thus aiding in achieving the desired product formulation.	Xylene sulfonate and cumene sulfonate
Opacifiers	HDD	Opacifiers are additives used for aesthetic purposes (eg liquid detergents). When used alone they reduce translucence of the product and when combined with a dye, they give the product a desired colour.	Water insoluble metal compounds, such as titanium dioxide.
Acids/Alkalis	HSC	They aid in the removal of deposits of inorganic (acids) and organic nature (alkalis).	*Acids:* amidosulfonic acid (inorganic); citric acid, acetic acid, formic acid, lactic acid, etc (organic). *Alkalis:* sodium and potassium hydroxide, sodium carbonate (soda), sodium metasilicate, ammonia, organic amines (e.g. mono-, di- and triethanolamine)
Scouring abrasives	HSC	They ease hardened stains from a variety of surfaces via mechanical scouring action (friction). Types: physical, mineral and chemical.	*Mineral:* calcium carbonate, sodium carbonate, borax. *Chemical:* trichloroisocyanuric acid and mixtures of sodium hypochlorite
Thickening agents	HSC	Thickening agents modulate viscosity, thus the rheology of the product. They are broadly categorised as organic or inorganic (salts, clays). Organic splits into associative/non-associative and natural/synthethic.	*Examples from various classes*: Hydroxyethyl cellulose; xanthan; alginates; polyvinyl alcohol; cross - & non-crosslinked acrylics; HMHEC; HEUR; HASE; sodium chloride; bentonite

Sources: ([382]) ([383]) ([384]) ([385]) ([386]) ([387]) ([388]) ([389]) *(Karsa, 2007; Steber, 2007; Tomlinson and Carnali, 2007; Schwarzbauer and Jovančićević, 2018; Basketter et al., 2012; Lai, 2005; Smulders and Sung, 2011; Smulders and Rähse, 2011)*; ACI et al. 2021([390]); AISE, 2018 ([391]); J. Seetz et al. 2018 ([392]); ACI, 2019 ([393]).

5.1.2. Supply chain and production processes overview

Once raw materials have been selected and converted into ingredients, manufacturers select which of them will be used for the production of detergents and cleaners. This decision is taken based on the desired formulation and is complex, driven by multiple dynamic factors such as cost (of ingredients or energy),

382 Karsa, D.R., 'Biocides', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 593–623. DOI 10.1016/B978-044451664-0/50018-8

383 Steber, J., 'The Ecotoxicity of Cleaning Product Ingredients', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 721–746. DOI 10.1016/B978-044451664-0/50022-X

384 Tomlinson, A., and J. Carnali, 'A Review of Key Ingredients Used in Past and Present Auto-Dishwashing Formulations and the Physico-Chemical Processes They Facilitate', Handbook for Cleaning/Decontamination of Surfaces, Elsevier, 2007, pp. 197–255. DOI 10.1016/B978-044451664-0/50006-1

385 Schwarzbauer, J., and B. Jovančićević, Organic Pollutants in the Geosphere, Fundamentals in Organic Geochemistry, Springer International Publishing, Cham, 2018. DOI 10.1007/978-3-319-68938-8

386 Basketter, D., N. Berg, C. Broekhuizen, M. Fieldsend, S. Kirkwood, C. Kluin, S. Mathieu, and C. Rodriguez, 'Enzymes in Cleaning Products: An Overview of Toxicological Properties and Risk Assessment/Management', Regulatory Toxicology and Pharmacology, Vol. 64, No. 1, October 2012, pp. 117–123. DOI 10.1016/j.yrtph.2012.06.016

387 Lai, Kuo-Yann, ed., Liquid Detergents, 0 ed., CRC Press, 2005. ISBN 978-0-429-11637-7

388 Smulders, E., and E. Sung, 'Laundry Detergents, 2. Ingredients and Products', in Wiley-VCH Verlag GmbH & Co. KGaA (ed.), Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2011, p. o15_o13. DOI 10.1002/14356007.o15_o13

389 Smulders, E., and W. Rähse, 'Laundry Detergents, 3. Production, Testing and Economic Aspects', in Wiley-VCH Verlag GmbH & Co. KGaA (ed.), Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, 2011, p. o15_o14. DOI 10.1002/14356007.o15_o14

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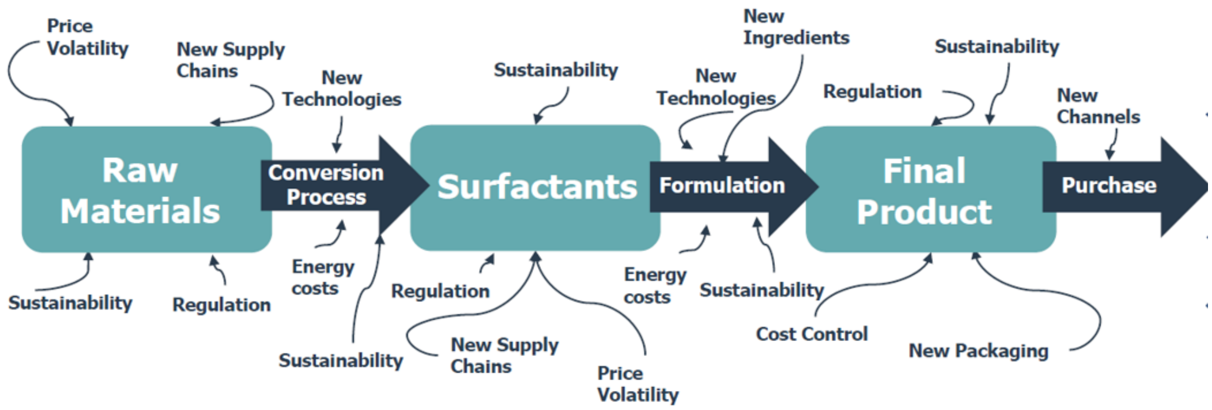
391 AISE, 2021. Preservatives: key biocidal ingredients to preserve liquid detergents. https://www.aise.eu/cust/documentrequest.aspx?UID=05f6ce01-13e3-4c09-90a9-97dd7cc54b99 (Accessed 23/06/23)

392 J. Seetz, G. Bongen, K. Henning, 2018. Impact of the New Chelating Agents GLDA and MGDA in Detergents. https://www.sofw.com/en/sofw-journal/articles-en/47-home-care/612-impact-of-the-new-chelating-agents-glda-and-mgda-in-detergents (Accessed 23/06/23)

393 American Cleaning Institute, 2019. The science of soap. https://www.cleaninginstitute.org/sites/default/files/assets/1/AssetManager/ScienceofSoap.pdf (Accessed 23/06/23)

sustainability and innovations (new technologies or ingredients) and stability (in terms of compatibility with other ingredients, packaging materials and under typical storage temperature ranges). Figure 36 presents an illustrative example of the complex value-chain of detergent and cleaner products, using surfactants as study case.

Figure 36 – Illustration of surfactants value chain complexity.



Source: Pantalena, J., 2023 ([394])

There are predictive models that aid in the design of the product, for example optimising cleaning performance ([395]) (Cheng et al., 2020). Other modelling studies strive to integrate simultaneously ingredients and suppliers choice, as a way to optimise the supply-chain and product design together, which could be environmentally and economically more efficient ([396]). Alternative approaches focus on the sustainability of the ingredients, establishing systems which either score/rank them or simply guarantee they have improved environmental performance. The voluntary eco-labelling programme *Safer Choice* of the US EPA ([397]), helps find products that perform and contain ingredients that are safer for human health and the environment. In particular, *Safer Choice* products may be formulated from the ingredients in the *Safer Chemicals Ingredients List* (SCIL) ([398]) and/or *CleanGredients ([399]).*

The manufacturing process might differ according to the type, format and/or manufacturer of the final product. Manufacturing generally starts by putting together all the selected ingredients into mixing vessels. Then, the process can be carried out in batch or continuous systems, which require lesser or higher degrees of automatization/resources, respectively ([400]). Spray drying is the traditional manufacturing process for powder detergents (See Figure 38), to which a densification step was added in order to produce more compact detergents (See Figure 37). Once densified, powder detergents were dried, shaped and/or milled as desired, prior to the post-addition step where temperature-sensitive ingredients are added (eg enzymes). The alternative to spray drying towers, non-tower technology, uses an increased number of dried materials ([401]). The final step is packaging, starting once liquid (blended) or solid (densified) detergent products are ready-to-

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[394] Pantalena, J., 2023. Challenges in the Surfactants Industry and the Path Forward for New Solutions. In: Proceedings of the 12th Wold Surfactant. Congress. CESIO. Rome, 4-7th June 2023.

[395] Cheng, K.C., Z.S. Khoo, N.W. Lo, W.J. Tan, and N.G. Chemmangattuvalappil, ‘Design and Performance Optimisation of Detergent Product Containing Binary Mixture of Anionic-Nonionic Surfactants’, Heliyon, Vol. 6, No. 5, May 2020, p. e03861. DOI 10.1016/j.heliyon.2020.e03861

[396] Taifouris, M., M. Martín, A. Martínez, and N. Esquejo, ‘On the Effect of the Selection of Suppliers on the Design of Formulated Products’, Computers & Chemical Engineering, Vol. 141, October 2020, p. 106980. DOI 10.1016/j.compchemeng.2020.106980

[397] US EPA, Safer Choice programme. https://www.epa.gov/saferchoice#:~:text=Safer%20Choice%20helps%20consumers%2C%20businesses%2C%20and%20purchasers%20find,source%2C%20such%20as%20using%20safer%20ingredients%20in%20products. (Accessed 23/06/23)

[398] US EPA, Safer Chemical Ingredients List (SCIL). https://www.epa.gov/saferchoice/safer-ingredients#about (Accessed 23/06/23)

[399] CleanGredients. https://cleangredients.org/ (Accessed 23/06/23)

[400] Zoller, Uri, and Paul Sosis, eds., Handbook of Detergents, Part F, 0 ed., CRC Press, 2008. DOI 10.1201/9781420014655

[401] Schwarzbauer, J., and B. Jovančićević, Organic Pollutants in the Geosphere, Fundamentals in Organic Geochemistry, Springer International Publishing, Cham, 2018. DOI 10.1007/978-3-319-68938-8

use. The selection of packaging materials considers product compatibility and stability, cost, safety, sustainability, circularity (design for recycling) and ease of use. Typically, using pouches and/or rigid plastic for liquid products and cardboard boxes for solids as powders.

Some remarks on the manufacturing process by product type are:

Powder detergents are produced by spray drying, agglomeration, dry mixing or combinations of these methods ([402]). Powder production requires densification (or compaction) to ensure desired bulk density ([403]). During the spray drying process, liquid and powder ingredients are combined to form a slurry which is then pumped through a tower and sprayed under high pressure to form small droplets, which are then hot-air dried to form hollow granules ([404]) (Zoller and Sosis, 2008). An agglomeration process consists of blending solid and liquid ingredients in the presence of a liquid binder, which leads to higher bulk density powders. Following a screening process to ensure granules are of the correct size, temperature sensitive ingredients such as enzymes are added (See Figure 39).

Liquid detergent production in batch processes is the simplest manufacturing process, as ingredients are introduced to an agitated tank, where additional mixing or heating can be provided through a recirculation loop. In a continuous process, both dry and liquid ingredients are blended using in-line mixers.

Detergent tablets consist of one or more layers, each layer potentially containing different ingredients which otherwise would interact and compromise storage stability ([405]) (Smulders and Rähse, 2011). Once granules of the desired bulk density range, after post-addition/mixing/sieving, are ready they are compacted via rotatory die presses, wrapped and packaged.

Detergent sheets are a relevant innovative trend with regards to product format and production. The initial steps are shared with liquid and powder detergents, namely mixing and drying (via heating). Then, once the evaporation steps are completed, large pieces of the dried detergent are transferred to a cutting machine which trims pieces to the desired size for the detergent sheets ([406]).

[402] US EPA, Fifth Edition, Volume I Chapter 6: Organic Chemical Process Industry. https://www.epa.gov/sites/production/files/2020-10/documents/b06s08.pdf (Accessed 23/06/23)

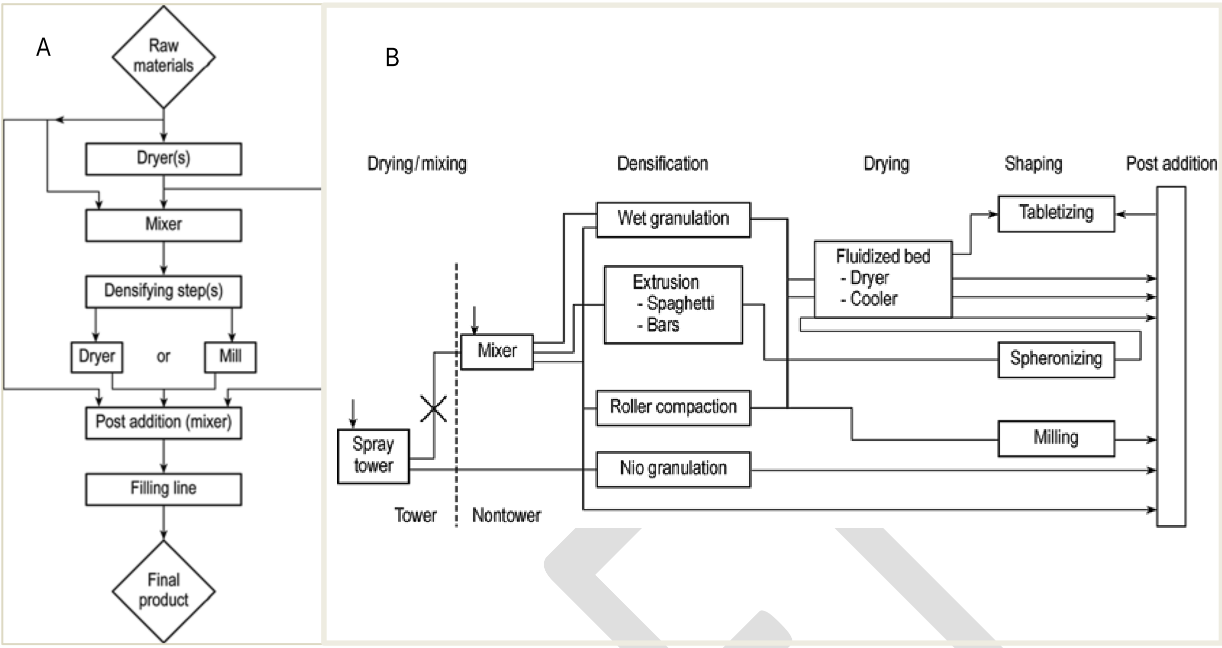
[403] Bulk density is a mass to volume ration, in this case the weight of detergent powder per volume that occupies, usually expressed in g/cm3, kg/m3, or g/100 ml.

[404] Zoller, Uri, and Paul Sosis, eds., Handbook of Detergents, Part F, 0 ed., CRC Press, 2008. DOI 10.1201/9781420014655

[405] Schwarzbauer, J., and B. Jovančićević, Organic Pollutants in the Geosphere, Fundamentals in Organic Geochemistry, Springer International Publishing, Cham, 2018. DOI 10.1007/978-3-319-68938-8

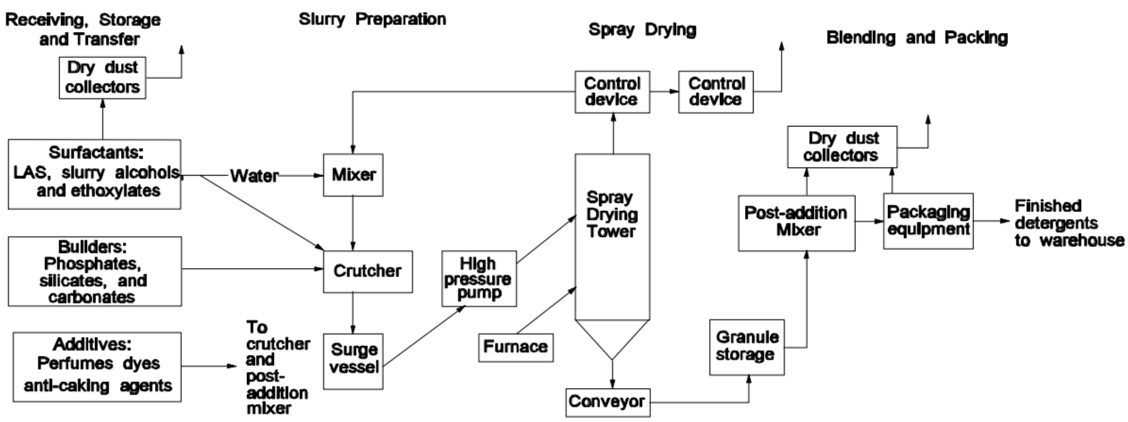
[406] greatfactory.co/pages/production (Accessed 26/06/23)

Figure 37 – (A) Manufacturing of compact powder detergents; (B) chain of different processes



Source: (Smulders and Rähse, 2011) ([407])

Figure 38 – Manufacture of spray-dried detergents

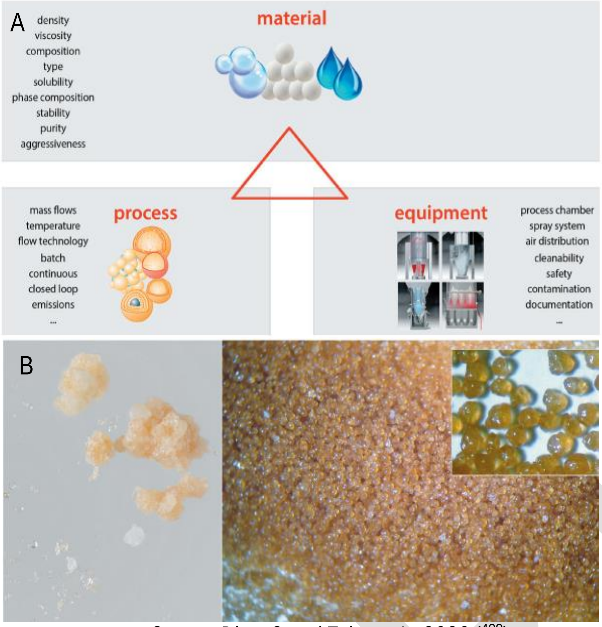


Source: US EPA ([408])

[407] Schwarzbauer, J., and B. Jovančićević, Organic Pollutants in the Geosphere, Fundamentals in Organic Geochemistry, Springer International Publishing, Cham, 2018. DOI 10.1007/978-3-319-68938-8

[408] US EPA, Fifth Edition, Volume I Chapter 6: Organic Chemical Process Industry. https://www.epa.gov/sites/production/files/2020-10/documents/b06s08.pdf (Accessed 23/06/23)

Figure 39 – (A) Factors influencing particle design; (B) example of spray dried enzyme powder and spray granules from an enzyme solution.



Source: Ding, G and Teiwes, A., 2020 ([409]).

[409] Ding, G and Teiwes, A., 2020. Process Technologies to Optimize Detergent Manufacturing. SOFW Journal 10/20 | Volume 146 | Thannhausen, Germany Glatt_FA_104_Process-Technologies-to-Optimize-Detergent-Manufacturing_en_SOFW_2020-10.pdf (Accessed 23/06/23)

5.2. Non-Life cycle analysis impacts review

The toxicity impact categories used in PEF methodology (i.e. human toxicity (carcinogenic), human toxicity (non-carcinogenic) and ecotoxicity) have a low degree of robustness compared the other impact categories that are reported on. this lack of robustness stems from the difference between: (i) the inherent need for models to make simple and universally applicable rules and assumptions when in fact, and (ii) the much more complex and variable real-life behaviour of chemicals in the environment. Consequently, models that try to predict how much 10 mg of a particular toxic chemical going down the toilet will affect fish survival in a natural watercourse is far from perfect science.

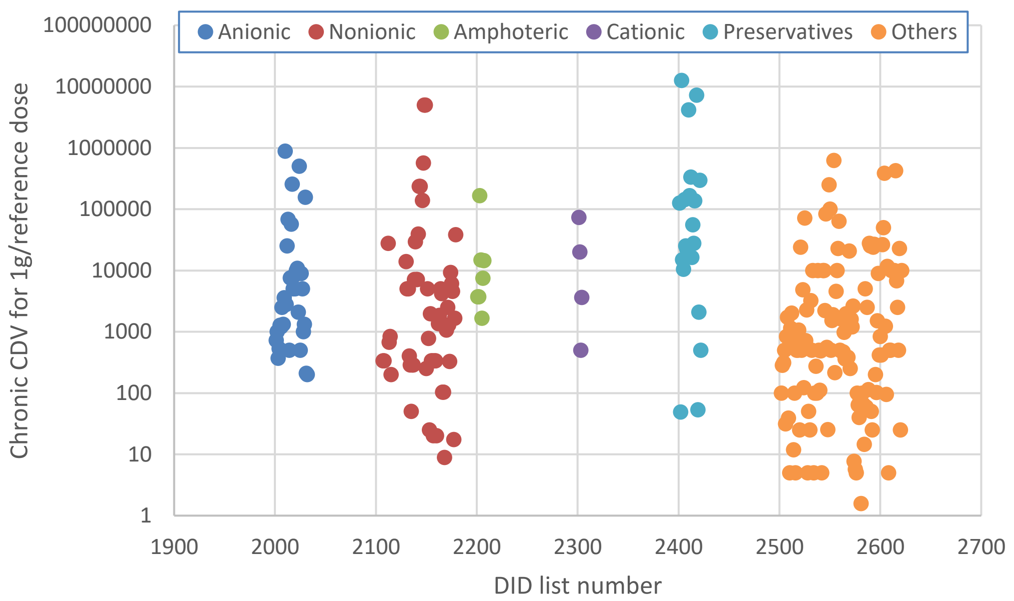
The EU Ecolabel criteria take a simplified approach that focuses on two highly relevant product properties, biodegradability and aquatic toxicity, and uses this to calculate a number known as the Critical Dilution Volume (CDV). The concept of the CDV means the equivalent volume of water needed to dilute a dose of detergent down to a low risk of harm to aquatic life. The higher the CDV value, the more dilution is needed and thus the worse (more ecotoxic) is the detergent ingredient or formulation. A lower biodegradability rate and a higher aquatic toxicity contribute to higher CDV values.

5.2.1. A look at CDV values for DID list substances

To aid EU Ecolabel applicants to calculate CDV results in a consistent manner, the Detergent Ingredient Database was formed (often referred to as the DID list). This list has been updated in 2014 and is in the process of being updated again during 2023-24.

In order to highlight the difference in CDV values for one group of substances with a common and essential functionality (eg surfactants), applying a same 1g per reference dose for each ingredient generated the following spread of CDV values.

Figure 40. Spread of CDV values for different surfactants, preservatives and other detergent ingredients on a logarithmic scale.



Source: DID list, available online under multiple tabs here.

A fair comparison would be to compare anionic surfactants with anionic surfactants, non-ionic surfactants with non-ionic surfactants and so on, because there is a chance that these substances are likely to be able to substitute each other in similar concentrations. However, within any one group of surfactant type, there is at least a factor of 100 difference between the lowest and highest CDV results. The largest spread exists amongst the non-ionic surfactants, which also had the highest number of entries on the DID list. Within this substance group, a factor of more than 100,000 difference exists in CDV values.

A similar degree of spread was observed for the preservatives, although it is worth highlighting the very good (low) CDV values for benzyl alcohol and phenoxy-ethanol preservatives that was due to a combination of ready biodegradability and low chronic aquatic toxicity. However, it is unlikely that low toxicity preservatives could be substituted for more toxic ones on a 1 to 1 basis for a given desired preservation effect in a given detergent formulation.

With the other DID list ingredients, it is recommended to try and break them down into different sub-categories of detergent ingredient with common functionalities so that a more reasonable comparison can be made (e.g. builders, anti-foaming agents, thickeners etc.).

5.2.2. A closer look at preservatives

Preservatives are needed to prevent unwanted growth of micro-organisms in liquid detergent products, which include the increasingly popular liquid laundry detergents (gaining market share at the expense of powder varieties) and also hand dishwashing detergents and some hard surface cleaners. According to AISE, the main preservatives used in detergent formulations are: MIT, BIT, CMIT/MIT, bronopol and phenoxyethanol.

Each of these preservatives have had their hazard profiles evaluated and been assigned a harmonised CLP classification as part of the work being done under the Biocidal Products Regulation (BPR). With the notable exception of phenoxyethanol, these harmonised classifications or reclassifications are restricting the potential use of preservatives as summarised in the table below.

Table 24. Before and after impact of CLP reclassifications on the allowance of preservatives in EU Ecolabel detergents

Substance	CAS No.	When reclassified and for what hazard(s)?	Type of classification	Effective limit in EUEL detergent products*
Bronopol	52-51-7	1st ATP (2009): H302, H312, H315, H318, H335, H400 (M=10)	Harmonised	0,010% wt. (100 ppm)
Bronopol part II	52-51-7	Proposal (ongoing): H301, H331, H312, H315, H318, H335, H400 (M=10), H411	If accepted: harmonised	0,010% wt. (100 ppm)
1,2 benzisothiazol-3(2H)-one (BIT)	2634-33-5	11th ATP (2018): H302, H317 (0,05%), H318, H315, H400	Harmonised	0,010% wt. (100 ppm)
1,2 benzisothiazol-3(2H)-one (BIT part II)	2634-33-5	Proposal (ongoing): H302, H330, H317 (0,036%), H318, H315, H400, H410	If accepted: harmonised	0,010% wt. (100 ppm)
2-methyl-2H-isothiazol-3-one (MIT)	2682-20-4	13th ATP (2018): H301, H311, H314, H318, H317 (0,0015%), H330, H400 (M=10), H410	Harmonised	0,0015% wt. (15 ppm)
reaction mass of 5-chloro-2-methyl-2H-isothiazol-3-one and 2-methyl-2H-isothiazol-3-one (3:1) (CMIT:MIT)	55965-84-9	13th ATP (2018): H301, H310, H314, H318, H317 (0,0015%), H330, H400, H410	Harmonised	0,0015% wt. (15 ppm)
Phenoxyethanol	122-99-6	17th ATP (2021): H302, H318, H335	Harmonised	No horizontal limit

*presuming no specific derogation being granted and that the preservatives comply with the bioaccumulation factor <

The red text in the above table indicates a barrier in the sense that those hazard codes are restricted horizontally in EU Ecolabel detergents. As a general rule, any particular substance with one or more of those hazards cannot be used in quantities >0,010% by weight unless specifically derogated. Some of the H317 hazards are associated with even more stringent limits due to the CLP classification rules for mixtures. The one entry in green text in the table indicates a lack of any barrier for the use of that substance in EU Ecolabel detergents. In the table above it can be seen that:

- All 5 preservatives have harmonised CLP classifications.
- Only 1 of the 5 preservatives (phenoxyethanol) do not have any EU Ecolabel restricted hazards (restricted hazards are highlighted in red).
- In terms of the CLP rule of mixtures, the most restrictive hazard category for the isothiazoline preservatives is H317 (skin sensitisation). The limits for H317 mean that only 15ppm of MIT, 15ppm

of CMIT or 500ppm (maybe soon 360ppm) of BIT could be used before the whole formulation is classified as skin sensitising. The generic concentration for H317 substances is 1000ppm.

- If the proposed Bronopol reclassification goes ahead, it will have 4 EUEL restricted hazards instead of 1, which makes derogation more difficult to justify.

No derogations have been made for any preservatives in the current EU Ecolabel criteria and the reclassifications in the last few years do not seem to be a major issue affecting license applications. In total, the DID list mentions some 20 preservatives and a broader review is proposed with a sub-group of expert stakeholders to determine which of these preservatives are most relevant and in which types of formulation and at what concentration ranges they are most effective. It may also come to light that in many cases no preservatives are needed because surfactant concentrations are high enough, or the pH extreme enough, to inhibit microbial growth. Armed with this information, a more precise LCA screening and sensitivity analysis can be done if it is desired to explore and identify any preservation strategies with the lowest environmental impact.

5.2.3. A closer look at fragrances

While fragrances are a crucial part of marketing strategies of detergent manufacturers and an important factor in consumer choices, the substances included in fragrance formulations include many CLP hazards that would normally be restricted in EU Ecolabel criteria. However, because they are often present in small concentrations in the fragrance formulation, and that whole fragrance formulation only forms a small part of the overall detergent formulation, most of these substances would fall under the 0,010% wt. individual limit for horizontal CLP hazard restrictions for EU Ecolabel products that are mixtures.

The only other requirements on fragrance compounds are that they comply with IFRA code of practice. This is an industry-led standard and covers general industry good practice and safety principles. However, it is not clear at all if the IFRA standards encourage in any way less hazardous fragrance compounds at the expense of more hazardous alternatives. In order to have a better idea of what types and numbers of compounds are involved, stakeholders have been requested to provided examples of SDSs for fragrance formulations, some examples of data for fragrance formulations are given in the data collection section in this same chapter of the PR (see section 5.4.2).

5.2.4. Considering the necessity of existing derogations

A summary of the derogations for hazardous substances at levels greater than 0,010% wt. of the detergent product is provided below.

Table 25. Before and after impact of CLP reclassifications on the allowance of preservatives in EU Ecolabel detergents

Substance / DID reference?	CAS No.	Derogated hazards	Applicable detergent product groups
Surfactants / Various	Various	H400 & H412	LD, IILD, DD, IIDD, HDD, HSC
Subtilisin / Protease	9014-01-1 / 9001-92-7	H400 & H411	LD, IILD, DD, IIDD, HDD, HSC
Enzymes* / Protease & Non-protease	Various	H317 & H334	LD, IILD, DD, IIDD, HDD, HSC
NTA (trisodium nitrilotriacetate)**	5064-31-3	H351	LD, IILD, DD, IIDD, HDD, HSC
ε-phthalimido-peroxy-hexanoic acid (PAP)***	128275-31-0	H400 & H412	IILD
Peracetic acid/hydrogen peroxide used as bleaching agent	79-21-0	H400, H410 & H412	IILD

*including stabilisers and other auxiliary substances in the preparations. Supposedly also refers to cellulase, amylase, mannanase, lipase etc.

**as an impurity in MGDA and GLDA In concentrations lower than 0,2 % in the raw material as long as the total concentration in the final product is lower than 0,10 %.

***used as bleaching agent at max concentration of 0,6 g/kg of laundry.

It is recommended to check in more detail the share of EU Ecolabel licenses that are actively applying the derogations above and whether or not suitable alternatives exist that do not require derogation. In terms of the surfactant derogations, a look at the CESIO CLP recommendations document could help provide an overview of the classification landscape with this substance group that is of fundamental importance to detergents.

Table 26. Extent to which different categories of surfactant have EUEL restricted classifications. Current derogations highlighted in orange (% values rounded up to nearest integer).

EUEL restricted hazard	Anionics – alkylether sulfate salts (n=118)	Anionics – alkylsulfate salts (n=132)	Anionics – other (n=169)	Nonionics – alcohol ethoxylates (n=207)	Nonionics – other (n=67)	Cationics (n=13)	Amphoterics (n=42)
Not classified	61 (52%)	22 (17%)	19 (12%)	46 (23%)	23 (35%)	4 (31%)	7 (17%)
H311	0	0	0	0	0	2 (16%)	0
H330	0	0	0	0	1 (2%)	0	0
H361d	0	0	0	0	1 (2%)	0	0
H373	0	0	0	0	0	0	1 (3%)
H400	0 (0%)	0 (0%)	8 (5%)	44 (22%)	9 (14%)	5 (39%)	7 (17%)
H410	0	0	0	0	9 (14%)	4 (31%)	0
H411	0	0	8 (5%)	9 (5%)	12 (18%)	2 (16%)	6 (15%)
H412	13 (11%)	34 (26%)	15 (9%)	74 (36%)	4 (6%)	1 (8%)	11 (27%)
H413	0	0	1 (1%)	0	0	0	0

The findings in the table above reveal that while a lot of surfactants did have H400 and/or H412 classifications, there were also many other surfactants that did not have these classifications. Even assuming the maximum spread of H400 and H412 classifications, each surfactant category had at least 42% of its individual substance types without these hazards. The relative shares of surfactants with H400 or H412 also varied a lot depending on the type of surfactant in question.

However, further discussion is needed in order to determine if the less hazardous or non-hazardous surfactants are actively commericalised or have a similar efficacy as those that require the H400 and/or H412 derogation.

The derogation for enzymes seems reasonable since there are apparently important life cycle impact reductions that can be achieved where small amounts of enzymes can greatly reduce the quantity of surfactant needed for a given detergency effect. Enzymes are expensive ingredients and only used in small quantities, but modest increases can result in lower doses being needed or lower concentrations of surfactant in the same dose. More formulations will be requested from stakeholders to try to verify the extent to which this happens. One such comparison will be made in a sensitivity analysis for powder laundry detergent in this draft of the study.

5.3. Environmental analysis, innovation and best practices

Two of the most significant sustainability drivers for innovation in the detergency and cleaning fields are the transition towards the use of renewable materials and improved environmental performance, generally by lowering eco-toxicity and enhancing biodegradability of ingredients. Ingredients such as enzymes are both produced from renewable materials and are biodegradable; however most of the rest of key organic ingredients (eg surfactants, polymers) have limited biodegradability, or are from fossil origin or both[410].

The production of detergent ingredients from renewable raw materials can boost sustainability but, for this to be so, the production process has to be technically and economically viable, whilst simultaneously guaranteeing environmental safety and LCA net positive impacts (Longati et al., 2023; Jimoh and Lin, 2019). It can imply changing the source of the raw materials (eg. petro-based to bio-based) and/or changing the production process (eg from chemical derivitisation to fermentation bio-reactors).

5.3.1. Biosurfactants

The term surfactant is shorthand for "SURFace ACTive AgeNT". This group of chemicals comprises a large number of different structures that have the common property of being able to reduce surface tensions

[410] Scheidgen, Arnd, 2023. A Decade of Green Transformation – Regulatory and Sustainability Strategy in Consumer Brands. In: Proceedings of the 12th Wold Surfactant. Congress. CESIO. Rome, 4-7th June 2023.

between different liquids and with particle surfaces. A key property that enables this functionality is the amphiphilic nature of polymeric compounds (ie having a hydrophilic part and a lipophilic part). Micro-organisms naturally produce such compounds to form protective biofilms, to help ingest substrates that would not be soluble within their cellular cytoplasm and/or to help certain materials pass through their cell walls.

In the last decade or so there has been a massive increase in research into the development and testing of biosurfactants in a wide range of applications, ranging from oil recovery from petroleum sludge to pharmaceuticals (Jimoh and Lin, 2019[411]). In between are a diverse range of possibilities in industrial processes and consumer products, of which use in detergents is especially interesting.

Biosurfactants are produced by micro-organisms to create biofilms that serve both to protect themselves from the external environment and to facilitate the metabolisation of carbon and nitrogen rich substrates in the surrounding environment. In laboratory conditions, micro-organism growth can be optimised by placing them in any one or more of many different bio-based substrates (eg corn steep liquor, soap stock, animal fat[412], waste cooking oil[413], brewery waste[414], residues from olive oil and wine production[415]). In such cases, biosurfactant production can actually be viewed to some extent as an added-value recovery route from many industrial by-products and wastes. This is in sharp contrast to the use of petrochemicals as feedstock for the production of the chemical surfactants widely used today. [416]

Differences in the nature and chemistry of biosurfactants result from the use of different micro-organisms, different genetic variations of a given micro-organism and the nature of the growth substrate used. Other factors such as temperature, light, pH, agitation levels, oxygen content and the presence of micronutrients will affect yields and possibly the nature of the biosurfactant structure as well. The main categories of biosurfactant, together with some examples[417], are:

- Glycolipids: such as Rhamnolipids, Sophorolipids, Mannosylerythritollipids, Xylolipids, Cellobiolipids, Flocculosin, Glucolipid and Polyol lipids.
- Lipopeptides: such as Surfactin, Arthrofactin, Iturin, Fengycin, Lichenysin, Pumilacidin, Serrawattin, Viscosin and Gramicidin.
- Phospholipids/Fatty acids/Neutral lipids: such as Corynomucolic acid, Spiculicporic acid and Oleic acids.
- Polymeric biosurfactants: such as Emulsan, Liposan, Alasan, Mannan-lipid-protein, Biodispersan, Mannoprotein, Protein PA and Bioemulsan.

Researchers are demonstrating that these microbially produced products can be concentrated up and used directly in applications for surfactants (the so-called 2nd generation of biosurfactants), which present potentially important advantages over 1st generation biosurfacants, which were simply the use of bio-based feedstocks to chemically derive surfactant compounds (commonly referred to as oleochemical surfactants)[418].

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411 Jimoh A.A. and Lin, J., 2019.Biosurfactant: A new frontier for greener technology and environmental sustainability.Ecotoxicology and Environmental Safety 184 (2019) 109607, https://doi.org/10.1016/j.ecoenv.2019.109607

412 Jimoh et al., 2019. Biosurfactant: A new frontier for greener technology and environmental Sustainability. Ecotoxicology and Environmental Safety 184 (2019) 109607, https://doi.org/10.1016/j.ecoenv.2019.109607

413 Lipens et al., 2021. Glycolipid Biosurfactant Production from Waste Cooking Oils by Yeast: Review of Substrates, Producers and Products. Fermentation, 2021, 7, 136. https://doi.org/10.3390/fermentation7030136

414 Correa Nazareth et al., 2021. Bioconversion of low-cost brewery waste to biosurfactant: An improvement of surfactin production by culture medium optimization. Biochemical Engineering Journal 172 (2021) 108058, https://doi.org/10.1016/j.bej.2021.108058

415 Chebbi et al., 2021. Potentials of Winery and Olive Oil Residues for the Production of Rhamnolipids and Other Biosurfactants: A Step Towards Achieving a Circular Economy Model. Waste and Biomass Valorization (2021) 12:4733–4743, https://doi.org/10.1007/s12649-020-01315-8

416 Bach, Hermann, 2023. Sustainable cleaning – From lowering footprint of today's surfactants to sustainability by design. In: Proceedings of the 12th Wold Surfactant. Congress. CESIO. Rome, 4-7th June 2023.

417 Sansarode and 2018. Biosurfactant: Classification, properties and recent application in cosmetic. Journal of Emerging Technologies and Innovative Research (JETIR) JETIR1810927. Accessed online here: https://www.jetir.org/papers/JETIR1810927.pdf

418 Baccile et al., 2017. Development of a Cradle-to-Grave Approach for Acetylated Acidic Sophorolipid Biosurfactants. ACS Sustainable Chem. Eng. 2017, 5, 1186−1198, DOI: 10.1021/acssuschemeng.6b02570

Of the many types of biosurfactant compounds that can be produced, the chemical properties will vary based on molecular size, functional groups and chain lengths. The most promising biosurfactants that meet requirements for surfactant ingredients in detergents belong to the glycolipid and lipopeptide groups, especially those with a hydrophilic-lipophilic balance (HLB) of 13-16[419]. Biosurfactants can be used as complete or partial substitutes for chemical surfactants and generally exhibit similar or even superior characteristics, especially at lower temperatures (Banat et al., 2021)[420]. Several patents have been filed for biosurfactants in detergent and cleaning formulations (Jones and Stevenson, 2016[421]; De Rose et al., 2017[422]).

One of the most widely acclaimed benefits of 2nd generation biosurfactants is that they are more biodegradable and less ecotoxic than petrochemical and oleochemical alternatives. However, in a review of the environmental impacts of biosurfactants, Briem et al., (2022)[423] state that while microbially produced biosurfactants generally have lower toxicity than chemically derived alternatives, they are not necessarily non-toxic and, due to the complexity and diversity of such substances, general statements should be avoided until much more comprehensive data has been established. To illustrate this point, a comparison of selected lethality (LC50) and immobilisation (EC50) data presented by Briem et al. (2022) is shown below.

Table 27 – Comparison of LD50 and EC50 toxicity data for chemically derived surfactants (Syn-S) and microbially derived biosurfactants (Bio-S).

	Bioindicator	LC50	EC50	Reference (as cited in Briem et al.)
Bio-S: Mono-rhamnolipid	D. rerio [LC] D. magna [EC]	60 mg/L (48 h)	30 mg/L (48 h) 50 mg/L (24 h)	[26-LC] [26-EC]
Syn-S: Sodium dodecyl sulfate	D. rerio [LC] D. magna [EC]	4 mg/L (96 h)	18 mg/L (48 h) 24-29 mg/L (24h)	[64-LC] [65,66-EC]
Syn-S: LAS (C9-14)	D. magna		0.7-53 mg/L (48 h)	[67]
Syn-S: LAS (C10-18)	D. magna	0.1-30 mg/L (48 h)		[68]
Syn-S: LAE (C14AE1-AE9)	D. magna	0.8-10 mg/L (48 h)		[68]
Syn-S: Alkyl polyglycoside (C8)	D. magna		557 mg/L (48 h)	[69]
Syn-S: Alkyl polyglycoside (C12-14)	D. magna		12 mg/L (48 h)	[69]
Syn-S: Triton X-100	D. magna		18-26 mg/L (48 h)	[70]

The LC50 and EC50 concentrations indicate the concentration needed to kill or immobilise 50% of the test population. Therefore, lower concentrations indicate a higher toxicity and, for a given concentration, shorter

419 Banat et al., 2020. Biosurfactants: The green generation of speciality chemicals and potential production using Solid-State fermentation (SSF) technology. Bioresource Technology, 320(Part A), 1-13. [12422]. https://doi.org/10.1016/j.biortech.2020.124222

420 Banat et al., 2021. Biosurfactants: The green generation of speciality chemicals and potential production using Solid-State fermentation (SSF) technology. Bioresource Technology, 320(Part A), 1-13. [12422]. https://doi.org/10.1016/j.biortech.2020.124222

421 Jones, C.A., Stevenson, P.S., 2016. Perfumed fluid cleaning fluids comprising glycolipid biosurfactant and ethoxylated polyethylene imine. WO 2016139133.

422 De Rose, S.A., Lang, D.A., Littlechild-Bond, J.A., Novak, H.R., Singh, S., 2017a. Laundry detergent composition and laundering process. WO 2017036901.

423 Briem et al., 2022. Environmental Impacts of Biosurfactants from a Life Cycle Perspective: A Systematic Literature Review. Adv Biochem Eng Biotechnol (2022) 181: 235–270 https://doi.org/10.1007/10_2021_194

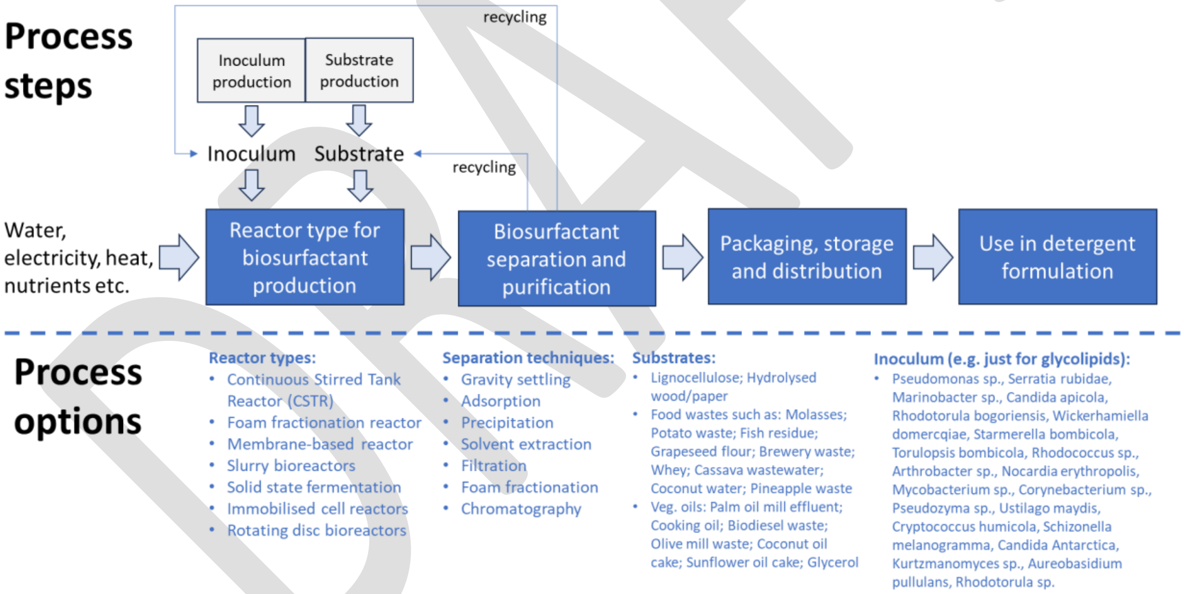
times indicate a higher toxicity. The values in the table above indicate that microbially produced biosurfactants (Bio-S) have generally lower LC50 values than synthetic surfactants (Syn-S), but that the difference with EC50 values is not so clear cut. It must also be borne in mind that the data presented is very limited and also from different studies, The best comparison would be to see comparative assessments of a number of Bio-S and Syn-S within the same study.

Most of the research conducted for the production of 2^{nd} generation biosurfactants has been reported at laboratory scale. Consequently, the economics and energy demand of the production process at larger scales are difficult to know accurately. Some important considerations, both from an economical and an environmental impact perspective, are[424]:

- The use of low value waste materials as carbon and nitrogen substrates.
- Genetic modification of micro-organisms to create higher yielding strains.
- The choice of incubation/growth technique, for example submerged fermentation versus solid state fermentation.
- Continuous, semi-continuous or batch operation for production processes.
- Potential to generate, identify and recover co-products from micro-organisms while they are producing biosurfactants (especially interesting in the case of enzyme co-products[425]).

There are many variables in the biosurfactant production process, as shown in the figure below.

Figure 41. Main process steps and variables for (2^{nd} generation) biosurfactant production. Based on Pott and Vonn Johannides, 2021[426]



Some important potential advantages of biosurfactants over chemical surfactants is their greater biodegradability and lower ecotoxicity. However, these points have been discussed in more detail for surfactants in general in the non-LCA impacts already in section 5.2.

424 Monteiro Vieira et al., 2021. An overview of current research and developments in biosurfactants. Journal of Industrial and Engineering Chemistry 100 (2021) 1–18, https://doi.org/10.1016/j.jiec.2021.05.017

425 Hmidet, N., Jemil, N., Nasri, M., 2019. Simultaneous production of alkaline amylase and biosurfactant by Bacillus methylotrophicus DCS1: application as detergent additive. Biodegradation 30, 247–258. https://doi.org/10.1007/s10532-018-9847-8

426 Pott and Von Johannides, 2021. Process Development in Biosurfactant Production. Adv Biochem Eng Biotechnol. https://doi.org/10.1007/10_2021_195

5.3.2. Probiotics

It is possible to go a step further with bio-surfactants. Instead of having to cultivate micro-organisms → harvest biosurfactants from them → isolate those chemicals for others simultaneous produced and then put them into detergent formulations, probiotics aim to deliver viable fermented bacteria to the point of cleaning. Once there, the bacteria will actively metabolise food sources, dirt and other bacteria on the dirty surface, generating enzymes and biosurfactants in-situ that have a cleaning effect.

Due to the nature of these products, they cannot use aggressive chemicals like bleach, ammonia or sodium hydroxide in appreciable concentrations. Hence the toxicity profile of probiotic cleaners will be inherently low out of necessity.

Another potential advantage is that the cleaner action is gradual and can continue for hours after the initial application. The aim is in fact to leave the bacteria there, in-situ, so aggressive scrubbing is not necessary. Examples of probiotic detergents already exist for floor cleaners, soaps and even drain cleaners. The use of probiotics is not particularly amenable to LD or DD products due to the aggressive environments and the relative lack of time in cycles for the bacteria to act. Despite these limitations, there are research projects investigating the potential for probiotic laundry detergents. With such products, the continued viability of probiotic spores in wastewater and in washed clothes could lead to significant environmental benefits or other unforeseen issues.

5.4. Life cycle assessment (LCA)

The production of components (raw materials, ingredients or intermediate products) is the life-cycle stage that contributes most to the overall impact of EU household goods, with detergents being one of the top product groups contributing to the consumption footprint (Castellani, Sanyé-Mengual, and Sala, 2021). This is related to the environmental profile of producing these goods together with their consumption intensity (Castellani, Sanyé-Mengual, and Sala, 2021), suggesting that actions focused on reducing the environmental footprint intrinsic to detergents coupled with better usage will decrease detrimental environmental impacts. Indeed, a quantification of the global cropland footprint of the European Union’s non-food bio-economy indicated that EU is a major cropland-based non-food products consuming region, with the majority of the land required being extra-EU and with oilseeds having in 2010 a 39% share of total EU’s non-food cropland demand (Bruckner et al., 2019). This reinforces the importance of careful selection of components and associated production processes as well as the relevance of proper consumers usage.

Since criteria should focus especially on areas of potentially high environmental impact, it is necessary to review the LCA literature to determine what kind of information is already in the public domain.

Reviewing the LCA literature will also help to identify gaps in the research and to help prioritise areas where more time and effort should be focused when carrying out LCA screening studies in the context of the EU Ecolabel criteria revision project. This will inform the data collection exercise required as part of the revision process.

5.4.1. LCA literature review

5.4.1.1. Methodology

In order to assess the main environmental impacts that occur across the life cycle of detergent products, the first step is to review the current LCA literature that is available in the public domain. There are many different types of LCA literature available, and priority will be given to the following types of information: PEFCRs > previous background research for EU Ecolabel > academic journal articles > industry reports and EPDs.

Relevant LCA studies were reviewed following an established screening and scoring procedure that is based on the guidance provided in the ILCD Handbook. Studies are screened based on three pass or fail criteria that relate to: (i) the scope; (ii) the impact assessment categories, and (iii) the outcomes of the study.

If a piece of literature does not pass the screening criteria, only sections 1 to 8 of the table below are filled out for that given document. If the articles or reports pass these screening criteria, they are then scored in more detail according to the full table below (i.e. sections 1 to 13).

Table 28 – Screening and scoring approach for LCA literature.

Minimum cut-off criteria		Scope: *[explain if functional unit been properly defined and if it is relevant for the research needs? Is the scope coherent with goal analysis, and in line with ISO 14040?]*	PASS/FAIL
		Impact assessment: *[is the study sufficiently broad, e.g. in terms of impact categories used?]*	PASS/FAIL
		Outcomes: *[are the outcomes relevant and applicable for the research needs?]*	PASS/FAIL
If "PASS" is obtained for the 3 aspects above, then proceed to scoring criteria below			
TOTAL SCORE (from criteria below)		SSCOPE= x/5 SDATA= x/5 SIMPACTS= x/5 SOUTCOMES = x/5 SROBUSTNESS= x/5 SREVIEW= x/5	STOTAL = y/30
1	*Item*	*Observation*	*Scoring*
1	title	*[Insert title of study or document]*	n/a
2	authors	*[Write the names of the author(s)]*	n/a
3	reference and year	*[Insert year and any journal or proceedings etc.]*	n/a
4	type of study	*[e.g. journal paper, report, EPD, presentation etc.]*	SSCOPE = X
5	scope	*[Briefly describe the scope of the study in your own words]*	
6	functional unit	*[Describe it/them here]*	
7	system boundaries	*[Describe them here as concisely and as clearly as possible]*	
8	assumptions (e.g. allocation)	*[describe any assumptions used in the study to fill data gaps or information gaps about the process]*	
9	data sources and quality	*[any general comments on data sources here, primary data is better, newer data is better than older, and local data is better than global]*	
	Life cycle stage 1	*[any specific comments about data sources in this particular stage]*	*X*
	Life cycle stage 2	*[same as for life cycle stage 1]*	*Y*
	Life cycle stage 3	*[same as for life cycle stage 1]*	*Z*
	Life cycle stage 4	*[same as for life cycle stage 1]*	*X*
	Life cycle stage 5	*[same as for life cycle stage 1]*	*Y*
	Life cycle stage 6	*[same as for life cycle stage 1]*	*Z*
	TOTAL		SDATA = *average of X,Y,Z,X,Y,Z*
10	Impact assessment categories/methods *	*[Describe any allocation used, as well as the impact categories that are reported and any particular details of the method used → closer to PEF or PCRs, the higher the score]*	SIMPACTS = X
11	Conclusions	*[e.g. does the study clearly identify the most important life cycle phases? Are main sources of impacts identified? Is improvement potential or sensitivity analysis included?]*	SOUTCOMES = Y
12	Strengths and weakness of the whole study, general comments	*[Based on reviewer opinion. Is method sufficiently transparent to allow someone to repeat it if they had the same data? May include individual judgments and general observations, such as ow quality of journal where article was published".*	SROBUSTNESS = Z
13	Subject to independent review?	*[very relevant in cases of EN ISO 14021 style "self-declarations" and in reports published for public agencies or private companies.]*	SREVIEW = X

5.4.1.2. *Overview of screening results*

In total, 45 pieces of literature were identified that were considered appropriate for review. The table below presents an overview of the reviewed literature, ordered by the type of detergent product it refers to and in order of the overall score received. More details of the reviews were compiled in a separate file for the sake of brevity.

Table 29. Summary of LCA literature review results (entries in red text indicate that they failed the screening stage).

