UK Energy-related Products Policy Study

Final report

November 2021

Contents

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Glossary

AC: Air Conditioning

B2B: Business to Business

B2C: Business to Consumer

BACS: Building automated control systems

BAT: Best Available Technology

BCAS: British Compressed Air Society

BCR: Benefit to Cost Ratio

BEIS: Department for Business, Energy and Industrial Strategy

BMS: Building Management System

BOMs: Bill of Materials

BREEAM: Building Research Establishment Environmental Assessment Method

CAGI: Compressed Air and Gas Institute

CAGR: Compounded Annual Growth Rate

CRM: Critical Raw Materials

Defra: Department for Environment, Food & Rural Affairs

EC: European Commission

ECA: Enhanced Capital Allowance

ECO: Energy Company Obligation

EEE: Electrical and Electronic Equipment

EEI: Energy Efficiency Index

EER: Energy Efficiency Ratio

EFCEM: European Federation of Catering Equipment Manufacturers

EPS: External Power Supply

ErPs: Energy related Products

ESOS: Energy Savings Opportunity Scheme

ETL: Energy Technology List

EU: European Union

EUP: Energy Using Products

EVs: Electric Vehicles

FCSI: The Foodservice Consultants Society International

FEA: Foodservice Equipment Association

GB: Great Britain

GBS: Government Buying Standards

GDP: Gross Domestic Product

GHG: Greenhouse gases

HEPS: Higher Environmental Performance Standards

HFCs: Hydrofluorocarbon

HVAC: Heating, Ventilation and Air Conditioning

ICT: Information and Communications Technology

IEA: International Energy Agency

JRC: Joint Research Centre

LED: Light Emitting Diode

MEPS: Minimum Energy Performance Standard

MFD: Multi-Function Device

MoU: Memorandum of Understanding

NGOs: Non-Governmental Organisation

PAS: Publicly Available Specification

PC: Personal Computer

PCB: Printed Circuit Board

Q&A: Question and Answer

R&D: Research and Development

RDCs: Refrigerated Display Cabinets

REEs: Rare Earth Elements

RFID: Radio Frequency Identification

RHI: Renewable Heat Incentive

RoW: Rest of the World

S&L: Standards & Labelling

SEG: Smart Export Guarantee

SRI: Self-Regulatory Instrument

TMM: Transitional Methods of Measurement

TV: Television

UK: United Kingdom

USA: United States of America

USB: Universal Serial Bus

USD: US Dollar

USDOE: US Department of Energy

VA: Voluntary Agreement

VAT: Value Added Tax

VSDs: variable speed drives

WEEE: Waste Electrical and Electronic Equipment

1 Executive summary

Following the UK's departure from the EU, new EU Ecodesign and Energy Labelling measures will not automatically apply in Great Britain from 2021. The Department for Business, Energy and Industrial Strategy (BEIS) and The Department for Environment, Food and Rural Affairs (Defra) will take on responsibility for setting standards and designing policy to limit the environmental impacts of Energy-related Products (ErPs) in the UK. There is an opportunity for ErPs to be a big contributor to meeting the UK’s net zero emissions by 2050 target, and the recent Ten Point Plan for a Green Industrial Revolution commits the UK to establishing a world class policy framework for ErPs.

The aim of the study was to identify ErPs (e.g., products that have a direct or indirect impact on energy consumption during use) which have the greatest environmental impact considering, in particular, their contribution to carbon emissions and resource depletion and the most potential for improving their environmental performance. The study also identified a list of horizontal measures (e.g., measures affecting a variety of different product groups) that could be deployed in the UK to improve energy efficiency, resource efficiency or circular economy aspects of product groups.

In Task 2, ICF’s study team prepared a long list of 262 product groups and 40 horizontal measures. The long list was consolidated into 184 product groups clustered into 16 product categories for the Task 3 analysis, based on similarity of components, and some product groups were screened where no market exists in the UK. The product groups were organised into the following categories:

- Commercial/industrial
- Consumer electronics
- Cooking
- Generation/conversion/supply
- Gym/fitness
- HVAC
- ICT
- Laboratory/medical
- Lighting
- Materials
- Motor driven
- Other (drones)
- Power tools
- Refrigeration

- Small appliances
- White goods

The horizontal measures were consolidated into 8 different measures:

- Production
- Resource/energy in use
- Extend use - durability
- Extend use – repairability/ upgradability
- End of use – recyclability
- End of use – remanufacture/ refurbishment
- Servitisation
- Product information/labelling and market surveillance

In Task 3, an evidence gathering exercise based on secondary evidence sources was completed, in consultation with stakeholders. Each product group was assessed against 17 evaluation criteria, grouped into categories such as market information, in-use resource consumption, technical improvement potential and cost, and circular economy criteria. Horizontal measures were scored against six criteria including potential coverage, existing examples, and potential costs/benefits. Over 300 stakeholders registered and over 110 responses were received on the Task 2 long list of products and horizontal measures. Preliminary results from Tasks 2 and 3 were shared via a remote stakeholder consultation meeting. Stakeholders thought the coverage of horizontal measures was representative, and broadly agreed the long list was comprehensive, with some products being recommended for inclusion or removal.

Over 60 responses were received on Task 3, with stakeholders broadly agreeing that the criteria used for shortlisted were fit for purpose and that energy related policy levers selected for analysis were suitable. Shortlisted horizontal measures were not ready at the time stakeholders were consulted, so their views were not obtained. Stakeholders did comment more generally in support of circular economy related horizontal measures.

The attribution of scores resulted in a shortlist of 26 product groups and 4 circular economy related horizontal measures to focus on in Task 4 based on their potential to drive energy and carbon savings and contribute to the UK's net zero emission target. The shortlisted product groups and horizontal measures are listed here. The status of energy related horizontal measures on standby regulations and smart appliances were also reviewed.

