Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024

Assistance to the European Commission

TASK 4 COMPLEMENTARY ANALYSES AND RECOMMENDATIONS FOR THE ECODESIGN AND ENERGY LABELLING WORKING PLAN 2020-2024

FINAL

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- Oeko-Institut e.V.: Unmanned aircrafts (drones), ecological profile, durability, greenhouse covers, market surveillance, non-tertiary coffee machines, tertiary coffee machines, hair dryers, firmware and software, scarce and critical raw materials
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LEGAL NOTICE

ACRONYMS

ABS	Acrylonitrile butadiene styrene	EPD	Environmental Product Declaration
AC	Alternate current/Direct current	EPR	Extended Producer Responsibility
AI	Artificial Intelligence	EPS	External Power Supply
ASTM	American Society for Testing and Materials	EPS	Expanded Polystyrene (foam)
BAT	Best Available Technology	EPTA	(Greek consultant)
BFR	Brominated Flame Retardants	ErP	Energy related product
BLDC	Brushless Direct Current	ETFE	Ethylene Tetrafluoroethylene
bn	Billion	EU	European Union
BNAT	Best Not yet Available Technology	EVA	Ethylene Vinyl Acetate
BOM	Bill of Materials	EVA	European Vending Association
BST	Base stations	EVA-EMP	European Vending Association - Energy Measurement Protocol
CAD	Computer Aided Design	FCM	Food Contact Materials
CBI	Coffee Business Intelligence	FDM	Fused Deposition Modelling
CECED	Conseil Européen de la Construction d'appareils Domestiques (predecessor of APPLIA)	FEM	Finite Element Modelling and Simulation
CEN	Comité Européen de Normalisation	FP7	Seventh Framework Programme (European Union research and development funding programme)
CENELEC	Comité Européen de Normalisation Électrotechnique	GER	Gross Energy Requirement
CFD	Computational fluid dynamics	GHG	Greenhouse Gas
CLASP	Collaborative Labelling and Standards Program (NGO)	GJ	Gigajoules
CLC/TC	Comité Européen de Normalisation Électrotechnique/Technical Committee	GPS	Gel Permeation Chromatography
CLP	Classification, Labelling and Packaging Regulation	GPS	Global Positioning System
CO2e	Carbondioxide equivalent	GPSD	General Product Safety Directive
CoC	Code of Conduct	GRP	Glass-fiber reinforced polyester
CPR	Construction Products Regulation	GS	Geprüfte Sicherheit (Tested Safety)
CRT	Cathode Ray Tube	GWh	Gigawatthours
DC	Direct Current	ha.	Hectares
DIN	Deutsches Institut für Normung (German Standardisation Organisation)	HALE	High altitude, long endurance
DOE	Department of Energy (USA)	HDPE	High-density polyethylene
DR	Drying Rate	HEPS	High Efficiency Performance Standards
DSC	Differential Scanning Calorimetry	HFRs	Halogenated Flame Retardants
EAP	Environment Action Plan	HIPS	High Impact Polystyrene
EASA	European Aviation Safety Agency	HKI	Industrieverband Haus-, Heiz- und Küchentechnik e.V.
EC	Electricity Consumption	HORECA	Hotel, Restaurant, and Catering / Café business
EC	European Commission	ibid.	ibidem (at the same place)
EC	European Community	IC	Integrated circuit
ECHA	European Chemicals Agency	ICAO	International Civil Aviation Organisation
ECOS	European Environmental Citizens Organsation	ICP	Inductively Coupled Plasma mass spectrometry
EEC	European Economic Community	IEC	International Electrotechnical Commission
EEE	Electrical and electronic equipment	IGU	Integrated Glazing Unit
EFCEM	European Federation of Catering Equipment Manufacturers	ISO	International Standardisation Organisation
EIA	Ecodesign Impact Accounting	kton	Kilo tonnes (metric, 1000 tonnes)
EMC	Electromagnetic Compatibility Directive	kW	Kilowatts
EN	European Norm	kWh	Kilowatthours
ENAK	(Swiss association for energy efficiciency in the hospitality industry)	LASE	Low altitude, short endurance
EPA	Environmental Protection Agency (USA)	LCA	Life Cycle Assessment
EPBD	Energy Performance of Buildings Directive	LCC	Life Cycle Cost

LCD	Liquid crystal display	PRODCOM	Production Communautaire (database)
LDPE	Low density polyethelene	PS	Polystyrene
LED	Light emitting diode	PUR	Polyurethane
LIDAR	Light detection and ranging	PVC	Polyvinylchloride
LLCC	Least Life Cycle Costs	RAN	Radio Access Network
LVD	Low Voltage Directive	REACH	Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals
M	Million	RED	Radio Equipment Directive
MAV	Micro-air vehicle	RoHS	Restriction of Certain Hazardous Substances Directive
MEErP	Methodology for the Ecodesign of Energy-related Products	SCIP	Substances of Concern In articles as such or in complex objects (Products)
MEMS	Micro-electromechanical systems	SD	Smart Dust
MEPS	Minimum Efficiency Performance Standards	SEM	Scanning electron microscopy
MJ	Megajoules	SFOE	Swiss Federal Office of Energy
ML	Machine learning	SMEs	Small & medium size entreprises
MoU	Memorandum of Understanding	SVHC	Substances of Very High Concern
MSA	Market surveillance authority	SVHC	Substances of Very High Concern
MSP	Manufacturer selling price	SW	Solid Works (software)
MSW	Municipal Solid Waste	TEC plastics	Technical plastics
Mt	Million tonnes (metric)	TGA	Thermal Gravimetric Analysis
Mt CO2 eq./yr	Megatonnes of CO2 equivalent per year	TGL	Thai Green Label
MWh	Megawatthours	TOTEM	Tool to Optimise the Total Environmental impact of Materials
NAV	Nano-air vehicle	TWh	TeraWatthour
NEMS	Nano electromechanical systems	UA	Unmanned aircraft
NIR	Near Infrared Radiation	UAS	Unmanned aircraft system / Unmanned aerial system
NMR	Nuclear Magnetic Resonance	UAV	Unmanned aerial vehicle
OCS	Office Coffee Service	UK	United Kingdom
PA6	Polyamide (nylon)	USB	Universal Serial Bus
PAH	Polycyclic Aromatic Hydrocarbons	UV	Ultraviolet Radiation
PAR	Photosynthetic Active Radiation	Uw	U-value (insulation value) of window
PAV	Pico-air vehicle	VFF	Verband Fenster + Fassade
PBB	Polybromated Biphenyle	VHK	Van Hosteijn en Kemna
PBDE	Polybromated Diphenyle Ether	VOC	Volatile Organic Compounds
PC	Polycarbonate	W	Watts
PC-ABS	Polycarbonate/acrylonitrile butadiene styrene	WEEE	Waste electrical and electronic equipment
PCR	Polycarbonate recycled	WG	Working Group
PE	Poly-ethylene	Wh	Watthours
PEF	Primary Energy Factor	WP	Working Plan
PEF	Product Environmental Footprint	XRF	X-Ray Fluorescence
PEFCR	Product Environmental Footprint Category Rule	XRM	X-ray microscopy
PET	Polyethylene Terephthalate	µUAV	Micro-unmanned aerial vehicle
PJ	PetaJoules		
PMMA	Polymethyl methacrylate		
PoE	Power over Ethernet		
POP	Persistent Organic Pollutants		
PP	Polypropylene		
PPS	Polyphenylene Sulfide		

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1 INTRODUCTION

This report presents the main results of the Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024. It is based on the results of the preceding tasks, the stakeholder consultation and dialogues throughout the study and complementary analyses. By reading this report, the reader will get a good overview of the activities and the main results of the work. For further details, we recommend reading Task 1, Task 2 and Task 3 reports.

1.1 The Working Plan study

The European Commission has launched a preparatory study that will inform and assist the Commission in preparing the Ecodesign and Energy Labelling Working Plan 2020-2024 as part of the implementation of the Ecodesign Directive 2009/125/EC[1] and Energy Labelling Regulation (EU) 2017/1369[2]. The study is carried out by Viegand Maagøe, Oeko-Institut and VHK for the European Commission, DG GROW. The study started in March 2020 and was completed by the end of April 2021.

Formally, this is the first combined Ecodesign and Energy Labelling Working Plan to be undertaken following the changes contained in the Energy Labelling Regulation (EU) 2017/1369 (Article 15). However, it should be noted that previous Ecodesign Working Plans informally always kept in mind the possibility of combining Ecodesign and Energy Labelling, where judged appropriate on a product-by-product basis.

The Working Plan study is the first step in a process aiming at publishing implementing measures and acts in the Official Journal. Figure 1 shows a brief overview of the process.

[1] https://eur-lex.europa.eu/eli/dir/2009/125/2012-12-04 (consolidated text)
[2] https://eur-lex.europa.eu/eli/reg/2017/1369/oj

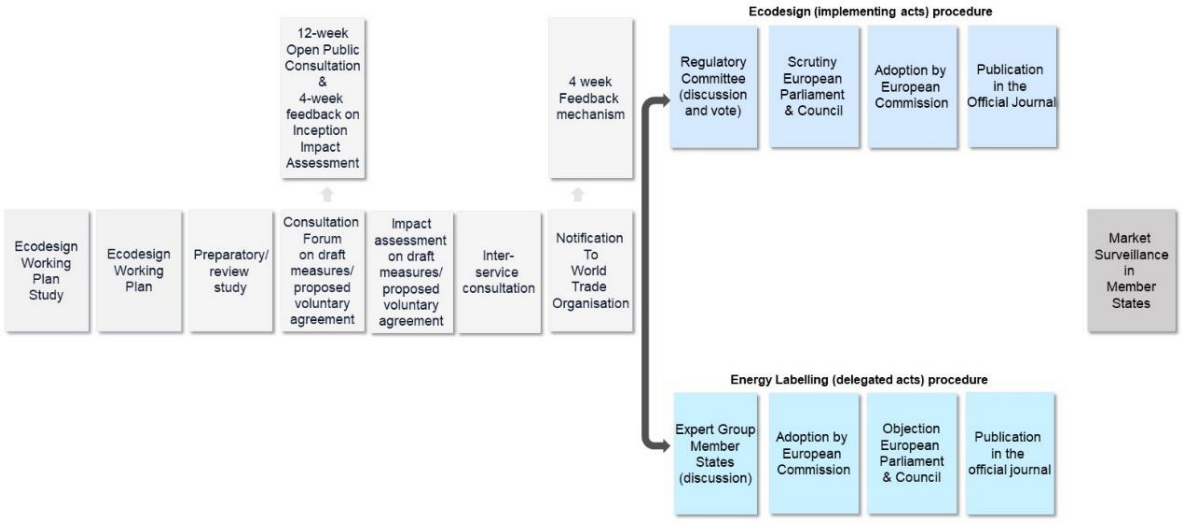


Figure 1: Process for establishing Ecodesign and Energy Labelling implementing measures and delegated acts.

1.2 Objectives

The following objectives of the Ecodesign and Energy Labelling Working Plan 2020-2024 preparatory study have been established:

1. Develop the approach for identification and prioritisation of product groups and horizontal initiatives for the working plan with a view to better take into account environmental impacts in all life-cycle stages and circular economy aspects such as products durability, reparability, recyclability and/or recycled content.

2. Analyse the product groups and horizontal initiatives regarding sales, stock, resource consumption, improvement potential, environmental impacts, regulatory coverage and feasibility, market surveillance impact and industrial competitiveness.

3. Inform and assist the European Commission in its decision-making process to compile the Ecodesign and Energy Labelling Working Plan 2020-2024 with a strong and transparent evidence base derived from scrutinising regulations and available studies, together with a thorough consultation process of relevant stakeholders.

1.3 The study team

The Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024 is carried out by a consortium consisting of:

- Viegand Maagøe A/S (lead)
- Oeko-Institut e.V.
- Van Holsteijn en Kemna BV

The collective experience of the consortium used for this study stems from involvement in European product policy & policy instruments during more than 20 years including:

- Ecodesign directive and energy labelling regulation since the preparatory phases

- Development of the MEEuP / MEErP (Methodology of Energy-using / Energy-related Products)
- Carried out more than 50 preparatory and review studies and impact assessments
- Two previous working plan studies
- EU Energy Star, Green Public Procurement, standardisation
- National Market Surveillance activities
- Ecodesign Impact Accounting
- ICT Impact Study for ENER (included in current Working Plan and a basis for the current study)
- Product design, technical knowledge, circular economy, LCA, scenario modelling, stakeholder consultations, policy instruments, etc.

1.4 Acknowledgements

The study team would like to express our appreciation to the European Commission (DG GROW and the Inter-Service Group (GROW, ENER, ENV, CNECT, JRC and JUST)) and to all stakeholders and other persons and organisations we have been in contact with during the study for all input, information and dialogue, which have been very useful for the quality of the work.

1.5 Disclaimer

The information and views set out in this study and in the study reports are those of the authors and do not necessarily reflect the official opinion of the European Commission.

All assumption, estimations, assessments and analyses have been made on the basis of data and information available and the study team's knowledge and experience, and reflecting the aim of the study i.e. to inform and assist the European Commission in its decision-making process to compile the Ecodesign and Energy Labelling Working Plan 2020-2024. Due to the amount of analyses made and the relatively limited resources available for each product group and horizontal initiative, obviously the study team had to focus on the main topics for each product and initiative and to recognise a certain level of uncertainties.

For product groups and horizontal initiatives finally selected for the Working Plan by the European Commission, detailed analyses will be carried out before any implementing measure will be established and a further policy process will be carried out.

2 EXECUTIVE SUMMARY

2.1 Task 1 Background, methodology and stakeholder consultation

2.1.1 Policy background

Strategies and action plans
Sustainable development, resource efficiency, circular economy and competitiveness comprise very important policy priorities for the long-term EU strategy "Clean Planet for All in 2050" and mid-term 2030 Energy Strategy.

Furthermore, in December 2019, The European Green Deal was presented by the Commission as a roadmap for making the EU's economy sustainable by setting out how to make the EU climate-neutral continent by 2050. The Green Deal provides a roadmap with actions to boost the efficient use of resources by moving to a clean, circular economy and stop climate change, revert biodiversity loss and cut pollution. It outlines investments needed and financing tools available, and explains how to ensure a just and inclusive transition.

Additionally, two Circular Economy Action Plans, one launched in December 2015, the other in March 2020, are specifically relevant for the EU's Ecodesign and Energy Labelling policies regarding recycling, re-use etc. of raw materials, products and waste and a broader sustainability product policy framework.

From this background, one of the primary objectives of the European Commission is to promote the greater integration of product-related policies to attain enhanced long-term sustainability and competitiveness in the EU.

This is especially the case given that many of the products potentially under consideration will be designed and manufactured from 2030 onwards, following new or revised Ecodesign and Energy Labelling requirements possibly to be made during the period 2020-2024, or thereafter. These products will be used, maintained, repaired and possibly upgraded during the period running up to 2050, and thus will make a key contribution to the above-mentioned 2050 strategy.

The Ecodesign Directive 2009/125/EC, together with the Energy Labelling Regulation (EU) 2017/1369, are fundamental building blocks in moving towards an optimal use of energy resources and circular economy models. Moving towards a more circular economy implies achieving even better environmental performance, higher energy and material efficiency and lower environmental externalities of products in the internal market. Together, the transparent future-oriented framework of EU-wide Ecodesign minimum requirements and Energy Labelling for energy-related products ensures the free movement of those better-performing products within the internal market.

The above framework reinforces the EU's competitiveness, since many companies involved in the supply and value chains of product and services in the EU – especially from a nu-

merical and EU GDP contribution perspective – comprise Small and Medium-sized Enterprises (SMEs), as well as larger companies. These SMEs utilise the very same Energy-related Products (ErP), which are regulated via Ecodesign and Energy Labelling regulations, and are able to make savings on their utilities (primarily energy, water and IT infrastructure) bills via the use of such improved products.

The above SMEs – together with larger enterprises – are also often involved in the value chains of producing the same regulated ErP goods, resulting in commercial and innovation benefits at regional, Member State and EU-wide levels, as well as in enhanced exports revenues derived from enhanced international sales of cutting edge products, engendered by Ecodesign and Energy Labelling measures.

The Ecodesign Directive pushes manufacturers and importers to produce more energy efficient products by setting minimum requirements on products to be placed on the EU market, while the Energy Labelling Regulation provides consumers with information about the energy efficiency of products via an EU-wide energy label grading products from A (most efficient) to G (least efficient), thus encouraging EU citizens to select more energy- and resource-efficient products. Additionally, both the Ecodesign Directive and the Energy Labelling Regulation provide information on product topics related to parameters such as energy use, environmental properties, etc.

The Commission estimates that the Ecodesign Directive and the Energy Labelling Regulation contribute to about half of the EU energy saving targets for 2020, where the Directive provides 85% and the Regulation 15%[3]. Additionally, the two legal instruments reduce fossil fuel imports by circa 23% for natural gas and circa 37% for coal; ensure a level playing field for the manufacturers; and provide economic savings for EU citizens for a modelled "basket" of products corresponding to about 500 EUR/year per household.

Over the years there has been a development from mainly focusing on energy in-use consumption and related environmental impacts to broader resource aspects, taking into account the full life-cycle including material use, durability, end-of-life aspects and circularity. This took place partly due to the two aforementioned Circular Economy Action Plans, which consider the Ecodesign implementing regulations and Energy Labelling delegated acts as important instruments to reach the targets; partly due to the implemented measures capturing a large part of the in-use saving potential and thereby increasing the importance of the other life-cycle impacts.

Ecodesign Directive[4]

The Ecodesign Directive 2009/125/EC of 21 October 2009 is a framework directive, which establishes EU-wide implementing measures for improving the environmental performance of energy-related products, such as household appliances, ICT products (Information and Communication Technologies) and electric motors, when they are placed or put into service on the EU market. Being a framework directive, it provides for the setting of requirements, which the energy-related products covered by implementing measures – adopted separately – must fulfil in order to be placed on the market or put into service. An alternative

[3] The Ecodesign Directive (2009/125/EC). European Implementation Assessment. European Parliament Research Service. Anna Zygierewicz. November 2017.

[4] https://ec.europa.eu/growth/industry/sustainability/ecodesign_en

is a self-regulation measure / industry voluntary agreement e.g. for imaging equipment (copy, print and scanner equipment).

The 2009 directive is a recast of the previous directive, Directive 2005/32/EC, where one important amendment incorporated into the recast 2009 version was the change of overall scope from 'energy using' to 'energy-related' products.

Product-specific implementing regulations and self-regulation are drafted on the basis of a preparatory study and revised on the basis of a review study following the Methodology for the Ecodesign of Energy-related Products (MEErP). Self-regulation typically takes place as a voluntary agreement proposed by the relevant industry stakeholders and according to Annex VIII of the 2009 Directive.

Article 16 of the Ecodesign Directive lays down the requirement that the Commission establish a working plan that should be amended periodically by the Commission after consultation with the Consultation Forum. Three working plans (after a transitional period plan launched soon after the adoption of the 2005 Directive) have been communicated to date (2009-2011, 2012-2014, 2016-2019). The current working plan preparatory study is launched to provide the basis for the fourth working plan.

Implementing measures may lay down specific Ecodesign requirements following the method described in Annex II of the Directive. Until now, implementing measures have only been established via these (Annex II) specific requirements. However, the Directive also provides an opportunity of setting generic Ecodesign requirements following Annex I in cases where it is not possible to set specific Ecodesign requirements. These requirements may relate to supply of information, and may be requirements for the manufacturer through establishing the product's ecological profile and evaluating alternative design solutions against benchmarks established by the Commission.

Energy Labelling regulation

The Energy Labelling Regulation of 4 July 2017[5] is a framework regulation in line with the Ecodesign Directive establishing the general framework for implementing EU energy labelling in EU. It replaces the former Energy Labelling Directive 2010/30/EU. The latest 2017 Energy Labelling regulation has maintained the same scope as the previous directive, but some of the provisions are modified and enhanced in order to improve the effectiveness of the framework legislative scheme. The specific requirements and the label classes are established through delegated acts.

One of the new elements in the framework Energy Labelling regulation is that it lays down an obligation on the Commission to establish and make periodic updates of a long-term working plan (Article 15). The working plan must, in line with the Ecodesign Working Plan, set out an indicative list of product groups which are considered priorities for the adaption of delegated acts. The working plan shall also set out plans for the revision and rescaling of labels for product groups with the exception of the rescaling of labels which were in force at 1 August 2017, for which the rescaling is provided for in Article 11 of the Regulation.

[5] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU.

The working plan should be reviewed every three years, and the Commission may choose to combine the working plan with the working plan that should be established in accordance with Article 16 of the Ecodesign Directive. This is the reason why the Commission has launched this combined study for Ecodesign and Energy Labelling.

There is to large extent synergy between the Ecodesign and Energy Labelling frameworks. Whilst Ecodesign addresses the supply side and pushes the market towards higher energy and resource efficiency, Energy Labelling addresses the demand side and pulls the market to even higher levels of efficiencies. The combined effects ensure dynamic improvements of the market. In this respect it also makes sense to elaborate a common working plan for both Ecodesign and Energy Labelling.

Other important improvements in the most recent Energy Labelling framework regulation are:

- the provisions for rescaling of the label to the A-G scale, at the same time taking into account the speed of technological progress for each product group, and ensuring that the top class(es) is empty in newly rescaled labels
- establishment of the product registration database (so-called "EPREL" database), which is a useful tool for consumers, dealers, market surveillance authorities, and for the regulatory process on revision of labels.

2.1.2 Stakeholder consultation

Stakeholder involvement is crucial for the success of the working plan study – as it is for other studies related to ecodesign and energy labelling. The stakeholders concerned are an important source of information and data and most of them are in varying degrees involved in implementation of potential measures.

The objective of involving stakeholders is to increase the quality of the assessments and analyses through the stakeholders' willingness to provide information, data and positions, and to comment on draft reports. It is also important to keep the relevant stakeholders informed about possible coming regulation(s) within areas of interest for them, and to attempt to seek their validation of compiled data, possible design solutions, and employment and financial feedback.

Stakeholder consultation has been quite extensive throughout the course of the study due to nature of this study being relevant for many industry sectors, industry associations, indudstry groupings, Member States, consumer organisations, environmental organisations, etc. In total, there were close to 600 persons registered on the study website for updates.

The communication hub for the stakeholder involvement was the study website established by the study team. In agreement with the European Commission, the domain name "ecodesignworkingplan20-24.eu" was selected for the website. The website contains descriptive information on the study and the study team, a registration webform for notification of news and updates, a meeting registration webform (in advance of the two stakeholder meetings held), published reports to be downloaded and contact information for the study team.

From the study outset, formal stakeholder consultations have been incorporated into considerations via two stakeholder meetings and sets of iterative written comments on the task reports circulated via the study website. Additionally, other stakeholder inputs have been provided via direct contact via telephone and email communications.

Originally, two one-day face to face meetings in Brussels were planned, however, due to the Covid-19 pandemic and like other stakeholder meetings, they had to be converted to online meetings. This gave an opportunity to invite more participants to the meeting - compared to traditional stakeholder face to face meetings - up to about 200, which was the limit of the online meeting platform. However, at the same time the form of the meetings had to be changed into being rather a shorted information meeting (3-4 hours duration) with a limited level of questions and answers, instead of a full day meeting with sufficient time for dialogues.

The first stakeholder meeting was held on 10 July 2020 attended by 164 stakeholders, experts etc. In advance of the meeting, drafts of Task 2 and 3 reports were available on the study website. The draft Task 3 report contained assessment of the product groups and horizontal initiatives selected at that time, totally 15. The slides presented and the minutes of the meeting can be downloaded from the study website (www.ecodesignworkingplan20-24.eu/documents).

In September 2020, draft Task 1 report and 1 additional Task 3 horizontal initative report were published.

The remaining Task 3 assessments of product groups and horizontal intiatives were published in advance of the second stakeholder meeting together with a draft of the Task 4 report and final drafts of the reports published in draft versions previously.

Stakeholders have been provided with between three and six weeks for commenting on the reports. Around 60 organisations, mainly industry associations, indudstry groupings, consumer organisations, environmental organisations and Member States have provided comments and position papers.

The second stakeholder meeting was held on 26 March 2021 attended by close to 200 persons.

2.1.3 Methodology

The study is performed through the following four tasks:

- Task 1 – Background, methodology and stakeholder consultation: The task establishes the background and the methodology through assessment of relevant sources and policies and launches the stakeholder contact and consultations, which includes establishment of the study website.

- Task 2 – Identification of product groups and horizontal initiatives: The task provides lists of potential product groups and horizontal initiatives through screening and assessment techniques. A selection of these product groups and horizontal initiatives is the basis for the analysis work in Task 3.

- Task 3 – Preliminary analysis of product groups and horizontal initiatives: The task performs analyses of product groups and initiatives selected in Task 2 in terms of sales, trade and stock, resource consumption, technical-economic improvement potential and a check of whether the results indicate that the product or initiative is within the scope of the Ecodesign Directive and the Energy Labelling Regulation.

- Task 4 – Based on the results in Task 3, a number of most relevant product groups and horizontal initiatives are selected for complementary analyses in Task 4 to provide a more holistic picture of them when including other environmental impacts; an analysis and view with regard to existing regulations for the same or similar products; regulatory feasibility; and industrial competitiveness. The results of Task 4 include fiches with data and information covering the selected products and initiatives and recommendations on possible inclusion on the Ecodesign and Energy Labelling Working Plan 2020-2024.

2.2 Task 2 Identification of product groups and horizontal measures

2.2.1 The identification process

In Task 2, the study team established a long list of potential product groups and horizontal initiatives and via a scoring matrix, stakeholder input and consultation with the Commission Inter-Service Group, a list of 31 products and initiatives were selected for more detailed analyses in Task 3. The process is detailed in the following.

2.2.2 Establishing the long list of potential product groups and horizontal initiatives

The first step consisted of establishing the long list of products and horizontal measures to be scored afterwards. This took place via defined groups of products and measures provided in the technical specifications of the study and detailed with the Commission during the study kick-off:

- Remaining product groups from previous Working Plans and Working Plan studies: This group contains product groups included in previous Ecodesign Working Plans and in preparatory studies informing previous Working Plans, but for which no implementing measures or self-regulations have been established.

- Complex product groups: The "complex product" group contains combined products in one product. E.g. pump + motor + variable speed drive + regulating device.

- Products with interactive and interoperable IT solutions: This product group overlaps partly with the above-mentioned complex products group. It contains more broadly interconnected products (regulated or still not regulated products) with interactions or automations, where an environmental improvement can exist through this interaction, e.g. home network connections and IoT (Internet of Things) devices.

- Product groups with potential for circular economy related requirements: The product group contains both existing ecodesign and/or energy labelling product regulations with potential for increased circular economy related requirements and new products, where circular economy related requirements could be relevant. Material efficiency may include longer lifetimes; more recycling opportunities; design for less material and less CRM (Critical Raw Materials) used as well as unbundling of combined products the individual products in the combination with different lifetimes for.

- Energy-related products: Energy-related products in this relation are products, which do not consume energy in the use phase or only marginally, but which impact the consumption of other products or systems.[6] No implementing measures have yet been adopted. Examples are windows, thermostats and luminaries.

- ICT product groups from a dedicated ICT study: In the Working Plan 2016-2019, a separate study was included for the following ICT products: data centres, telecommunication networks, electronic displays, audio and video, personal ICT equipment, imaging equipment, home and office equipment, ICT in public spaces, building automation and industrial sensors.

- New product groups not studied previously: This product group comprises all other product groups not studied previously. Reasons include that they were previously seen as product groups without sufficient improvement potential, or that any other legislation associated to the product did not allow the inclusion of this product group. For some of the product groups, this may have changed, both the legislative barrier, if any, and improvement potential due more focus on material efficiency and circular economy and due to technological developments. Furthermore, novel product types might exist that only entered the mass market a few years ago.

- Horizontal IT solutions to facilitate improved market surveillance: The initiative focuses on horizontal IT solutions, which could facilitate improved market surveillance and thereby release a further potential. Examples include greater use of electronic labelling or tagging and ability for the products to report continuously their energy consumption and usage pattern.

The groups are not mutually exclusive and a number of product groups may fall into more than one category. Totally, about 160 product groups and horizontal initiatives were identified. This list is provided in Annex A.

2.2.3 Selection for Task 3 analyses

Each of the product groups and initiatives were assessed regarding product characteristics and scored regarding relevance for the following focus areas: circular economy, IT and market surveillance; and relevance for implementing measures (Ecodesign Directive) and delegated acts (Energy Labelling Regulation).

[6] The Ecodesign Directive itself uses the term "Energy-related product" as a generic term for both products that consume energy and that do not consume themselves energy but affect the energy consumption of others. In this study, we use the term in the more restricted sense explained above.

The specific areas assessed were:

- Product and initiative characteristics
    - In WP (Working Plan), still without regulation
    - Recommended for WP, but not included
    - Not recommended for WP
    - Products with regulation
    - New products
    - Energy-related (only) products
    - Complex products
    - Industrial products
    - ICT / CE products
    - Buildings related
    - Horizontal product groups and initiatives

- Circular economy relevance
    - Lightweight design
    - Extended lifetime through increased repairs and upgrades
    - Extended lifetime through reduced SW & other obsolescence
    - Extended lifetime through increased durability
    - Increased recyclability & reuse of materials and components
    - Reduced amounts of critical & scarce raw materials
    - Post-consumer recycled content

- IT
    - Interactive / interoperable IT initiatives

- Market surveillance relevance
    - Electronic labelling
    - Product & component passport
    - Improved ICSMS / EPREL
    - Appliance resource consumption reporting
    - Demand flexibility control
    - Intelligent resource management

- Economic significance
    - Significant volume of sales

- Environmental significance
    - Production (materials, recycled content)
    - Use (energy, carbon, emissions, auxiliaries)
    - Reuse, repair, life
    - EoL recycle, recover, waste

- Significant saving potential
    - Significant environmental saving potential
    - Absence of legislation or market failure
    - Wide disparity in environmental performance

The scorings were used as a tool for assisting the study team and the Commission in selecting the product groups and horizontal initiatives in a consultative dialogue. The selections were made in batches allowing the study team to initiate the Task 3 analyses in parallel with the selection process. See an illustrative overview of the process in Figure 2.

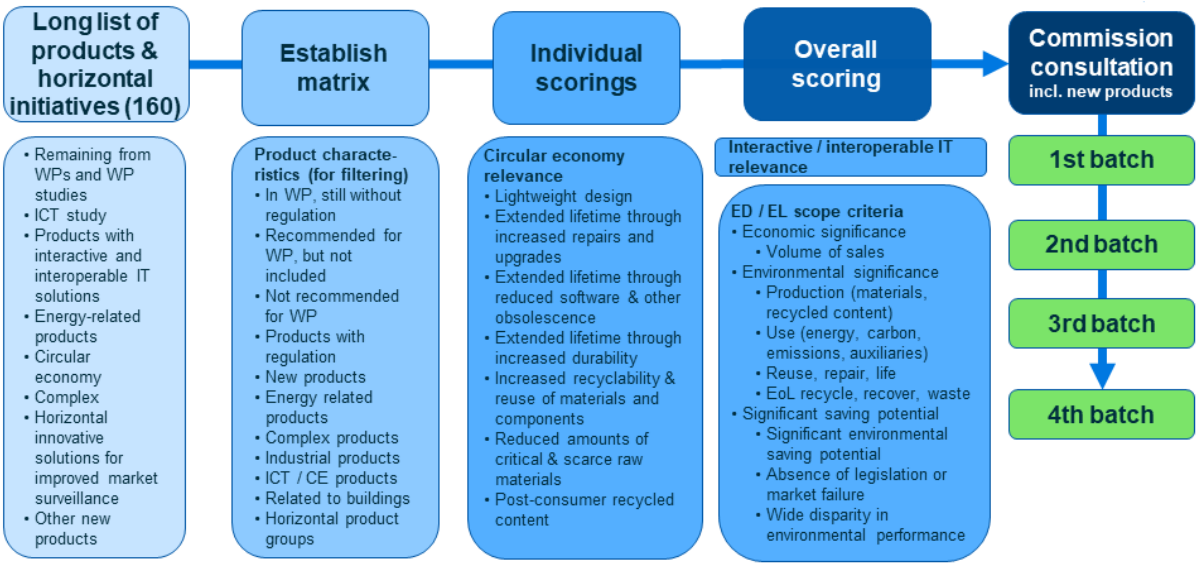


Figure 2: Illustrative overview of methodology and process for establishing the lists of product groups and horizontal initiatives to be assessed in Task 3.