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
Focus on detergent ingredients only				
Schowanek, 2017	Focused on LCI data for surfactants (n=15) and their precursors (n=17).	1000kg of surfactant active ingredient.	Not really using a classical LCA method and could have been screened out for this, but very relevant information included. Reported on primary energy demand and GWP.	22.5
Thannimalay, 2014	Cradle-to-gate assessment of two types of surfactant (petrochemical-based LAS and palm oil-based MES)	1kg of surfactant	Ecoindicator99 method was used and impact categories reported were GWP, EP, AP, POCP and primary energy use.	20
Forman, 2014	Cradle-to-gate analysis of linear alkyl benzene (LAB) production. A precursor of the popular surfactant (LAS).	1 tonne of LAB	Method used was TRACI 2.0 and impact categories reported were GWP, AP, EP, POFP and HT.	20
Baccile, 2017	Cradle-to-gate of biosurfactant production and a limited cradle-to-grave analysis for use in hand washing.	1kg dry biosurfactant (cradle-to-gate) 1 hand wash (cradle-to-grave)	ILCD midpoint (GWP, ODP, HT, PM, IR, POFP, AP, EP, ET, LU and RD) and ReCiPe endpoint methods (human health, ecosystems and resources).	18.5
Kopashelis, 2018	Gate-to-gate analysis of biosurfactant production (and bioemulsifiers). Scope is limited but very few studies in this area.	1kg of biosurfactants or 1kg of bioemulsifer.	Used the EPD v1.03 method and reported on the following impact categories: GWP, ODP, POF, AP, EP and non-renewable fossil energy.	18
Guilbot, 2013	Looks at a cradle-to-gate analysis for surfactant production and also at a cradle-to-grave view when used in a cosmetics product.	1kg of packaging APG surfactant 1 year of use of cosmetic product for one person.	Seven impact categories were selected for their relevance (ODP, GWP, mineral resources, petrochemical resources, eco-toxicity, AP/EP, and water consumption.	16.5
Aru, 2008	Cradle-to-gate for production of biosurfactant from waste oil substrate	1000kg of biosurfactant	Method not specified. Only GWP and AP impacts mentioned.	7.5
Leijten, 2023	Looks at the production of crude palm oil, from a cradle-to-gate perspective.	1 tonne of crude palm oil (CPO)	Not relevant since impact assessment and outcomes were not considered useful (only reported on GWP).	FAIL on impact categories and outcomes
Briem, 2022	Review of LCA articles on the production and use of biosurfactants	Various, but inevitable in terms of mass of surfactant.	Various. Methods included: Impact 2000+, Eco-indicator 1999, IPCC 2007, ReCiPe, ILCD and EPD 2008.	FAIL (outcomes not specific enough)

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
Lam, 2019	Cradle to gate for the production of crude palm oil, a precursor of feedstocks used to make certain detergent ingredients.	1 tonne of crude palm oil (CPO)	Not relevant since outcomes were not considered useful (only reported on GWP).	FAIL on outcomes.
Lokesh, 2019	Cradle-to-gate analysis of biosurfactant production from wheat straw residue or palm kernel oil	1kg of APG from wheat straw 1kg of APG biosurfactant from palm kernel and wheat grain	Not actually reported, since results were generated for life cycle costing only.	FAIL on impact categories and outcomes
Focus on laundry detergents (LD)				
Saouter, 2002b	Looks at the evolution of powder laundry detergents from an LCA perspective using typical products from 1988, 1992 and 1998.	Step 1 analysis: 1kg of product Step 2: 1000 wash cycles	Used the CML92 method and reported on AP, EP, Aquatic Toxicity, GWP, Human Toxicity, ODP and POFP impact categories.	27
PEFCR, 2019	Cradle-to-grave assessment of a representative heavy duty liquid LD.	Washing of 4.5kg of dry fabric	In line with the relevant impact categories for the EF methodology back in 2019.	26.5
Arendorf, 2014a	Cradle-to-grave analysis of a representative laundry detergent.	85g of powder laundry detergent (one normal dose)	The ReCiPe method was used to report on a wide variety of midpoint and endpoint impact categories.	25.5
Giagnorio, 2017	Cradle-to-grave assessment of an industrial laundry process with and without the membrane recovery of wastewater and detergents.	Two types of functional unit used: 1 kg of industrial laundry detergent product 1 year of industrial textile washing (2171 tonnes).	Three different methods were used: 1. ReCiPe; 2. Cumulative Energy Demand (CED); 3. IPCC 2007. Some 18 midpoint indicators and 3 endpoint indicators were used across these methods.	25.5
Golsteijn, 2015	A cradle-to-grave assessment of several different detergent product group categories (e.g. LD, DD, HDD and HSC).	For HDD: washing of 4 place settings. For LD: 1 wash cycle. For HSC spray: 1m2. For HSC toilet: one bowl cleaning.	Used the full suite of midpoint and endpoint indicators from the ReCiPe method.	25
Tomsic, 2023	Looks at the technical and LCA performance of a laundry detergent at different doses and wash cycle temperatures.	Not defined.	The ReCiPe method was used. A very broad range of midpoint and endpoint impact categories were reported on.	25
Kim, 2020	Scope is limited to impacts associated with packaging in 3 very different types of LD product.	10,000 doses of laundry detergent.	The TRACI 2.1 method was used. The main impact categories were: ODP, GWP, Smog, AP, EP, HT (carcinogenics and non-carcinogenics), respiratory effects, ecotoxicity and fossil fuel depletion.	24.5
Saouter, 2002	Cradle-to-grave analysis of laundry	1000 wash cycles	Used the CML92 method and reported on AP, EP,	23

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
	detergents in Belgium.		Aquatic Toxicity, GWP, Human Toxicity, ODP and POFP impact categories.	
Koemer, 2010	Very broad scope for the cradle-to-grave impacts of household laundry. Even includes impacts associated with washing machine manufacture and disposal.	1kg of clean and dry clothes.	Analysis was conducted on SimaPro with ecoinvent generic data. The main impact categories reported include: water use, energy use, GWP, EP, non-renewable resource depletion and land use.	21.5
Koning, 2010	Cradle-to-grave assessment of two laundry detergents (liquid and powder) with a look a several variables.	Not clearly defined, but many results reported on a per wash basis.	Not clearly explained, was based on some industry-used excel tool. Only carbon emissions reported.	21
Castellani, 2019	Cradle-to-grave review of common household products, including laundry detergents and dishwasher detergents.	One year of per capita consumption.	ILCD midpoint impact categories together with normalisation and weighting according to PEF methodology.	19.5
Nessi, 2014	Scope is limited to impacts associated with packaging. Looks at different packaging reuse/refill scenarios for LD, fabric softener and HDD products.	1000 litres of detergent	Not so clear what the methods was, but the impact categories reported included: GWP, ODP, POFP, AP, EP, Ecotoxicity, Human Toxicity, PM and various resource depletion categories.	19
Villota-Paz, 2023	Cradle-to-site approach looking at impacts of a “traditional” (palm-oil plus NaOH) versus a “Bio-Liquid Detergent” that can be used for multiple purposes.	1 litre of BLD (equivalent to around 20 washes)	Used the ReCiPe method and reported on the following impact categories: GWP, EP (freshwater and marine), LU, Fossil resource depletion and water use. Plus the 3 ReCiPe endpoint indicators.	19
Henkel, 2008	Cradle-to-grave assessment of a novel powder laundry detergent. Looked at the effect of changing wash temperature and loading per cycle.	1 wash cycle.	Method was not clearly defined. The main impact category was only GWP.	14
Eberle, 2007	Cradle-to-grave review of industrial laundry services, looking at LCA impacts of 3 different processes.	1kg of washed hygiene laundry (cotton)	Umberto 4.0 software used for the LCA. Impact categories were in line with CML92 or CML2001.	13.5
E COSI, 2022	Cradle-to-grave assessment of 33 different products, including mostly hard surface cleaners, but also some laundry detergents, dishwashing detergents and hand dishwashing detergents.	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system. Impact categories included GWP (Fossil, Biogenic and Land Use), AP, EP, POCP, ADPe, ADPff and WSF.	11.5
Palfy, 2021	Scope is packaging focused, but very little mention made of detergents at all.	Packaging for 10,000 litres of detergent product.	Not relevant since screened out partially based on scope, and definitely on the limited value of outcomes.	FAIL (on scope and outcomes)
Subramanian, 2016	Aim was to identify LCO data gaps for laundry detergent products.	Not defined.	Effectively limited to energy demand of ingredient manufacture. No actual LCA conducted.	FAIL on scope, impact categories

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
				and outcomes.
Godskesen, 2012	Looks at a municipality level impact of softening the public drinking water supply. Part of the study looks at the impact on detergent consumption in laundry.	1 year of household per capita water consumption in Copenhagen (41m3).	Not relevant since the study was excluded for multiple reasons.	FAIL (on scope, impact categories and outcomes)
Paloviita, 2008	Focuses on consumer behaviour with regards to dosing during the use phase.	Not relevant since study had no real LCA methodology, but screened anyway since it is an important variable for LCA exercises.		FAIL (on impact assessment)
Focus on dishwasher detergents (DD)				
Van Hoof, 2017	Takes a full cradle-to-grave and then a more focused cradle-to-gate approach to assessing impacts of two types of DD product (one with phosphate and one without).	1 wash cycle (for cradle-to-grave) 1 dose (for cradle-to-gate)	The ReCiPe method was used and reported on the following impact categories: Fossil Fuel Depletion; Climate Change; Particulate Matter; Natural Land Transformation; Freshwater Eutrophication; Solid Waste and USETox.	28
Arendorf, 2014b	Cradle-to-grave analysis of a representative dishwasher detergent product.	20g of dishwasher detergent (one tablet dose)	The ReCiPe method was used to report on a wide variety of midpoint and endpoint impact categories.	25.5
Castellani, 2019	Cradle-to-grave review of common household products, including laundry detergents and dishwasher detergents.	One year of per capita consumption.	ILCD midpoint impact categories together with normalisation and weighting according to PEF methodology.	19.5
Igos, 2014	Very limited scope, mainly focused on disposal stage of wastewater from DD products.	1 dishwasher cycle.	Only looked at the USETox reporting, which required a look in toxicity and biodegradability data available via REACH.	16
E COSI, 2022	Cradle-to-grave assessment of 33 different products, including mostly hard surface cleaners, but also some laundry detergents, dishwashing detergents and hand dishwashing detergents.	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system. Impact categories included GWP (Fossil, Biogenic and Land Use), AP, EP, POCP, ADPe, ADPff and WSF.	11.5
Focus on hand dishwashing detergents (HDD)				
Arendorf, 2014c	Cradle-to-grave analysis of a representative HDD product, under two use scenarios (full sink and direct application).	Manual washing of 4 place settings (2ml per place setting for full sink approach, or 3ml under direct application approach).	The ReCiPe method was used to report on a wide variety of midpoint and endpoint impact categories.	26
Moura, 2023	Cradle-to-grave analysis of 3 different hand dishwashing detergents.	200 washes of 4 place settings.	Used OpenLCA software and the ReCiPe, CML and AWARE assessment methods. Impact categories	26

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
			reported included: AP, EP, Resource scarcity (fossil and mineral), and water use.	
Golsteijn, 2015	A cradle-to-grave assessment of several different detergent product group categories (e.g. LD, HDD and HSC).	For HDD: washing of 4 place settings. For LD: 1 wash cycle. For HSC spray: 1m2. For HSC toilet: one bowl cleaning.	Used the full suite of midpoint and endpoint indicators from the ReCiPe method.	25
Van Lieshout, 2015	A cradle-to-grave analysis of several products (an all-purpose cleaner, two dishwashing detergents and a hand soap.	1kg of product	Used the ReCiPe and IPCC methods, while reporting on GWP, ODP, AP, EP (freshwater and marine), Human Toxicity, POFP, PM, Ecotoxicity (terrestrial, freshwater, marine), IR, various Land Use and Resource Depletion categories.	22
Nessi, 2014	Scope is limited to impacts associated with packaging. Looks at different packaging reuse/refill scenarios for LD, fabric softener and HDD products.	1000 litres of detergent	Not so clear what the methods was, but the impact categories reported included: GWP, ODP, POFP, AP, EP, Ecotoxicity, Human Toxicity, PM and various resource depletion categories.	19
Villota-Paz, 2023	Cradle-to-site approach looking at impacts of a "traditional" (palm-oil plus NaOH) versus a "Bio-Liquid Detergent" that can be used for multiple purposes.	1 litre of BLD (equivalent to around 20 washes)	Used the ReCiPe method and reported on the following impact categories: GWP, EP (freshwater and marine), LU, Fossil resource depletion and water use. Plus the 3 ReCiPe endpoint indicators.	19
E COSI, 2022	Cradle-to-grave assessment of 33 different products, including mostly hard surface cleaners, but also some laundry detergents, dishwashing detergents and hand dishwashing detergents.	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system. Impact categories included GWP (Fossil, Biogenic and Land Use), AP, EP, POCP, ADPe, ADPff and WSF.	11.5
Lucchetti, 2019	Only on upstream parts of cradle-to-gate analysis of soap production from waste vegetable oil or coconut oil. Ultimately article was about soap, not detergents, but authors used both terms interchangeably.	1 tonne of soap made from recovered vegetable oil.	Ecoindicator99 method used, reporting on 11 normalised impact categories.	FAIL on scope (soap is a cosmetics product)
Van Hoof, 2013	Looked at the use of an HDD in Spain and in Germany, and how impacts also change if water heated with a gas boiler or an electric one.	Hand washing of 10 plates (using one of two approaches, the "full sink" or "direct application".	Exclusively focused on impacts related to water use (e.g. green/blue/gray water consumption).	FAIL on impact categories
Focus on hard surface cleaners (HSC)				
Lopez de la	Cradle-to-grave analysis of an enzyme-	1kg of detergent (plus any	Method was not clear, but used OpenLCA and ecoinvent	26

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
Fuente, 2022	based hard surface cleaner	packaging)	database. Impact categories reported were: GWP, AP, EP, POCP, ADP (elements and fossil) and water scarcity.	
Golsteijn, 2015	A cradle-to-grave assessment of several different detergent product group categories (e.g. LD, DD, HDD and HSC).	For HDD: washing of 4 place settings. For LD: 1 wash cycle. For HSC spray: 1m2. For HSC toilet: one bowl cleaning.	Used the full suite of midpoint and endpoint indicators from the ReCiPe method.	25
Arendorf, 2014d	Cradle-to-grave analysis of a representative all-purpose cleaner.	Cleaning of a 0.24m2 area.	The ReCiPe method was used to report on a wide variety of midpoint and endpoint impact categories.	24
Yang, 2023	Cradle-to-gate analysis of a hard surface cleaning product (enzyme-based).	1kg of concentrated product	An eFootprint LCA software was used together with LCI databases including Chinese entries. Impact categories reported were GWP, AP, EP, RI, ODP, POFP, PED, ADP and WU.	24
Kapur, 2012	An incomplete cradle-to-grave assessment of some ecolabelled (Greenseal) and non-ecolabelled hard surface cleaners.	Annual cleaning of 100,000 sqft of office floor space (assuming 50% carpet).	Used the ReCiPe method with these impact categories: GWP, ODP, human toxicity (HT), POFP, PM, IR, AP, EP (freshwater and marine), Ecotoxicity (terrestrial, freshwater and marine) plus several land-related and resource-related indicators.	23.5
Dewaele, 2004	Cradle-to-grave assessment of three different products for hard surface cleaning (wet wipes, a trigger spray and a dilutable liquid product). Only the latter two are relevant.	One year of kitchen surface cleaning for one household (excluding floors).	Used a proprietary software developed by PWC (TEAM and DEAM). Most impact categories reported were based on CML92 (e.g. AP, EP, GWP, HT, ODP and POCP).	21.5
Vieshout, 2015	A cradle-to-grave analysis of several products (an all-purpose cleaner, two dishwashing detergents and a hand soap.	1kg of product	Used the ReCiPe and IPCC methods, while reporting on GWP, ODP, AP, EP (freshwater and marine), Human Toxicity, POFP, PM, Ecotoxicity (terrestrial, freshwater, marine), IR, various Land Use and Resource Depletion categories.	22
Villota-Paz, 2023	Cradle-to-site approach looking at impacts of a “traditional” (palm-oil plus NaOH) versus a “Bio-Liquid Detergent” that can be used for multiple purposes.	1 litre of BLD (equivalent to around 20 washes)	Used the ReCiPe method and reported on the following impact categories: GWP, EP (freshwater and marine), LU, Fossil resource depletion and water use. Plus the 3 ReCiPe endpoint indicators.	19
E COSI, 2022	Cradle-to-grave assessment of 33 different products, including mostly hard surface cleaners, but also some laundry detergents, dishwashing detergents and hand dishwashing detergents.	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system. Impact categories included GWP (Fossil, Biogenic and Land Use), AP, EP, POCP, ADPe, ADPff and WSF.	11.5

Primary author and year	Scope	Functional unit(s)	Method and impact categories	Overall score
Eide, 2003	Cradle-to-grave assessment of 4 different cleaning protocols for dairy infrastructure.	One year of cleaning for an average-sized Norwegian dairy	Not well defined, but focused mainly on energy consumption (similar pattern to GWP, POF and EP) and on EP (dominated by effluents).	FAIL on scope and outcomes

The table above shows that the scope of the articles found were reasonably well spread out in terms of relevance to detergent products (11 looking at detergent ingredients, 19 looking at laundry detergents, 7 looking at dishwasher detergents, 9 looking at hand dishwashing detergents and 12 looking at hard surface cleaners). However, it should be noted that almost all the articles focused on household products and that care should be taken when dealing with industrial or institutional products, which tend to be much more concentrated and may have different combinations of chemicals because they tend to be used in larger quantities and/or for more intensive cleaning activities. Industrial hard surface cleaners may be optimised for use with automated equipment and industrial dishwasher or laundry detergents may have certain chemistries tailored for certain features that are unique to professional appliances. The only references that focused on industrial applications were:

- Giagnorio et al., 2017 and Eberle, 2007 (industrial laundry), and
- Kapur et al., 2012 (industrial hard surface cleaners?),
- Lopez de la Fuente et al., 2022 (industrial hard surface cleaner), and
- Yang et al., 2023 (industrial hard surface cleaners).

Due to limited information about formulations and use stage energy consumption, particular effort will be made for data gathering for industrial and institutional detergent products.

There was a general lack of comparability between studies by different authors, even when they look at the same products, due to the use of different functional units, of different system boundaries and reporting according to different impact categories (e.g. normalised or not) and midpoint or endpoint. For clarity, midpoint categories refer to the quantification of direct impacts on the environment in specific manners (e.g. climate change, acidification, eutrophication etc.), whereas endpoint categories report on the aggregated effects of different midpoint impacts on a broader type of impact (e.g. human health, biodiversity and resource scarcity). A clear illustration of how midpoint and endpoint impact categories can relate is provided for the ReCiPe method on this webpage. Endpoint indicators allow for a simpler presentation of results for decision-making, but suffer from larger potential uncertainties due to the aggregation of results.

5.4.1.3. Overview of published studies

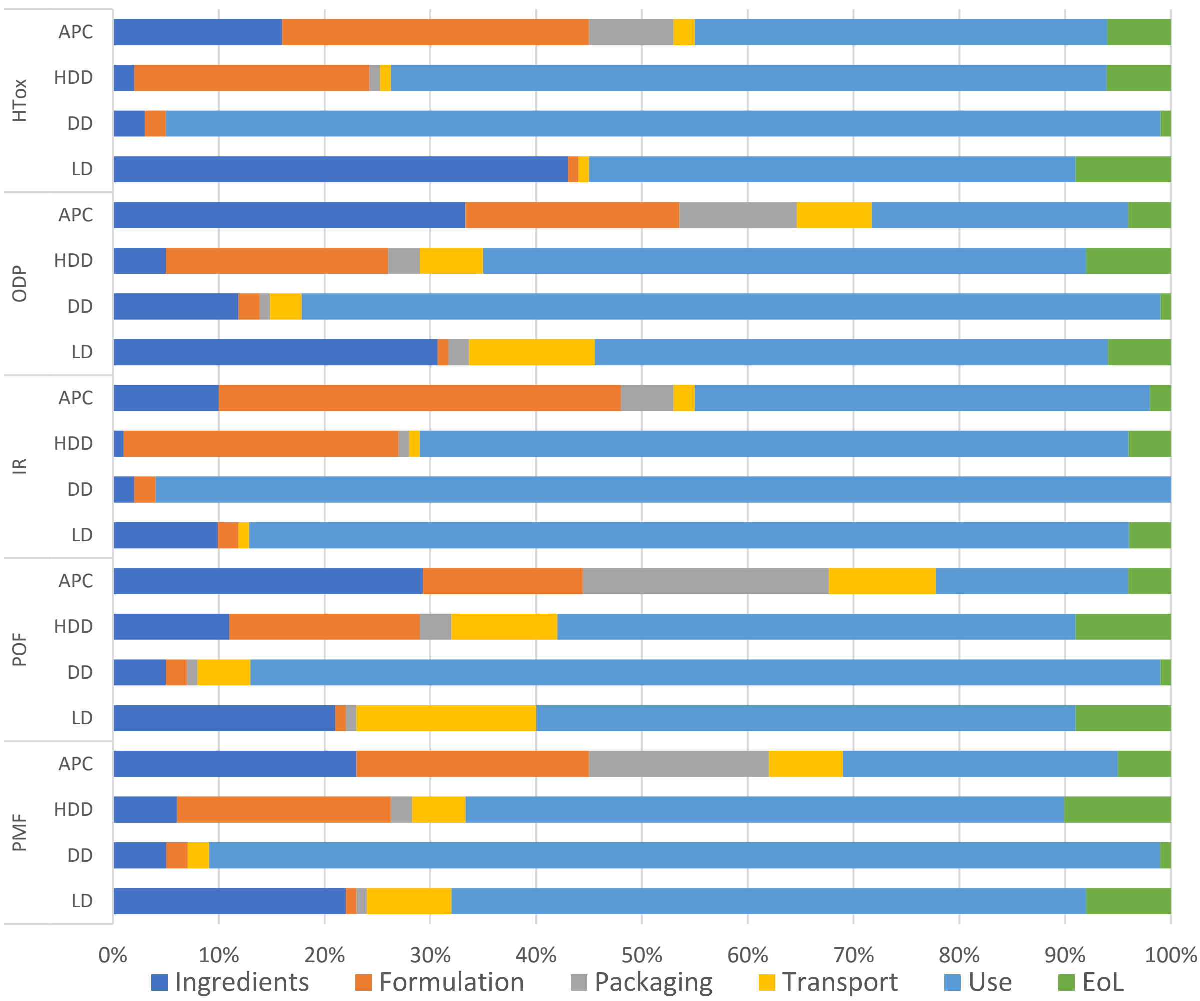
It is difficult to put together findings from different LCA studies by different authors in order to reach any general conclusions. This is because changing the functional unit will affect absolute results and changing any assumptions, allocations, LCA methodology, LCI datasets and system boundaries will affect both absolute and relative results.

However, the four preliminary reports published by Arendorf et al. in 2014 for laundry detergents, dishwasher detergents, hand dishwashing detergents and all-purpose cleaners have been carried out in a sufficiently consistent manner to allow a side-by-side comparison of the impacts with different detergent product types. These authors consistently reported on 17 midpoint indicators using the ReCiPe methodology. These comparable results are split into three main types of impact category (human health-, ecosystem- and resource-related).

5.4.1.3.1. Breakdown of human health-related LCA impacts by life cycle stage

The figure below shows a side-by-side comparison of % shares of the impact categories that are most closely related to human health (i.e. Particulate Matter Formation, PMF; Photochemical Oxidant Formation POF; Ionising Radiation, IR; Ozone Depletion Potential, ODP and Human Toxicity, HTox).

Figure 42. Human health-related LCA hot spots for LD, DD, HDD and APC detergent product types. Sources: Arendorf et al., 2014a, 2014b, 2014c and 2014d).



From the multiple data presented in the figure above, some clear patterns can be seen. For example:

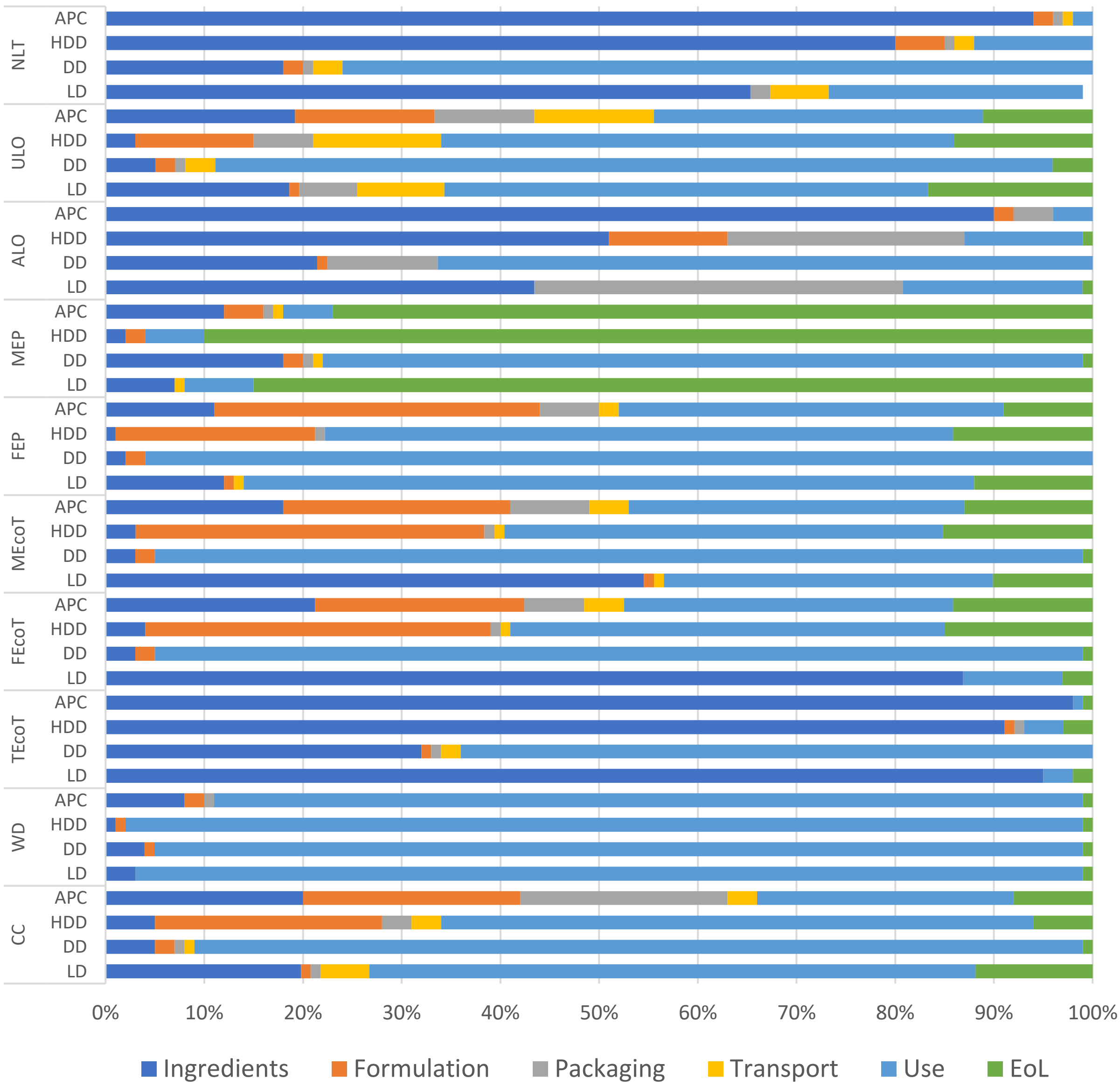
- End-of-Life stage impacts on human health are relatively minor (generally less than 10%) and are especially minor in the case of dishwasher detergents.

- Use stage impacts are always highly significant (generally more than 40%) and are especially high for DD products.
- Impacts with ingredients were very low for HDD products and quite low for DD products in relative terms when compared to LD and APC products.
- Impacts with the formulation stage should major differences in relative terms between detergent products, being much more significant for HDD and APC products, and generally negligible for LD and DD products.

5.4.1.3.2. Breakdown of ecosystem-related LCA impacts by life cycle stage

The figure below shows a side-by-side comparison of % shares of the impact categories that are most closely related to ecosystem impacts (i.e. Climate Change, CC; Water Depletion, WD; Terrestrial Ecotoxicity TEcoT; Freshwater Ecotoxicity, FEcoT; Marine Ecotoxicity, MEcoT; Freshwater Eutrophication Potential, FEP; Marine Eutrophication Potential, MEP; Agricultural Land Use, ALO; Urban Land Use, ULO; Natural Land Transformation and NLT).

Figure 43. Ecosystem-related LCA hot spots for LD, DD, HDD and APC detergent product types. Sources: Arendorf et al., 2014a, 2014b, 2014c and 2014d).



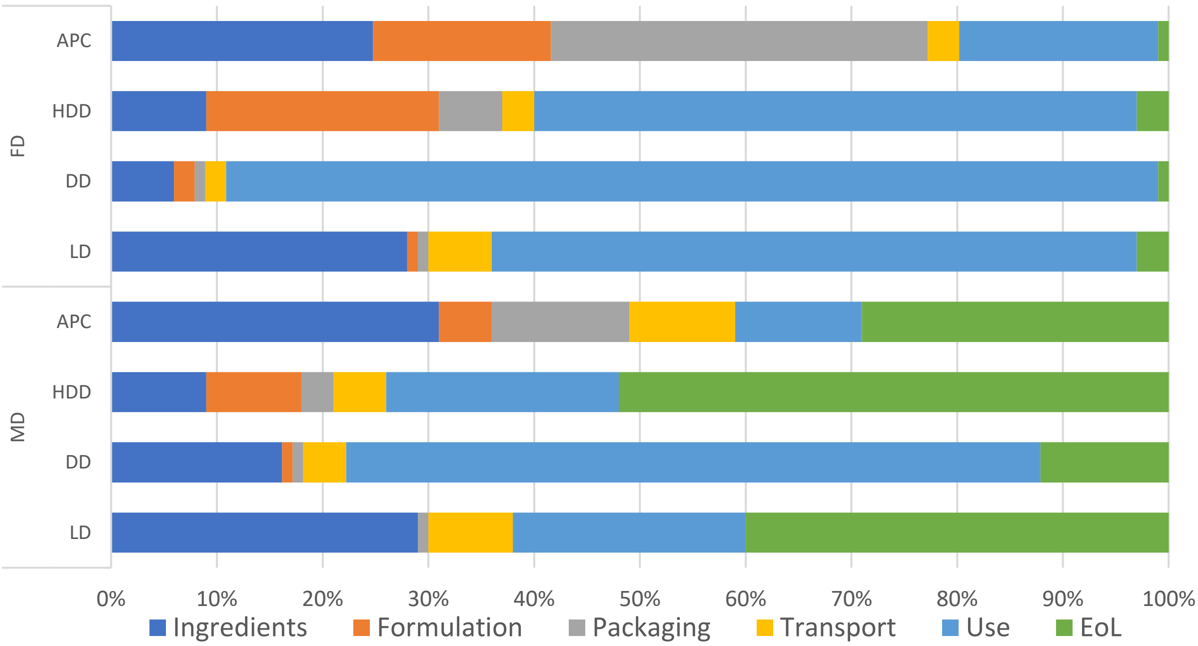
From the multiple data presented in the figure above, some general patterns and some very specific points can be seen. For example:

- End-of-Life stage impacts varied significantly both in terms of detergent product and of individual impact category. For LD, HDD and APC products, the EoL stage dominates the marine eutrophication impacts but was much less relevant for freshwater eutrophication. For DD products, all types of ecosystem-related impact category were insignificant.
- Ingredient stage impacts were most significant for terrestrial ecotoxicity, natural land transformation, agricultural land use and, for LD only, freshwater and marine ecotoxicity.
- Formulation stage impacts were much more significant for APC and HDD products than for LD and DD products.
- Transport stage impacts were insignificant, except for urban land occupation (with up to 15% for HDD and APC products).
- Trends with packaging impacts were not clear, but were significant for APC products for climate change (ca. 20%) and for agricultural land occupation for HDD (ca. 25%) and LD (ca. 38%).

5.4.1.3.3. Breakdown of resource-related LCA impacts by life cycle stage

The figure below shows a side-by-side comparison of % shares of the impact categories that are most closely related to resource-related impacts (i.e. Fossil Depletion, FD and Mineral Depletion, MD).

Figure 44. Resource-related LCA hot spots for LD, DD, HDD and APC detergent product types. Sources: Arendorf et al., 2014a, 2014b, 2014c and 2014d).



From the multiple data presented in the figure above, some clear patterns can be seen. For example:

- End-of-Life impacts are much higher on mineral resource depletion than fossil resource depletion.
- Resource depletion with transport was generally insignificant for all 4 types of detergent product and for both mineral and fossil resource depletion.
- Resource impacts of packaging are relatively much more important with APC products than with HDD products, and those of HDD products are in turn much more significant than with DD and LD products.
- Formulation impacts are relatively highest in HDD products and then in APC products, but were completely insignificant in LD and DD products.

- Use stage resource impacts were always significant, but especially so with DD products and least so with APC products.

5.4.1.3.4. Concluding remarks on overview of relative results published by Arendorf et al.

The overall aim of the LCA research in this report is to help identify hot-spots to help justify where EU Ecolabel criteria should be prioritised. In this context, it is important to note that certain life cycles stages are more important for one type of detergent product than another. These differences stem from important differences in:

- Differences in the quantities and types of chemicals used in detergent products.
- Energy consumed during the use stage.

As impacts associated with ingredients and use stage energy decrease, impacts associated with formulation, packaging, transport and EoL with relatively increase. This is clearly illustrated with APC products, where little or no additional energy is needed during the use stage.

With regards to impacts such as toxicity and eutrophication, impacts will be strongly dependent on the assumptions made about the toxicity and biodegradability profiles of the ingredients used. Much of this information is incomplete for substances and it has been an issue flagged in a number of LCA studies, for example by Igos et al (2014). In the in-house LCAs to be carried out in this project, some special attention will be paid to the chemical profile information associated with LCI datasets used.

5.4.1.4. Overview of LCA literature on laundry detergents

The following literature was reviewed which involved the consideration of laundry detergent products from a life cycle perspective.

Table 30. Basic details of studies reviewed regarding the LCA of laundry detergents

Primary author and year	Ingredients	Formulation	Packaging	Transport	Use	EoL	Functional unit	Method
Arendorf, 2014a	X	X	X	X	X	X	85g of powder laundry detergent (one normal dose)	ReCiPe method, reported on midpoint and endpoint indicators.
Castellani, 2019	X	X	X	X	X	X	76.5g or 71.4g of liquid laundry detergent (one normal dose)	ILCD midpoint impact categories together with normalisation and weighting according to PEF methodology.
E COSI, 2022 (in Italian)	X	X	X	X	X	X	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system.
Eberle et al., 2007	X	?			X	x	1kg of washed hygiene laundry (with a reference flow of 7.2,g, 12g or 16g of detergent (plus other chemicals).	Used Umberto 4.0 software to calculate LCA results and reported on indicators in line with CML92 or CML 2001.
Giagnorio, 2017	X	X	X	?	X	X	Two types of functional unit used: 1 kg of industrial laundry detergent product 1 year of industrial textile washing (2171 tonnes).	ReCiPe, Cumulative Energy Demand (CED) and IPCC methods used, reported on midpoint and endpoint indicators.
Golsteijn, 2015	X	X	X	X	X	X	1 wash cycle, with a reference flow of 81.5g of compact powder or 63.8g of tablet.	Used the full suite of midpoint and endpoint indicators from the ReCiPe method.
Henkel, 2008	X	X	X	X	X	X	1 wash cycle.	Method not clear. Reported on GWP only.
Kim, 2020			X				10,000 doses of laundry	TRACI 2.1. Impact categories

Primary author and year	Ingredients	Formulation	Packaging	Transport	Use	EoL	Functional unit	Method
							detergent.	included ODP, GWP, AP, EP, HTox, ETox and fossil fuel depletion.
Koemer, 2010	X	X	X	X	X	X	1kg of clean and dry clothes.	Main impact categories reported include: water use, energy use, GWP, EP, non-renewable resource depletion and land use.
Koning, 2010	X	X	X	X	X	X	Not clearly defined, but many results reported on a per wash basis.	Not clearly explained, was based on some industry-used excel tool. Only carbon emissions reported.
Nessi, 2014			X				1000 litres of detergent	Not so clear what the methods was, but the impact categories reported included: GWP, ODP, POFP, AP, EP, Ecotoxicity, Human Toxicity, PM and various resource depletion categories.
Palfy, 2021			X				Packaging for 10,000 litres of detergent product.	Not relevant since screened out partially based on scope, and definitely on the limited value of outcomes.
PEFCR, 2019	X	X	X	X	X	X	Washing of 4.5kg of dry fabric	In line with the relevant impact categories for the EF methodology back in 2019.
Saouter, 2002a	X	X	X	X	X	X	1000 wash cycles	Used the CML92 method and reported on AP, EP, Aquatic Toxicity, GWP, Human Toxicity, ODP and POFP impact categories.
Saouter, 2002b	X	X	X	X	X	X	Step 1 analysis: 1kg of product Step 2: 1000 wash cycles	Used the CML92 method and reported on AP, EP, Aquatic Toxicity, GWP, Human Toxicity, ODP and POFP impact categories.
Tomsic, 2023					X		Not defined.	The ReCiPe method was used. A very broad range of midpoint and endpoint impact categories were reported on.
Villota-Paz, 2023	X		X	X			1 litre of BLD (equivalent to around 20 washes)	Used the ReCiPe method and reported on the following impact categories: GWP, EP (freshwater and marine), LU, Fossil resource depletion and water use. Plus the 3 ReCiPe endpoint indicators.

The studies that focused on packaging will not be discussed in great detail in this report since it is clear that packaging impacts are not an LCA hotspot for any impact category with LD products from the figures in section 5.4.1.3 (with the notable exception of ALO impacts, which seemed out of place).

There is also some justification for not reviewing in detail the studies that are much older, since LCI datasets will have changed as well as actual representative product formulations, washing machine energy efficiencies and grid electricity factors. Likewise, studies that only report on carbon are of limited value since they fail to identify any potential trade-offs of low carbon measures (consider nuclear power as a clear example, which generates low GWP electricity but with major impacts relating to ionising radiation).

Based on these considerations, we only review in more detail a limited number of the literature sources identified above.

5.4.1.4.1. Arendorf et al., 2014a

These results have already been presented in the earlier overview section, where LD results were compared side-by-side to those of DD, HDD and APC products in other studies published in parallel by the same authors.

Key assumptions: a wash cycle temperature of 40°C, detergent dose of 85g and an assumed processing energy of 40.7 KJ to formulate the 85g of LD product, 0.53kWh and 49 L water per wash cycle and an assumed recycling rate of 83.2% for carboard packaging. Any non-recycled packaging was part landfilled (65.3%) or part incinerated (34.7%).

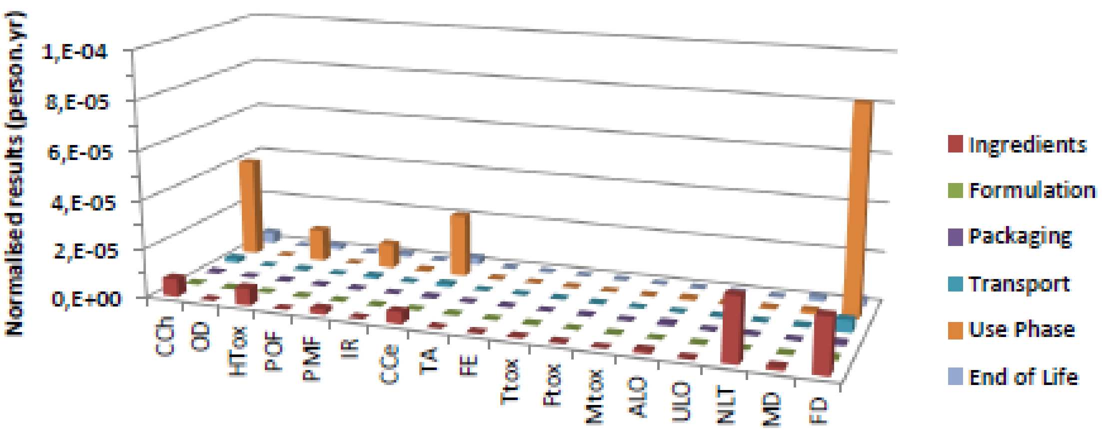
Formulation: a full formulation was provided for a typical powder laundry detergent (see Table 39).

Sensitivity analysis: looked at a number of variables on assumptions in order to see how they would affect the result. This included wash cycle temperature (30, 40 or 60°C), on electricity grid factors (EU, FR, CH and NL), detergent dosage (+20% and -20%) and surfactant origin (petrochemical, palm oil or a mix of the two). The main conclusions from the sensitivity analyses on selected impact categories were:

- Changing the laundry cycle wash temperature from 60°C to 40°C or 30°C was highly significant, typically affecting cradle-to-grave LCA impact category results by 10 to 40%.
- For a given wash cycle temperature, electricity grid factors could have a potentially high influence on cradle-to-grave LCA results. Changing from an EU average to the French or Swiss national grid factors could reduce a number of impact categories by anywhere between 15 and 50%. Results could just as easily increase if selecting a national grid with higher than EU-average grid factors.
- Under-dosing or over-dosing of detergent product by 20% could have an effect of around 7-15% on many impact category results, highlighting the importance of following dosing instructions.

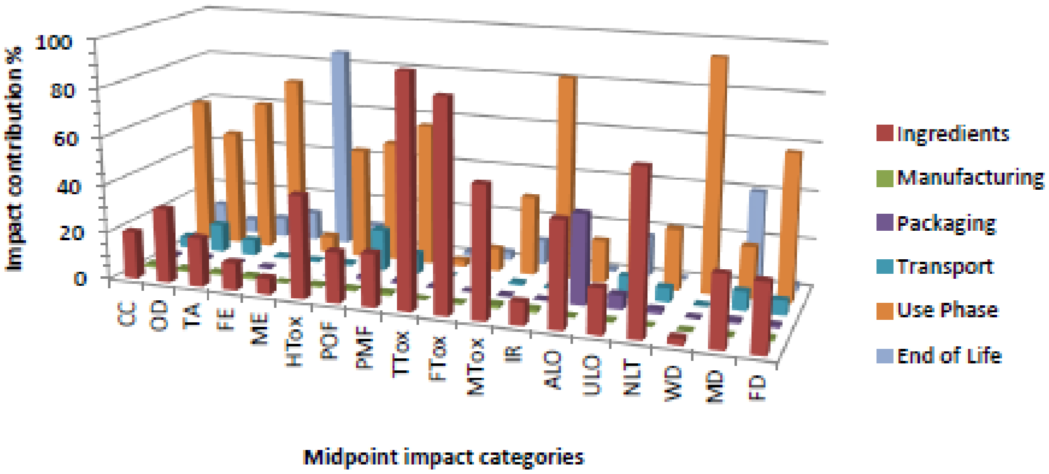
Main findings: In terms of normalised results, the results for Fossil Depletion (FD), Climate Change (CC), Natural Land Transformation (NLT) and Human Toxicity (HTox) were found to be most significant.

Figure 45. Normalised (EU citizen, 2000) midpoint impact categories results for LCA of LD reported by Arendorf et al., 2014a.



The use stage dominated all of these normalised endpoint impacts due to electricity consumption to heat the water and run the washing machine. The only exception was with NLT impacts, which were dominated by the ingredient stage, due to the oleochemical sourcing of materials for ingredients.

Figure 46. Midpoint impact categories results for LCA of LD reported by Arendorf et al., 2014a.



For midpoint categories, each category was dominated by either the ingredient stage (TTox, ETox, MTox, ALO and NLT) or the use stage (CC, ODP, TA, FE, POF, PMF, IR, WD or FD). The only other LCA stage that became significant for any midpoint impact categories was the End-of-Life stage (for ME and MD).

5.4.1.4.2. Castellani et al., 2019

The study by Arendorf et al (2014a) looked at a powder laundry detergent, whereas the study by Castellani et al., (2019) looked at two liquid laundry detergents (one as a baseline and one "eco innovation" option).

Key assumptions: a wash cycle temperature of 40°C, detergent dose of 76.5g or 71.4g, an assumed energy consumption of 0.638 kWh or 0.488 kWh per cycle and an assumed water consumption of 50L water per cycle.

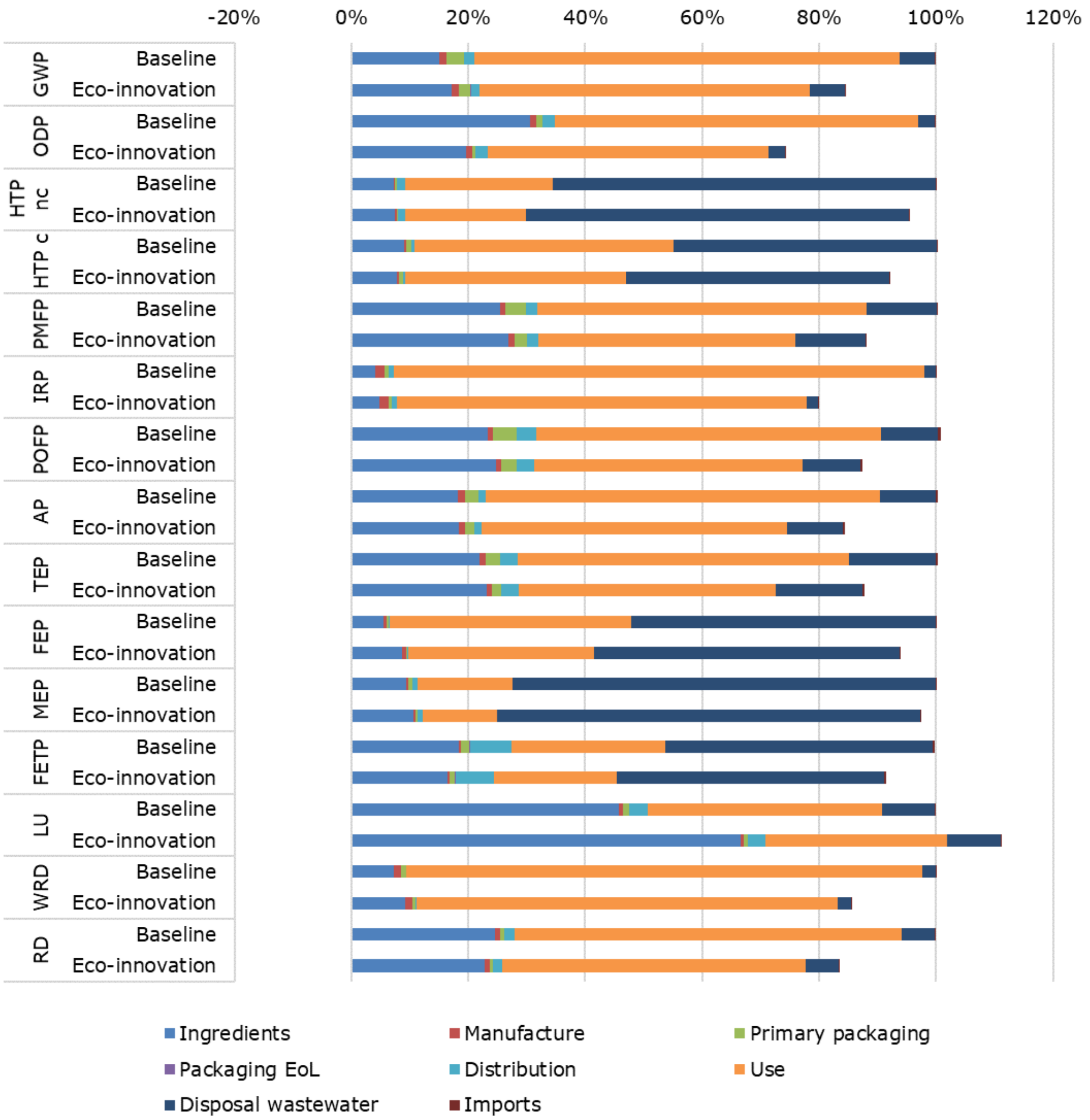
Formulation: a full formulation was provided for a typical liquid laundry detergent and for an "eco" liquid laundry detergent (see Table 39).

Sensitivity analysis: the study considered the following variables:

- Altering of formulation and related Critical Dilution Volumes by choosing less toxic ingredients (see Annex 3 for more details).
- Reduction of production stage electricity consumption (by 5%, 10% or 20% compared to baseline).
- Improvement of road transport vehicles for distribution (from Euro 4 to Euro 6 lorries).
- Assume packaging recycling rates are increased (not clear by how much).
- Use of more efficient packaging (i.e. less packaging per dose) by increasing container from 650 mL to 1500mL.

Main findings: The overall effect of the eco-innovation scenario on lifecycle impacts was as shown below.

Figure 47. Influence of eco-innovation measures on cradle-to-grave LCA impacts of laundry detergents. Source: Castellani et al., 2019.



The results above show that, compared to the baseline, eco-innovation measures reduced impacts by between 5 and 25% for all impact categories, with the notable exception of Land Use, where impacts increased by around 10%. This increase in Land Use impacts will no doubt be related to an increase of oleochemical sourced compounds to substitute petrochemical ones in the eco-innovation scenario.

In most cases, the reductions were most significant in the use stage, thus being linked to decreases in energy and water consumption in the wash cycle. The one impact category where eco-innovation reduced impacts associated with ingredients was ODP, but it was not clear which specific ingredient changes were responsible for this.

The effect of more efficient packaging and lorries in the distribution stage did not show any appreciable influence on overall LCA results, in large part due to the fact that these stages only had a small share of overall impacts to begin with.

5.4.1.4.3. Golsteijn et al., 2015

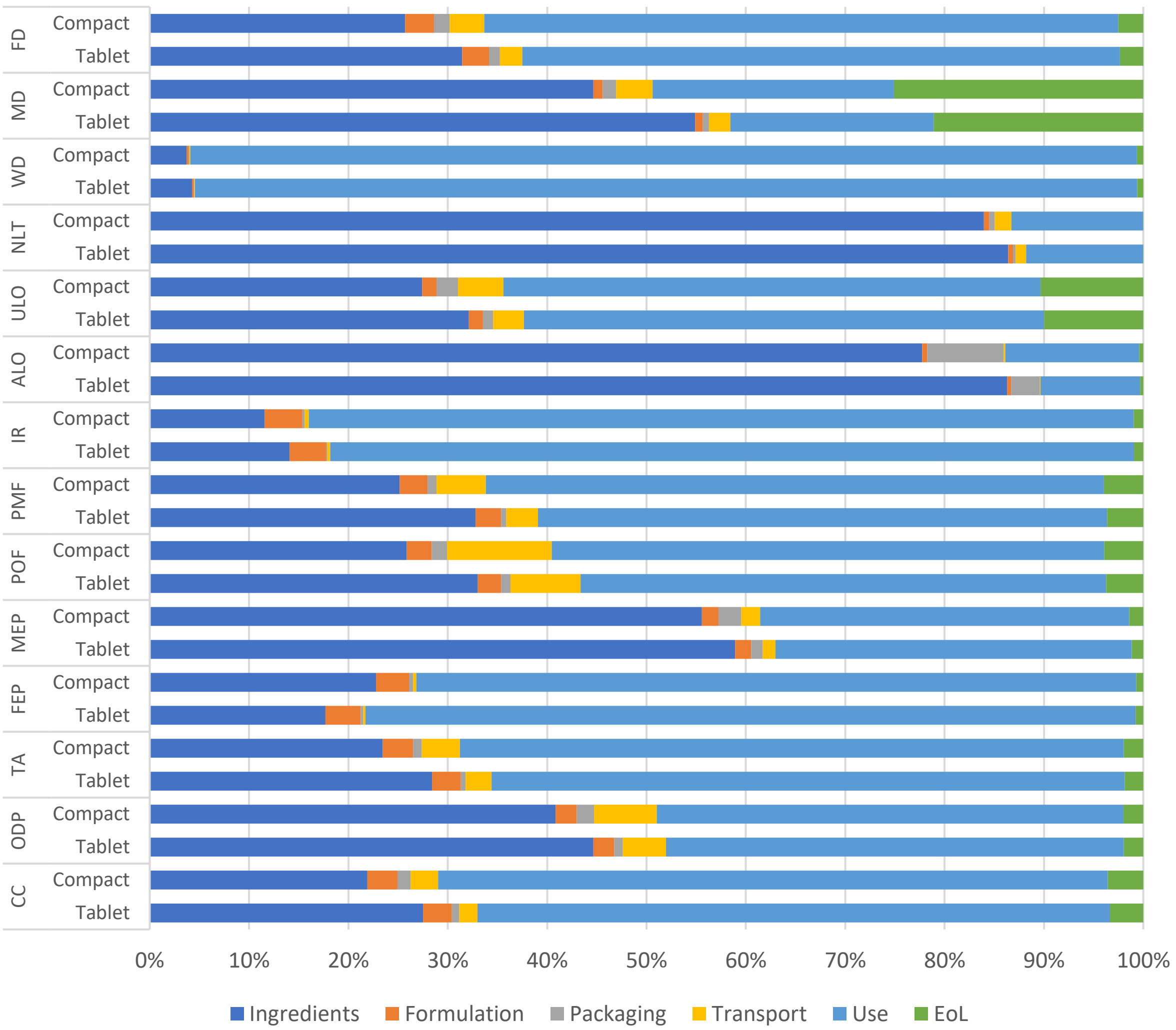
This study looked at several different types of detergent product that are relevant to the EU Ecolabel scope and, while this particular section focuses on results with a compact powder laundry detergent and a tablet laundry detergent, the study will also be referred to again in the sections on HDD and HSC products.

Key assumptions: 81.5g dose for compact powder detergent; 63.8g dose for laundry tablet; a wash cycle using 60L of water with a wash cycle temperature of 40°C; water was heated by electricity and 0.70 kWh is consumed per cycle; 0.01% product loss during production stage; renewable ingredients for surfactants travelling 8000km by boat; other ingredients travelling 2000km by truck; product distribution being 1200km by lorry; all wastewater going to at least secondary wastewater treatment; 83.2% of paper & board waste being recycled; 31.9% of plastic being recycled and any none recycled material is either landfilled (65.3%) or incinerated (34.7%).