Product Groups Shortlisted for Task 4

- Commercial/industrial - 4 types of compressors
- Consumer electronics - Displays and televisions
- Cooking - Non-domestic hobs

- Generation/conversion/supply/storage - Rechargeable batteries
- Generation/conversion/supply/storage - External power supplies
- Heating ventilation and cooling - Building Automated Control systems (BACS)
- Heating ventilation and cooling - Patio heaters
- Heating ventilation and cooling - Space heaters
- Heating ventilation and cooling - Water heaters
- Heating ventilation and cooling - Split system air conditioners
- Heating ventilation and cooling - Heat emitters
- ICT - Servers
- ICT - Smartphones
- ICT - Computers and laptops
- Lighting - LED lamps and luminaires
- Materials - Ink and toner cartridges
- Materials - Taps and showers
- Motor driven - Water pumps
- Refrigeration - Refrigerated appliances with a direct sales function including retrofit measures
- Refrigeration - Refrigerated containers
- Small appliances - Vacuum cleaners
- White goods - Professional dishwashers

Horizontal Measures Shortlisted for Task 4

- Requirements for material content and declaration
- Repairability measures – modular design
- Product support
- Mandatory minimum warranty/guarantee

To compare product group potential for future policy interventions, further research was undertaken in Task 4. High level estimates[1] were used to assess the scale of baseline energy consumption and emissions for a single year of product sales. A hypothetical scenario was then developed to assess the maximum saving potential over 10 years (and additional cost) if annual sales of typical products were replaced with sales of best available technology (BAT)

[1] Due to the large number of products assessed during the study (e.g. 184 products in Task 3 and 26 products in Task 4), limited evidence and simple assumptions underpin the analysis undertaken. This reduced the robustness of the analysis, which can be considered a limitation to the study. Further research is recommended in order to fully evidence technology specific policy options.

products in a single year. The savings were then scaled to identify potential energy savings based on a mix of policy levers using a ratio developed from previous research that compared three scenarios (business as usual, a set of existing policy levers and a BAT scenario) for different product categories. Looking at the 26 shortlisted product groups, this analysis identified the following product groups as having the highest potential for future savings.

Table 1.1 Shortlisted product groups with the highest potential for future savings

Product Group	**Maximum technical potential savings (with BAT)**		**Savings that can be achieved with a mix of policy levers**	
	Energy (TWh)	Carbon (MtCO2e)	Energy (TWh)	Carbon (MtCO2e)
Non-Domestic Building Automated Control Systems	50.5	9.7	20.3	3.9
Domestic Building Automated Control Systems	25.6	4.8	10.3	1.9
Curtains, blinds, doors and covers for refrigerated display cabinets	15.4	3.2	8.3	1.7
Hobs	10.9	2.0	3.1	0.6
Servers	7.9	1.6	3.2	0.7

Source: ICF

If all non-domestic BACS in the UK sold in one single year were BAT, it would mean up to 50 TWh and 9.7 MtCO2e savings over the 10 years to follow. Although achieving 100% of BAT sales would be a highly ambitious undertaking, with the implementation of mix of policy levers that would increase the sales of BAT non-domestic BACS, up to 20.3 TWh and 3.9 MtCO2e could be saved over 10 years from the units sold in one single year.

Each of the 26 product groups was also compared against a list of energy related policy levers to assess, based on secondary evidence sources, potential impacts and time required to add into an existing policy lever or implement a new one. The policy levers were selected at the start of the study and Task 3 stakeholder feedback broadly supported their inclusion in this analysis.

Policy Levers Covered in Task 4

- Minimum energy performance standards
- Technology deployment and diffusion
- Grants, subsidies and loans
- Tax programmes
- Public procurement
- Communications campaigns
- Energy labelling (mandatory information labels)

- Energy labelling (voluntary endorsement labels)
- Obligation schemes
- Implementation aid and advice programmes

The literature identified few instances of policy lever impacts that were attributable to specific products. In most cases, where impacts were available, they were attributed to the overall policy lever, to a specific sector or at a building level. Due to this lack of evidence, product group and policy lever specific impacts could not be assigned.

Time to implement (a new policy lever) estimates were also developed to enable comparison of product groups and policy lever combinations in Task 4. Estimates ranged from 6 months to over 3 years for each product group and policy lever combination and were based on classifying products into three categories ('clear winners', 'energy saving add on products' and 'products with a range of performance'). Depending on this categorisation, certain information pre-requisites informed the amount of time needed to develop and implement a policy lever.

For example, all four compressor product groups have products with a range of energy performance on the market. An agreed method to test the energy performance of this product is a prerequisite to setting any minimum energy performance standards or energy labelling policy levers. Being able to choose a more energy efficient product to purchase depends on the existence of this information, so information provision is a prerequisite for certain policy levers such as advice/aid in implementation campaigns or fiscal incentives.

Product groups with existing minimum performance standards or energy labelling regulations, or those with existing energy performance test standards have significantly shorter times to implement a new policy lever, whereas those without these pre-requisites are assumed to take much longer to develop a policy.

Trade-offs were also considered for each product group. First, a high-level assessment of the energy related policy levers and circular economy related horizontal measures were assessed to consider potential trade-offs. Because of the nature of the shortlisted horizontal measures (e.g., a focus on information provision, repairability, product support and extension of warranties), no conflicts were identified with energy related policy levers.

Broad impacts in terms of costs and benefits incurred along the supply chain were also considered for each type of policy lever. The second trade-off considered how the distribution of impacts might change when applied to specific product groups. This high-level analysis did not identify any impacts along the supply chain that would vary significantly across the product groups, but more detailed analysis on this topic would be required as part of any future policy appraisal.

The results of the further analysis have been summarised into 25 fact sheets[2], contained in the Part B annexes of this report. This information is intended to help policy makers compare the candidacy of the 26 shortlisted product groups for future policy levers. Baseline energy

[2] Domestic and non-domestic BACS were combined into a single factsheet

consumption and emissions, alongside with technical potential savings/ costs and estimates of time required for potential future policy lever to be implemented all help structure a foundation for future policy development for ErPs. To accommodate the large scope of the products reviewed in the study, high level estimates using limited evidence and simple assumptions underpin in the analysis. This can be considered a limitation of the study. In all cases, it is recommended that further evidence, analysis and stakeholder engagement take place as part of defining future policy options.

The horizontal measure case studies were published in a separate report. This study identified that circular economy related measures are in their infancy. Although the industry is gaining expertise in this subject area, as indicated by numerous voluntary initiatives and research projects, the data and maturity of regulations and initiatives do not yet allow the assessment of impacts relating to energy reduction, greenhouse gas emissions, and use of resources.

2 Study definition

The study definition defines the relevant background and purpose of the study, clarifies context and scope, and presents methods used during the study.

2.1 Background

Following the UK's departure from the EU, new EU Ecodesign and Energy Labelling measures will not automatically apply in Great Britain from 2021 onwards[3]. Instead of the European Commission, the UK Government will take on responsibility for setting standards and designing policy to limit the environmental impacts of Energy-related Products (ErPs) in the UK. The UK Government will seek to:

Maximise energy and carbon savings - Supporting the Government's Net Zero target through minimising energy bills, reducing GHG emissions and promoting more resource efficient products.