Table 1 provides an overview of the selected product groups and horizontal measures for Task 3 indicating the related type of product group and measure.

The main reasons for de-selecting the remaining products and initiatives in the long list were anticipated low saving potential, complex products or initiatives or ongoing overlapping activities.

Table 1: Overview of the 31 selected product groups and horizontal initiatives for Task 3 indicating the related areas: ● indicates belonging to the area and (●) as partly belonging.

Product / initiative	Remaining from WPs	Complex	Interactive/ interoper-able IT	Circular economy	Energy-related	ICT Study	New	Market surveil-lance
Uninterruptible Power Supplies	●					●		
Professional laundry appliances	●							
Professional dishwashers	●							
Windows	●			●	●			
Non-tertiary coffee machines	●							
Interconnected home audio and video			●			●	(●)	
Small network equipment for home and office use			●			●	(●)	
Low temperature emitters					●		●	
Aircurtains		●			(●)		●	
Small-scale cooking products							●	
Unmanned aircrafts (drones)		●		●			●	
Water decalcifiers / softeners					●		●	
Base stations		●	●			●	●	
Industrial smart sensors					●	●	●	
Hair dryers							●	
Tertiary hot beverage equipment							●	
Greenhouse covers					●		●	
Lightweight design				●	●		●	
Durability				●			●	
Post consumer recycled content				●			●	
Universal external power supply				●	●		●	
Universal batteries for battery products				●	●		●	
Ecological profile				●			●	
IT solutions for improved market surveillance			●				●	●
Professional cooking appliances							●	
Swimming pool heaters	(●)						(●)	
Street lighting systems via PV							●	
Enterprise network equipment	●		●			●		
Electric vehicle chargers							●	
Firmware and software		●		●			●	
Scarce and critical raw materials				●			●	

2.3 Task 3 Preliminary analyses of product groups and horizontal initiatives

Task 3 contains the bulk of the technical analyses of 31 product groups and horizontal initiatives selected in Task 2. The analyses and the reporting follow basically the same structure, though adapted to the specific group and initiative where necessary. The structure is based on MEErP (Methodology for the Ecodesign of Energy-related Products, used for preparatory and review studies) and adapted to the resources available for the study team to perform these analyses.

The topics for Task 3 analyses are:

- Scope, policy measures and test standards
- Market
- Usage
- Technologies
- Energy, emissions and costs
- Saving potential

The Task 3 assessments are at a technical level aiming at deciding the size of potential savings. The selected product groups and horizontal initiatives are different in nature and scope, where some may be very broad and not fully defined, while others are narrower and well-defined. This has been taken into account when making the final recommendations for the Working Plan.

The Task 3 analyses consist of the following basic steps, which may be deviated from, corresponding to data and information available:

1. Scope, policy measures and test standards: Assessment of proposed scope, existing policy measures (if any) and availability of test standards

2. Market: Assessment of sales and stock data for EU27 for product types in scope and estimated development to 2030 and in some cases up to 2050. This is supplemented with a description of the present market, and anticipated development trends.

3. Usage: Description of typical usages and types of users. Data is collated for usage in terms of times, hours etc. per year.

4. Technologies: Description of typical technologies for BAU (Business As Usual), BAT (Best Available Technology) and BNAT (Best Not yet Available Technology). Data is presented for average intensity / efficiency, as far as data are available, and improvement opportunities.

5. Energy, materials, emissions and costs: Where relevant and possible, calculation or estimation of impact on resources for design, use and end-of-life in BAU and life cycle cost (LCC). The LLC figures are for acquisition, use during the life of the product and end-of-life data for the users, the economy and including externalities.

6. Savings potential: Estimations of saving potential (energy, resources, utilities costs, etc) and of economic feasibility. For lifetime extensions, this may be assessed per

lifetime year taking into account a potential higher in-use consumption for lifetime extended products compared to the newer products on the market.

Data sources include:

- Previous preparatory studies, review studies and impact assessments within Ecodesign and Energy Labelling
- The ICT Impact Study
- EIA, Ecodesign Impact Accounting
- Material related to Ecolabel, Green Public Procurement, Product Environmental Footprint, Code of Conducts and EU Energy Star
- Other studies: e.g. market data, Life Cycle Assessments, articles published by think-tanks, NGOs or governmental bodies, etc.
- Input from stakeholders
- Estimations by the study team

2.4 Task 4 Complementary analyses and recommendations

For Task 4, 16 product groups and horizontal initiatives were selected in agreement with the European Commission, from the 31 analysed in Task 3 (see section 3.1 for the selection criteria).

Task 4 provides complementary analyses of these product groups and horizontal initiatives together with a brief summary of Task 3 analyses for them. They are presented in 2 pages fiches providing a good overview of all the selected groups and initiatives.

Based on the analyses in Task 3 and Task 4, all the product groups and horizontal initiatives are recommended to be included in the Ecodesign and Energy Labelling Working Plan 2020-2024, however, combining two of them into one (professional laundry appliances and dish-washers) and adding firmware to durability, while software has been separated into an initiative called application software.

Table 2 presents an overview of the saving potentials and ratings provided in the fiches in previous section. The ratings have been provided on the basis of the suitability, feasibility for and positive impact of potential implementing measures and the related improvement of the environmental performance, as follows:

- +: Low positive impact
- ++: Medium positive impact
- +++: High positive impact

For the recommendations, the ratings are defined as:

- +: Recommended for the working plan, however, with lower rating due to lower saving potential, other issues related to the implementation and/or need for a pre-study.
- ++: Recommended for the working plan, however, with lower saving potential and/or less easy implementation compared to +++.
- +++: Highly recommended for the working plan due to higher saving potential and/or easier implementation.

Table 2: Overview of the 15 products and initiatives recommended for the Working Plan.

Product groups & horizontal initiatives	Primary energy savings PJ 2030			Resource efficiency	Other environmental impacts	Regulatory coverage and feasibility	Cost-effectiveness	Industrial competitiveness	Recommendations
	Use phase	Material content	Rate						
Product groups									
Professional laundry appliances and dishwashers	53		++	++	++	+++	+++	+++	+++
Professional cooking appliances	117		+++	+	++	++	++	++	++
Low temperature emitters	170		+++	+	+	++	++	+++	++
Swimming pool heaters	14-63		++	+	+	++	++	+++	+
Enterprise network equipment	22	3	+	+	+	++	+++	+++	+
Small network equipment for home and office use	69	7	++	+	+	+	++	++	++
Universal external power supplies		12-27	+	+++	+	+	++	+	++
Uninterruptible power supplies	55	1	++	+	+	++	++	++	+++
Industrial smart sensors	76-152	5	+++	++	+	++	++	++	+++
Horizontal initiatives									
Lightweight design		180	+++	+++	+	++	+++	+++	++
Recycled content		160	+++	++	+	+	+	+	+
Ecological profile			+++	++	++	++	++	++	++
Durability and firmware		175-1052	+++	+++	+	+++	+++	+++	+++
Application software			+++	++	+	+	++	+++	+
Scarce and critical raw materials			+++	+++	+	++	+++	+++	+++

3 SELECTION OF PRODUCT GROUPS AND HORIZONTAL INITIATIVES FOR TASK 4

3.1 Selection criteria

Totally 31 product groups and horizontal initiatives were analysed in Task 3, of those, 7 were horizontal initiatives. In a dialogue with the Commission, the most promising candidates for the actual Working Plan were selected for complementary analyses in Task 4 aiming at around 15-16 totally, which is about the double of what is in the current Working Plan.

First, the horizontal initiatives were assessed on their merits, savings or otherwise, as they potentially can impact all products, and it was concluded only not to take forward 'Innovative IT solutions facilitating market surveillance'. Then, the product groups were selected based on their energy and material content savings, though also other factors were taken into consideration. When comparing the energy and material content savings, differences in extent of scope were taken into account. See the rationales for the selections and non-selections in the next sections.

Based on the selection criteria, 16 product groups and horizontal initiatives were selected for Task 4.

Table 3 provides an overview of the 31 product groups and initiatives from Task 3 together with their energy and material content savings. Many of the horizontal initiatives were not possible to quantify. After the table, a brief explanation is provided for each of the product groups and initiatives selected and not selected.

The quantifiable saving potentials for primary energy consumption were calculated in Task 3 with the following assumptions:

- Data based on previous preparatory studies or other relevant studies and updated where necessary with input from stakeholders or sources; or where no data were available, estimated and calculated by the study team.
- Covering the present EU-27
- Extrapolated to 2030
- Converted to primary energy consumption, using 2.1 as conversion factor (also called primary energy factor) for electricity
- Assuming full stock replacement

For the selection for Task 4, which requires comparable saving potentials, the potentials have been harmonised regarding lifetimes, by assuming full stock replacement by 2030 of products with lifetimes of 10 years or less and proportionally for products with longer lifetimes, e.g. the potential for products with 20 years lifetime would be halved. The assumption behind this is that the measures take effect this year. In reality, this is of course not the case and the potentials rather reflect savings to be achieved 10 years after effective date of the measures.

Table 3: Overview of the 31 products and initiatives from Task 3 showing primary energy savings in the use phase and related to the material savings (embedded in materials), harmonised to 10 years lifetime. Blank cells: Not quantified or small potential.

Product groups & horizontal initiatives	Primary energy savings PJ 2030		Selected for Task 4
	Use phase	Material content	
Product groups			
Professional laundry appliances	33		X
Professional dishwashers	20		X
Professional cooking appliances	117		X
Small-scale cooking products	39		
Low temperature emitters	170		X
Windows	70		
Water decalcifiers / softeners	20	20	
Swimming pool heaters	14-63		X
Aircurtains	2	1	
Non-tertiary coffee machines	6	8	
Tertiary hot beverage equipment	19	1	
Hair dryers	15	1	
Street lighting systems via PV	70		
Greenhouse covers	14-15		
Unmanned aircrafts (drones)			
Enterprise network equipment	22	3	X
Small network equipment for home and office use	69	7	X
Interconnected home audio and video	18	13	
Universal external power supplies		12-27	X
Universal batteries		19-45	
Uninterruptible power supplies	55	1	X
Electric vehicle chargers	11		
Base stations	30		
Industrial smart sensors	76-152	5	X
Horizontal initiatives			
Lightweight design		180	X
Recycled content		160	X
Ecological profile			X
Durability		175-1052	X
Innovative IT solutions facilitating market surveillance			
Firmware and software			X
Scarce and critical raw materials			X

3.2 Selected products and initiatives

- **Professional laundry appliances (washer, washer extractor, tumble dryer):** In 2014, a Consultation Forum meeting decided on the basis of a previously carried out Ecodesign preparatory study to postpone measures until measurement standards were developed. Now, these have been developed (except for very large products). The saving potential assessed in the current study is relatively large, about 33 PJ.

- **Professional dishwashers (undercounter, hood-type)**: Professional dishwashers were studied together with the professional laundry appliances and the same decision was taken regarding postponing measures until measurements standards were developed. These are also available for undercounter and hood-type dishwashers. The saving potential is not very large (20 PJ), however, this product group

may be handled together with professional laundry appliances similar to the previous preparatory study – also in a following policy process, impact assessment etc. and thereby requiring less workload for all involved parties compared to a separate process for just this product group.

- **Professional cooking appliances (ovens, hobs, range cookers, griddles, fryers, range hoods, other)**: The saving potential is very large, 117 PJ/year. Though it covers a broad range of cooking appliances, the product group even after a reduction in scope is still considered as having sufficiently high potential for Ecodesign measures.

- **Low temperature emitters (radiators optimised for low- and medium temperature regimes <45 °C)**: There is a very high potential, estimated about 170 PJ, by using low temperature radiators suitable for heat pump systems without the need for installing surface (floor-) heating or bulky standard radiators. Policy measures like Ecodesign and Energy Label including development of appropriate test standards for capturing the potential should be further assessed in Task 4.

- **Swimming pool heaters (residential, smaller and larger public)**: Depending on the level of stringency of measures, a high saving potential may exist, up to about 63 PJ, as electric resistance heaters and gas heaters are still available on the market in 2030, and more effective alternatives exist (condensing gas heaters and heat pumps).

- **Enterprise network equipment (switches, routers)**: The saving potential assessed in Task 3 is relatively small, about 22 PJ/year, but it belongs to the ICT product group, which there is a specific focus on.

- **Small network equipment for home and office use:** Small network equipment for home and office use cover a broad range of products for connection to the internet and for the local area network. The saving potential is high, about 69 PJ for the use phase and additional 7 PJ for the production phase.

- **Universal external power supplies (EPSs currently regulated[7])**: The saving potential depends much on the assumptions for how big the reduction of EPS sales would be, which again depends on potential measures implemented; the range is in the order from 12 PJ/year to 27 PJ/year. The area may have a big impact on the production side, the supply chain and the consumers and it is therefore relevant to further assess in Task 4.

- **Uninterruptible power supplies (standard systems used in enterprises and data centres**): A preparatory study has been carried out in 2014 showing large energy saving potential, however, without being carried through to implemented regulation due to changed market conditions. However, there is still a high saving potential estimated at about 55 PJ/year. Existing measures include the voluntary EU Code of Conduct on Energy Efficiency and Quality of AC Uninterruptible Power Systems (UPS) from 2011 (a new draft is under development), but it is seen as not

[7] Commission Regulation (EU) 2019/1782 of 1 October 2019 laying down ecodesign requirements for external power supplies pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulation (EC) No 278/2009

sufficient for capturing the saving potential. The impact of the recently published proposal on batteries needs to be explored regarding in particular the proposed performance and durability criteria.

- **Industrial smart sensors:** Industrial smart sensors and sensor functionalities are mainly energy-related products i.e. the energy consumption of the sensors themselves is marginal, while the impact on energy consumption of connected products such as electric motors, pumps and fans can be very large, about 76-152 PJ/year. The sensors measure vibrations, temperature and other performance related parameters, which feed into an optimisation of performance, lowering energy consumption, improving maintenance etc. The market is expected to increase rapidly during the next years.

- **Lightweight design**: Lightweighting of products, i.e. effecting the same functionality with less material, is a very effective design strategy for material efficiency and with a very high estimated potential, 180 PJ in primary energy savings. It is relevant for all for all products in the scope of Ecodesign Directive but more for products with significant environmental impact of materials and with lightweighting potential.

- **Recycled content**: Post-consumer recycled material for manufacturing of new products is a very effective measure for material efficiency and with a very high estimated potential, 160 PJ in primary energy savings. It is an important subject not only for the circular economy but also for reducing the dependence of our industry on extra-EU imports. Therefore, it is strategically important to assess fundamentally new directions for the circular economy and potential Ecodesign regulatory measures.

- **Ecological profile**: The scope covers those energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling where the method for setting specific minimum ecodesign requirements according to Annex II of Ecodesign Directive 2009/125/EC is limited or cannot be applied and therefore Annex I provides interesting opportunities for e.g. rather complex products and product systems; ErP with high impacts / improvement potential of raw material extraction, manufacturing and end-of-life phases; ErP with environmentally relevant use of consumables; and/or IT ErP with mainly indirect environmental impacts, e.g. by shifting impacts of the use phase from the IT product into the cloud.

- **Durability**: Durability includes measures to facilitate reliability, maintenance, repair, upgrade and reuse of energy-related products currently or in future regulated under EU Ecodesign and Energy labelling. The estimated potential, 175-1052 PJ/year, is very approximate and is based on implementing durability requirements for all current Ecodesign and/or energy labelling measures and assumptions on the stringency of measures.

- **Scarce and critical raw materials**: The scope covers all energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling with relevant content of Critical Raw Materials (CRM) due to their supply risks and scarcity from an EU perspective; and/or other raw materials with high environmental and/or social risks and impacts.

- **Firmware and software**: The scope covers partly all energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling using firmware or system software for executing their main functionalities related to reducing software-related hardware obsolescence and to reducing the risk of software updates deteriorating energy/resource efficiency of products; and partly application software used on computer systems regarding energy and resource efficiency of this software. There are high potential energy and resource savings expected for this horizontal initiative.

3.3 Not selected products and initiatives

- **Small-scale cooking products**: There is a reasonable saving potential (about 39 PJ/year), however it is based on rough estimates. The product group is very diverse consisting of multi-cookers, pressure cookers, steamers, rice cookers, deep fryers, sous-vide cookers (water baths and sticks), slow cookers and other products such as fondues and air fryers. The saving potential is mainly based on insulation, precise temperature and time control and electromagnetic induction heating. Especially design changes for increased insulation and use of electromagnetic induction heating will require larger redesigns and may result in larger appliances less attractive to the consumers.

- **Windows**: Windows for buildings were the subject of an Ecodesign preparatory study (2013-2015), but the following Consultation Forum meeting showed limited support for going forward with a traditional product-related energy label, however, interest was expressed in other labelling options (e.g. an 'installer label') that consider site-specific parameters such as climate. The energy saving potential replacing all windows is very large, however, taking the low renovation rate into account, the obtainable saving potential in 2030 is estimated at about 70 PJ. This is still sufficiently high, however, based on Member State and stakeholder input received, the conclusion is that it will be difficult to develop Ecodesign implementing measures or Energy Label delegated acts.

- **Water decalcifiers / softeners**: Calcification shortens product life and decalcifiers help but payback not self-evident. The saving potential, 20 PJ/year for the use phase and 20 PJ/year for the material content, is uncertain and it is seen as being difficult to regulate in the current Ecodesign directive.

- **Aircurtains**: The direct saving potential is very low, about 2 PJ/year for the use phase and 1 PJ/year for the materials content. An indirect saving potential for the rest of the building exists because the aircurtain has in insulating impact, however, this is small, around 2-4 PJ/year.

- **Non-tertiary coffee machines**: The energy saving potential is low, about 6 PJ/year for the use phase. The saving potential of 8 PJ/year for the material content for material content may be rather achieved via horizontal material efficiency measures (see "Durability") instead of a dedicated vertical product regulation.

- **Tertiary hot beverage equipment**: The energy saving potential is low, about 19 PJ/year for the use phase and 0.5 PJ/year for the material content. The saving potential for material content may be achieved via horizontal material efficiency measures.

- **Hair dryers:** The energy saving potential is low, about 15 PJ/year for the use phase and 1 PJ/year for the material content. The saving potential for material content may be achieved via horizontal material efficiency measures.

- **Street lighting systems via PV**: The energy saving potential is high, 70 PJ/year, however, there are many other activities on-going on lighting (Ecodesign) and street lighting (Covenant of Mayors, EU Smart Cities initiative, etc.) already. It is recommended to include these systems in the review of the lighting legislation, planned for 2024. Moreover, many light sources and control gears used for street lighting are regulated in the new Ecodesign lighting regulation (taking effect from September 2021).

- **Greenhouse covers**: The energy saving potential is low, about 14-15 PJ/year. There are also opportunities for material savings, but potentials are assumed to be low.

- **Unmanned aircrafts (drones)**: The main environmental impact is material content and that the energy consumption in the use phase is negligible in comparison. However, the data available for Task 3 assessments were too scarce for calculating energy consumption and saving potentials. The product group is furthermore very diverse and it may be difficult to establish measures covering the various drone types. It may be relevant to look at the product group again when the market is more mature and homogenic.

- **Interconnected home audio and video**: The energy saving potential is relatively low, about 18 PJ/year in the use phase and 13 PJ/year for the material content. The majority of the savings can be obtained by better market surveillance especially related to networked standby. Furthermore, the saving potential related to the materials can be captured by horizontal measures regarding material efficiency and avoidance of software obsolescence.

- **Universal batteries**: The energy saving potential is about 19-45 PJ/year for the material content depending on the stringency of measures. This is relatively low taking into account the uncertainty of a possible measure harmonising interoperability, connectors etc. for battery - device and battery – charger. This is also seen in connection to the proposal for a regulation concerning batteries and waste batteries, repealing the Batteries Directive that was published during the preparation of this analysis (December 2020). Interoperability is not included in the proposal and it is seen as difficult to propose a parallel regulation for universal batteries. Further consideration would seem only possible in a future revision of the batteries regulation or for a new ecodesign/SPI framework.

- **Electric vehicle chargers (wallboxes, public chargers)**: The energy saving potential is quite low, about 11 PJ/year. After 2030 the potential savings increase, and in 2050 the saving potential is almost 76 PJ/year. However, the market is very

much in development also technically and it is considered that measures are too early to etablish.

- **Base stations**: The energy saving potential is relatively low, about 30 PJ/year, and part of the realisation of the potential, i.e. enabling of power management features in the network, may not be used by some network operators due to a concern about customer experience being impacted negatively. Other parts of the potential are expected to be realised by the industry without regulation.

- **Innovative IT solutions facilitating market surveillance**: Interesting innovative IT solutions exist such as improved and extended EPREL, digital product passport, webcrawlers and use meters, however, some of the measures are already under part of on-going work (e.g. EPREL) and others are more for consideration beyond the working plan (e.g. product passports)

4 COMPLEMENTARY ANALYSES WITHIN TASK 4

Where Task 3 assessed and reported scope; existing policy measures and standards; market data (sales, stock, assumed lifetime); usage; technologies; energy consumption, emissions, costs; and saving potential, Task 4 provides complementary analyses regarding:

- Further environmental impacts: Resource efficiency impact, where relevant, and other environmental impacts such as hazardous chemicals, other emissions and health.
- Route to market: Assessment of possible involvement of craftsmen, architects, advisers etc. in the decision-making of selection of product or service to purchase.
- Existing regulatory coverage and regulatory feasibility: Existing measures including third country legislation relevant for the product group and regulatory feasibility for Ecodesign implementing measures and Energy Labelling delegated acts.
- Cost-effectiveness of a potential regulation: Considered cost for potential implementing measures and recovery of the costs for the manufacturers and consumers in a life cycle cost perspective.
- Industrial competitiveness: Impact on competitiveness for EU manufacturers including specific impact on SMEs; impact on industrial innovation, etc.

The results of Task 4 aim at facilitating the Commission's decision-making process to compile the subsequent Ecodesign and Energy Labelling Working Plan 2020-2024. The level of details of the analyses should therefore be seen in this perspective.

See also the methodology section in Task 1 for further details of the assessments.

5 FICHES FOR PRODUCT GROUPS AND HORIZONTAL INITIATIVES

5.1 Fiches

The fiches combine information and data from Task 3 with the complementary analyses in Task 4 and provide the results in a brief form. The fiches therefore give a quick overview of the main results of Task 3 and Task 4. Where necessary, Annex B provides more details on the complementary analyses.

The fiches are structured as follows (see the previous chapter for definition of the Task 4 topics):

- Scope
- Potential energy and GHG savings 2030
- Resource efficiency
- Other environmental impacts
- Route to market
- Regulatory coverage and feasibility
- Cost-effectiveness
- Industrial competitiveness
- Recommendations

For horizontal initiatives the same structure has been followed as much as possible and adapted to the specific initiative where necessary.

Apart from the scope, each of the topics above is provided with rough ratings provided on the basis of the suitability, feasibility for and positive impact of potential implementing measures and the related improvement of the environmental performance, as follows:

- +: Low positive impact
- ++: Medium positive impact
- +++: High positive impact
- na: Not available

For the recommendations, the ratings are defined as:

- +: Recommended for the working plan, however, with lower rating due to lower saving potential, other issues related to the implementation and/or need for a pre-study.
- ++: Recommended for the working plan, however, with lower saving potential and/or less easy implementation compared to +++.
- +++: Highly recommended for the working plan due to higher saving potential and/or easier implementation.

In the following, the individual fiches are provided. See Annex B for details. In the chapter following the fiches, an overview table of the ratings is provided together with recommendations for each product group and horizontal initiative.

Professional laundry appliances

Scope

Professional laundry appliances, together with professional dishwashers, were subject to a preparatory study in 2011, which concluded that these products met all the eligibility criteria, but that there were no suitable test standards. After Consultation Forums in 2013 and 2014 it was decided to wait with measures until such test standards were developed.

Following standardisation request (M/539) CENELEC standards EN 50640 and EN 50594 with focus on laboratory testing of smaller sizes were developed, whereas the CEN 17116-series deal with on-site assessment of large appliances. Current test standards for professional laundry appliances representing close to 90% of the total energy and other environmental impacts of this product category.

Potential energy & GHG savings 2030 [++]

Primary energy use phase	33 PJ
- of which electricity 1.3 TWh	3 PJ
Water saving	66 Mm3
GHG savings	2 Mt CO2eq.

Projected (maximum) savings in 2030, from Ecodesign measures, are based on a 20-25% saving compared to the Business-as-Usual in that year.

Resource efficiency [++]

- Most energy (for heating of wash-water or drying) comes from fossil fuels. Most CO2 and energy savings would come from heat recovery and use of heat pumps. A more accurate control of water levels in washing saves on energy, CO2 and water. More efficient and better performing motors help in better wash action, higher spin speeds. The latter also helps in reducing drying energy.
- Durability and lifetime: Product life is in the order of 8 years for the smaller appliances (<40 kg) and 14-17 years for the large appliances. Products are very robust and repairability is a must for the clients.
- End-of-life (recyclability, recycled content): The dominant material in the sector is stainless steel with recycling rates higher than 90%.
- Critical raw material: No significant amounts are used in these products.

Other environmental impacts [++]

- The professional washing machines use approx. 280 kton of detergent of miscellaneous type annually. No studies were found to indicate as regards the environmental impact and saving potential of modern professional detergents.
- Wear and tear of textiles due to cleaning and drying is always a concern, but the professional laundry service sector is known to have the expertise to avoid this type of textile-damage.
- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

Professional washing machines and dryers in smaller sizes (<40 kg) are found in launderettes (coin & card) and common laundry rooms. Larger sizes (>40kg, tunnel washers) are typical for hospitality sector, hospitals, nursing homes, professional laundries, general and high-tech industry/services.

The market for professional laundry appliances is a mature, mainly replacement market with modest growth of 1-2% per year. Buyers are professionals with a keen interest in the total life cycle costs, which includes durability and a good service level.

Regulatory coverage and feasibility [+++]

Existing measures:

- Products are currently not covered by any mandatory regulation, but under the European Commission EMAS programme, optimised laundry cleaning is part of the Best Environmental Management Practice for Tourism (BEMP). EMAS-registered organisations in the tourism sector shall take the relevant sectoral reference documents into account
- Relevant test standards are EN 50640, EN 50594 and the EN 17116-series.

No regulatory barriers towards setting of ecodesign implementing measures under the Ecodesign Directive have been identified.

Cost-effectiveness [+++]
It is estimated that the measures may result in €0.2 bn higher acquisition costs but €1.3 bn lower expenditure per annum, meaning that they are cost-effective.

Industrial competitiveness [+++]
Most manufacturers for professional laundry appliances are EU-based, ready to support the required service and respond to customer wishes. Factories are medium-sized, independent or subsidiaries of large companies. Given the traditional clientele, R&D efforts towards energy efficiency are limited, but the development of a set of the new test standards, can give a new impulse to this sector.

Recommendations [+++]
It is recommended to include the product group in the Working Plan. The energy and carbon savings in the use phase are significant and can be delivered with the new test standards. The prior study and the development of the standards should also help to develop Ecodesign measures efficiently.

Professional dishwashers

Scope

Professional dishwashers, together with professional laundry appliances, were subject of a preparatory study in 2011, which concluded that these products met all the eligibility criteria, but that there were no suitable test standards. After Consultation Forums in 2013 and 2014 it was decided to wait with measures until such test standards were developed.

Following a standardisation request, CENELEC standard EN 63136:2019 was developed for laboratory testing of undercounter (DW1) and hood-types (DW2/3, see picture), estimated to represent 95% of unit sales and up to 75% of energy and material consumption of commercial dishwashers in the EU.

Potential energy & GHG savings 2030 [++]

Primary energy use phase	20 PJ
- of which electricity 1.8 TWh	4 PJ
Water saving	17 Mm3
GHG savings	1 Mt CO2eq.

Projected (maximum) savings in 2030, from Ecodesign measures, are based on a 15% saving compared to the Business-as-Usual in that year.

Resource efficiency [++]

- Most savings come from the use phase, through
  - recycling of rinse water to wash and prewash cycles and efficient pre-rinse spray valves;
  - recovery of 20 % of wash water through filtration for rinsing;
  - optimised circulation of drying air;
  - recirculation of 65 % of drying air;
  - recovery of heat and moisture from vented drying air to preheat rinse water.
- Durability and lifetime: Product life for products in the scope is in the order of 8 years. Products are very robust and repairability is a must for the clients.
- End-of-life (recyclability, recycled content): The dominant material in the sector is stainless steel with recycling rates higher than 90%.
- Critical raw material: No significant amounts are used in these products.

Other environmental impacts [++]

The professional dishwashers use approx. 350 kton of detergent of miscellaneous type per year. An EMAS BMEP study (see below) recommends to use environmentally friendly (ecolabelled) detergents. This type of measures is probably outside the scope of Ecodesign.

- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

Dishwashers are mainly used in commercial services like restaurants and hotels (65%), hospitals and other institutional services (23%) and commercial food sales (butchers, bakeries, grocers etc.) (10%).

The market for professional dishwashers is a mature, mainly replacement market with modest growth of 1-2% per year. Buyers are professionals with usually a keen interest in the total life cycle costs, which includes durability and a good service level.

Regulatory coverage and feasibility [+++]

Existing measures:

- Products are currently not covered by any mandatory regulation, but under the European Commission EMAS programme, optimised (professional) dishwashing is part of the Best Environmental Management Practice for Tourism (BEMP). EMAS-registered organisations in the tourism sector shall take the relevant sectoral reference documents into account
- Relevant test standard is EN 63136:2019.

No regulatory barriers against setting of ecodesign implementing measures under the Ecodesign Directive have been identified.

Cost-effectiveness [++]
For the envisaged types (DW1 and DW2) the measures give €0.5 bn higher acquisition costs and €0.16 bn lower annual expenditure. At 8 year product life this results in positive payback (~3 years) and life cycle cost saving.

Industrial competitiveness [+++]
Many manufacturers of professional dishwashers are EU-based, ready to support the required service and respond to customer wishes. Factories are medium-sized, independent or subsidiaries of large companies. Given the traditional custom-base, R&D efforts towards energy efficiency are limited, but the development of the new test standard, can give a new impulse to this sector.

Recommendations [+++]
It is recommended to include the product group in the Working Plan. The energy and carbon savings in the use phase are significant and can be delivered with the new test standard. The prior study and the development of the standards should help to develop Ecodesign measures efficiently.

Professional cooking appliances

Scope

Professional cooking appliances cover appliances to be used in an area not accessible to the public with an intended professional use with low scale food production.

The specific equipment types considered are[8]:

- Ovens
- Hobs and grills
- Fryers (deep fryers)
- Bain Maries
- Bratt pans
- Pasta cookers
- Range hoods

Potential energy & GHG savings 2030 [+++]

Primary energy use phase	117 PJ[9]
GHG savings	9 Mt CO2e[10]

It is a very large and diverse product category, containing a large number of appliance types and variants. However, the majority of potential energy savings comes from ovens, hobs/grills and fryers (94 PJ/year, 80%), which is more homogenous though still with variants. However, the saving potential is interesting even if the scope is reduced, due to generally high usage pattern.

Resource efficiency [+]

- Durability and lifetime: The lifetime of professional cooking appliances is generally high, about 11 years in average.
- Disassembly and repair: It is assumed that professional appliances are generally repaired more than household appliances, based on the fact that there is a quite well-developed repair-service market.
- End of Life: There is a well-developed second-hand market for professional cooking appliances, and many repair service companies also offer used appliances for sale.
- Recycling: Most of the appliances are primarily made of metals, and metals generally have a high recycling rate, which is also believed to be the case for professional cooking appliances. The electrical appliances are part of the WEEE Directive, setting requirements e.g. to parts that need to be removed prior to recycling.

Other environmental impacts [++]

Apart from electricity or gas, some of the professional cooking appliances use water for their main function, especially Bain Maries. No data were found for Bain Maries. Furthermore, some ovens use water for cleaning from a permanent water connection.

- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [++]

Professional cooking appliances are B2B products, usually purchased from wholesalers specialising in industry/professional kitchen equipment, which may include installation. Hence, there is a direct dialogue and often guidance involved in the purchase situation, which gives a good opportunity to design for energy efficiency.