Formulation: defined formulas were assumed for the study, but while information was provided in a suitably transparent manner, it was not detailed enough to accurately repeat the study. For example, the supplementary material says that the content of builders was in the range of 15-30%, but this would involve unspecified quantities of defined builder compounds (in this case: polycarboxylates, zeolite powder and sodium sulfate).

Main findings: A comparison of relevant impacts for the compact powder and tablet formats for laundry detergent can be made since impact category values were provided for each impact category and per life cycle stage in the supplementary material of Golsteijn et al., (2015).

Figure 48. Comparison of relative midpoint impacts for compact powder format and tablet format laundry detergents. Source: Golsteijn et al., 2015.



The relative impacts show similar patterns in terms of showing which life cycle stages are most important for any given impact category. The only impact categories where the use stage did not dominate, it was because the ingredient stage dominated (specifically with Metal Depletion, Natural Land Transformation, Agricultural Land Occupation, and Marine Eutrophication Potential). The authors confirmed that it was oleochemical fractions of surfactants that were driving the impacts on NLT and ALO, while it was the builders that were driving impacts on MD and MEP (i.e. one or more of polycarboxylates, zeolites and/or sodium sulphate).

The formulation stage never managed to account for much more than 5% of any impact category. The packaging impacts were similarly insignificant. The End-of-Life stage was generally insignificant too, with the notable exception of Metal Depletion and less so with Agricultural Land Occupation.

It is interesting to note that the tablet format laundry detergent showed consistently higher relative impacts at the ingredients stage than the compact powder laundry detergent. This was despite the fact that the dose with the tablet format was much smaller (63.8g versus 81.5g).

5.4.1.4.4. PEFCR, 2019

There were no named authors for this report and we refer here to the content of version 1.2 of the PEFCR study published in September 2019. The study focused solely on heavy duty liquid laundry detergents for use in household washing machines.

Key assumptions: a wash cycle temperature of 40°C, detergent dose of 75mL, an assumed energy consumption of 0.638 kWh per cycle and an assumed water consumption of 50L water per cycle. For wastewater treatment, a specific electricity consumption of 0.28kWh/m3 sewage was assumed.

Formulation: a full formulation was provided for a household heavy duty liquid laundry detergent (HDLLD, see Table 39).

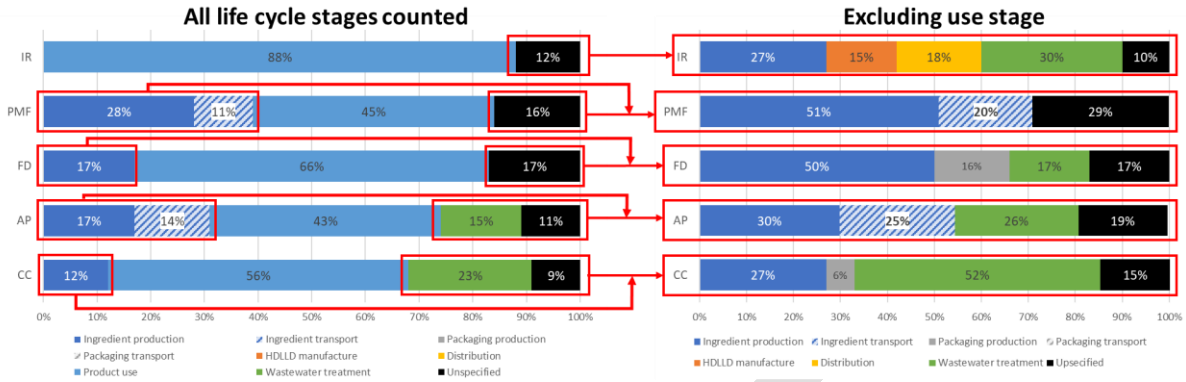
Sensitivity analysis: the 2019 study did not report on any sensitivity analysis, but some considerations of possible variations that could occur were found in a previous PEFCR screening report from 2014. In this report, the following variations could be considered as plausible:

- HDPE plastic in primary packaging could vary from 2.4 to 4.2 g/75mL of HDLLD.
- PP plastic in primary packaging cap and spout could vary from 0.35 to 1.10g/75mL of HDLLD.
- Paper label mass on primary packaging could vary from 0.05 to 0.15g/75mL of HDLLD.
- Recycled plastic content of primary packaging could vary from 0 to 100%.
- Specific electricity consumption in the formulation plant can be 0.16 kWh/kg HDLLD +/- 30%.
- Specific water consumption in the formulation plant can be 0.6 L/kg HDLLD +/- 25%.
- Dosage can vary from 60 to 75mL/cycle, with overdosing considered to be +25% (i.e. 94mL).
- Water consumption during the use stage can be 50L/cycle +/- 30%.
- Wash cycle temperature can vary from 30 to 60°C.
- Compare average EU electricity mix with the French and Polish national mixes.

Main findings: A full breakdown of results was not provided, but followed the rules in line with v6.3 of the PEFCR guidance. These rules state that the life cycle stages representing at least 80% of total impacts for relevant impact categories must be identified and the contributions of each of these stages expressed. If the use stage accounts for more than 50% of total impacts, then the results should also be communicated without the use stage being included.

The study found the following life cycle stages to be most relevant: climate change (CC), acidification potential (AP), fossil resource depletion (FD), particulate matter formation (PMF) and ionising radiation (IR).

Figure 49. LCA results for a representative HDLLD product including the use stage (left) and excluding the use stage (right). Source: PEFCR, 2019.



The results shown above show that the use stage dominated all five of the most relevant impact categories that were reported as % shares in the PEFCR report for HDLLD products. In cases where the use stage accounted for more than 50% of impacts (i.e. with the IR, FD and CC categories), it was necessary to also report the share of impacts (split up to a new 100%) with the use phase excluded. For comparability, we also calculated how the distribution would look without the use phase results for the PMF and AP impact categories in the figure above.

The report also offered some additional insights on what sub-categories were behind the impacts at each life cycle stage. For this breakdown, it is easier to show via a table.

Table 1. Breakdown of main impacts within the ingredient making and use phase life cycle stages, only highlighting individual contributions accounting for 2% or more.

	Results including the use phase					Results excluding the use phase				
	CC	AP	FD	PMF	IR	CC	AP	FD	PMF	IR
Ingredients: Surfactants		2%		10%		6%	No breakdown provided in report without use phase excluded	24%	No breakdown provided in report without use phase excluded	
Ingredients: Propylene glycol				4%		3%		6%		3%
Ingredients: Citric acid		2%				4%		5%		7%
Ingredients: Enzymes						2%				3%
Ingredients: Sodium hydroxide										2%
All ingredients phase	12%	17%	17%	28%	3%	27%		49%		27%
Use: Electricity	52%	40%	63%	40%	84%	n/a		n/a		n/a
Use: Water	3%	3%	3%	5%	3%	n/a		n/a		n/a
All use phase	56%	43%	66%	45%	87%	n/a		n/a		n/a

The % shares for surfactant contributions to each impact category are likely to be significantly higher than those reported above because the representative product counted with at least 7 types of surfactants, but only results for a few of them were added for any particular impact category (because they were not all >2% at individual surfactant level). Nonetheless, the results confirm the leading role that surfactants play in terms of environmental impacts associated with ingredients in liquid laundry detergents.

5.4.1.4.5. Tomsic et al., 2023

A final study that is worth mentioning for the LCA impacts of laundry detergents is that of Tomsic et al., (2023). These authors focused exclusively on the use phase of the life cycle of laundry detergent, using the same standard detergent and varying the detergent load and wash cycle temperature. Apart from considering LCA results, they also looked at the cleaning performance – in terms of lightness of washed cotton fabrics (these were standard soiled fabrics according to EN 60456) and bacterial removal.

Formulation: a full formulation was described thanks to an EN standard detergent being used. Specifically this was "ECE reference detergent 98", a phosphate-free detergent without bleach or enzymes. The composition was as follows:

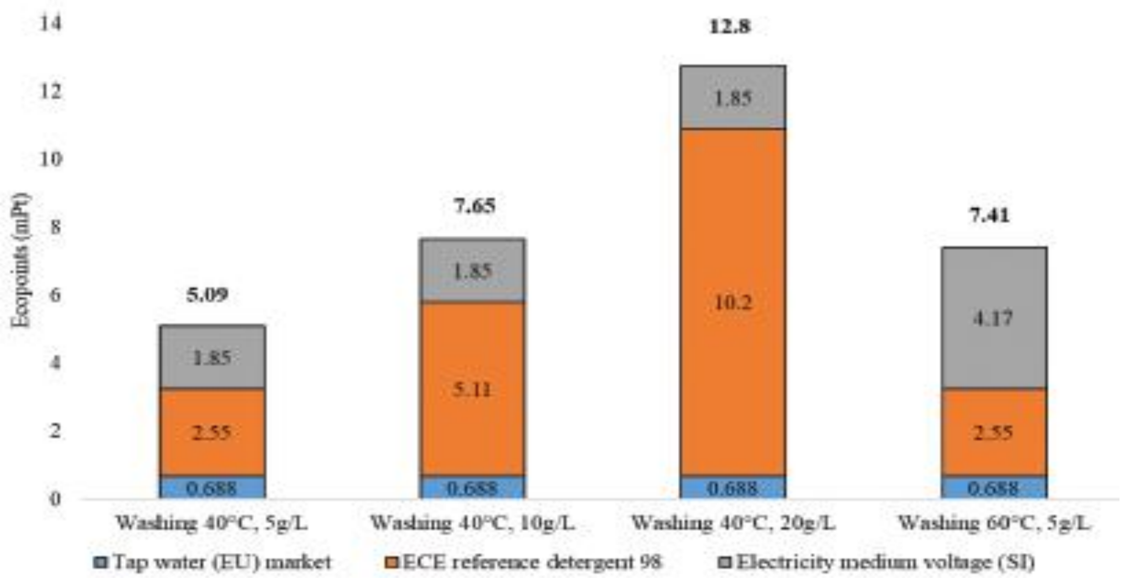
- 75 g linear sodium alkylbenzene sulfonate,
- 40 g ethoxylated fatty alcohol,

- 28 g sodium soap,
- 50 g antifoaming agent DC –42485,
- 250 g sodium aluminosilicate zeolite,
- 91 g sodium carbonate,
- 40 g sodium salt of a copolymer of acrylic and maleic acid,
- 26 g sodium silicate,
- 10 g carboxymethyl cellulose,
- 6 g diethylenetriamine penta (methylene phosphoric acid), and
- 60 g sodium sulphate.

Sensitivity analysis: the main variables investigated were the type of soiling (EMPA 101, EMPA 114, EMPA 116 or EMPA 160), the wash temperature (40C or 60°C) and detergent load (5g, 10g or 20g).

Main findings: The most relevant results were neatly summarised in a single graph, as shown below.

Figure 50. Endpoint LCA results focused purely on use stage water consumption, use stage electricity consumption and detergent consumption.



The results clearly show that detergent consumption is the largest environmental impact when washing at 40°C, even when the dose is reduced to 5g/L. Increasing the wash cycle temperature from 40°C to 60°C more than doubles the impacts associated with use phase electricity consumption. Overall, the results imply that a higher wash cycle temperature could be compensated if detergent dosage is reduced by half.

However, the general consideration by Tomsic et al., (2023) that laundry detergent consumption is more significant on LCA impacts than the use phase electricity consumption is at odds with the rest of the literature on this subject. It is likely that the reduced important of the use stage electricity consumption will be linked to the very specific washing cycle and conditions that were used in this study, being in line with the EN 60456 method and not being so representative of real-life washing cycles.

5.4.1.5. Overview of LCA literature on dishwasher detergents

The following literature was reviewed which involved the consideration of dishwasher detergent products from a life cycle perspective.

Table 31. Basic details of studies reviewed regarding the LCA of dishwasher detergents

Primary author and year	Ingredients	Formulation	Packaging	Transport	Use	EoL	Functional unit	Method
Arendorf, 2014b	X	X	X	X	X	X	20g of dishwasher detergent (one normal dose)	ReCiPe method, reported on midpoint and endpoint indicators.
Castellani, 2019	X	X	X	X	X	X	20g or 19g of dishwasher detergent (one normal dose under two scenarios)	ILCD midpoint impact categories together with normalisation and weighting according to PEF methodology.
E COSI, 2022 (in Italian)	X	X	X	X	X	X	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system.
Igos et al., 2014	X					X	One wash cycle (reference flows of three different detergents not clearly stated).	Focused on human toxicity and ecotoxicity.
Van Hoof et al., 2017	X				X	X	18.94g or 15.05g (one wash cycle with different DD products).	Looks at selected ReCiPe midpoint indicators to report on normalised results, plus reporting on USETox and CDV parameters.

Compared with laundry detergents, fewer LCA studies could be found for dishwasher detergents. In the next sub-sections, we present some of the most pertinent points relating to LCA impacts associated with dishwasher detergent products.

5.4.1.5.1. Arendorf et al., 2014b

These results have already been presented in the earlier overview section, where DD results were compared side-by-side to those of LD, HDD and APC products in other studies published in parallel by the same authors.

Key assumptions: a wash cycle temperature of 60°C, detergent dose of 20g and an assumed processing energy of 40.7 KJ to formulate the 20g of DD product (not clear if the 40.7 KJ corresponds to some other mass of DD product). Also assumed that 1.42 kWh and 18.5 L water per wash cycle and an assumed recycling rate of 83.2% for carboard packaging and 31.9% for plastic packaging. Any non-recycled packaging was part landfilled (65.3%) or part incinerated (34.7%). The assumptions on waste were linked to Eurostat data from 2012.

Formulation: a full formulation was provided for a typical dishwasher detergent (see Table 40).

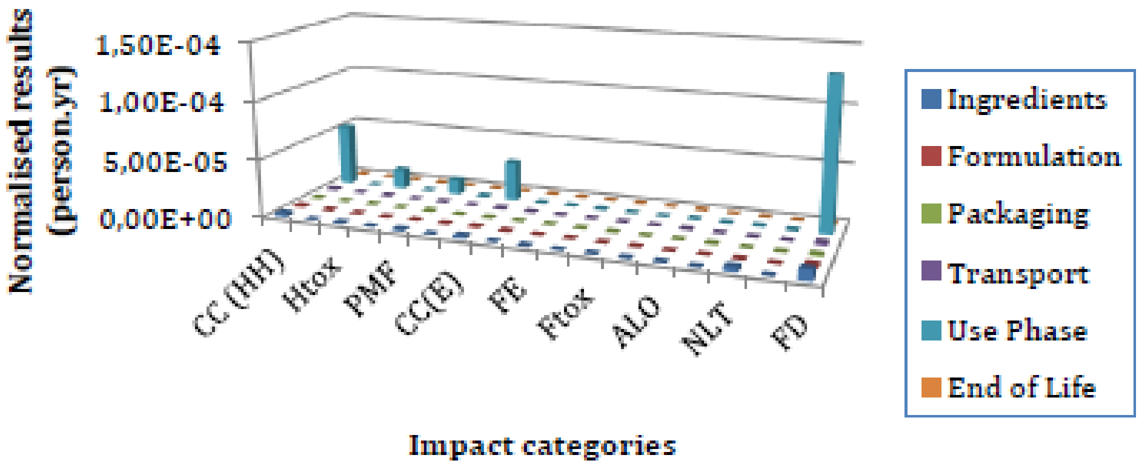
Sensitivity analysis: looked at a number of variables on assumptions in order to see how they would affect the results for relevant impact categories identified by the authors (CC, HTox, PMF, NLT, WD and FD). This included wash cycle energy consumption (±25% and ±50% of baseline), electricity grid factors (EU, FR or CH), detergent dosage (+20% and -20% of baseline) and surfactant origin (petrochemical, palm oil or a mix of the two). The main conclusions from the sensitivity analyses on selected impact categories were:

- Changes in the electricity consumption of the dishwasher cycle had a major effect on all of the impact categories and to a similar extent. This was because the use stage dominates the DD LCA results and it is precisely electricity consumption that dominates the use stage impacts. The only impact category that was not so sensitive was Water Depletion (WD), were changes were around 5 times less severe.
- For the baseline dishwasher cycle energy consumption of 1.42 kWh, changing electricity grid factors from the EU average to the FR or CH national averages had a dramatic effect on LCA results (60 to 90% reductions on the baseline for all impact categories). This could be expected because of the fact that DD LCA impacts are already dominated by electricity consumption in the use phase. These reductions can be expected for FR (high degree of nuclear energy) and CH (high degree of hydropower).

- Under-dosing or over-dosing of detergent product by 20% could have an effect of around 4-7% on the different impact category results. This again was predictable since, due to the dominance of use stage energy on overall LCA impacts, it is evident that the impacts associated with detergent production only play a minor role.
- The effect of surfactant origin (i.e. oleo or petro-based) showed some influence only on the Natural Land Transformation (NLT) impact category. However, the graph of results in Arendorf 2014b does not make sense, since it shows the mix of ole- and petro-based origins as the baseline, while the 100% oleo- and 100% petro-sourced options have the same result in the graph (precisely Figure 24 of Arendorf et al., 2014b). A side-by-side comparison of the effect of surfactant origin on all the detergents assessed by Arendorf 2014a, 2014b, 2014c and 2014d is provided later in Error! Reference source not found..

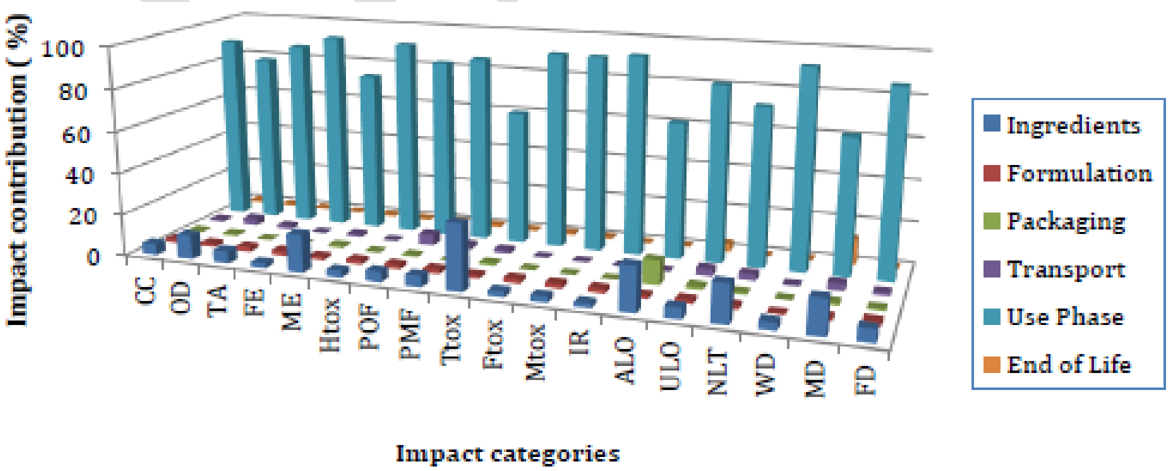
Main findings: In terms of normalised results, the results for Fossil Depletion (FD), Climate Change (CC), Natural Land Transformation (NLT) and Human Toxicity (HTox) were found to be most significant.

Figure 51. Normalised (EU citizen, 2000) midpoint impact categories results for LCA of DD reported by Arendorf et al., 2014b.



The use stage dominated all of these normalised midpoint impacts due to electricity consumption to heat the water and run the dishwasher. The dominance of the use phase was so strong, that the NLT impacts from oleochemical ingredients barely registered in the figure above.

Figure 521. Midpoint impact categories results for LCA of DD reported by Arendorf et al., 2014b.



For midpoint categories, each category was dominated by the use stage (64 to 95%. Ingredients were only making a noticeable contribution in the TTox (32%), ALO (21%), NLT (18%), ME (18%), ME (16%) and OD

(12%) impact categories. All other life cycle stages had negligible contributions for all impact categories, except for packaging and only with ALO (11%).

5.4.1.5.2. Castellani et al., 2019

The study by Castellani et al., (2019) looks at two dishwasher detergents (one standard and one “eco”). The study is essentially an extension of the Arendorf 2014b study.

Key assumptions: a wash cycle energy consumption of 1.42 KWh (baseline) or 0.90 kWh (eco-scenario), detergent dose of 20g (baseline) or 19g (eco-scenario) and an assumed water consumption of 18.5L (baseline) or 10L (eco-scenario) of water per cycle.

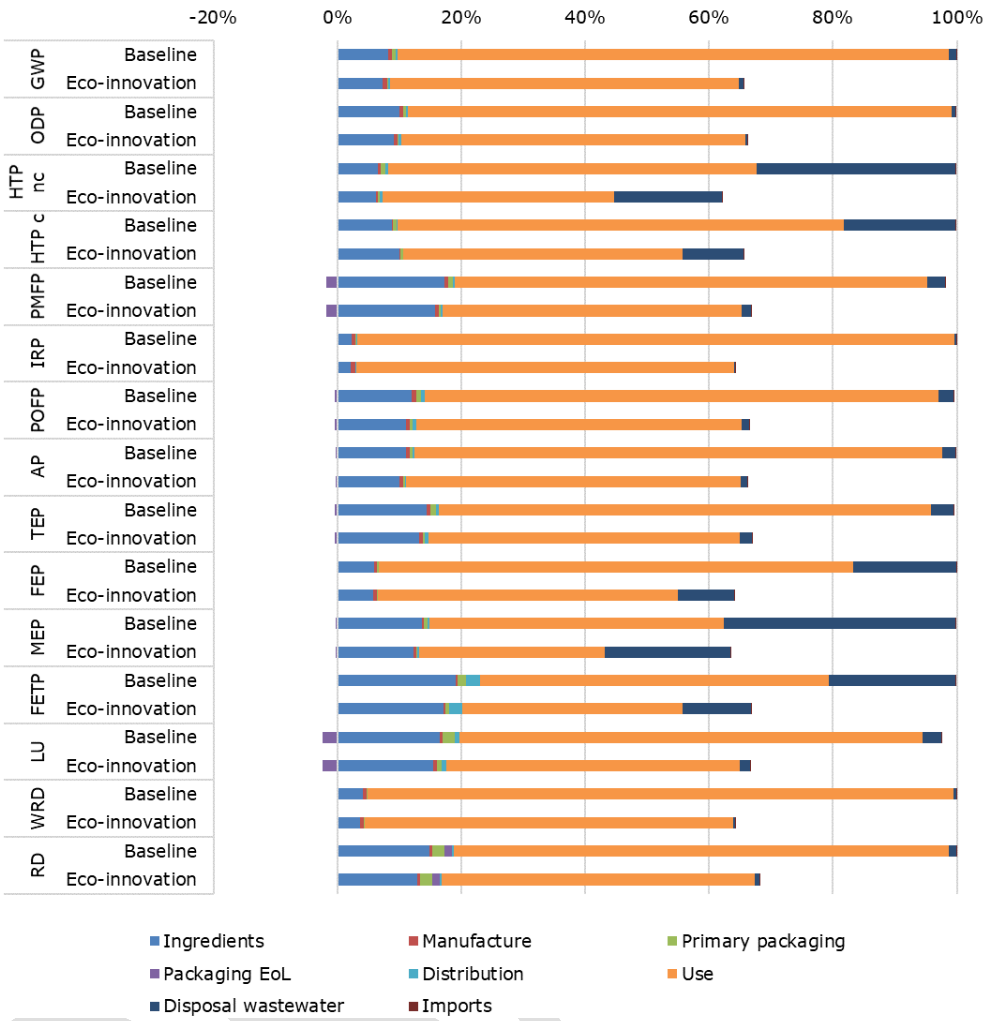
Formulation: a full formulation was provided for a typical liquid laundry detergent and for an “eco” liquid laundry detergent (see Table 39). The main differences in the two formulations were that the eco-scenario contained a lot more sodium percarbonate, had GLDA added as a new ingredient and had much lower quantities of enzymes, of sodium silicate and maleic acid/acrylic acid copolymer.

Sensitivity analysis: the study considered the following variables:

- Altering of formulation and related Critical Dilution Volumes by choosing less toxic ingredients (see Annex 3 for more details).
- Reduction of production stage electricity consumption (by 5%, 10% or 20% compared to baseline).
- Improvement of road transport vehicles for distribution (from Euro 4 to Euro 6 lorries).
- Assume packaging recycling rates are increased (not clear by how much).
- Use of more efficient packaging (i.e. less packaging per dose) by increasing container from 650 mL to 1500mL.

Main findings: The overall effect of the eco-innovation scenario on lifecycle impacts was as shown below.

Figure 53. Influence of eco-innovation measures on cradle-to-grave LCA impacts of dishwasher detergents. Source: Castellani et al., 2019.



Comparing the results above, it is clear that major improvements are made in the eco-innovation scenario for all impact categories. Upon closer inspection, all of the improvements are dominated by improvements in the use phase, which in turn are linked to the assumed reduction of wash cycle electricity consumption from 1.42 to 0.90 kWh/cycle.

The chemical formulation of the eco-scenario is also delivering notable reductions in impacts at the disposal stage, especially with regards to marine and freshwater eutrophication, with human toxicity and with freshwater ecotoxicity.

5.4.1.5.3. Van Hoof et al., 2017

This study looks at the environmental profile (LCA, USETox and Critical Dilution Volume) of two household dishwasher detergent products, one with phosphate and one being phosphate free. Consequently, the study is not a "pure" LCA study, but still shows some interesting results.

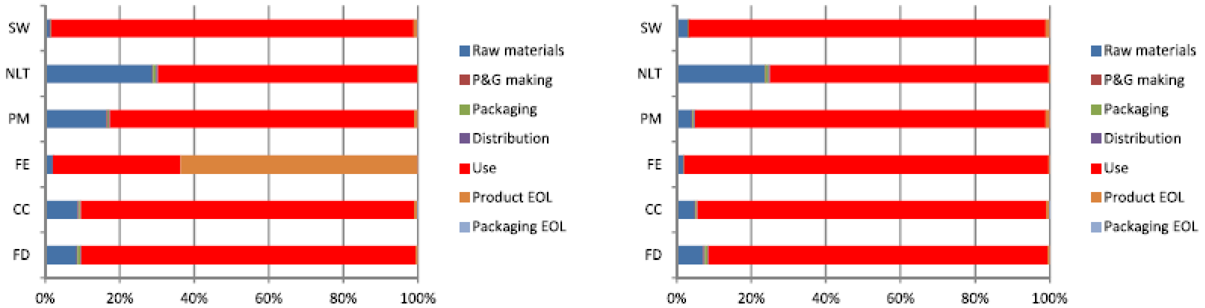
Key assumptions: Apart from the formulations, which can be presumed to be fully known by the authors since they were working directly with P&G, the only assumptions clearly stated in the paper where on the dose mass (18.94 g/dose for the phosphate-containing DD and 15.05 g/dose for the phosphate-free DD product). The authors did go into detail explaining assumed degradation and toxicity factors for ingredients, by providing them in supplementary material.

Formulation: defined formulas were not provided in the study, but the presence/absence of different ingredients was made for both DD products being studied, so that the main differences could be seen. The main differences were:

- The use of MGDA (Methyl Glycine Diacetic Acid) instead of STPP (Sodium TriPolyPhosphate) in the phosphate-free formulation.
- The use of an unspecified bleach catalyst instead of an unspecified bleach activator in the phosphate-free formulation.

Main findings: Several interesting results were presented by the authors. First of all, there is a comparison of the relative impacts of different life cycle stages for the two scenarios (with a phosphate-containing DD product and a phosphate-free DD product).

Figure 542. Contribution of different life cycle stages to selected ReCiPe impact categories and solid waste (SW) generation for a phosphate-containing DD product (left) and a phosphate-free DD product (right). Source: Van Hoof et al., 2017.



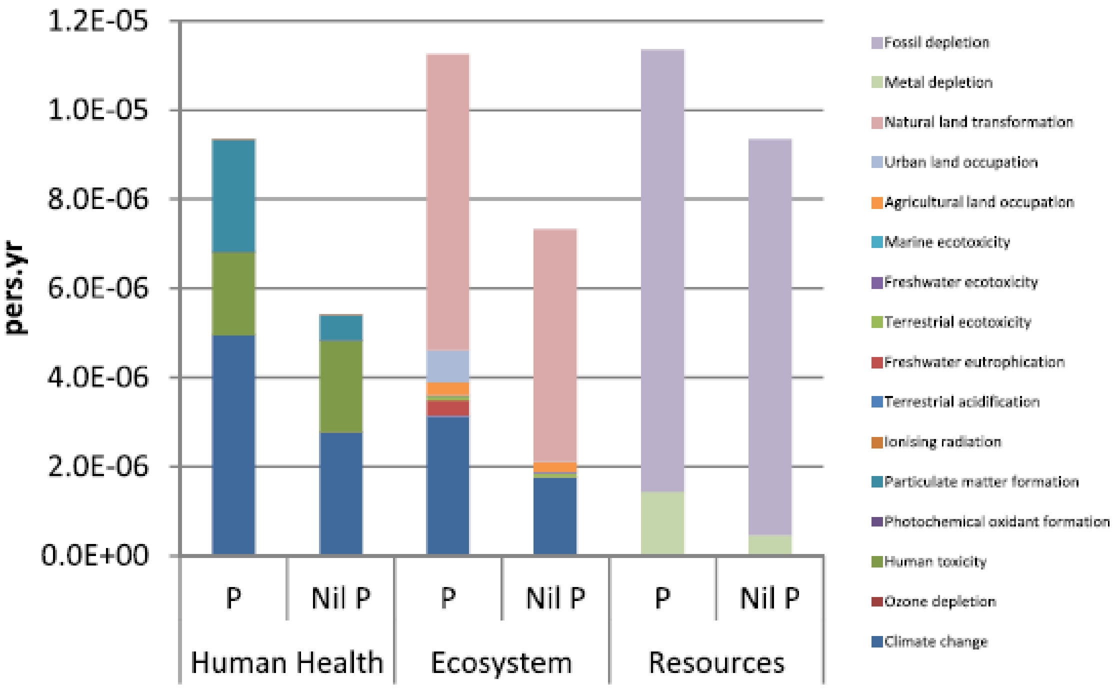
From the data above, it can be seen that the use phase dominates all impacts with the phosphate-free DD product. A similar behaviour is noted with the phosphate-containing DD product, with the exception of freshwater eutrophication (FE). In the case, the “Product EOL”, which is essentially the disposal of the product via wastewater, is accounting for over 60% of the FE impacts.

Since the authors did not define conditions of the use stage, it can be assumed that the same wash cycle energy consumption applied to both cases. If that is so, then the main sources of differences are coming from the ingredients stage, where impacts are similar or significantly lower for the phosphate-free product, with the exception of the solid waste metric.

In a separate graph, the authors presented the % reductions of the impact categories that were generated by the new phosphate-free DD product. These reductions were: ca. 99% for eutrophication; 77% for particulate matter; 44% for climate change; 23% for natural land transformation and 10% for fossil depletion.

The authors had also calculated all of the ReCiPe midpoint indicators and converted them into normalised ReCiPe endpoint results, which are shown below.

Figure 55. Normalised ReCiPe endpoint results for the two types of DD product, with a breakdown of contributing midpoint impacts. Source: Van Hoof et al., 2017.



Of particular interest here is the fact that, when looking at Freshwater Eutrophication alone as a midpoint category in Figure 54, there was a massive difference based on whether the product contained phosphate or not. However, when normalising results and converting them to endpoints, that massive difference in freshwater eutrophication only made a small difference in endpoint ecosystem impacts.

The biggest differences coming from the different formulations were reflected in results for climate change, metal depletion and marine ecotoxicity.

5.4.1.6. Overview of LCA literature on hand dishwashing detergents

The following literature was reviewed which involved the consideration of hand dishwashing detergent products from a life cycle perspective.

Table 32. Basic details of studies reviewed regarding the LCA of hand dishwashing detergents (HDD)

Primary author and year	Ingredients	Formulation	Packaging	Transport	Use	EoL	Functional unit	Method
Arendorf, 2014c	X	X	X	X	X	X	Hand washing of 4 place settings (using 8ml or 12ml of HDD depending on scenario)	ReCiPe method, reported on midpoint and endpoint indicators.
Moura, 2023	X	X		X	X	X	200 washes of 4 dinner plates, 4 knives and 4 forks.	OpenLCA software and the ReCiPe, CML and AWARE assessment methods. Impact categories reported included: AP, EP, Resource scarcity (fossil and mineral), and water use.
Golsteijn, 2015	X	X	X	X	X	X	Washing of 4 place settings.	Used the full suite of midpoint and endpoint indicators from the ReCiPe method.
Van Lieshout, 2015	X	X		X	X	X	Not clearly defined, but presumably 1kg of product.	Used the ReCiPe method and reported on endpoint impacts.

Primary author and year	Ingredients	Formulation	Packaging	Transport	Use	EoL	Functional unit	Method
E COSI, 2022 (in Italian)	X	X	X	X	X	X	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system.
Nessi, 2014			X				1000 litres of detergent product.	Not so clear what the methods was, but the impact categories reported included: GWP, ODP, POFP, AP, EP, Ecotoxicity, Human Toxicity, PM and various resource depletion categories.
Villota-Paz, 2023	X	X	X	x			1 litre of BLD (equivalent to around 20 washes)	Used the ReCiPe method and reported on selected midpoint indicators and the 3 endpoint indicators.
Lucchetti, 2019	X	X		x			1 tonne of soap	Ecoindicator99 method used, reporting on 11 normalised impact categories.
Van Hoof, 2013	X	X	X		X	X	Hand washing of 10 plates (using one of two approaches, the “full sink” or “direct application”.	Exclusively focused on impacts related to water use (e.g. green/blue/gray water consumption).

Compared with laundry detergents, fewer LCA studies could be found for hand dishwashing detergents. In the next sub-sections, we present some of the most pertinent points relating to LCA impacts associated with hand dishwashing detergent (HDD) products.

5.4.1.6.1. Arendorf et al., 2014c

These results have already been presented in the earlier overview section, where HDD results were compared side-by-side to those of LD, DD and APC products in other studies published in parallel by the same authors.

Key assumptions: a wash water temperature of 40°C (higher would be uncomfortable for hands) and a wash water volume of 7.5L per 4 place settings (full sink method) or 15L per 4 place settings (direct application method) – combining the volume and temperature, the specific energy consumption for water heating was considered to be 0.05kWh (full sink) or 0.11kWh (direct application) on a per 4 place settings basis. It was also assumed that water heating was done electrically and not via a gas boiler.

The authors also assumed a specific manufacturing energy consumption of 3.2 MJ/kg HDD product[427]. Regarding disposal, 100% of wastewater was assumed to go to at least secondary treatment and recycling rates of 83.2% and 31.9% were assumed for cardboard for plastic packaging respectively. Any non-recycled packaging was part landfilled (65.3%) or part incinerated (34.7%). The assumptions on waste were linked to Eurostat data from 2012.

Formulation: a full formulation was provided for a typical hand dishwashing detergent (see Table 41). In any case, the formulation was dominated by softened water (84%) and a mix of anionic and non-ionic surfactants (13.85%).

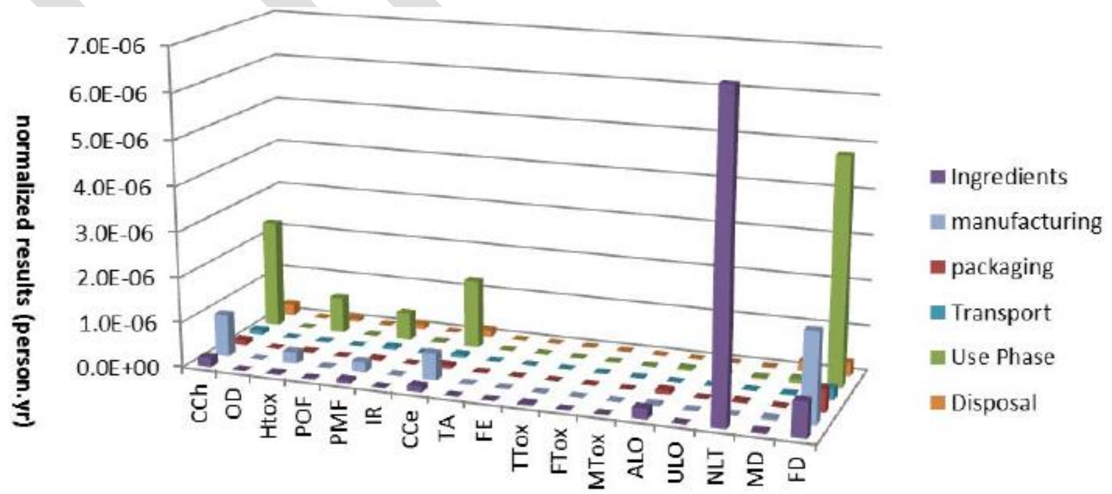
Sensitivity analysis: looked at a number of variables on assumptions in order to see how they would affect the results for relevant impact categories identified by the authors (CC, HTox, PMF, NLT and FD). This included dishwashing technique (full sink or direct application), reducing water use (3.75L, 7.5L or 15L), water temperature (15, 30 40 or 60°C), surfactant origin (100% petro, 100% oleo or 50/50 petro/oleo), dosage (4mL, 8mL or 16mL), electricity mix (EU, FR, CH or NL). The main conclusions from the sensitivity analyses on selected impact categories were:

[427] The authors referenced: Koehler A and C Wildbolz, 2009. Comparing the Environmental Footprints of Home-Care and Personal-Hygiene Products: The Relevance of Different Life cycle Phases. ES&T 43(22):8643-8651

- With the full sink method assuming a lower specific detergent consumption, lower water consumption and thus lower use phase energy consumption, it was unsurprising that the full sink method consistently reduced impacts across all impact categories reported. Reductions in all impact categories reported were similar, being in the range of 35% to 50% when compared to the direct application method.
- Reducing water consumption while keeping all other variables the same also meant a corresponding reduction in use phase energy consumption. Varying the volume of water used had very significant and similarly proportional effects on the CC, HTox, PMF and FD impact categories. The effect on the NLT impact category was much less, since these impacts are dominated by the surfactant ingredients.
- Changes in the wash water temperature from 40 to 30°C showed relatively minor changes (e.g. 10-15%) on the impact categories. However, going down to 15°C resulted in major reductions in impacts (e.g. 50-75%) except for NLT, where reductions were only around 15% since these NLT impacts are dominated by surfactant ingredients and not the use phase.
- Changing electricity grid factors from the EU average to the FR or CH national averages had a dramatic effect on LCA results (40 to 50% reductions on the baseline for all impact categories). This could be expected for FR (high degree of nuclear energy) and CH (high degree of hydropower). However, with the NL electrical grid, impacts for CC, NLT and FD actually increased, while those for HTox and PMF decreased in comparison to the EU average. This was probably linked to the significant share of natural gas combustion for electricity production in the NL.
- Under-dosing or over-dosing of detergent product by a factor of 2 (i.e. 4, 8 or 16mL) had a significant effect on all impact categories, especially on NLT. Halving the dose reduced impacts by 15-40%, while doubling the dose increased impacts by 25 to 45%.
- The effect of surfactant origin (i.e. oleo or petro-based or a mix of both) showed a major influence only on the Natural Land Transformation (NLT) impact category, with more oleo content creating an increase in NLT impacts. Changing the surfactant origin did not noticeably affect the CC and HTox impact. When shifting towards oleochemical sources, PMF impacts increased slightly while FD impacts decreased slightly.

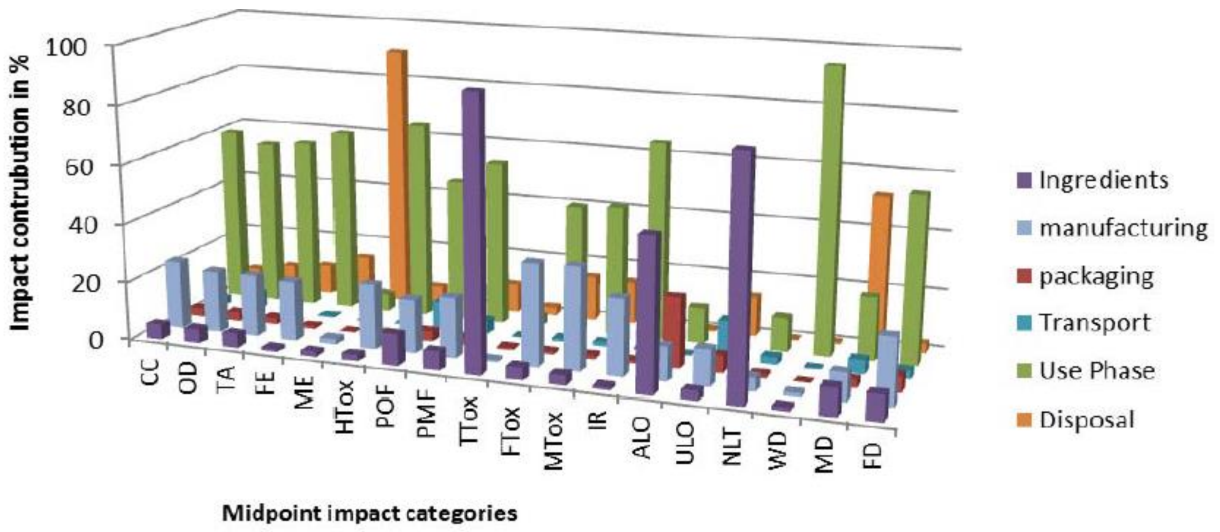
Main findings: In terms of the shares of environmental impact split by life cycle stage, the authors found the following results below.

Figure 563. Normalised (EU citizen, 2000) midpoint impact categories results for LCA of HDD reported by Arendorf et al., 2014c.



The single most significant endpoint was NLT and this was related to oleochemical-based surfactants in the ingredients stage. The next most significant impact category was FD, related to electricity consumption at during the use stage (to heat water) and then for electricity consumption at the manufacturing stage. Other notable impacts for CC, HTox and PMF were also linked at different life cycle stages to electricity consumption.

Figure 57. Midpoint impact categories results for LCA of HDD reported by Arendorf et al., 2014c.



For midpoint categories, there was a much more even split between life cycle stages than was previously observed with LD and DD products. This is largely due to the fact that use stage energy consumption is much less intense with hand dishwashing. The impact categories that were most dominated by a single life cycle stage were: ME – disposal stage; TTox – ingredients stage; IR – use stage; ALO – ingredients stage; NLT – ingredients stage; MD – disposal, and FD, use stage.

In sharp contrast to LD and DD products, the manufacturing stage was significant (i.e. ca. 20% or more) for 11 of the 18 midpoint impact categories. Packaging and transport stages remained insignificant for all impact categories, with the exception of ALO (ca. 20%) for packaging.

5.4.1.6.2. Moura et al., 2023

This study evaluated the environmental impacts of three different HDD products manufactured in Brazil. They followed ISO 14045 methodology (about "eco-efficiency") but the findings were considered relevant enough to be presented here in this LCA review. The study covered cradle-to-grave aspects, but did not seem to include packaging production or packaging disposal. While the authors carried out an LCA assessment according to three methods (ReCiPe, CML and AWARE), we focus on the ReCiPe results as this was the most commonly used method when reviewing the LCA literature.

Key assumptions: very specific transport distances were selected for the ingredients going to the formulation plant (ranged from 1272 to 2712km). Real estimates of factory to retailer store transport were estimated to be between 0 and 26km, depending on which detergent was being considered. Consumer transport was assumed to be 10km. To clean the 800 place settings a total of 1.2L of product A, 1.3L of product B or 1.33L of product C was assumed to be necessary.

A total of 768L of water was assumed to be consumed for the washing of 800 place settings (the same for all three detergents, presumably because dilution water for concentrated products was also counted, not clear though). All wastewater was assumed to go to a wastewater treatment plant.

Formulation: formulations were provided for three different hand dishwashing detergents (A, B and C - see Table 41). The main differences between them was the degree of concentration, which was reflected in the water content (90-95% for product B, 45-55% for product A and 20-25% for product C). Product B is considered as the "ready-to-use" format. The other main difference was that product A used EDTA as a chelating agent while the other two did not.

Main findings: The main results according to the ReCiPe analysis showed that the production of water and wastewater treatment dominated all the midpoint impact categories. The fact that water is dominating the impacts must be because some heating of water is assumed, but the authors did not mention this important detail, neither confirming that water was not heated or saying how and by how much it was heated. The shares of the top three contributing processes to each ReCiPe midpoint category were (in order of products A, B and C):

- Acidification: wastewater treatment (37.3%, 41.4%, 41.4%); water production (36.9%, 40.8%, 40.9%) and surfactants (6.8%, 6.5%, 7.4%).

- Freshwater eutrophication: wastewater treatment (73.8%, 77.1%, 77.0%); water production (15.9%, 16.6%, 16.6%) and surfactants (2.7%, 2.5%, 2.8%).
- Fossil resource scarcity: water production (31.0%, 37.3%, 37.2%); wastewater treatment (22.6%, 27.2%, 27.2%) and surfactants (17.3%, 18.1%, 20.4%).
- Mineral resource scarcity: water production (69.3%, 71.1%, 71.3%); wastewater treatment (23.7%, 24.3%, 24.4%) and surfactants (2.0%, 1.8%, 2.0%).

Overall, the results for the three detergents were very similar despite the fact that the concentrations of the formulations were very different. A more detailed investigation of variable during the use phase, for example with consumer overdosing risk being higher with the concentrated products, would have been interesting to see. Also, the fact that water consumption was assumed to be the same for all three products seems a gross over-simplification. Finally, since wastewater treatment and water production were considered to be the hotspots, a lot for information behind the assumptions with these inputs should have been provided.

5.4.1.6.3. Golsteijn et al., 2015

These results have already been presented in the earlier overview section, where HDD results were compared side-by-side to those of LD, DD and APC products in other studies published in parallel by the same authors.

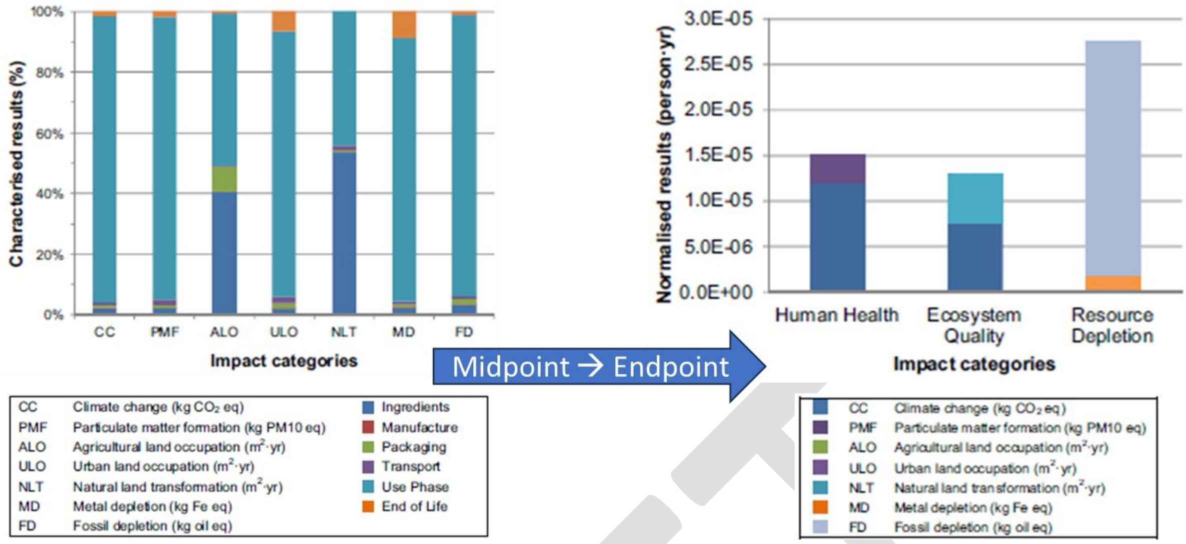
Key assumptions: the surfactant was assumed to be 100% oleochemical (mixture of palm oil-based and coconut oil-based). Many other assumptions were almost identical to those of Arendorf et al., 2014c. It was assumed that 8ml of HDD product was required to was 4 place settings using the full sink method, and that this increased to 12ml if using the direct application method. A wash water volume of 7.5L per 4 place settings (full sink method) or 15L per 4 place settings (direct application method). However, while a maximum temperature of 45°C was assumed for the full sink method, no higher because of discomfort for hands, a lower temperature was assumed for the direct application, since both warm and cold water would be used. These assumptions translated into an assumed energy consumption of 0.27kWh for heating the 7.5L of water with the full sink method and 0.30kWh for heating the 15L of water with the direct application method.

Regarding disposal, 100% of wastewater was assumed to go to at least secondary treatment and recycling rates of 83.2% and 31.9% were assumed for cardboard for plastic packaging respectively. Any non-recycled packaging was part landfilled (65.3%) or part incinerated (34.7%). The assumptions on waste were linked to Eurostat data from 2012.

Formulation: a full formulation was provided for a typical hand dishwashing detergent (see Table 41). In any case, the formulation was dominated by softened water (83-85%) and a mix of anionic and non-ionic surfactants (13.85%).

Main findings: the results were presented graphically for HDD products with the full sink method in terms of both midpoint categories by life cycle stage, and endpoint impacts with a breakdown by contributing category.

Figure 584. ReCiPe midpoint and endpoint impacts for an HDD product used in the full sink approach. Source: Golsteijn et al., 2015.



The use phase dominated (i.e. 86-98%) all of the midpoint impact categories due to the electricity consumed to heat washing water. The only exceptions were the ALO and NLT impact categories, where the use phase shares were reduced to 44% of NLT and 50% of ALO. In these cases, impacts on NLT and ALO were being taken up by the oleochemical surfactant ingredients (around 40% of ALO and just over 50% of NLT).

When looking at normalised endpoint results, resource depletion (dominated by fossil resource depletion) was the main impact. Climate change was the next most significant normalised impact, followed by NLT (ingredient-related) and PMF (electricity-related).

5.4.1.6.4. Van Lieshout et al., 2015

These authors presented LCA results according to the ReCiPe endpoint analysis for 4 products, 2 of which were HDD products (referred to in the article as “dish soap”).

Key assumptions: the authors assumed that 5299 kg of water is used for hand dishwashing by the time 1kg of HDD product has been consumed. Only a vague reference to a USGS survey was made with regards to average L of water consumed for hand dishwashing, but no values were defined in the text. Average transportation distance for supplier to factory (1200km by truck), factory to regional distributor (3400km by freight train) and regional distributor to user (800km by biodiesel truck) were also assumed. While these assumed distances make sense in the US, they are very long for a European context.

Formulation: no formulations were provided in the article. It was only stated that across the 4 products studied, one all-purpose cleaner, one hand soap and two HDD products) a total of 19 ingredients were used.

Main findings: the authors found that ingredients accounted for 40-50% of total endpoint impacts and that the most important ingredient by far was SLS. It is also worth pointing out that the authors, after not finding an ecoinvent entry for SLS, used a proxy of 60% fatty alcohol sulfate and 40% sodium carbonate. The use phase accounted for most of the rest of endpoint impacts (ca. 35% or 45% of totals).

When looking at individual ReCiPe impact categories, the authors found that Climate Change was the most significant, closely followed by Fossil Depletion, then Natural Land Transformation and finally Human Toxicity.

5.4.1.7. Overview of LCA literature on hard surface cleaners (HSC)

The following literature was reviewed which involved the consideration of hard surface cleaning products from a life cycle perspective.

Table 33. Basic details of studies reviewed regarding the LCA of hard surface cleaners (HSC)

Primary author and year	Ingredients	Formulation	Packaging	Transport	Use	EoL	Functional unit	Method
Arendorf, 2014d	X	X	X	X	X	X	Cleaning of a 0.24m2 area.	ReCiPe method, reported on midpoint and endpoint indicators.
Golsteijn, 2015	X	X	X	X	X	X	1m2 of cleaned surface (for window or bathroom cleaner) Cleaning of one toilet bowl (for toilet cleaners)	Used the full suite of midpoint and endpoint indicators from the ReCiPe method.
Kapur et al., 2012	X	X	X	X	X	X	Annual cleaning of 100,000 sqft of office floor space (assuming 50% carpet).	Used the ReCiPe method with the main impact categories.
Van Lieshout, 2015	X	X		X	X	X	Not clearly defined, but presumably 1kg of product.	Used the ReCiPe method and reported on endpoint impacts.
E COSI, 2022 (in Italian)	X	X	X	X	X	X	1kg of detergent product.	Method followed was in accordance with EPD product category rules in the Environdec system.
Nessi, 2014			X				1000 litres of detergent product.	Not so clear what the methods was, but the impact categories reported included: GWP, ODP, POFP, AP, EP, Ecotoxicity, Human Toxicity, PM and various resource depletion categories.
Villota-Paz, 2023	X	X	X	x			1 litre of BLD (equivalent to around 20 washes)	Used the ReCiPe method and reported on selected midpoint indicators and the 3 endpoint indicators.
Lucchetti, 2019	X	X		x			1 tonne of soap	Ecoindicator99 method used, reporting on 11 normalised impact categories.

Compared with laundry detergents, fewer LCA studies could be found for hand dishwashing detergents. In the next sub-sections, we present some of the most pertinent points relating to LCA impacts associated with hand dishwashing detergent (HDD) products.

5.4.1.7.1. Arendorf et al., 2014d

These results have already been presented in the earlier overview section, where all-purpose cleaner (APC, a sub-category of HSC) results were compared side-by-side to those of LD, DD and HDD products in other studies published in parallel by the same authors.