Reduce demand on resources – Ecodesign measures can be used to ensure that products and materials are kept in use for longer, placing less demand on the planet's natural resources and supporting the Government's commitment to double resource productivity by 2050.

Support a world class regulatory framework – Establish a world class Energy-related Products policy framework that encourages UK innovation and works for consumers and businesses.

2.2 Purpose of this study

To meet these objectives, Government will need a robust evidence base that informs decision making on ErPs to investigate further as candidates for potential policy development. This study enables BEIS and Defra to assess which products are the most relevant in terms of their overall environmental impact considering their contribution to carbon emissions, resource depletion and technical potential for improving their environmental performance or facilitating improved performance.

In addition, this study is intended to help provide an initial indication of which policy measures may be most appropriate in encouraging better environmental performance and driving the uptake of more energy and resource efficient products and systems. The study does not provide an assessment of specific policy options for individual products and recommendations around suitability of policy levers do not necessarily reflect the direction of Government policy. It will be for policy makers to decide exactly which policies and products to take forward.

[3] Subject to the terms of the Northern Ireland Protocol, existing and future EU Ecodesign and Energy Labelling regulations will continue to apply in Northern Ireland

2.3 Policy lever options for products policy

As set out in the Energy-Related Products Call for Evidence, Government is interested in exploring a range of ways to drive the uptake of more energy and resource efficient products whether that is traditional minimum standards (Ecodesign) and energy labelling or other policy levers. This study identified product groups for a range of products policies, including but not limited to Ecodesign and Energy Labelling regulations. The goal was to identify product groups and horizontal measures with high potential for savings (energy, emissions, resources) and associated cost savings. In terms of a cost-benefit analysis, this savings potential is associated with benefits.

Policy costs will change considerably depending on the policy lever used. The stakeholder who bears the cost will also depend on the policy lever. For example, a scrappage scheme (encouraging early replacement of less efficient product by offering a payment towards a more efficient product) would incur high costs to Government compared to minimum performance standards, where consumers would bear the cost of a more efficient product. This example also highlights the trade-offs between different policy levers[4]. Depending on how it is designed, a scrappage scheme could go against circular economy measures such as lifetime extension, reuse, and repair measures.

The study helps to identify these trade-offs to support decision-making as to which policy levers are most appropriate in achieving Government objectives. Some levers depend on the existence of other ones to be implemented. For example, policies like energy labelling (either mandatory or endorsement types) or higher environmental performance standards (HEPS) such as the Energy Technology List would be necessary for public procurement levers to be applied. The study identifies which levers or combination of levers could be effective in achieving improved environmental performance and/or encouraging the uptake of the most energy and resource efficient products available on the market.

Consideration of actual policy levers to be applied to the product groups took place in Task 4, and evidence was sought to allow consideration of technical trade-offs such as energy efficiency gains at the expense of use of polluting materials or higher quantities of materials.

There are many different types of policy levers. The IEA Policy and Measures database[5] categorises energy efficiency related policies as included in Table 2.1.

Table 2.1 Energy efficiency related policy levers

Policy type	Policy sub-type
Fiscal incentive	Direct investment Funds to sub-national governments

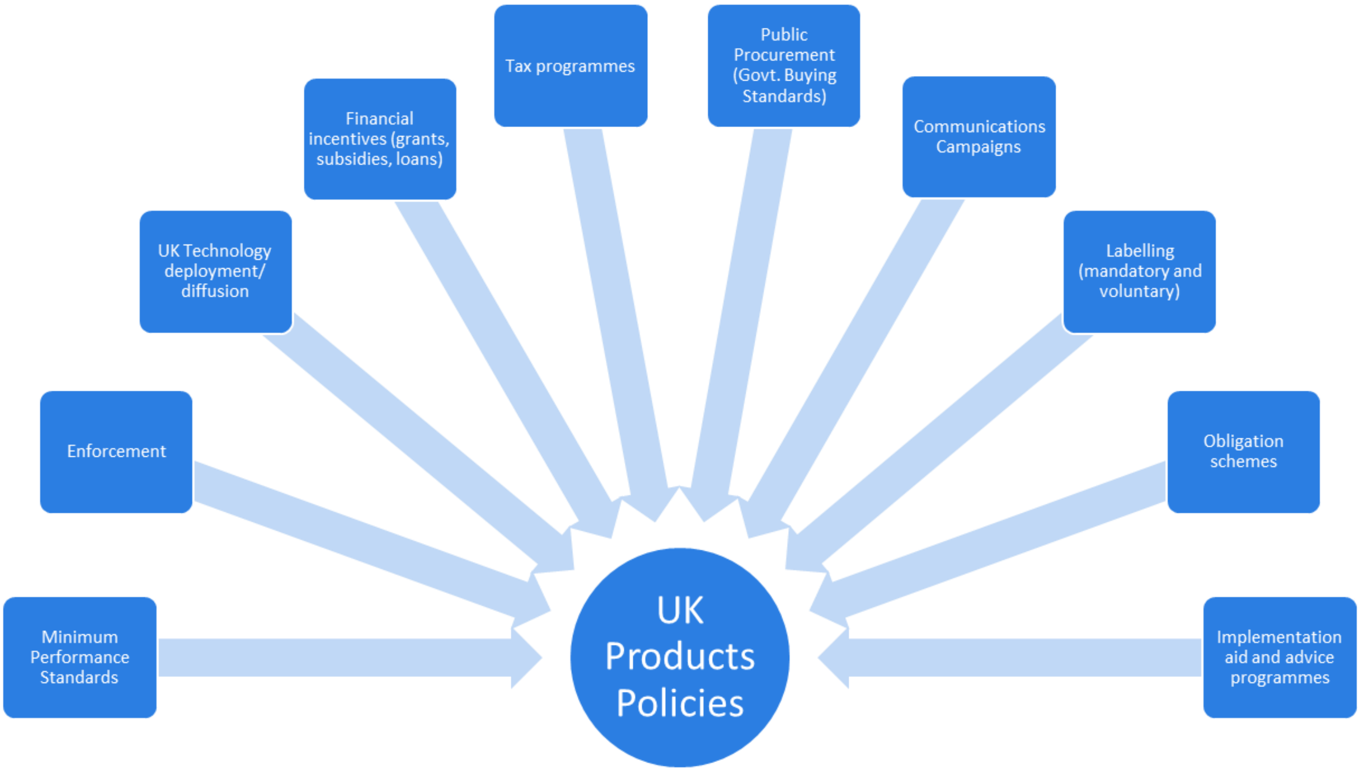
[4] See Section 2.5.3 for more details.
[5] https://www.iea.org/policiesandmeasures/energyefficiency/