Regulatory coverage and feasibility [++]

European measurement standards are not available or in development for all equipment types, but there are other standards available such as German DIN standards, French NF and US ASTM standards, which may assist in developing transitional methods and standards.

A potential barrier could be a clear definition of professional vs. household appliances, but for most appliances, the professional types are quite different.

A preparatory study should include a proper scoping, which may reduce the number of appliances to include in the study e.g. by focusing on ovens, hobs/grills and fryers.

Cost-effectiveness [++]

For the end-users, who are primarily restaurants and bars, there are significant savings associated

[8] See full table in Annex

[9] Partly electricity (223 PJ) and partly gas (162 PJ), see also Annex.

[10] 10 MT CO2/year from electricity, 9 MT CO2/year from gas

with improved energy efficiency, reducing the use cost. Increased purchase costs could potentially be a barrier for starting up a new business and purchasing multiple appliances at once due to increased start-up costs, even if the LCC (Life Cycle Cost) decreases. However, leasing and rental agreement are quite common in the professional cooking appliance market, which diminish this issue.

Industrial competitiveness [++]

Manufacturers of professional cooking appliances will be able to offset increased production and R&D costs by increasing product prices. For similar household appliances the ED regulations in place have shown to increase the speed of innovation regarding energy efficiency, because the least efficient products are removed from the market or have to be improved in order to stay on the market. The majority of the manufacturers are EU companies.

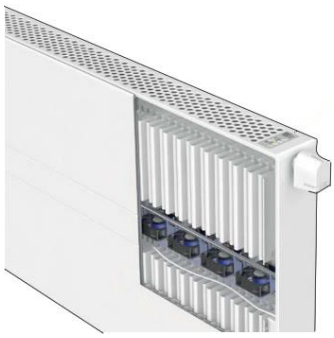
Recommendations [++]

The energy saving potential is large, even if the scope will be reduced. Measurement standards need to be developed for several of the product groups.

It is therefore recommended to include the product group in the Working Plan.

In order to determine the exact scope to be investigated in full preparatory study, a Task 0[11] scoping study is recommended to be performed first.

[11] Task 0 is an optional task in the MEErP methodology used for screening of large or inhomogeneous product groups, https://ec.europa.eu/docsroom/documents/26525/attachments/1/translations/en/renditions/pdf



Low temperature heat emitters

Scope

Low temperature heat emitters (a.k.a. LT-radiators) are a 'drop-in' replacement for standard high temperature radiators, optimised for low- and medium temperature regimes (<45°C), making them the perfect fit for modern heat pump systems without the need for installing surface (floor-) heating or bulky standard radiators and/or engaging in significant energy renovation of the existing house or building.

Some may be equipped with fans for quick heat-up, but they should be fully capable – as opposed to convectors or fan-coils – to operate without them, relying on best unforced convection performance.

Potential energy & GHG savings 2030 [+++]

Primary energy use phase	170 PJ
GHG savings	10 Mt CO2e

Projected (maximum) savings in 2030 of 170 PJ are based on the assumption that in that year, one quarter of the existing buildings will have replaced their standard gas boiler + standard radiators by a heat pump + LT radiator.

Resource efficiency [+]

- The main resource efficiency impact is more energy and CO2 emission savings because of facilitating more efficient space heating. Note that space heating is the largest single energy consumer in the EU.
- Durability and lifetime: LT-radiators are expected to have a similar lifetime as standard radiators, i.e. 40 years, which is close to the average life of buildings.
- End-of-life (recyclability, recycled content): The dominant materials in the sector are steel and aluminium with recycling rates higher than 90%.
- Critical raw material: No significant amounts are used in these products.

Other environmental impacts [+]

- When LT-radiators are equipped with electrical fans and fan controls, repairability demands will be required (spare part availability, documentation) and the WEEE may apply for a small control-PCB, which should then be easily dismountable; electric components should be without hazardous substances or substances of very high concern (e.g. certain phthalates).

Route to market [+++]

LT radiators are a new, innovative product in a conservative market. First commercial models appeared only a few years ago, showing promising growth rates with early adopters. Yet, for a wider audience the product is still unknown with installers, consumers and even national energy agencies in the EU. Appropriate Ecodesign and Energy Label measures can make the difference to make high-efficiency heat pump systems accessible for a wider public, but also for a level playing field in industry to set appropriate LT-radiator test standards that would show the difference in performance with standard radiators, which today is not the case (lowest test temperature EN442 and EN16430 is 50◦C).

Regulatory coverage and feasibility [++]

Existing measures:

- Products are currently not covered by any regulation.
- Relevant test standards are EN442 and EN16430

Cost-effectiveness [++]

Low temperature heat emitters represent the best available technology in the market for radiators. Payback periods are estimated around 5 to 10 years.

Industrial competitiveness [+++]

Over the years, heat emitter (radiator) manufacturing companies, localised mainly in the EU, have rationalized their production locations and optimized their processes in order to minimize manufacturing costs; R&D efforts are limited. The development of a set of adjusted test standards together with a dedicated energy labelling scheme, can give a new impulse to this sector and simultaneously improve competitiveness of the EU manufacturers.

Recommendations [++]
It is recommended to include the product group in the Working Plan. The energy and carbon savings in use phase are large and there are no negative side effects.

Given the current market situation as described above, market forces alone will not give this product group enough impetus to contribute significantly to the energy and climate goals. Labelling measures for heat emitters that consider LT heat dissipation versus emitter volume and formfactor are important.

Swimming pool heaters

Scope

Heaters for the following swimming pool categories and similar:

- Residential indoor and outdoor pools
- Shared indoor and outdoor pools in residential multi dwellings
- Hotels, wellness centres etc. indoor and outdoor pools
- Municipal indoor and outdoor pools
- Leisure centers indoor and outdoor pools

Most common technologies for heating are: gas heaters (natural gas or propane gas, and typical non-condensing) (23%), heat pumps (23%), electric heaters (23%) and solar heaters (30%). Oil heaters are not seen to have any significant position on the market.

Potential energy & GHG savings 2030 [++]

Primary energy use phase	14-63 PJ
GHG savings	1-4 Mt CO2e

The lower saving potential is based on requirements for gas heaters and heat pumps, while the higher potential includes requirements for electric heating which in practice means only allowing heat pumps.

The largest part of the higher potential (47 PJ/year) concerns the residential types, followed by the municipal and leisure center pools (11 PJ/year)

Resource efficiency [+]

- Durability and lifetime: Because all the heaters provide the same service, i.e. heated water, it is expected that the heaters will only be replaced due to cost implications or environmental reasons. This could give preference to replace a gas heater with a heat pump or a solar heater or to repair the existing heater. Therefore, it is expected that lifetime extension potentials exist mainly in improving repairability. Average lifetimes of the heaters are from 4.5 years for electric heaters and 12.5 years for solar heaters.
- End-of-life (recyclability): Most of the material content of gas heaters, heat pumps and solar heaters is steel and iron, followed by non-ferrous metals, plastics, glass (solar heaters) and small amounts of electronics. Electric heaters contains much plastics, non-ferrous metals and electronics. Most of the materials can be separated in a recycling process. Heat pumps containing refrigerants shall be properly marked to ensure that the refrigerant is correctly handled.
- Critical raw material: Products in scope contain CRMs in the electronics, and special attention should be put on the components containing these materials, e.g. PCBs and ICs. These should be easily removed at end-of-life.

Other environmental impacts [+]

- Heat pumps: Refrigerants in heat pumps are often R32, which has a GWP of 675, meaning that the combined stock of heat pumps in 2020 contains refrigerants amounting to 0.6 CO2e[12]. Hence, it is important to consider how to avoid leaks and proper handling at end-of-life.
- Gas leaks: Gas is delivered to the heater through many connections that all can develop leaks, imposing a risk of explosion or fire. In addition, methane has a GWP of 25.
- Carbon monoxide: Faulty gas heaters may pose a serious health risk if they are placed in indoor spaces with poor ventilation.
- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [++]

Simpler systems can be delivered as plug and play for installation by the residential consumer. Larger residential and public systems will be delivered and installed by dedicated pool heater companies, who can advise on type of systems appropriate for specific usages.

Regulatory coverage and feasibility [++]

No EU level policy measures nor standards exist for swimming pool heaters. US DOE has mandatory energy conservation standards for gas-fired pool

[12] Assuming all heat pumps in the stock uses R-32 with a GWP of 675 and a filling og approximately 0.8 kg of refrigerant.

heaters[13]. US and French (only pool heat pumps) standards are available.
It has to be considered if regulation can be established resulting in removal of electric resistance heaters from the market and only allowing heat pumps. Energy labelling may also be considered, however, the expected energy savings will then be lower.
No other regulatory barriers towards setting of Ecodesign requirements under the Ecodesign Directive have been identified, however, measurement methods need to be established. The US DoE and the French standards combined with transitional methods for the regulations (EU) 813/2012[14] and (EU) 814/2012[15] can be a basis for setting transitional methods and preparing a standardisation request.

Cost-effectiveness [++]
Low-cost pool heat pumps are on the market (below 500 EUR for small units), which can substitute more expensive electric and gas heaters cost-effectively apart from pools with very infrequent use of heating.
For larger pool systems, cost-effective systems using heat pumps, condensing gas boiler or district heating.

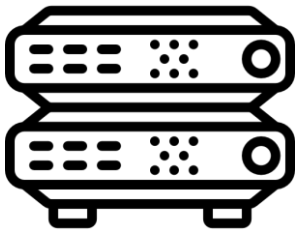
Industrial competitiveness [+++]
The market is dominated by EU manufacturers including SMEs and manufacturers from far east. It is assumed that a regulation would not negatively impact the industrial competitiveness, and that costs of improving the product efficiencies can be covered by increased product price assuming no increase in LCC (Life Cycle Cost) for the consumers. Contrary, due to the global green transition, it is expected that consumers would demand environmentally better pool heaters.

Recommendations [+]
The product group may be relevant for the working plan, however, with the lowest rating due to the uncertainty about realisation of the higher end of the potential. Measurement methods need to be established.

[13] Electronic Code of Federal Regulations, September, 2020, Title 10: Energy PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS Subpart C—Energy and Water Conservation Standards, https://www.ecfr.gov/cgi-bin/text-idx?SID=762f10cb94fc6de0f518360b9b303233&mc=true&node=se10.3.430_132&rgn=div8

[14] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2014.207.01.0002.01.ENG

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2014.207.01.0022.01.ENG



Enterprise network equipment

Scope

Routers and switches used in enterprises and public organisations except smaller offices including:

- Core routers
- Edge routers
- Access routers
- Modular managed switches
- Fixed managed switches
- Fixed unmanaged switches
- Switches with routing capability

Potential energy & GHG savings 2030 [+]

Primary energy use phase	22 PJ
Primary energy material	3 PJ
GHG savings	1 Mt CO2e

The saving potential include related savings for cooling, UPS losses etc. The energy savings are mainly obtained via:

- Power supply efficiency criteria, also taking power supply to PoE devices into account, aiming at reducing losses in the power supply.
- Active state minimum efficiency requirement based on a performance efficiency indicator, aiming at reducing the overall power consumption in active state.
- Power management requirements such as adaptive active cooling, and energy efficient Ethernet, aiming at powering down circuitries etc. partly or fully in dependency of the traffic load.

Resource efficiency [+]

- Durability and lifetime: Products in scope are often replaced before end of technical lifetime due to need for upgrades (50%-100% longer technical lifetime compared to economic lifetime). Lifetime can be improved with resource efficiency requirements e.g. minimum requirements for firmware and software updates and upgradeable design (software and hardware) however balanced against a slower stock replacement with energy efficient products. Furthermore, the technological development may require newer and more performing products, though there may still be areas where older, and lower performing products are still useful.
- End-of-life (recyclability): Electronics and plastic can be difficult to separate in the current recycling processes polluting the waste streams and loosing valuable raw materials. Requirements may be added regarding how to remove relevant parts and regarding information on CRM etc. Requirements in other regulatory measures on collection and recycling rates for CRM and scarce materials may be considered.
- Critical raw material: Products in scope contains both CRMs and precious materials, and special attention should be put on the components containing these materials, e.g. PCBs and ICs. These should be easily removed at End-of-Life.

Other environmental impacts [+]

- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

Enterprise network equipment is a B2B market with mostly highly professional purchasers, however, external IT support companies may also be involved especially for smaller enterprises and public organisations. The public sector typically purchases via public tenders.

Regulatory coverage and feasibility [++]

Existing measures:

- EMC class B products[16] (which some of network products are) fall under the standby, off and network standby regulation[17]
- EU green public procurement criteria for data centres, server rooms and cloud services containing among others purchasing criteria for network equipment, however, non-binding for the manufacturers and the individual purchasers and without specific product-related criteria[18]

[16] EMC Class B products are intended for use in residential/domestic environments but may also be used in nonresidential/non-domestic environments.

[17] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02008R1275-20210301

[18] https://ec.europa.eu/environment/gpp/eu_gpp_criteria_en.htm

- US Energy Star for Large Network Equipment covers the products in scope (3rd country scheme)[19]

No regulatory barriers towards setting of ecodesign implementing measures under the Ecodesign Directive have been identified. Measurement methods for energy efficiency of router and switch equipment exist.[20]

Cost-effectiveness [+++]

No mandatory schemes for energy efficiency have been in effect on the EU market nor broadly on the global market, though US Federal agencies are required to purchase energy-efficient products, which for network equipment correspond Energy Star certified products. Therefore, there has barely been a push on the market through minimum energy efficiency requirements.

This is noticeable through examples of BAT vs average products e.g. one BAT product saving over 50% in annual energy costs indicating that there are low efficiency products on the market. Efficienct technology exists, e.g. Energy Efficient Ethernet reduces power consumption during periods of low data activity and may save 25-30% at an annual level.

Due to the products being always on and having a long lifetime (typically 10 years), design changes improving the environmental performance (e.g. Energy Efficient Ethernet, power supply efficiency, adaptive active cooling, etc.) would typically be very cost-effective.

Industrial competitiveness [+++]

The global network equipment market is dominated by one very large supplier (Cisco) covering 56% of the enterprise network market and a few others (Huawei, HPE, Nokia and Juniper) covering most of the remaining market (23%).[21] It is assumed that a regulation would not negatively impact the industrial competitiveness, and that costs of improving the product efficiencies can be covered by increased product price assuming no increase in LCC (Life Cycle Cost) for the enterprise consumers.

Recommendations [+]

The product group may be relevant for the working plan, however, with the lowest rating due to low energy saving potential.

No major barriers towards an implementing measure have been identified.

[19] https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20LNE%20Program%20Requirements%20Including%20Version%201.0%20Specification_0.pdf

[20] ETSI ES 203 136 V1.2.1. Measurement methods for energy efficiency of router and switch equipment

[21] https://www.itcandor.com/network-2019/ Data include other network products than just routers and switches.

Small network equipment for home and office

Scope

- Integrated access device (IAD)
- Wireless router
- Modem
- Switch
- Network Attached Storage
- IoT gateway
- IoT cellular gateway
- Complex set top boxes (CSTB)
- Other network equipment

Potential energy & GHG savings 2030 [++]

Primary energy use phase	69 PJ
Primary energy material	4 PJ
GHG savings	3.5 Mt CO2e

The saving potential may be larger than the table indicates if performance requirements[22] are introduced to reduce the number of Mesh access points in a home (electricity and material savings). Furthermore, performance requirements could reduce the need to replace[23] the internet provider's router or IAD. Savings related to CSTBs are included, because the Voluntary Agreement is foreseen to be terminated.

Resource efficiency [+]

- Durability and lifetime: Products in scope are often replaced before end of technical lifetime due to desire for upgrades, new protocols, new internet provider, lack of software upgrades, etc. Lifetime can be improved with resource efficiency requirements e.g. minimum requirements for firmware and software updates and upgradeable design (software and hardware)
- End-of-life (recyclability, recycled content): Electronics and plastic can be difficult to separate in the current recycling processes polluting the waste streams and loosing valuable raw materials. Requirements may be added regarding how to remove relevant parts and regarding information on CRM etc.
- Critical raw material: Small amounts in individual products. However, the combined amounts of valuable materials are considered high.
- Standard devices delivered with the internet provider (see route to market): Some consumers may acquire other devices and the standard device may not be used.
- Universal gateways: Gateways are linked to specific systems and in some cases, several gateways with same functionality need to be installed e.g. to cover both light bulbs and radiator thermostats. Furthermore, change of systems may result in short gateway lifetimes.

Other environmental impacts [+]

- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

Many internet providers give a wireless router or integrated access device with the internet subscription requiring a minimum contract period or via a rental agreement. Some providers give a choice of several types of equipment. Even though the equipment often is provided in connection with a subscription, a large B2C market exists.

The different routes to the consumers are not seen as creating a barrier towards possible implementing measures.

Regulatory coverage and feasibility [+]

Existing measures:

- All products fall under the standby, off and network standby regulation.
- Complex set top boxes are included in the VA for these products, but the VA is foreseen to be terminated.
- Broadband equipment is in scope of the EU Code of Conduct on Energy Consumption of Broadband Equipment
- US Energy Star for Small Network Equipment covers the products in scope (3rd country scheme)

[22] Performance requirements regarding range and signal strength

[23] Or use it in bridge mode

The standby regulation already covers all small network equipment for home and office, and a voluntary agreement covers the CSTBs. However, no regulatory measures exist regulating energy consumption in the use phase for most of the products. There are no regulatory barriers towards setting Ecodesign requirements under the Ecodesign Directive identified though care should be taken to avoid overlaps with existing and expected future regulations[24]. However, there many products in the product group and some of them are complex products.
No EU measurement methods for energy efficiency in active mode exist but Energy Star for Small Network Equipment may be a basis for transitional measures.

Cost-effectiveness [++]
The annual energy consumption has improved, but further improvement options exist. The existing measures have not created the necessary push, and inefficient products are allowed on the market. This is noticeable through examples of BAT vs average product savings between 20 and 50% in annual energy cost. Efficient technology exists, e.g. and are already available on the market.
Due to the large numbers in both homes and in the EU, even small saving could lead to considerable savings. Efficient products exist without large price variations indicating that more efficient products would be cost-efficient for both consumers and manufacturers.

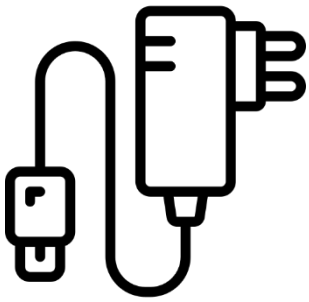
Industrial competitiveness [++]
Many actors dominate the global small network equipment market for home and office use due to the diverse product group. However, OEMs producing routers, modems, switches etc. are mainly larger companies such as Netgear, Linksys, Asus, TP-link, D-link, etc. In recent years other large companies have entered the market, such as Google[25] and Amazon[26]. The market for CSTBs includes among others Technicolor and Arris.
It is assumed that a regulation would not negatively impact the industrial competitiveness, and that costs of improving the product efficiencies can be covered by increased product price assuming no increase in LCC (Life Cycle Cost) for the consumers.

Recommendations [++]
It is recommended to include the product group in the Working Plan but with a mid-rating (++) due to amount of products in the product group of which some of them are complex products. There is a reasonable amount of energy savings in use phase and of resource efficiency. There are no major barriers towards an implementing measure.

[24] Gateways have also been mentioned in the Ecodesign preparatory study for Building Automation and Control Systems https://ec.europa.eu/energy/studies_main/preparatory-studies/ecodesign-preparatory-study-building-automation-and-control-systems_en

[25] https://store.google.com/product/nest_wifi

[26] https://www.amazon.com/Eero-6-Router/dp/B085VM9ZDD



Universal external power supplies

Scope

The suggested scope is based on the existing Ecodesign regulation for EPSs (External Power Supplies) covering energy efficiency and no load losses: Commission Regulation (EU) 2019/1782, however the scope for universal EPSs may be extended to cover EPSs for more types of equipment. It defines an EPS as a device that meets among others the following criteria (see all criteria in the Annex):

- it is designed to convert alternating current (AC) power input from the mains power source input into one or more lower voltage direct current (DC) or AC outputs;
- it is contained in a physical enclosure separate from the device or devices that constitute the primary load;
- it has nameplate output power not exceeding 250 watts.

A potential for material efficiency exists if EPSs and end-products are unbundled as a common practice and the EPS is only delivered, when the consumer does not already possess a suitable EPS or any other suitable way to power the product.

Potential energy & GHG savings 2030 [+]

Primary energy consumption [PJ] (materials)	12-27
Total material weight [Kt]	28-60
GHG emissions [Kt CO2-eq]	1513

It is difficult to estimate the effect of unbundling and of the related consumer behaviour and therefore the savings are based on a range of scenarios. The lower end of the saving potential is based on a mid-case scenario reducing EPS sales with 17%, while a high-case scenario reduces the sales with 37%.

Additional savings may be exploited by including wireless chargers in the scope and propose mandatory requirements to decouple power adapters from phones.

Due to the large number of EPSs in homes and enterprises, even small reductions in the numbers could lead to considerable savings.

Resource efficiency [+++]

- Increased lifetime: Products in scope are often replaced before the end of the technical lifetime due to the main product's replacement. Interoperability could increase the lifetime of the power supplies.
- Reducing waste: Unbundling and applying a power delivery standard can reduce the number of needed power supplies in households and reduce electronic waste.
- Raw materials: Small amounts in individual products. However, the combined amount of valuable raw materials is considered reasonable due to the high number of EPSs.
- Standard devices delivered with the main product (see route to market): Some consumers may acquire another EPS, as the standard EPS may not meet the consumers' expectations regarding, e.g. the size of the EPS or the charging speeds.
- Less transport: Products sold without a power supply and fewer power supplies in the stock could reduce the impact of transportation.

Other environmental impacts [+]

- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

The majority of the EPSs are sold bundled with the main product, such as smartphones, tablets, shavers etc. Many consumers may expect that the main product comes with a suitable EPS. Even though the EPSs are bundled with the main product, a sizeable B2C market exists (spare parts, faster charging). Recently several manufactures have decided to unbundle the EPS from their products[27].

The different routes to the consumers are not seen as creating a barrier towards possible implementing measures.

[27] Phones sold with no charger: Why is this a trend? | Inquirer Technology

Regulatory coverage and feasibility [+]
Existing measures:

- A majority of EPSs are covered by the Commission Regulation (EU) 2019/17824 regarding energy efficiency and no-load losses
- The EU Code of Conduct on External Power Supplies[28] (latest update from October 2013)

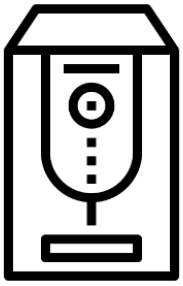
No regulatory measures exist regulating the interoperability, wireless chargers and a range of EPSs outside the scope of the regulation such as power tool chargers. However, there are several activities targeting the so-called "common chargers".
It needs to be properly considered how to establish measures towards the unbundling assessed here. It may be of voluntary or mandatory nature.
Standards to ensure interoperability already exist or are under developments especially USB PD (Power Delivery) (IEC 62680-1-2, IEC 62680-1-3, IEC 63002).

Cost-effectiveness [++]
Some manufacturers are already promoting interoperable power supplies, and other manufacturers are already selling products without an EPS. However, no existing measures have created a large push to ensure interoperable EPSs.
Interoperable EPSs exist and are typically priced slightly higher, but the need for fewer EPSs reduces the overall costs for the consumers. The unbundling is seen as cost-effective for both consumers and manufacturers.

Industrial competitiveness [+]
The main EPS OEMs (Original Equipment Manufacturers) are located in the Far East. A large part of the EPSs are branded according to the end product (e.g. Apple, Samsung, Phillips and Sony).
When the aim of the measure is reduction of the amount of EPSs sold, the industry sector broadly would therefore be impacted such measure. It would however also create a demand for interoperable EPSs that can be used for several products with a slightly larger price tag compared to traditional EPSs and some of the economic losses can be regained.

Recommendations [++]
It is recommended to include the product group in the Working Plan for further assessments including refining the scope and developing implementing measures. There is a reasonable amount of energy savings related to resource efficiency and it is an area of interests for EU citizens who experience EPSs kept in stock but without any use. However, the type of implementing measure needs detailed studies.

[28] https://ec.europa.eu/jrc/en/energy-efficiency/code-conduct/external-power-supplies (EU Code of conduct for EPS)



Uninterruptible power supplies

Scope

A UPS is a combination of electronic power converters, switches and energy storage devices (such as batteries) constituting a power system for maintaining the continuity of power to a load in the case of input power failure.

A previous preparatory study[29] included the following base cases, which are still relevant to consider[30]:

- UPS below 1.5 kVA
- UPS 1.5 to 5 kVA
- UPS 5 to 10 kVA
- UPS 10 to 200 kVA

Potential energy & GHG savings 2030 [++]

Primary energy use phase [PJ]	55
Primary energy material [PJ]	1
GHG savings [MT CO2eq]	2.5

The savings in primary energy use are based on BAT level from the preparatory study, however, with updates in the baseline from which the savings are calculated assuming an increase in energy efficiency since this study. The energy saving potential for material is based on an increase in product lifetime of 20% by applying resource efficiency requirements.

Resource efficiency [+]

- Durability and lifetime: The lifetime of the batteries and thus the possible replacements impacts highly the overall resource efficiency
- End-of-life (recyclability, recycled content): Electronics, plastics and batteries can be difficult to separate in the current recycling processes polluting the waste streams and loosing valuable raw materials. Possible requirements may include information on removal of relevant parts such as PCBs and batteries etc.
- Critical raw material: The content of critical raw materials is considered high due to the products' amount of electronics and batteries.
- Modularity: A modular design for all products may prove to benefit the overall resource efficiency, with higher lifetimes, the option the separate electronics, batteries and the casing at end-of-life and perhaps upgradable modules (better performance or higher capacity)

Other environmental impacts [+]

- Mining of conflict minerals: Cobalt and other raw materials are considered as conflict minerals. Efforts should be made to reduce the impact locally where the materials are mined.
- Transportation: Risks of fire or explosion when transporting lithium-ion batteries can pose a challenge regarding end-of-life handling of UPSs.
- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

Route to market depends on type of UPS systems. One group of devices is supplied as standard off the-shelf product as business to consumer (B2C) products. This includes UPS units for desktop PCs, home servers and other domestic and office purposes. Another group of UPS systems is business to business (B2B) products, typically server rooms and data centres, where standardised UPS modules are rack or tower mounted.

A third and a fourth group of UPS systems may also be defined as highly specialised UPS for hyperscale data centres and tailor-made solutions to ensure the power supply in cases where a power breakdown would be critical, dangerous or with life-threating consequences (e. g. in hospitals).

Suppliers often have web-based selector tools assisting the consumer to select a UPS suitable for the purpose.

The different routes to the consumers are not seen as creating a barrier towards possible implementing measures, but special care should be taken to clearly exempt tailor-made solutions for critical functions.

[29] Carried out by Ricardo-AEA Ltd, 2014, but a decision to develop implementing measures was not taken.

[30] There also exists UPS systems above 200 kVA, but these are generally custom-made to fit specific requirements

Regulatory coverage and feasibility [++]

Existing measures:

- Uninterruptible power supplies (UPS) were the subject of an Ecodesign Preparatory Study in 2014
- UPS systems are in scope of the EU Code of Conduct for AC Uninterruptible Power Systems
- Product Environmental Footprint Category Rules (PEFCR) in 2019[31].
- US Energy Star for Uninterruptible Power Supplies

UPS were the subject of an Ecodesign preparatory study, but the decision to develop Ecodesign and/or Energy Label measures was postponed due to the expected decrease in sales, the US-EU Agreement on the Energy Efficient Labelling of Office Equipment (now expired) and the development of the Code of Conduct for UPS.

Today, the market for UPS products is growing. The EU Energy Star label for UPS was abolished, and the CoC for UPS does not seem to be very active since its outset in 2016, judging from their website[32].

No regulatory barriers to setting Ecodesign requirements under the Ecodesign Directive have been identified, but special attention should be put on the proposal for a new battery regulation to avoid overlaps.

Measurement methods for energy efficiency exist[33].

Cost-effectiveness [++]

The energy efficiency of UPS system has recent years improved, but further improvement exists. The CoC has not created the necessary push, and inefficient products are allowed on the market.

This is noticeable through examples of the assumed BAT vs average product savings, where savings between 20% and above 50% in annual energy cost are achievable. Efficient technology exists and are already available on the market.

Due to the amount of power transmitted through UPSs, even small savings can have a high impact.

Industrial competitiveness [++]

The market is fragmented with the presence of several large players from Europe (e.g., ABB, Eaton Corporation, APC by Schneider Electric, Piller Group), USA (e.g., CyberPower Systems, Emerson Electric, General Electric Company) and Asia (e.g., Delta Electronics, Huawei Technologies, Toshiba). Therefore, the market concentration will be relatively low.

It is assumed that a regulation would not negatively impact the industrial competitiveness and that costs of improving product efficiencies can be covered by increased product price, assuming no increase in LCC (Life Cycle Cost) for the consumers.

Recommendations [+++]

It is recommended to include the product group in the Working Plan. There is a reasonable amount of energy savings in use phase and of resource efficiency. There are no major barriers towards an implementing measure. However, it is needed to take into account the future of the CoC for the product group and the proposal for a new battery regulation.

[31] https://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_UPS.pdf

[32] However, stakeholders involved on the CoC have informed that they are working on updating the CoC.

[33] The main standards relevant for UPS is the European Standard series EN IEC 62040 (safety requirements, conformity assessment regarding EMC, performance and test requirements and harmonized requirements to declare the environmental aspects relating to UPS during the entire life cycle)

Industrial smart sensors

Scope

The scope is wired and wireless industrial smart sensors or sensor functionalities (e.g. integrated in motors or Variable Speed Drives) connected to or built into products such as electrical motors, fans, pumps and compressors and connected drives and control systems to lower running costs (energy, auxiliaries), optimise maintenance (lower costs and down-time), increase product life and integrate systems across platforms. The sensors measure, process, store and communicate data on vibration, temperature and other performance parameters.

The optimisation for energy savings takes mainly place for the products in a system perspective e.g. an electric motor connected to a ventilation system or a pump system. Use of sensors in an Ecodesign perspective should be considered as energy-related rather than energy using products. Furthermore, it is important to recognise that products with sensors or sensor functionality will not automatically save energy; only when sensor data will actively be used for optimisation, maintenance, repairs etc., the saving potential will be achieved.

Potential energy & GHG savings 2030 [+++]

Primary energy use phase	0 PJ
Primary energy material	5 PJ
Other savings (related products)	76-152 PJ
GHG savings (material sensors)	0.41 Mt CO2e

The interval for energy savings in related products reflects a rough estimate of the impact[34] based on sensor functionality requirements on new electric motors except small motors (< 0.75 kW) and special motors, where the sensor functionality is actively used for 20% of the installations saving in average 5-10%.

Resource efficiency [++]

- Durability and lifetime: The lifetime of battery supplied sensors can be improved by ensuring battery capacity is sufficient or making batteries exchangeable. Possible trade-offs with battery material consumption should be considered. Sensors may also be supplied via energy harvester. Sensor functionality may be built into devices (motors, fans, pumps compressors) with energy supply from the device.
- Durability and lifetime of connected products: Sensors can improve the lifetime of motors, fans, etc. to which they are connected.
- End-of-life (recyclability, recycled content): Sensors are covered by WEEE[35] and is therefore discarded with other electronic waste, as part of the product which they are used in.
- Critical raw material: Small amounts in individual sensors, primarily in circuit boards and batteries, however the combined amounts of valuable materials are considered high.

Other environmental impacts [+]

- Health: Using smart sensors in industrial settings has a positive impact on health and safety as they help avoid excessive vibrations and noise levels.
- Flame retardants: Halogenated flame retardants are used mainly in cables, PCBs and connectors.
- Plasticisers (phthalates): Small amounts in PVC cables.

Route to market [+++]

Primarily a B2B product purchased as integral part of other products, or purchased separately for subsequent installation. If purchased separately for existing equipment, they are primarily sold as part of larger projects involving multiple pieces of equipment to implement production monitoring, smart factories or industry 4.0 projects.