Key assumptions: the authors assumed a specific manufacturing energy consumption of 3.2 MJ/kg HSC product[428]. The average EU energy mix from ecoinvent was used for all electricity flows. The study did not evaluate emissions to wastewater due to a lack of data and the nature of use of HSC products. A detailed set of assumptions for primary and secondary packaging were provided, and transport of raw materials was assumed to be 8000km by boat for renewable raw materials for surfactants, and 2000km by lorry for other ingredients (except water).

For the use phase with trigger sprays, an average of 5 sprays per 1m2 of surface were assumed, consuming 4.7g of HSC product. Together with this, an estimated 0.04 kWh of electricity was assumed to be consumed in the use phase thanks to the use of an average of 0.55L water at 40°C.

[428] The authors referenced: Koehler A and C Wildbolz, 2009. Comparing the Environmental Footprints of Home-Care and Personal-Hygiene Products: The Relevance of Different Life cycle Phases. ES&T 43(22):8643-8651

Regarding disposal, recycling rates of 83.2% and 31.9% were assumed for cardboard for plastic packaging respectively. Any non-recycled packaging was part landfilled (65.3%) or part incinerated (34.7%). The assumptions on waste were linked to Eurostat data from 2012.

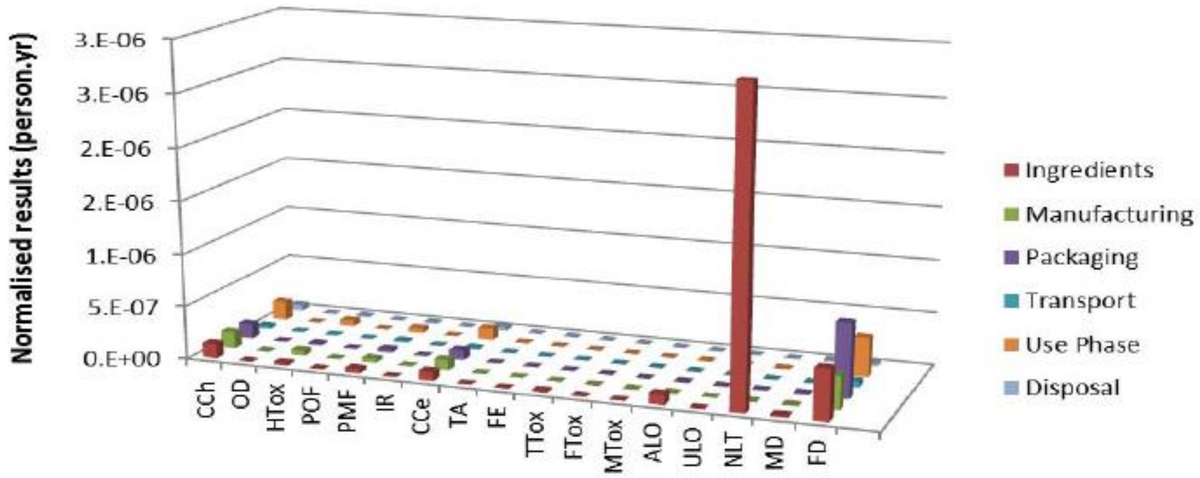
Formulation: an estimated formulation was provided for a typical all-purpose cleaner (see Table 42).

Sensitivity analysis: looked at a number of variables on assumptions in order to see how they would affect the results for relevant impact categories identified by the authors (CC, ALO, NLT and FD). This included changes in formulation (conventional vs green compliant vs worst case conventional), temperature of the water used (ambient, 30 40 or 50°C), quantity of water used (none, 0.55L, 1.1L or 1.65L), surfactant origin (100% petro, 100% oleo or 50/50 petro/oleo), dosage (half, normal, double or triple), electricity mix (EU, FR, CH or NL). The main conclusions from the sensitivity analyses on selected impact categories were:

- The worst-case conventional formulation generally meant higher concentrations of the active ingredients compared to the conventional baseline formulation. The green-compliant formulation actually used different ingredients (e.g. sodium citrate instead of sodium hydroxide and sodium carbonate, and some different types of surfactant). While the worst case conventional formulation was always worse, the green compliant formulation was sometimes better and sometimes worse in individual impact categories – this was especially influenced by origins of surfactant raw materials.
- The effect of surfactant origin was examined using different generic datasets from ecoinvent (unspecified origin, palm oil, palm kernel oil, coconut oil and petrochemical). When looking at results for the CC, ALO, NLT and FD impact categories, the worst result overall was coconut oil, especially on the land-related categories of ALO and NLT.
- Varying the dosage of the HSC product had almost directly proportional effects on the results for CC, ALO, NLT and FD impact categories – highlighting the dominant effect that upstream life cycle stages have on the overall LCA results.
- Reducing warm water consumption in the use stage had the most significant effects on CC and FD impact categories and a much less significant effect on the land-related indicators (NLT and ALO) because less warm water meant less electricity consumption (CC and FD impacts dominated by this aspect). The authors confirmed that reducing warm water consumption also reduced other impacts such as FE, HTox and IR.
- Changing electricity grid factors from the EU average to the FR, CH or NL national averages had a dramatic effect on LCA results (40 to 65% reductions on the baseline for CC, ALO, NLT and FD impacts). This could be expected for FR (high degree of nuclear energy) and CH (high degree of hydropower). However, with the NL electrical grid, impacts for CC, NLT and FD actually increased, while those for HTox and PMF decreased in comparison to the EU average. This was probably linked to the significant share of natural gas combustion for electricity production in the NL.

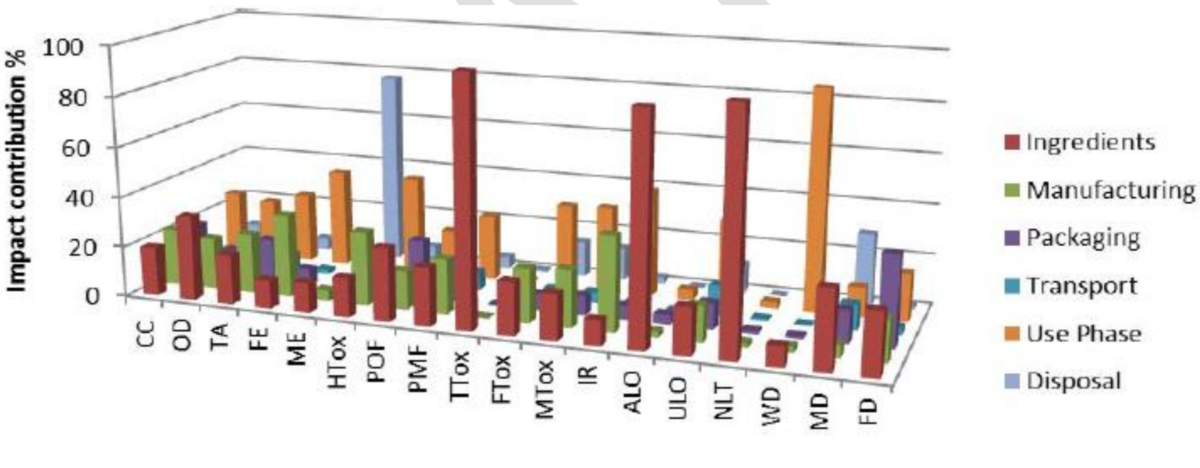
Main findings: In terms of the shares of environmental impact split by life cycle stage, the authors found the following results below.

Figure 59. Normalised (EU citizen, 2000) midpoint impact categories results for LCA of HSC reported by Arendorf et al., 2014d.



The single most significant normalised midpoint impact by far was NLT and this was purely from the ingredients stage. The next most significant midpoint impact was FD, whose sources of impacts were quite evenly shared between the ingredient, manufacturing, packaging and use phase stages. Packaging dominated because of the relatively high shares of plastic packaging used for products that tend to contain a lot of water.

Figure 60. Midpoint impact categories results for LCA of an HSC product reported by Arendorf et al., 2014d.



Compared to LD or DD products, the impacts are much more evenly shared across different life cycle stages. This can be considered to be due to the fact that the use stage is much less energy intensive and that ingredients are generally more dilute, so manufacturing and packaging become more relevant. Nonetheless, some impacts were still clearly dominated by one life cycle stage, for example WD (water consumed in the use stage); ALO and NLT (oleochemical raw materials for surfactant ingredients); TTox (ingredients) and ME (disposal stage). The authors did not specify which ingredient(s) were the main sources of TTox impacts and the report did not clearly explain how wastewater from the use of HSC products would end up in wastewater treatment plants (quite obvious for toilet cleaning, some assumptions would be needed for floor cleaning and need to consider some cleaning without any water (i.e. direct from spray).

5.4.1.7.2. Golsteijn et al., 2015

This study looked at 4 different HSC type detergent products, one window/glass trigger spray product; one bathroom cleaner trigger spray product; one acid-based toilet cleaner product and one bleach-based toilet cleaner product.

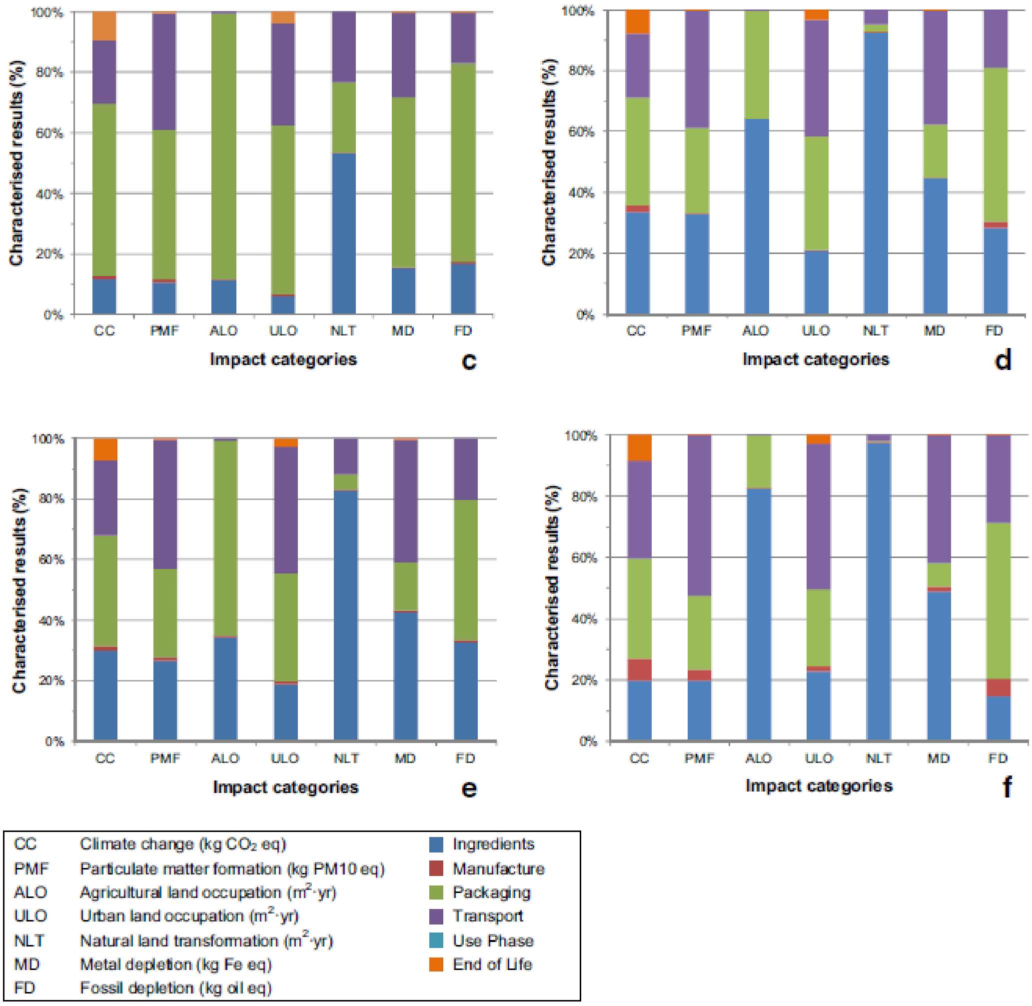
Formulations: only ranges of ingredients were provided and these have been compiled in Table 42.

Table 34. Key assumptions for the 4 HSC products studied by Golsteijn et al., 2015

	Window/glass cleaner spray	Bathroom cleaner spray	Acid-based toilet cleaner	Bleach-based toilet cleaner
Reference flow	10mL to clean 1m2 of surface		50mL for one clean of bowl	80mL for one clean of bowl
Transport to factory	8000km for oleochemicals for surfactants, 2000km by lorry for other ingredients			
Production waste	0.01%			
Transport to retailers	1200km by lorry			
Unit size	750mL			
Primary packaging per unit	34g PET bottle, 31g PP spray; 2g paper label	48g HDPE bottle, 21.7g PP spray; 1.5g paper label	46g HDPE bottle, 10.4g PP cap, seal & nozzle; 0.86g PE spout, 2g paper label	42g HDPE bottle, 8.2g PP spout, 4.3g PP cap; 2.4g paper label
Secondary packaging per unit	21.5g cardboard	34.1g cardboard	23.5g cardboard	23.5g cardboard
Packaging recyc. rates	Paper & board: 83.2%; Plastic 31.9%			
Non-recyc. waste fate	Landfill 65.3%; Incineration: 34.7%			

Main findings: A comparison of LCA results split by life cycle stage in terms of selected ReCiPe midpoint impact categories are presented below for the four different HSC products analysed.

Figure 61. Comparison of ReCiPe midpoint indicators for 4 different HSC products (c-window/glass cleaner; d-bathroom cleaner spray; e-acid-based toilet cleaner, and f-bleach-based toilet cleaner). Source: Golsteijn et al., 2015.



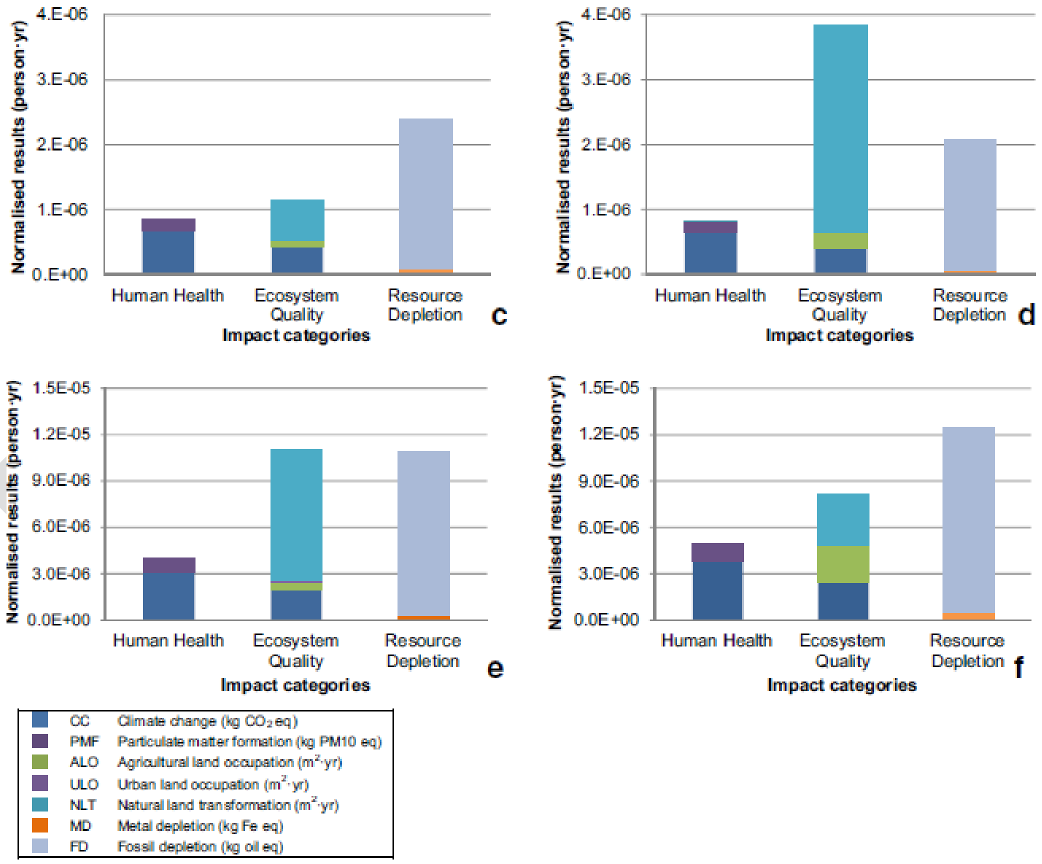
The relevance of different life cycle stages for all HSC products was completely different from LD and DD products, and notably different from HDD products, because the use phase is completely irrelevant for all of the impact categories shown above (CC, PMF, ALO, ULO, NLT, MD and FD). This was because no warm water was assumed to be used during the use stage.

For all four types of HSC products, NLT impacts were clearly dominated by the ingredients stage (especially due to oleochemical sources for surfactants). Generally speaking, the ingredients stage was least significant with the window/glass cleaner, which had the highest water content (>93%), but even in this case, ingredients consistently accounted for at least 10% of each impact category. ALO impacts for the packaging stage were dominated by the cardboard in secondary packaging.

As a general rule, whenever impacts with ingredients because less significant, this made impacts with packaging and transport more significant. The share of impacts associated with packaging compared to transport decreased in the following order (packaging more significant first): glass/window spray cleaner > acid-based toilet cleaner ≈ bathroom spray cleaner > bleach-based toilet cleaner.

Despite the lack of impacts from the use phase, the manufacturing and end-of-life disposal impacts were still insignificant for all 4 HSC products.

Figure 62. Comparison of normalised ReCiPe endpoint impacts for 4 HSC products broken down by contributing midpoint impact categories (c-window/glass cleaner; d-bathroom cleaner spray; e-acid-based toilet cleaner, and f-bleach-based toilet cleaner). Source: Golsteijn et al., 2015.



In terms of endpoint impacts, although ecosystem and resource impacts were always higher than human health impacts, the results varied considerably between different HSC products. For the bathroom spray cleaner, the ecosystem impact was almost twice as high as resource depletion, whereas for the window/glass spray cleaner, it was the opposite, with resource depletion being twice as high as ecosystem impacts.

Fossil depletion impacts were quite consistent when comparing the two spray cleaners (c and d) and when comparing the two toilet cleaners (e and f). Fossil depletion impacts were dominated by the consumption of polymer resin for making plastic primary packaging. The two big variables in endpoint impacts where associated with changes to the NLT and ALO impact categories, which are closely linked to the type of ingredients and the sourcing of raw materials to make them (more oleochemical → higher NLT and ALO impacts) and the amount of cardboard required in secondary packaging (more board → higher ALO impacts).

5.4.1.7.3. Kapur et al., 2012

This study looks at a total of 7 HSC products: three types of all-purpose cleaner (conventional, Green Seal glucoside-based and Green Seal H2O2-based), two types of glass cleaner (conventional and Green Seal) and two types of bathroom cleaner (conventional and Green Seal).

Formulations: only ranges of ingredients were provided and these have been compiled in Table 42.

Key assumptions: the study was focused on the US and the functional unit was based on a defined office space (100,000 sq ft, 50% of which is carpeted). This area and the USEPA "Green Cleaning Pollution Prevention Calculator" was used to defined the quantities of HSC products needed for one year. Based on this, the reference flows for the functional unit were calculated as:

- 79.5 kg/year of all-purpose cleaner
- 88.1 kg/year of glass cleaner
- 109.0 kg/year of bathroom cleaner.

Primary packaging materials were assumed to be virgin HDPE, with 1 US gallon (3.78 L) containers weighing 120g and 32oz (909 mL) containers weighing 65g. Transport from factory to final use was estimated to be 1600km by a diesel truck.

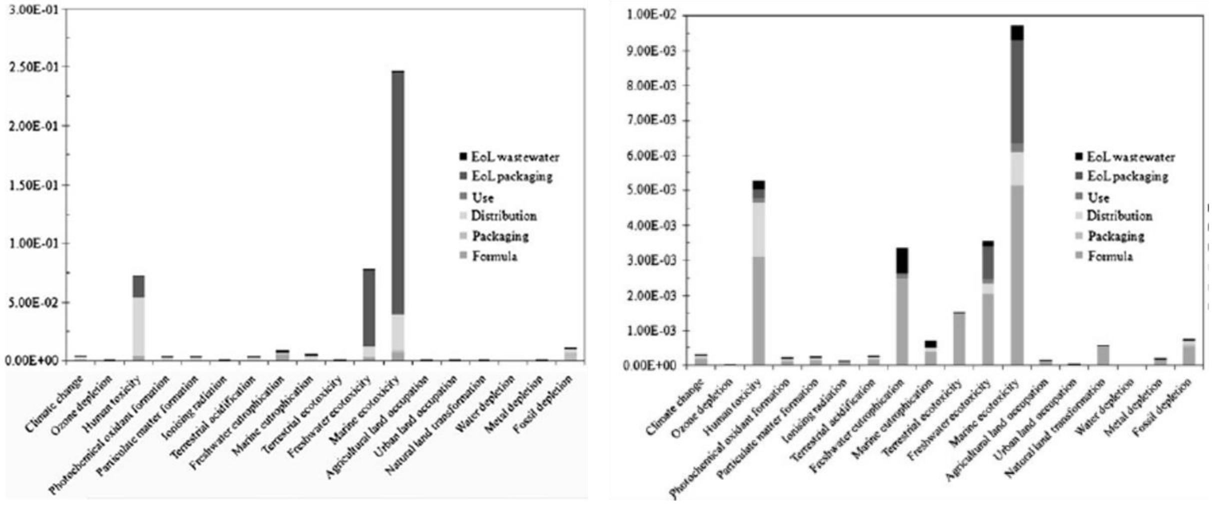
The dilution of the product before use was assumed to differ by a factor of two, with the Green Seal products assumed to need twice as much dilution as the conventional ones. For the all-purpose cleaners, the specific dilution ratios assumed were 1:32 for Green Seal, and 1:16 for conventional. For the glass and bathroom cleaners, the specific dilution ratios assumed were 1:16 for Green Seal and 1:8 for conventional.

The consumption of mops, clothes and any wipes during cleaning were excluded from the study as this would not be a point of differentiation when comparing products.

Main findings: for all-purpose cleaners, the results for ReCiPe midpoint indicators showed that the Ready-To-Use conventional product had the highest results for 13 of the 18 impact categories (CC, HTox, POF, PMF, IR, TA, FE, ME, TEcoT, FEcoT, MEcoT, WD, MD and FD). The glucoside-based Green Seal all-purpose cleaner was the highest for the other 5 impact categories (OD, TecoT, ALO, ULO and NLT).

Due to 7 different HSC products being compared, there are lots of possible comparisons that could be made. Details of raw data are provided in online supplementary material. A useful comparison of ReCiPe normalised endpoint impacts for a ready to use conventional all-purpose cleaner and the glucoside-based Green Seal all-purpose cleaner are shown below.

Figure 63. Normalised ReCiPe midpoint impact categories for a ready to use APC product (left) and a Green Seal compliant APC that is based on glucoside (right). Source: Kapur et al., 2012.



The comparison above would have been easier to understand if the normalised impacts for both products had been on identical scales on the y-axis. The left-hand y-axis actually reads 3.00E^{-01} at the top, while the right-hand y-axis reads 1.00E^{-02}. This is a factor of 30 difference in scale. Consequently, it can be said that normalised impacts were much higher or at least comparable for the conventional ready to use all purpose cleaner than the Green Seal glucoside-based product.

In terms of individual impact categories, the most relevant by some distance was ME (Marine Eutrophication), followed by Human Toxicity (HTox) and Freshwater Ecotoxicity (FEcoT).

In terms of life cycle stage contribution, the ingredients (formula) stage was by far the most significant for the Green Seal all-purpose cleaner, while it was the End-of-Life stage that was most relevant for the convention ready to use all-purpose cleaner.

Sensitivity analysis: the authors found that replacing petrochemical-based ethoxylated alcohol (AE7) surfactant with the same chemical, but from coconut oil sources, led to and increase in ALO by 146% and an increase in NLT by 238%. But reductions in CC, FD and non-renewable energy were all less than 15%.

Changing the transport distance from factory to final use from 1600km to 160km for the all-purpose cleaners showed some significant reductions (i.e. >10%) in the CC, HTox, POF, PMF, TA, ME, FD and non-renewable energy. The biggest reductions were for CC, HTox, POF, PMF and TA. The improvements were consistently more substantial for the conventional ready-to-use (RTU) product than the glucoside Green Seal product. This will be due to the fact that the Green Seal product was assumed to need twice as much dilution, implying that the RTU product is half as concentrated. Less concentrated products will have proportionately larger transport impacts for a given functional unit, since the quantity of product to ship for a given job is much higher.

5.4.1.8. LCA relevant issues for detergent packaging

The evolution of detergent products in the last 10 years is worth considering because this was how long ago since preliminary research was conducted for the current EU Ecolabel criteria development for detergent products. In this section, a brief mention is made of how product evolution could affect environmental impacts.

Shift to more concentrated products (for LD, DD, HDD and HSC, except trigger sprays)

More concentrated products require less packaging per dose and generally less transport impacts at the distribution stage. Packaging reduction can lead to important improvements in hand dishwashing detergents and hard surface cleaners, but these improvements can be cancelled out or lead to higher overall impacts if consumers do not adapt their behaviour to using lower doses with more concentrated products. With concentrated liquid laundry detergents, the improvement potential is less, but the same issue exists, namely that the risk of overdosing is very real according (Paloviita and Jarvi, 2008).

Shift to refill packs and in-store distribution to reusable containers (not for pods and capsules)

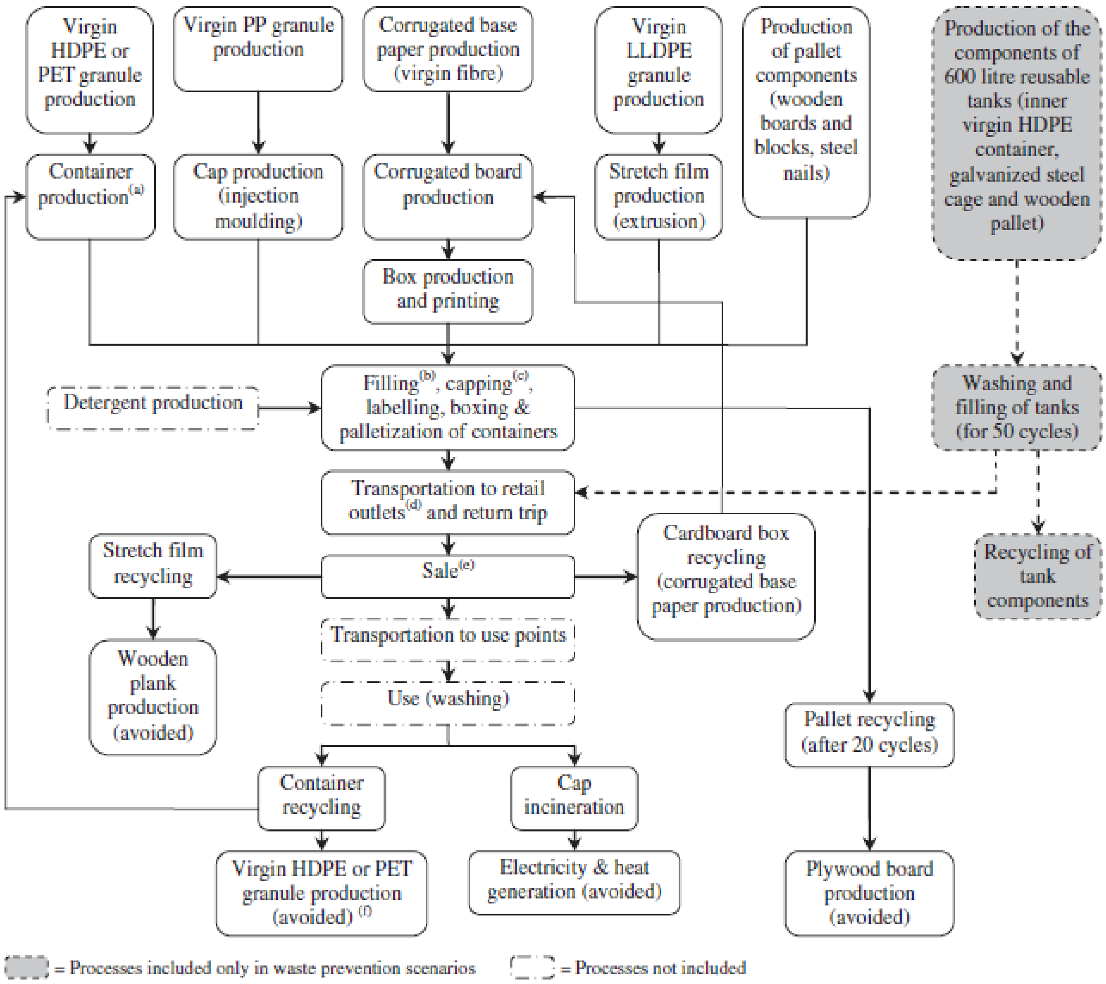
Refill packs can result in more or less significant savings in packaging. For example, less significant in terms of refill bottles for trigger spray hard surface cleaners (where the refill pack is almost identical, just missing the trigger spray), and more significant in terms of pouches for liquid laundry detergents. In the latter case, the refill pouches can often contain 70% less plastic than the rigid plastic bottles that they would refill. However, there are a number of potential trade-offs with the refill pouches. For example:

- The refill pouches have to be made of virgin plastic while the rigid PET or HDPE containers can high contents of recycled material.
- The refill pouches need to use large amounts of plasticiser and additives.
- The refill pouches are not easy to recycle, while the rigid PET or HDPE containers are.
- This risk of accidental tears and misalignment during the detergent packing process - leading to production loses - is generally higher with refill pouches than with rigid plastic containers.
- To prevent damage during storage and distribution, secondary packaging of refill pouches generally uses thicker cardboard than that used with rigid PET or HDPE containers.

While there are no published studies that breakdown these numbers and quantify trade-offs, they should be considered before proposing any potential criterion that requires or rewards this type of packaging.

The other way of reducing packaging impacts is to consider an in-store dispenser for detergent products where consumers bring their empty bottle to the store and fill it up from a larger tank located in the store, before paying by mass or volume filled. In a scenario where consumers could fill 1L reusable containers with dishwashing detergent, Scharpenberg et al., (2021) showed that significant improvements could be made when focusing the assessment only on the stages relating to packaging use and transport. In another paper, the following system boundaries were used in a study focusing solely on liquid detergents:

Figure 64. Main processes included in system boundary of liquid detergent refill study. Source: Nessi et al., 2014.



Nessi et al., (2014) found that the packaging-related impacts with single use containers reduced when using HDPE instead of PET and reduced as container volumes increased. With reusable containers, environmental benefits only become evident after at least 5 refills and even then, there are concerns about increased exposure of users to potentially toxic chemicals during the cleaning, transport and refilling of used containers.

5.4.1.9. Oleochemical versus petrochemical origins for surfactant compounds

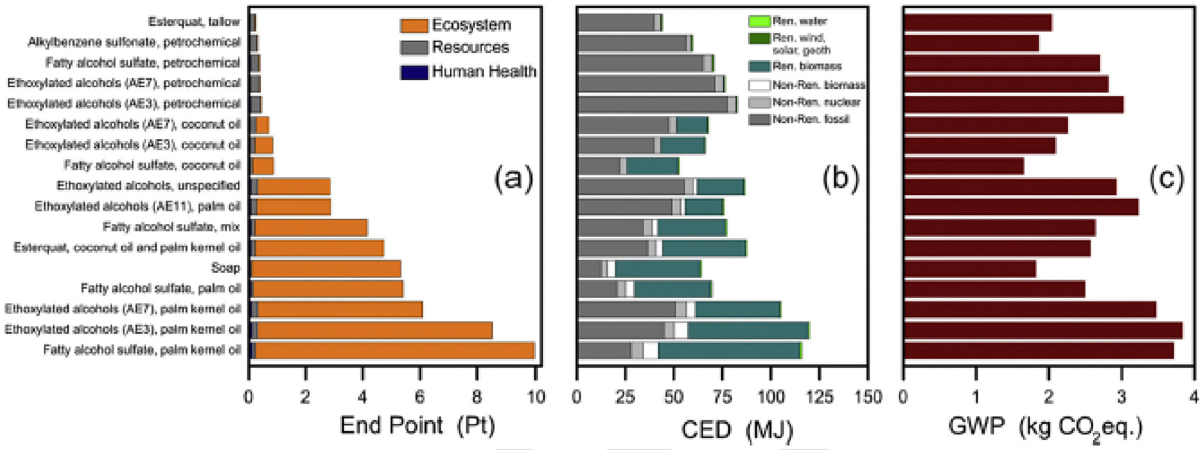
Surfactants are the universal ingredient present in virtually all detergent products. From a cradle-to-gate perspective, surfactants account for significant shares of environmental impacts. The production of surfactants is an energy intensive process involving alkylation and sulfonation of oil-based precursor materials.

A shift from petrochemical sources to oleochemical (i.e. bio-based) sources for precursor materials has been one of the most apparent marketing strategies for detergent brands in their green claims, stating a "% plant-based ingredients content". From an LCA perspective, moving to oleochemical sources such as palm kernel oil or coconut oil should offer clear benefits in terms of reducing impacts associated with fossil fuel resource depletion, but would be expected to come at the cost of higher impacts associated with land use.

When looking from a cradle-to-gate perspective, Thannimalay and Yusoff (2014) found that making Linear Alkyl Benzene Sulfonate (LAS) from petrochemical sources or Methyl Ethyl Sulfonates (MES) from palm oil showed that the palm-oil product had a number of much higher midpoint impact categories (carcinogens, ionising radiation and acidification, eutrophication, land use and mineral resource depletion). On the other hand, the petrochemical-based LAS had higher impacts only in fossil resource depletion and ecotoxicity. This led the authors to conclude on the need for palm oil production processes to be greatly improved.

When looking at individual surfactant chemicals from different LCA method perspectives and impact categories, Giagnorio et al., (2017) found some notable differences at the cradle-to-gate level.

Figure 655. Cradle-to-gate results for the production of different surfactant chemicals. Source: Giagnorio et al., 2017.



By far the most significant differences between surfactant chemicals was with ReCiPe endpoint indicators, specifically the ecosystem impact. Although all the substances are slightly different in Figure 65 and may have different reaction chemistries, there was at least two chemicals that could be directly compared for Palm kernel oil-basis, coconut oil-basis and petro-basis, namely “Ethoxylated alcohols (AE7)” and “Ethoxylated alcohols (AE3)”. As a general rule, the surfactants based on palm kernel oil had the highest impacts, followed by palm oil, the coconut oil and then petrochemical or tallow-based surfactants.

In the sensitivity analysis conducted by Arendorf et al., (2014a, 2014b, 2014c and 2014d) the main effects of changing petrochemical for oleochemical surfactants are shown below. Red text in the table approach is used to highlight very significant increases in impacts, while green text is used to highlight any reductions in impacts (both relative to the petrochemical-based surfactant results).

Table 35. Effect of changing from petro- to oleo-chemical sources on cradle-to-grave LCA results of selected impact categories for different detergent products. Sources: Arendorf et al., 2014a, 2014b, 2014c and 2014d.

Impact category	Laundry Detergent		Dishwasher Detergent		Hand Dishwashing Detergent		Hard Surface Cleaner		
	Petro-	Oleo-	Petro-	Oleo-	Petro-	Oleo-	Petro-	Oleo-CO	Oleo-PKO
POF	100%	100.0%	100%	100.0%	100%	101.3%	100%	110.3%	96.6%
PMF	100%	100.9%	100%	100.0%	100%	100.0%	100%	115.4%	100.0%
TEcoT	100%	157.0%	100%	149.8%	100%	1850.6%	100%	8750.0%	10000.0%
ALO	100%	111.7%	100%	102.8%	100%	284.7%	100%	456.3%	1437.5%
NLT	100%	99.9%	100%	100.0%	100%	665.8%	100%	110.0%	3100.0%
MD	100%	100.0%	100%	100.0%	100%	103.6%	100%	121.7%	117.4%
FD	100%	98.0%	100%	100.0%	100%	95.9%	100%	94.7%	94.7%

All other impact categories not mentioned above had only minor changes between petro- and oleo-chemically sourced surfactants. In general, the changes in impacts caused by moving to oleochemical sources were largest with the Terrestrial EcoToxicity impacts, followed by Natural Land Transformation and the Agricultural

Land Occupation. These impacts are clearly linked to potential deforestation impacts caused by palm oil and palm kernel oil production in Indonesia and Malaysia in particular.

Another pattern can be observed when comparing particular impact categories across the different detergent products. Impacts were greatest with HSC products, then HDD products and then, at much less extreme levels, with LD and DD products. This trend follows the pattern of a progressively less energy intensive use phase. As the use phase becomes less significant, the ingredients stage becomes relatively more important, a thus so does the effect of changing the surfactant precursor origin.

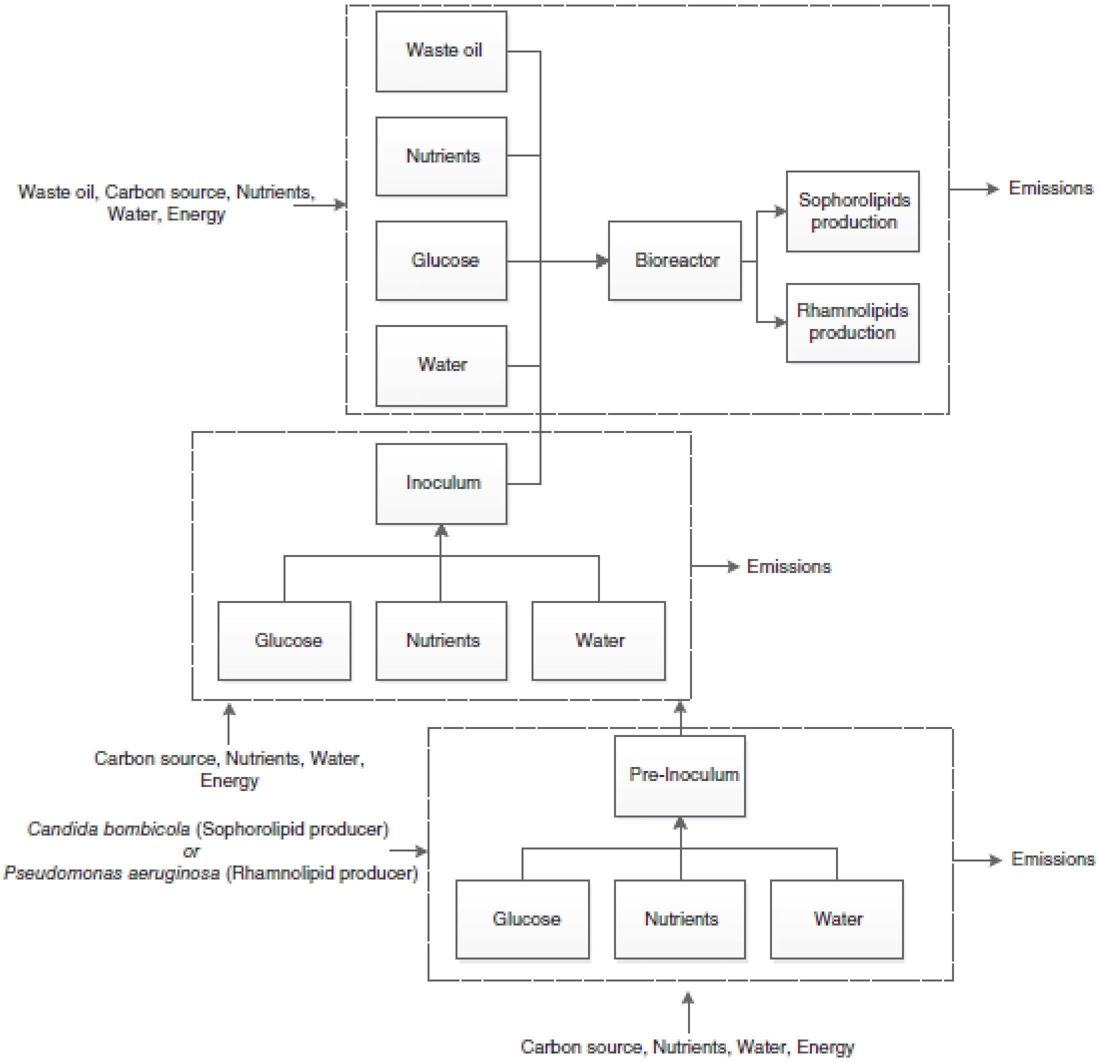
However, in terms of benefits of shifting from petrochemical to oleochemical precursors, only a marginal (ca. 5%) benefit was found in reducing fossil resource depletion. These findings should be carefully examined in the in-house LCA studies to be conducted and will also need to be considered when dealing with rationale for any criteria relating to palm oil or requirements for bio-based or plant-based ingredients.

5.4.1.10. The emergence of microbial-based surfactants

Research into the production and use of biosurfactants is a rapidly growing field but there are only a handful or articles that investigate the potential life cycle impacts of these substances (Briem et al., 2022). There are major potential LCA benefits with microbial-based biosurfactants because they can be produced anywhere (unlike the petrol-, palm oil- or coconut oil-based surfactants) and can directly produce the biosurfactant compounds needed, with the only processing being limited to separation and concentration of the desired compounds.

The production process can be broadly split into three main stages: pre-inoculum, inoculum and bioreactor, as shown below.

Figure 66. Overview of main cradle-to-gate production of microbial-based biosurfactant production. Source: Kopsahelis et al., 2018.



Following the figure above, some major variables that can be expected to affect the LCA results are:

- Nutrient source for pre-inoculum, inoculum and bioreactor stages.
- Yield factors in the bioreactor.
- Whether the bio-reactor is operated in batch, semi-continuous or continuous mode.
- Recovery of solvents from separation stages.
- Efficacy and toxicity profile of biosurfactants produced.
- Generation of co-products together with biosurfactants

A purer nutrient source may be necessary at the pre-inoculum and inoculum stages due to risks of contamination with foreign micro-organisms. However, the bioreactor may be able to accept nutrient sources from any number of carbon and nitrogen rich waste sources or secondary products. Some examples include waste cooking oil (Lipens et al., 2021) and brewery residues (Correa Nazareth et al., 2021).

Yield factors reported in the literature vary a great deal. Yields will depend on many factors, especially on the type and specific strain of micro-organism. There is the potential for genetically modified micro-organisms to be tailored to the specific bio-reactor conditions. For any given micro-organism, the bio-reactor conditions can be optimised for yield, considering variables such as temperature, pH, salinity, micro-nutrient levels, oxygen levels and light levels.

While biosurfactants are generally considered to be less toxicity and more biodegradable than oleochemical or petrochemical alternatives, there is a need for more substantial data as these substances are commercialised. These factors will affect results for LCA impact categories related to ecotoxicity, human toxicity and eutrophication.

Microbial activity will inevitably produce other materials apart from biosurfactants and there is the potential to separate other co-products from liquor and dead cells, such as sugars, proteins and enzymes. Allocation methods for any co-products could have a major influence on LCA results for biosurfactant production but nothing has been reported on this so far in the LCA literature.

Another major limitation with the limited LCA data available for microbial-based surfactants (Guilbot et al., 2013; Baccile et al., 2017; Kopsahelis et al., 2018; Lokesh et al., 2019 and Briem et al., 2022) is that all primary data is associated with laboratory or pilot scale systems. Data at a full industrial scale would most likely result in a more efficient process, but how much more efficient is difficult to predict.

A comparison of oleochemical and petrochemical surfactants is quite simple because the final substance is effectively the same, it is the source of raw materials and their processing that differs. However, microbial-based biosurfactants are completely different compounds and their efficacy will be different. Therefore, a one-to-one comparison is unlikely to be justifiable if attempting to compare the effects of changing from a conventional surfactant to a microbial-based biosurfactant in an LCA study.

A useful proxy for determining the efficacy of a surfactant is the Critical Micellar Concentration (CMC) (Monteiro Vieira et al., 2021) and some general commentaries imply that microbial-based biosurfactants are more efficacious (i.e. having lower CMC values) (Sharma et al., 2021).

5.4.1.11. Summary of key published studies

A comprehensive screening exercise has been conducted in order to find relevant literature for LCA studies related to the four main types of detergent product (LD, DD, HDD and HSC), and also for studies relating to key ingredients (especially biosurfactants).

In total, some 45 studies were identified as sufficiently relevant for screening. Many studies offered one or two points of interest, but there were very few studies that were sufficiently comprehensive and provided sufficient details to be of direct use in the subsequent EFIA studies that will be carried out.

Despite these limitations, some clear patterns emerged from the LCA literature review, which will help inform the criteria review process for EU Ecolabel detergent products.

- The importance of use-stage impacts are very important for LD and DD products. In these cases, use stage impacts were dominated by the consumption of electricity to heat water.
- The use stage impacts of HDD products rely on assumptions made about the temperature and quantities of water used and the dosage rates of HDD product. Due to the manual and highly variable nature of hand dishwashing, there is high uncertainty in assumptions for this stage.
- As use stage impacts decrease, the relative shares and importance of ingredients, transport and end-of-life increase. This was evident when comparing relative life cycle stage contributions for HSC and HDD products (relatively low use stage contribution) with LD and DD products (relatively high use stage contribution).
- Packaging impacts were most significant with the HSC and HDD products, although the benefits of using recycled content versus virgin material, of using HDPE versus PET and so on have only been investigated to a very limited extent in the literature.
- Impacts associated with land use were very sensitive to the choice of raw material used to make organic chemical ingredients (i.e. petrochemical versus oleochemical feedstocks). A shift from petrochemical to oleochemical (e.g. palm oil, palm kernel oil or coconut oil) created a modest reduction in impacts on fossil resource depletion, but caused hugely significant increases in land use impacts.
- The contribution of impacts during the product manufacturing stage (i.e. the factories where products are formulated) was very low for all detergent product types and for all impact categories.

The results in the literature were almost exclusively using well established LCA methods from several years ago, especially using the ReCiPe method and ecoinvent datasets. The few studies relating to PEF methodology (basically Castellani et al 2019 and the PEFCR from 2019) also did not use the most recent EF datasets or the updated methodology that was only made public in 2021. Nonetheless, the formulation data and modelling assumptions used in the literature can serve as an initial contribution to the data gathering exercise that will help contribute to the screening LCA studies that appear later in this chapter.

5.4.2. Data gathering exercise for LCA studies

The most challenging parts of conducting any LCA study is in the gathering of data. With detergent products, the biggest challenge is in obtaining information on the substances used as ingredients and their relative concentrations. Since the exact formulation is commercially sensitive information, it is generally not made available except via non-disclosure agreements (NDAs).

5.4.2.1. Identifying suitable datasets for the LCA studies

There are hundreds of substances that can be used in the detergent products covered by the EU Ecolabel. Fortunately, there is a solid basis for identifying the most relevant substances thanks to the existence of the Detergent Ingredients Database (DID). Although the primary purpose of the DID was to present a single and consistent point of reference for biodegradability and toxicity data, it can also serve a useful secondary purpose for cross-checking for relevant entries in Life Cycle Inventories (LCIs).

The methodology for carrying out LCA studies that support the background research for EU Ecolabel detergent criteria is to be aligned with the general PEF methodology defined in Commission Recommendation (EU) 2021/2279. In order to do this, access has been granted to EF datasets that provide data in a PEF-compliant manner.

Consequently, as a first step in data collection, we have mapped the DID entries against the ECHA C&L inventory in order to gather information on CAS numbers and to facilitate a cross check with the EF datasets – either for direct matches or suitable proxies. An illustration of what the results of this cross-check look like is provided in the table below just for preservative compounds. Text in green in the last column indicates that there was a direct match between the DID substance and the EF datasets. Text in orange indicates that there was no direct match, but a proxy could be identified. Text in red is the worst case, where even finding a proxy was not possible.

Table 36. Cross-check results of DID, ECHA C&L inventory and EF/Ecoinvent datasets for preservative compounds

DID No.	CAS No.	Ingredient name	ECHA C&L inventory	EF/Ecoinvent dataset entries
Preservatives				
2401	2634-33-5	1,2-Benzisothiazol-3-one (BIT)	H302, H315, H317, H318, H400	Proxy: benzo[thia]diazole-compound production
2402	100-51-6	Benzyl alcohol	H302, H332	Direct entry: benzyl alcohol production
2403	30007-47-7	5-bromo-5-nitro-1,3-dioxane	H302, H314, H318, H373, H400, H410	No proxy
2404	52-51-7	2-bromo-2-nitropropane-1,3-diol (Remark: Formaldehyde donor)	H302, H312, H315, H318, H335, H400	No proxy
2405	79-07-2	Chloroacetamide	H301, H317, H361f	No proxy
2406	78491-02-8	Diazolinidylurea	H319	No proxy
2407	50-00-0	Formaldehyde	H301, H311, H314, H317, H331, H341, H350	Direct entry: formaldehyde production, methanol oxidation
2408	111-30-8	Glutaraldehyde	H301, H314, H317, H330, H334, H335, H400, H410, H411	No proxy
2410	55965-84-9	CMI + MI in mixture 3:1 (CAS 55965-84-9) (§)	H301, H310, H314, H317, H318, H330, H400, H410	Proxy: benzo[thia]diazole-compound production
2411	2682-20-4	2-Methyl-2H-isothiazol-3-one (MI)	H301, H311, H314, H317, H318, H330, H400, H410	Proxy: benzo[thia]diazole-compound production
2412	35691-65-7	Methyldibromoglutaronitrile	H302, H315, H317, H318, H330, H400, H410, H411	No proxy

DID No.	CAS No.	Ingredient name	ECHA C&L inventory	EF/Ecoinvent dataset entries
2413	94-13-3	Methyl-, Ethyl- and Propylparaben	H412	No proxy
2414	90-43-7	o-Phenylphenol	H315, H319, H335, H400	No proxy
2415	532-32-1	Sodium benzoate	H319	No proxy
2416	70161-44-3	Sodium hydroxy methyl glycinate	H302, H315, H317, H319, H332, H335, H341, H350	No proxy
2418	3380-34-5	Triclosan	H315, H319, H400, H410	No proxy
2419	122-99-6	Phenoxy-ethanol	H302, H318, H335	Proxy: phenoxy-compound production
2420	50-81-7	Sorbate and sorbic acid	H314, H315, H318, H319	No proxy
2421	2372-82-9	N-(3-Aminopropyl)-N-dodecylpropane-1,3-diamine	H301, H314, H373, H400, H410	No proxy
2422	770-35-4	Phenoxypropanol	H319	Proxy: phenoxy-compound production

The lack of direct generic data for relevant chemicals in the EF/Ecoinvent datasets is a real issue that will limit the accuracy of any LCA results relating to the chemical formulation of detergent products. As can be seen from the table, on 2 out of the 20 preservative compounds have direct entries.

In the case of no direct entry, the next best option is to find a proxy. There are different ways to do this, for example looking at direct entries for substances that belong to the same family of compounds. Failing this, reference could be made to precursor compounds if the synthesis pathway and raw materials are the same. The proper identification of proxies is time consuming and requires expert judgement, especially if more than one proxy is potentially available.

Without reproducing the above table for all the ingredients in the DID list, we provide below the actual EF datasets for substances that were flagged for use in the LCA screening studies. Red text in the table highlights uncertainties about the type of surfactant being referred to.

Table 37. EF dataset entries identified for surfactants and other DID substances that can be used in LCA screening studies

Chemical ingredient	Description
Surfactants	
Non-ionic surfactant (EO derivate)	Non-ionic surfactant, ethyleneoxidederivate production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Non-ionic surfactant (Fatty acid)	Non-ionic surfactant, fatty acid derivate production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic/Nonionic? surfactant: Ethoxylated alcohol AE3 (oleo)	AlcoholEthoxylate (oleo) production, 3 moles EO {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic/Nonionic? surfactant: Ethoxylated alcohols AE7 (oleo)	AlcoholEthoxylate (oleo) production, 7 moles EO {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic/Nonionic? surfactant: Ethoxylated alcohols AE>20 (oleo)	AlcoholEthoxylate (oleo), >20 moles EO production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic/Nonionic? surfactant: Ethoxylated alcohols AE3 (petro)	AlcoholEthoxylate (petro) production, 3 moles EO {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI
Anionic/Nonionic? surfactant: Ethoxylated alcohols AE7 (petro)	AlcoholEthoxylate (petro) production, 7 moles EO {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Not sure what is the exact difference with above entry.	Ethoxylated alcohol (AE7) production, petrochemical {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic surfactant (LAS)	Alkylbenzene sulfonate production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic surfactant: AES (oleo)	Alcohol ether sulphate (oleo based) production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic surfactant: AES (petro)	Alcohol ether sulphate (petro based) production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Anionic surfactant?: FAS	Fatty acid sulphonate derivate production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Cationic surfactant: Esterquat (CO+PKO derived)	Esterquat production, from coconut oil and palm kernel oil
Amphoteric surfactant: Amine	Amine oxide production {EU+EFTA+UK} | technology mix | production mix, at plant

Chemical ingredient	Description
oxide	| 100% active substance | LCI result
Other ingredients	
Zeolite	Zeolite {GLO} | from aluminium hydrate, sodium silicate and sodium hydroxide | single route, at plant | 2- 2.5 g/cm3 | LCI result
Sodium carbonate	Soda production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Citric acid	Citric acid production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Polycarboxylates	Polycarboxylate production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Sodium percarbonate	Sodium percarbonate, powder production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
TAED	EDTA production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Enzymes	Enzymes production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Sodium sulphate	Sodium sulphate production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Soap	Soap production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Phosphonates	Sodium tripolyphosphate production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Ethanol	Ethanol production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Water	Water, completely softened {EU+EFTA+UK} | average technology mix | production mix, at plant | Technology mix for supply of softened water to users | LCI result
Sodium silicate	Sodium silicate powder production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Ethylene glycol butyl ether	Ethylene glycol production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Glycerine	Glycerine, from soybean oil production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Triethanolamine	Triethanolamine production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Distrylbiphenyl	Optical brightener, distyrylbiphenyl production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Triazinylaminostilben	Optical brightener, triazinylaminostilben production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Bentonite	Bentonite production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Acrylic acid	Acrylic acid production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Carboxymethyl cellulose	Carboxymethyl cellulose production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Dye	Average dye*
Preservative	Benzo[thia]diazole-compound {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Fragrance	Hexylcinnamic aldehyde production {GLO} | technology mix | production mix, at plant | 100% active substance | LCI result
Sodium hydroxide	Sodium hydroxide production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Phenoxyethanol	Phenoxy-compounds {EU+EFTA+UK} | average technology mix | production mix at plant | 100% active substance | LCI result
Propylene glycol	Propylene glycol production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Sodium chloride	Sodium chloride powder production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result
Sodium phosphate	Sodium phosphate production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result

*An average of 6 different processes for pigment production.