Policy type	Policy sub-type
	Infrastructure investments Grants and subsidies Loans on more efficient products Tax relief Tax on least efficient products User charges Cap and trade Utility based incentives
Awareness raising	Communications campaign Advice/Aid in Implementation Energy Label Endorsement label Professional training and qualification
Regulation	Auditing Building regulation Minimum energy performance standards (MEPS) Public procurement (Govt Buying Standards) Obligation schemes
Innovation support	Strategic planning Demonstration project Technology deployment and diffusion Technology development
Voluntary programmes/ agreements	Negotiated Agreements (Public-private sector)

Policy type	Policy sub-type
Other	Public Voluntary Schemes Unilateral Commitments (Private sector) Enforcement improvements (Monitoring & evaluation)

However, it is unlikely that all the energy efficiency related policy levers would be suitable for products policy. Figure 2.1 contains a non-exhaustive list of policy options suitable for products policy which were explore in the Energy-Related Products: Call for Evidence.

Figure 2.1 Policy lever options for products policy



The policy levers are described in Table 2.2 below. Although the policy levers described are energy related, many can also be applied to increase the uptake of resource efficient products. Circular economy related policy levers are considered separately, and in the case studies that will be contained in a separate report.

Table 2.2 Energy related policy lever descriptions

Policy lever	Description
Minimum performance standards (includes Enforcement)	Typically mandatory, MEPS force the removal of the least efficient products from the market and often increase over time to factor in the rate of technological change.
UK Technology deployment and diffusion	Removes non-technical barriers to adoption by demonstrating capability of new technology. Removal of market entry barriers can significantly improve technology uptake and associated energy savings.
Grants, subsidies, loans	Can be rebates, discounts, or other measures to incentivise purchase of more efficient products. Grants & subsidies intend to remove the barrier of higher first costs often seen with products that are more efficient. Loans are often provided with low or no interest rates.
Tax programmes	Taxes on least efficient products consists of a supplement levied on the purchase price of an ErP. It is used to affect consumer behaviour in addition to raise revenues.
Public procurement	Public procurement uses the purchases power of a government to create demand for more efficient products, which in turn can encourage more investments in such products by manufacturers.
Communications campaigns	Communication campaigns drive change in consumer behaviour to reduce energy consumption. For this analysis, they are assumed to apply to residential sector products.
Energy labelling – mandatory information labels	Labels seek to remove information gaps and assist consumers with the purchasing decision. Mandatory energy labelling requires the display of an energy label at the point of sale.
Energy labelling – voluntary endorsement labels	Labels seek to remove information gaps and assist consumers with the purchasing decision. Voluntary labelling allows a third-party recognition of high efficiency products.
Obligation schemes	Obligation schemes concentrate the responsibility for saving energy with energy suppliers, who in turn use their

Policy lever	Description
	knowledge of their customer base to implement energy efficiency measures.
Implementation aid and advice programmes	Implementation aid and advice programmes can empower consumers and building owners to make more energy efficient purchasing or building choices by understanding the relative impact of their behaviour. Could also target specific industry sectors.

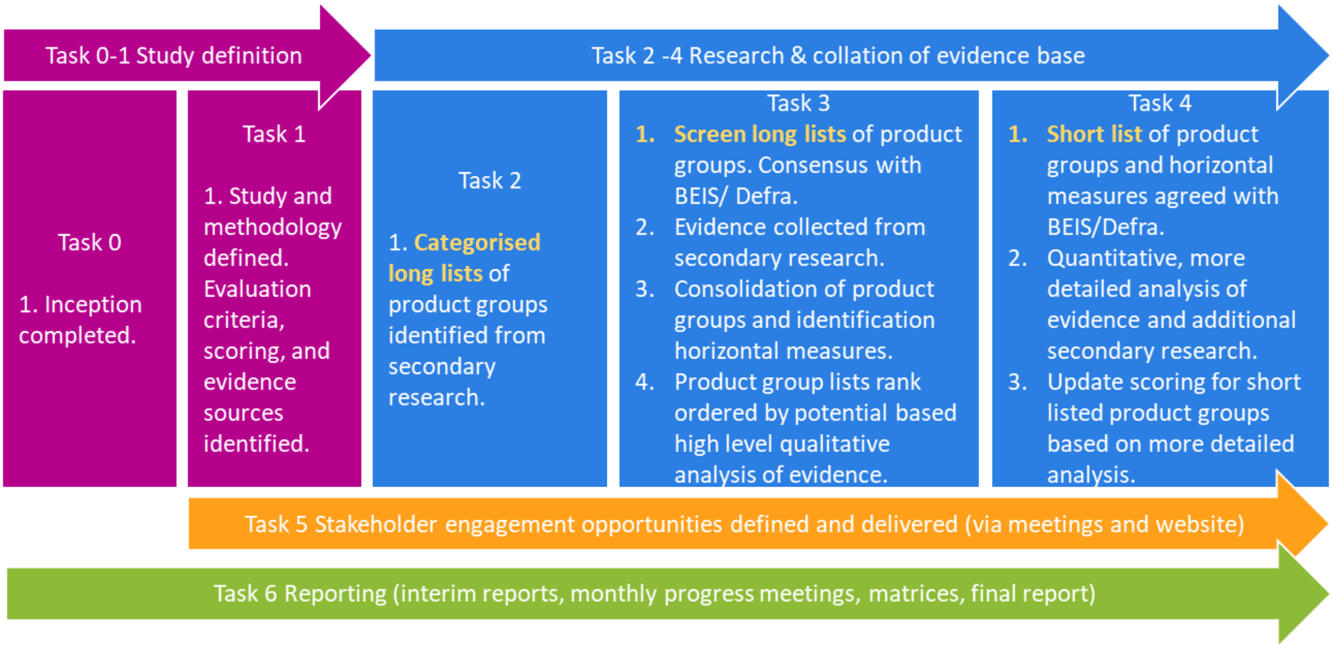
3 Methodology

This section outlines ICF's approach and presents the evaluation criteria, approach taken to attribute scores against the criteria and evidence used to inform scoring decisions, and the level of analytical detail used at each stage of the study.