Regulatory coverage and feasibility [++]

There are Ecodesign measures in place for motors, industrial fans and pumps. For these existing regulations, a requirement for sensor functionality could be added, ensuring the presence of smart sensors and specific minimum performance characteristics of the sensors such as measuring accuracy, functionality, interoperability etc. However, details of such requirement need to be further analysed; also because the saving impact will only

[34] See assumptions in the Annex.

[35] Covered under Monitoring and control instruments used in industrial installations

take place when the sensor functionalities are actively exploited.

There are no current Ecodesign measures for compressors, however, a preparatory study was finalised in 2017[36] and the Impact Assessment process is on-going.

These potentially amended Ecodesign regulations would not capture:

- Installation of smart sensors in the existing product stock, but some of this potential may be captured by other EU regulations such as the EED[37]
- That the information provided by the sensors is used for monitoring and controlling the equipment and industrial processes, however the same dilemma is also seen in other regulations[38]

To further support capturing these aspects within the Ecodesign framework, a product specific regulation for industrial sensors could be drafted that sets information requirements regarding compatible communication protocols and monitoring software[39], requirements for battery/sensor lifetime, or if possible (and environmentally feasible) incentivize energy harvesters, e.g. using point systems for scoring compatibility and durability[40]. Setting these requirements for sensors sold separately, would make it easier for end-users to install sensors on their existing production equipment.

Cost-effectiveness [++]

For the end-users, who are primarily industrial or production companies, there are significant savings associated with installing smart sensors for production monitoring, moving towards so-called smart factories and Industry 4.0. The following savings have been estimated for such a CBM (Condition Based Maintenance & Monitoring) program: [41,42,43]:

- Maintenance costs: 14-30% reduction
- Downtime: 20-45% reduction[44]
- Breakdowns: 70-75% reduction
- Production: 15-25% improvement

On average, repair cost for a failed asset is typically 50% higher than if the problem had been addressed prior to failure.

These savings have to offset not only the sensor costs, but also the cost of the software and control units to read the information send by the sensors. There is a good indication that this is possible, since it has been estimated that a properly functioning CBM programme can provide savings of 8-12% over the traditional Production Monitoring schemes[45].

Industrial competitiveness [++]

OEMs of sensors are mainly larger tech companies and the costs of improving the product efficiencies can be covered by increased product price. Sometimes the sensor OEMs also supply the monitoring software for reading the sensor inputs.

OEMs of the related products, i.e. the pumps, fans and motors are also large OEMs, and their products would have a small price increase if built-in smart sensors and sensor functionality were made mandatory. However, offsetting this by increasing product price seams feasible, given the estimated savings at the end user (i.e. production companies) as indicated above.

Industrial competitiveness might be hampered by sensor OEMs utilising proprietary communication protocols between sensors and monitoring system, making it difficult for end-users and motor-/fan-/pump OEMs to freely choose between different sensor brands, once one has been chosen.

In an extra-EU perspective, an EU regulation may foster technological innovation and development that give EU manufacturers improved competitiveness.

Recommendations [+++]

It is recommended to include the product group in the Working Plan. The calculated saving potential for the related products is very large, and it is an innovative and emerging technology area.

No major barriers towards an implementing measure have been identified, however, studies need to clarify which form such measure should have.

[36] https://www.eco-compressors.eu/

[37] Energy Efficiency Directive, e.g via Article 8 and Annex VI, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0027-20210101

[38] E.g the ecodesign regulation for servers and data storage products requiring information on the operating condition classes, which only results in savings, if the data centre operator increases the cooling setpoint temperature.

[39] It would be more efficient to set requirements for the use of protocols, but this would be equivalent to setting technolgy specific requirements, which is not possible under the ED.

[40] According to Annex 1 of the Directive.

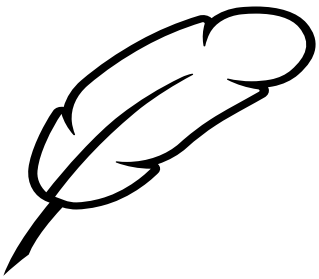
[41] Gulati, Ramesh (2012-08-17). Maintenance Best Practices. Industrial Press, Inc.

[42] Niki Bishop, Improve reliability with essential asset monitoring, InTech, 2012

[43] Intel IoT Industrial Automation – Solution Brief – Improving Downtime and Energy Efficicency with IoT-Connected Air Compressors (https://cdrdv2.intel.com/v1/dl/getcontent/333853)

[44] For motors, ABB estimates a 70% reduction in unplanned downtime using smart sensors.

[45] Gopalakrishna Palem, Condition-Based Maintenance using Sensor Arrays and Telematics, International Journal of Mobile Network Communications & Telematics (IJMNCT) Vol. 3, No.3, June 2013. DOI: 10.5121/ijmnct.2013.3303



Lightweighting

Scope

Circular economy is not just about the end of product-life such as durability, recycling recovery of critical raw materials (CRM). It is just as much, and even more, about the beginning: the material that goes into the product. It is the scope of this horizontal issue to develop policy measures that consider both the beginning and end of the product life, with all their trade-offs.

For simplicity reasons this strategy is referred to as 'lightweighting' but reducing product weight is not a goal in itself. It should always be corrected for specific impact of the materials and it is only one aspect of the dematerialisation strategy.

SWOT (Strength, Weakness, Opportunities and Threats)

- The strength of lightweighting is that there are many advantages for producers, traders and consumers in having products that are lighter and usually also smaller and more mobile. Hence, as is often assumed, that market forces will take care of lightweighting without the need for regulatory measures.
- The weakness of not including lightweighting in a holistic approach for material efficiency is that the other measures that are regulated, like recycling, repairability, durability and critical raw materials take center stage in the design considerations, often at the expense of material input. For instance, following minimum recycling requirement under WEEE (in mass%) for ICT and household appliances may lead to more, not less, absolute material use in order to meet the relative partial target.
- The preparatory and review ecodesign and energy label studies of the last three decades have shown that, as a side-effect or by planning, most products have become lighter. Spectacular examples are electronic displays, including TVs, where product weight has diminished by 90% for the same size in this millennium (e.g. 6 versus 60kg for a 32"TV), while at the same time hazardous impacts were largely removed. One could say that it is only a side-effect of new technology, but the weight and volume saving was a necessary condition and explains also why even the new technology flat screens TVs became 50% lighter over the years. But also for traditional products like gas-fired central heating boilers the lightest product weighs half of the average product at the same functionality (25 versus 50 kg). Conclusion: There are many products with significant differences in the amount and type of material input for production, not being addressed by current legislation. This is an important opportunity.
- The consequence of incorporating lightweighting in a holistic approach may be that there is a new balance with less recycling, repairability and durability, because of lower material input. However, the exercise requires careful preparation in terms of calculation method e.g. including not only weight but also whether it is a high or low environmental impact material. The energy content of the material could be a good proxy for such a correction e.g. in combination with avoiding/penalising CRM (Critical Raw Materials) and SVHC (Substances of Very High Concern), but this has to be thoroughly investigated to avoid sub-optimisation. It should furthermore be assessed if miniaturisation as part of a lightweighting effort would have any potential adverse effect of higher environmental impacts as a result (e.g. more high-tech miniaturisation of ICs and other components, and higher environmental impact during production stage).

Regulatory coverage & feasibility [++]

There are no problems in assessing product weight and there are tests to determine most material types. The main discussion point, and possibly point of investigation, is assessing values for the correction, e.g. energy content. Caution dictates to start with one product group pilot before possibly introducing the holistic material efficiency measures in a broader sense.

Cost-effectiveness [+++]

As mentioned, there are usually many advantages to light-weighting in terms of handling and costs. Industry would need some time to the new methodology, but after that may find a holistic approach more in line with common sense also for production and sales.

Industrial competitiveness [+++]

Lightweighting can be achieved in many different ways: better design methods, innovative materials and production techniques but also by increasing multi-functionality. It can be expected that especially SMEs will be the early adopters of these innovative developments. No negative impact on EU industry competitiveness has been identified.

Recommendations [++]

A holistic approach to materials efficiency, weighing all parameters is completely new for the regulators and thus there are risks of failure. Having said that, with thorough research and a cautionary approach it could be a very valuable addition to the 2020-2024 Ecodesign and Energy Labelling Working Plan.

Without pre-empting the outcome of a systematic and comprehensive study on the subject, the study team estimates that targeted Ecodesign and/or Energy Label measures could lead to ErP material savings of at least 20%. This comes down to a saving of: 2.5-3 Mt/a in material inputs, 180 PJ/a primary energy saving in materials production, 15-20% reduction in carbon and other emissions from materials production.

Recycled content

Scope

Recycled content is the amount of post-consumer recycled material that goes into the manufacturing of a new product, expressed either as a fraction of the total material input (in %) or in absolute numbers (kg per unit, million tonnes Mt in aggregates). The scope is to make (increasing) recycled content a part of a holistic and balanced material efficiency policy, also within Ecodesign.

SWOT (Strength, Weakness, Opportunities, Threats)

- Recycled content is the demand side of recycling and just as important for the circular economy as the effort to recycle the product at its disposal. If the EU becomes more self-sufficient in increasing recycled content for the products produced within its territory, not only for plastics but also for critical raw materials e.g. for batteries, this could become a strong point not just for the environment but also the EU industry, making it less dependent on extra-EU imports.
- Until a few years ago, the industry and NGOs were not too concerned over the recycled content of products sold in the EU. The recycled plastics were mainly exported, especially to China, and thus were presumably put to good use. Recycled plastics were – most of the time – economically competitive with virgin plastics because of a lower price at an acceptable performance. Now that easy exports and low prices are no longer there, the low EU attention in this area is a weakness and an extra effort is needed.
- There are three recycling loops to consider: Recycled content from recycling of the same product, recycled content from generic source (recycled plastics suppliers) and – still in its infancy – chemical recycling (reworking the recycled plastic chemically in a as-good-as-new new material). The opportunities for the EU lie in better logistics, material sorting techniques, test standards to guarantee minimum plastics performance and – especially for chemical recycling – process optimization.
- The biggest threat for regulatory measure is in not finding a method to verify the recycled content of a product. There are promising laboratory techniques for materials recognition, but it must be investigated if they can be accurate, repeatable and reproducible enough.

Regulatory coverage & feasibility [+]

This would be a fundamental and ambitious subject with and probably no immediate results for a number of years. However, it is an important subject not only for the circular economy but also for reducing the dependence of our industry on extra-EU imports. To test feasibility the upcoming work on vacuum cleaners could be a possible test case.

Cost-effectiveness [+]

Whether increasing recycled content is cost-effective depends very much on the price of the virgin material. At the moment there can be doubts for plastics in that respect, but for critical raw materials the situation is more favourable.

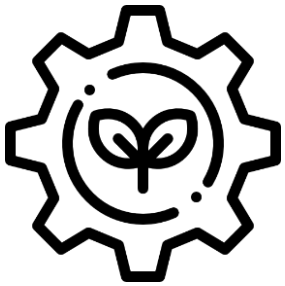
Industrial competitiveness [+]

There are threats and opportunities for SMEs, depending on the specific material and the market situation.

Recommendations [+]

It is strategically important to invest in fundamentally new directions for the circular economy, even though at the moment it is too soon to be discussing regulatory measures. The recommendation is to launch a more detailed study on the topic with the vacuum cleaners as an included case study.

Without pre-empting the outcome of a systematic and comprehensive study on the subject, the study team estimates that targeted Ecodesign and/or Energy Label measures could lead to ErP material savings corresponding to primary energy savings around 160 PJ/a.



Ecological profile

Scope

The scope covers those energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling where the method for setting specific minimum ecodesign requirements according to Annex II of Ecodesign Directive 2009/125/EC is limited or cannot be applied, e.g.,

- rather complex products and product systems;
- ErP with high impacts / improvement potential of raw material extraction, manufacturing and end-of-life phases;
- ErP with environmentally relevant use of consumables; and/or
- IT ErP with mainly indirect environmental impacts, e.g. by shifting impacts of the use phase from the IT product into the cloud.

Potential methodological measures related to the ecological profile

- Identification of benchmarks by the Commission based on information gathered during the preparation of specific implementing measures.
- Development of a kind of standard (reporting) template to be used as basis for ecological profiles in Ecodesign implementing measures, allowing better transparency and comparability among different products.
- Definition of assessment criteria facilitating the compliance assessment of ecological profiles by market surveillance authorities.

Potential measures on applying an ecological profile to product categories

Complex products and product systems

- Limitations of Annex II: Difficulty in setting specific ecodesign requirements due to variety of functions and impacts/improvement potentials being highly application-dependent; difficulty in identifying average or characteristic usage profiles (duty cycles); often, no implementing measures adopted at all after preparatory study process, or only voluntary agreement.
- Application of Annex I: Possibility of taking into account customized approaches; more flexibility for manufacturers to use a mix of measures to reach a specified level of performance improvement instead of adopting no requirements at all due to methodological constraints in setting specific minimum requirements; exploiting the high improvement potential of these product groups which would else not be covered by Ecodesign measures.
- Product examples for applicability of Annex I: Customized professional laundry/dishwashing appliances, photovoltaic systems, data storage systems, professional machine tools, medical equipment, Building Automation and Control Systems etc.

Products with high impacts/improvement potential of raw material extraction, manufacturing and End-of-life phases

- Limitations of Annex II: Rather generic assessment approaches within MEErP / EcoReport tool for the life cycle phases regarding raw materials extraction, reuse/lifetime extension and recycling, thus not enough incentivizing/benefitting product specific design options.
- Application of Annex I: Improvement potential better addressed by dedicated design options as listed in Annex I: Extension of lifetime, incorporation of used or post-consumer recycled components, design to facilitate reuse, design to facilitate recycling.
- Product examples for applicability of Annex I: Smartphones, games consoles, printers, battery operated appliances (handheld power tools, etc.)

Products with relevant use of consumables

- Limitations of Annex II so far: Rather generic assessment approaches within MEErP / EcoReport tool for consumables not benefitting enough specific product design options; often no implementing measures regarding product specific design options on reducing the impacts of related consumables
- Application of Annex I: Improvement potential could be better addressed by taking into account design options as listed in Annex I: Quantity and nature of consumables needed for proper use and maintenance
- Product examples for applicability of Annex I: Printers (e.g. product design facilitating the use of reused/recycled cartridges), washing machines / dishwashers (product design leading to reduced consumption of detergents).

Products with mainly indirect environmental impacts, e.g. by shifting impacts of the use phase into the cloud

- Limitations of Annex II so far: No assessment approaches within MEErP / EcoReport tool for indirect environmental impacts caused by large data streams / high network utilization and computing power shifting from product to cloud
- Application of Annex I: Benefitting specific design options on data sufficiency, reducing software related obsolescence, etc.
- Product examples for applicability of Annex I: Smart appliances, smartphones, interconnected home audio, video & voice service equipment interoperable IT solutions, networking equipment.

Regulatory coverage & feasibility [++]

Existing measures (regulatory feasibility / implementation: see recommendations), however, with methodological measures to be solved:

- The method for setting generic Ecodesign requirements is included in Annex I of Ecodesign Directive 2009/125/EC.

Measures can be applied under the Ecodesign Directive in product-specific regulations, by a) solely applying an ecological profile according to Annex I of Ecodesign Directive 2009/125/EC; b) a hybrid approach combining specific minimum requirements according to Annex II with an ecological profile according to Annex I; or c) applying Annex I (generic requirements) and Annex II (specific requirements) by combining different product policy instruments (Ecodesign, Energy Labelling, Ecolabel, or Green Public Procurement).

Cost-effectiveness / Industrial competitiveness [++]

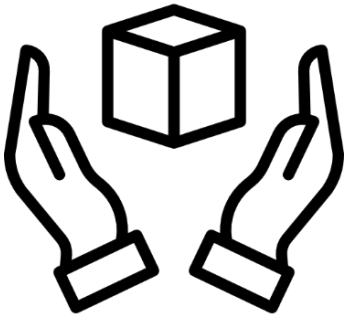
Initial additional costs for manufacturers/importers (both large and SMEs) due to generic ecodesign requirements on lifecycle assessments for establishing ecological profiles for their products; these might pay back in the medium-term by providing the possibility of targeted identifying and realizing environmental savings and efficiency potentials. A multi-dimensional view can better take into account possible trade-offs between different environmental aspects, e.g. durability and reparability; durability and recyclability; light-weighting and use of recycled material etc.; thus offering more flexibility and being better alignable to different individual sustainability design strategies of manufacturers. Providing ecological profiles might give a further market impulse for consumption and public procurement of sustainable products by empowering citizens and public procurers being able to choose products with greater transparency. This could facilitate improving the competitiveness of the EU manufacturers.

Recommendations [++]

The applicability of ecological profiles according to Annex I of Ecodesign Directive 2009/125/EC could be further examined in the next Working Plan.

Future legislative implementation is recommended by:

- Standardisation mandate to develop a kind of standard (reporting) template to be used as basis for ecological profiles in Ecodesign implementing measures, allowing better transparency and comparability among different products and the definition of assessment criteria facilitating the compliance assessment of ecological profiles by market surveillance authorities.
- Applying Annex I on those energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling where the method for setting specific minimum ecodesign requirements according to Annex II of Ecodesign Directive 2009/125/EC is limited or cannot be applied; by a) solely applying Annex I of Ecodesign Directive 2009/125/EC; b) by using a hybrid approach combining specific minimum requirements according to Annex II with an ecological profile according to Annex I; or c) applying Annex I (generic requirements) and Annex II (specific requirements) by combining different product policy instruments (Ecodesign, Energy Labelling, Ecolabel, or Green Public Procurement).



Durability

Scope

Measures to facilitate reliability, maintenance, repair, upgrade and reuse of products are included in the term "durability". The scope covers all energy-related products currently or in future regulated under EU Ecodesign and Energy labelling with specific focus on product categories with

- short, decreasing, or wide ranges of lifetime(s) and innovation cycles within a product category;
- high failure rates;
- higher impacts in the manufacturing phase compared to the use phase throughout the lifecycle;
- key functions with a relatively high dependence on software, and in turn, on regular software updates.

Potential energy & GHG savings 2030 [+++]

Primary energy use phase	175-1052 PJ
GHG savings	8-46 Mt CO2e

The interval reflects a rough estimate of the impact of a light and a deep durability scenario, respectively[46].

Potential durability measures related to product design

- Product-specific durability and reliability requirements for the product and/or key materials and components in further product categories
- Extending requirements on reparability / upgradeability (e.g. availability and delivery time of spare parts) and reusability (e.g. tools for safe data deletion, presence of of integrated password and factory reset for facilitating reuse)
- Definition of certain operating condition classes that might include e.g. environmental aspects as temperature, humidity, or Ingress Protection Levels (IP rating).
- Battery durability / replaceability as a cross-cutting issue for battery-operated products.
- Requirements to combat software-related obsolescence as a cross-cutting issue.
- Remote access to products for error diagnostics/ mandatory incorporation of use meters incl. consumer feedback mechanisms regarding optimized use and maintenance to assess future requirements on maintenance, guarantees, use patterns in standards, combatting premature obsolescence.

Potential durability measures related to information / labelling

- Availability of repair and maintenance instructions to non-professional repairers and/or consumers.
- Information about the minimum duration of commercial warranties.
- Average statistical parameters on reliability or failure rates (e.g. on the product-specific Energy Label, and/or in the product information sheet),
- Introduction of a Reparability Scoring Index, Reparability label or Product Circularity Data Sheets (PCDS) to assist purchasing decisions.
- Product-specific labelling of minimum lifetime with civil law effect applied in case of non-conformities.
- Mandatory provision of a product's life cycle assessment information by manufacturers (e.g., inter alia, the use of the generic Ecodesign ("Ecoprofile") provisions of the 2009 Ecodesign Directive, Annex I).
- Taking into account developments of a digital "Product Passport" under the Sustainable Products Initiative (SPI) as envisaged in the Commission's European Green Deal to provide information on a product's origin, composition, repair and dismantling possibilities and end of life handling, as well as interlinkages to other product information systems such as the EPREL database, the concept of a "battery passport" (and database) of the Battery Regulation or others.

[46] See assumptions in the annex.

Potential methodological needs to facilitate durability measures

- Revision of the MEErP (EcoReport tool, as needed), better facilitating systematic assessment of durability and trade-off analyses as key aspects in all preparatory and review studies.
- Systematic modelling of potential trade-offs from increased durability (e.g. decreased manufacturing (and EoL) and slower stock exchange with energy- and resource efficient products) in product-specific preparatory studies.
- Further methodological analysis regarding the use and benefits of statistical parameters on reliability/ failure rates, Reparability Scoring, or minimum lifetimes for the purpose of setting information requirements.
- Standardisation activity on definitions and methodologies to facilitate the provision of information on lifetime aspects of products such as expected and minimum lifetime and reliability scorings.
- Evaluating components' "reuse" value, and apportioning possible "bonus" points to real, validated incorporation of reused components in new products placed on the market (remanufacturing strategy).
- Development of a set of "generic / minimum durability requirements" to be used as basis for Ecodesign/Energy labelling implementing measures

Regulatory coverage & feasibility [+++]

Existing measures (regulatory feasibility / implementation: see recommendations):

- Durability requirements already implemented in some product specific Ecodesign regulations.
- European standards related to durability, reparability, reusability and upgradeability (EN 45552:2020, EN 45554:2020).
- Further established EU and national ecolabel and GPP criteria on durability of products

Measures can be applied under the Ecodesign Directive and Energy Labelling Regulation. Measures under the Ecodesign Directive could be implemented horizontally for defined product groups (similar to the standby regulation[47]), thus also cover additional product categories not regulated by product-specific regulations so far, or vertically through amendments to existing product-specific regulations.

Cost-effectiveness / Industrial competitiveness [+++]

Initial higher production costs for manufacturers/importers (both large and SMEs) and purchase costs for consumers due to higher-quality materials or products or reparability measures will pay back in the medium-term by in total lower LCC due to longer lasting products, emerging circular business models like product service systems, closing of material loops and decreasing dependency on imports of critical raw materials. The development of a reparability or durability labelling scheme can give a new market impulse and simultaneously improve competitiveness of the EU manufacturers. In the repair sector gains of turnover are expected due to job creation especially for SMEs and social enterprises located in the EU.

Recommendations [+++]

It is recommended to include "durability" as priority topic in the next Working Plan. There are high energy, GHG emissions and resource savings; prolonging the use of products also has significant reduction potential for further environmental and social impacts resulting from the extraction and use of materials of otherwise newly-manufactured products.

To exploit the savings potential as far as possible, future legislative implementation of durability (to be prepared by a horizontal preparatory study) is recommended by:

- Setting horizontal minimum requirements on durability for all ErPs (defining exemptions to the application of specific aspects, for example by excluding product categories with long lifetimes, low failure rates, low manufacturing stage impacts, etc.).
- Defining priority product groups where - beyond horizontal minimum requirements - more stringent durability performance requirements could apply at a product-specific level.
- Introducing labelling requirements on durability.

[47] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02008R1275-20170109

Scarce and critical raw materials

Scope

The scope covers all energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling with relevant content of

- Critical Raw Materials (CRM) due to their supply risks and scarcity from an EU perspective; and/or
- other raw materials with high environmental and/or social risks and impacts.

Potential methodological measures related to critical raw materials

- Updating the list of Critical Raw Materials in current MEErP and EcoReport tool to the 2020 EU CRM list
- Beyond CRM, adding further raw materials with high environmental risks and impacts to the EcoReport tool to take them into focus of future assessments and implementing measures. For example, there are a number of raw materials not in the 2020 EU CRM list, i.e. not relevant from a scarcity perspective, but with high environmental impacts, such as copper, gold, lead, molybdenum, nickel, palladium, platinum, rhenium, rhodium, selenium, silver, tellurium, and zinc.
- Revising the current approach of characterization factors and weighting of raw materials as applied in the MEErP 2011 methodology with the objective to better take into account further environmental risks / impacts in combination with the scarcity of raw materials. For example, whereas cobalt has a comparably low ranked characterization factor applying the current MEErP methodology 2011, it has a high environmental impacts according to a classification scheme of Dehoust et al. (2020)[48] where a broader set of environmental risks was analysed.
- Developing a prioritisation scheme for the relevance of raw materials in terms of criticality / scarcity in combination with environmental risks and impacts aiming at setting potential implementing measures:
  - Highest priority: CRM with high environmental risks/impacts
  - Second highest priority: raw materials beyond CRM with high environmental risks and/or CRM with medium to high environmental risks.
- Ensuring a systematic analysis in all future preparatory and review studies of the existence, location in components and – ideally - amount of those priority raw materials either categorized as CRM and/or having high environmental risks/impacts.
- Development of a set of "generic / minimum requirements on (critical) raw materials" to be used as basis for Ecodesign implementing measures.
- Outlook: Developing / applying a methodology composed of multiple indicators to additionally combine social impacts together with supply and environmental risks and impacts of commonly used raw materials in energy-related products.

Potential measures on (critical) raw materials related to product design / information

- Implementing measures facilitating durability of the products and/or components containing relevant (critical) raw materials.
- Implementing measures facilitating the recyclability of those products and/or components containing relevant (critical) raw materials, such as
  - Requirements on design for disassembly
  - Requirements on information and declaration for facilitating recycling operations based on the guidance of standard EN 45558:2019 with regard to substance, amount and location in components of the ErP.
  - Requirements on dismantling information for facilitating recycling operations such as the sequence of dismantling steps, tools or technologies needed to access the targeted component.

[48] Dehoust, G.; Manhart, A.; Dolega, P.; Vogt, R.; Kemper, C.; Auberger, A.; Becker, F.; Scholl, C.; Rechlin, A.; Priester, M. (2020): Environmental Criticality of Raw Materials, An assessment of environmental hazard potentials of raw materials from mining and recommendations for an ecological raw materials policy (UBA TEXTE, 80/2020). Umweltbundesamt (ed.), 2020. Online available at https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-06-17_texte_80-2020_oekoressii_environmentalcriticality-report_.pdf, last accessed on 17 Jun 2020

- Promoting the use of recycled raw materials which, however, requires reliable tracing and verification methods for Market Surveillance Authorities.
  - Design requirements setting a minimum share of recycled raw materials.
  - Labelling requirements on the applied share of recycled raw materials
- Implementing measures for enhancing the recovery rate from the waste flows or streams.
- Increasing the collection/take back rate of appliances/goods that contain CRM.

Regulatory coverage and feasibility [++]

Existing measures (regulatory feasibility / implementation: see recommendations):

- Critical raw materials addressed in MEErP methodology, analysed in various Ecodesign preparatory studies and implemented in few product specific Ecodesign regulations (information requirements).
- European standard EN 45558:2019 ('General method to declare the use of critical raw materials in energy-related products')

Future measures can be applied under the Ecodesign Directive, either horizontally (similar to the standby regulation[49]) for defined raw materials used in energy-related products, thus can also cover additional product categories not regulated by product-specific regulations so far; or vertically as requirements on relevant (critical) raw materials in product-specific regulations.

Cost-effectiveness / Industrial competitiveness [+++]

Implementing measures on (critical) raw materials could contribute to reducing the pressure on further resource extraction needs for the purpose of manufacturing new products, thus facilitating the EU and EU manufacturers being less dependent on new imports of Critical Raw Materials (CRM) from non-EU countries and reducing the overall environmental impacts of resource extraction. Implementing measures on raw materials in ErP taking additionally into account environmental (and perspectively social) risks and impacts could further reduce emerging financial/reputational risks in the global supply chains of EU manufacturers.

Initial R&D costs for manufacturers/importers (both large and SMEs) due to potential changes in their supply chains, product design using recycled or alternative raw materials with lower risks, product durability design and/or declaration measures will pay back in the medium-term by lower LCC due to longer lasting products, emerging circular business models, closing of material loops and decreasing dependency on imports of critical raw materials. Declaration of relevant (critical) raw materials can give a further market impulse for recycling facilities and simultaneously improve competitiveness of the EU manufacturers.

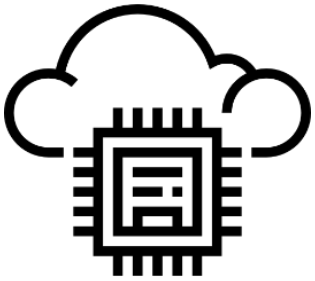
Recommendations [+++]

It is recommended to include critical raw materials (CRM), and in a broader sense, relevant raw materials with higher risks of environmental impacts during their mining production as priority topic in the next Working Plan.

On the basis of a prioritisation scheme of raw materials being CRM and/or having high or medium to high environmental risks and impacts (see Annex), future legislative implementation (to be prepared by a horizontal preparatory study) is recommended by:

- Updating the MEErP and EcoReport tool to the 2020 EU CRM list and other relevant raw materials with high environmental risks/impacts during their mining production.
- Setting horizontal minimum requirements on these raw materials (e.g. information / declaration requirements) applicable to ErPs containing these raw materials.
- Defining priority product groups where - beyond horizontal minimum requirements - more stringent requirements could apply at a product-specific level (e.g. use of secondary raw materials, design for recycling).
- Exploring further means of addressing the "Circular Economy" value of Critical Raw Materials (CRM) and other raw materials with high environmental risks/impacts, aiming at retaining these materials within the EU.
- Outlook: Developing / applying a methodology composed of multiple indicators to additionally combine social impacts together with supply and environmental risks and impacts or commonly used raw materials, e.g. in the framework of the Sustainable Products Initiative (SPI) as envisaged in the Commission's European Green Deal.

[49] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02008R1275-20170109



Firmware and software

Scope

- The scope for following measures A) and B) covers all energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling using *firmware or system software* for executing their main functionalities.
- The scope for measures C) covers *application software* used on a computer system to perform special functions for end-users beyond the basic operation of the computer, such as word processors, databases, image or video editing.

Potential measures on firmware and system software

A) Reducing software-related hardware obsolescence, e.g.:

- Requirements on the availability of relevant firmware / system software including reset software for a minimum period of years (to be defined product-specific) after the placing the last product on the market, free of charge or at a fair, transparent and non-discriminatory cost.
- Requirements on availability of software-updates for a minimum period of years (to be defined product-specific) after the placing the last product on the market, free of charge.
- User options for installing software updates, e.g. to not install, install or uninstall the update; providing the user a choice to install only security updates or also other (e.g. functional) updates.
- Possibility of rolling back software to previous versions.
- Possibility of full software compatibility with open source Operating Systems and/or open source Virtual Machine software (where applicable).
- Requirements regarding uninstallation of software / data removal, i.e. possibility to completely remove the software product from the computer system after the end of its operating life without leaving any unnecessary traces of data.
- Requirements on the release of hardware from manufacturer dependency at the end of the support period ("jailbreak"); i.e. if the product is dependent on external services provided by the manufacturer, a software update must be provided at the end of the support period so that the product can be used further without restrictions.
- Studying the relevance and feasibility of firmware-based usage counters facilitating repair operations.
- Information requirements for end-users:
  - Instructions for installation of relevant software and firmware including reset software.
  - Information on the minimum guaranteed availability of firmware/system software.
  - Information requirements on how updates might affect the original system characteristics (e.g. Random-Access Memory, RAM, or Central Processing Unit, CPU).
  - Description of the process for uninstalling the product software and secure data deletion.

B) Reducing the risk of software updates deteriorating energy/resource efficiency of products

- Consistent application of the article on software updates in all new or revised Ecodesign regulations when software is a relevant part of the main functionality of the appliance.
- Introducing a complementary requirement under EU Energy Labelling regulations that software updates shall not have the effect of changing the product's performance in a way that the declared energy efficiency class deteriorates.
- Specification of the requirement how to inform users about possible implications on decreasing energy and/or resource efficiency of the product to facilitate an informed decision.

Potential measures on application software

C) Energy and resource efficiency of application software

- Minimum Ecodesign requirements on energy and resource efficiency of application software, e.g. energy demand, CPU cycles, hardware utilization, support for the energy management system, etc.).
- Energy Labelling requirements to display the energy and resource efficiency of application software products to end consumers.
- Further information requirements, e.g. instructions on efficient use of the application software, support for the energy management system.

Potential methodological measures related to application software

- Development of a standard measurement methodology including definition of standard reference system(s) (e.g. desktop, notebook and/or tablet computer with defined operating system(s)) on which the application software products shall be tested, and standard usage scenarios.
- Identification of benchmarks and efficiency classes on the basis of information gathered during the preparation of the specific implementing measure.
- Possible revision of the MEErP and/or EcoReport tool, if needed, facilitating systematic assessment of software aspects in products, potential trade-off analyses, and allowing the analysis and definition of implementing measures for application software products.