5.4.2.2. *Limitations of surfactant datasets*

Surfactants are one of the key ingredients in virtually all detergent products covered by the EU Ecolabel and it is worth commenting on the current disparities that exist between the EF datasets, the DID list and real-life surfactants on the market.

A large number of individual surfactant compounds exists, that are often distinguished only by minor differences, for example in the carbon chain length or the degree of ethoxylation. According to a list published by CESIO, the European association for surfactant producers, these chemicals can be divided as follows:

- Anionic - with the following families: alcohol ethoxylates (over 200 compounds with 31 different CAS numbers); alkylether sulfate salts (over 110 different compounds with 18 different CAS numbers); alkylether salts (around 130 different compounds with 22 different CAS numbers) and then others such as hydrotopes, sulfosuccina(ma)tes, alkyl phosphate esters, fatty alcohol phosphoric acid esters and some other types which, together, amount to around 170 different compounds with some 99 different CAS numbers). In total, around 610 substances with around 170 different CAS numbers.
- Non-ionic – various types of compounds such as: alkanolamides; alkyl polyglucosides; fatty acid-N-methylglucamides; fatty acid ethoxylates; fatty acid EO glycerol esters; sorbitan ethoxylated fatty acid esters and fatty amines with ethoxylation. Altogether these amount to around 67 different compounds with 41 different CAS numbers.
- Cationic – limited to quaternised alkanolamine esters (esterquats) and quaternary ammonium salts. In total accounting for some 13 different substances and 6 different CAS numbers.
- Amphoteric - includes amphoacetates, amine oxide, alkylamidopropyl amine oxides, alkylamidopropyl betaines and alkylbetains. In total accounting for some 42 different substances and 14 different CAS numbers.

The vast range of 700+ surfactant substances that exist in reality is represented by just 14 direct entries in the EF dataset. Clarifications are still needed on some of the entries in order to be sure about which types of surfactant they belong to (e.g. anionic or non-ionic). Furthermore, with the oleochemical-based entries using mixed sources, it was not possible to obtain the separate underlying data for palm oil and coconut oil, for example. These factors will affect the accuracy of any LCA results that relate to variations in the choice of surfactant and of the source material for a given surfactant. To make sure that we have a good picture of non-LCA impacts associated with these substances, they are dealt with in more detail in the non-LCA impacts section.

5.4.2.3. *Limitations of fragrance datasets*

When attempting to gather information on substances used in fragrances, it was explained that the combinations of fragrances are the most closely guarded secrets with regards to detergent products. Many different substances are involved in fragrance formulations, which also helps make it very difficult to copy or reproduce. An examination of several Safety Data Sheets (SDSs) for individual fragrance formulations showed dozens of different substances, many of which contain hazards that would, in principle, be horizontally restricted in EU Ecolabel products.

For the purposes of the LCA study, we assume a mix of the same four fragrance compounds identified in the 2019 PEFCR for heavy duty liquid laundry detergents, namely: "hexylcinnamic aldehyde" + "dihydromyrcenol" + "hexyl salicylate" + "beta-pinene". In addition to the PEFCR approach, we also assume a plasticiser content for the remainder of the fragrance formulation, using a proxy entry of "benzoic acid" for the plasticiser content. An assumed split of 15% for each of the four fragrance compounds is used and 40% for the remainder being the plasticiser.

As with surfactants, there are hundreds of different fragrance compounds but only a handful of EF dataset entries, in this case four direct entries in the EF datasets. This will affect the accuracy of any LCA results that relate to choices made for fragrance substances and fragrance content. To make sure that we have a good picture of non-LCA impacts associated with these substances, they are dealt with in more detail in the non-LCA impacts section.

5.4.2.4. *Information from formulation safety data sheets*

As part of a broader consultation exercise by the JRC, stakeholders were requested to share SDSs of detergent formulations. Even though SDSs only need to provide information on ingredients with CLP hazards and only specify percentage ranges of those ingredients, it is still a useful set of information to help inform LCA study assumptions, so long as the SDS can be linked to a specific type of detergent product.

Table 38. Main hazard ingredients flagged in detergent formulation SDSs (each row corresponds to one product SDS).

Classified ingredient	CAS number	Conc. range	Comments
Hand Dishwashing detergent			
Alcohols C12-14 ethoxylated sulfates D-Glucopyranose, oligmers, decyl octyl glycosides Cocamidopropyl betaine CMIT:MIT (3:1)	68891-38-3 68515-73-1 61789-40-0 55965-84-9	10 to 20% 3 to 5% 0.1 to 1% <0.0015%	Industrial use, concentrated
Laundry detergent			
Isopropyl alcohol Alcohol ethoxylate poly(oxy-1,2-ethanediyl), alpha-isotridecyl-omega hydroxy linear (C12-14) alkanol, ethoxylated, sulfated, sodium salt sodium p-cumene sulphonate Alcohols, C13-15, branched and linear, ethoxylated 2-(2-butoxyethoxy)ethanol Citric acid	67-63-0 68439-51-0 9043-30-5 68891-38-3 15763-76-5 157627-86-6 112-34-5 77-92-9	5 to 10% 2.5 to 5% 3 to 5% 3 to 5% 1 to 2.5% 0.25 to 0.5% 0.1 to 0.25% 0.1 to 0.25%	For industrial laundry - delicates
Sodium hydroxide Alcohols, C13-15, branched and linear, ethoxylated (7EO) Alcohols, C13-15, branched and linear, ethoxylated (4EO) Alcohols, C13, branched, ethoxylated EDTMPA and Na-EDTMPA Glycerin	1310-73-2 157627-86-6 157627-86-6 69011-36-5 22042-96-2 56-81-5	5 to 10% 5 to 10% 2.5 to 5% 2.5 to 3% 1 to 2.5% 0.5 to 1%	For industrial laundry (emulsified product)
Dishwasher detergents			
Sodium carbonate peroxide Sodium silicate Sodium carbonate Alcohols, C16-18, ethoxylated Subtilisin	15630-89-4 1344-09-8 497-19-8 68439-49-6 9014-01.1	10 to 25% 2.5 to 10% 2.5 to 10% 2.5 to 10% 0.1 to 1.0%	Dishwasher detergent tablets
Sodium hydroxide Tetrasodium (1-hydroxyethylidene)bisphosphonate Phosphonic acid, Na-salt	1310-73-2 3794-83-0 40372-66-5	5 to 15% 1 to 5% 1 to 5%	Industrial dishwasher product
Nonionic surfactant 2-Hydroxy-1,2,3-propanetricarboxylic acid	"Polymer" 77-92-9	5 to 15% 5 to 15%	Industrial dishwashing rinse aid
Sodium hydroxide Alcohols, C13-15, branched and linear, ethoxylated (7EO) Alcohols, C13-15, branched and linear, ethoxylated (4EO) Alcohols, C13, branched, ethoxylated EDTMPA and Na-EDTMPA Glycerin	1310-73-2 157627-86-6 157627-86-6 69011-36-5 22042-96-2 56-81-5	5 to 10% 5 to 10% 2.5 to 5% 2.5 to 3% 1 to 2.5% 0.5 to 1%	Industrial dishwasher product
Sodium hydroxide Disodium metasilicate pentahydrate 1-hydroxyethanoldiphosphonic acid Na salt Sodium carbonate	1310-73-2 10213-79-3 29329-71-3 497-19-8	25 to 50% 10 to 20% 1 to 10% 1 to 10%	
Sodium hydroxide Potassium hydroxide Phosphonic acid Alcohol , C12-15, ethoxylated, propoxylated	1310-73-2 1310-58-3 13598-36-2 120313-48-6	25 to 50% 5 to 9.3% 1 to 2.7% 1 to 3%	
Silicic acid, K salt Sodium hydroxide 1-Hydroxyethanediphosphonic acid Na salt	1312-76-1 1310-73-2 29329-71-3	10 to 25% 3 to 5% 1 to 6.1%	
Hard surface cleaners			
Citric acid	77-92-9	5-5.5%	Limescale remover
Citric acid	77-92-9	1 to 5%	

Classified ingredient	CAS number	Conc. range	Comments
Alkyl, C10-16, polyglucoside	110615-47-9	1 to 5%	
Citric acid Lactic acid D-Glucopyranose, oligmers, decyl octyl glycosides	5949-29-1 79-33-4 68515-73-1	30 to 50% 5 to 10% 0.1 to 1%	
3-butoxy-2-propanol Propane-2-ol 1-methoxy-2-propanol	5131-66-8 67-63-0 107-98-2	1 to 1.2% 0.5 to 0.8% 0.5 to 1.0%	Glass cleaner
3-butoxy-2-propanol Propane-2-ol 1-methoxy-2-propanol	5131-66-8 67-63-0 107-98-2	1 to 1.2% 0.5 to 0.8% 0.5 to 1%	
Propan-2-ol	67-63-0	1 to 5%	
Propan-2-ol	67-63-0	1 to 10%	
Sodium carbonate	497-19-8	1 to 2%	Kitchen degreaser / kitchen surface cleaner
Sodium carbonate	497-19-8	1 to 2%	
Alkyl ethersulfate, Na salt Propan-2-ol 2-(2-butoxyethoxy)ethanol Potassium hydroxide Alkylpolyglucoside Phosphonic acid	68891-38-3 67-63-0 112-34-5 1310-58-3 161074-93-7 13598-36-2	10 to 25% 10 to 20% 1 to 10% 2 to 3% 1 to 3% 1 to 1.7%	
Hexyl D-glucoside Fatty alcohol, ethoxylated 2-butoxyethanol Disodium metasilicate pentahydrate Sodium carbonate	54549-24-5 68439-46-3 111-76-2 10213-79-3 497-19-8	3 to 10% 3 to 10% 1 to 10% 3 to 5% 1 to 10%	
Ethoxylated C10 alcohols D-Glucopyranose, oligmers, decyl octyl glycosides CMIT:MIT (3:1)	78330-20-8 68515-73-1 55965-84-9	1 to 3% 0.1 to 1% <0.0015%	
Citric acid	77-92-9	5 to 5.5%	Acid-based toilet cleaner
Citric acid D-Glucopyranose, oligmers, decyl octyl glycosides	5949-29-1 68515-73-1	10 to 20% 0.1 to 1%	
Citric acid monohydrate Alcohols, C9-C11, C10rich, ethoxylated	5949-29-1 78330-20-8	2.5 to 10% 1.0 to 2.5%	
2-Ethylhexyl glucoside Sodium carbonate	 497-19-8	2 to 2.5% 0.5 to 1.0%	Floor cleaner
Sodium Lauryl Ether Sulfate	68891-38-3	1 to 5%	
Methanesulphonic acid Lactic acid Decyl alcohol, ethoxylated Isotridecanolethoxylate Hexyl D-glucoside Fatty alcohol, ethoxylated	75-75-2 79-33-4 POLYMER POLYMER 54549-24-5 68439-46-3	25 to 50% 10 to 25% 3 to 10%	Industrial application cleaners (concentrated)
Alkyl ethersulphate, Na salt Propan-2-ol 2-(2-butoxyethaoxy)ethanol Potassium hydroxide Alkylpolyglucoside Phosphonic acid	68891-38-3 67-63-0 112-34-5 1310-58-3 161074-93-7 13598-36-2	10 to 25% 10 to 20% 1 to 10% 2 to 3% 1 to 3% 1 to 1.7%	
Ethanol Alkyl ethersulphate, Na salt Alkyl alcohol ethoxylate Alkylglucoside Phosphonic acid Sodium hydroxide	64-17-5 68891-38-3 160875-66-1 ?? 13598-36-2 1310-73-2	10 to 25% 5 to 10% 3 to 8.7% 1 to 3% 1 to 1.8% 1 to 1.2%	
Propan-2-ol Hexyl D-glucoside Fatty alcohol, ethoxylated CMIT:MIT (3:1)	67-63-0 54549-24-5 68439-46-3 55965-84-9	1 to 10% 3 to 10% 3 to 10% <0.0015%	
2-Propylheptanolethoxylate CMIT:MIT (3:1) Ethanol 2-Methoxymethylethoxy-propanol	160875-66-1 55965-84-9 64-17-5 34590-94-8	1 to 3% 0.001 to 0.0015% 1 to 10% 1 to 10%	

The data above from SDSs provided by industry stakeholders only indicates ingredients with CLP hazards that are present in the detergent formulations. Although an analysis of a much larger number of SDSs would be necessary before drawing any conclusions, some of the following patterns were observed:

- Preservatives were only identified in some of the formulations, and in these cases they were isothiazoline substances (CMIT:MIT or MIT alone).
- Concentrated products tended to be 4 to 10 times more concentrated than ready-to-use products.
- A broad variety of surfactants were used in the formulations.
- The pure alcohols were mainly propan-2-ol or ethanol.
- For pH adjustment of the formulations, citric, sodium hydroxide or potassium hydroxide were used.
- Industrial-use products are always concentrated.

Regarding the first point, preservatives are needed in water-based products where the pH and chemical composition are amenable to bacterial or fungal growth. The general lack of classical preservatives (i.e. biocidal active substances) in many formulations will be due to other qualities of the formulation making conditions highly unfavorable for bacterial or fungal growth – for example, high alcohol content or high or low pH.

5.4.2.5. Representative formulations based on data reported in LCA literature

In this section, we aim to compare information on formulations in a side-by-side manner. Unfortunately the chemical names are not always the same and so, in order to avoid potential wrong descriptions, if there is any doubt about whether different authors are talking about the same ingredient, a separate row is created for each entry.

Laundry detergents: Formulations should be read vertically. It is also worth noting that the Arendorf 2014a reference is looking at a compact powder LD, while Castellani et al., (2019) look at liquid LD products (the one on the left being a standard product and the one on the right being an "eco" product). Finally, the last two formulations are standard formulas that are specified for use in laboratory testing of washing machines.

It is worth noting that the specifications for the IEC standard detergents are much more specific in the sense that they sometimes define any active contents or commercial identifiers. Care must be taken in making the right assumptions about what form ingredient chemicals are being considered when a % concentration in detergent products is defined.

Table 39. Comparison of LD formulations cited in the literature.

Ingredient	LCI ref.	Arendorf, 2014a	IEC 60456.2011	IEC 60335-2-7.2002	PEFCR, 2019	Castellani, 2019	
Water	Water, completely softened, at plant/RER S	7.80		7.8	70.22	70.22	61.69
Sodium carbonate	GLO: Sodium carbonate from NH4Cl production, at plant	22.17	11.6				
Sodium sulphate	Sodium sulphate, powder, production mix, at plant/RER S	19.89	6.5	16.8			
Sodium percarbonate	Sodium percarbonate, powder, at plant/RER S	13.27					
Sodium perborate tetrahydrate (active Oxygen 10.0-10.4%)	??		20	20			
Sodium Linear Alkylbenzene Sulfonate (LAS)	Alkylbenzene, linear, at plant/RER S	8.69	8.8	6.4			
Ethoxylated fatty alcohol C12-C14 (7EO)	??		4.7				
Ethoxylated tallow alcohol (14 EO)	??			2.3			
Sodium alkyl ether suphates	??				3.55	3.55	9.0

(SLES, mix of oleo- and petro-based)							
LAS alkylbenzene sulfonate (petro)	??				6.83	6.83	-
Soap	??		3.2	2.8	2.41	2.41	3.0
Ethoxylates oleo+petro) & other non-ionic surfactants	??				5.91	5.91	7.0
Sodium hydroxide	??				1.72	1.16	1.5
Triethanolamine	??				0.59	1.16	-
Glycerine	??				0.58	1.43	2.5
Polypropylene glycol	??				2.27	1.43	2.5
Preservatives	??				0.02	0.46	-
Zeolite	Zeolite, powder, at plant/RER S	7.04					
Sodium aluminium silicate zeolite 4 A (80 % active substance)	??		28.3				
Sodium silicate	Layered sodium silicate, SKS-6, powder, at plant/RER S	4.71	3.0	6.0			
Magnesium silicate	??			1.5			
Bleach precursor	RER: etylenediamine, at plant						
Bentonite	Bentonite, at processing/DE S	4.48					
C12-15 alkylethoxysulphate (3EO)	RER: fatty alcohol sulphate mix, at plant*	3.08					
Sodium acrylic acid	Empty process**	1.48					
EDTA	??			0.2			
TAED	??		3.0				
Carboxymethyl cellulose	Carboxymethyl cellulose, powder, at plant/RER S	1.23	1.2	1.0			
Citric	Empty process**	0.99					
Citric acid	??	-			1.61	1.61	-
Salts of citric acid and other salts	??	-			0.67	0.67	2.5
Perfume	Empty process**	0.76			0.71	0.71	0.20
Polymers	??				0.70	0.46	0.5
Sodium salt of a copolymer from acrylic and maleic acid (granulate)	??		2.4				
Polycarboxylate polymer	Polycarboxylates, 40 % active substance, at plant/RER S	0.57					
Sodium Tripolyphosphate (STPP)				35.0			
Phosphonate (HEDP)	Empty process**	0.53				-	0.3
Sodium phosphonate	??				0.41	0.41	-
Phosphonate (DEQUEST 2066, 25 % active acid)	??		2.8				
Enzymes	Empty process**	0.34	0.4		0.58	0.58	0.30
Sodium chloride	Sodium chloride, powder, at plant/RER S	0.07			0.42	0.46	1.8
Dye	Empty process**	0.01			0.03	0.03	-
Optical whitener for cotton (stilbene type)	??		0.2	0.2	0.06		
Optical brighteners	??					0.03	-
Optical brighteners	??					0.03	-
Others	??				0.70	0.46	-
Benzoisothiazoline	??					-	0.1
Methylisothiazoline	??					-	0.1
Glucoside	??					-	7.0
Antifoam agent (polydimethylsiloxane)	??		3.9			-	0.01

* Alcohol sulphate (AS) C12-18, 25 % mix of petrochemical, palm kernel oil, coconut oil, palm oil

** Due to a lack of data, these ingredients are modelled as empty processes which causes uncertainty in the impact assessment.

In the table above, the first three formulations relate to powder laundry detergents and the last three relate to liquid laundry detergents. The first big difference it obvious the water content (goes from 5-10% to 60-75%). The liquid laundry detergents use solvents like glycerine and propylene glycol that are not needed in powder formulations. On the other hand, the powder detergents use large concentrations of inorganic salts and zeolite powder that cannot be used in liquid detergents. The same situation applies to the use of sodium percarbonate and sodium perborate, which are bleaching agents that can be used only in powder detergents.

It is worth noting that the baseline scenario used by Castellani et al. (2019) is virtually identical to the formulation reported in version 1.2 of the PEFCR report for heavy duty liquid laundry detergents.

Dishwasher detergents: The formulations listed in the table below were found from two LCA studies and three technical standards used for testing of dishwashers. Any references to LCI entries are linked to the Arendorf or Castellani formulations. The two formulations listed under IEC 60335-2-58 refer to one phosphate-containing formula (left) and one phosphate-free formula (right). It is also worth noting that there were a lot of different entries relating to sodium silicate, and care must be taken when trying to find LCI entries for this substance because sodium silicate, sodium disilicate, sodium silicate pentahydrate etc. will have different per kg environmental impacts and may be supplied at different concentrations and levels of purity.

Table 40. Comparison of DD formulations cited in the literature.

Ingredient	LCI ref.	Arendorf, 2014b	Castellani, 2019		IEC 60335-2-5.2011	IEC 60335-2-58.2002		IEC 60436.2015
Sodium citrate dihydrate	Citric acid (from Moataza, 2009)	30%	30%	25%	-	-	30.0%	30.0%
Maleic acid/acrylic acid copolymer Na salt	RER: Polycarboxylates, 40% active substance, at plant	6%	6.0%	3.0%	-	-	-	12.0%*
Sodium percarbonate	GLO: Sodium carbonate from ammonium chloride production, at plant	7%	7.0%	15.0%	-	-	-	7.0%
Sodium perborate monohydrate		-	-	-	-	-	5,0%	-
Tetra Acetyl Ethylene Diamine (TAED, 92% active)	RER S: ethylene diamine tetracetic acid (EDTA)M, at plant	2%	2.0%	3.0%	-	-	2.0%	2.0%
Sodium silicate	RER/S: Layered sodium silicate, SKS-6, powder, at plant	10%	10.0%	4.0%	-	-	-	-
Sodium disilicate		-	-	-	-	-	25.0%	10.0%
Sodium metasilicate KO (anhydrous)		-	-	-	40%	25.0%	-	-
Sodium Metasilicate pentahydrate		-	-	-	-	37.0%	-	-
Linear fatty alcohol ethoxylate	RER: Fatty alcohol sulphate mix, at plant (Alcohol sulphate (AS) C12-18, 25% mix of petro-, PKO-, CO- and PO.	2%	2.0%	0.75%	-	-	-	-
Fatty alcohol ethoxylate		-	-	0.75%	-	-	-	-
Protease savinase	Empty process	1%	0.0%	0.01%	-	-	-	-
Amylase termamyl	Empty process	0.5%	0.5%	0.01%	-	-	-	-
Sodium carbonate	GLO: Sodium carbonate from ammonium chloride production, at plant	43.5%	43.5%	43.48%	-	-	-	-
GLDA (N,N-Dicarboxymethyl glutamic acid tetrasodium salt)	Not sure if authors used any process or left it empty.	-	-	5.0%	-	-	-	-
Pentasodium-triphosphate ("Tripoly") Thermphos NW		-	-	-	50%	24.0%	-	-
Sodium sulphate (anhydrous)		-	-	-	5.75%	-	-	-

Sodium carbonate		-	-	-	-	10.7%	23.0%	35.5%
Sodium dichloroisocyanurate-dihydrate CDB 56 C		-	-	-	2.25%	2.3%	-	-
Plurfac RA 43		-	-	-	2.00%	-	-	-
Plurafac LF 403**		-	-	-	-	1.0%	2.0%	2.0%
Sokalan CP5 compound (50% active substance)		-	-	-	-	-	12.0%	-
Amylase***		-	-	-	-	-	0.5%	1.0%
Protease***		-	-	-	-	-	0.5%	0.5%

* Additional detail added was: "Sokalan CP 5 Gran (BASF), 50% active on sodium carbonate"

** Additional detail added was: "(BASF) Linear fatty alcohol ethoxylate"

*** Additional details added were: "Sainase 16.0T 160KNPU/kg (Novozymes)" for amylase, and "Duramyl 120T, 600KNU/kg (Novozymes)" for protease.

Hand dishwashing detergents: The formulations listed below were found from three of the LCA studies reviewed. The product A and product C references of Moura et al., 2023 refer to highly concentrated HDD formulations. Such highly concentrated products seem strange for HDD purposes due to the high risk of overdosing and such variation is more commonly observed in HSC products.

Table 41. Comparison of HDD formulations cited in the literature.

Ingredient	LCI ref.	Arendorf, 2014c	Golsteijn et al., 2015	Moura et al, 2023. Det. A	Moura et al, 2023. Det. B	Moura et al, 2023. Det. C
Softened water	RER: water, completely softened, at plant	84%	83-85%	-	-	-
Well or tap water				45-55%	90-95%	20-25%
Surfactant system (anionic & non-ionic)*	RER: ethoxylated alcohols*	13.85%	13.85%	-	-	-
Fatty Alcohol Sulfate (Sodium Lauryl Sulfate, SLS) (foaming agent)		-		5-10%	1-2%	10-15%
Linear Alkylbenzene Sulfonate (LAS) petro-based (surfactant).		-		18-23%	2-6%	40-45%
Phenoxyethanol	RER: ethylene glycol, at plant	0.5%	<1%	-	-	-
Sodium hydroxide	RER: sodium hydroxide, 50 % in H2O, production mix, at plant	0.1%	<0.2%	5-10%	1-3%	20-25%
Sodium chloride	RER: sodium chloride, powder, at plant	0.1%	<2.0%	-	-	-
Ethanol, denatured	RER: ethanol from ethylene, at plant	0.05%	<0.1%	-	-	-
Propylene glycol	RER: propylene glycol, at plant	0.05%	<0.1%	-	-	-
Perfume	Empty process	0.25%	<0.5%	1-2%	1-2%	1-2%
Dye (2 types)	Empty process	0.05%	<0.1%			
Preservatives	Empty process	0.05%	<0.1%	-	-	-
Isothiazoline (preservative)	Based on Jin et al., 2013**	-		1-2%	1-2%	1-2%
Cocamide diethanolamine (Thickening agent)		-		10-15%	1-2%	1-5%
EDTA, Ethylene Diamine Tetra Acetic acid (chelating agent)		-		10-15%	-	-

* Assumed a combination of 6 variations of surfactant: 1/6th Alcohol Ethoxylates (AE3, petro); 1/6th Alcohol Ethoxylates (AE3, palm kernel oil); 1/6th Alcohol Ethoxylates (AE3, coconut oil); 1/6th Alcohol Ethoxylates (AE7, petro); 1/6th Alcohol Ethoxylates (AE7, palm kernel oil) and 1/6th Alcohol Ethoxylates (AE7, coconut oil).

** Jin Y, Li K, Lu X, Zhang X, Wang Y, Zhou S, Li C (2013) Process for continuously producing 3-isothiazolinone derivatives and intermediate products thereof. Depositante: Beijing Tianqing Chemicals Co., Ltd. U.S. Patent n. 8,507,691. https://patents.google.com/patent/US20100234613A1/en

Hard surface cleaning (HSC) products: The formulations listed below were found from the LCA studies reviewed. Only one of the formulations from the Arendorf et al., 2014d study was presented because it was not clear what the full alternative formulas were and it may just have been a hypothetical sensitivity analysis.

Table 42. Comparison of HSC formulations cited in the literature.

Ingredient	LCI ref.	Arendorf, 2014d – APC product	Yang et al., 2023 – Concentrated HSC	Golsteijn 2015 acid toilet cleaner	Golsteijn 2015 bleach toilet cleaner	Golsteijn 2015 – glass spray	Kapur., 2012 – eco glass cleaner	Kapur., 2012 – normal glass cleaner	Kapur., 2012 – eco all purpose spray	Kapur., 2012 – normal all purpose cleaner	Kapur, 2012 – eco-H2O2 all purpose cleaner	Golsteijn 2015 bathroom spray	Kapur, 2012 – eco bathroom cleaner	Kapur 2012 – normal bathroom cleaner
Softened water	RER: water, completely softened, at plant	81%	-	≥83%	≥86%	93%	rest	Rest	rest	Rest	Rest	≥90%	Rest	Rest
Ethylene glycol butyl ether (solvent)	RER S: Ethylene glycol diethyl ether, at plant/kg or	3% (0-5%)	-	-	-	-	-	0.15-5%	5-10%	0-5%	-	-	-	-
Propylene glycol monobutylether	RER: propylene glycol, liquid, at plant	-	-	-	-	1%	-	-	-	-	-	-	-	-
Diethylene glycol ethyl ether		-	-	-	-	-	2-5%	-	-	-	-	-	5-10%	-
Sodium carbonate (additive)	GLO: Sodium carbonate from ammonium chloride production, at plant	3% (0-5%)	-	-	-	-	-	-	-	0-5%	-	-	-	0-2%
Sodium hydroxide (additive)	RER: sodium hydroxide, 50 % in H2O, production mix, at plant	3% (0-5%)	-	0-1%	0.5-2.0%	-	-	-	-	0-5%	-	-	-	-
Sodium hypochlorite		-	-	-	3-5%	-	-	-	-	-	-	-	-	0-5%
Hydrogen peroxide		-	-	-	-	-	-	-	-	-	1-5%	-	-	-
Perfume	Empty process	< 0.5%	-	0-1%	1%	-	-	-	-	-	-	1-2%	-	-
Perfume, citral	Empty process	-	-	-		<1.0%	-	-	-	-	-		-	-
Dye (2 types)	Empty process	< 0.1%	-	0-1%		-	-	-	-	-	-		-	-
Preservatives	Empty process	0-1%	-			-	-	-	-	-	-		-	-
Sodium citrate / citric acid	Citric acid* Citric acid ‡	0-2%	2.0%	-	-	-	-	-	1-5%	-	-	2-5%	1-5%	-
Formic acid	RER: formic acid, at plant	-	-	5-10%	-	-	-	-	-	-	-	-	-	-
Alcohol ethoxylate		-	-	-	-	-	-	2%	1-5%	-	7-13%	-	1-5%	-
Alkylphenol ethoxylate	Kapur, 2012 referred to “ethoxylated phenol” for bathroom cleaner, the same thing?	-	-	-	-	-	-	2%	-	5-15%	-	-	-	0-5%?
Alkyl ethoxylate (non-ionic surfactant)	RER S: Ethoxylated alcohols (AE7), palm kernel oil, at plant	10% (5-15%)	-	-	-	-	-	-	-	-	-	-	-	-

AES (surfactant)		-	16.0%	-	-	-	-	-	-	-	-	-	-	-
SDS (surfactant)		-	17.0%	-	-	-	-	-	-	-	-	-	-	-
FAS (surfactant)	RER: fatty alcohol sulphate, mix, at plant †	-	-	0-5%	-	<1%	-	-	-	-	-	-	-	-
	Confusing description by authors	-	-	-	4-6%	-	-	-	-	-	-	-	-	-
Lauryl glucoside		-	-	-	-	-	5-10%	-	1-5%	-	-	-	1-5%	-
Sodium xylene sulfonate		-	-	-	-	-	5-10%	-	-	-	0-5%	-	-	-
Sodium Lauryl Sulfate		-	-	-	-	-	1-5%	2%	-	-	-	-	-	-
Glycerol**		-	60.0%	-	-	-	-	-	-	-	-	-	-	-
Propylene glycol	CLCD-China-ECER v0.8	-	5.0%	-	-	-	-	-	-	-	-	-	-	-
Amylase	Primary data	-	0.32%	-	-	-	-	-	-	-	-	-	-	-
Cellulase	Primary data	-	0.32%	-	-	-	-	-	-	-	-	-	-	-
Ethanol	RER: ethanol from ethylene, at plant	-	-	-	-	< 5.0%	-	-	-	-	-	-	-	-
Ethyl alcohol		-	-	-	-	-	0.1-1.5%	-	-	-	-	-	-	-
Isopropyl alcohol		-	-	-	-	-	-	10%	-	-	-	-	-	-
Phosphoric acid		-	-	-	-	-	-	-	-	-	-	-	-	0.5-10%

* A reference to "Moataza (2009)" was stated with the LCI reference for citric acid.

** One of the key findings of the study was to substitute a lot of the glycerol with water – thus reducing environmental impacts.

† Assumes raw material origin of 25% petrochemical, 25% palm oil, 25% coconut oil and 25% palm kernel oil.

††Citric acid data for Golsteijn, 2015 was provided by Unilever.

5.4.2.6. Representative formulations based on license holder data

In order to demonstrate compliance with EU Ecolabel criteria, it is necessary for applicants to disclose details of the full formulation. This information is covered by an NDA between the applicant and the competent body, but applicants are also free to share this information with the JRC, with the understanding that data would only be used for research into the EU Ecolabel criteria revision process and any formulations would only be presented in aggregated and anonymised forms in any JRC reports, if presented at all.

Based on the information gathered so far on license holder formulations, it has been possible to run LCA screening for hot spot identification and sensitivity analyses on up-to-date formulations for the following product groups:

- Powder laundry detergents
- Hand dishwashing detergents
- Hard surface cleaner: acid-based toilet cleaner
- Hard surface cleaner: bathroom cleaner
- Hard surface cleaner: kitchen cleaner

The information on representative formulations will be presented directly in the PEF analyses to be presented in the next section. Given the large number of products covered by the EU Ecolabel, further formulation data is requested for the following products listed in the table below for a future draft of these studies.

Table 43. Formulation types and comparisons of most relevance for deriving useful LCA-supported conclusions for EU Ecolabel criteria

Laundry detergents	Dishwasher detergents
• Formulations for similar products, one being heavy-duty and the other being light duty. • "Cold" temperature compatible vs conventional temperature compatible (and associated dosages). • Liquid format LD currently on market. • Capsule / pod format LD. • With/without fabric softener incorporated. • With/without stain remover incorporated. • Similar products with/without phosphate. • Similar products with/without dye. • Similar products with/without fragrance. • Key distinctions between industrial and household formulations. • Comparison of products with more enzymes and less surfactants. • Fabric softener formulation, dosing and overall contribution to impacts of a typical laundry cycle. • Stain remover formulation and dosing assumptions.	• "Single function" formulations. • "All-in-one" formulations. • "Rinse aid" formulations. • Capsule/gel format (with/without dye). • Liquid format? • Similar products with/without phosphate. • Key distinctions between industry and household formulations. • Comparison of products with more enzymes and less surfactants.
Hand dishwashing detergents	**Hard surface cleaners**
• Differences in formulations between ready to use and concentrated products. • Dosing assumptions for ready to use and concentrated products. • Sensitivity of assumptions with wash water temperature and volumes used. • Comparison of different "preservation" options.	• Formulations defined by sub-category (e.g. glass cleaner, toilet cleaner, floor cleaner, multi-purpose cleaner etc.). • Differences in formulations between ready to use and concentrated products. • Dosing assumptions for ready to use and concentrated products. • Formulation differences for products containing active micro-organisms*. • Comparison of different "preservation" options. • Comparison of acid-based and bleach-based formulations. • Formulations using microbial-based surfactants (e.g. rhamnolipids) instead of conventional ones. • Probiotic formulations using active microbes.

*EF dataset assumption for microorganisms would need to be discussed carefully. Most relevant proxy might be production of yeast…

As indicated in the table above, it is not just information on formulations that is relevant, but also the associated recommended dosages and intended uses/functionalities that are needed in order to be able to compare similar products that have one or two key differences.

5.4.3. In-house LCA screening studies

5.4.3.1. General methodology

The Product Environmental Footprint (PEF) is a type of LCA to measure the environmental performance of a product or service via multiple environmental parameters and across the product or service life cycle. The purpose of a PEF methodology is to account for all activities throughout the lifecycle in a standardised way for each product category to ensure comparability of results on a European level. As far as the authors are aware, there are no currently valid PEFCRs for detergent products (the only previously published draft PEFCR for household Heavy Duty Liquid Laundry Detergents (HDLLD) expired at the end of 2021). Consequently, a number of LCA screening studies have been carried out following the general PEF methodology set out in Commission Recommendations 2021/2279 and 2021/9332.

For clarity, it is noted that these studies have not been carried out with the intention of creating PEF category rules for detergent products. The main purpose is instead to screen for LCA hotspots and to use this information to help provide context and supporting rationale for criteria proposals in the revision process of EU Ecolabel criteria for detergent products.

A PEF study has a number of phases which should be completed: Goal definition; Scope definition; Life cycle inventory (LCI); reporting of Environmental Footprint Impact Assessment (EFIA) results; Interpretation of results. Consequently, the following sections are split into these phases. The first few sections will describe the goal and scope definition for all the PEF studies as these are consistent for all the PEF studies, whereas the LCI, LCIA, interpretation and reporting will be split for each of the studies as these vary.

5.4.3.1.1. Goal definition

The aim of the goal definition is to set the context of the study. The goal definition should answer what the aim of the study is, what its intended applications are, who is commissioning the study and who are the target audience.

The goal of this study is to quantify the potential environmental impact and hotspots of four groups of detergent products across their entire life cycle. The four groups of detergent products are:

1. laundry detergents (both liquid and powder),
2. hand dishwashing detergents,
3. dishwashing detergents, and
4. hard surface cleaners (kitchen surface cleaner and both toilet cleaner).

The composition of each of the detergent groups will be further elaborated in the respective sections below. The results of the studies will be used in the revision of the EU Ecolabel criteria for detergent products in terms of identifying areas within the life cycle of the four groups of detergent products where existing or new criteria will have a significant positive effect on the environmental performance of the products.

This study represents average groups of detergent products in Europe and does not represent individual brands or products. Hence, the study will give an overall picture of the environmental performance of detergents. No comparisons between the products are made.

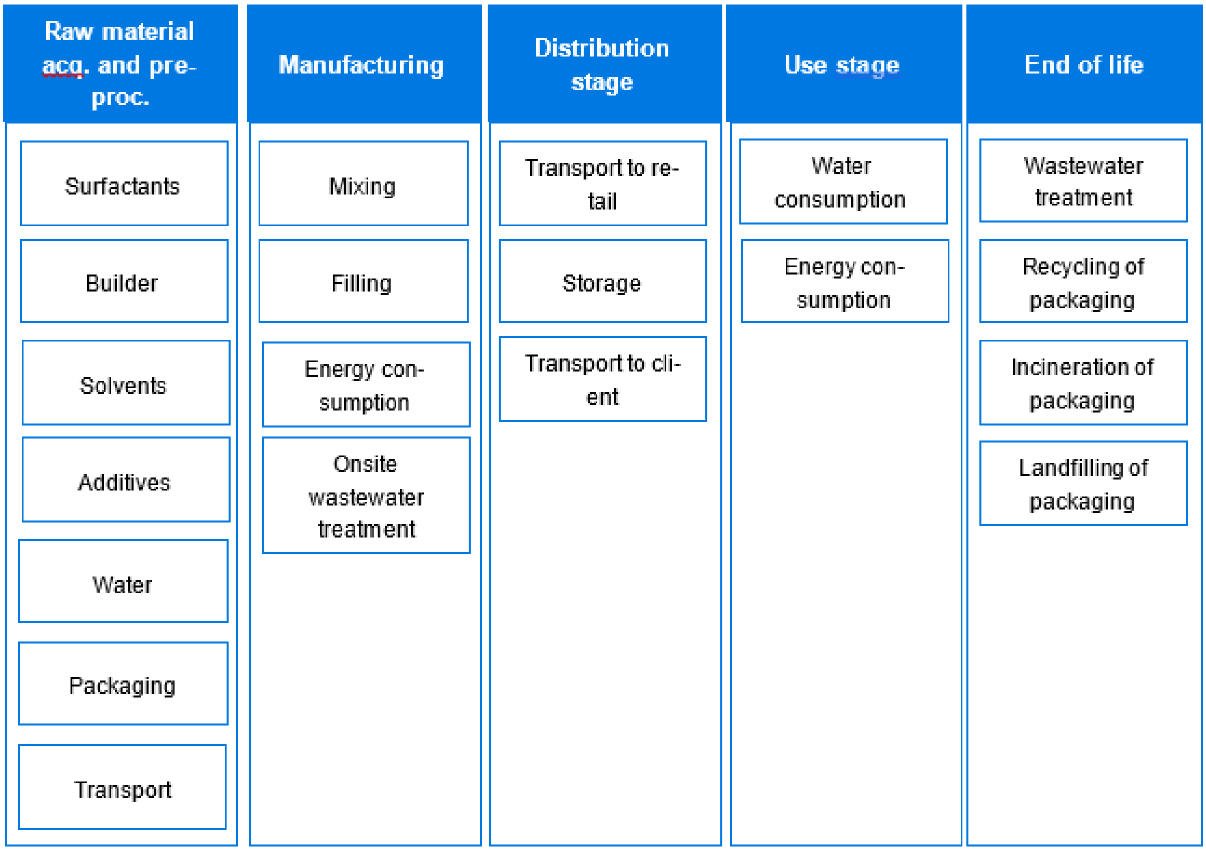
The commissioner of the study is the European Commission in the form of the Joint Research Centre and the target audience is relevant stakeholders (e.g. producers, associations).

5.4.3.1.2. Scope definition

The scope of the study describes what the system to be evaluated contains, as well as possible technical specifications. The scope should include the system boundaries, assumptions and limitations and impact categories that will be considered. Due to the fact that a number of different products are being studied, which have a number of different reference flows and functional units between them, these are not mentioned until the section where results are reported.

The system boundaries were defined according to the PEF methodology. Hence, including the life cycle stages: raw material acquisition and pre-processing (LCS1), manufacturing (LCS2), distribution stage (LCS3), use stage (LCS4), and End of Life (LCS5). Thus, this study is a cradle-to-grave study. The figure below presents the five life cycle stages and their appertaining processes included in the study.

Figure 67. Schematic representation of the life cycle stages and processes included in the PEF studies for the selected detergent products.



It is assumed that all raw materials and packaging are sourced within Europe, for which reason the pre-defined distances and transportation modes in section 4.4.3.4 of the PEF Recommendation has been used.

Raw material acquisition and pre-processing: This life cycle stage starts with the extraction of re-sources from nature and ends with the production of product components. Specifically, this stage includes mining and extraction of resources; pre-processing of material input to the product in scope, this also includes recyclable materials; agricultural and forestry activities, transportation within and between raw material acquisition and preprocessing facilities and to the production facility; finally, it includes the production of packaging materials. For all these processes are also included the energy, natural resources and infrastructure needed to produce any intermediary products.

Manufacturing: This life cycle stage starts with the product components entering the production facility and ends with the final product leaving the premises. It includes chemical processing; manufacturing (mixing of formulation, filling of bottles, and labelling); furthermore, it includes the treatment of wastewater and other waste generated during manufacturing.

Distribution stage: This life cycle stage starts when the final product leaves the manufacturing facility. This stage includes transport from factory gate to warehouse and/or retail; storage at warehouse (e.g. lighting and heating) and/or retail; and transport to the final client.

Use stage: This life cycle stage describes the expected use of the final product. In this case it is the use of detergent products for either automatic dishwashing, hand dishwashing, laundry, and cleaning of hard surfaces. Depending on the product, the use stage consists of differing amounts of water and energy consumed during washing and cleaning. The consumption of scourers, mops and clothes is excluded from the scope of assessment.

End of life: This is the last stage of the life cycle and starts when the detergent product and the ac-companying packaging is disposed by the user, and it ends when the product of the study is returned to nature or enters another products' life cycle as recycled input. It is modelled using the Circular Foot-print Formular (CFF). In this case end of life includes the transportation from final client to waste management sites is included as a part of the waste treatment processes; the treatment of wastewater generated during washing and cleaning and the disposal of the packaging material. The packaging material is both recycled, incinerated and landfilled according to the split defined in PEF.

5.4.3.1.3. Impact categories

In this study, all EF impact categories defined in the PEF method will be included. The table below shows a list of the impact categories as well as the abbreviations used in this study. In the sections below the investigated system will be described. However, the functional unit and reference flow will be specified in a separate section for each of the investigated detergent types.

Table 44. PEF impact categories, abbreviations and units.

Impact category	Abbreviation	Unit
Acidification – EF impact category that addresses impacts due to acidifying substances in the environment. Emissions of NOx, NH3 and SOx lead to releases of hydrogen ions (H+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.	AP	mol H^+-Eq
Climate change – EF impact category considering all inputs and outputs that result in greenhouse gas (GHG) emissions. The consequences include increased average global temperatures and sudden regional climatic changes. **Climate change: fossil** **Climate change: biogenic** **Climate change: land use and land use change**	CC CC - fossil CC - biogenic CC - LULUC	kg CO2-Eq
Ecotoxicity, freshwater – EF impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.	ETox	CTUe
Particulate matter – EF impact category that accounts for the adverse effects on human health caused by emissions of particulate matter (PM) and its precursors (NOx, SOx, NH3).	PM	disease incidence
Eutrophication – EF impact category related to nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland that accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen, resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure, expressed as the oxygen required for the degradation of dead biomass. To assess the impacts due to eutrophication, three EF impact categories are used: **eutrophication, terrestrial;** **eutrophication, freshwater;** **eutrophication, marine.**	E-Te E-Fr E-Ma	mol N-Eq kg P-Eq kg N-Eq
Human toxicity: carcinogenic - EF impact category that accounts for adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin – insofar as they are related to cancer.	HTox-c	CTUh
Human toxicity: non-carcinogenic - EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin – insofar as they are related to non-cancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.	HTox-nc	CTUh
Ionising radiation: human health - EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.	IR	kBq U235-Eq

Impact category	Abbreviation	Unit
Land use - EF impact category related to use (occupation) and conversion (transformation) of land area by activities such as agriculture, forestry, roads, housing, mining, etc.	LU	dimensionless (pt)
Ozone depletion – EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons).	OD	kg CFC-11-Eq
Photochemical ozone formation – EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx) and sunlight.	POF	kg NMVOC-Eq
Energy resources: non-renewable – EF impact category that addresses the use of non-renewable fossil natural resources (e.g. natural gas, coal, oil).	ER	MJ, net calor. value
Material resources: metals/minerals – EF impact category that addresses the use of non-renewable abiotic natural resources (minerals and metals).	MR	kg Sb-Eq
Water use – EF impact category that represents the relative available water remaining per area in a watershed, after demand from humans and aquatic ecosystems has been met. It assesses the potential for water deprivation, to either humans or ecosystems, based on the assumption that the less water remaining available per area, the more likely it is that another user will be deprived.	WU	m^3 world Eq deprived

5.4.3.1.4. Normalisation and weighting factors

The PEF methodology allows for impact categories to be normalised and weighted using the factors provided in the table below. These factors allow for a single PEF score to be obtained from the combined impact category results.

Table 45. Normalisation and weighting factors for PEF impact categories

Impact categories	Unit	Normalisation factors	Weighting factors
Acidification	mol H^+-Eq	5,56E+01	6,20%
Climate change	kg CO2-Eq	7,55E+03	21,06%
Ecotoxicity, freshwater	CTUe	5,67E+04	1,92%
Particulate matter	disease incidence	5,95E-04	8,96%
Eutrophication, freshwater	kg P-Eq	1,61E+00	2,80%
Eutrophication, marine	kg N-Eq	1,95E+01	2,96%
Eutrophication, terrestrial	mol N-Eq	1,77E+02	3,71%
Human toxicity, cancer	CTUh	1,73E-05	2,13%
Human toxicity, non-cancer	CTUh	1,29E-04	1,84%
Ionising radiation	kBq U235-Eq	4,22E+03	5,01%
Land use	Dimensionless (pt)	8,19E+05	7,94%
Ozone Depletion	kg CFC-11-Eq	5,23E-02	6,31%
Photochemical ozone formation	kg NMVOC-Eq	4,09E+01	4,78%
Resource depletion, fossil	MJ, net calor. value	6,50E+04	8,32%
Resource depletion, minerals & metals	kg Sb-Eq	6,36E-02	7,55%
Water use	m^3 world Eq deprived	1,15E+04	8,51%

5.4.3.1.5. Circular Footprint Formula

According to the PEF method, all waste treatment processes occurring in a PEF study must use the Circular Footprint Formular (CFF). The CFF is described in section 4.4.8.1 of the PEF Recommendation. The CFF is divided into three parts (1) material, (2) energy, and (3) disposal. The three equations can be seen below:

Figure 68. The Circular Footprint Formula. Copied from the PEF guide.

Material

$$(1-R_1)E_V + R_1 \times \left(A \times E_{recycled} + (1-A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1-A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$$

Energy

$$(1-B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$$

Disposal

$$(1-R_2-R_3)E_D$$

In this study, packaging materials being handled at end of life e.g. plastic (PET, HDPE, PP) and cardboard, the recycling and energy recovery is modelled using the CFF. The applied parameters follow the values in Annex C of the PEF method.

The material recycling equation is calculating the virgin material used, the use of recycled material as a substituting material and lastly material sent to recycling after being used. This equation is important to consider since there is a good opportunity for the industry to incorporate recycled content in detergent product packaging.

The energy calculation accounts for power and heat recovered from waste to energy facilities. Efficiency of the energy recovery is based on EcoInvent and the emission factors for the substituted heat and energy is based on EF 3.1 database.

Lastly the disposal of the content is calculated as the remaining material that is not recycled or used for energy recovery.

5.4.3.2. Life cycle inventory (LCI)

Unless specified otherwise, these studies use information from the Environmental Footprint (EF 3.1) datasets for inputs on generic data. Other available datasets such as Ecoinvent were not used to attempt to fill any gaps in the EF3.1 datasets because of potential differences in the structure and scope of data provided. A proper comparison of underlying data would not have been possible because the EF datasets were provided without any details of the breakdown of how different sub-processes contributed to the overall result for a given chemical or process.

Some of the most important entries in the EF dataset for chemical ingredients are flagged already in the section on data collection. Later in the EFIA results sections, any specific or proxy EF datasets for packaging and ingredients are mentioned.

5.4.3.3. Screening LCA of Liquid Laundry Detergent (LLD) products

5.4.3.3.1. Background information and assumptions

Definition of the product: For the purpose of this LCA screening, LLD products are considered as laundry detergents <u>in liquid form</u> falling under the scope of Regulation (EC) No 648/2004 which is effective at 30 °C or below and are marketed and designed to be used for the washing of textiles principally in household machines, but not excluding its use in public laundrettes and common laundries.

Functional unit and reference flows: The functional unit (FU) it the wash of 1 kg dry laundry in a washing machine at 40 °C in an average European household.

An average load of a washing cycle is assumed to be 4.5 kg dry laundry. The LLD consumption for a full load of laundry is variable and depends on factors such as wash cycle temperature, degree of soiling and water hardness. In this study, the average dosage per washing cycle is assumed to be 75 mL detergent based on Castellani et al (2019) and the pilot PEFCR for HDLLD. For simplicity, a specific density of 1.00 g/mL for the LLD is assumed as well, so 75 mL corresponds to 75 g. The dosage per FU is therefore 17 g.

Raw material acquisition and preprocessing: The composition of an average LLD detergent is based on Castellani et al. 2019 and is shown together with LCI processes from the EF 3.1 database shown below.

Table 46. LCI of a standard formulation of an average LLD using the EF 3.1 database.

Ingredient	%	EF 3.1 process
Sodium Alkyl ether sulfates	4%	Proxy: Non-ionic surfactant, fatty acid derivate production {GLO}
LAS Alkylbenzene sulfonate	7%	Alkylbenzene sulfonate production {EU+EFTA+UK}
Ethoxylates and other non-ionic surfactants	6%	AlcoholEthoxylate (petro) production, 7 moles EO {EU+EFTA+UK}
Citric acid	2%	Citric acid production {EU+EFTA+UK}
Salts of citric acid and other salts	0,7%	Citric acid production {EU+EFTA+UK}
Sodium phosphonate	0.4%	Sodium phosphate production {EU+EFTA+UK}
Enzymes	0.6%	Enzymes production {EU+EFTA+UK}
Dye	0.03%	Proxy: 14% Yellow pigment {GLO}, 14% White pigment {GLO}, 14% Terracotta pigment {GLO}, 14% Red pigment {GLO}, 14% Orange pigment {GLO}, 14% Green pigment {GLO}, 14% Blue pigment {GLO}
Fragrances	0.7%	Proxy: 15% Hexylcinnamic aldehyde production {GLO}, 15 % Dihydromyrcenol production {GLO}, 15% Hexyl salicilate production {GLO}, 15% Beta-pinene production {GLO}, 40% Benzoic acid production {GLO}
Optical brighteners	0.03%	Triethanolamine production {GLO}
Optical brighteners	0.03%	Optical brightener, distyrylbiphenyl production {GLO}
Soap	2%	Soap production {EU+EFTA+UK}
Sodium hydroxide	1%	Sodium hydroxide production {EU+EFTA+UK}
Triethanolamine	1%	Triethanolamine production {GLO}
Glycerine	1%	Proxy: Mix of four glycerines found in the EF 3.1 database
Propylene glycol	1%	Propylene glycol production {EU+EFTA+UK}
Preservative	0.5%	Proxy: Benzo[thia]diazole-compound {EU+EFTA+UK}
Polymers	0.5%	Proxy: Polycarboxylate production {EU+EFTA+UK}
Sodium chloride	0.5%	Sodium chloride powder production {EU+EFTA+UK}
Others	0.5%	Empty process
Water	70%	Water, completely softened {EU+EFTA+UK}

Primary and secondary packaging is included in this phase of the life cycle. The composition is also derived from Castellani et al. 2019 and is shown in below together with the LCI processes used in the study.

Table 47. LCI of both primary and secondary packaging for liquid laundry detergent.

Type of packaging	Amount	EF 3.1 process
Primary:	**Per FU**	
HDPE bottle	0.0009 kg	Plastic can, body HDPE {EU+EFTA+UK}
PP Cap	0.002 kg	Screw cap, PP {EU+EFTA+UK}
Secondary:	**Per FU**	
Cardboard box	0.0034 kg	Corrugated board, uncoated {EU+EFTA+UK} | "virgin" Kraft Pulping Process, pulp pressing and drying | production mix, at plant

Manufacturing: In the manufacturing stage, the use of electricity, water, heat, and output of wastewater has been included. The data for electricity and water usage are based on the AISE KPI-report from 2023. For heat, the split between heat and electricity presented in Golsteijn et. al. (2015) has been applied to the electricity factor. An assumption of detergent product wasted in the manufacturing process has been estimated to be around 2% and has also been included in the study.