3.1 Overall approach

The overall approach to this study has been summarised in Figure 3.1. This methodology section outlines ICF's proposed detailed approach to Tasks 2-4.

Figure 3.1 Overall approach to the study



3.2 Task 2: Product groups and horizontal measures - scoping

The scope of this review focused on product group categories within scope of EU Ecodesign and Energy Labelling and unregulated product categories in EU and the RoW as well as horizontal measures. Horizontal measures have been identified from the list of publications reviewed in Table 2.11 'Resource efficiency/circular economy evidence sources.' These publications relate mainly to UK and EU markets as Europe is a leader in this field.

Table 3.1 contains all the types of product lists that were prepared in Task 2 'Identification of product groups and horizontal measures to be considered'. The lists of products were created based on standards and labelling regulations in place in the EU and RoW and for unregulated product categories.

Evidence sources for the secondary research included EU related studies for standards and labelling measures (e.g., preparatory studies, review studies, Ecodesign workplans, etc) and their RoW equivalents from other countries. Additional information was sought from NGOs, international organisations, and academia.

Task 2 resulted in a categorised long list of product groups and horizontal measures as presented in Table 3.1. Stakeholders were invited to provide feedback on these product groups and to recommend changes to the list. A list of recommendations and actions taken has been included in Annex 3. Task 2 also considered products proposed and other suggestions relating to horizontal measures and resource efficiency in responses to the Energy-related products Call for Evidence.

Table 3.1 Types of products groups to be prepared by this study

Task 2 Long List Product Categories	Type of product group list	Evidence sources
Current MEPS & labelling or VA/SRI in the EU	List of product groups with MEPS, labelling, Voluntary Agreement (VA) or Self-Regulatory Instrument (SRI) in the EU.	Commission websites, CLASP website
Current policies in RoW (ex. EU) - regs and voluntary	List of product groups with a policy measure in the Rest of World (RoW) – either mandatory or voluntary.	CLASP website
Considered for regulation in the EU	List of product groups previously considered for regulation in Europe. Consideration ranges from mention in a workplan to completed European Commission preparatory study.	Preparatory studies that have not progressed to regulation, Ecodesign workplans, Ecodesign review studies
Considered for policies in the RoW	List of product groups previously considered for regulation in RoW.	National Government websites
Products not considered previously - current potential	List of product groups not known to be considered previously but identified as candidates due to current potential.	Ecodesign workplans, consideration by ICF technical experts

Task 2 Long List Product Categories	Type of product group list	Evidence sources
Products not considered previously - future potential	List of product groups not known to be considered previously, but identified as candidates due to future potential (e.g., small market now projected to grow significantly in the future)	Ecodesign workplans, consideration by ICF technical experts
Complex product (product systems potential)	List of complex product groups	Consideration by ICF technical experts
Smart product potential	List of smart product groups. By smart we mean products which are connected and are able to modulate their electricity consumption in response to signals, such as price.	Consideration by ICF technical experts
UK policy with potential circular economy	List of product groups under regulation but without circular economy	Consideration by ICF technical experts
Energy-Related Product (not energy consuming)	List of energy related product groups (e.g., windows, insulation)	Preparatory studies that have not progressed to regulation, Ecodesign workplans, Ecodesign review studies
Horizontal measures – current and developing	List of horizontal measures in place and under development in Europe and Rest of World. By horizontal measures we mean requirements that could be applied to many or all products, including for products where specific ecodesign requirements do not yet exist. Horizontal measures may relate to energy efficiency, e.g., standby mode requirements, or to resource efficiency, e.g., availability of spare parts.	Preparatory studies that have not progressed to regulation, Ecodesign workplans, Ecodesign review studies

3.2.2 Horizontal measures - scoping

Horizontal measures are requirements that could be applied to many or all products, including for products where specific Ecodesign requirements do not yet exist. Horizontal measures may relate to energy efficiency, e.g., standby mode requirements, or to resource efficiency, e.g., availability of spare parts. In this exercise, we have identified a range of measures relating to resource efficiency and circular economy that could be applied across a number of products or product groups, however in practice any of these could also be tailored and applied vertically to specific products or product groups in future regulations. As set out in section 1.3 this study looked at which policies may be most suitable for specific products.

Through some initial desk research, we have assessed the information in the European Commission Ecodesign Workplan preparatory study (Table 3.2), reviewed documentation[6][7][8][9][10] and developed the following measures to assess further and to attribute to products or product groups.

The following list separates out horizontal measures for consideration, dependent on the phase of the product lifecycle they relate to. Items 1-6 contain aspects of product design that could potentially be addressed with Ecodesign requirements. Item 7 relates to alternative business models and item 8 is about product information. Note that some measures feature in more than one group.

1. Production

- Energy demand
- Other resource/material demand
- Hazardous materials and chemicals
- Minimum recycled content
- Production waste

2. Resource/energy in use

- Energy - standby and off mode
- Energy smart reporting and functionality (e.g., energy smart appliances)
- Water efficiency
- Demand & footprint of other consumables (e.g., printer ink)
- Universal power supplies
- Universal batteries

3. Extend use – durability

[6] 25 Year Environment Plan
[7] Clean growth strategy
[8] Our Waste, Our Resources: a strategy for England
[9] Environmental Bill
[10] A new Circular Economy Action Plan: For a cleaner and more competitive Europe

- Expected lifetime
- Extended warranties
- Availability of firmware updates
- Address premature obsolescence

4. Extend use – reparability / upgradeability

- Modular design
- Ease of disassembly
- Availability of spare parts
- Information for repairers
- Diagnostic software and systems
- Information for consumers -

5. End of use – recyclability

- Ease of extraction of constituent materials e.g., CRM
- Product composition with recyclable materials
- Information for recyclers
- Reverse logistics e.g., take back schemes

6. End of use – remanufacture / refurbishment

- Ease of extraction of components / core suitable for remanufacture/ refurbishment
- Ease to refurbish whole device
- Information for remanufacturers / refurbishers
- Reverse logistics e.g., take back schemes

7. Servitisation

- Product as a service
- Shared / pooled services

8. Product information/labelling and market surveillance

- Product passports

- Environmental footprint
- Information for consumers
- Information for repairers
- Information for remanufacturers / refurbishers
- Information for recyclers
- QR codes
- Tagging / RFID chipping
- Smart reporting

3.3 Task 3: Preliminary analysis – Evaluation criteria

Task 3 started with the categorised long list of product groups identified in Task 2. Due to the large number of product groups that were identified during Task 2, an initial screening and consolidation was conducted to remove product groups that were poor candidates for future products policies and to consolidate similar products together where it made sense technically. Stakeholder feedback improved this task and BEIS and Defra feedback also contributed to this exercise.