Regulatory coverage and feasibility [++]

Existing measures (regulatory feasibility / implementation: see recommendations):

- A) and B): Requirements already implemented in some product specific Ecodesign regulations.
- A): European standards related to durability, reparability, reusability and upgradeability (EN 45552:2020, EN 45554:2020) include references to software and are defining firmware and software as parts constituent of a product.
- C): Established national ecolabel requirements on "resource and energy-efficient software products" (Blue Angel, Germany[50])

- Measures on A) can be applied under the Ecodesign Directive, measures on B) and C) both under the Ecodesign Directive and Energy Labelling Regulation. Measures on A) under the Ecodesign Directive could be implemented horizontally together with further requirements on "durability" (similar to the standby regulation), thus also cover additional product categories not regulated by product-specific regulations so far, or vertically through amendments to existing product-specific regulations. Measures on B) could be implemented horizontally or as pre-requisite in all product-specific Ecodesign / Energy Labelling regulations.
- For measures on C), finally, a new product-specific Ecodesign and/or Energy Labelling regulation on application software "products" would be necessary, prepared for example on the basis of a feasibility study.

Cost-effectiveness / Industrial competitiveness [++]

Potentially additional costs for manufacturers / importers (both large and SMEs) and higher purchase costs for consumers due to additional Ecodesign requirements on firmware / system software of products will pay back in the medium-term by in total lower LCC due to longer lasting products and higher energy and resource efficiency of the software. Procuring energy and resource efficient application software can also provide economic benefits to private, professional and public consumers, such as companies and public institutions, by reducing hardware capacities and obsolescence.

The development of efficiency requirements and/or an Energy Labelling scheme for application software products can give a new market impulse and simultaneously improve competitiveness of the European software developers, thus, in the software application sector gains of turnover are expected due to job creation especially for SMEs and start-up enterprises located in the EU.

Recommendations [+++]

It is recommended to include "firmware" as priority topic under the initiative for durability in the next Working Plan. There are high energy, GHG emissions and resource savings due to prolonging the use of products by reducing software-related hardware obsolescence and preventing the risk of deteriorated energy and resource efficiency after software updates. To exploit the saving potential as far as possible, future legislative implementation of durability (to be prepared by a horizontal preparatory study) is recommended by:

- Setting horizontal minimum requirements on firmware / system software for all ErPs to increase durability by reducing software-related hardware obsolescence.
- Including and further specifying requirements on software updates horizontally or as pre-requisite in all product-specific Ecodesign and Energy Labelling regulations to reduce the risk of deteriorating energy/ resource efficiency of products after updates.
- Considering interfaces with other legislation and initiatives, such as Sale of Goods Directive, Digital Content Directive, or the upcoming 'empowering consumers for the green transition' initiative.

Regarding potentially setting efficiency requirements on application software, it is recommended to initiate a feasibility study on the possibility of setting energy and resource efficiency measures on application software.

[50] https://www.blauer-engel.de/en/products/electric-devices/resources-and-energy-efficient-software-products/resources-and-energy-efficient-software-products

6 RECOMMENDATIONS

6.1 Overview of the recommended product groups and horizontal initiatives for the Working Plan

Based on the analyses in Task 3 and Task 4, the 16 product groups and horizontal initiatives assessed in Task 4 are recommended to be included in the Ecodesign and Energy Labelling Working Plan 2020-2024. It has to be noted that "horizontal" in the sense of this study means that these topics are applicable to a broader set of different product groups. It does not necessarily mean that horizontal requirements and implementing measures have to be adopted; minimum requirements on these topics could also be applied in product-specific regulations.

Table **4** presents an overview of the saving potentials and ratings provided in the fiches in previous section. The ratings have been provided on the basis of the suitability, feasibility for and positive impact of potential implementing measures and the related improvement of the environmental performance, as follows:

- +: Low positive impact
- ++: Medium positive impact
- +++: High positive impact

For the recommendations, the ratings are defined as:

- +: Recommended for the working plan, however, with lower rating due to lower saving potential, other issues related to the implementation and/or need for a pre-study.
- ++: Recommended for the working plan, however, with lower saving potential and/or less easy implementation compared to +++.
- +++: Highly recommended for the working plan due to higher saving potential and/or easier implementation.

Please notice that based on the Task 4 assessments, these changes in the groupings have taken place:

- Professional laundry appliances and professional dishwashers have been merged into one product group due to the similarities regarding the product groups and the regulatory processes such as impact assessments and stakeholder consultations.
- The initiative for firmware and software have been split because firmware is much related to durability and has therefore been merged with this initiative, while software has been separated into an initiative called application software.

Table 4: Overview of the 15 products and initiatives recommended for the Working Plan.

Product groups & horizontal initiatives	Primary energy savings PJ 2030			Resource efficiency	Other environmental impacts	Regulatory coverage and feasibility	Cost-effectiveness	Industrial competitiveness	Recommendations
	Use phase	Material content	Rate						
Product groups									
Professional laundry appliances and dishwashers	53		++	++	++	+++	+++	+++	+++
Professional cooking appliances	117		+++	+	++	++	++	++	++
Low temperature emitters	170		+++	+	+	++	++	+++	++
Swimming pool heaters	14-63		++	+	+	++	++	+++	+
Enterprise network equipment	22	3	+	+	+	++	+++	+++	+
Small network equipment for home and office use	69	7	++	+	+	+	++	++	++
Universal external power supplies		12-27	+	+++	+	+	++	+	++
Uninterruptible power supplies	55	1	++	+	+	++	++	++	+++
Industrial smart sensors	76-152	5	+++	++	+	++	++	++	+++
Horizontal initiatives									
Lightweight design		180	+++	+++	+	++	+++	+++	++
Recycled content		160	+++	++	+	+	+	+	+
Ecological profile			+++	++	++	++	++	++	++
Durability and firmware		175-1052	+++	+++	+	+++	+++	+++	+++
Application software			+++	++	+	+	++	+++	+
Scarce and critical raw materials			+++	+++	+	++	+++	+++	+++

Table 5 shows the 15 products and initiatives according to the ratings.

Table 5: Grouping of the products and initiatives according to ratings.

Ratings	Product groups / horizontal initiatives
+++: Highly recommended for the working plan due to higher saving potential and/or easier implementation.	Professional laundry appliances and dishwashers Uninterruptible power supplies Industrial smart sensors Durability and firmware Scarce and critical raw materials
++: Recommended for the working plan, however, with lower saving potential and/or less easy implementation compared to +++.	Professional cooking appliances Low temperature emitters Small network equipment for home and office use Universal external power supplies Lightweight design Ecological profile
+: Recommended for the working plan, however, with lower rating due to lower saving potential, other issues related to the implementation and/or need for a pre-study.	Swimming pool heaters Enterprise network equipment Recycled content Application software

Table 6 shows the selected product groups and initiatives subdivided according to energy efficiency potential (low, medium, high) and realisability (complex / smooth).

Table 6: Subdivision on low, medium and high energy and/or resource efficiency potential and complex and smooth realisability.

		Energy and/or resource efficiency potential		
		Low	**Medium**	**High**
Realisability	**Complex**	• Swimming pool heaters • Universal external power supplies	• Small network equipment for home and office use	• Ecological profile • Application software • Low temperature emitters • Lightweight design • Recycled content • Industrial smart sensors • Professional cooking appliances
	Smooth	• Enterprise network equipment	• Professional laundry appliances and dishwashers • Uninterruptible power supplies	• Durability and firmware • Scarce and critical raw materials

Some of 15 product groups and initiatives would require more traditional preparatory studies and typical implementing measures and thereby can be seen as more low-risk selections. Others are more innovative and would require other kind of studies (such as pre-studies and screening studies) and implementing measures and can be seen as having more uncertainty, however, they are also more forward-looking and can over time capture high saving potentials. See a subdivision in Table 7.

Table 7: Subdivision of the selection on traditional / innovative and vertical / horizontal.

	Traditional	**Innovative**
Vertical product groups	• Professional laundry appliances and dishwashers • Professional cooking appliances • Swimming pool heaters • Enterprise network equipment • Small network equipment for home and office use • Uninterruptible power supplies	• Low temperature emitters • Universal external power supplies • Industrial smart sensors • Lightweight design
Horizontal initiatives	• Durability and firmware (depending on the level of implementation)	• Recycled content • Ecological profile • Application software • Scarce and critical raw materials

6.2 Individual recommendations

6.2.1 Professional laundry appliances and professional dishwashers

Professional laundry appliances and dishwashers are a few products still in the category 'low hanging fruit': a preparatory study was done in 2011 and the products were found eligible in 2014, but robust test standards were lacking. The energy saving potential is reasonable and it is expected that the merging of the two product groups will reduce the resources needed for all parties involved. Following a mandate to the ESOs those test standards now exist for most base cases, representing > 80% of the total impact. In other words, the job can now be completed.

6.2.2 Professional cooking appliances

The energy saving potential is large, even if the scope will be reduced. Measurement standards need to be developed for several of the product groups. In order to determine the exact scope to be investigated in full preparatory study, a Task 0 scoping study is recommended to be performed first.

6.2.3 Low temperature emitters

Heating emitters are a vital component in a hydronic central heating system, determining to a large extend whether energy-efficient renewable heating systems like heat pumps can be applied without excessive costs. Introducing energy labelling for heating emitters in general, including innovative Low Temperature emitters only recently on the market, can facilitate consumer acquiring and installing heat pumps or hybrids especially in existing housing, without too high costs for adapting the installation. It is recommended to include the product group in the Working Plan. The energy and carbon savings in use phase are large and there are no negative side effects. Given the current market situation as described above, market forces alone will not give this product group enough impetus to contribute significantly to the energy and climate goals. Labelling measures for heat emitters that consider LT heat dissipation versus emitter volume and formfactor are important.

6.2.4 Swimming pool heaters

The product group may be relevant for the Working Plan, however, with the lowest rating due to the uncertainty about realisation of the higher end of the potential. Measurement methods need to be established.

6.2.5 Enterprise network equipment

The product group may be relevant for the working plan, however, with the lowest rating due to low energy saving potential. No major barriers towards an implementing measure have been identified.

6.2.6 Small network equipment for home and office use

It is recommended to include the product group in the Working Plan but with a mid-rating (++) due to amount of products in the product group of which some of them are complex

products. There is a reasonable amount of energy savings in use phase and of resource efficiency. There are no major barriers towards an implementing measure.

6.2.7 Universal external power supplies

It is recommended to include the product group in the Working Plan for further assessments including refining the scope and developing implementing measures. There is a reasonable amount of energy savings related to resource efficiency and it is an area of interests for EU citizens who experience EPSs kept in stock but without any use. However, the type of implementing measure needs detailed studies.

6.2.8 Uninterruptible power supplies

It is recommended to include the product group in the Working Plan. There is a reasonable amount of energy savings in use phase and of resource effi-ciency. There are no major barriers towards an implementing measure. However, it is needed to take into account the future of the CoC for the product group and the proposal for a new battery regulation.

6.2.9 Industrial smart sensors

It is recommended to include the product group in the Working Plan. The calculated saving potential for the related products is very large, and it is an innovative and emerging technology area.

6.2.10 Lightweight design

So far, lightweighting has been largely disregarded as a crucial ingredient of circular economy design strategy. Yet, saving virgin material on the production side – weighted for their relative impact – is the yardstick for all the other circular economy efforts to follow during the product life and – as opposed to many end-of-life measures – independent of consumer behaviour and volatile economics. For that reason alone, introducing this factor horizontally in a coherent and holistic design strategy is worth investigating and it could be a very valuable addition to the 2020-2024 Ecodesign and Energy Labelling Working Plan. Without pre-empting the outcome of a systematic and comprehensive study on the subject, the study team estimates that targeted Ecodesign and/or Energy Label measures could lead to ErP material savings of at least 20%. This comes down to a saving of: 2.5-3 Mt/a in material inputs, 180 PJ/a primary energy saving in materials production, 15-20% reduction in carbon and other emissions from materials production.

6.2.11 Recycled content

Recycled content in the production phase is the natural counterpart of the recycling at end-of-life. However, because verification of compliance is not self-evident, and the EU could find easy exports of recycled plastics to Asia, optimising for recycled content seemed a solution looking for a problem rather than the other way around. However, now that Asian countries are less keen to import recycled plastics and the prices of virgin plastics start to become competitive with recycled alternatives, it is time for a pro-active approach and – through pilot projects – try to develop policy measures that will work. The recommendation is to launch a more detailed study on the topic with the vacuum cleaners as an included case study. Without pre-empting the outcome of a systematic and comprehensive study on the subject, the study team estimates that targeted Ecodesign and/or Energy Label

measures could lead to ErP material savings corresponding to primary energy savings around 160 PJ/a.

6.2.12 Ecological profile

The applicability of ecological profiles according to Annex I of Ecodesign Directive 2009/125/EC could be further examined in the next Working Plan. Future legislative implementation is recommended by:

- Standardisation mandate to develop a kind of standard (reporting) template to be used as basis for ecological profiles in Ecodesign implementing measures, allowing better transparency and comparability among different products and the definition of assessment criteria facilitating the compliance assessment of ecological profiles by market surveillance authorities.
- Applying Annex I on those energy-related products (ErP) currently or in future regulated under EU Ecodesign and Energy Labelling where the method for setting specific minimum ecodesign requirements according to Annex II of Ecodesign Directive 2009/125/EC is limited or cannot be applied; by a) solely applying Annex I of Ecodesign Directive 2009/125/EC; b) by using a hybrid approach combining specific minimum requirements according to Annex II with an ecological profile according to Annex I; or c) applying Annex I (generic requirements) and Annex II (specific requirements) by combining different product policy instruments (Ecodesign, Energy Labelling, Ecolabel, or Green Public Procurement).

6.2.13 Durability and firmware

It is recommended to include "durability" as priority topic in the next Working Plan. There are high energy, GHG emissions and resource savings; prolonging the use of products also has significant reduction potential for further environmental and social impacts resulting from the extraction and use of materials of otherwise newly-manufactured products. To exploit the savings potential as far as possible, future legislative implementation of durability (to be prepared by a horizontal preparatory study) is recommended by:

- Setting horizontal minimum requirements on durability for all ErPs (defining exemptions to the application of specific aspects, for example by excluding product categories with long lifetimes, low failure rates, low manufacturing stage impacts, etc.).
- Defining priority product groups where - beyond horizontal minimum requirements - more stringent durability performance requirements could apply at a product-specific level.
- Introducing labelling requirements on durability.

Firmware is included in this initiative because there are high energy, GHG emissions and resource savings due to prolonging the use of products by reducing software-related hardware obsolescence, preventing the risk of deteriorated energy and resource efficiency after software updates. To exploit the savings potential as far as possible, future legislative implementation of durability (to be prepared by a horizontal preparatory study) is recommended by:

- A) Setting horizontal minimum requirements on firmware / system software for all ErPs to increase durability by reducing software-related hardware obsolescence.
- B) Including and further specifying requirements on software updates horizontally or as pre-requisite in all product-specific Ecodesign and Energy Labelling regulations to reduce the risk of deteriorating energy/ resource efficiency of products after updates.

- Consideration of interfaces with other legislation and initiatives, such as Sale of Goods Directive, Digital Content Directive, or the up-coming 'empowering consumers for the green transition' initiative.

6.2.14 Scarce and critical raw materials

It is recommended to include critical raw materials (CRM), and in a broader sense, relevant raw materials with higher risks of high environmental impacts during their mining production as priority topic in the next Working Plan.
On the basis of a prioritisation scheme of raw materials being CRM and/or having high or medium to high environmental risks and impacts (see Annex), future legislative implementation (to be prepared by a horizontal preparatory study) is recommended by:

- Updating the MEErP and EcoReport tool to the 2020 EU CRM list and other relevant raw materials with high environmental risks/impacts during their mining production.
- Setting horizontal minimum requirements on these raw materials (e.g. information / declaration requirements) applicable to ErPs containing these raw materials.
- Defining priority product groups where - beyond horizontal minimum requirements - more stringent requirements could apply at a product-specific level (e.g. use of secondary raw materials, design for recycling).
- Exploring further means of addressing the "Circular Economy" value of Critical Raw Materials (CRM) and other raw materials with high environmental risks/impacts, aiming at retaining these materials within the EU.
- Outlook: Developing / applying a methodology composed of multiple indicators to additionally combine social impacts together with supply and environmental risks and impacts or commonly used raw materials, e.g. in the framework of the Sustainable Products Initiative (SPI) as envisaged in the Commission's European Green Deal.

6.2.15 Application software

Regarding potentially setting efficiency requirements on application software, it is recommended to initiate a feasibility study on the possibility of setting energy and resource efficiency measures on application software.

7 ANNEX A: LONG LIST OF PRODUCT GROUPS AND HORIZONTAL INITIATIVES

The list is divided into product groups and horizontal initiatives and sorted in alphabetic order.

Product groups

Aerials, antennas, radars, radio navigation and control items
Air filters for ventilation units
Air purifiers
Aircurtains
Amusement park and fairground equipment
Anti-legionella water equipment
Aquarium equipment other than pump
Base stations & subsystem
Basic electronic unit parts (capacitors, resistors, printed circuits)
Battery-powered ICT devices
Blowers
Centrifugal clothes driers
Clothes ironing products, tertiary (ironing machines and presses)
Cloud computing
Cold water applications, other equipment
Commercial lighting equipment
Common power adaptors
Construction products
Cooling towers & fans
Curtains, interior & exterior blinds, shutters, solar shadings
Decalcifiers of drinking water for home and commercial (restaurants, bars)
Defibrillators
Detergent
District heating and district cooling pipes
Domestic and commercial steam ovens, fryers and grills (not yet covered)
Domestic kitchen appliances incl. toasters
Drinking water circulators
Drones / quadrocopter
Ducts and duct systems
Electric music instruments
Electric toys
Electric vehicle chargers
Electrical insulators
Electrically operated clocks and watches
Elevators, escalators and moving walkways
Energy harvesting subsystems
Energy using equipment used in means of transport (other than refrigerated containers)
Equipment transformers
Fixed tap water heating devices

Fluid handling
Fluid power: hydraulic and pneumaticequipment
Fuels and additives
Games consoles
Gaming automates and tables
Goods transport and logistic systems
Greenhouse covers
Gymnasium or athletics articles - treadmills
Hair dryers
Handheld power tools
Healthcare products
Hot food presentation and storage equipment
Humidifiers and dehumidifiers (domestic, tertiary, industrial)
Imaging equipment and consumables
Industrial cleaning of articles
Industrial drying of articles (not materials)
Industrial equipment for special processes
Industrial machines for food manufacture (other than ovens)
Industrial process heating equipment, other than ENTR 4
Industrial robots
Industrial sensing and controlling
Industrial sensors
Infrared reflective paints ("cool roof coatings")
Interconnected home audio, video & voice service equipment (not yet covered)
Inverters and converters
IoT battery driven sensors
Large scale electrolysis equipment
Lasers
Lathes, milling machines and drilling centres
Lawn and ride-on mowers
Lighting applications not covered by existing lots
Low-temperature space heating radiators/convectors
Lubricants
Luminaires
Machinery not belonging to group "transport"
Machines and equipment for textile and clothes industry
Material processing equipment other than ENTR 5
Measuring transformers
Medical equipment not covered by SRI, Diagnostic and Therapeutic
Medium / large power generation
Medium large electric power transport and distribution
Medium/large electric power storage
Mining / tunnelling machinery
Mobile (outdoor) equipment
Mobile power generators
Non-tertiary coffee machines
Opto-chemical process equipment
Other ICT products from ICT study
Other special purpose ventilation

Packing equipment
Painting equipment, painting lines, powder coating plants
Paper production equipment, other than ENTR 5
Patio heaters
Person transport, other
Personal care: blowers (hand driers)
Personal care: equipment with motors and moving parts
Personal care: heating equipment
Personal care: suntanning equipment
Personal weighing scales
Photographic equipment
Plastics industry machines, other than ENTR 5
Power cables (domestic)
Pre-fabricated houses of small size for temporary use (garden houses)
Printing equipment incl. 3D-printers
Product design for optimising waste heat recovery
Professional cooking appliances
Professional dishwashing appliances
Professional kitchen appliances
Professional laundry appliances (washers & driers)
Professional sound and imaging equipment
Router, W-Lan-Router, Internet boxes, multimedia boxes
Safety and signaling lighting equipment
Satellites for (rural) internet
Sewing machines (domestic, tertiary)
Small network equipment for home and office use
Small scale electric power generation (<50 MW)
Small scale electric power storage (< 50 MW)
Small scale electrolysis equipment
Small-scale cooking products
Smart appliances
Smartphones and other telecom edge products
Soft starters
Solar shadings for windows
Soundbars
Space heating: ionisation heaters
Streaming services
Street lighting systems with/without PV
Swimming pool and spa equipment, permanently installed
Telecom end terminating equipment, non-portable
Tertiary hot beverage equipment incl. free-standing hot beverage vending machines
Textiles dry cleaning equipment
Thermal insulation (non building)
Thermal insulation of buildings
Uninterruptible Power Supplies
Universal batteries
Universal external power supplies
Unmanned aircrafts (drones)
Variable speed drives

Video projectors
Water cookers
Water pump units
Water, steam and sand cleaning appliances
Windows
Wired & wireless chargers (inductive chargers), other power supplies, common charger
Woodworking machinery: Thicknessing planer, jointer, sawmills etc

Horizontal Initiatives
Battery-driven products (horizontal)
Durability
Ecological profile
Firmware and software
IoT LAN/WAN initiative
Lightweight design
Market surveillance
Packaging
Packaging of medical products / disposable surgical instruments (as a substitute for sterilisation)
Post-consumer recycled content
Scarce and critical raw materials
Software and apps (horizontal)

8 ANNEX B: DETAILS FOR THE FICHES

8.1 Professional laundry appliances

Table 8. Base Cases and standards developed by CEN and CENELEC

Type of appliance	CEN TC214 WG05	CLC TC59X SWG1.12	CLC TC59X WG2.1
Washing Machines			
WM1: Semi-professional washer extractor		EN 50640:2018[51]	
WM2: Professional washer extractor, <15 kg			
WM3: Professional washer extractor, 15-40 kg			
WM4: Professional washer extractor, >40 kg	EN 17116-4:2019[52]		
WM5: Professional washer dryer			
WM6: Professional barrier washer			
WM7: Washing tunnel machine	EN 17116-3:2019[53]		
Dryers			
D1: Semi-professional dryer, condenser			
D2: Semi-professional dryer, air vented			
D3: Professional cabinet dryer			
D4: Professional tumble dryer, <15 kg		EN 50594:2018[54]	
D5: Professional tumble dryer, 15-40 kg			
D6: Professional tumble dryer, >40 kg	EN 17116-2:2019[55]		
D7: Pass-through (transfer) tumble dryer			

Market

Table 9. Sales and stock (in 1000 units)

	Sales (units x 1000)					Stock (units x 1000)				
Year	1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
GENERAL TOTAL	***96***	***103***	***114***	***126***	***139***	***989***	***1092***	***1207***	***1332***	***1472***
1. Non-household washing machines	**68**	**75**	**83**	**92**	**102**	**709**	**783**	**865**	**955**	**1055**
Washer-extractors < 40kg (WM1/2/3)	67.2	74.2	82.0	90.5	100.0	695	767	848	936	1034
Washer-extractors > 40kg (WM4/6)	1.0	1.1	1.2	1.3	1.4	13	14	16	17	19
Tunnel washer (WM7)	0.10	0.11	0.12	0.13	0.15	1.2	1.3	1.5	1.6	1.8
2. Non-household dryers	**28**	**28**	**31**	**34**	**37**	**280**	**309**	**342**	**377**	**417**
Condensor dryer (D1)	2.8	3.1	3.4	3.7	4.1	21	24	26	29	32
Air vented tumble dryer < 40kg (D2/4/5)	20.9	23.1	25.5	28.2	31.1	242	267	295	326	361
Air vented tumble dryer > 40kg (D6)	3.5	0.3	0.3	0.4	0.4	3.5	3.6	3.9	4.4	4.8
Pass-through dryer (D7)	1.1	1.2	1.3	1.4	1.6	13	14	16	17	19

[51] EN 50640:2018 Household and similar electric appliances - Methods for measuring the performance of clothes washing machines intended for commercial use (successor of prEN 50640:2017)

[52] EN 17116-4:2019 Specifications for industrial laundry machines - Definitions and testing of capacity and consumption characteristics - Part 4: Washer-extractors (successor of EN 17116-4:2017)

[53]EN 17116-3:2019 Specifications for industrial laundry machines - Definitions and testing of capacity and consumption characteristics - Part 3: Continuous tunnel washer (successor of EN 17116-3:2017)

[54] EN 50594:2018 Household and similar electric appliances -Methods for measuring the performance of tumble dryers intended for commercial use (successor of prEN 50594:2017)

[55] EN 17116-2:2018 Specifications for industrial laundry machines - Definitions and testing of capacity and consumption characteristics - Part 2: Batch drying tumblers (successor of EN 17116-2:2017)

Product

In the laundry equipment group the smaller capacity units, e.g. up to 40 kg capacity, have a similar built and technology as top-range household machines, with a dominant use of stainless steel for housing, drum and tub. The controls have a limited number of options compared to top-range household machines but are very robust and easy-to-use. The motor is typically more robust, not a universal motor with a belt drive but a sturdy AC motor or – in the more recent models – a brushless DC with variable speed drive. The medium to big-sized washer extractors and driers, with load-capacity of up to 100 kg, often have special provisions to enhance ergonomic loading. In a 2017 EMAS-document on optimised small-scale laundry operations in the hospitality sector also options for water re-use and heat recovery are discussed. [56]

Figure 3. (From left-to-right) dryer[57], tunnel-washer[58], big washer-extractor[59]

A technical discussion of the large laundry operations like tunnel washers is given in a 2017 EMAS reference document, prepared by JRC-IPTS. [56]

[56] Styles D., Schönberger H., Galvez Martos J. L., Best Environmental Management Practice in the Tourism Sector, EUR 26022 EN, doi:10.2788/33972. Extract 5.4 Optimised small-scale laundry-operations, Extract 5.5 Optimised large-scale or outsourced laundry operations. https://ec.europa.eu/environment/emas/takeagreen-step/pdf/BEMP-5.5-FINAL.pdf

[57] https://www.danube-international.com/img/galeria//IMG_5026.JPG, retrieved May 7, 2020.

[58] https://www.milnor.com/wp-content/uploads/2014/06/20140618ARCO-MURRAY-cwww.JackRamsdale.com2481-417x600.jpg, retrieved May 7, 2020.

[59] https://www.domuslaundry.com/img/galeria/dhs-120_touch_tilt-262.jpg, retrieved May 7, 2020.

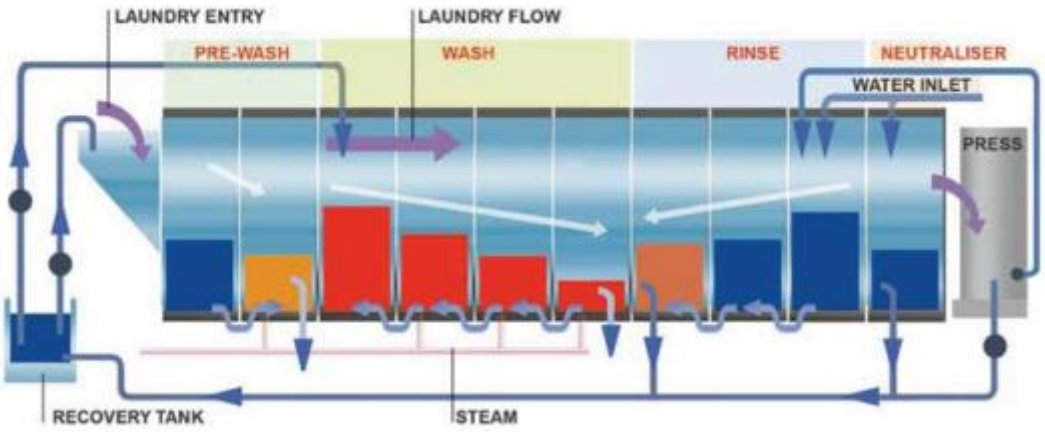


Figure 4. An example of a 10 module continuous batch washer with counter-flow water current and **steam heating** *(source: Girbaud in EMAS-report)*

Environmental and monetary impact

Table 10. Environmental and economic improvement scenario for the EU in 2030, in a scenario with measures ('ECO') versus Business-As-Usual ('BAU')[60]

impact	Energy primary		of which electric		Water		GHG		Acquisition		Expenditure	
scenario	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU
unit	*PJ*	*PJ*	*TWh*	*TWh*	*Mm3*	*Mm3*	*MtCO2*	*MtCO2*	*bn €*	*bn €*	*bn €*	*bn €*
Total	***169***	***-41***	***4.7***	***-1.3***	***327***	***-82***	***10.4***	***-2.5***	***0.9***	***0.2***	***6.9***	***-1.3***
Non-household washing m.	**42**	**-10**	**1.8**	**-0.4**	**327**	**-82**	**2.5**	**-0.6**	**0.6**	**0.1**	**2.9**	**-0.5**
Washer-extractors < 40kg	24.6	-4.9	1.6	-0.3	251	-60.4	1.4	-0.3	0.5	0.1	2.0	-0.3
Washer-extractors > 40kg	4.1	-0.9	0.1	0.0	28	-8.4	0.2	-0.1	0.1	0.0	0.3	0.0
Tunnel washer	13.3	-4.2	0.1	0.0	48	-12.8	0.9	-0.3	0.1	0.0	0.6	-0.2
Non-household dryers	**127**	**-31**	**2.9**	**-0.9**	**-**	**-**	**7.9**	**-1.9**	**0.3**	**0.1**	**4.0**	**-0.8**
Condensor dryer	1.3	-0.5	0.1	-0.1	-	-	0.1	0.0	0.0	0.0	0.0	0.0
Air vent.tumble dryer < 40kg	29.8	-11.0	1.5	-0.6	-	-	1.8	-0.7	0.1	0.1	1.0	-0.3
Air vent.tumble dryer > 40kg	4.5	-1.5	0.1	0.0	-	-	0.3	-0.1	0.0	0.0	0.1	0.0
Pass-through dryer	91.6	-18.1	1.1	-0.2	-	-	5.8	-1.2	0.1	0.0	2.8	-0.5

Note that since the above projections were made for the EU, in 2014, there have been several events that will have diminished the positive outcome: The UK left and Croatia entered the EU (-13%), the primary energy factor for electricity decreased (from 2.5 to 2.1), not all base cases were covered by the standards and the implementation of measures was delayed by a few years due to the lack of standards. In summary, the benefits in the year 2030 will be at least 20% less than indicated above, but still considerable.

[60] Pers. Comm. VHK, 2014.

8.2 Professional dishwashers

Table 11. Base Cases and CENELEC standard

Type of appliance	CLC TC59X WG2.1
DW1: Undercounter	EN 63136:2019[61]
DW2: Hood-type	
DW3: Utensil/Pot (drafts are known)	Possibly in the future
DW4: Conveyor-type one-tank	
DW5: Conveyor-type multi-tank	

Market

Table 12. Sales and stock (in 1000 units)

	Sales (units x 1000)					Stock (units x 1000)				
Year	1990	2000	2010	2020	2030	1990	2000	2010	2020	2030
Non-household dishwashers	**192**	**213**	**235**	**259**	**287**	**1576**	**1741**	**1923**	**2124**	**2347**
Water-change (DW1)	16.0	17.7	19.5	21.6	23.8	182	201	222	245	271
One tank (DW2/3)	167.1	184.5	203.9	225.2	248.7	1291	1426	1575	1740	1922
One tank pots/utensils (DW4)	2.2	2.4	2.6	2.9	3.2	17	18	20	22	25
One tank conveyor-type (DW5)	5.9	6.5	7.1	7.9	8.7	67	73	81	90	99
Multiple tank (DW6)	1.2	1.3	1.4	1.6	1.7	18	20	23	25	28

Environmental and monetary impact

Table 13. Environmental and economic improvement scenario for the EU in 2030, in a scenario with measures ('ECO') versus Business-As-Usual ('BAU')

impact	Energy primary		of which electric		Water		GHG		Acquisition		Expenditure	
scenario	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU	BAU 2030	ECO-BAU
unit	*PJ*	*PJ*	*TWh*	*TWh*	*Mm3*	*Mm3*	*MtCO2*	*MtCO2*	*bn €*	*bn €*	*bn €*	*bn €*
Non-househ. dishwashers	**136**	**-22.0**	**14.2**	**-2.2**	**152**	**-17**	**7.2**	**-1.2**	**1.3**	**0.7**	**5.8**	**0.0**
DW1 Water-change	2.9	-0.2	0.3	0.0	7	-1	0.2	0.0	0.1	0.0	0.2	0.0
DW2 One tank	85.9	-11.2	9.5	-1.2	108	-13	4.4	-0.6	1.0	0.5	3.8	0.2
DW3 One tank pots/utensils	0.1	0.0	0.0	0.0	0	0	0.0	0.0	0.0	0.0	0.0	0.0
DW4 One tank conveyor-type	27.3	-6.0	2.6	-0.6	21	0	1.5	-0.3	0.1	0.1	1.0	-0.1
DW5 Multiple tank conveyor-type	20.2	-4.5	1.7	-0.4	15	-3	1.1	-0.2	0.1	0.0	0.7	-0.1

Note that since the above projections were made for the EU, in 2014, there have been several events that will have diminished the positive outcome: The UK left and Croatia entered the EU (-13%), the primary energy factor for electricity decreased (from 2.5 to 2.1), not all base cases were covered by the standards. In summary, the benefits in the year 2030 are estimated to be at least 20% less than indicated above, but still significant.