Distribution: In the distribution stage, an equal split between distribution from factory to local, intracontinental, and international retail or distribution centres has been assumed, due to the lack of data. It is, furthermore, assumed that all products will go to retail before going to the consumer and so transport from the distribution centre to retail has been included. Furthermore, as defined by section 4.4.5 of the PEF Recommendation, both lighting and heating of storage in distribution centre and retail has been included. To account for losses during distribution, a 5% loss has been included and for losses in households, a further 5% loss has been included as defined by the PEF method.

Use: In the use stage, a laundry machine with a 40°C program is assumed with the use of 50 L of tap water for washing an average load of 4.5 kg dry laundry, which results in 11.25 L per FU. The energy used for this programme has been calculated using AISE's Laundry energy model 2014, which can be found in the PEFCR for HDLLD.

End-of-life: The end-of-life stage consists of the transport of waste, waste processing in the form of recycling, incineration with energy recovery and landfilling. The CFF is used to calculate the impacts related to end-of-life. The end-of-life in this case covers wastewater treatment after the use of detergent, recycling, incineration and landfilling of packaging. The CFF has been applied to each of the different material types present in the packaging. The different variables used have been taken from Annex C in the PEF method.

Data quality: The assessment of the data quality is split up into the different life cycle stages; raw material acquisition and pre-processing (LCS1), manufacturing (LCS2), distribution stage (LCS3), use stage (LCS4), and End of Life (LCS5).

- LCS1: Data quality regarding the average composition of dishwasher detergent is fair. However, the literature data is approximately 10 years old and formulation data from products on the market today are needed in order to validate if important changes have been made. For some ingredients, no LCI data was available in the EF 3.1 database and here proxies were used as a best guess. Only the ingredients regarding "other chemicals" in LLD have been left empty in this study. However, the mentioned "other chemicals" category only made up 0,5 % of the formulation. The data quality for the packaging is good.
- LCS2: The data quality of the manufacturing process retrieved from AISE is fair. Unfortunately, the energy input was not divided into heat and electricity and estimates of the division were made based on Golsteijn et al. 2015. The datasets used from the EF 3.1 database for electricity, wastewater treatment and water are good.
- LCS3: All data regarding the distribution stage was retrieved from the default scenarios provided in section 4.4.3 of the PEF Recommendation. The quality of the LCI data is good and the overall data quality of this life cycle stage is good.
- LCS4: The data quality of the use stage is good. The data inputs are retrieved using AISE's Laundry energy model from 2014, calculating the energy input of washing 1 cycle.
- LCS5: The data in the End-of-Life stage is based on the CFF parameters provided in the Annex C in the PEF method. The overall data quality of this life cycle stage is good.

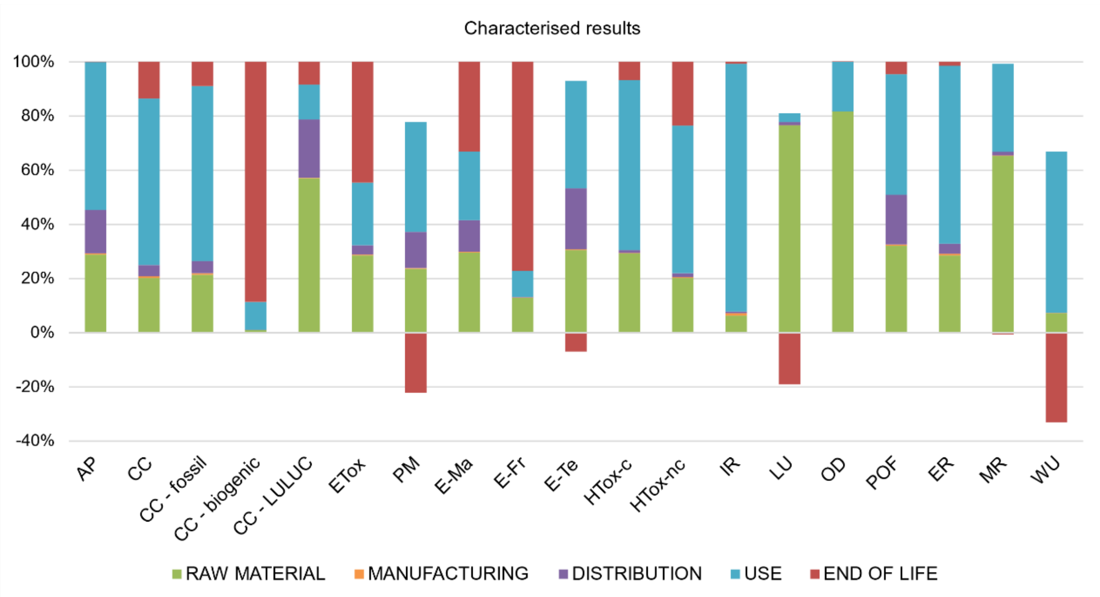
The data used in this study represents average LLD. Hence, the results do not address the environmental performance of individual products. No data was found for the share of local, intracontinental, and international distribution and might not reflect the actual conditions. No data was found on the type of dye, preservative or fragrance and several different chemicals can be used for those purposes. In this study, an average of the available pigment processes in the EF 3.1 database was used for the proxy dye, which is still missing any reference to dye solvents or stabilising additives. Regarding preservatives, the EF 3.1 LCI datasets of benzo[thia]diazole was used as proxy. Regarding fragrances several safety data sheets were found to get insight in the composition. Based on that, a proxy was created consisting of 40% benzoic acid as a proxy in itself for phthalate, and a mix of four compounds used in fragrances available in the EF 3.1 database (Hexylcinnamic aldehyde, Dihydromyrcenol production, Hexyl salicilate production, and Beta-pinene).

It was desired to investigate the differences between petrochemical-based surfactants with oleochemical alternatives from different sources. However, the EF database just comprises dataset names "oleochemical mix" representing a mix of different sources (e.g. palm kernel oil, coconut oil etc.) without being able to see what are the % shares or contributions of the individual processes. Hence, a full analysis of the importance of alternative oleochemical sources was not possible at this stage.

5.4.3.3.2. Life cycle impact assessment (LCIA) for LLD: results and interpretation

Whole life cycle contribution analysis for LLD products: A contribution analysis was made to identify hotspots in the life cycle stages of LLD, the results are presented below.

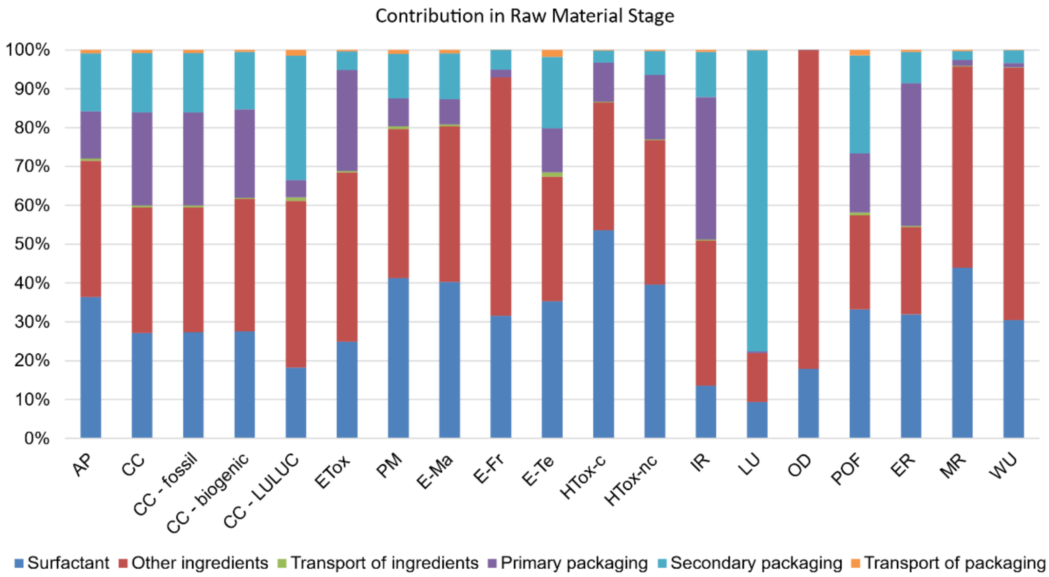
Figure 69. Characterised results for an average LLD presented in percentage of total impact, split by life cycle stage for each of the impact categories (see Table 44).



Generally, the most contributing life cycle stage to the impact of washing 1 kg of dry laundry with an average LLD is the use stage followed by the raw material stage. Within CC-biogenic and E-Fr impacts, the EoL stage is by far the most contributing stage. There are negative impacts (i.e. environmental benefits) in the EoL stage for PM, E-Te, LU, and WU due to recycling and energy recovery from incineration and wastewater treatment. The impacts from the use stage are related to the energy consumption in the washing process, where the water is to be heated to 40 °C.

Raw material stage contribution analysis for LLD products: This stage consists of several sub-processes. The contribution of the sub-processes to the total impact of this life cycle stage are evaluated in the figure below.

Figure 70. Contribution analysis of the subprocesses included in LCS1 - raw material acquisition and preprocessing of LLD to different impact categories (see Table 44).

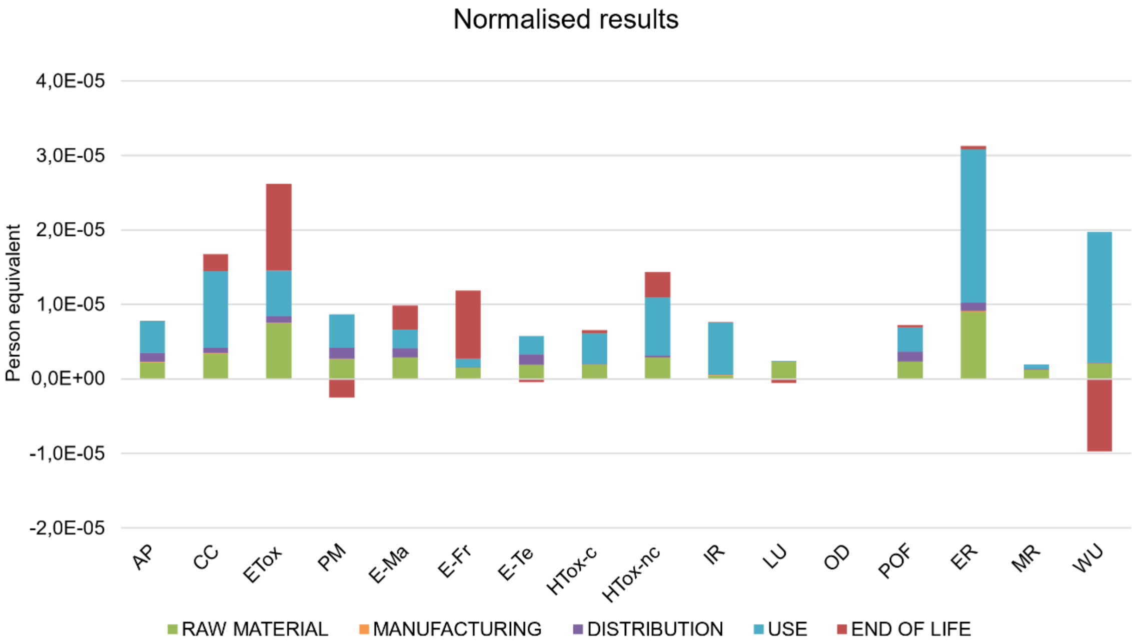


Within this life cycle stage, surfactants contributed the most to impacts as a single ingredient, which is not unexpected given that these ingredients account for 17% of the total formulation (with the remainder being 13% “other ingredients” and 70% water). There were too many “other ingredients” for them to be accurately portrayed individually in the column chart above. However, the two main contributors across all impact categories were citric acid or propylene glycol, or a combination of both. It is also worth mentioning the relatively high contribution of the proxy preservative “Benzo[thia]diazole”, which had a notable contribution to impacts from “other ingredients” despite only accounting for 0.5% of the 13% fraction of “other ingredients”.

The one impact category where ingredients did not dominate is LU, where the secondary packaging contributes the most, due to the production of cellulose fibres used in the cardboard boxes. The transport of ingredients and packaging have a very small impact in this life cycle stage.

Normalised results for LLD products: The characterised results presented above are normalised using the EF 3.1 normalisation factors, which can be found in Table 45. The figure below shows the normalised results within all impact categories.

Figure 71. Normalised results of an average LLD presented in Person Equivalent (using EF 3.1 normalisation factors) for different impact categories (see Table 44).



The highest impacts are seen in the impact category ER, where the energy consumption in the use stage contributes the most. Other significant normalised impacts are seen in ETox, where end of life is responsible for most of the impact and WU where it is again the use stage that contributes the most. The lowest impacts are seen within OD, LU, and MR.

Weighted and normalised results for LLD products: Weighting the LCA results is a mandatory step in the PEF methodology. During weighting, the normalised results are multiplied by weighting factors reflecting the importance of the different life cycle impact categories. Table 48 shows the weighted results. The weighting factors can be found in Table 45. The weighted results are aggregated across all impact categories obtaining an overall score for each life cycle stage.

Table 48. Weighted results of normalised total impacts of LLD life cycle stages

	Value	Unit	% share
Raw material	2.86E-06	mPR	26.6%
Manufacturing	5.27E-08	mPR	0.5%
Distribution	6.35E-07	mPR	5.9%
Use	7.14E-06	mPR	66.6%
End-of-life	-4.27E-08	mPR	-0.4%
TOTAL	1.06E-05	mPR	100%

Sensitivity analysis for LLD products: A sensitivity analysis was made in this study to assess the different scenarios. The scenarios assessed in this study are presented below:

- **"Global procurement"**: All ingredients are procured outside of Europe as opposed to the baseline where it is all procured inside Europe – looked at from a normalised results per impact category perspective.
- **"Recycled bottle":** The packaging consisted of virgin HDPE and cardboard in the baseline is replaced with recycled HDPE and 88% recycled cardboard – looked at from a normalised results per impact category perspective.
- **"Lower temperature washing":** The energy savings caused by lower wash temperature cycles are assessed against how much extra detergent would cause those savings to be cancelled out – looked at from a single PEF score perspective.
- **"Less hazardous preservative":** This scenario assumed that the proxy Benzo[thia]diazole preservative could be replaced by less toxic alternatives (benzyl alcohol or lactic acid) on a one-to-

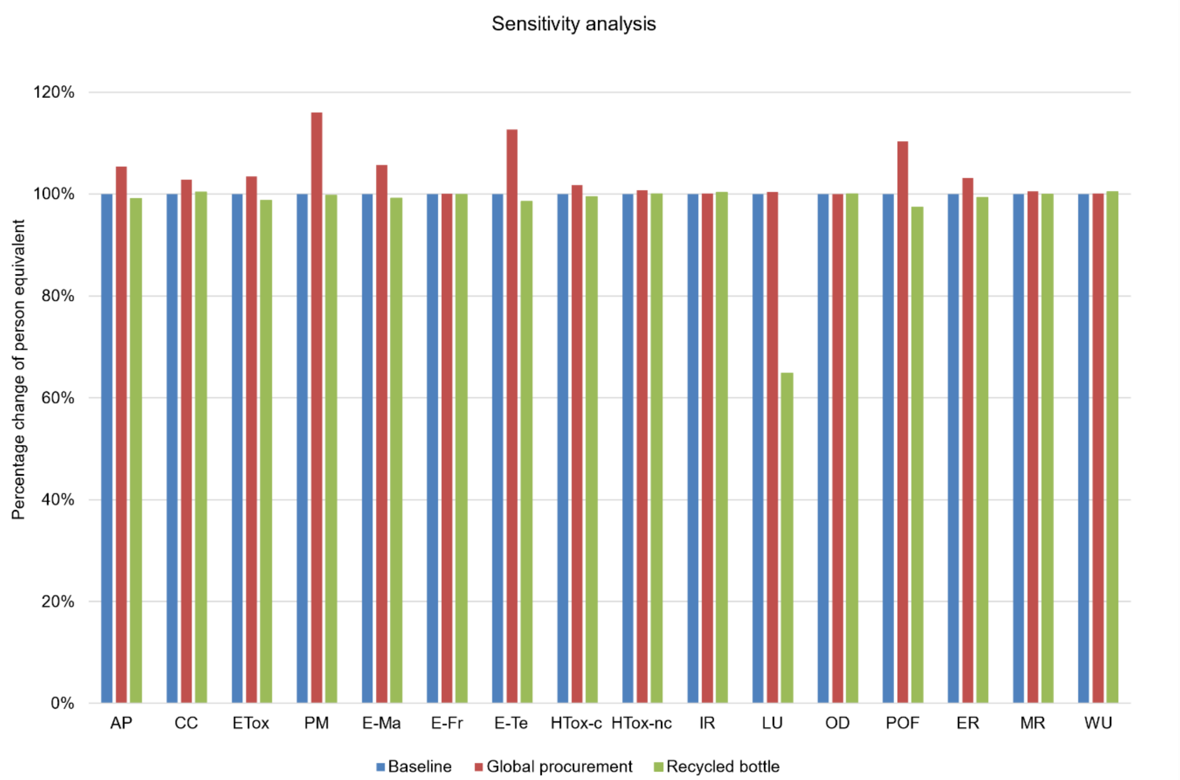
one basis or on a two-to-one basis – looked at from the normalised impacts for the raw material stage only.

- **“Fragrance**-free and dye-free”: The same LLD formulation is assumed but with fragrance or dye components removed (simply increasing the water content to compensate).

The results are presented in the sub-sections below.

Global procurement and recycled packaging: The figure below shows the results of the two of the three sensitivity scenarios in relation to the baseline presented in the sections above.

Figure 72. Relative changes (baseline set at 100%) to normalized results for three different sensitivity analyses with LLD products (see Table 44 for explanations of impact categories).

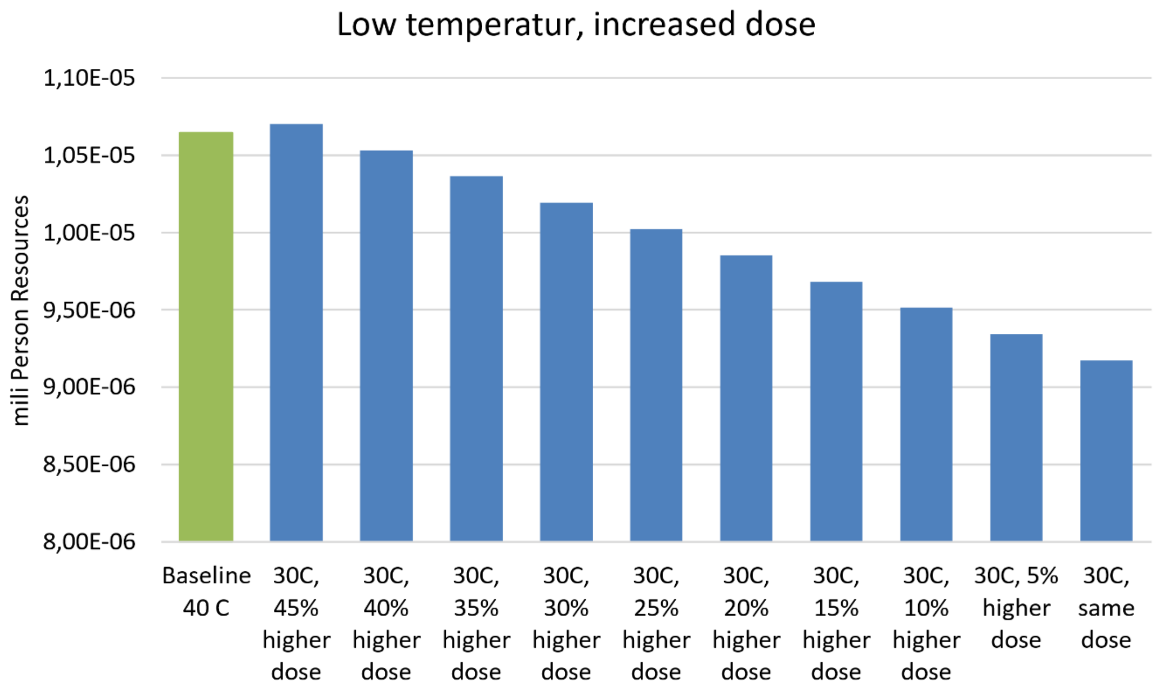


For the scenario “Global procurement” there is a relatively big change in AP, PM, E-Ma, E-Te and POF compared to the baseline (+5%, +16%, +6%, +13% and +10%, respectively). This is caused by the extra transport that is necessary when sourcing globally. In no impact categories does “Global procurement” score lower than the baseline. Unsurprisingly, global procurement of ingredients can thereby be concluded to increase the environmental impact of LLD products.

The scenario “Recycled packaging” resulted in very minor reductions in several impact categories (-1% in CC, ETox, HTox-c, and POF, and -2% in ER). A 35% reduction is seen in LU, which is related to the benefit of recycling cardboard. The LCA benefits of using recycled packaging material were much less significant than improved transportation patterns in relation to ingredient procurement and sales distribution.

Low temperature wash versus increased detergent dosing: As the use stage proved to be the most contributing life cycle stage, a sensitivity analysis was made in this parameter reducing the washing temperature to 30°C. However, decreasing the temperature might result in the need to increase of concentration and/or dosage of the LLD to maintain a given level of detergency. Hence, an analysis was made decreasing the temperature while increasing the dosage. The graph below shows the benefit of lowering the washing temperature as well as the consequence of increasing the dosage of LDD to the point when the trade-off between these two parameters cancel each other out. The result of the analysis is shown in the figure below.

Figure 73. Single PEF score results showing the benefits of decreasing the washing temperature from 40 to 30°C as well as the trade-off caused by potential needed increases in the LLD dosage to compensate for the lower temperature.

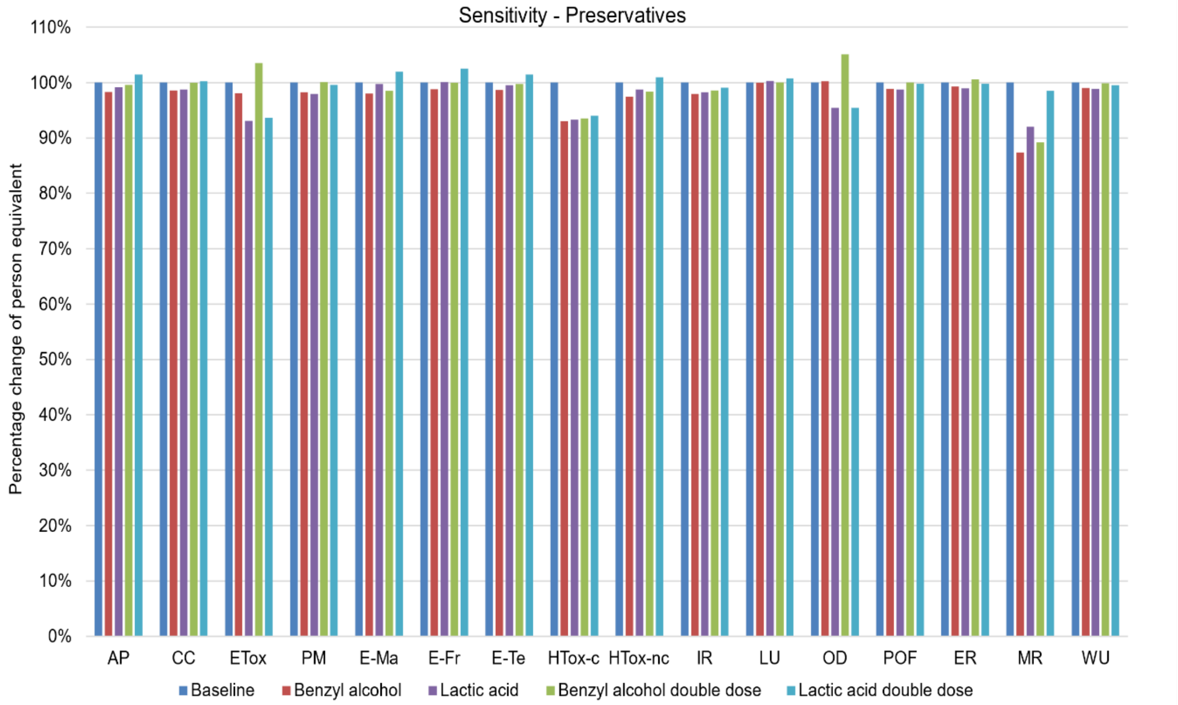


Lowering the washing temperature 10°C and maintaining the same dosage results in a 14% reduction in environmental impact. However, by increasing the dosage this benefit decreases and if the dose is increased by 45% the benefits of lowering the washing temperature by 10°C are lost.

Less hazardous preservatives: Preservatives can consist of several different chemical compounds. This study assesses the sensitivity of those parameters. Even though there are very limited options to examine in the EF datasets for preservatives, a comparison was made of replacing the proxy preservative "Benzo[thia]diazole" with two alternative less toxic preservatives – benzyl alcohol (a proxy for sodium benzoate) and lactic acid.

Furthermore, it assesses the influence of an increase in the number of preservatives as typically one needs more of the less toxic preservatives to obtain the same preservation effect as the more toxic ones. The results are only looking at the raw material stage as this is the only stage affected by the change and this will also make the change in results more visible.

Figure 74. Assessment of the sensitivity of the choice of preservative and its relative concentration in LLD products (baseline is 0.5% benzo[thia]diazole).

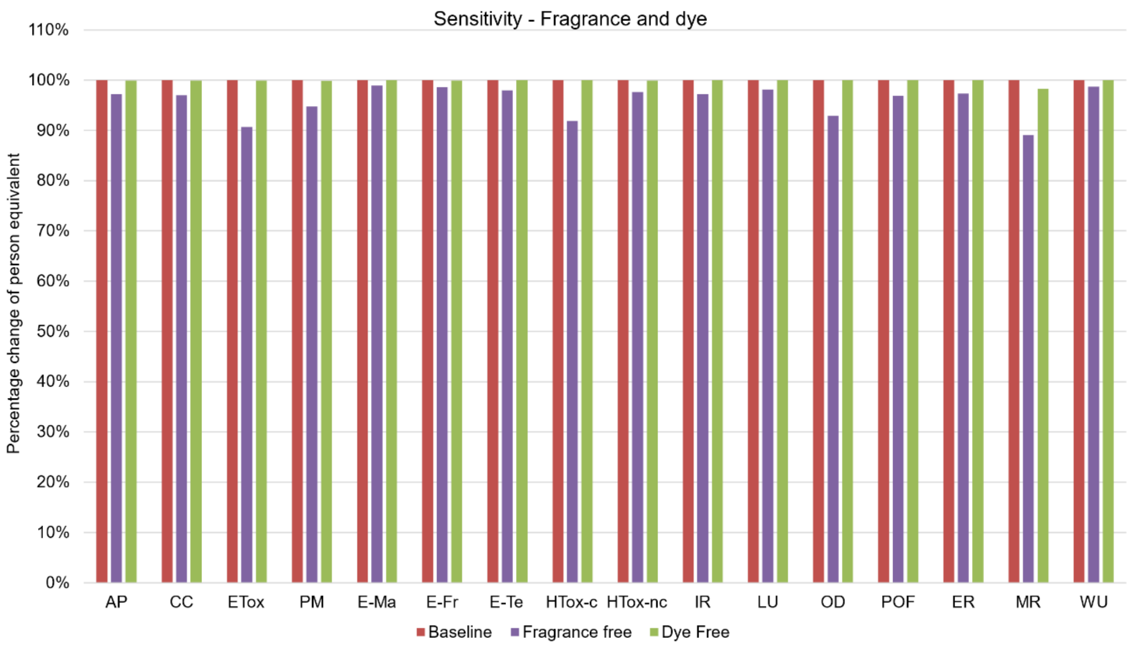


The figure above shows, that the shift to less toxic preservatives, assuming a one-to-one replacement rate, has a positive effect within the toxicity impact categories ETox and HTox-c, as these are less harmful to living organisms. Another reduction is seen within MR. Other benefits are also seen in all other impact categories, but to lower extents. However, if the less toxic preservatives require double the quantity for the same preservation effect, the benefits are much less, and in some cases worse than the original baseline scenario (e.g. 1.0% benzyl alcohol for ETox and OD impacts).

Fragrance-free or dye-free formulations: Since fragrances and dyes are not required for the core detergency function of detergent products, it can be argued that some valid environmental improvements would be to not use these ingredients in the first place.

The figure below shows the results of removing fragrance and dye from the formulation replacing it with water. The results are shown for the raw material stage, because this is the stage were changes are dominant and it will be easier to see the effects of any changes.

Figure 75. Assessment of scenarios with fragrance and dye free alternatives.



It is evident that the omission of fragrance even though it only makes up less than 1% of the formulation, has a significant effect on impacts associated with the ingredients. Removing the fragrance(s) reduces ETox, HTox, OD, and MR impacts (by -9%, -8%, -7%, and -11%, respectively). On the other hand, removing dyes from the formulation showed no or only minor reductions in impacts (generally -2% or less). However, it must be added that the proxy for dyes is still missing some potentially important assumed ingredients and this analysis should be repeated once a better proxy can be defined.

Summary and interpretation of screening LCA results for LLD products: Conducting the EFIA study and appertaining sensitivity analyses revealed the following conclusions:

- Use and raw material and pre-processing stages are the most contributing life cycle stages when assessing the environmental performance of LLD per kg of dry laundry at 40°C. The use stage is driven by the electricity consumption of the washing machine. In the raw material and pre-processing stage, the impacts are related to the surfactants and other ingredients. Generally speaking, the biggest impacts are associated with the ingredients used in highest quantities.
- The highest normalised impacts are seen within ER, Etox, and WU categories.
- The weighted results revealed the use stage to account for 67% of the environmental impacts of LLD.
- Reducing the washing temperature 10°C brings a potential reduction of 14%. However, if lowering results in increasing the detergent dosage the benefits will be lower. Increasing the detergent dose by 45% will effectively cancel out the gained benefit of lowering the temperature.
- Replacing the preservative with a less toxic alternative has a positive impact on the toxicity impact categories ETox and HTox-c, as well as for MR. However, if larger amounts of preservative are needed, the positive impacts reduce. Especially when replacing it with benzyl alcohol. Only small changes are seen within the remaining impact categories.
- Removing fragrance from the formulation has significant positive environmental effects even though they account for less than 1%. The benefits are especially seen within toxicity categories.

With regards to the revision of the EU Ecolabel criteria on LDD this study revealed the importance on the formulation as contribute the most in the raw material and pre-processing stage. One could set criteria on the use of surfactants as well as criteria on the use of fragrance. Most of the environmental impacts are caused by the use stage, which can only be addressed indirectly through criteria on consumer information.

5.4.3.4. Screening LCA of Powder Laundry Detergent (PLD) products

5.4.3.4.1. Background information and assumptions

Definition of the product: For the purpose of this LCA screening, PLD products are considered as laundry detergents <u>in powder form</u> falling under the scope of Regulation (EC) No 648/2004 which is effective at 30°C or below and are marketed and designed to be used for the washing of textiles principally in household machines, but not excluding its use in public laundrettes and common laundries.

Functional unit and reference flows: The functional unit is the wash of 1 kg dry laundry in a washing machine at 40°C in an average European household.

As with LLD, the recommended dosing rates for PLD vary, depending on factors such as degree of soiling and water hardness. In this study, the average dosage is assumed to be 14 g detergent per kg dry laundry based on information taken from EU Ecolabel license applications.

Raw material acquisition and preprocessing: The composition of an average PLD is derived from a combination of formulations for EU Ecolabel PLD products, making some type of representative EU Ecolabel PLD. The minor components of the representative formulation are not listed in the table below, partly for reasons of confidentiality and partly because of the large number of small concentrations of chemicals. However, these small amounts of ingredients were accounted for in the LCA study. The representative formulation could potentially change in any updated study in the next draft if more PLD formulations are shared as well. Table 49 shows the average formulation together with the LCI processes from the EF 3.1 database used in this study.

Table 49. LCI of a standard formulation of an average PLD using the EF 3.1 database.

Ingredient	%	EF 3.1 process
Sodium sulfate	26%	Sodium sulphate production {EU+EFTA+UK}
sodium carbonate	24%	Soda production {EU+EFTA+UK}
Zeolite	15%	Zeolite {GLO}
Sodium bicarbonate	12%	Sodium bicarbonate production {EU+EFTA+UK}
Laureth-7	6%	Proxy: Non-ionic surfactant, ethyleneoxidederivate production {GLO}
Sodium carbonate peroxide	6%	Sodium percarbonate, powder production {EU+EFTA+UK}
Water	5%	Water, completely softened {EU+EFTA+UK}
TAED	1%	Proxy: EDTA production {EU+EFTA+UK}
Cellulose gum	1%	Carboxymethyl cellulose production {EU+EFTA+UK}
Sodium silicate	1%	Sodium silicate powder production {EU+EFTA+UK}
Sodium C12-C18-alkyl sulfate	0,5%	Proxy: Alkylbenzene sulfonate production {EU+EFTA+UK}
Fragrance	0.3%	Proxy: 15% Hexylcinnamic aldehyde production {GLO}, 15 % Dihydromyrcenol production {GLO}, 15% Hexyl salicilate production {GLO}, 15% Beta-pinene production {GLO}, 40% Benzoic acid production {GLO}
Potassium Sorbate	0.00003%	Proxy: Ascorbic acid production {EU+EFTA+UK}
Sodium Benzoate	0.00003%	Proxy: Benzoic acid production {GLO}
Combination of enzymes	0.03%	Enzymes production {EU+EFTA+UK}
Other ingredients	ca. 2.2%	Various proxies for the remaining individual compounds

The table below shows the inventory used for the modelling of primary and secondary packaging. The data is derived from Arendorf et al. 2014a. Tertiary packaging was not included due to the limited amount of available data.

Table 50. LCI of both primary and secondary packaging for powder laundry detergent.

Type of packaging	Amount	EF 3.1 process

Primary:	Per FU	
Cardboard box	8.24E-04 kg	Corrugated board, uncoated {EU+EFTA+UK}
Secondary:	Per FU	
Cardboard box	1.0706E-05 kg	Corrugated board, uncoated {EU+EFTA+UK}

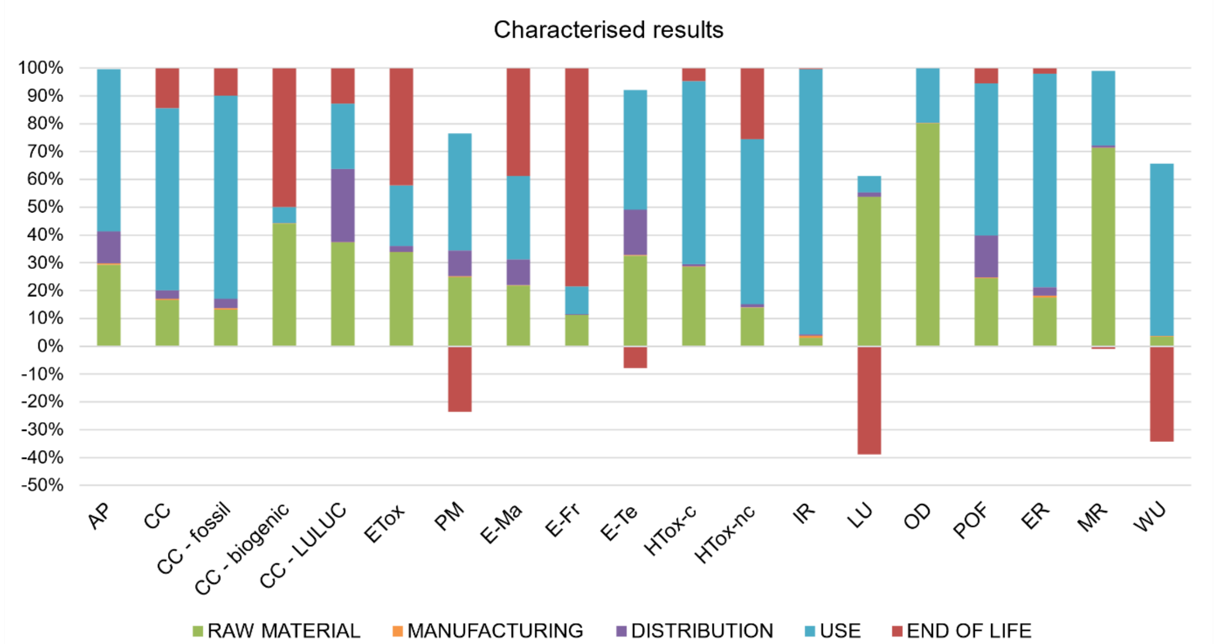
All other background information and assumptions for PLD products can be considered as the same as for LLD products, except the data quality in the raw material and pre-processing. For PLD the data quality is good as it is collected through a survey sent to detergent manufacturers. The data has been anonymised to protect the confidentiality of the data. As shown above some proxies have been used due to lack of exact matches in the EF 3.1 database.

In terms of energy consumption in the manufacturing stage, an important difference can be expected between LLD and PLD products because of the process of feeding slurry into a spray drying tower in PLD manufacturing. This process does not happen in LLD manufacturing and requires the rapid drying of slurry in temperatures of several hundred degrees Celsius – normally achieved by the combustion of natural gas. However, no accurate data could be found for specific energy consumption for this process prior to publication of these draft studies. Estimates were not provided in the PEFCR report either because the scope was purely on LLD products.

5.4.3.4.2. Life cycle impact assessment (LCIA) for PLD: results and interpretation

Contribution analysis for PLD products: A contribution analysis was made to identify hotspots in the life cycle stages of PLD in the same manner as for LLD. The figure below presents the results of the contribution analysis.

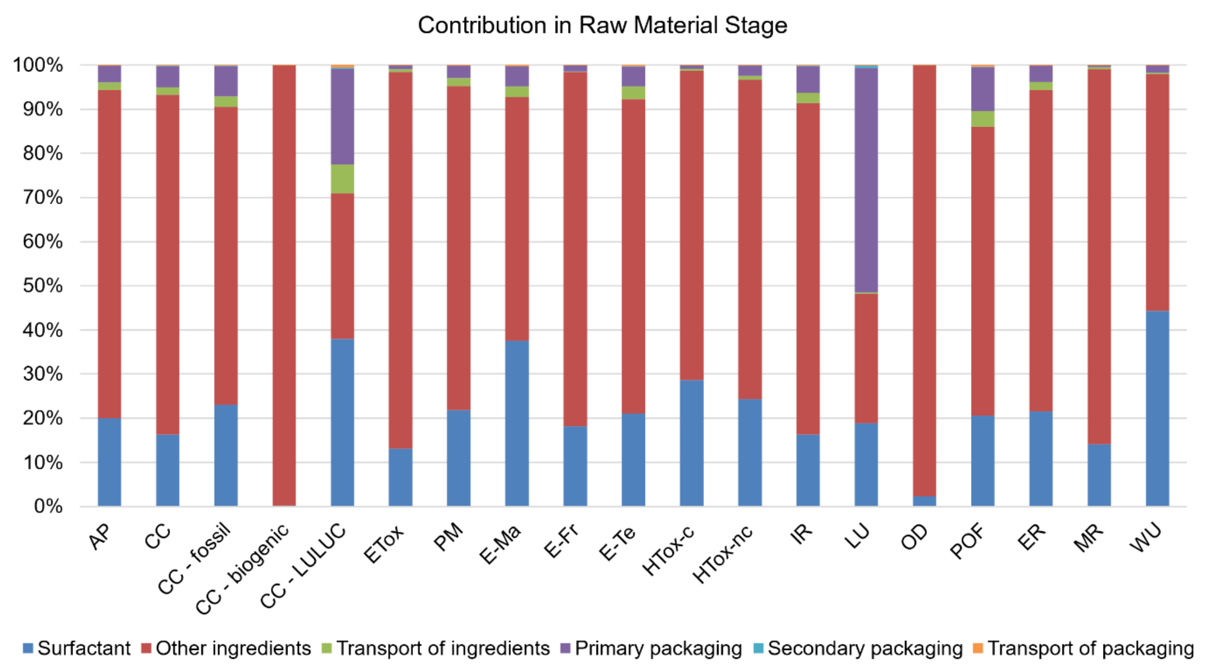
Figure 766. Characterised results for PLD life cycle stages, presented in percentage of total impact, split by life cycle stage for each of the impact categories (see Table 44).



Looking at the results above, the two most impacting life cycle stages per kg of laundry washed with PLD are the raw material stage and the use stage. There are some negative impacts (i.e. environmental benefits) for PM, E-Te, LU and WU, due to recycling and energy recovery in the EoL stage. The impacts in the use stage are primarily stemming from the use of electricity of the washing machine. The impacts related to the EoL primarily stems from the wastewater treatment.

The raw material and preprocessing stage consists of many sub-processes. The contribution of these sub-processes to the total impact of the raw material and preprocessing life cycle stage is evaluated in the figure below.

Figure 77. Contribution analysis of the subprocesses included in the raw material and preprocessing of PLD products to different impact categories (see Table 44).



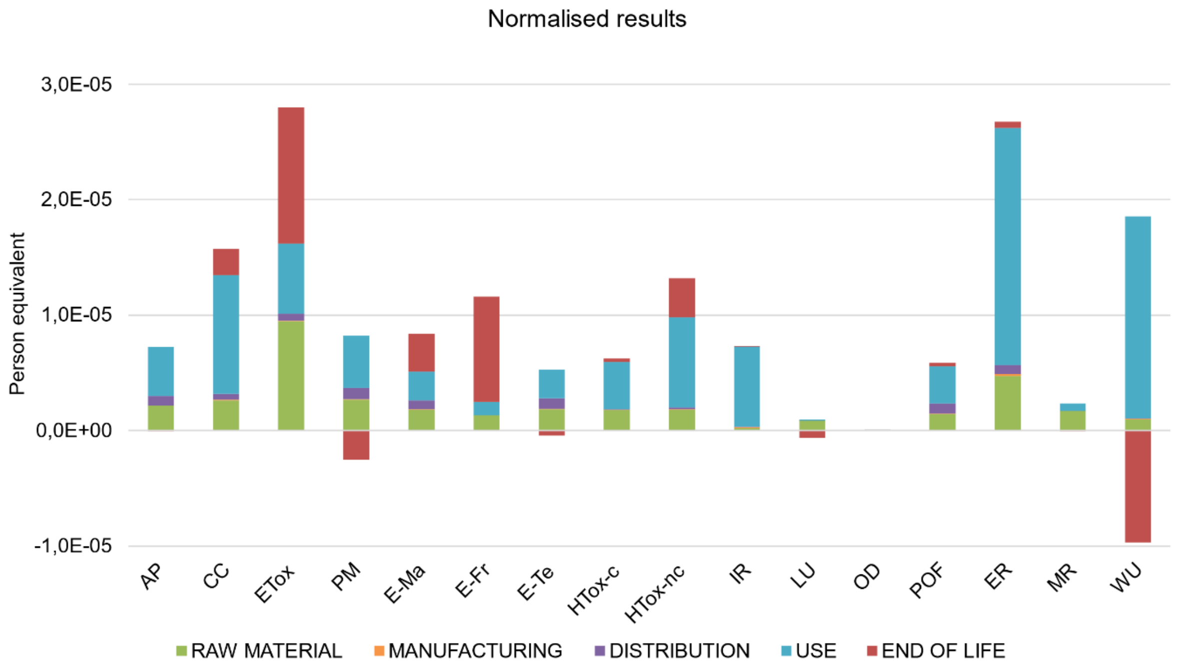
Surfactants, which are the crucial ingredient common to almost all detergent products, only accounted for a relatively small fraction of the total ingredient content (ca. 6.5%), which is much lower than the 17% in the LLD product examined in the previous section. For this reason, it is to be expected that surfactants contribute less to the overall impacts of the raw materials life cycle stage in PLD than in LLD, which was the case.

The “other ingredients” in the composition of detergents, apart from surfactants, are what is contributing with most in 17 of 19 impact categories within the life cycle stage raw material acquisition and pre-processing. The impact category CC-biogenic and OD impacts were strongly dominated by sodium sulphate, which was the most common ingredient, accounting for 26% of the formulation. All other impact categories were dominated by contributions from the following four ingredients in varying proportions: sodium carbonate (24% of formulation), sodium sulphate (26%), sodium bicarbonate (12%) and zeolite (15%).

Within LU the primary packaging makes up 50 % of the contribution, which is related to the growing of trees for cellulose pulp production for cardboard production.

Normalised results for PLD products: The characterised results presented in the last section are normalised 9using the EF 3.1 normalisation factors, which can be found in Table 45.

Figure 78. Normalised results of an average PLD presented in Person Equivalent (using EF 3.1 normalisation factors) for different impact categories (see Table 44).



The figure above shows the normalised results for all impact categories, split by life cycle stage. The highest impacts are seen with E-Tox, ER and WU. With ETox impacts, important contributions come from the raw material, use and end-of-life stages. With ER and WU, the use stage is by far the most important source of impacts. The lowest normalised impacts are seen with OD and LU.

Weighted results for PLD products: Weighting the LCA results is a mandatory step in the PEF methodology. During weighting, the normalised results are multiplied by weighting factors reflecting the importance of the different life cycle impact categories. Table 51 shows the weighted results. The weighting factors can be found in Table 45. The weighted results are aggregated across all impact categories obtaining an overall single PEF score for each life cycle stage.

Table 51. Weighted results using the EF 3.1 weighting factors provided by the European Commission.

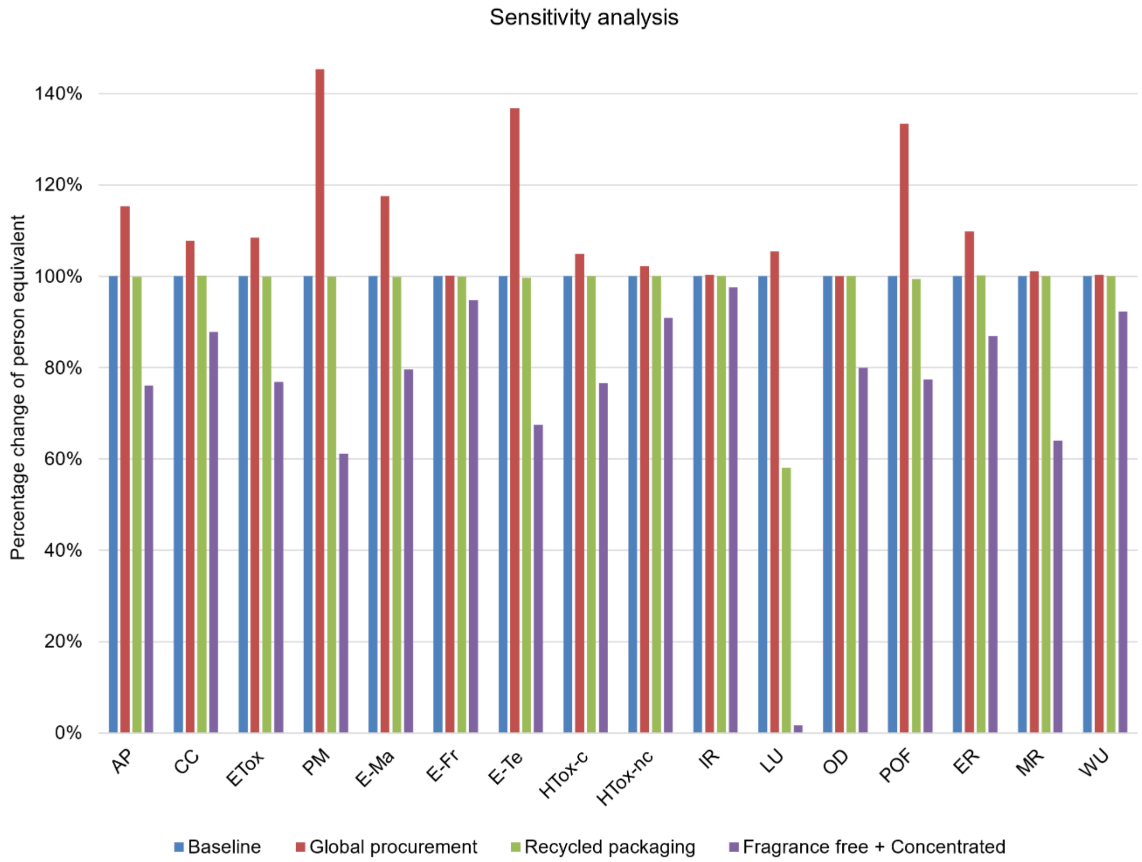
	Value	Unit	% share
Raw material	2.09E-06	mPR	21.3%
Manufacturing	4.43E-08	mPR	0.5%
Distribution	4.31E-07	mPR	4.4%
Use	7.14E-06	mPR	73.1%
End-of-life	7.35E-08	mPR	0.8%
TOTAL	9.78E-06	mPR	100%

Sensitivity analyses for the PLD life cycle: A number of sensitivity analyses were made in this study to assess different parameters in the LCA model. In this study three scenarios are addressed. The scenarios test the influence of data gaps on the results and evaluate the consequences of changing parameters. Other scenarios access the change of inputs to reduce the environmental impacts of PLD. The three scenarios assessed in this study are presented below:

- **"Global procurement"**: All ingredients are procured outside of Europe as opposed to the baseline, where it is all procured inside Europe.
- **"Recycled packaging"**: The packaging consisting of virgin cardboard in the baseline is replaces with 88% recycled cardboard.
- **"Fragrance free and low dose formula"**: The PLD formulation is replaced with a fragrance free and low dose variant. For confidentiality reasons the full formulation is not provided, but it contains much higher levels of sodium carbonate, sodium silicate, sodium bicarbonate, sodium acrylic maleic

acid copolymer and enzymes than the "representative PLD" used in the baseline. The dosage per FU for the alternative formulation is 7g/kg dry laundry compared to the 14 g/kg dry laundry in the baseline.

Figure 79. Relative changes (baseline set at 100%) to normalized results for three different sensitivity analyses with PLD products (see Table 44).



The figure above shows the results of the three sensitivity scenarios in relation to the baseline presented in the sections above. Shifting from the procurement of raw materials within Europe to global procurement has a high effect on the environmental impact of the PLD as seen in the figure above. Highly significant changes are seen in PM, E-Ma, E-Te and POF compared to the baseline (+45%, +18%, +37% and +33%, respectively) and significant changes in AP, CC, ETox, and ER (+15%, +8%, +8% and +10%, respectively). This is caused by the extra transport that is necessary when sourcing globally. In no impact categories does "Global procurement" score lower than the baseline. Unsurprisingly, global procurement of Ingredients can thereby be concluded to increase the environmental impact of PLD products.

Shifting from virgin cardboard to a large share of recycled cardboard reduces the impact within LU with 42%. This is related to the reduction in land used for forestry, when cardboard is recycled. Otherwise, no changes are seen in the results compared to the baseline.

Changing the formulation to a fragrance-free and low dose alternative, that halves the amount of detergent product needed to wash 1 kg of dry laundry makes a highly significant reduction in most normalised impact categories. The largest reductions are seen in LU, PM, MR, and E-Te (-98%, -39%, -36%, and -33%, respectively). Within CC impacts, the reduction is -12% even though this is dominated by electricity consumption in the use phase. Based on this scenario it can be concluded that the formulation of PLD is sensitive to change, especially if it is associated with significant changes in the required dosages.

Summary and interpretation of results for PLD products: Conducting the EFIA study and appertaining sensitivity analyses revealed the following conclusions:

- The use stage is the most contributing life cycle stage followed by the raw material stage, when assessing the environmental performance on PLD per 1 kg of dry laundry and at a washing temperature of 40°C.
- Within the raw material stage, the other ingredients in the formulation apart from the surfactants contributed the most to this life cycle stage. The most significant other ingredients were also the most common ones (i.e. sodium sulphate, sodium carbonate, sodium bicarbonate and zeolite).
- The highest normalised impacts are seen with the categories of ETox, ER and WU.
- The weighted results reveal that the use stage accounts for 73% of the impacts followed by the raw material stage with 21%. It remains to be seen how significant the manufacturing stage is once the specific energy consumption from spray drying towers is factored in.
- A sensitivity analysis using a more concentrated and fragrance free was conducted and the formulation of PLD is of high importance from a cradle-to-grave perspective, producing reductions in all 19 impact categories.
- Transport distances of ingredients was also a significant contributor to overall results, but only for some impact categories (mostly PM, E-Te, POF, E-Ma and AP).
- Using recycled material in the packaging has only a small impact on the results, except for LU.

In relation to the revision of the criteria of the EU Ecolabel for PLD this study revealed the importance if the formulation as the environmental performance might change significantly when changing the formulation. One could consider criteria related to the use of fragrance, as they do not serve the function of cleaning the clothes, but is purely an accessory, which can easily be omitted.

5.4.3.5. Screening LCA of Dishwashing Detergent (DD) products

5.4.3.5.1. Background information and assumptions

Definition of the product: For the purpose of this LCA screening, Dishwasher Detergents (DD) comprise any detergent for dishwashers falling under the scope of Regulation (EC) No 648/2004 which is marketed and designed to be used exclusively in household dishwashers and in automatic dishwashers for professional use of the same size and usage as that of household dishwashers. The most used format of DD products are tablets. Therefore, this study focuses on tablets for dishwashers. This study represents an average DD and not a specific product or brand.

Functional unit and reference flow: The LCA on DD describes the amount of detergent required to run one dishwashing cycle for a normal sized household dishwasher, assumed to be able to clean 10 to 14 place settings and serving pieces[429] per cycle. This will require 1 tablet of dishwashing detergent equivalent to 20 grams.

Raw material acquisition and preprocessing: The composition of the dishwasher detergent is based on Arendorf et al. (2014b). The table below shows the inventory data used in the compilation of an average tablet used for dishwashing.

Table 52. LCI of a standard formulation of an average dishwasher detergent using the EF 3.1 database.