For example, an initial look at standards and labelling in RoW has identified minimum performance standards for kimchi[11] refrigerators. It is likely that UK market size is either tiny or non-existent (compared to the South Korean market) and therefore this product group was removed from the list. An example of product consolidation is to assess domestic networking product groups together, as the products can be technically similar, having similar end-use and improvement options.

Table 3.2 sets out the evaluation criteria used in Task 3. They have been organised into a matrix that can be used to report results. Scoring against criteria was based on evidence available from secondary research and information provided by stakeholders. ICF technical experts used their judgement (based on their techno-economic experience working on product groups) where clear evidence was not available to allocate scores. In addition, availability of evidence (or lack thereof), was a criterion used to recommend advancing a product group to Task 4. The scores were used to inform which products to shortlist.

[11] Kimchi is a cabbage-based pickle popular on the Korean peninsula.

Table 3.2 Task 3 – scoring criteria for product groups

Task 3 Preliminary Assessment	Market score	Resource consumption score (in-use phase)	Material demand and circular economy score	Technical improvement potential score	Technical improvement costs score	GHG emissions score	Cost-effectiveness score	Potential for life extension score	Combined circular economy & market score
Product A									
Product B									
Product C									
Product D									

For horizontal measures, a similar consolidation exercise was undertaken at the start of Task 3 with Defra analysts. ICF then evaluated this consolidated list of horizontal measures separate to the product groups, as they have their own set of criteria. The horizontal measures criteria used to support the assessment were:

- Breadth of coverage across products and product groups
- Measure being planned, considered or previously implemented
- Costs of implementation
- Predicted impact on resource efficiency and energy demand

Secondary research identified the various measures in use in the EU and RoW. Measures related to circular economy and resource efficiency are relatively new (compared to energy standards and labelling programmes). EU based reports are an important information source, and secondary research in RoW did not identify any mature programmes, however all relevant information was captured.

3.3.2 Task 3: Scoring product groups and horizontal measures against criteria

To score the environmental impacts of the product groups, assessment criteria were broken down into sub-criteria listed in Table 3.3. Scores were then assigned to product groups based on evidence collected by the research team. The scores were used to help inform a shortlist of product groups to assess in more detail in Task 4. The list was selected to incorporate products that may have both high potential for improving their energy performance and resource efficiency as well as products that may have more potential for one or the other. Consideration was given to ensure that products included in the shortlist and therefore in the Task 4 assessment covered a range of sub-sectors.

Table 3.3 Attribution of scores to product groups

Criteria	Attribution of scores will be based on sub-criteria
Market	Imports (units/yr) Exports (units/yr)

Criteria	Attribution of scores will be based on sub-criteria
	Production (units/yr) Annual sales (units/yr) Market growth (%) Existence of energy efficiency related measures (yes or no) Price (£)
In-use resource consumption	Type of fuel consumed Per unit typical annual energy consumption (kWh/yr) Per unit water consumption (yes or no) Per unit consumables use (yes or no)
Circular economy and resource efficiency	Product weight (kg) Presence of critical raw materials (low, medium, high) Product lifetime (years) Duration of guarantee (years)
Technical improvement potential	Energy consumption reduction potential (%) Fuel switching potential (yes, partial, no) Water consumption reduction potential (%)
Technical improvement cost	Costs associated with achieving improvements related to technical improvement potential (%)
Combined scores	GHG emissions score (annual sales * per unit energy consumption * type of fuel consumed) Cost efficiency of reducing energy consumption (potential to reduce energy consumption * cost to reduce energy consumption) Potential for life extension (product price * lifetime * duration of guarantee)

To help ensure the outputs of Tasks 3 and 4 can aid in decision making, the approach to developing the scoring matrix was developed with simplicity and flexibility in mind.

- Scoring against these sub-criteria was kept simple to enable a large research team to systematically assign scores. This was important to ensure score comparability against different product groups. A one to five score was assigned based on one of the following approaches. Examples are provided in Table 3.4 and are described here. Number ranges against each score (e.g., unit sales per year, kWh consumed per year, kg weight of product, % improvement, lifetime in years).
- Binary scores (yes or no).
- Judgement based scores (low, medium, high) were completed by a single team to help ensure consistency.

A complete list of the sub-criteria and the scoring approach is provided in 0. Scoring associated with each sub-criterion were tested against a cross-section of different product groups before being finalised. To minimise unique inputs, combined scores were developed to assist with decision making. For example, a 'GHG emissions' score was based on 3 separate scores (annual sales * annual energy demand * fuel type).

Table 3.4 Example scoring approach

Score category	UK annual sales	Water consumption	Presence of critical raw materials
Highest (5)	>500k/yr	Yes	High
High (4)	201-500k/yr		
Medium (3)	101-200k/yr		Medium
Low (2)	10-100k/yr		
Lowest (1)	<10k/yr	No	Low

Horizontal measures could not be assessed using the same criteria as products, and a systematic means for doing this was developed. As part of Task 3, the long list of horizontal measures was consolidated into 14 high level horizontal measures to make the scoring exercise more manageable. The measures focused on the following priority areas:

- Product information/ labelling requirements (e.g., information for the industry, product passports)
- Product requirements (e.g., modular design, availability of spare parts, lifespan, recyclability
- Suitability for remanufacture)

- Energy-focussed (e.g., stand by and smart functionality)
- New business models (e.g., reverse logistics and servitisation).
- This list is not exhaustive.

Two sets of criteria in two separate short-listing exercises were used to assess horizontal measures in Task 3. We initially focused on coverage (e.g., could a wide range of products be covered with a single measure), pre-implementation of the measure (e.g., has it been trialled or implemented in other regions), suitability and overall impact, GHG emissions reduction potential and greater resource efficiency, cost to implement and suitability for eco-modulation of producer obligations. Assessment criteria were broken down into sub-criteria listed in Annex 2.