[61] EN 63136:2019 Electric dishwashers for commercial use - Test methods for measuring the performance (successor of EN 50593:2017)

8.3 Professional cooking appliances

EU stock of professional cooking equipment

Please notice that stock data in this section have not been updated after new data from stakeholders were received – as mentioned in Task 3 report. The energy saving potentials have been updated.

Table 14. Forecasts of the EU stock of professional cooking appliances (1000s, own calculations)[62].

Product category	Sub category	Heat source	2020	2025	2030
Ovens	Static oven	Electricity	-	-	-
		Gas	-	-	-
	Convection oven*	Electricity	275	284	308
		Gas	60	62	68
	Steam and combi oven	Electricity	2,477	2,559	2,774
		Gas	544	562	609
	Other; Air impingement, microwave and hybrid (rapid cooker)	Electricity	306	316	342
		Gas	67	69	75
Hobs and grills	Grills including chargrill	Electricity	318	329	356
		Gas	318	329	356
	Fry-tops	Electricity	637	658	713
		Gas	318	328	356
	Hobs, gas	Electricity	-	-	-
		Gas	2,029	2,096	2,272
	Hobs, induction	Electricity	314	324	352
		Gas	-	-	-
	Hobs, infrared	Electricity	374	386	419
		Gas	-	-	-
	Hobs, electric resistance	Electricity	665	687	744
		Gas	-	-	-
Steam cookers		Electricity	1,019	1,053	1,142
		Gas	224	231	251
Bain-marie		Electricity	829	856	929
		Gas	414	428	464
Fryers		Electricity	2,488	2,569	2,786
		Gas	1,242	1,283	1,391
Bratt pans		Electricity	277	286	310
		Gas	138	143	155
Pasta cookers		Electricity	138	143	155
		Gas	69	71	77
Range hoods		Electricity	3.646	3.766	4.082
Total			**19,187**	**19,817**	**21,483**

Energy consumption of professional cooking equipment

Please notice that energy consumption data in this section have not been updated after new data from stakeholders were received – as mentioned in Task 3 report. The energy saving potentials have been updated.

Table 15. Primary annual energy consumption in kWh per appliance[63].

Product	Fuel	Lifetime [years]	Estimated yearly primary energy consumption per standard kWh/appliance
Ovens			

[62] Combination of table 20 and 21 from Task 3 report.

[63] Based on own calculations from Energy Star requirements combined with information from: S. Mudie[1], E.A. Essah[1], A. Grandison[1] and R. Felgate[4] (2013), Electricity Use in the Commercial Kitchen, University of Reading, Reading, Berkshire, UK, [2]Mitchells & Butlers plc., Birmingham, UK, Printed in International Journal of Low-Carbon Technologies, Oxford University Press

Product	Fuel	Lifetime [years]	Estimated yearly primary energy consumption per standard kWh/appliance
Static oven	Electricity	12	13860
	Gas	18	17584
Convection oven	Electricity	11	13860
	Gas	18	17584
Steam and	Electricity	11	19459
combi oven	Gas	11	14639
Hobs and grills, inkl. griddles and ranges			
Grills including	Electricity	10	27300
Chargrill	Gas	11	35169
Fry-tops / griddles	Electricity	10	27300
	Gas	11	35169
Hobs, gas	Gas	11	35000
Hobs, induction	Electricity	10	20000
	Gas	11	
Hobs, infrared	Electricity	10	20000
	Gas	11	
Hobs, electric resistance	Electricity	10	20000
	Gas	11	
Steam cookers	Electricity	12	40250
	Gas	12	63499
Bain-marie	Electricity	10	17815
	Gas	10	22269
Fryers	Electricity	10	50400
	Gas	11	58614
Bratt pans	Electricity	11	27300
(Tilting bratt pans)	Gas	11	35169
Pasta cookers	Electricity	11	11573
	Gas	11	7145
Range hoods	Electricity	11	3549

Aggregate EU use phase saving potential of professional cooking appliances excluding range hoods for 2030 assuming the stock was replaced with more efficient models (**Error! Reference source not found.**). These figures were updated with the new data received from stakeholders. See below the table.

Table 16. Aggregate EU use phase saving potential of professional cooking appliances stock excluding range hoods (primary energy GWh. Source: Own calculations adjusted with data input from EFCEM and HKI)

Product category	Primary energy savings 2030	
	GWh/year	PJ/year
Convection ovens	1,610	5,796
Steam and combi ovens	7,027	25,297
Grills including chargrill Rise and fall grill	5,366	19,316
Fry-tops / Griddle plates	4,934	17,763
All hobs: gas, induction, infrared and electric resistance	3,796	13,664
Bain-marie (electric and gas)	1,859	6,692
Fryers	3,510	12,635
Bratt pans and kettles (incl. tilting)	4,254	15,314

Pasta cookers (electric and gas)	262	943
Total	**32,617**	**117,422**

As the table shows, the total energy saving potential in 2030 for the use phase for all professional cooking appliances excluding range hoods is calculated to be about 33 TWh/year (117 PJ/year) for gas and electricity combined.

Adjustments were made on the basis of new data inputs from stakeholders; primarily data from EFCEM (European Federation of Catering Equipment Manufacturers) and HKI (industrial association of House, Heating and Kitchen Technology). After the second stakeholder meeting, EFCEM and HKI provided more accurate estimations on the European stock of professional cooking appliances (extrapolated from the German market)[64] in addition to commenting on the assumptions made for the first version of the current task 3 study. The study team assessed the data and information and used the data for the above adjustments of the resulting energy saving potential where appropriate.

The main input used for the adjustments are the following:

Regarding stock data: Overall the estimated stock of appliances in the current study (15.5 mill.) is in line with the estimate from EFCEM/HKI (12.4 mill.). However, for individual product groups EFCEM/HKI suggests some major shifts which will impact the saving potentials significantly:

- For convection ovens, HKI expects the double (HKI 688,000 vs. 335,000 first estimated by the study team).
- For steam and combi ovens, HKI expects the half (HKI 1,580,000 vs. 3,020,000).
- For the group `Other´ the total number is about 5-6 times larger (HKI 1,760,000 micro ovens and 197,000 pizza ovens (air impingement) vs. 373,000 totally), however this category is still assumed to have neglegible savings potential.
- For grills HKI expects around 50 % more (HKI 1,530,000 rise and fall grills vs 636,000)
- For frytops / griddle plates HKI expects the stock is about two and a half times (HKI 1,470,000 vs 955,000)
- For hobs in general about a third stock is expected by HKI (HKI 1,169,000 vs 3,380,000)
- Steam cookers are not so common in the EU (HKI estimates 20,000 vs. 1,240,000) and is therefore considered negligable. This is one of the product groups for which a significant saving potential was assumed in the first draft version.
- For fryers, HKI finds the stock to be around the half (HKI 1,720,000 vs 3,730,000). Specifically for fryers HKI mentions that the extrapolation from the German market probably will underestimate the stock since other parts of EU have other food traditions. Together with the above mentioned correction for the expected lower energy consumption for European fryers, the total aggregated potential savings on fryers are

[64] Adrian Brändle, Estimation of the stock of food service equipment in professional kitchens on the EU 27 market, Industrieverband Haus-, Heiz- Und Küchentechnik E.V HKI (2021)

cut by 75 % compared to the original estimates. Fryers is one of the product groups for which a significant saving potential was estimated.

- For tilting bratt pans and kettles, HKI expects the stock to be three times as large (HKI 1,270,000 vs 415,000)
- For pasta cookers the same as for tilting bratt pans and kettles

Additionally, EFCEM/HKI mentions multipurpose cooking appliances (367,000), pressure boiling kettles (66,000), pressure bratt pans (80,000), woks (214,000) and belt frying automats (3,000) as common cooking appliances. The sales/stock, energy consumption, and saving potentials of these would probably be too low to be relevant for this study.

Furthermore, it is assumed that Covid 19 will have more than a short term impact on the market development and stock. EFCEM[65] informs that the impact of Covid19 on their member companies' markets is more severe than expected in the current study. The market has shown a 25-30 % decrease in 2020, a drop that is expected to continue in 2021 and the reason is similar problems in the sector of professional kitchens. Furthermore, a large number of used appliances are expected on the market for the coming years, and there might be a long-term impact on the number of kitchens and nature of their business in the coming years (less business travel, more home office etc.). In a preparatory study this development and the degree of recovery of the market must be followed and the long-term impact on the stock from 2030 and beyond analysed further.

Regarding the energy saving potential, some main points are that:

- The energy consumption values to use for the energy saving calcuations are based on the US Energy Star label, which probably are overestimated due to larger and less efficient equipment in USA. This is particular the case for the fryers. For the revised estimate, the energy consumption is supposed to be closer to the measurements by Mudie et al (2013)[66]
- 3-layer glass is already now more common than suggested in the current study.
- Steam injector for steam ovens might not be a good solution because it will leave out a large share of the expected improvement potential.

[65] European Federation of Catering Equipment Manufacturers EFCEM, Stakeholder comment 26th March 2021

[66] S. Mudie[1], E.A. Essah[1], A. Grandison[1] and R. Felgate[4] (2013), Electricity Use in the Commercial Kitchen, [1]University of Reading, Reading, Berkshire, UK, [2]Mitchells & Butlers plc., Birmingham, UK, Printed in International Journal of Low-Carbon Technologies, Oxford University Press

8.4 Low temperature emitters

System

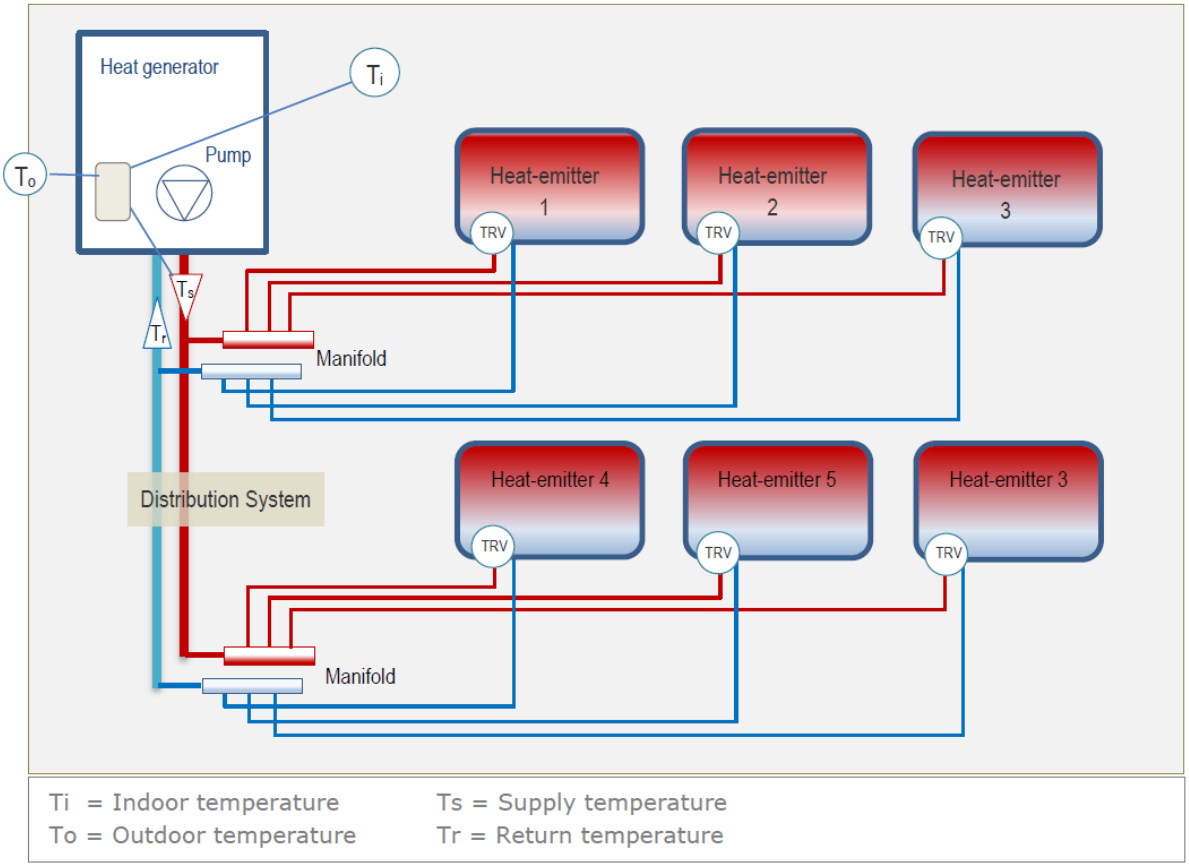


Figure 5. *Space Heating Components* *(source: Review Study of Commission Ecodesign and Energy labelling Regulation on Space and Combination heaters – Task 4, p.28)*

Table 17. *Heat load, system temperatures and average emitter capacity over the years (source: Viessmann, Vaillant et al.)*

Year of construction	Heat load dwelling [W/m2]	System design temperature	Avg. emitter capacity @ design temp. for avg. 100m^2 dwelling
Old (before 1960)	≥ 250	80°C	>25 kW
1960 – 1977	130 - 250	80°C	20 kW
1977 – 1982	70 – 130	70°C	13 kW
1982 – 1995	60 – 100	70°C	10 kW
1995 – 2002	40 – 60	65°C	6 kW
2002 – 2009	30 – 50	60°C	5 kW
2009 –	25 – 40	50°C	4 kW
Passive house	≤ 15	40°C	< 2 kW

Market

Market research companies indicate that the *hydronic radiator market* is expected to expand again in the EU with an annual growth rate of around 2.5% due to an increased

activity in the building construction and renovation market[67]. In 2018 the market size was estimated at 1.2 billion euro.

In 2014 the total amount of radiator sales in the EU (UK excluded) was around 26.5 million units. The radiator market had been declining since 2004 and from 2014 to 2018 it even declined slightly further than before. This measured decline was principally due to the stagnant market in building construction and the growing application of floor heating at the cost of wall mounted emitters in the newbuilt market.
The largest share of the radiator sales relates to hydronic emitters (see Figure 6. Market heat emitters and their types 2014 (various sources).Market heat emitters and their types 2014 (various sources).. The number includes various types of emitters, amongst which:

- steel panel radiator (share: 49%)
- aluminium radiator (share: 14%
- convectors (share 1.5%)
- electric emitters (share: 15%)
- other (share: 20.5%)

These 'other emitters' include oil filled emitters, cast iron emitters, towel warmers and decorative steel tubular emitters (see Figure 6).

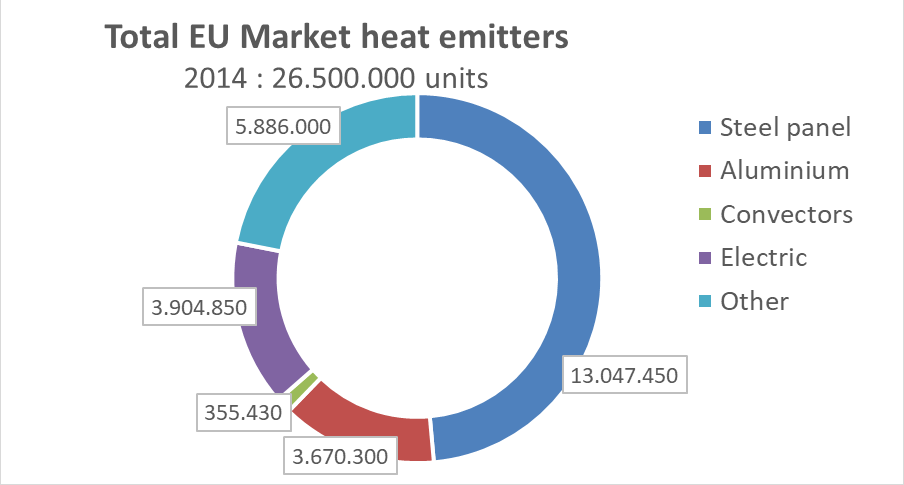


Figure 6. Market heat emitters and their types 2014 (various sources).

[67] Global Market Insights, *Europe Hydronic Radiators Market Forecasts – 2019-2025 Report* (May, 2019) https://www.gminsights.com/industry-analysis/europe-hydronic-radiators-market

Product

At the same outer dimensions (LxHxD= 1000 x 500 x 140 mm) the ***LT radiator has a ~50% higher heat output*** than the ***standard steel radiator*** both in static and forced low temperature regime of 45/35/20 oC (supply/return/ambient temperatures). This is shown in the first and last yellow columns of figure 3. The aluminium radiators, popular only in parts of the EU and generally more expensive, have a better performance than the steel radiator but still 20% less than an optimised LT radiator.

Compared to a **standard copper-aluminium (Cu/Al) convector** and at the same outer dimensions, the ***LT product has a 40% higher heat output*** at the same forced low temperature temperature regime.). This is shown in the second and last orange columns of figure 3.

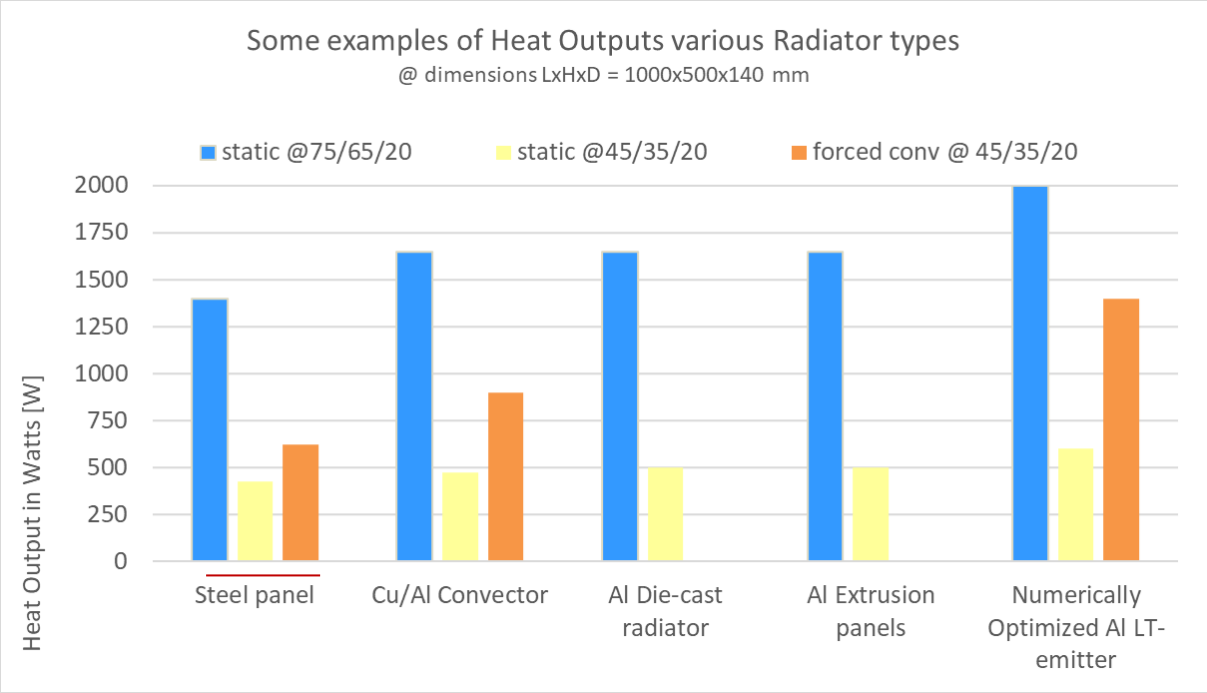


Figure 3. Examples of heat emitters and their heat output at standard and low temperature regimes (source VHK 2020)

8.5 Swimming pool heaters

Resource efficiency

Average lifetimes for swimming pool heaters are estimated at:

- Gas heaters: 7.5 years
- Heat pumps: 10 years
- Electric heaters: 4.5 years
- Solar heaters: 12.5 years

Oil heaters are not seen to have any significant position on the market.

Average weight of gas heaters and heat pumps is 75 kg and 100 kg, respectively, and the main content is steel (62% and 85%). Average weigth of electric heaters is 8 kg and of solar heaters is 82 kg.

Assumed BoM of swimming pool gas heater

Material	Share [%]	Weight [kg]
Plastics	8.0%	6.0
Steel – galvanized	62.1%	46.6
Cast iron	2.6%	2.0
Ins. Ceramic	1.8%	1.4
Stainless steel	5.9%	4.4
Aluminium die cast	4.3%	3.2
Copper	9.4%	7.1
Brass	3.6%	2.7
Electronics	1.5%	1.1
Others	0.8%	0.6
Total	100.0%	75.0

Assumed BoM of swimming pool heat pumps

Material	Share [%]	Weight [kg]
Steel	85%	83
Titanium	2%	2
Plastics	14%	14
R410a refrigerant	1%	1
Total	100%	100

Assumed BoM of swimming pool electric heater

Material	Share [%]	Weight [kg]
Plastics	24.2%	1.9
PA6	24.8%	2.0
Steel - galvanised	3.8%	0.3
Stainless steel	3.6%	0.3
Copper	14.0%	1.1
Brass	10.5%	0.8
Electronics	9.1%	0.7
Others	10.0%	0.8
Total	100%	8.0

Assumed BoM of swimming pool solar heater.

Material	Weight [kg]
Heated glass	12
Copper	5
Aluminium	11
Steel	40
Polyurethane	7
Fibre glass	5
EPDM	2

Material	Weight [kg]
Total	82

8.6 Enterprise network equipment

Potential energy and GHG savings 2030

The saving potential is calculated on the basis of a complete replacement of the stock of standard switches and routers in enterprises, public organisations and data centres, totally about 17 million units in 2030 for EU27. The economic lifetime is assumed to be 10 years. The annual electricity consumption including overhead for cooling, UPS etc. is about 10 TWh corresponding to 76 PJ in primary energy consumption (conversion coefficient: 2.1). Average energy savings are estimated at 30% resulting in primary energy savings of about 22 PJ in 2030.

8.7 Small network equipment for home and office use

Potential energy and GHG savings 2030

The standby regulation already regulates standby and networked standby, which is responsible for approximately half of the energy consumption. This means that the active mode of small networking equipment for home and office use is responsible for a consumption of 14 TWh electricity (108 PJ of primary energy) each year. Hence, even minor energy improvements can have a significant impact. Based on data from The Power Consumption Database[68], it seems that a product such as a router can have an energy consumption of 1 watt to 10 watts and even up to 20 watts or higher. Based on these numbers, it seems that there is a potential for a significant energy saving by setting a limit on the active mode power consumption and push the manufactures to produce energy-efficient BAT (Best Available Technology) products.

Also, it is essential to consider the power allowances in standby and networked standby. When products gradually move from standby to network standby, the annual energy consumption is expected to increase.

Table 18 shows the energy saving potential for replacement of current stock.

[68] The Power Consumption Database (tpcdb.com)

Table 18: Energy saving potential 2030 for replacement of current stock

Product type	Energy saving		CO2 saving Kt CO2
	Annual electricity savings	Annual primary energy savings[69]	
	TWh	PJ	
Home Network Attached Storage equipment (NAS)	0.4	3.0	152
Home/office network equipment	4.9	36.8	1862
IoT Cellular Gateway	0.1	0.5	38
IoT Home/Office Gateway	0.2	1.5	76
Complex set top boxes	2.6	19.6	988
Other equipment (Wi-Fi extenders, powerline adapters and other small products)	1.1	8.0	418
TOTAL	**9.2**	**69.3**	**3496**

In addition, by applying resource efficiency requirements such as minimum requirements for firmware and software updates (to secure as a minimum security updates) and, in some cases, upgradeable design (software and hardware), the lifetime can be improved. If the lifetime of each product can be improved by an average of one year, the approximate savings in CO2 would annually be an additional 75 kt.

Further materials savings may be obtained if performance requirements and interoperability between MESH compatible routers are implemented.

8.8 Universal external power supplies

Scope

The suggested scope is based on the existing ecodesign regulation for EPSs covering energy efficiency and no load losses: Commission Regulation (EU) 2019/1782). It defines an EPS as a device that meets the following criteria:

- (a) it is designed to convert alternating current (AC) power input from the mains power source input into one or more lower voltage direct current (DC) or AC outputs;
- (b) it is used with one or more separate devices that constitute the primary load;
- (c) it is contained in a physical enclosure separate from the device or devices that constitute the primary load;
- (d) it is connected to the device or devices that constitute the primary load with removable or hard-wired male/female electrical connections, cables, cords or other wirings;
- (e) it has nameplate output power not exceeding 250 watts;
- (f) and it is used with electrical and electronic household and office equipment included in Annex I, which contains a list of electrical and electronic household and office equipment including toys, leisure and sports equipment.

The regulation excludes the following types of power supplies:

[69] A CC factor of 2.1 is used

- voltage converters;
- uninterruptible power supplies;
- battery chargers without power supply function;
- lighting converters;
- external power supplies for medical devices;
- active power over Ethernet injectors;
- docking stations for autonomous appliances;
- external power supplies placed on the market before 1 April 2025 solely as a service part or spare part for replacing an identical external power supply placed on the market before 1 April 2020, under the condition that the service part or spare part, or its packaging, clearly indicate 'External power supply to be used exclusively as spare part for' and the primary load product(s) it is intended to be used with.

Potential energy and GHG savings 2030

The overall assumption is that EPSs to a higher degree than now are unbundled from the product and can be used for several products and product types and can be transferred from an old product to a new product replacing the old product and thereby reducing the sale and manufacturing of EPSs.

The assumptions in reductions are based on the common charger study. The study considered two overall policy options: Increased interoperability (via several levels of increased interoperability) and decoupling of EPS and the product (via three scenarios, lower case, mid case and higher case).

Based on the study and simplifying the assessments, the following two scenarios have been established, indicating the percentage reduction in EPS sales and manufacturing compared to the baseline scenario:

- Mid case decoupling scenario combined with interoperability: 17% reduction
  - This is considered the most realistic scenario in the common charger study.
  -
- High case decoupling scenario combined with interoperability: 37% reduction
  - This is considered as the maximum possible scenario in the common charger study.

In the common charger study, separate reduction assumptions for EPS and cable have been established, while here, a weighted average based on the weight of the EPS and the cable is used.

It was not in the scope of the common charger study to consider a mandatory requirement for manufacturers and distributors to decouple power adapters from phones. The decoupling rates therefore, are based on the likely impacts of voluntary initiatives. The decoupling rates are thus depended on to what extent the manufacturers and distributors decide to offer phones without a charger and to what extent the consumers choose to buy phones without a charger. The decoupling rates comes with uncertainty because no one knows how the market will react to the initiatives—however, the common charger study based the assumptions on consumer surveys and industry stakeholder consultations.

The conclusion is that an initiative for a universal EPS could provide 3-7 PJ savings in primary energy consumption for the 2020 sales and 12-27 PJ savings for the total 2020 stock for a total replacement in addition to corresponding savings in material, GHG emissions and consumer expenditure.

8.9 Uninterruptible power supplies

Potential energy and GHG savings 2030

Based on the efficiencies provided in a draft proposal for an updated CoC for UPS systems and on the comments received from the industry, it seems that the current efficiency has reached the "intermediate level" from the preparatory study. The BAT scenario from the preparatory study is still used as an indicator for the possible savings.

The total saving potential[70] for electricity consumption amounts to 7.2 TWh in 2030. Savings in embedded energy by increasing product lifetime by 20% are marginal compared to the use phase savings and estimated to be 0.8 PJ.

The saving potential[70] for GHG emissions related to electricity consumption amounts to 2.5 MT CO2eq in 2030. The savings in embedded GHG emissions are marginal in comparison at 44 kt CO2eq.

While it is important to take into account the energy consumption and related GHG emissions, several social and local environmental effects are imperative to take into consideration in the case of battery production. UPS, and in particular batteries, pose a significant fire risk. UPS are often operating without surveillance, and close to flammable equipment (IT equipment, cables etc.). Accidental fire can have tragic social impacts and significant environmental impacts (smoke pollution, material loss).

Social impacts are especially linked to the raw material extraction and processing in the battery supply chains. Some specific metals give rise to especially severe concerns such as child and forced labour, or generally detrimental working conditions[71]. Furthermore, some of the materials originate from conflict areas, where armed conflict is present, or the risk of armed conflict breaking out is severe. Local environmental impacts from mining and refining raw materials cover a wide range, from leaching toxic chemicals into waterways and ecosystems to local air pollution from dust and toxic gasses. Furthermore, mining areas are also frequently subject to the removal of vegetation and topsoil, with large impacts on local ecosystems. Hence, it is important to focus on proper resource management of batteries at End-of-life to minimise these impacts.

8.10 Industrial smart sensors

EU market for smart industrial sensor

Market and stock data is based on the ICT study[72] and summarized in Table 19 below. In conclusion the European Union market was €1.92bn sales in 2020. At an end-user price of €220/unit this results in sales of around 8.6 million units in 2020 in the EU.

[70] Note that these projections are all based on lead-acid (VRLA) batteries and did not take into account the technology switch from VRLA to lithium-ion batteries. It also did not take into account improved 'smart grid' control options.

[71] Follow-up feasibility study on sustainable batteries under FWC ENER/C3/2015-619-Lot 1

[72] ICT Impact study July 2020. Prepared by VHK and Viegand Maagøe for the European Commission

Table 19. EU market figures for 2020

Global sales	40	billion Euro[73]
Industrial sector	19	%
EU share of global sales	25.3	%
Sales EU industrial sector	1.92	billion Euro
Price/unit	220	Euro
Units sold in EU industrial sector	8.7	million

With an average product life of 5 years (considering that the battery is non-replaceable), the stock is calculated to be 53.4 million units in 2020 and 120.8 million units in 2025. Sales and stock are shown in the graph below and table 2.