Ingredient	%	EF 3.1 process
Anionic surfactant (LAS)	2%	Proxy: Alkylbenzene sulfonate production {EU+EFTA+UK}
Citric acid	30%	Citric acid production {EU+EFTA+UK}
Maleic acid/acrylic acid copolymer sodium salt	6%	Proxy: Polycarboxylate production {EU+EFTA+UK}
Sodium percarbonate	7%	Sodium percarbonate, powder production {EU+EFTA+UK}
TAED	2%	Proxy: EDTA production {EU+EFTA+UK}
Sodium silicate	10%	Sodium silicate powder production {EU+EFTA+UK}
Protease savinase	1%	Enzymes production {EU+EFTA+UK}
Amylase termamyl	1%	Enzymes production {EU+EFTA+UK}
Sodium carbonate	44%	Soda production {EU+EFTA+UK}

The production of packaging is included in this phase of the life cycle. The table below shows the inventory used for the modelling of primary and secondary packaging. Tertiary packaging was not included due to the limited amount of available data.

Table 53. LCI of both primary and secondary packaging for dishwasher detergent.

Type of packaging	Amount [kg]	EF 3.1 process
Primary:	**Per FU**	
Flowwrap film	0.00035	Plastic, shrink wrap {EU+EFTA+UK}
Shrinkwrap	0.00018	Plastic, shrink wrap {EU+EFTA+UK}
Secondary:	**Per FU**	
Cardboard box	0.003	Corrugated board, uncoated {EU+EFTA+UK}

Manufacturing: For the manufacturing stage, inputs of electricity, water and heat, and outputs of wastewater have been counted. The data for electricity and water usage are based on the AISE KPI-report from 2023. An assumption of detergent wasted in the manufacturing process has been estimated to be around 2 % and has been included in the study.

Distribution: In the distribution stage, an equal split between distribution from factory to local, intracontinental, and international retail or distribution centre has been assumed, due to the lack of data. It is furthermore assumed that all products will go to retail before going to the consumer. This is based on the

[429] A more detailed definition of place settings and serving pieces can be found in IEC 60436.

PEFCR for household Heavy Duty Liquid Laundry Detergents. Transport from the distribution centre to retail has been included. Furthermore, as defined by the PEF method, both lighting and heating of storage in distribution centres and retail has been included.

Use: The use stage consists of one washing cycle in an average dishwasher. Part D in the PEF method describes default data for modelling the use stage and the use of a dishwasher and default assumptions with regards to water and electricity consumption per washing cycle is provided and was used in this study (water consumption: 15 L and electricity consumption: 1.2 kWh). The production of the dishwasher itself is not included in the study.

End of life (EoL): The DD is assumed to be packed in cardboard boxes. The end-of-life stage consists of the transport of waste and waste processing in the form of recycling, incineration with energy recovery and landfilling. The CFF is used to calculate the impacts related to EoL. The EoL in this case covers wastewater treatment after the use of detergent, recycling, incineration and landfilling of packaging. The CFF has been applied to each of the different material types present in the packaging. The different variables used have been taken from Annex C in the PEF method.

Data quality: The assessment of the data quality is split up into the different life cycle stages; raw material acquisition and pre-processing (LCS1), manufacturing (LCS2), distribution stage (LCS3), use stage (LCS4), and End of Life (LCS5).

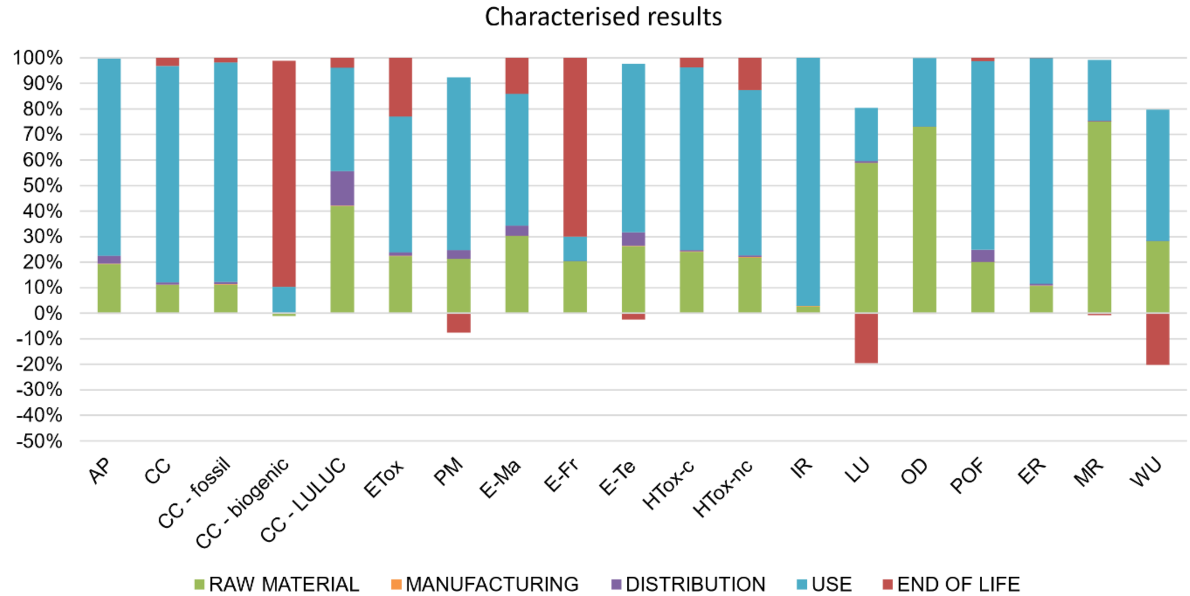
- LCS1: Data quality regarding the average composition of DD is fair. The literature data is approximately 10 years old but validated with current product formulation as described above. For some ingredients no LCI data was available in the EF 3.1 database and here proxies were used as a best guess. The data quality for the packaging is good.
- LCS2: The data quality of the manufacturing process retrieved from AISE is fair. Unfortunately, the energy input was not divided into heat and electricity and estimates of the division had to be made. The datasets used from the EF 3.1 database for electricity, wastewater treatment and water are good.
- LCS3: All data regarding the distribution stage was retrieved from the default scenarios provided in the PEF method. The quality of the LCI data is good and the overall data quality of this life cycle stage is good.
- LCS4: The data quality of the use stage is good. Data is taken from the default assumption in the PEF method and the LCI data is good.
- LCS5: The data in the EoL stage is based on the CFF parameters provided in the Annex C in the PEF method. The overall data quality of this life cycle stage is good.

The data used in this study represents an average DD. Hence, the results do not address the environmental performance of individual products. No data was found for the share of local, intracontinental, and international distribution and assumptions might not reflect the realistic conditions. It was desired to investigate the differences between petrochemical based surfactants with an olechemical alternative. However, the EF database just comprises dataset names oleochemical and represents a technology mix of different olechemical sources (e.g. palm kernel oil, coconut oil etc.) but does not comprise of the individual processes. Hence, an analysis of the importance of the oleochemical alternatives was not possible.

5.4.3.5.2. Life cycle impact assessment (LCIA) for DD: results and interpretation

Contribution analysis for DD products: For DD products, the results are indicated in the figure below.

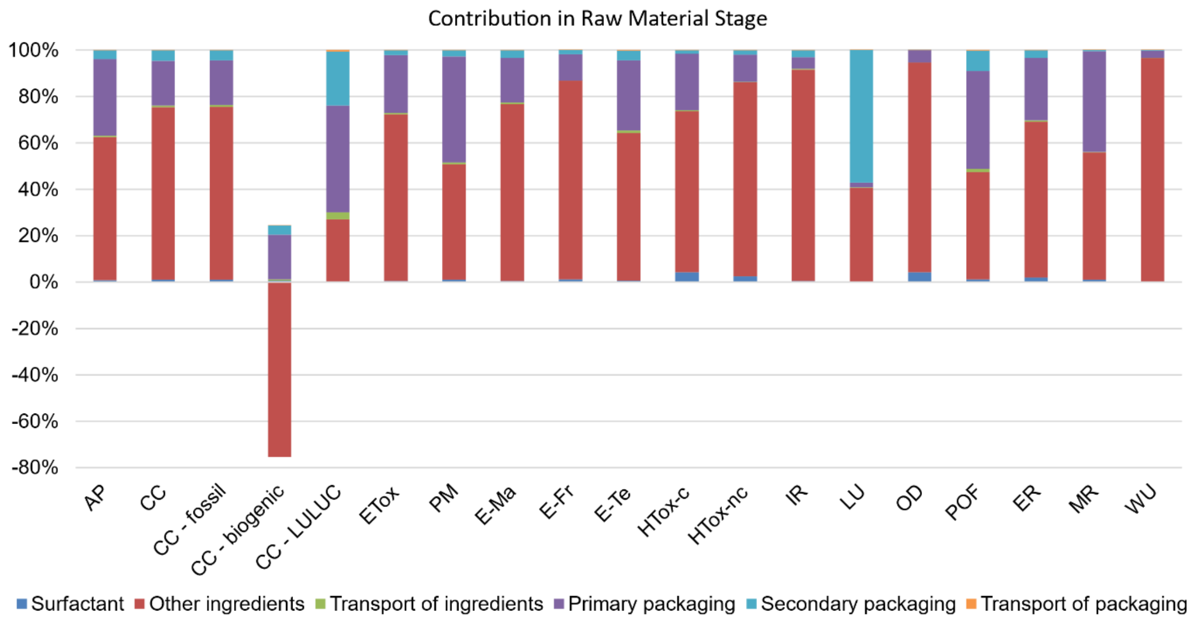
Figure 80. The characterised results for a DD tablet in percentage of total environmental impact, split by life cycle stage for all impact categories (see Table 44).



As shown in the figure above, the most contributing life cycle stage to the environmental impact of one dishwashing cycle is the use stage followed by the raw material and preprocessing stage. In PM, LU, MR and WU, are some negative impacts also occurred (i.e. environmental benefits) as a result of recycling and energy recovery in the EoL stage. The impacts in the use stages are primarily stemming from the use of electricity for the dishwasher.

The figure below shows the processes contributing most to the impact of one dishwashing cycle within the raw material and preprocessing stage.

Figure 81. Contribution analysis of the subprocesses included in LCS1 - raw material acquisition and preprocessing of DD products to different impact categories (see Table 44).

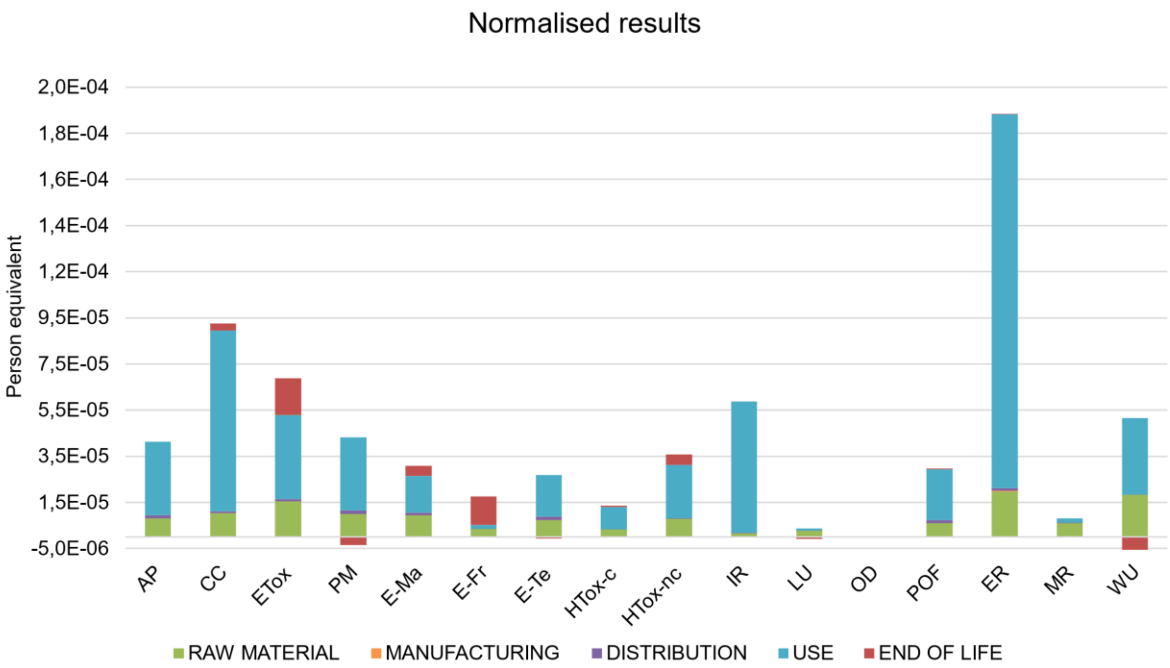


Surfactants, the essential ingredient common to virtually all detergent products, only make up a very minor share of impacts during this stage – to be expected due to the very small share of surfactants in the formulation (ca. 2%). It is especially the other ingredients that result in the biggest environmental impact.

Citric acid, the second most common ingredient at 30% of the formulation, dominated the impacts of “other ingredients” for all impact categories except for CC-biogenic (where a high negative impact was recorded that needs some further investigation), ODP and E-Fr. With ODP impacts, sodium silicate and TAED dominated, while with E-Fr, impacts were dominated by sodium carbonate (the most common ingredient at 44% of the formulation), then by citric acid and TAED. Thereafter it is the primary packaging, which contributes to around 10% or more of around half of the impact categories.

Normalised results for DD products: The characterised results presented in the section above are normalised using the EF 3.1 normalisation factors, which can be found in Annex 3. The figure below shows the normalised results within all impact categories.

Figure 82. Normalised results of an average DD tablet presented in Person Equivalent (using EF 3.1 normalisation factors) for different impact categories (see Table 44).



The highest impacts by some margins are seen in the impact category ER, where the energy in the use phase contributes the most. This is followed by CC, ETox and IR, where the use phase is also dominant, although ETox is also influenced by raw material and end-of-life stages. The lowest impacts are seen within OD, LU and MR. Generally, the use phase dominated normalised impacts for all impact categories except for E-Fr and MR.

Weighted results for DD products: Weighting the LCA results is a mandatory step in the PEF methodology. During weighting, the normalised results are multiplied by weighting factors reflecting the importance of the different life cycle impact categories. The weighted results are shown below.

Table 54. Weighted result using the weighting factors from the EF 3.1. methodology by the European Commission

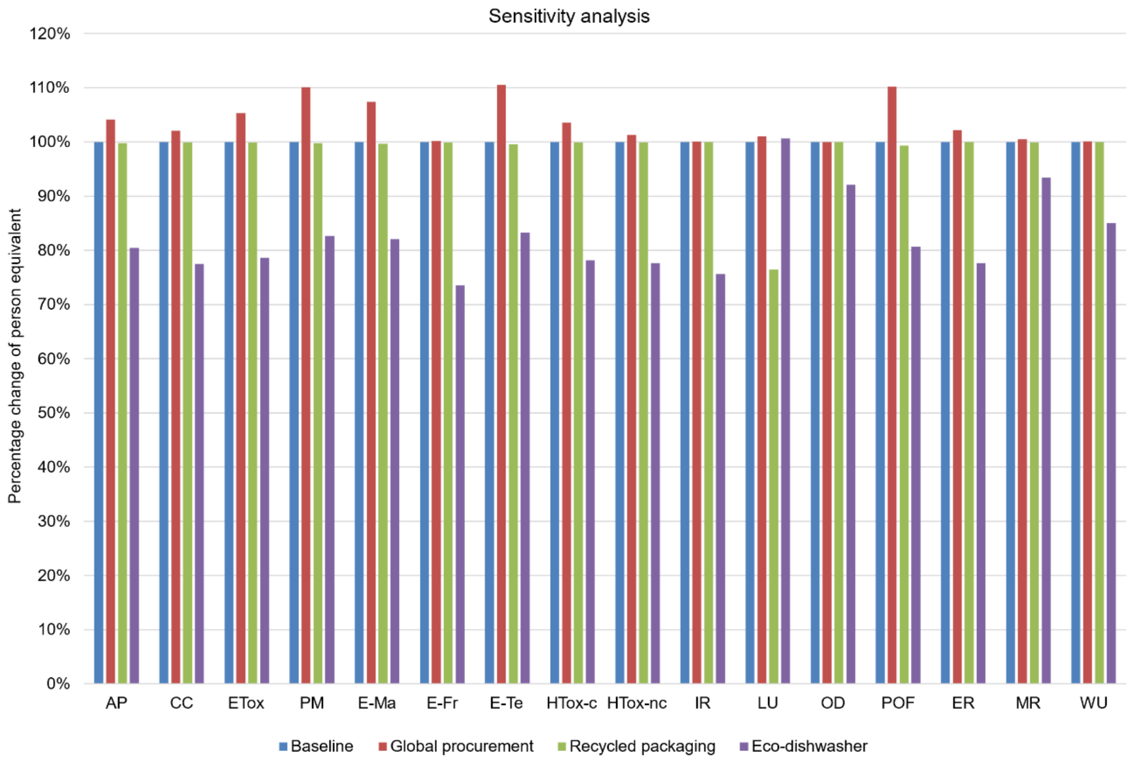
	Value	Unit	% share
Raw material	8.94E-06	mPR	21.0%
Manufacturing	6.32E-08	mPR	0,1%
Distribution	6.72E-07	mPR	1,6%
Use	3.29E-05	mPR	77.2%
End-of-life	-3.84E-08	mPR	-0.09%
TOTAL	4.26E-05	mPR	100%

The PEF weighting factors can be found in Table 45. The weighted results are aggregated across all impact categories obtaining an overall score for each life cycle stage. The scoring exercise confirms the dominance of the use stage and the very minor roles of the manufacturing, distribution, and end of life stages.

Sensitivity analysis for DD products: A sensitivity analysis was made in this study to assess different scenarios, which are presented below:

- **"Global procurement"**: All ingredients are procured outside of Europe as opposed to the baseline where they are all procured inside Europe.
- **"Recycled packaging":** The cardboard box is made of 88% recycled cardboard instead of virgin (88% recycled input is defined by the EF 3.1 dataset).
- **"Eco-dishwasher"**: The dishwasher is a more energy efficient model than the one in the baseline or an eco-cycle is used in a conventional dishwasher.

Figure 83. Relative changes (baseline set at 100%) to normalized results for three different sensitivity analyses with DD products (see Table 44 for impact category abbreviations).



In the scenario "global procurement" especially the impact parameters PM, E-Ma, E-Te and POF are affected (+10%, +7%, +11% and +10%, respectively). When procurement is global, there is a higher environmental impact because of the added transport when the raw materials need to be transported further distances.

The influence of recycled packaging had no notable impact on results, except for one very clear benefit in the 24% reduction in LU impact, due to the avoidance of the need to produce new cellulose fibres from wood for making cardboard.

The introduction of a more energy efficient dishwasher (scenario "Eco-dishwasher") has a high impact in terms of lowering the impact on almost all impact parameters (-15% to -26% on most impacts). This makes sense, as the use stage is the biggest contributor to the normalised environmental impact categories of DD products.

Summary and Interpretation of results for DD products: Conducting the PEF study and appertaining sensitivity analyses revealed the following conclusions:

- The most contributing life cycle stage in the environmental performance of DD was revealed to be the use stage followed by the raw material stage. The impacts in the use stage are related to the electricity consumption of the dishwashing machine.

- The other ingredients apart from the surfactants contribute the most in the raw material stage, especially citric acid, then sodium silicate, TAED and sodium carbonate. The packaging made a more significant contribution compared to LD products.
- The largest normalised impacts are seen in ER followed by CC. The weighted results show that the use stage accounts for 77% of the single PEF score, followed by 21% in the raw material stage.
- Using an eco-program can reduce the environmental impact of DD by 15-26%, This is related to the lower electricity consumption of the eco-program.

With regard to the revision of the EU Ecolabel criteria on DD this study revealed the importance of the formulation as the ingredients are the most contribution subcategory within raw material and pre-processing. Furthermore, this is a parameter the industry can control, in contrast to the use stage. The use stage can only be addressed indirectly through criteria on consumer information. However, it is up to the consumer to read and follow the instructions.

5.4.3.6. Screening LCA on Hand Dishwashing Detergent (HDD) products

5.4.3.6.1. Background information and assumptions

Definition of the product: For the purposes of this screening EFIA, Hand Dishwashing Detergents (HDD) are defined as any detergents falling under the scope of Regulation (EC) No 648/2004 on detergents which are marketed and designed to be used to wash by hand items such as glassware, crockery and kitchen utensils including cutlery, pots, pans and ovenware. The product group shall comprise products for both private and professional use. The products shall be a mixture of chemical substances and shall not contain micro-organisms that have been deliberately added by the manufacturer.

The most used type of hand dishwashing detergents (HDD) is liquid detergent with a high water content (83-85%). This study represents an average HDD and not a specific product or brand.

Functional unit and reference flows: The LCA on HDD describes the amount of detergent required to run one dishwashing cycle for four place settings and serving pieces[430]. Using the “full sink”[431] washing method, this is assumed to require 10 mL of detergent and 15 L of warm water, which required 0.08 kWh of electricity to heat. These assumptions are in the middle of the two scenarios used in Arendorf et al. 2014c. For simplicity, a specific density of 1.00 g/mL for the HDD is assumed as well, so 10 mL corresponds to 10 g.

Raw material acquisition and preprocessing: The composition of the HDD is based on a handful of EU Ecolabel license application formulations provided during the data gathering exercise conducted by the JRC. In order to protect confidentiality, the exact details of the minor ingredients have been hidden and grouped together. However, the study did account for the individual ingredients in the concentrations that were representative of the HDD formulations. If more data is gathered, a greater aggregation can help ensure better anonymisation of individual product data in the next draft of these studies. The table below shows the average HDD formulation along with inventory data used in this study.

Table 55. LCI of a standard formulation of an average hand dishwashing detergent using the EF 3.1 database.

Ingredient	Conc.	EF 3.1 process
Water	83.0%	Water, completely softened {EU+EFTA+UK}
Alcohols, C12-14, ethoxylated, sulfates, sodium salts	12%	Proxy: Alkylbenzene sulfonate production {EU+EFTA+UK}
D-Glucopyranose, oligomeric, C10-16(even numbered) alkyl glycosides	2%	Proxy: Ethoxylated alcohol (AE7) production, petrochemical {EU+EFTA+UK}
1-Propanaminium, 3-amino-N-(carboxymethyl)-N,N-dimethyl-, N-C8-18(even numbered) acyl derivs., hydroxides, inner salts	1%	Proxy: Alkyl amidopropylbetaine production {EU+EFTA+UK}
Various other minor ingredients:	Sum: 3%	Proxy: Carboxymethyl cellulose production {EU+EFTA+UK} Sodium chloride powder production {EU+EFTA+UK} Citric acid production {EU+EFTA+UK} Proxy: Phenoxy-compounds {EU+EFTA+UK} Proxy: Benzo[thia]diazole-compound production {GLO} Sodium hydroxide production {EU+EFTA+UK}

The production of packaging is included in this phase of the life cycle. The next table shows the inventory used for the modelling of primary and secondary packaging. Tertiary packaging was not included due to the limited amount of available data. The amounts shown in the table are from Arendorf et al. 2014c.

[430] According to IEC 60436, 4 place settings with serving pieces would correspond to a total of 47 items: 2 dinner plates, 2 dessert plates, 2 dessert bowls, 2 mugs, 4 glasses, 4 forks, 4 knives, 4 soup spoons, 4 dessert spoons, 4 tea spoons, 2 soup plates, 2 melamine dessert plates, 2 saucers, 2 cups, 1 small pot, 1 oval platter, 1 melamine bowl, 2 serving spoons, 1 serving fork and 1 gravy ladle.

[431] See: Stamminger R, A Elschenbroich, B Rummler, G Broil, 2007. Washing-up Behaviour and Techniques in Europe. Hauswirtschaft und Wissenschaft, 1, 31–37.

Table 56. LCI of both primary and secondary packaging for HDD derived from Arendorf et al. 2014c.

Type of packaging	Amount [kg]	EF 3.1 process
Primary:	650 mL bottle	
PET (bottle body)	0.0038 kg	PET bottle, transparent {EU+EFTA+UK}
PP (cap)	0.0365 kg	Screw cap, PP {EU+EFTA+UK}
PE label	0.0009 kg	Label, plastic {EU+EFTA+UK}
Secondary:	Box of 16 bottles	
Cardboard box	0.411 kg	Corrugated board, uncoated {EU+EFTA+UK}
LDPE	0.0263 kg	Low density polyethylene (LDPE), fossil fuel-based {GLO}

Manufacturing: For the manufacturing stage, the use of electricity, water, heat, and output of wastewater has been included. The data for electricity and water usage are based on the AISE KPI-report from 2023. For heat, the split between heat and electricity presented in Golsteijn et. al. (2015) has been applied to the electricity factor. An assumption of detergent product wasted in the manufacturing process has been estimated to be around 2%, and has also been included in the study.

Distribution: In the distribution stage, an equal split between distribution from factory to local, intracontinental, and international retail or distribution centre has been assumed, due to the lack of data. It is furthermore assumed that all products will go to retail before going to the consumer. Transport from the distribution centre to retail has been included. Furthermore, as defined by the PEF method, both lighting and heating of storage in distribution centres and retail has been included. To account for losses during distribution a 5% loss has been included and for losses in the home, another 5% loss has been included as defined by the PEF method.

Use: The use stage consists of one wash, assuming the sink is fully filled with water and that additional rinsing water may also be used. The inputs required for a hand dishwash are water and heat to warm the water. As for the DD products, the PEF method Part D describes default assumptions for common product categories: one of them being dishwashing. It describes both machine and hand dishwashing. These assumptions are used in the calculation of the consumption of heat. According to the assumptions in PEF Part D, it is assumed that the water is heated using natural gas. A full sink wash with rinsing is assumed to consume 11,25 L of water.

End of life (EoL): Hand dishwashing detergent is packaged in plastic bottles, typically PET and a PP cap. The EoL stage consists of the transport of waste and waste processing in the form of recycling, incineration with energy recovery and landfilling. The EoL in this case covers wastewater treatment after the use of detergent, recycling, incineration and landfilling of packaging. The CFF has been applied to each of the different material types present in the packaging. The different variables used have been taken from Annex C to the PEFCR guidance (v6.3).

Data quality: The assessment of the data quality is split up into the different life cycle stages; raw material acquisition and pre-processing (LCS1), manufacturing (LCS2), distribution stage (LCS3), use stage (LCS4), and end of life (LCS5).

- LCS1: Data quality regarding the average composition of dishwasher detergent is good, based on feedback received on real formulations in current EU Ecolabelled products. For some ingredients no LCI data was available in the EF 3.1 database and proxies had to be used as a best guess. The data quality for the packaging is fair based on an older literature source.
- LCS2: The data quality of the manufacturing process retrieved from AISE is fair. Unfortunately, the energy input was not divided into heat and electricity and estimates of the division were made. The datasets used from the EF 3.1 database for electricity, wastewater treatment and water are good.
- LCS3: All data regarding the distribution stage was retrieved from the default scenarios provided in the PEF Recommendation. The quality of the LCI data is good and the overall data quality of this life cycle stage is good.
- LCS4: The data quality of the use stage is good. Data is taken from the default assumption in the PEF method and the LCI data is good. The amount of water is fair, it is based on the average size of a kitchen sink with 7.5 L of water for soaking, plus an extra 50% rinsing water.

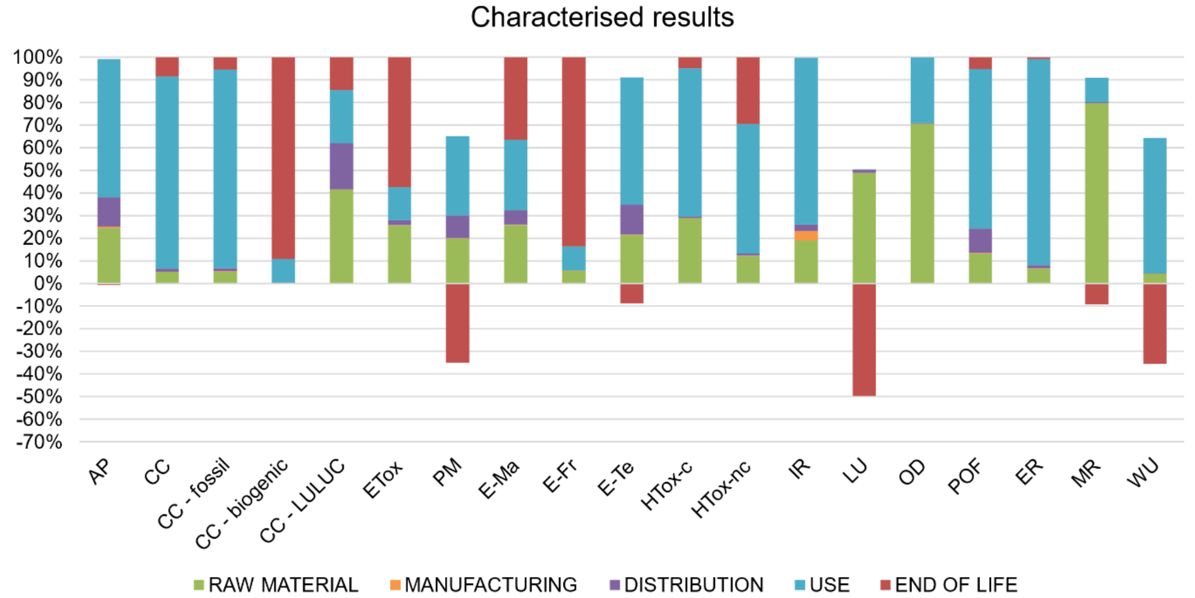
- LCS5: The data in the EoL stage is based on the CFF parameters provided in the Annex C in the PEF Recommendation. The overall data quality of this life cycle stage is good.

The data used in this study represents an average HDD. Hence the results do not address the environmental performance of individual products. No data was found for the share of local, intracontinental, and international distribution and assumptions might not reflect the realistic conditions. The effect of changing from petrochemical-based surfactants to oleochemical alternatives could have been assessed, but the EF database just comprises dataset named "oleochemical mix" that combines different sources (e.g. palm kernel oil, coconut oil etc.) but does not allow data from the separate sources to be identified. Hence, a detailed analysis of the importance of different oleochemical alternatives was not possible.

5.4.3.6.2. Life cycle impact assessment (LCIA) for HDD: results and interpretation

Contribution analysis for HDD products: For HDD the results are indicated in the figure below.

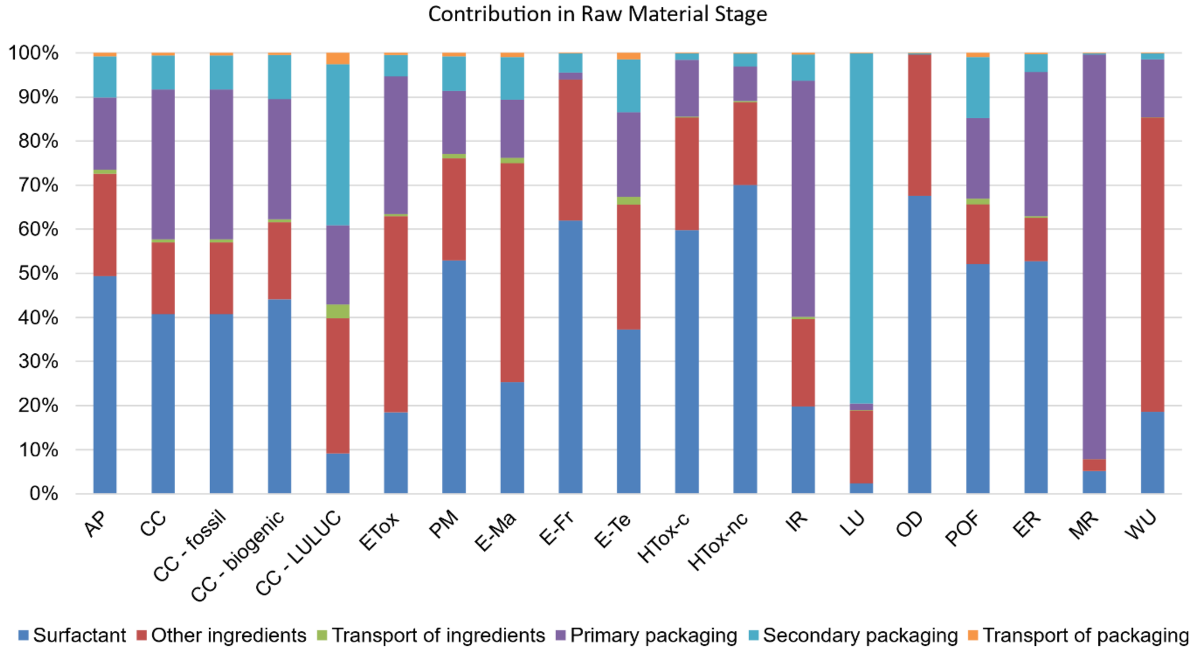
Figure 84. The characterised results for a HDD product in percentage of total environmental impact, split by life cycle stage for all impact categories (see Table 44).



As evident in the figure above, the most contributing life cycle stages to the impact of one dose of an average HDD are generally the use stage and the raw material stage. However, the end-of-life stage dominated some impact categories too (CC-biogenic, E-Fr, ETox and LU. There are some negative impacts (i.e. environmental benefits) in the EoL stage for PM, LU, MR, and WU categories because of waste recycling and wastewater treatment. It was not possible to explore the underlying sub-processes associated with the end-of-life benefits, but these can include recycling and energy recovery of packaging and biogas production from sewage sludge. The impacts in the use stage originate primarily from the use of natural gas for heating the water used during dishwashing.

Raw material acquisition and preprocessing consists of several subprocesses. The contribution of the subprocesses to the total impact of this life cycle stage are evaluated in the figure below.

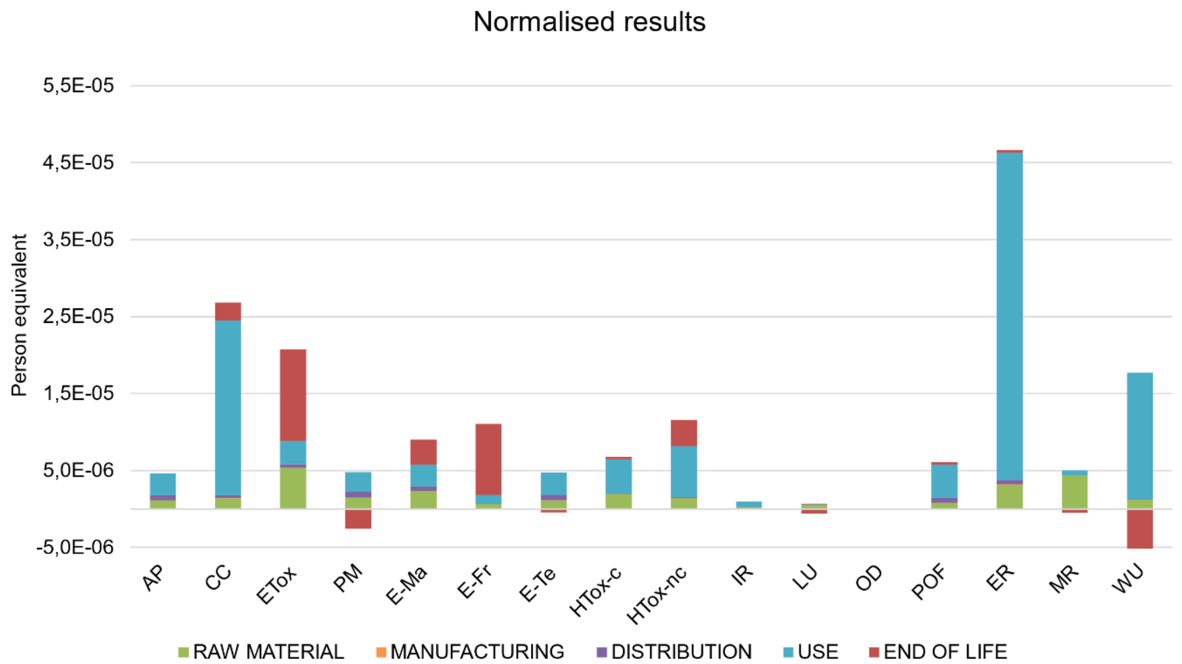
Figure 85. Contribution analysis of the subprocesses included in LCS1 - raw material acquisition and preprocessing of HDD products to different impact categories (see Table 44).



In 11 out of 19 impacts categories "Surfactants" is the most contributing process. However, "Other ingredients" shows to be of importance too, and "other ingredients" is dominating in ETox, E-Ma and WU. Two bigger exceptions are MR where "Primary packaging" is responsible for most of the impact due to the plastic used in the bottle. Furthermore, LU where "Secondary packaging" is dominating due to cardboard production.

Normalised results for HDD products: The characterised results presented in the previous section are normalised using the EF 3.1 normalisation factors.

Figure 86. Normalised results of an average HDD presented in Person Equivalent (using EF 3.1 normalisation factors) for different impact categories (see Table 44).



The figure above shows the normalised results within all impact categories. The highest impacts are seen in the impact category ER, then CC. In both cases, energy consumption to heat water in the use phase contributes the most. The lowest impacts are seen within OD, LU, and IR.

Weighted results for HDD products: Weighting the LCA results is a mandatory step in the PEF methodology. During weighting the normalised results are multiplied by weighting factors reflecting the importance of the different life cycle impact categories. The weighted results are shown in the table below. The weighting factors can be found in Table 45. The weighted results are aggregated across all impact categories obtaining overall score for each life cycle stage.

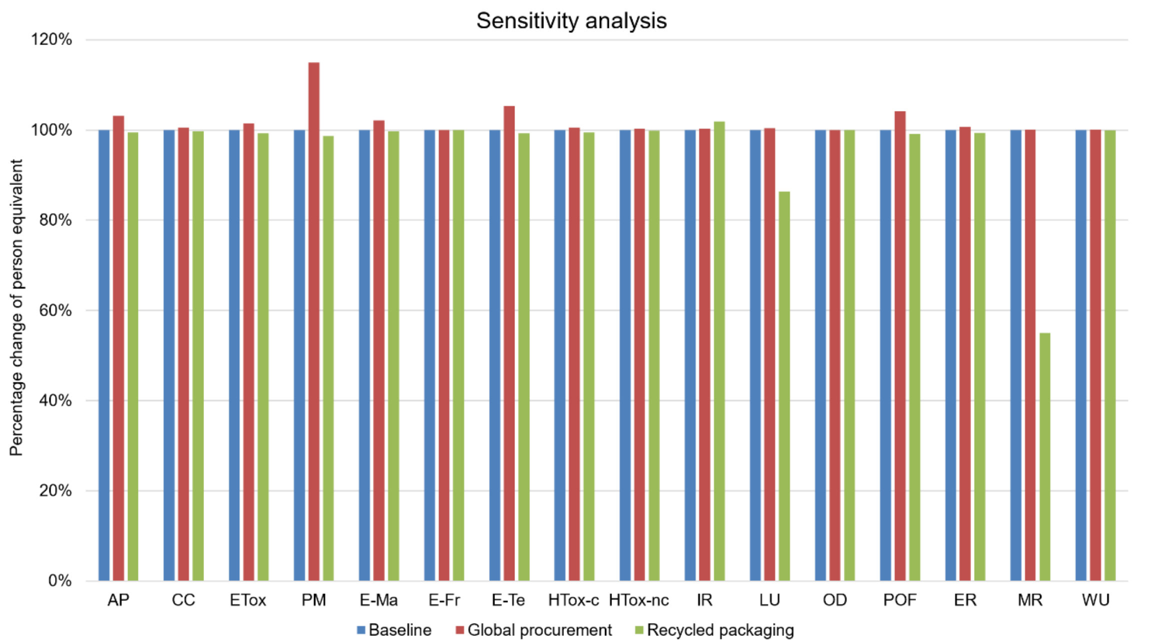
Table 57. Weighted results using the EF 3.1 weighting factors provided by the European Commission.

	Value	Unit	% share
Raw material	1.56E-06	mPR	12.2%
Manufacturing	3.16E-08	mPR	0.2%
Distribution	3.17E-07	mPR	2.5%
Use	1.09E-05	mPR	85.0%
End-of-life	2.19E-08	mPR	0.2%
TOTAL	1.29E-05	mPR	100%

Sensitivity analysis for HDD products: A sensitivity analysis was made in this study to assess the different scenarios. The scenarios analysed are presented below:

- **"Global procurement":** All ingredients are procured outside of Europe as opposed to the baseline where it is all procured inside Europe.
- **"Recycled packaging":** The bottle is made of 100 % recycled PET instead of virgin PET and the cardboard is made of 88% recycled cardboard instead of virgin (88% recycled input is defined by the EF 3.1 dataset).
- **"Manual dosing":** Considering the overdosing (+50%) and underdosing (-50%) depending on user habits.

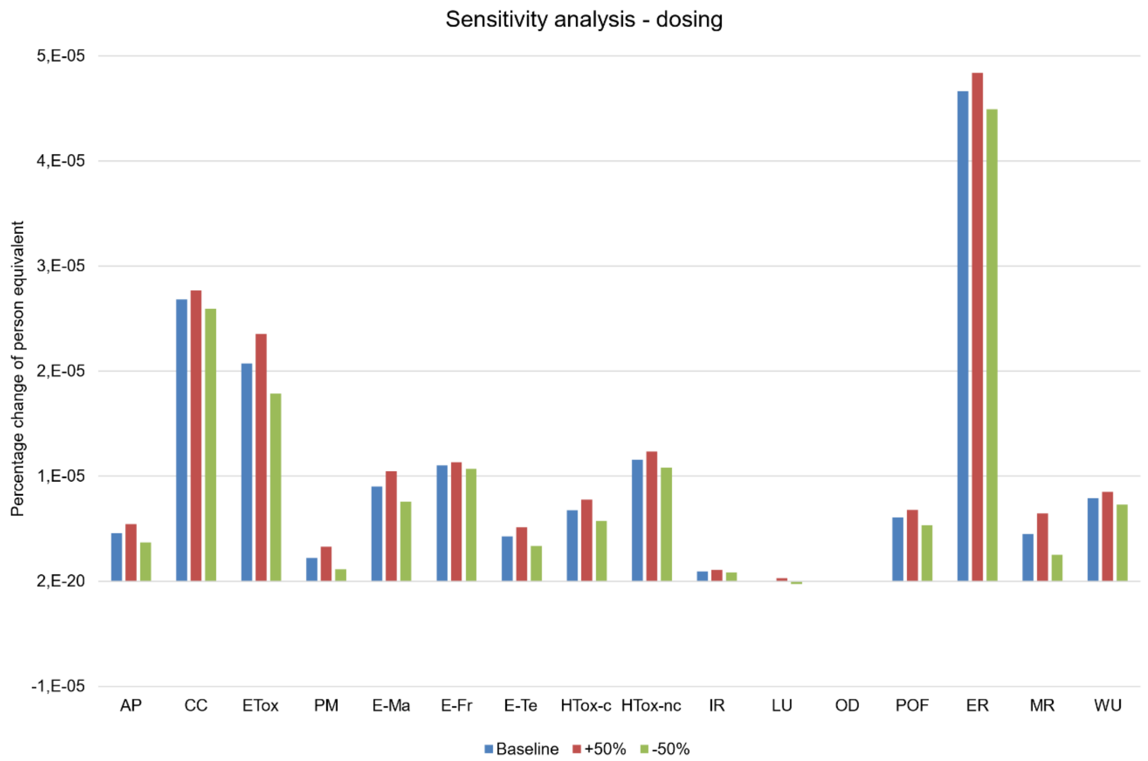
Figure 87. Relative changes (baseline set at 100%) to normalised results for two different sensitivity analyses with HDD products (see Table 44).



The figure above shows the results of the first two sensitivity scenarios in relation to the baseline presented in the sections above. For the scenario "Global procurement" there is a large change in PM (+15%) compared to the baseline. This is caused by the extra transport that is necessary when sourcing input materials globally. On no impact category does "global procurement" score lower than the baseline scenario. The procurement can thereby be concluded to increase the environmental impact of the HDD. However, the "global procurement" scenario was not so significant as with the LD and DD products, probably because there is much more water in these products which is always procured locally.

The scenario "recycled packaging" slightly reduces the impact in most environmental parameters (typically around 1%) but caused a major reduction in MR impacts (-45%) and a significant reduction in LU impacts (-14%). This major reduction in MR is due to the reduction in virgin material consumption.

Figure 88. Showing the impact related to dosing insecurities. Impact category abbreviations are explained in Table 44.



The figure above investigates the change in impact caused by overdosing and underdosing on normalised environmental impact categories. Although clear effects on the dosing can be consistently seen in all impact categories, the scale of the effects are disproportionate and much small compared to the change in dose. This is a reflection of the fact that the energy to heat the water dominates the whole life cycle and this was kept constant in the dosing scenarios.

Summary and interpretation of results for HDD products: Conducting the PEF study and appertaining sensitivity analyses revealed the following conclusions:

- The most contributing life cycle stage of a manual dishwashing cycle using HDD is the use stage, due to the energy consumption for heating water (85% of PEF score). The raw material and pre-processing stage are the second most contributing life cycle stage (12.2% of PEF score).
- The surfactant ingredients in HDD products dominate impacts in the raw material stage.
- The highest normalised environmental impacts are seen in ER and CC categories.
- Over- and underdosing shows impact across all impact categories, but only to relatively minor levels.

In terms of the revision of the criteria for the EU Ecolabel on HDD, the formulation will become important in cases where lower temperature water might be used to wash. This would in turn lead to a greater importance on the dosing scenarios. The contribution of surfactant ingredients is the most significant to the raw material stage impacts in these types of detergent product and therefore more importance is given here to benefits from the choice of low environmental impact surfactants.

5.4.3.7. Screening LCA on kitchen surface cleaner products

5.4.3.7.1. Background information and assumptions

Definition of the product: The category of hard surface cleaning products covers a wide variety of cleaning products, all-purpose cleaners, kitchen cleaners, window cleaners and sanitary cleaners. This study represents the environmental performance of a kitchen surface cleaning spray, these products tend to be formulated for optimum grease removal.

Functional unit and reference flow: The functional unit of this study is the cleaning of 0,24 m2, which in turn is assumed to require a reference flow of 5 sprays of product, corresponding to the usage of approximately 4,7 g of HSC product. No additional water is assumed to be used for cleaning.

Raw material acquisition and preprocessing: The composition of the kitchen surface cleaner was based on input from expert stakeholders while the packaging assumptions are based on Arendorf et al. (2014d). The table below shows the inventory data used in the compilation of a kitchen surface cleaner.

Table 58. LCI of a standard formulation of a kitchen surface cleaning product using the EF 3.1 database.

Ingredient	**%**	**EF 3.1 process**
Water	93%	Water, completely softened {EU+EFTA+UK}
Disodium Carbonate	3%	Proxy: Sodium bicarbonate production {EU+EFTA+UK}
Alcohols, C12-14, ethoxylated, sulfates, sodium salts	2%	Proxy: AlcoholEthoxylate (oleo) production, 3 moles EO {EU+EFTA+UK}
Non-ionic surfactant (exact ingredient name withheld for confidentiality)	1%	Proxy: Non-ionic surfactant, ethyleneoxidederivate production {GLO}
Exact ingredient name withheld for confidentiality	0.5%	Proxy: Carboxymethyl cellulose production {EU+EFTA+UK}
Citric acid monohydrate	0.25%	Proxy: Citric acid production {EU+EFTA+UK}
Fragrance	0.25%	Proxy: 15% Hexylcinnamic aldehyde production {GLO}, 15 % Dihydromyrcenol production {GLO}, 15% Hexyl salicilate production {GLO}, 15% Beta-pinene production {GLO}, 40% Benzoic acid production {GLO}

The production of packaging is also included in this phase of the life cycle. The next table shows the inventory used for the modelling of primary and secondary packaging. Tertiary packaging was not included due to a limited amount of available data.

Table 59. LCI of both primary and secondary packaging for kitchen surface cleaner.

Type of packaging	Amount [kg]	EF 3.1 process
Primary	For a 500 ml bottle	
PET	0.022	PET bottle, transparent {EU+EFTA+UK}
PET bottle grade	0.0681	PET bottle, transparent {EU+EFTA+UK}
PP	0.02	Screw cap, PP {EU+EFTA+UK}
LDPE	0.02	Low density polyethylene (LDPE), fossil fuel-based {GLO}
Secondary	Per bottle in a box of 10 bottles	
LDPE	0.00253	Low density polyethylene (LDPE), fossil fuel-based {GLO}
Cardboard	0.0395	Corrugated board, uncoated {EU+EFTA+UK}

Manufacturing: For the manufacturing stage, the use of electricity, water, heat, and output of wastewater has been included. The data for electricity and water usage are based on the AISE KPI-report from 2023. For heat, the split between heat and electricity presented in Golsteijn et. al. (2015) has been applied to the electricity factor. An assumption of detergent wasted in the manufacturing process has been estimated to be around 2% and has as well been included in the study.

Distribution: In the distribution stage, an equal split between distribution from factory to local, intracontinental, and international retail or distribution centre has been assumed, due to the lack of data. It is furthermore assumed that all products will go to retail before going to the consumer. Transport from the distribution centre to retail has been included. Furthermore, as defined by the PEF method, both lighting and heating of storage in distribution centre and retail has been included.

Use: The use stage in this study does not have any processes included.

End of Life (EoL): Kitchen surface cleaning is packaged in trigger plastic bottles, typically PET and a PP cap. The EoL stage consists of the transport of waste, waste processing in the form of recycling, incineration with energy recovery and landfilling. The end of life in this case covers recycling, incineration and landfilling of packaging. The CFF has been applied to each of the different material types present in the packaging. The different variables used have been taken from Annex C in the PEFCR guidance (v6.3).

Data quality: The assessment of the data quality is split up into the different life cycle stages; raw material acquisition and pre-processing (LCS1), manufacturing (LCS2), distribution stage (LCS3), use stage (LCS4), and End of Life (LCS5).

- LCS1: Data quality for processes used to model kitchen surface cleaner is good. The data for the composition of the detergent is from data for household product formulations from EU Ecolabel application files that were shared with the JRC. The literature data for packaging is approximately 10 years old. However, no LCI data was available in the EF 3.1 database for most ingredients and proxies had to be used as a best guess.
- LCS2: The data quality of the manufacturing process retrieved from AISE is fair. Unfortunately, the energy input was not divided into heat and electricity and estimates of the division were made. The datasets used from the EF 3.1 database for electricity, wastewater treatment and water are good.
- LCS3: All data regarding the distribution stage was retrieved from the default scenarios provided in the PEF method. The quality of the LCI data is good and the overall data quality of this life cycle stage is good.
- LCS4: The data quality of the use stage is good. Data is taken from the default assumption in the PEF method and the LCI data is good.
- LCS5: The data in the End-of-Life stage is based on the CFF parameters provided in the Annex C in the PEF method. The overall data quality of this life cycle stage is good.

The data used in this study represents a handful of typical household kitchen cleaners with the EU Ecolabel, but the collection of more formulations could potentially affect what the representative formulation would be.

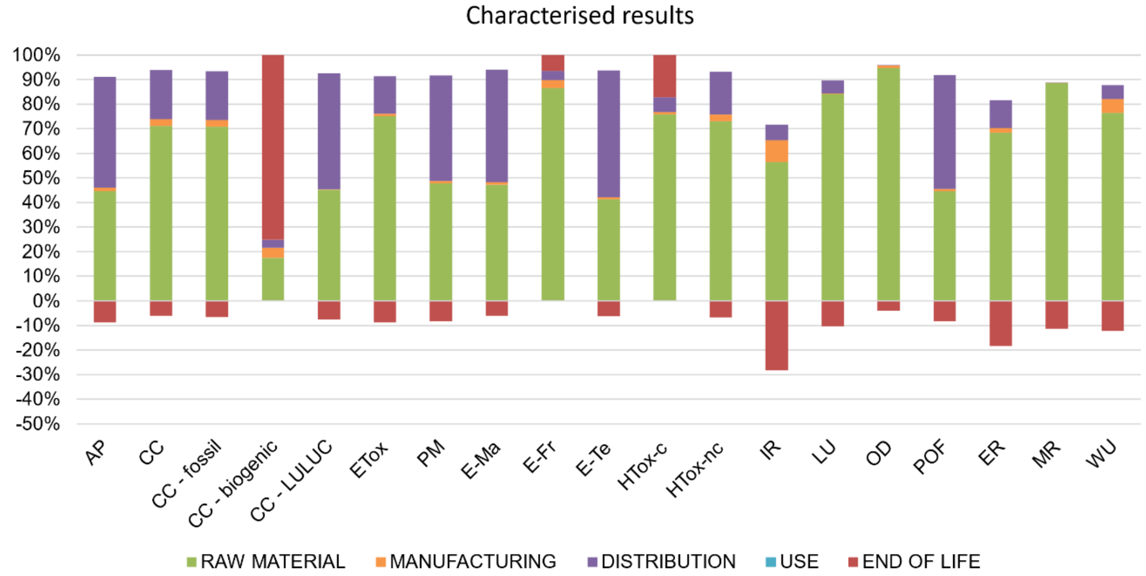
No data was found for the share of local, intracontinental, and international distribution and assumptions might not reflect the realistic conditions. No data was found on fragrance and several different chemicals can be used for that purpose. To create a proxy several safety data sheets were found to get insight in the composition. The proxy consists of 40% benzoic acid as a proxy for phthalate, and a mix of four compounds used in fragrances available in the EF 3.1 database (Hexylcinnamic aldehyde, Dihydromyrcenol production, Hexyl salicilate production, and Beta-pinene).