Table 3.5 presents the second set of criteria used on the second shortlisting exercise. Criteria included market data (price per unit) and the circular economy whole life of resource efficiency data (e.g., materials, hazardous substances, CRM content, etc.). These criteria were applied to each product group. High/low scores were assigned to each criterion based on how each measure aimed to reduce the environmental footprint of products

Weighting was assigned to each criterion and the shortlist of 26 products was scored. The top 10% and 25% of products were identified. The results of this exercise helped inform the four horizontal measures selected for Task 4.

Table 3.5 Task 3 – scoring criteria for horizontal measures.

Horizontal Measure	How does this measure primarily aim to reduce environmental footprint?	Typical price per unit	Materials (weight)	Hazardous substances	CRM content	Lifespan	Duration of guarantee
HM 1	e.g., recovery and recycling of more material at EoL	Low	High	High	Low	Low	High
HM 2	e.g., more sustainable purchasing decisions	High	High	High	High	High	High
HM 3	e.g., products longevity	High	High	High	High	High	Low

3.4 Task 4: Further analysis

3.4.1 Purpose, approach and outputs

The purpose of carrying out further analysis of shortlisted products and horizontal measures was to identify existing evidence on product performance, improvement potential and the policy levers available to potentially realise that potential in the UK. The shortlisted product groups are listed in Table 3.6.

Table 3.6 List of shortlisted products.

Annex No.	Sub-sector	Product group
8	Commercial/Industrial	Low pressure air compressors
9	Commercial/Industrial	Oil free air compressors
10	Commercial/Industrial	Standard air compressors
11	Commercial/Industrial	Refrigeration compressors
12	Consumer electronics	Electronic displays and TVs
13	Cooking	Non-domestic electric and gas hobs
14	Generation, conversion, supply, storage	Rechargeable batteries
15	Generation, conversion, supply, storage	External power supplies
16	Heating, Ventilation, Cooling	Building automated control systems (BACS)
17	Heating, Ventilation, Cooling	Electric and gas patio heaters
18	Heating, Ventilation, Cooling	Space heaters
19	Heating, Ventilation, Cooling	Water heaters
20	Heating, Ventilation, Cooling	Split system air conditioners
21	Heating, Ventilation, Cooling	Heat emitters

Annex No.	Sub-sector	Product group
22	ICT	Servers
23	ICT	Smart phones
24	ICT	Computers and laptops
25	Lighting	LED and luminaires
26	Materials	Inkjet and toner cartridges
27	Materials	Taps and showers
28	Motor driven	Water pumps
29	Refrigeration	Refrigerating appliances with a direct sales function
30	Refrigeration	Refrigerated containers
31	Small appliances	Vacuum cleaners
32	White goods	Professional dishwashers

The first step was to refine the scope of the product groups by identifying the specific products that would be in scope of the further analysis. This decision was made based on the 80/20 rule (e.g., focus on the 20% of specific products in a product group that are responsible for 80% of the energy consumption).

Where relevant, the scope of the product groups was defined to match or be similar to the scope identified by the associated European Commission preparatory study, draft Ecodesign and Energy Labelling regulations, or actual Ecodesign and Energy Labelling regulation.

Next, we identified additional evidence on the energy performance, material composition and circular economy topics related to each of the specific products. This was based on available evidence discovered during the literature review. The purpose of this information is to give policy makers a summary of the available evidence for each of the shortlisted products, and to help inform judgements on where to focus future evidence and analysis gathering efforts.

The outputs of this analysis have been presented in the form of factsheets (see Part B annexes) for each shortlisted product group and case studies for each shortlisted horizontal measure (to be published in a separate report). The factsheets contain a definition of each sub-sector and product group, market information, energy performance and resource efficiency information, outputs of the energy-related policy lever analysis, summary of stakeholder feedback and a short discussion section. The methods used are explained in the following sections.

The development of the horizontal measure case studies is on-going, and the outcome will be published later in a separate report.

3.4.2 Analysis of significant environmental impacts

We used the evidence from Task 3 and further research to carry out additional light touch quantitative analysis for shortlisted products to enable further analysis of significant environmental impacts (energy consumption and associated carbon emissions). The goal was to validate and further evidence the judgements made in Task 3, to improve the evidence base and to create high-level estimates to inform the magnitude of savings that can potentially be achieved for each product.

No scenario modelling was carried out based on specific policy levers. A simple analysis took place to estimate the theoretical maximum savings that could be achieved if all products sold were best available technologies (BAT) that minimise energy consumption or maximise energy savings. BAT technologies are based on currently available technologies.

To provide an illustration of the proportion of BAT savings that could be achieved via a collection of new and revised policies, a 2009 estimate of UK products policy and BAT savings was used to inform assumptions[12]. Although these estimates are over ten years old and the policy and technology state of play is much changed, the ratio of policy versus BAT savings from this previous work helps illustrate future potential savings. Sub-sector level ratios were derived for the following sub-sectors and applied to the shortlisted products:

- Consumer electronics
- ICT
- Domestic appliances
- Domestic central heating systems
- Air conditioning products
- Motors
- Commercial refrigeration

An average proportion of BAT savings has been calculated and used to estimate policy savings for shortlisted products that are not within those categories.

[12] Saving energy through better products and appliances

The saving estimates in each factsheet are not timebound. They are based on the estimate of lifetime savings achievable by units sold each year (usually based on best estimates closest to 2020).

3.4.3 Assessing energy-related policy lever suitability

Using information from the evidence base developed to date and additional research, we carried out an assessment of the suitability of each policy lever for each product group. This involved a series of steps including:

Evaluation of the characteristics of each policy lever and development of a set of prerequisites and suitability criteria to assess each policy lever against each product group.

Identification of the existence of energy-related test standards (or agreed approach for assessing energy performance) for each of the shortlisted products. Test standards can be international, European or British standards.

Identification of existing UK policy levers and assessment of shortlisted product groups already included in the policy lever.

Identification of examples of policy levers and their impacts from the rest of the world (RoW) to estimate potential future impacts to product groups.

An assessment of each of the policy lever and product group combination took place to provide indicative estimates of the time needed to implement a policy lever and to identify indicative future potential impacts. These steps are described in more detail in the following sections.