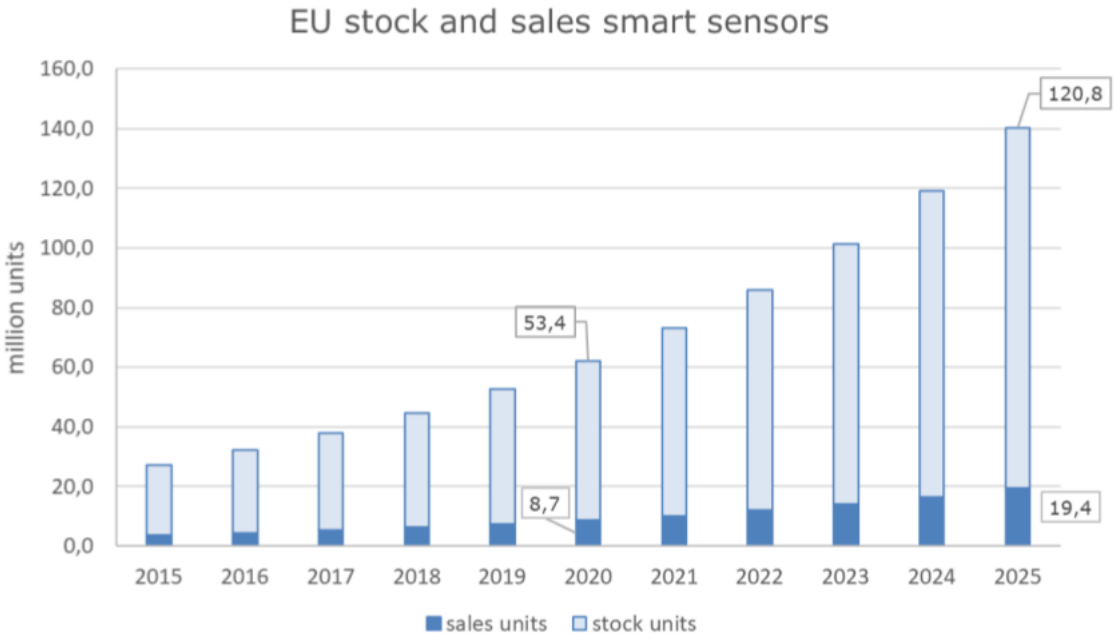


Figure 7: Sales and stock of industrial smart sensors in the EU

Table 20. Sales and stock

Sales [mln. units]			Stock [mln. units]		
2015	**2020**	**2025**	**2015**	**2020**	**2025**
4	8.7	19.4	26	53.4	120.8

Energy consumption and savings of smart sensors

[73] Conversion from USD from Global Market Insights, Report on Smart Sensors: https://www.gminsights.com/industry-analysis/smart-sensor-market and https://www.slideshare.net/Abhishekjha244/smart-sensor-market-forecast-and-industry-analysis-report-2016-2024 and https://www.variantmarketresearch.com/press-release/global-smart-sensors-market-is-estimated-to-reach-101-billion-by-2025-says-variant-market-research

The total energy use per smart sensor is derived from the consumption the different parts as illustrated in the drawing below[74]: 0.36 Wh/yr (sensor and electronics) + 0.006 Wh/yr (sensor communication) + 0.24 Wh/yr (gateway communication to remote storage) + 0.042 Wh/yr (writing data on remote storage) + 1 Wh/yr (data analysis and interface)[75] = **1.65 Wh/yr**.

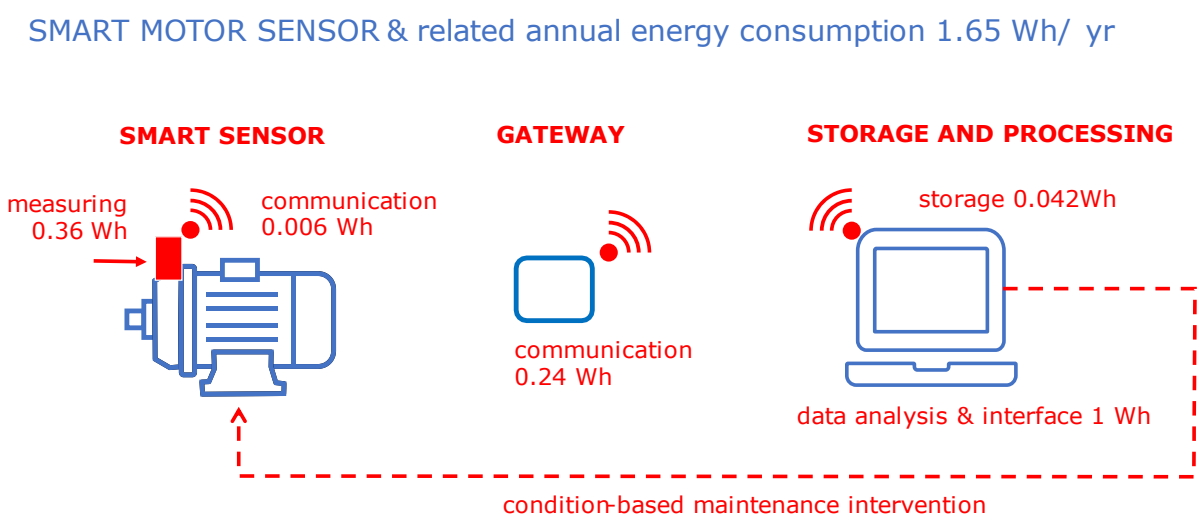


Figure 8: Energy consumption components in smart monitoring
Source: ICT Study 2020

The EU stock in 2020 of around 53.4 million units will then use around 88 MWh/yr when one sensor consumes 1.65 Wh/year. In Table 21 it can be seen that the primary energy used to produce materials for the industrial smart sensors is almost 6 times higher.

Table 21: Energy and material input of industrial sensors 2020

Annual input EU-27 2020	**ENERGY INPUT (stock)**		**MATERIAL INPUT (stock)**	
	Annual electricity	Annual primary energy[76]	Combined weight[77]	Primary energy
	TWh	PJ	Kt	PJ
Industrial smart sensors	0.09	0.67	14	4

Due to the extremely low in-use energy consumption of industrials smart sensors, no energy consumption saving option has been considered for the use phase energy consumption of the sensor itself.
For potential material savings it was estimated that if the lifetimes were doubled (from 5 to 10 years), half of the production primary energy could be saved. This was made as a simple calculation for 2025, assuming requirements were in force by 2020, hence 5 years

[74] ICT Impact study July 2020. Prepared by VHK and Viegand Maagøe for the European Commission

[75] The analysis is done once per hour (8760 times/year) and involves setting up reference values for 'normal behaviour' especially in the beginning and then a relatively simple floating point operations in a stochastics context. This should be possible within 1 Wh/year (approx.. 0.4 Ws per operation).Probably the most energy-intensive part, which the study team does not consider part of the strict sensor functionality, is the graphics user interface (GUI) for managing a few hundred sensors.

[76] CC factor 2.1

[77] It is assumed that the average weight of an industrial smart sensor is equal to the weight of ABB Anility Smart Sensor https://search.abb.com/library/Download.aspx?DocumentID=9AKK106930A9867&LanguageCode=en&DocumentPartId=&Action=Launch

later, only half the number of sensors would need to be produced compared to no lifetime extension, resulting in 5 PJ savings (see Table 22).

Table 22: Assumed obtainable energy savings related to materials of smart sensors 2025

EU-27 based on stock	Material saving	
	Primary energy saving	CO2 saving
	PJ	kt CO2-eq.
Industrial Smart Sensors 2025	**5.0**	411.3

Energy consumption and savings from connected products

The largest energy saving potential comes from connected products, i.e. the motors, fans, pumps and compressors. By far the largest share of these savings comes from motors, even if only considering motors above 0.75 kW and no special motors (see Table 23 below). For these motors, it is assumed that 25% already have sensors installed, and at a 5-10% energy saving, this gives a potential energy savings of 50-100 TWh/year (380-760 PJ/year) for the entire stock, based on 2018 stock numbers.

The potential is however only achieved, when sensor functionality is established on the motor-driven systems and when the capabilities of the functionalities are exploited. If this is the case for 20% of the new installations, which in average save 5-10%, the total saving potential in 2030 (total stock replacement assumed) is 76-152 PJ.

Table 23: Motors, fans, pumps and air compressors installed and their electricity use in EU (source: VHK, EIA 2018 update)

	Life (years)	Installed (000 units)		Electricity use (TWh/year)	
		2020	2030	2020	2030
Small & special*	8-16	322,540	339,582	183	187
Medium (S) 0.75-7.5 kW (3 ph)	9	81,829	87,369	160	157
Medium (M) 7.5-75 kW (3 ph)	11	13,635	14,656	265	262
Medium (L) 75-375 kW (3 ph)	16	1,593	1,751	574	574
Large LV 375-1000 kW (3 ph)	18	176	194	286	301
Total electric motors		**419,773**	**443,551**	**1,468**	**1,481**
Total excl. small & special motors		**97,233**	**103,970**	**1,286**	**1,294**
Industrial fans >125W	15	241,065	272,904	153	159
Water pumps	11	19,830	22,884	134	153
Standard air compressors	9-12	1,141	1,229	56	58
Total other industry products with electric motors		**262,036**	**297,017**	**343**	**371**

**=<0.75kW, 1-phase>0.75 kW, Brake, Explosion, 8-pole*

8.11 Lightweight design

Materials in ErP sold

Figure 9 shows that some product groups have a more significant impact in terms of total weight than others. The total weight of all product groups was calculated as 14.6 Mton. The most heavy product group is 'Tyres' with a total weight of 3.1 Mton (equal to 21% of the overall weight), followed by 'Domestic Refrigerators' (RF, Lot 13) with 1.2 Mton (8%) and the 'Washing Machines' (WM, Lot 14) with 0.9 Mton (7%).

Figure 2 summarizes the data per material cluster.

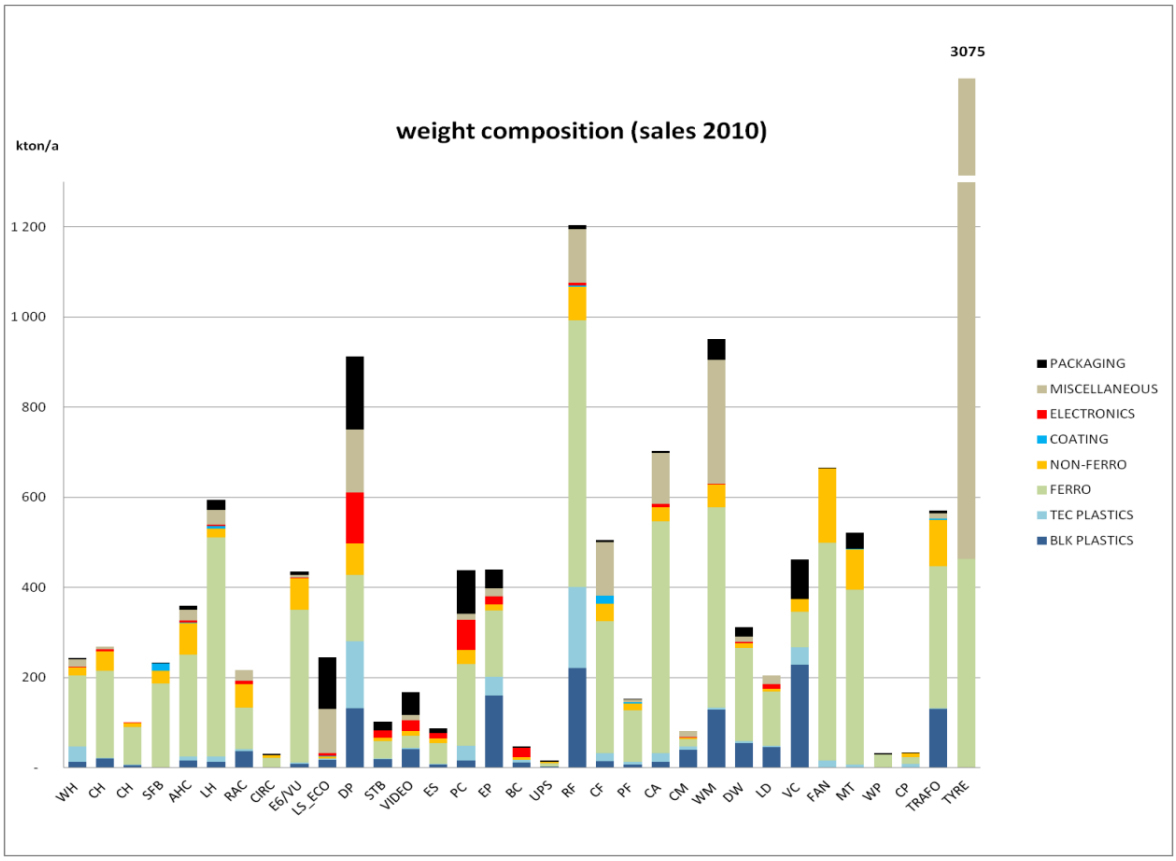


Figure 9. Total weight of the products sold in 2010

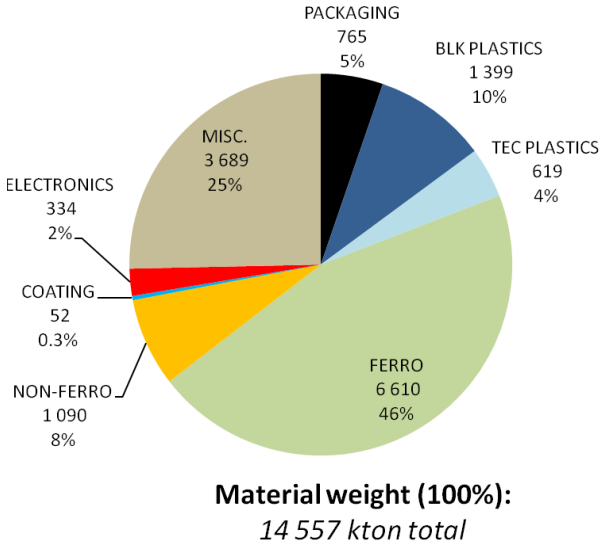


Figure 10. Material consumption per category in products sold in 2010

Table 24.Material Inputs for products sold in the reference year 2010, in kton/a (data underlying Figure 9).

	BULK PLASTIC	TEC PLASTIC	FERRO	NON-FERRO	COATING	ELEC.	MISC.	PACK>	TOTAL
WH dedicated Water Heater	12	34	159	17	0	2	16	3	**243**
CHC Central Heating boiler	6	1	69	12	0	1	1	0	**89**
CH Central Heating	25	6	357	41	0	4	0	0	**434**
SFB Solid Fuel Boilers	0	0	187	28	16	1	0	0	**232**
AHC total Heating & Cooling	16	9	226	70	1	4	25	8	**359**
LH Local Heaters	12	12	486	19	6	4	32	23	**594**
RAC Room Air Conditioner	36	4	93	51	0	7	24	0	**216**
CIRC Circulator pumps <2.5 kW	1	0	21	5	0	0	0	2	**30**
VU Ventilation Units (res & nonres)	8	2	340	71	0	1	6	7	**435**
LS Light Sources, mln units ECO	17	2	0	5	0	7	98	114	**244**
DP electronic DisPlays	131	150	147	70	0	113	140	163	**913**
STB Set Top Boxes	18	2	39	6	0	16	1	19	**102**
VIDEO	41	2	27	11	0	24	12	50	**167**
ES Enterprise Servers	7	1	47	9	0	12	0	10	**86**
PC Personal Computers	15	33	181	32	0	67	13	97	**438**
EP & IJ imaging equipment	160	42	146	14	0	16	19	41	**440**
BC Battery Charged devices	11	6	0	6	0	20	0	4	**47**
UPS Total	2	0	7	3	0	1	0	2	**15**
RF Household Refrigeration	221	180	592	74	3	6	119	9	**1204**
CF Commercial Refrigeration	13	19	293	39	17	1	118	5	**505**
PF Professional Refrigeration	6	6	114	15	3	0	6	1	**152**
CA Cooking Appliances	12	19	516	30	0	8	114	4	**703**
CM household Coffee Makers	40	7	17	3	0	2	13	0	**81**
WM household Wash Machine	129	4	446	50	0	2	275	46	**952**
DW Household Dishwashers	55	4	207	10	0	4	11	22	**312**
LD household Laundry Drier	45	3	121	6	0	10	20	0	**205**
VC Vacuum Cleaners	228	39	79	28	0	0	0	88	**461**
FAN Industrial Fans >125W	0	15	484	165	0	0	0	2	**666**

MT Motors 0.75-375 kW	0	7	389	88	2	0	0	37	**522**
WP Water pumps	0	0	29	0	0	0	0	4	**33**
CP Standard Air Compressors	0	8	16	8	0	0	0	1	**32**
TRAFO Utility Transformers	131	1	315	104	2	0	13	5	**570**
TYRE	0	0	463	0	0	0	2612	0	**3075**
TOTAL	**1399**	**619**	**6610**	**1090**	**52**	**334**	**3689**	**765**	**14557**

Materials in ErP in use

The total weight of materials 'in stock' (in use) is 161 Mton. This is 11 times more than the weight of products sold in the year 2010. Roughly this signifies a materials-weighted average lifetime of 11 years. Figure 11 provides the distribution over the product groups, showing that products with a short life, like Tyres (4 years life) become less dominant, and products with a long life like 'Utility Transformers' (TRAFO, 32.3 years life) become more dominant, compared to their relative position in materials sales.

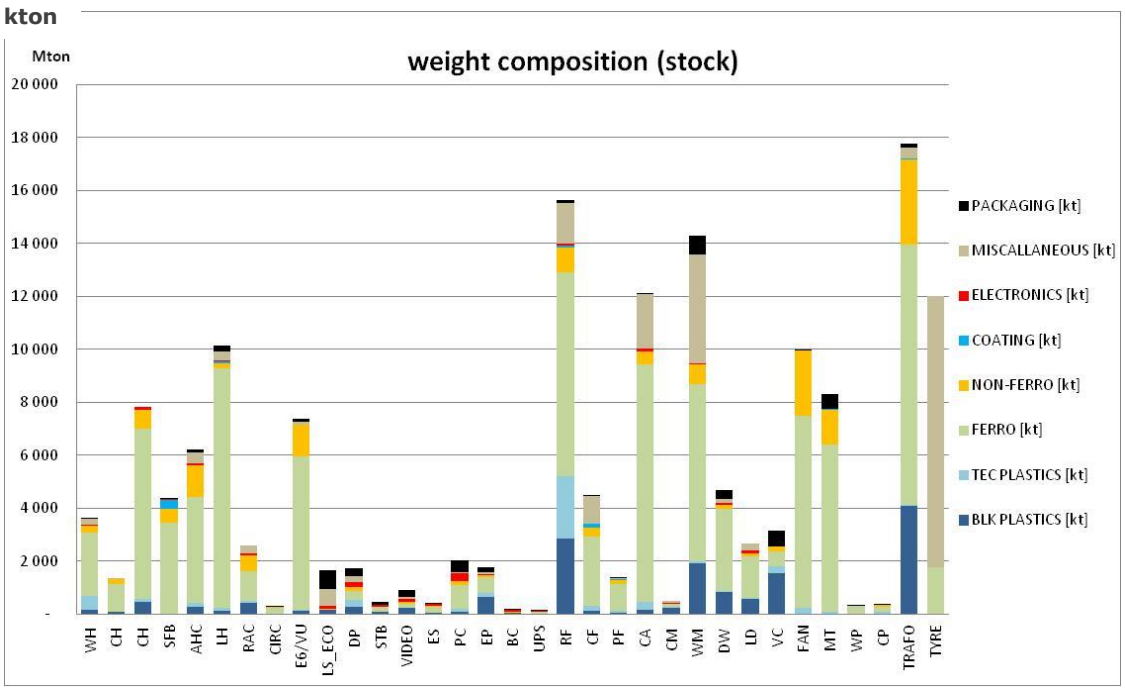


Figure 11. Total weight of products in the stock (sales 2010 x lifetime), in kton

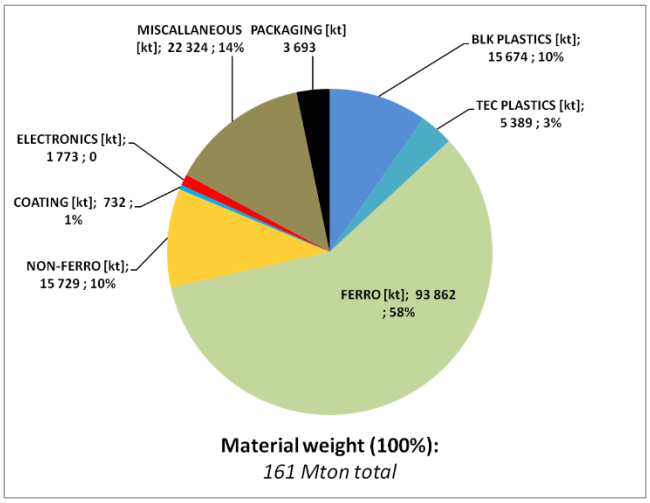


Figure 12. Consumption for the main categories

The Top 5 most used materials in stock are galvanized steel sheet (47 Gton), cast iron (23 Gton), stainless steel 18/8 (13 Gton), steel tube/profile (13 Gton) and PolyPropylene (PP, 10 Gton).

To find the maximum proportion of materials consumption in ErP products relative to total consumption in the EU, Table 7 gives a comparison at the most detailed level for those materials where data are available. ErP-materials that make up more than 10% of EU-total consumption are marked within a box.

Table 25. Selected materials consumption total EU versus regulated ErP (2010)

Materials	**EU** ***kt***	**ErP** ***kt***	**ErP/EU** ***%***
PLASTICS			
LDPE (1,3)	8222	56	0.7%
HDPE (2)	5784	25	0.4%
PP (4)	9178	645	7.0%
PS, EPS (5,6,7)	3346	409	12.2%
PVC (8)	4923	96	1.9%
ABS (9,10)	908	269	29.6%
PET	3346	17	0.5%
BULK Plastics	**35707**	**1518**	**4.3%**
PA (11)	860	76	8.8%
PC (12)	621	173	27.8%
PMMA (13)	287	88	30.7%
Tec-pl (14+)	956	12	1.3%
PUR (15,16)	3585	255	7.1%
Other	5784	3	0.1%
E-glass fibre	1004	11	1.1%
TEC plastics	**13097**	**607**	**4.6%**
FERRO			
St sheet galvanised (21)	24867	3450	13.9%
Plastic coated (38)	4231	15	0.4%
Other flat products (incl. 24, ferrite)	5978	78	1.3%
St tube/profile (22)	12341	843	6.8%
Fe castings (23)	11511	1411	12.3%

Stainless coil/sheet (25)	3670	828	22.5%
FERRO TOTAL	**62598**	**6625**	**10.6%**
NON-FERRO			
Al sheet/extrusions (26)	7500	170	2.3%
Al-Castings (27, 32)	3200	288	9.0%
Cu-Winding wire (28)	375	166	7.4%
Cu-wire (29)	1854	183	9.9%
Cu-tube/sheet(30)	833	246	9.2%
Cu-alloy castings (31)	*403*	32	8.0%
MgZn5 cast (33)	62	5	7.3%
NON-FERRO total	**14227**	**1090**	**7.7%**
MISCELLANEOUS			
Special glass (54)	662	437	66.0%
Other graphic papers (57)	22402	135	0.6%
Cardboard box material (56)	24077	512	2.1%
Natural rubber (93)	1150	854	74.2%
Synthetic rubber (94)	2350	1349	57.4%
MISC. total	**50641**	**3287**	**6.49%**
TOTAL OVERALL (for above materials)	**176270**	**13127**	**7.45%**

Lightweighting examples

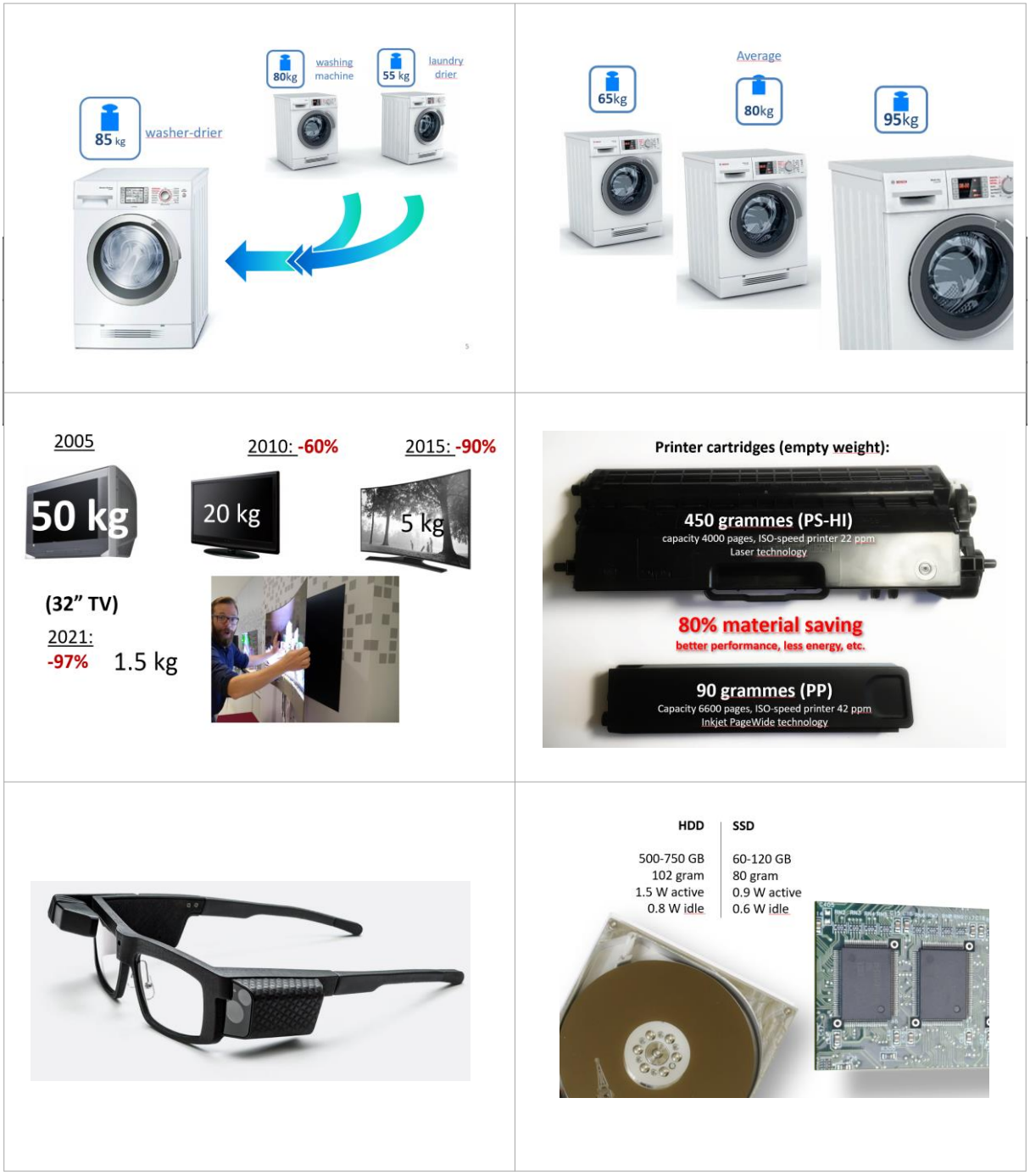
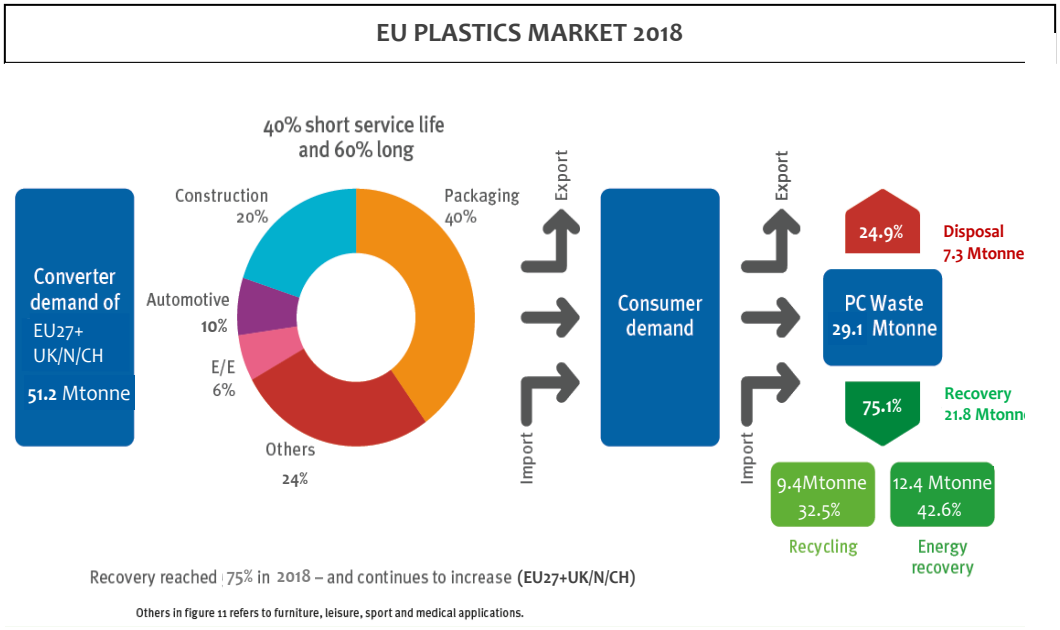


Figure 13. Some examples: (top-left): washer-drier replacing washer + drier. (top-right): different product weights in the market. (mid-left): light-weighting of TVs over the past 20 years. (mid-right). Printer cartridges with 80% weight saving. (bottom-left): Iristick glasses with display, camera, audio (bottom-right) Solid State Drive versus Hard Disk Drive.

8.12 Recycled content

EU Strategy

In its drive towards a Circular Economy[78], the Commission has committed itself to a series of packages to bolster the uptake of secondary raw materials into the production of new products. It has launched an EU-wide pledging campaign to ensure that by 2025, 10 million tonnes of recycled plastics find their way into new products on the EU market -each year - a figure that has also been endorsed by "The Circular Plastics Alliance" from – reportedly - an EU market of 4 million tonnes for recycled plastics in 2019 helping to deliver the circular economy with a life cycle approach.



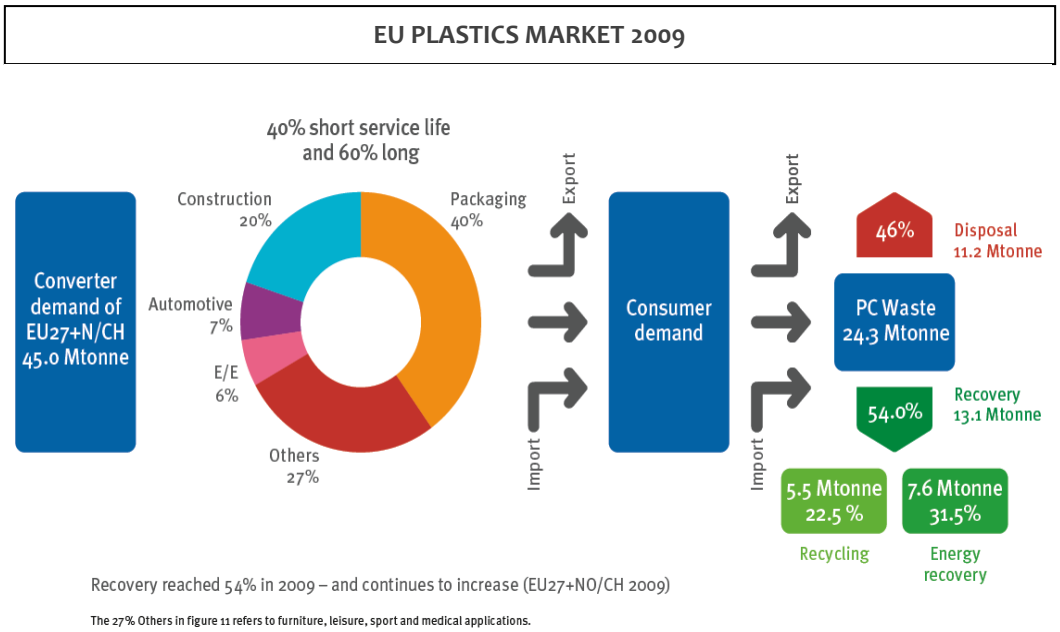


Figure 14. European Plastics Market 2009 and 2018 (source: Plastics Europe 2010, 2019)

[78] https://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy.pdf

EU Plastics use in Ecodesign

The typical applications of plastics, per product group, are given hereafter. The source is a comprehensive analysis of materials consumption in Energy-related Products (ErP) that VHK prepared for the European Commission in 2016. The analysis was part of its Ecodesign Impact Accounting (EIA) for the Commission in 2016 and still constitutes the most comprehensive assessment to date.[79] (see also Chapter on Lightweighting).