It was desired to investigate the differences between petrochemical based surfactants with an oleochemical alternative. However, the EF database just comprises dataset names oleochemical and represents a technology mix of different oleochemical sources (e.g. palm kernel oil, coconut oil etc.) but does not comprise of the individual processes. Hence, an analysis of the importance of the oleochemical alternatives was not possible.

5.4.3.7.2. Life cycle impact assessment (LCIA) for kitchen surface cleaner: results and interpretation

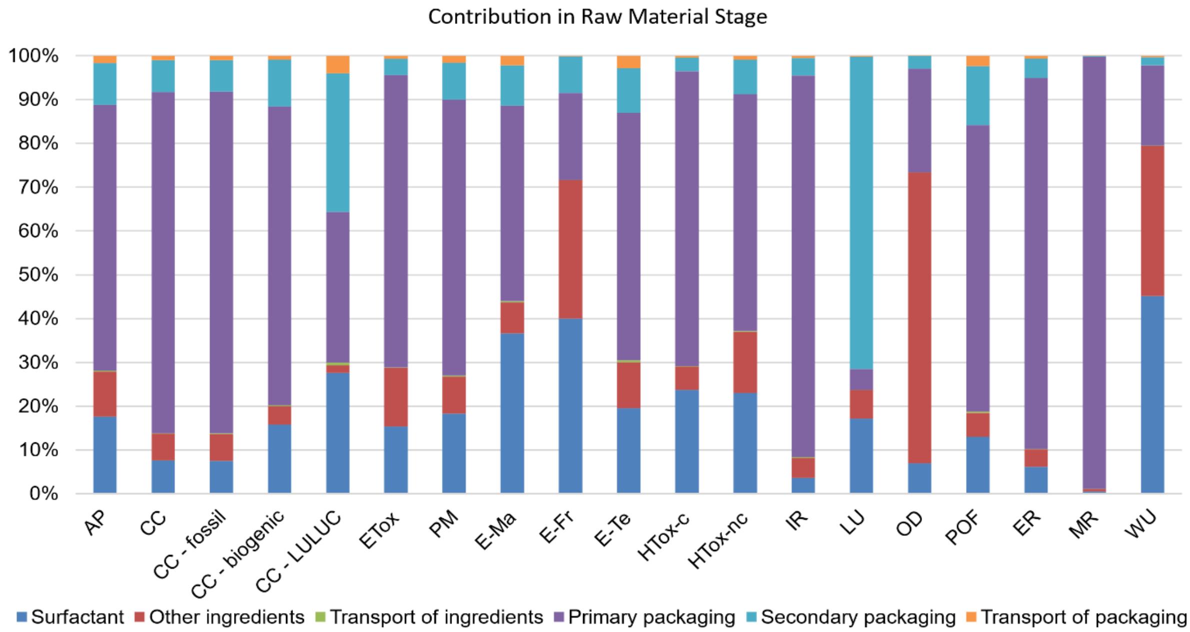
Contribution analysis for kitchen surface cleaner: For kitchen surface cleaner the results are presented in the figure below.

Figure 89. The characterised results for a kitchen surface cleaning product in percentage of total environmental impact, split by life cycle stage for all impact categories (see Table 44).



As can be seen in the figure above, the most contributing life cycle stages are the raw material and preprocessing and distribution stages. There are some negative impacts (i.e. environmental benefits) in the EoL stage in 16 of 19 impact categories due to recycling of packaging and energy recovery. The distribution stage contributes very significantly (i.e. >30%) to the AP, CC-LULUC, E-Ma, E-Te, and POF impact categories. This is related to emissions from diesel combustion in the lorries. For other types of detergent products that require the use of heated water in the use phase, it is instead the water heating in the use phase that tends to dominate life cycle impacts. However, the kitchen surface cleaner analysed here is ready to use and does not require the addition of water, let alone warm water. On the other hand, the kitchen surface cleaner formulation has a high water content, which is transported across countries in some cases during product distribution.

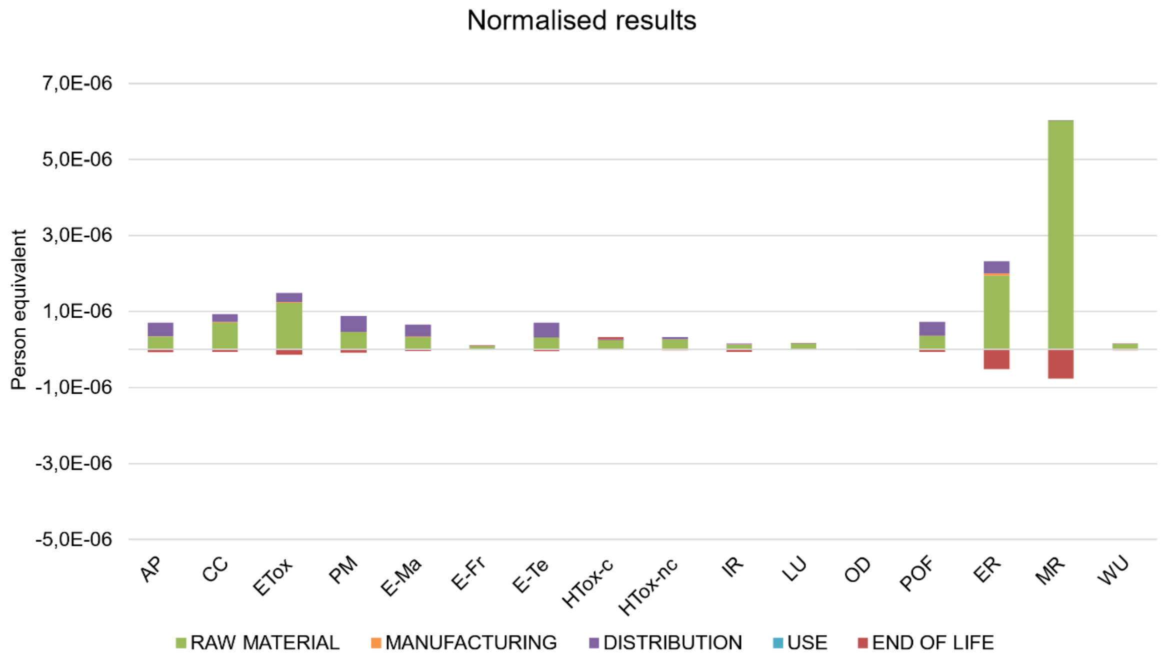
Figure 90. Contribution analysis of the subprocesses included in LCS1 - raw material acquisition and preprocessing of kitchen surface cleaner to different impact categories (see Table 44).



The figure above shows the contribution of the subprocesses included in LCS1 Raw material acquisition and pre-processing. It is evident that the most contributing sub-process is primary packaging in 16 of 19 impact categories. This is most likely due to the fact that kitchen surface cleaners, that are ready to use, have a low concentration of chemicals and mostly consist of water. Hence, the input of plastic in the packaging contributes relatively more. The surfactant and other ingredients still have notable contributions to impacts in this life cycle stage, but this varies a lot depending on the impact category in question.

Normalised results for kitchen surface cleaner: The characterised results presented above for all life cycle stages0 are normalised using the EF 3.1 normalisation factors, which can be found in Table 45.

Figure 91. Normalised results of a kitchen surface cleaner presented in Person Equivalent (using EF 3.1 normalisation factors) for different impact categories (see Table 44).



The highest normalised impacts in the graph above are seen in the impact categories MR and ER, which are closely related to the raw material and preprocessing life cycle stage (especially primary packaging).

Weighted results for kitchen surface cleaner: Weighting the LCA results is a mandatory step in the PEF methodology. During weighting the normalised results are multiplied by weighting factors reflecting the importance of the different life cycle impact categories. The table below shows the weighted results. For the weighting the EF 3.1 weighting factors from the PEF method has been used, which can be found in Table 45. The weighted results are aggregated across all impact categories obtaining overall score for each life cycle stage.

Table 60. Weighted results using the EF 3.1 weighting factors provided by the European Commission.

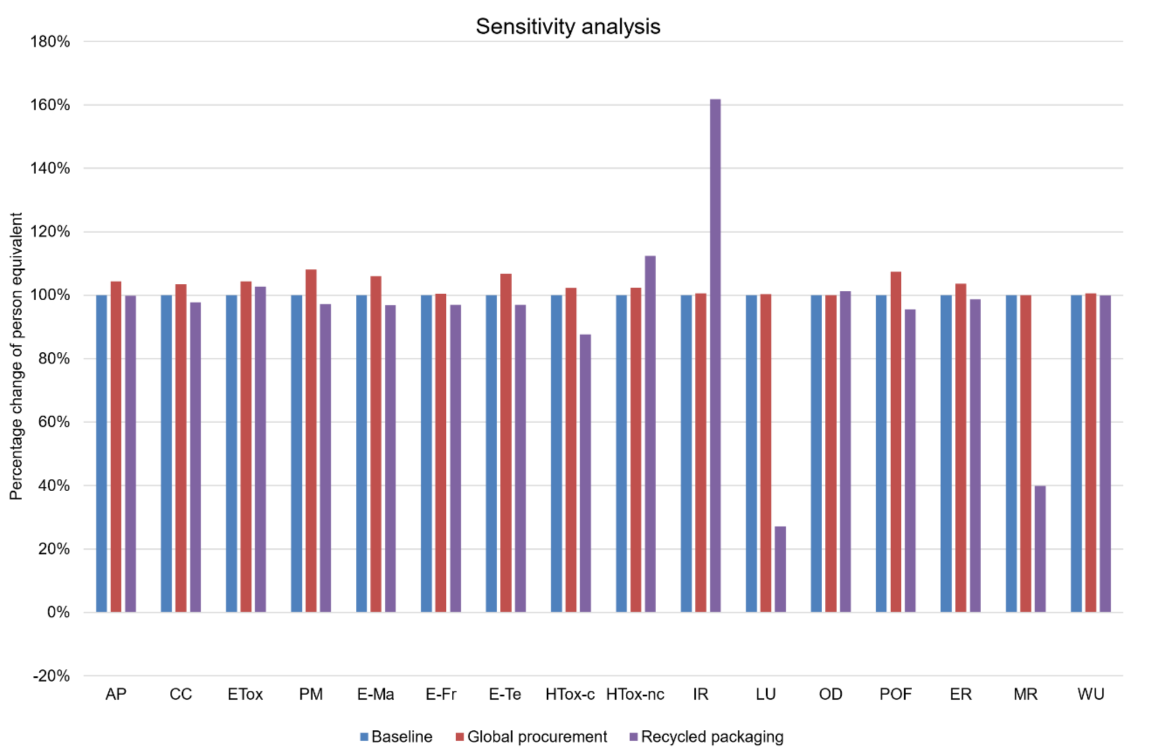
	Value	Unit	% share
Raw material	9.31E-07	mPR	95%
Manufacturing	1.49E-08	mPR	2%
Distribution	1.77E-07	mPR	18%
Use	0.00E+00	mPR	0%
End-of-life	-1.40E-07	mPR	-14%
TOTAL	9.83E-07	mPR	100%

Sensitivity analysis for kitchen surface cleaner: A sensitivity analysis was made in this study to assess the different scenarios. The two scenarios accessed in this study are presented below:

- **"Global procurement"**: All ingredients are procured outside of Europe as opposed to the baseline where it is all procured inside Europe.

- **"Recycled packaging"**: The bottle is made of 100 % recycled PET instead of virgin PET and the cardboard packaging is made of 88% recycled material (in accordance with the EF 3.1 database).

Figure 927. Relative changes (baseline set at 100%) to normalised results for two different sensitivity analyses with kitchen cleaning products (see Table 44).



The figure above shows the results of the two sensitivity scenarios in relation to the baseline normalised results presented in the sections above. The figure shows that the results are sensitive to the two scenarios.

An increase in raw material transport distances under the "Global procurement" scenario showed increases in impacts for AP (+4%), PM (+8%), E-Ma (+6%), E-Te (+7%) and POF (+7%). Less significant increases were also noted in other impact categories and in no impact category did impacts decrease compared to the baseline. These results reflect the importance of transport impacts to the overall life cycle impacts of kitchen surface cleaning products.

Changing packaging to recycled materials had larger effects on LCA results, and in a beneficial way. Impacts were reduced for 60% and 73% for MR and LU respectively. Smaller benefits were noted for other impact categories as well. However, a very large and unexpected increase (+62%) was noted in IR impacts when changing to recycled packaging. This was also accompanied by a 12% increase in HTox-nc impacts. These unexpected increases merit an examination of the underlying sub-processes that relate to recycled PET and this detail will be requested before the next draft of these studies is made available.

Summary and interpretation of results for HSC kitchen surface cleaners: Conducting the PEF study and sensitivity analysis led to the following conclusions:

- The raw material stage and the distribution stage are the most contributing life cycle stages for the kitchen surface cleaner products.
- Within the raw material stage, most of the impacts come from primary packaging rather than the ingredients.
- The highest normalised environmental impacts are seen within MR and ER, linked to packaging.
- The weighted results show that across impact categories the raw material stage accounts for 95% of the environmental impact, followed by distribution, which accounts for 18%.
- A sensitivity analysis showed that global procurement increases the environmental impact of the kitchen surface cleaner by up to 7%.

- Recycled packaging reduced the impact in 10 out of 19 impact categories, but led to increases in 2 impact categories.

5.4.3.8. Screening LCA on acid-based toilet cleaner products

The Environmental Footprint Impact Assessment (EFIA) of acid-based toilet cleaner products (an example of a hard surface cleaner) is provided below.

5.4.3.8.1. Background information and assumptions

Definition of the product: The category of hard surface cleaning products covers a wide variety of cleaning products, all-purpose cleaners, kitchen cleaners, window cleaners and sanitary cleaners. This study represents the environmental performance of an acid-based toilet cleaner.

Functional unit and reference flow: The functional unit of this study is cleaning one toilet bowl, which in turn is assumed to require a reference flow of 50 mL of product with an assumed density of 1,08 g/mL. No additional water is assumed to be used for cleaning.

Raw material acquisition and preprocessing: The composition of the acid-based toilet cleaner is based on selected formulation data for EU Ecolabel license applications that were shared with the JRC. Packaging assumptions are based on Arendorf et al. (2014d). The table below shows the inventory data used in the compilation of an acid-based toilet cleaner.

Table 61. LCI of a standard acid-based toilet cleaning product using the EF 3.1 database.

Ingredient	%	EF 3.1 process
Water	85,0%	Water, completely softened {EU+EFTA+UK} | average technology mix | production mix, at plant | Technology mix for supply of softened water to users | LCI result
Citric acid, monohydrate	10,0%	Citric acid production {EU+EFTA+UK}
Glycerin	1,0%	Proxy: Mix of four glycerines found in the EF 3.1 database
Nonionic surfactant (name withheld for confidentiality)	2,0%	Non-ionic surfactant, fatty acid derivate production {GLO}
Citrate salt (name withheld for confientiality)	1,0%	Proxy: Citric acid production {EU+EFTA+UK}
Xanthan gum	0,8%	Empty process
Perfume	0,2%	Proxy: 15% Hexylcinnamic aldehyde production {GLO}, 15 % Dihydromyrcenol production {GLO}, 15% Hexyl salicilate production {GLO}, 15% Beta-pinene production {GLO}, 40% Benzoic acid production {GLO}

The production of packaging is included in this phase of the life cycle. The next table shows the inventory used for the modelling of primary and secondary packaging. Tertiary packaging was not included due to a limited amount of available data.

Table 62. LCI of both primary and secondary packaging for acid-based toilet cleaner.

Type of packaging	Amount [kg]	EF 3.1 process
Primary	**For a 750 ml bottle**	
HDPE	0,046	PET bottle, transparent {EU+EFTA+UK}
PP cap	0,0104	Screw cap, PP {EU+EFTA+UK}
PE	0,00086	Low density polyethylene (LDPE), fossil fuel-based {GLO}
Paper	0,002	Label, paper {EU+EFTA+UK}
Secondary	**Per bottle in a box**	
Cardboard	0,0235	Corrugated board, uncoated {EU+EFTA+UK}

Manufacturing: For the manufacturing stage, the use of electricity, water, heat, and output of wastewater has been included. The data for electricity and water usage are based on the AISE KPI-report from 2023. For heat, the split between heat and electricity presented in Golsteijn et. al. (2015) has been applied to the electricity factor. An assumption of detergent wasted in the manufacturing process has been estimated to be around 2% and has as well been included in the study.

Distribution: In the distribution stage, an equal split between distribution from factory to local, intracontinental, and international retail or distribution centre has been assumed, due to the lack of data. It is furthermore assumed that all products will go to retail before going to the consumer. Transport from the distribution centre to retail has been included. Furthermore, as defined by the PEF method, both lighting and heating of storage in distribution centre and retail has been included.

Use: The use stage in this study does not have any processes included.

End of Life (EoL): Acid-based toilet cleaner is packaged in plastic bottles with a cap and a spout, typically an HDPE bottle and a PP cap. The EoL stage consists of the transport of waste, waste processing in the form of recycling, incineration with energy recovery and landfilling. The end of life in this case covers wastewater treatment after the use of detergent, recycling, incineration and landfilling of packaging. The CFF has been applied to each of the different material types present in the packaging. The different variables used have been taken from Annex C in the PEF method.

Data quality: The assessment of the data quality is split up into the different life cycle stages; raw material acquisition and pre-processing (LCS1), manufacturing (LCS2), distribution stage (LCS3), use stage (LCS4), and End of Life (LCS5).

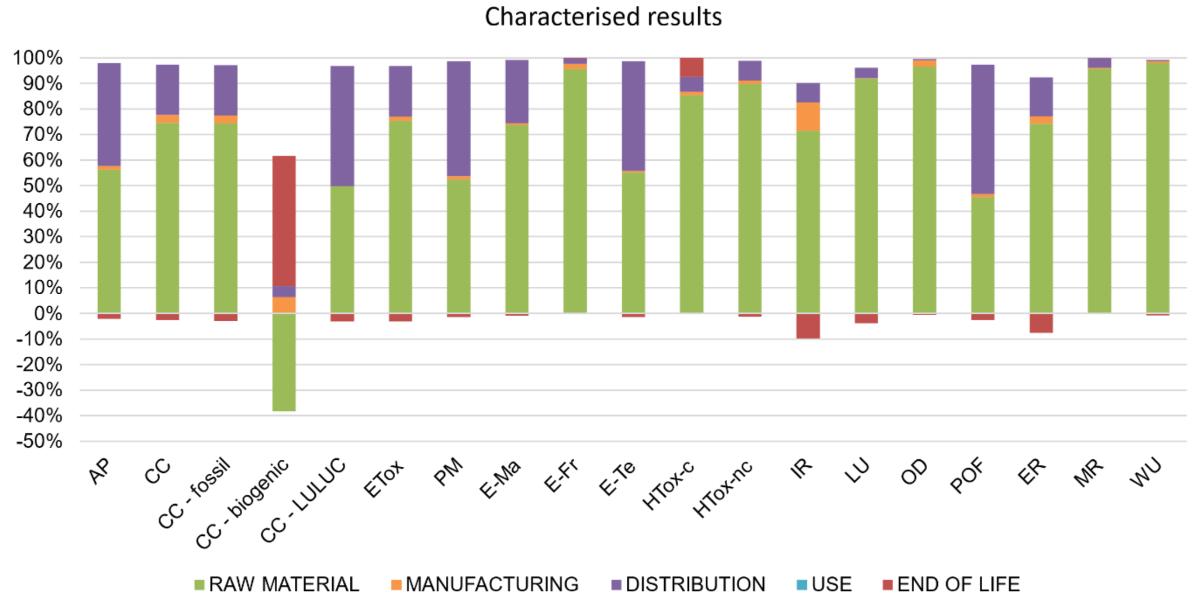
- LCS1: Data quality for processes used to model acid-based toilet cleaner is good. The data for the composition of the detergent is from various EU Ecolabel license application forms. The literature data for packaging is approximately 10 years old. For some ingredients no LCI data was available in the EF 3.1 database and here proxies were used as a best guess.
- LCS2: The data quality of the manufacturing process retrieved from AISE is fair. Unfortunately, the energy input was not divided into heat and electricity and estimates of the division were made. The datasets used from the EF 3.1 database for electricity, wastewater treatment and water are good.
- LCS3: All data regarding the distribution stage was retrieved from the default scenarios provided in the PEF method. The quality of the LCI data is good and the overall data quality of this life cycle stage is good.
- LCS4: The data quality of the use stage is good. Data is taken from the default assumption in the PEF method and the LCI data is good.
- LCS5: The data in the End-of-Life stage is based on the CFF parameters provided in the Annex C in the PEFCR guidance (v6.3). The overall data quality of this life cycle stage is good.

The data used in this study represents an average acid-based toilet cleaner. Hence, the results do not address the environmental performance of individual products. No data was found for the share of local, intracontinental, and international distribution and assumptions might not reflect the realistic conditions. The same proxy for fragrances was used as for other detergent products in these studies.

5.4.3.8.2. Life cycle impact assessment (LCIA) for acid-based toilet cleaner: results and interpretation

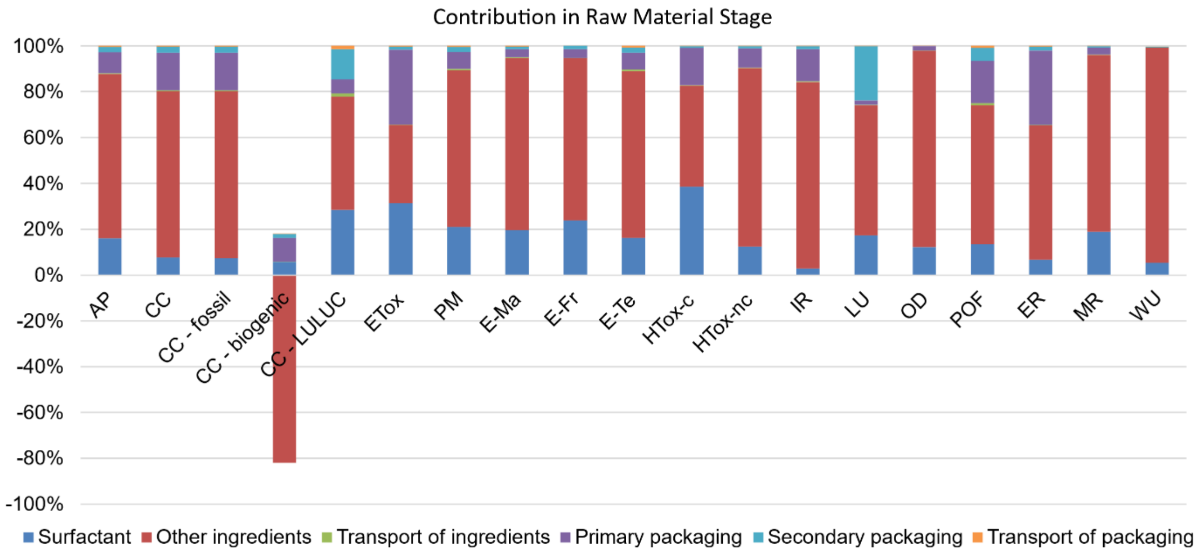
Contribution analysis for acid-based toilet cleaner: For acid-based toilet cleaner the results are shown in the figure below.

Figure 93. The characterised results for an acid-based toilet cleaning product in percentage of total environmental impact, split by life cycle stage for all impact categories (see Table 44).



As can be seen in the figure above, the most contributing life cycle stages are the raw material and distribution stages. There are some small negative impacts (i.e. environmental benefits) in EoL stage in 11 of 19 impact categories due to recycling of packaging and energy recovery. The distribution stage contributes most significantly (i.e. >30%) to the impact within the categories AP, CC-LULUC, PM, E-Te, and POF. This is related to the emissions from diesel combustion in the lorries. For other types of detergent products that require the use of heated water in the use phase, that process tends to dominate life cycle impacts. However, the acid-based toilet cleaner analysed here is ready to use and does not require the addition of water, let alone warm water. Any water consumed is presumed to only comes afterwards, with the normal use of the toilet. On the other hand, the acid-based toilet cleaner formulation has a high water content, which is transported across countries in some cases during the product distribution stage.

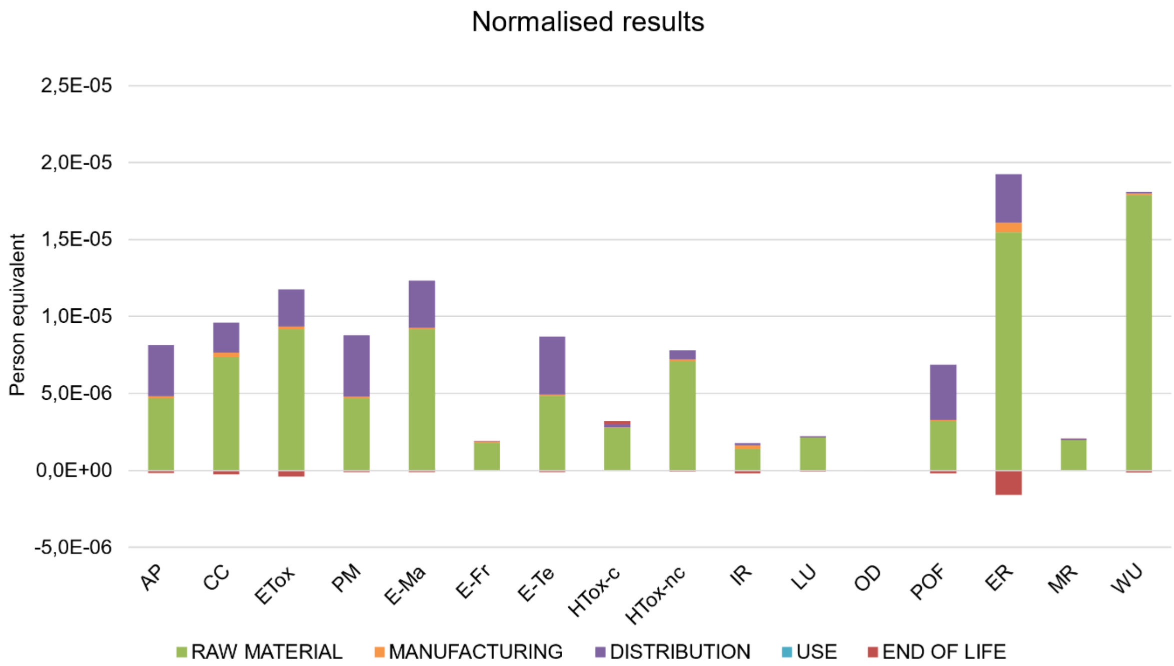
Figure 94. Contribution analysis of the subprocesses included in LCS1 - raw material acquisition and preprocessing of acid-based toilet cleaner to different impact categories (see Table 44).



The figure above shows the contribution of the subprocesses included in LCS1 Raw material acquisition and pre-processing. It is evident that the most contributing subprocess is “other ingredients” in all impact categories. In reality, the impacts for “other ingredients” were dominated by those of citric acid for all impacts without exception – even the negative impact (i.e. environmental benefit) with CC-biogenic impacts was associated with citric acid. This could be expected since of the 15% of ingredients that were not water, 11% was citric acid or a proxy thereof. The surfactant and packaging still have notable contributions to impacts in this life cycle stage, but this varies a lot depending on the impact category in question.

Normalised results for acid-based toilet cleaner: The characterised results presented in the section above are normalised using the EF 3.1 normalisation factors, which can be found in Table 45.

Figure 95. Normalised results of an acid-based toilet cleaner presented in Person Equivalent (using EF 3.1 normalisation factors) for different impact categories (see Table 44).



The highest normalised impacts in the figure above are seen for ER and WU categories, mostly stemming from the “other ingredients” in raw material and preprocessing life cycle stage.

Weighted results for acid-based toilet cleaner: Weighting the LCA results is a mandatory step in the PEF methodology. During weighting the normalised results are multiplied by weighting factors reflecting the importance of the different life cycle impact categories. The table below shows the weighted results. The weighting factors can be found in Table 45. The weighted results are aggregated across all impact categories obtaining overall score for each life cycle stage.

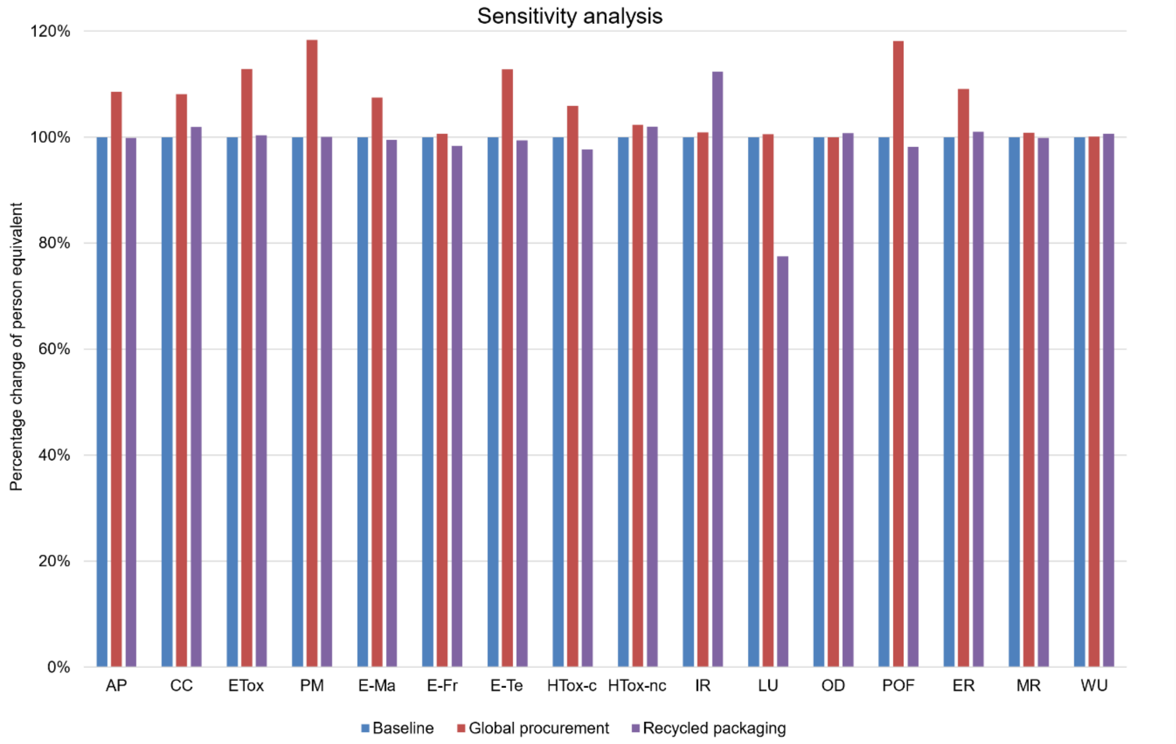
Table 63. Weighted results using the EF 3.1 weighting factors provided by the European Commission.

	Value	Unit	% share
Raw material	6.46E-06	mPR	80%
Manufacturing	1.71E-07	mPR	2%
Distribution	1.73E-06	mPR	21%
Use	0.00E+00	mPR	0%
End-of-life	-2.58E-07	mPR	-3%
TOTAL	8.10E-06	mPR	100%

Sensitivity analysis for acid-based toilet cleaner: A sensitivity analysis was made in this study to assess the different scenarios. The two scenarios accessed in this study are presented below:

- **“Global procurement”**: All ingredients are procured outside of Europe as opposed to the baseline where it is all procured inside Europe.
- **“Recycled packaging”**: The bottle is made of 100% recycled HDPE instead of virgin HDPE and the cardboard packaging is made of 88% recycled material (in accordance with the EF 3.1 database).

Figure 968. Relative changes (baseline set at 100%) to normalised results for two different sensitivity analyses with kitchen cleaning products (see Table 44).



The figure above shows the results of the two sensitivity scenarios in relation to the baseline results presented in the sections above. The figure shows that the results are sensitive to the two scenarios to varying degrees.

An increase in raw material transport distances under the “Global procurement” scenario showed significant increases in impacts for ETox (+13%), PM (+18%), E-Te (+13%) and POF (+18%). Less significant increases were also noted in other impact categories and in no impact category did impacts decrease compared to the baseline. These results reflect the importance of transport impacts to the overall life cycle impacts of acid-based toilet cleaners.

Changing to recycled materials reduces the impact in most of the impact categories. However, recycled packaging leads to increases in impact in IR (+12%), OD (+1%), CC (+2%), HTox-nc (+2%), and WU (+1%), but cannot be said to be significant except for in IR. On the other hand, it reduces impact slightly in E-Fr (-1%), E-Te (-1%), hTox-c (-2%), and POF (-2%), and significantly in LU (-23%). A closer look at the precise reasons why HDPE recycling is leading to increases in a number of impact categories is merited and access will be requested to check the underlying sub-processes behind the recycled HDPE dataset before the next draft of this study.

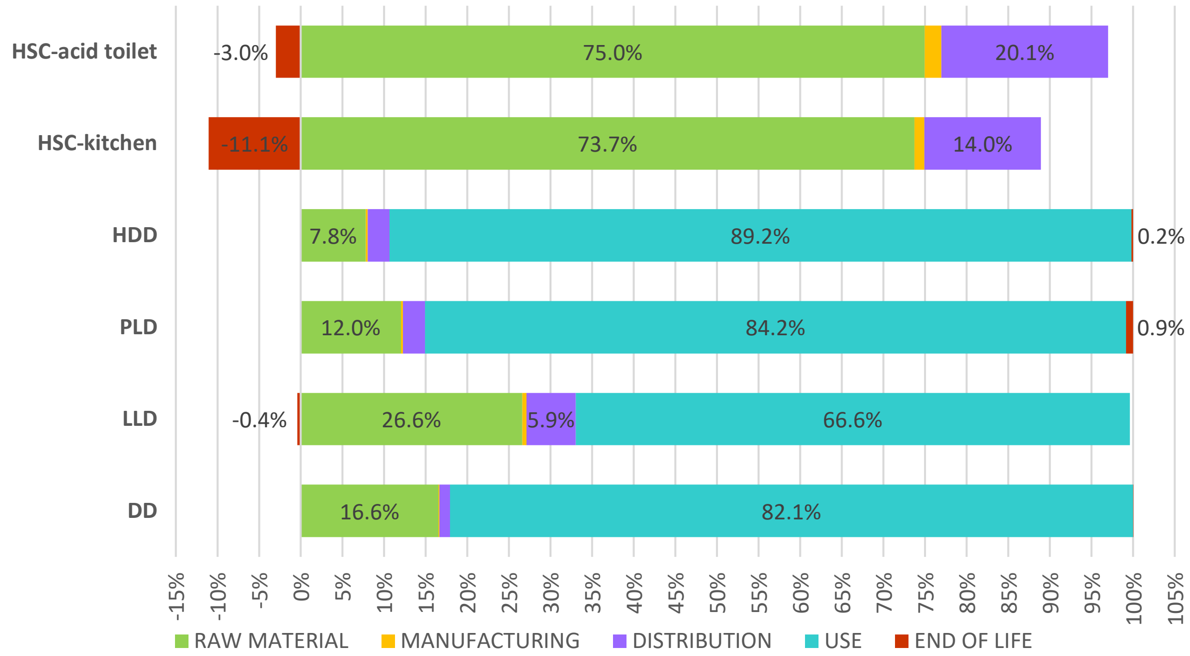
Summary and interpretation of results for HSC acid-based toilet cleaner: The screening study led to the following conclusions:

- The raw material stage and the distribution stage are the most contributing stages for the acid-based toilet cleaner life cycle.
- Within the raw material stage most of the impact comes from citric acid.
- The highest normalised environmental impacts are seen within ER and WU.
- The weighted results show that across impact categories the raw material stage accounts for 80% of the environmental impact, followed by distribution which accounts for 21%.
- A sensitivity analysis showed that global procurement increases the environmental impact of the kitchen surface cleaner by up to 18% for PM and POF impacts, and less so for several other impacts.
- Recycled packaging reduced the impact in 5 out of 19 impact categories but increased impact in 6 out of 19 impact categories.

5.4.3.9. Conclusions of in-house LCA screening studies

From the in-house PEF studies carried out for different detergent product groups, it became evident that the importance of different life cycle stages and associated processes varied quite a lot, stemming from significant differences in energy consumption in the use phase. These differences can be seen more clearly via a side-by-side breakdown of single PEF scores and normalised impacts of the in-house PEF studies for these different detergent products.

Figure 97. Comparison of relative life cycle stage contributions to overall PEF scores for six different detergent products



The varying importance of the use stage: From the spread of data above, the relative importance of the use stage can be seen to vary a huge amount between the different product groups. Use stage impacts were expected to be high DD products, due to the typically higher washing cycle temperatures used (e.g. 60°C), and for LD products, due to wash cycle temperatures typically being 40°C. An even larger share of use stage impacts can be expected for industrial LD and DD products since cycle temperatures tend to be higher due to the need for faster washing and the added importance of sanitation and hygiene in these contexts. However, use stage impacts may be offset in the industrial setting if dosing is optimised and appliances are also fully loaded for economical reasons.

It was surprising to see the large relative use stage impacts for the HDD product life cycle. This was because warm water was assumed to be used for manual dishwashing (40°C) and because the detergent has a generally low impact (ca. 94% water).

At the other extreme, use stage impacts were virtually zero with the two HSC products because no energy was needed to heat water and negligible water consumption was also assumed. Any consumption or degradation of auxiliary cleaning materials (cloths, scourers, mop heads etc.) were excluded from the scope.

The varying importance of the raw material stage: this stage consisted of both ingredients and packaging material production. It is interesting to note the relatively higher raw material impacts associated with LLD compared to PLD products, since for these products, the wash cycle energy consumption assumptions were the same. A closer look at the breakdown of detergent ingredients between LLD and PLD products would be necessary in order to be more certain of any improvement potentials.

While some real formulation data was made available for PLD products for this study, the LLD data essentially comes from the PEFCR study, published in 2019 (and formulation data will have been provided several years before 2019). The more formulations that can be provided for a given detergent product type and sub-category, the more accurate and useful will be any improvement potential analysis in the next draft of this PR.

As the use stage influence decreases, other stages come to the fore: A clear pattern emerges of the distribution and end-of-life stages becoming more significant as the use stage becomes less significant. Transport assumptions in the distribution stage can be reduced by minimising the transport of the product, which is mainly water. Distribution impacts can be reduced either by selling in more local and regional markets, or only shipping concentrated formulations.

Remaining doubts about the manufacturing stage: For all products, it is clear that the manufacturing stage, the one stage which EU Ecolabel license holders have most direct influence over, is insignificant from an LCA perspective. This could change for the PLD products if reasonable data for spray drying of slurry is made available for the next draft of the PR.

Many detergent producers are already in the habit of collecting and reporting specific energy consumption (GJ/tonne product) or CO2 (kgCO2eq./tonne product) as these are two of the KPIs included in the AISE sustainability reporting. Unfortunately, the AISE reports only include a single aggregated value and it is not clear if underlying results are set at factory level or can be disaggregated to different types of detergent product lines from the same factory. Currently there are no EU Ecolabel criteria requirements on this but, as implied from the figure above, the influence on LCA impacts would be negligible (except possibly with PLD – yet to be confirmed).

5.4.4. Improvement potential

A summary of some of the potential contributing factors to LCA impacts are summarised below, together with how data has been or would need to be evaluated to inform about potential improvements.

Table 64. Summary of main aspects considered for improvement potential from an LCA perspective

Aspects	Relevant life cycle stage(s)	Link to EUEL criteria?	Assess improvement potential?
Cold wash compatible LD formulations.	Use stage (possible trade-off at ingredients stage)	Already locked in by the definition of LD products and reinformed in Fitness for use criteria.	Yes. An initial look taken for hypothetical trade-off with LLD in sensitivity analysis. Ultimately depends on user behaviour. Potential trade-off if people use low temp. compatible formulas at higher temps – a kind of overdosing.
Use of gas boiler to heat water for washing instead of electricity in appliance.	Use stage.	No.	No. This is way beyond the control of the detergent manufacturer and often beyond the control of even the consumer.
Raw material source for surfactants (petro- versus various oleo-chemicals).	Raw material - ingredients	Yes, sustainable sourcing of palm oil and palm kernel oil.	Yes. Clear picture from LCA literature review, was investigated using EF datasets, but more detail needed before final conclusions.
Probiotic or microbial-based biosurfactants to substitute chemical ones.	Raw material – ingredients and end-of-life stages.	Tenuous. There is a general non-GMO requirement on micro-organisms intentionally added to HSC products.	Yes. But almost no data available in public domain. Efforts underway to gather primary data.
Procurement of local or regional ingredients	Raw material - ingredients	No.	Yes. Has been looked at in sensitivity analyses of the in-house LCA screening studies.
Fragrance-free or dye-free formulations	Raw material - ingredients	Tenuous. There are already general conditions tailored for these substance groups.	Yes. Has been looked at in sensitivity analyses of the in-house LCA screening studies for LLD products.
Low- or no-preservation strategies	Raw material - ingredients	Tenuous. There are already some general conditions tailored for this substance groups.	Yes. Has been looked at in a rough way in the sensitivity analyses of the in-house LCA screening studies for LLD products.
Minimum recycled content for packaging	Raw material - packaging	Yes. An option in the packaging criteria, but not mandatory.	Yes. Has been looked at in sensitivity analyses of the in-house LCA screening studies.

Aspects	Relevant life cycle stage(s)	Link to EUEL criteria?	Assess improvement potential?
Dose compaction	Raw material – ingredients and in distribution stage.	Yes. There are maximum dose requirements for g/kg laundry. Also may link to CDV criteria.	Yes. In one example of PLD, in a sensitivity analysis of two alternative representative formulations in the in-house LCA screening studies. But this made it impossible to isolate the effects.
Enzyme addition to reduce surfactant requirements.	Raw material - ingredients	Tenuous. Restrictions on certain hazards with enzymes (derogations too). May help reduce doses as well.	
Dose control	Use phase	Dosing instructions in user information and automated dosing for IILD and IIDD.	Yes. Overdosing and underdosing scenario run in sensitivity analysis for HDD products in the in-house LCA screening study.

Some further considerations on the points in the table above are mentioned below.

5.4.4.1.1. Cold wash temperature formulation

Since the EU Ecolabel criteria already require LD formulations to be low-temperature compatible, this means that the improvement potential in EU Ecolabel criteria is irrelevant. Discussions with expert stakeholders revealed that low temperature compatible formulations tend to require more chemicals to maintain a given detergency effect. However, we have not been able to compare side by side formulations of similar products, one being low-temperature compatible and the other not – this is what would be required to verify that claim.

The lack of formulations to compare led us to run a hypothetical assessment where the impacts of reducing the wash cycle temperature from 40 to 30°C were compared and how the theoretical effect of additional detergent dose would affect results. If the dose was maintained the same at both temperatures, the single PEF score was reduced from 0.0000107 to 0.0000092 – a decrease of 14.3% of total LCA impacts. As wash cycles approach the ambient water temperature, the savings would increase substantially as heating energy tends towards zero. Presuming that lower temperatures require more detergent for a given detergency effect, we assessed the effect of increasing detergent dose on the overall PEF score. A hypothetical 45% increase in detergent was enough to cancel out the LCA benefits from the wash cycle temperature reduction. More permutations of this relationship could be explored in the next draft of the PR if necessary.

If more detergent being needed at lower temperature is true as a general rule, the knock-on effect of this is that consumers may be overdosing LD products when using a low temperature formulation at higher temperature wash cycles. In order to reduce the risk of this happening, dosing instructions should also be tailored to the wash cycle temperature.

5.4.4.1.2. Oleochemical versus petrochemical sources for surfactants

This issue has been well explored in the LCA literature and was initially explored in the in-house LCA screening studies. Results are naturally more sensitive to detergent products that have higher concentrations of surfactants. The LCA literature review identified major increases (50 to 9900%) in certain LCA impact categories (terrestrial ecotoxicity, agricultural land occupation and natural land transformation) when shifting from petrochemical to oleochemical resources. The expected benefits in reduced fossil resource depletion were however modest (2 to 5%). For these reasons, it is not recommended to make any mandatory requirements for EU Ecolabel detergents to use plant-based (i.e. oleochemical) surfactants.

5.4.4.1.3. Global procurement of ingredients

The transport distances for ingredients used in detergents was assessed as part of sensitivity analyses and consistently showed an influence on the following impact categories for the different detergent products.

Table 65. Effect of shifting to a pure global procurement scenario from a mixed procurement scenario on normalised PEF impact categories.

Detergent product group	% change in impacts when moving to a global procurement scenario from a mixed baseline scenario															
	AP	CC	ETox	PM	E-Ma	E-Fr	E-Te	HTox-c	HTox-nc	IR	LU	OD	POF	ER	MR	WU
Liquid laundry detergents (LLD)	+5	+3	+3	+16	+6	0	+13	+2	+1	0	0	0	+10	+3	+1	0
Powder laundry detergents (PLD)	+15	+8	+8	+45	+18	0	+37	+5	+2	0	+5	0	+33	+10	+1	0
Dishwasher detergents (DD)	+4	+2	+5	+10	+7	0	+11	+4	+1	0	+1	0	+10	+2	+1	0

Hand dishwashing detergents (HDD)	+4	+1	+2	+24	+3	0	+6	+1	0	0	-1	0	+4	+1	0	0
Kitchen cleaner	+4	+4	+4	+8	+6	0	+7	+2	+2	+1	0	0	+7	+4	0	+1
Acid-based toilet cleaner	+9	+8	+13	+18	+7	+1	+13	+6	+2	+1	+1	0	+18	+9	+1	0

The increases in impacts associated with the global procurement scenario showed some cross-cutting effects for all detergent products in the sense that the most affected impact categories were the same throughout. The significance of these impacts varied depending on the total impacts associated with the rest of the product life cycle (linked to ingredient production and packaging). The water content was also an important variable as this would be unaffected by the global procurement scenario. Highly significant improvements were flagged for PLD products and this could perhaps justify a more detailed assessment.

However, if benefits of less global procurement are to be confirmed, how to reflect ingredient sourcing in potential EUEL criteria would face the challenge of trying to respect one of the fundamental principles that criteria should not create artificial barriers to the market. Consequently, instead of a criterion on “ingredients must come from less than an X km radius of the formulation plant”, a requirement to estimate the average CO2 footprint of the ingredient and packaging transport could be made. According to discussions with industry stakeholders, supply chains are quite direct, with very few intermediate actors involved that could complicate estimations of ingredient and packaging procurement carbon footprints.

5.4.4.1.4. Fragrance-free or dye-free formulations

Fragrance and dye compounds have nothing to do with the core function of detergency. Fragrances are more about consumer perception and the idea of something “smelling clean”. The reduction of fragrances can actually create a new problem with certain users how will tend to overdose if they are expected a certain “smell” in laundered products or cleaned surfaces. With products marketed as fragrance-free from the beginning, this issue is avoided. Dye compounds are purely about the visual perception of the product and have nothing to do with customer perception after use, but more to do with customer perception at the point of making a purchasing decision.

The idea of removing fragrances and dyes from detergent formulations was explored in a hypothetical sensitivity analysis for a LLD product, where these compounds were simply substituted for water. The baseline fragrance content was 0.7% by weight and the dye content, 0.03% by weight.

Table 66. Hypothetical effect of removing dyes and fragrances from a LLD product.

Scenario	% change in impacts when removing either fragrances or dyes from the formulation															
	AP	CC	ETox	PM	E-Ma	E-Fr	E-Te	HTox-c	HTox-nc	IR	LU	OD	POF	ER	MR	WU
Removing fragrance	-2.8	-3.0	-9.3	-5.3	-1.1	-1.4	-2.1	-8.1	-2.4	-2.8	-1.9	-7.1	-3.1	-2.7	-10.9	-1.3
Removing “dye”	-0.1	-0.1	-0.1	-0.2	0	-0.1	-0.1	-0.1	-0.1	0	0	0	-0.1	0	-1.7	-0.1

The results show that removing fragrances had a much bigger impact on LCA results than dyes. This can to a large extent be explained by the fact that the fragrance content was around 23 times higher than the dye content.

A major caveat for this sensitivity analysis (and subsequent comments here on improvement potential) is that the inputs for both fragrances and dyes were based on proxies. The proxy for fragrances even had a proxy for the assumed phthalate content of the fragrance formulation. The proxy for dyes was purely based on a mixture of EF dataset entries for pigments and is missing inputs for other components, like a solvent and stabiliser compounds.

Although these caveats undermine the credibility of any conclusions that can be drawn, it is likely that the potential LCA impact reduction could be higher than indicated above for LLD products. If better proxy data can be found for fragrances and dyes, then the sensitivity analysis and improvement potential could be repeated for LLD products and extended to other types of detergent product.

5.4.4.1.5. Less hazardous preservatives

The preservation of detergent products in necessary in liquid products with a high water content and pH conditions that are amenable to micro-organism growth. The increasing trend in LLD at the expense of PLD market share meant that an investigation into the potential substitution of preservatives for less hazardous alternatives could be of interest.

It must be noted that the sensitivity analysis performed was purely hypothetical and that the EF datasets for preservatives only presented one generic entry that was considered suitable for a proxy for conventional preservatives. In terms of alternative, less toxic preservatives, benzyl alcohol and lactic acid were chosen. These latter two chemicals did have dedicated EF datasets.

Table 67. Hypothetical effect of replacing a proxy preservative (Benzo[thia]diazole) at 0.5%.

Scenario	% change in impacts when removing either fragrances or dyes from the formulation															
	AP	CC	ETox	PM	E-Ma	E-Fr	E-Te	HTox-c	HTox-nc	IR	LU	OD	POF	ER	MR	WU
1to1 BA*	-1.7	-1.4	-1.9	-1.8	-2.0	-1.2	-1.3	-7.0	-2.5	-2.0	-0.1	+0.3	-1.1	-0.7	-12.7	-1.0
1to1 LA*	-0.8	-1.3	-6.9	-2.1	-0.2	+0.1	-0.5	-6.7	-1.3	-1.8	+0.3	-4.6	-1.2	-1.1	-8.0	-1.2
1to2 BA**	-0.4	0	+3.6	+0.1	-1.5	0	-0.2	-6.5	-1.6	-1.4	0	+5.1	0	+0.6	-10.8	-0.1
1to2 LA	+1.4	+0.2	-6.4	-0.4	+2.0	+2.5	+1.4	-6.0	+0.9	-0.9	+0.7	-4.5	-0.2	-0.2	-1.5	-0.5

*BA stands for Benzoic acid, LA stands for Lactic acid
**1to2 stands for the 0.5% baseline preservative being replaced by 1.0% of the BA or LA preservative.

The results show that there are some consistently important improvements with human toxicity (carcinogenic) impacts. In general, considering that the preservative only accounts for 0.5% of the formulation, many of the changes in impacts are proportionally larger. This is to be expected since much of the detergent products (except PLD) are water.

The sensitivity analysis here was just to have an idea of the potential benefits of removing preservatives. In order to make a more realistic improvement potential analysis, similar formulations, ideally from the same manufacturer, would need to be compared. Furthermore, the lack of EF datasets for preservatives limits the credibility of any improvement potential assessment in this area.

5.4.4.1.6. Recycled content in packaging

The improvement potential in this area was run for a number of different detergent products in the sensitivity analyses in the in-house screening LCA studies. This was based on assumptions of primary and secondary packaging and then assuming a 100% virgin plastic → 100% recycled plastic or 100% virgin cardboard → 88% recycled cardboard. The main findings are summarised below.

Table 68. Effect of shifting to a pure global procurement scenario from a mixed procurement scenario on normalised PEF impact categories.

	% change in impacts when going from virgin to recycled packaging scenario															
	AP	CC	ETox	PM	E-Ma	E-Fr	E-Te	HTox-c	HTox-nc	IR	LU	OD	POF	ER	MR	WU
LLD	-0.9	+0.4	-1.3	-0.2	-0.8	-0.1	-1.4	-0.5	+0.1	+0.3	-35.2	0	-2.6	-0.7	0	+0.5
PLD	-0.2	+0.2	0	0	-0.2	0	-0.3	0	+0.1	0	-41.9	0	-0.6	+0.2	0	+0.1
DD	-0.2	-0.1	-0.1	-0.2	-0.3	-0.1	-0.4	-0.1	-0.1	0	-23.5	0	-0.7	0	-0.1	0
HDD	-0.6	-0.3	-0.9	-2.1	-0.4	0	-0.8	-0.7	-0.2	+2.0	-25.0	0	-0.9	-0.6	-48.4	0
HSC-KC	-0.2	-2.2	+2.7	-2.7	-3.1	-3.0	-3.0	-12.4	+12.4	+61.8	-72.9	+1.3	-4.4	-1.2	-60.2	-0.1
HSC-ATC*	-0.2	+1.9	+0.4	0	-0.5	-1.6	-0.6	-2.3	+2.0	+12.4	-22.5	+0.8	-1.8	+1.0	-0.2	+0.6

*ATC stands for Acid-based Toilet Cleaner

All of the recycled packaging scenarios showed highly significant and beneficial influences on Land Use (LU) impacts for the six detergent products studied. Reductions in LU impacts can be considered as being most related to the recycled cardboard.

It should also be noted the major benefits of recycled content in PET primary packaging on MR impacts (PET was used in the HDD and HSC-KC products). When HDPE packaging was used (i.e. with LLD and HSC-ATC products) the benefits of recycled content were not seen.

An unusual and high increase in impacts associated with IR impacts was noted with both HSC-KC and HSC-ATC products and an examination of the sub-processes behind the recycled content EF dataset is merited in order to determine where these additional impacts come from.

For most impact categories, the improvement due to recycled content packaging was only minor. The EU Ecolabel criteria currently incentivises the use of material efficient packaging or packaging with a high recycled content (or both). A closer analysis of EUEL license data could shed some light on how ambitious the current packaging requirements are.

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