Table 1. Amount and type of plastics consumed annually in ErP sold in EU27+UK 2010
(source: VHK, EIA Special materials report, 2016)

		BLK Plastics [kt]							TEC plastics [kt]				
	ErP product group	**PE** [1]	**PP**	**PS**	**EPS**	**HI-PS**	**PVC**	**ABS** [2]	**PA6**	**PC**	**PMMA**	**PUR** [3]	**TOTAL**
Hot Water	WH dedicated Water Heater	0.1	1.7	4.9	0.5		0.3	4.9	7.0	0.0		27.4	46.9
	CHC Central Heating Combi	-	2.8	0.2				2.8				0.7	6.7
	(2.5%)												***54***
Heating, Ventilation, AirCo	CH Central Heating	-	23.2	1.9				-				6.4	31.5
	SFB Solid Fuel Boilers	0.1						-				-	0.1
	AHC total Heating & Cooling	-					6.7	9.3		8.9		-	24.9
	LH Local Heaters	-						12.3		12.3		-	24.7
	RAC Room Air Conditioner	-	36.1					-	4.4			-	40.5
	CIRC Circulator pumps	0.5	1.4					-				-	1.9
	VU Ventilation Units	11.0					3.9	0.5		1.6		0.8	17.7
	(6.7%)												***141***
Lig	LS Light Sources	-						-		0.1		2.1	***2***
Electronics	DP electronic DisPlays	-		0.3	13.5	34.3	35.0	61.3	8.6	49.6	85.9	5.7	294
	STB Set Top Boxes	0.2	0.0	0.6		0.6	2.1	15.0	0.4	0.4		0.9	20.4
	VIDEO game consoles, DVD	0.3	0.3	2.5			9.3	29.1	0.2	1.1		0.7	43.6
	ES Enterprise Servers	1.0	0.0	3.4			0.6	1.5	0.0	0.8		0.1	7.5
	PC Personal Computers	7.4	0.1	0.1	1.8		0.8	14.2	13.5	16.0	1.3	2.5	57.7
	EP & IJ imaging equipment	8.2	4.1	40.4	3.0	62.5	2.0	47.5	9.8	25.3	0.6	6.4	210
	BC Battery Charged devices	0.8	0.0				6.0	3.9	0.1	6.1		-	16.9
	UPS Uninterruptible	0.3	0.0		0.1		0.3	1.5	0.0	0.0	0.0	0.0	2.4
	(30.8%)												***653***
Food appliances	RF household Refrigeration	5.6	28.8	159.4	0.5		12.1	17.9	0.7	0.3		179.5	405
	CF Commercial Refrigeration	0.5	0.5	0.9	3.9	1.0	6.2	4.5	0.2	0.8	0.0	18.0	36.4
	PF Professional Refrigeration	0.4	0.7		0.7	3.6	1.3	0.4	1.2	0.0		5.2	13.4
	CA Cooking Appliances	11.7	0.2		2.1		1.9	0.6	6.9	7.2		5.0	35.6
	CM household Coffee Makers	-	28.3	0.5			0.6	10.2	2.1	0.2		4.2	46.2
	(25.3%)												***536***
Cleaning	WM hh.Washing Machine	23.8	109.3				3.0	15.8	1.3	2.6		-	155
	DW Household Dishwashers	7.2	39.0	3.9	0.4		3.0	5.8	2.9		0.0	1.0	63.2
	LD household Laundry Drier	-	9.9	25.1			0.6	9.4	0.8	0.4	0.2	1.5	47.9
	VC Vacuum Cleaners	-	227.8					-		38.8		-	267
	(25.2%)												***533***
Industrial	FAN Industrial Fans >125W	-						-	14.8			-	14.8
	MT Motors 0.75-375 kW	-			36.6			-				6.6	43.2
	WP Water pumps	1.3						-				0.0	1.4
	CP Standard Air Compres-	-	0.2				0.1	-	0.7	0.0		7.0	8.0
	(3.2%)												***67***
Misc	TRAFO Utility Transformers	0.5	130.3					-				1.3	***132***
		3.8 %	*30.4 %*	*11.5 %*	*3.0 %*	*4.8 %*	*4.5 %*	*12.7 %*	*3.6 %*	*8.1 %*	*4.2 %*	*13.4 %*	*100 %*

[79] VHK, EIA II - Special Report Materials 2016, for the European Commission, 2016

	TOTAL (kton)	**81**	**645**	**244**	**63**	**102**	**96**	**268**	**76**	**173**	**88**	**283**	**211**

[1]=includes LDPE, HDPE, LLDPE; [2]=includes SAN (2% of values); [3]=includes all thermosets & fillers/fibres,70% is rigid PUR

Plastics impacts

According to this source, the sales of plastics in the Energy-related Product (ErP) group in the EU27+UK amounted to 2.1 million tonnes, i.e. 4.7% of EU converter demand in 2010. Taking into account converter production loss (10%) and underestimation of the packaging fraction, this is coherent with the 6% for E/E products given by Plastics EuropeThe EcoReport tool developed for Ecodesign analysis gives key environmental impacts of virgin versus recycled material for 3 plastics: HDPE, PVC and PET (see Table below).

Table 26. Ecoreport environmental impacts virgin versus recycled plastics (examples)

Source: VHK for virgin plastics, Fraunhofer IZM for recycled plastics[80]

Key impact per kg plastic	***unit***	***HDPE***	***HDPEr***	***credit***	***PVC***	***PVCr***	***credit***	***PET***	***PETr***	***credit***
Primary Energy	*MJ*	76.56	9.44	67.12	56.61	26.00	30.61	78.80	11.92	66.88
Electr energy	*MJ*	9.83	1.76	8.07	11.11		11.11	13.37	1.66	11.71
Feedstock fd	*MJ*	54.10		54.10	22.93		22.93	38.83		38.83
Water process	*ltr*	3.40	3.91	-0.51	11.00	69.20	-58.20	7.30	4.80	2.50
Water cooling	*ltr*	31.00		31.00	62.00		62.00	36.00		36.00
Waste hazardous	*g*	5.44		5.44	5.00		5.00	1.60	0.00	1.60
Waste non-hazardous	*g*	38.34	0.08	38.26	67.09		67.09	92.15	0.22	91.93
GWP Global Warming	*kg CO2 eq.*	1.81	0.67	1.14	2.16	2.06	0.10	3.11	0.80	2.31
AD Acidification	*g SO2 eq.*	6.09		6.09	14.99	1.67	13.32	34.37	0.00	34.37
VOC Volatile Organics	*g*	0.16		0.16	0.00		0.00	1.30	0.04	1.26
POP Persistent Organic	*ng i-Teq*									
Hma Heavy Metals air	*mg Ni eq.*							2.27	0.03	2.24
PAH Polyclic Aromatics	*mg Ni eq.*	0.34		0.34	0.03		0.03	1.45	0.00	1.45
PM Particulates	*g*	0.86	0.05	0.81	2.90		2.90	5.00	0.04	4.96
HMw Heavy Metals water	*mg Hg/20*	0.00		0.00	2.81		2.81	0.00	0.00	0.00
EP Eutrophication	*g PO4*	29.82	0.06	29.75	313.99	1.84	312.15	380.26	2.06	378.20

Recycled instead of virgin plastics saves 100% on feedstock, waste, cooling water and PAHs. Almost complete (97%-99%) savings on acidification, VOC, POP, particulates, eutrophication and heavy metals emissions. There is on average a 78% saving on primary energy (67 MJ/kg on average) and 50% saving on Global Warming Potential (2.31 kg CO2 eq.). Only for process water, recycling uses more than producing the virgin material.

Especially as regards the energy and global warming potential, there is the alternative route of energy recovery, i.e. incineration with waste heat recovery usually where the plastics are a fraction in incinerated municipal solid waste (MSW). An American study assessed the lower heating value of HDPE in MSW to be ~37 MJ/kg. So, instead of saving 67 MJ/kg of primary energy (virgin minus recycling), one could also compare this 67 MJ/kg with the 37 MJ/kg from energy recovery and come to a saving of 30 MJ/kg from recycling.

As regards the monetary costs, assuming an average virgin plastics cost of €2/kg and a recycled plastic costs of €1/kg, replacing virgin by recycled plastics will save 50% on strict materials cost. Having said that, due to the procurement and quality aspects being more critical, additional costs for recycled plastics can be expected. Still, a 25% monetary saving (€0.25/kg) seems a fair assumption.

Naturally, these are only rough estimates that will need to be investigated in a comprehensive study.

[80] https://ec.europa.eu/growth/industry/sustainability/ecodesign_en (EcoReport)

Saving potential

Recycled content of plastics is part of the MEErP-accounting but in terms of environmental impacts usually dwarfed by impacts during the use phase and --with one exception[81]-- has not led to proposals for policy measures. For horizontal measures in this field new priorities need to be set.

The target of 10 Mt of recycled plastics in 2025 means that 20% of the 51 Mt EU plastics input would come from recycled plastics. For ErP and in 2030 an extra ~0.5 Mt of recycled plastics would seem realistic. For ErP in 2040 an extra 1 Mt recycled plastics would be inline with the commitment from the European Plastics industry.

Using 0.5 Mt of recycled plastics instead of 0.5 Mt of virgin plastics gives 33.5 PJ primary energy saving, equivalent to 9.3 TWh primary energy saving annually. Using 0.5 Mt of recycled plastics instead of incinerating with heat recovery 0.5 Mt non-recycled plastics gives 15 PJ primary energy saving, equivalent to 4.2 TWh primary energy saving annually. In 2040, at 1 Mt recycled plastics for ErP, the primary energy savings are double, i.e. 18.6 TWh or 8.4 TWh primary energy.

In monetary terms, at a saving of €0.25/kg, the annual saving for the EU would amount to €125 million in 2030 and €250 million in 2040.

The recycled plastics promotion would involve all market actors, from materials-industry[82] to suppliers[83], various end-product industries[84], distributors[85], consumers[86], recyclers[87], etc.

Table 27. European Plastics Industry facts & figures

European Plastics Industry	# Employees	€ bn Turnover	#Companies
Plastics Manufacturers	140,000	100	2,000
Plastics Converters	1,600,000	260	50,000
Plastics Recyclers	30,000	2	1,000

source: circularplastics.org

8.13 Ecological profile

Annex 1 of Ecodesign Directive 2009/125/EC - Method for setting generic ecodesign requirements

Generic ecodesign requirements aim at improving the environmental performance of products, focusing on significant environmental aspects thereof without setting limit values. The method referred to in this Annex must be applied when it is not appropriate to set limit values for the product group under examination. The Commission must, when preparing a draft implementing measure to be submitted to the Committee referred to in Article 19(1),

[81] In the recent Review study on Vacuum Cleaners (ibid. 1) specific Ecodesign measures were proposed on recycled content of plastics, but the proposal was rejected in the 2nd stakeholder meeting on the grounds on insufficient confidence in the effectiveness of market surveillance. Consequently it was not followed up.

[82] Plastics Europe, CEFIC

[83] EU Plastics Converters (EUPC), Polyolefin Circular Economy Platform (PCEP), European Carpet and Rug Association (ECRA), PETcore Europe, Vinyl Plus

[84] APPLiA, EHI, Digital Europe, etc.

[85] E.g. EuroCommerce.

[86] ANEC-BEUC

[87] Plastics Recyclers Europe, EERA and others

identify significant environ-mental aspects which must be specified in the implementing measure.
In preparing implementing measures laying down generic ecodesign requirements pursuant to Article 15, the Commission must identify, as appropriate to the product covered by the implementing measure, the relevant ecodesign parameters from among those listed in Part 1, the information supply requirements from among those listed in Part 2 and the requirements for the manufacturer listed in Part 3.

Part 1. Ecodesign parameters for products

1.1. In so far as they relate to product design, significant environmental aspects must be identified with reference to the following phases of the life cycle of the product:
(a) raw material selection and use;
(b) manufacturing;
(c) packaging, transport, and distribution;
(d) installation and maintenance;
(e) use; and(f) end-of-life, meaning the state of a product having reached the end of its first use until its final disposal.
1.2. For each phase, the following environmental aspects must be assessed where relevant:
(a) predicted consumption of materials, of energy and of other resources such as fresh water;
(b) anticipated emissions to air, water or soil;
(c) anticipated pollution through physical effects such as noise, vibration, radiation, electromagnetic fields;
(d) expected generation of waste material; and
(e) possibilities for reuse, recycling and recovery of materials and/or of energy, taking into account Directive 2002/96/EC.
1.3. In particular, the following parameters must be used, as appropriate, and supplemented by others, where necessary, for evaluating the potential for improving the environmental aspects referred to in point 1.2:
(a) weight and volume of the product;
(b) use of materials issued from recycling activities;
(c) consumption of energy, water and other resources throughout the life cycle;
(d) use of substances classified as hazardous to health and/or the environment according to Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (1) and taking into account legislation on the marketing and use of specific substances, such as Council Directive 76/769/EEC of 27 July 1976 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (2) or Directive 2002/95/EC;
(e) quantity and nature of consumables needed for proper use and maintenance;
(f) ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, complexity of tools necessary for disassembly, use of component and material coding standards for the identification of components and materials suitable for reuse and recycling (including marking of plastic parts in accordance with ISO standards), use of easily recyclable materials, easy access to valuable and other recyclable components and materials; easy access to components and materials containing hazardous substances;
(g) incorporation of used components;

(h) avoidance of technical solutions detrimental to reuse and recycling of components and whole appliances;
(i) extension of lifetime as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability;
(j) amounts of waste generated and amounts of hazardous waste generated;
(k) emissions to air (greenhouse gases, acidifying agents, volatile organic compounds, ozone depleting substances, persistent organic pollutants, heavy metals, fine particulate and suspended particulate matter) without prejudice to Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approxi-mation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (3);
(l) emissions to water (heavy metals, substances with an adverse effect on the oxygen balance, persistent organic pollutants); and
(m) emissions to soil (especially leakage and spills of dangerous substances during the use phase of the product, and the potential for leaching upon its disposal as waste).

Part 2. Requirements relating to the supply of information

Implementing measures may require information to be supplied by the manufacturer that may influence the way the product is handled, used or recycled by parties other than the manufacturer.
This information may include, as applicable:
(a) information from the designer relating to the manufacturing process;
(b) information for consumers on the significant environmental characteristics and performance of a product, accom-panying the product when it is placed on the market to allow consumers to compare these aspects of the products;
(c) information for consumers on how to install, use and maintain the product in order to minimise its impact on the environment and to ensure optimal life expectancy, as well as on how to return the product at end-of-life, and, where appropriate, information on the period of availability of spare parts and the possibilities of upgrading products; and
(d) information for treatment facilities concerning disassembly, recycling, or disposal at end-of-life.
Information should be given on the product itself wherever possible.
This information must take into account obligations under other Community legislation, such as Directive 2002/96/EC.

Part 3. Requirements for the manufacturer

1. Addressing the environmental aspects identified in the implementing measure as capable of being influenced in a substantial manner through product design, manufacturers of products must perform an assessment of the product model throughout its lifecycle, based upon realistic assumptions about normal conditions and purposes of use. Other environmental aspects may be examined on a voluntary basis.
   On the basis of this assessment, manufacturers must establish **the product's ecological profile**. It must be based on environmentally relevant product characteristics and inputs/outputs throughout the product life cycle expressed in physical quantities that can be measured.
2. Manufacturers must make use of this assessment to evaluate alternative design solutions and the achieved environmental performance of the product against benchmarks.
   The benchmarks must be identified by the Commission in the implementing measure on the basis of information gathered during the preparation of the measure.

The choice of a specific design solution must achieve a reasonable balance between the various environmental aspects and between environmental aspects and other relevant considerations, such as safety and health, technical requirements for functionality, quality, and performance, and economic aspects, including manufacturing costs and marketability, while complying with all relevant legislation.

8.14 Durability

Potential energy and GHG savings 2030-2050

The overall saving potential of durability measures can only be estimated very roughly as it depends on several conditions. The calculations were based on the following assumptions:

- The total electricity use, total primary energy use and total greenhouse gas emissions of the product categories in scope include the whole lifecycle. However, durability measures (lifetime extension through durable design, repairs etc.), have greater implications to the manufacturing phase whereas the use phase and end-of-life phase were assumed as being not affected by such measures. The share of the manufacturing phase to the life cycle impacts varies not only depending on the product categories but also on the materials and efficiency of single products as well as on the impact categories. As a simplified approach, across all product categories in scope an average relative share of the manufacturing phase (out of the total life cycle impacts) of 20% to the electricity use, primary energy use and GHG emissions was taken (own estimation).
- Further, the saving potential depends on the basic situation in each product category (e.g. basic lifetime, replacement cycles). For some categories, a higher saving potential can be expected than for others; as a simplified approach, an estimated average was taken across all product categories.
- Finally, the saving potential depends on the number, kind and effectiveness of durability measures applied to each of the different product categories. For the estimation of the saving potential, we have based our calculations on the following durability scenarios. Please note that the durability measures subsumed under the scenarios are only for illustrative purposes, as the effectiveness of each of the single measures will again depend on the particular situation in each product category, and is to be assessed in further detail in the preparatory or revision studies:
    - "**Light" durability scenario**": overall effectiveness, i.e. annual saving potential of measures on electricity use, primary energy use and GHG emissions of the manufacturing phase is estimated to be **5%**; possible measures leading to this effectiveness might be, e.g., mainly easy to adopt information requirements "nudging" consumers to repairs
    - **"Medium" durability scenario**: overall effectiveness, i.e. annual saving potential of measures on electricity use, primary energy use and GHG emissions of the manufacturing phase is estimated to be **15%**; possible measures leading to this effectiveness might be, e.g., mainly requirements facilitating reparability and repair of products through availability of spare parts; reparability information for repair services; remote access to error diagnostics; reparability scoring index labelled;
    - **"Deep" durability scenario**: overall effectiveness, i.e. annual saving potential of measures on electricity use, primary energy use and GHG emissions of the manufacturing phase is estimated to be **30%**; possible measures leading

to this effectiveness might be, e.g., mainly requirements improving the durability of the products; minimum durability of key components (e.g. battery); requirements to combat software-related obsolescence; use meters embedded within products, including consumer feedback mechanisms regarding optimized use and maintenance; commercial guarantees; product-specific labelling of minimum lifetime with civil law effect to be applied in the case of non-conformities.

Table 28. Estimated annual saving potential due to durability measures 2020, 2030 and 2050 of currently regulated ErP for ECO scenario for the sectors 'residential' and 'tertiary/services' (based on Ecodesign Impact Accounting study by VHK, 2019)

Based on ECO scenario for the sectors Residential and Tertiary/Services	2030	2050	2030	2050	2030	2050
	"Light" durability scenario (5% effectiveness)		"Medium" durability scenario (15% effectiveness)		"Deep" durability scenario (30% effectiveness)	
Electricity (TWh/a)	14	15	42	44	85	89
Electricity (PJ/a)	51	53	153	160	305	320
Primary Energy (TWh/a)	49	47	146	142	292	284
Primary Energy (PJ/a)	175	171	526	512	1052	1024
GHG emissions (Mt CO_{2eq}/a)	8	6	23	19	46	37

Depending on the applied durability scenario as outlined above, this results in estimated overall annual savings of 8-46 Mt CO_{2eq}/a GHG emissions in 2030 (6-37 Mt CO_{2eq}/a in 2050), 49-292 TWh/a primary energy in 2030 (47-284 TWh/a in 2050), or 175-1052 PJ/a primary energy in 2030 (171-1024 PJ/a in 2050).

In addition to that, further savings might arise due to the following reasons:

- The estimated savings potential only includes the effects of the manufacturing stage. According to stakeholder feedback, however, also the end-of-life phase is affected by improved durability measures as it would potentially increase re-use, preparation for re-use of products and would potentially improve recycling rates, closing material loops and bring higher recycling revenues.
- The estimated saving potential above neither includes industrial product categories nor the application of the product categories in scope in the industrial sector. If durability measures would also be applied to these settings, the overall savings potential might increase accordingly. It is recommended to include systematic data-based assessments of the potential for improvement in durability in the product specific preparatory or review studies for each of the industrial product groups like industrial fans, electric motors, water pumps, circulators, compressors, welding equipment and transformers.
- As no data is available so far in the Ecodesign Impact Accounting, the calculations do not take into account further product categories for which – as yet – there are no Ecodesign and/or Energy Labelling regulations in existence (these may be, inter alia, either currently under development within Ecodesign Working Plan 2016-2019, e.g., mobile phones, smartphones and tablets or electric kettles; or that may solely be included in the future, within the actual EELWP 2020-2024. Thus, further saving potential is expected if durability measures were also to be applied to these product categories.

8.15 Scarce and critical raw materials

Categorisation of raw materials according to their scarcity (CRM) and their Environmental Hazard Potential (EHP)

Table 29 provides an overview of raw materials categorized according to their aggregated Environmental Hazard Potentials (EHP) based on Dehoust et al. (2020); the columns differentiate between those included in the EU list of CRM 2020, either already taken into

account in the current MEErP guideline and EcoReport tool or not yet included, and those which are not on the 2020 EU list of CRM, and also not included in the MEErP/ EcoReport tool so far.

An initial priorisation scheme for the next Ecodesign and Energy Labelling Working Plan could be as follows:

- **Highest priority**: CRM with high environmental risks/impacts, i.e. antimony, cobalt, germanium, indium, bismuth; not yet included in MEErP/EcoReport tool: Light rare earth elements (LREE), phosphate rock, vanadium
- **High priority**: CRM with medium to high or medium environmental risks (beryllium, gallium, niobium, magnesium; not yet included in MEErP/EcoReport tool: Borates, heavy rare earth elements (HREE), scandium, lithium, bauxite, titanium) and raw materials not in 2020 EU CRM list, but with high environmental risks (copper, gold, lead, molybdenum, nickel, palladium, platinum, rhenium, rhodium, selenium, silver, tellurium, zinc – all not yet included in MEErP/EcoReport tool)
- Medium priority: raw materials not in 2020 EU CRM list, but with medium to high or medium environmental risks: aluminium, silica sand; chromium, gypsum, iron, iron ore, magnesite, manganese, tin

Table 29: Overview of raw materials included in the EU list of CRM 2020, in the MEErP EcoReport tool and their aggregated Environmental Hazard Potentials (EHP); source: own compilation based on Dehoust et al. (2020)[88], European Commission (2020)[89] and VHK & COWI (2011)[90]

EHP	2020 CRM list		Not in 2020 EU CRM list / not included in MEErP/EcoReport
	Already included in MEErP/EcoReport	Not yet included in MEErP/EcoReport	
No or no aggregated EHP available	☑ Platinum Group Metals (PGM)	- Baryte	- Bentonite - Diatomite - Feldspar - Limestone - Perlite - Potash - Rare earths - Talc
Low EHP	☑ Natural Graphite	- Coking Coal	- Clay (Kaolin and kaolinitic clay)
Low to medium EHP	☑ Fluorspar ☑ Tantalum ☑ Tungsten		
Medium EHP	☑ Magnesium	- Bauxite - Lithium - Titanium	- Chromium - Gypsum - Iron - Iron ore - Magnesite - Manganese - Tin
Medium to high EHP	☑ Beryllium ☑ Gallium ☑ Niobium	- Borates - Heavy rare earth elements (HREE)[91] - Scandium	- Aluminium - Silica sand
High EHP	☑ Antimony ☑ Cobalt ☑ Germanium ☑ Indium	- Bismuth - Light rare earth elements (LREE)[92] - Phosphate rock - Vanadium	- Copper - Gold - Lead - Molybdenum - Nickel - Palladium - Platinum - Rhenium - Rhodium - Selenium - Silver - Tellurium - Zinc

[88] Dehoust, G.; Manhart, A.; Dolega, P.; Vogt, R.; Kemper, C.; Auberger, A.; Becker, F.; Scholl, C.; Rechlin, A.; Priester, M. (2020): Environmental Criticality of Raw Materials, An assessment of environmental hazard potentials of raw materials from mining and recommendations for an ecological raw materials policy (UBA TEXTE, 80/2020). Umweltbundesamt (ed.), 2020. Online available at https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-06-17_texte_80-2020_oekoressii_environmentalcriticality-report_.pdf, last accessed on 17 Jun 2020

[89] European Commission (2020): Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability. COM/2020/474 final; online available https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0474&from=EN, last accessed 19.09.2020

[90] VHK and COWI (2011): Methodology for Ecodesign of Energy-related Products - MEErP 2011 - Methodology Report, Part 1: Methods. Online available at https://ec.europa.eu/docsroom/documents/26525/attachments/1/translations/en/renditions/native, last accessed on 16 Jun 2020

[91] Only partly included in MEErP: only Y (yttrium)

[92] Only partly included in MEErP: Sc (scandium) and Nd (neodymium)

8.16 Firmware and software

Exemplary energy and resource efficiency potential of software application products

Within the research project "Development and application of criteria for resource-efficient software products with consideration of existing methods", sponsored by the German Federal Environment Agency, Gröger et al. (2018)[93] has developed the methodological basis for determining the use of resources by software, comparing application software products with each other and making efficiency demands on them.

An evaluation methodology for the resource efficiency of application software products was developed to identify the extent to which hardware resources are used and amount of energy is required (hardware efficiency, energy efficiency, and resource management). The applicability of the criteria was tested by applying it to 11 different software products: 2 word processing programs, 3 Internet browsers, 3 content management systems and 3 database systems.

Standard usage scenarios were defined for these software product groups to be used as reference unit for all measurements of energy consumption and hardware usage. For the System Under Test (SUT), first the basic load of the device was determined by measurement, i.e. the average utilisation of the CPU, working memory and permanent storage, and the amount of data transmitted via the network without the application software to be tested. The application software to be measured was then installed and started on the device. As long as the software was still in an idle state, i.e. after the start but without execution of a usage scenario or interaction with the user, the idle load was measured. The third measurement was used to determine the (gross) utilisation of the system during the active operation of the application software by a standard usage scenario. Standardised evaluations ensured that software products that have gone through the same usage scenarios could be compared in terms of their energy efficiency and their use of hardware capacities. During the course of the scenario, usage of the hardware capacity and energy consumption were measured and the active tasks were recorded in the activity log of the load driver. It was possible to monitor and record the CPU, main and hard disk storage, network load and total system energy consumption.

The measurement results pointed out clear differences in energy consumption between the tested application software products with same functionality during their actual operation, see following figure.

[93] Gröger, J.; Köhler, A.; Naumann, S.; Filler, A.; Guldner, A.; Kern, E.; Hilty, L. M.; Maksimov, Y. V. (2018): Entwicklung und Anwendung von Bewertungsgrundlagen für ressourceneffiziente Software unter Berücksichtigung bestehender Methodik (UBA TEXTE, 105/2018). Umweltbundesamt (ed.), 2018. Online available at https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2018-12-12_texte_105-2018_ressourceneffiziente-software_0.pdf, last accessed on 25 May 2020.

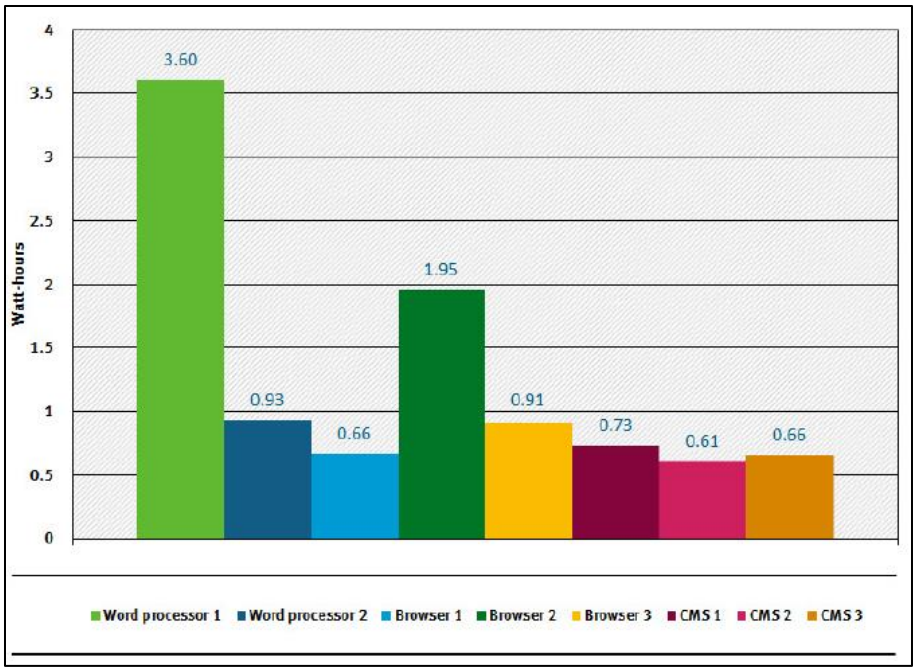


Figure 15: Comparison of energy consumption of the local device (SUT(Client)) during the execution of the standard usage scenario; source: Gröger et al. (2018)

According to Gröger et al. (2018), the energy consumption of the three analysed Content Management Systems (CMS) was relatively close within the range of approx. 0.61 to 0.73 watt hours (Wh). On the other hand, the three browsers showed clearer differences with approx. 0.66 Wh for browser no. 1 and 1.95 Wh for browser no. 2. Finally, the differences were most obvious between the two measured word processing programmes. Programme no. 1 consumed almost four times as much energy (3.6 Wh) as word processing programme no. 2 (0.93 Wh), although both programs run through the same standard usage scenario and perform the same tasks. Programme no. 2 required only about a quarter of the electrical energy and was therefore significantly more energy efficient. One reason for the higher energy consumption of a software application was for example due to a lack of data compression. The results of the measurements according to Gröger et al. (2018) further showed that there were also discernible differences between the software products in terms of hardware efficiency (processor utilization, working memory, permanent storage, bandwidth for network access).

Another criterion for example was the utilization levels of hardware resources if a software was in idle mode. Idle describes the state after the software has been started, but in which no user interaction takes place or calculations are performed. The results of the measurements by Gröger et al. (2018) for three different web browsers showed that browsers no. 1 and 2 increased the processor load (CPU) by around 1 percent in addition to the base load of the measurement system when being in idle. The idle mode of Browser 3, on the other hand, led to an additional utilization of the processor of 12 percent, i.e. browser 3 used twelve times the amount of hardware resources (based on CPU utilization), see following figure.

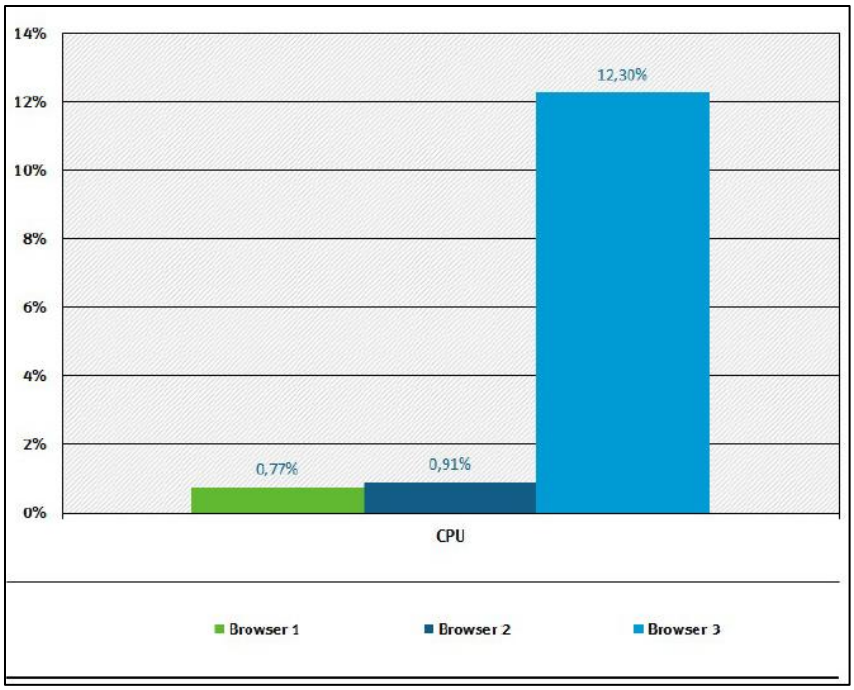


Figure 16: Hardware Utilization (CPU) of three web browsers in idle mode; source: Gröger et al. (2018)

This is particularly relevant against the background that the excessive use of hardware could also lead to programme execution taking too long, which might lead to companies, administrations or private users taking this supposedly slow hardware out of service and purchasing new, faster hardware (i.e. software-induced hardware obsolescence). On the other hand, there is also a connection between the functional scope of a software product and its hardware usage. As the number of functionalities offered by an application software increase, the demand on the hardware and energy consumption usually increase as well.
Based on these findings, basic award criteria on resource and energy efficiency of software products (minimum system requirements, hardware utilisation and electrical power consumption in idle mode, hardware utilisation and energy demand when running a standard usage scenario, and support for the energy management system were developed for the German Blue Angel Ecolabel.