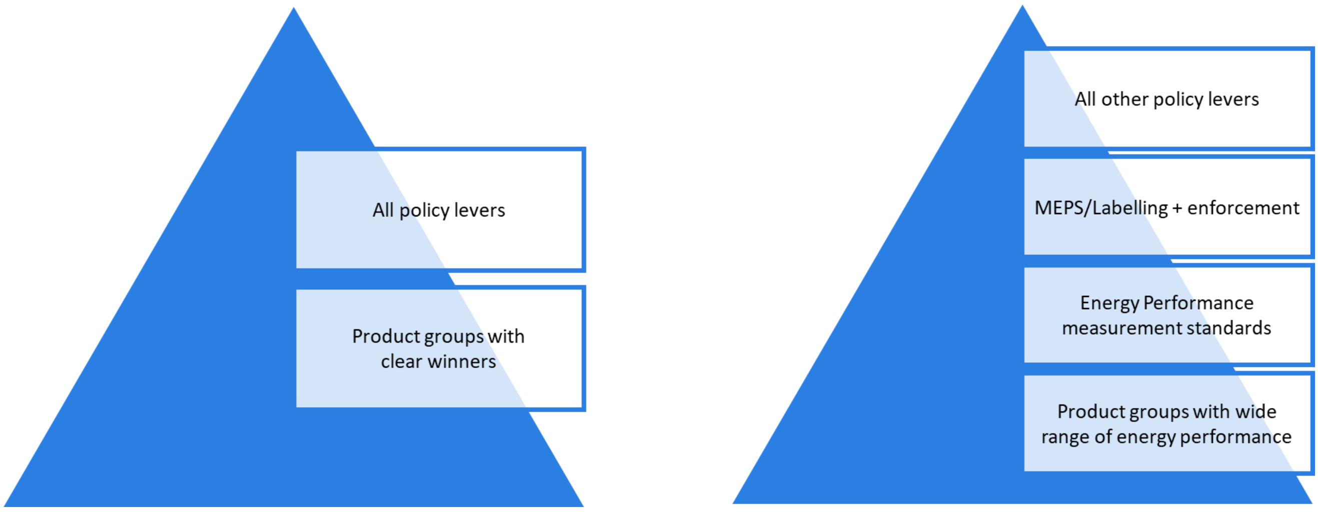
This analysis is intended to provide an indication of which policy levers might be suitable for each shortlisted product based on the criteria discussed below. This can help to inform Government decisions but is not necessarily an indication of the direction of Government policy. In many instances, it is recommended that more research and consultation is undertaken on a product-by-product basis before implementing any policies.

3.4.3.1 Policy lever suitability criteria

The policy levers included in this analysis mostly depend on the ability of stakeholders to discern between poor performing, typical, and high efficiency products. In some cases, this is easy to discern, particularly where product switching is the result of a policy intervention. For example, LED lighting is clearly more efficient than incandescent lighting and having a building automated control system installed is more efficient than not having one installed.

To account for this, we categorised the product groups into two categories: ‘clear winners’ and ‘wide range of energy performance’. Clear winners are immediately suitable for all policy levers, whilst the second category requires labelling to discern between product energy performance. Underpinning the labelling are energy performance related measurement standards. Product groups with a range of energy performance therefore need to have measurement standards and labelling in place to be suitable for most policy levers. On this basis, MEPS and labelling (either mandatory or voluntary) can be considered foundation policies or enablers of other policy levers. This is illustrated in Figure 3.2 below, which shows this policy lever hierarchy.

Figure 3.2 Policy lever hierarchy



Source: ICF

In addition to this policy hierarchy, many of the policy levers are only suitable for products in a specific sector or sub-sector. For example, obligation schemes such as the UK's Energy Company Obligation and communication campaigns such as the 'Big Energy Saving Week' are targeted to residential end users of products, whilst public procurement programmes such as Government Buying Standards and financing programmes such as Salix Finance are targeted to public sector end users of products.

The complete matrix of suitability criteria used to inform policy lever suitability can be found in Annex 4.

3.4.3.2 Identification of energy-related performance measurement standards

To assist with judgements on the time required to develop a new policy lever, an assessment of the current state of play of energy-related performance measurement standards for each of the shortlisted product groups took place. This was used in conjunction with the presence of MEPS and labelling policy levers to help judge the amount of time required to implement a policy lever for a shortlisted product group. For the same reasons, an assessment of the published resource efficiency/circular economy related standards or those under development took place in the horizontal measure case studies. The results of this assessment are included in 0.

3.4.3.3 Identification of existing UK policy levers related to each product group

In addition to the time required to develop a new policy lever, an assessment of existing policy levers in the UK took place to identify policy levers already applicable to the shortlisted product groups and that could be expanded to include them. This information was also helpful to understand how the policy levers worked and whether estimates of the policy lever impact were available via evaluation studies. The policy levers are listed in 0 and discussed further in Section 4.

3.4.3.4 Identification of policy levers in the Rest of World

We also carried out research to identify policy levers in the RoW to help with understanding policy levers and their potential impacts if applied to the UK or its constituent countries. This was not a comprehensive review of all available products policies but was intended to be a sampling of a variety of policy levers outside the UK. In addition to identification of the policy, evaluation studies were sought to help assess future potential impacts of the policy levers on the shortlisted product groups. The results of this effort are discussed further in Section 4.

3.4.4 Developing estimates of implementation time for each policy lever

Each factsheet contains a table in the 'Information on select policy levers and horizontal measures' section. For selected policy levers, an estimate of the time needed to implement[13] (in years) has been developed to give policy makers a way to compare the amount of time that may be required to implement a new policy. These estimates were made based on Table 3.8 and Table 3.9 below and adjusted for each product group as needed. The key assumptions are explained at the bottom of the table.

Table 3.7 Assumptions used to develop indicative time needed to implement estimates for each policy lever Status categories – current state of play regarding criteria used for time to implement estimates

Status Category	Status category description
A	No MEPS, labelling, standards, or transitional method of measurement. No existing policy lever.
B	MEPS, labelling, standards, or transitional method of measurement are under development. No existing policy lever.
C	MEPS, labelling, standards, or transitional method of measurement exist. Time is based on an estimation of time required to revise an existing regulation. No existing policy lever.
D	No MEPS, labelling, standards, or transitional method of measurement. Suitable existing policy lever.

[13] Implementation dates are not necessarily the same as the date mandatory requirements take effect. For example, Ecodesign policies usually have a transition period of 12-18 months after passing of legislation and before requirements take effect.

Status Category	Status category description
E	MEPS, labelling, standards, or transitional method of measurement are under development. Suitable existing policy lever.
F	MEPS, labelling, standards, or transitional method of measurement exist. Time is based on an estimation of time required to revise an existing regulation. Suitable existing policy lever.

Table 3.8 Assumptions used to develop indicative 'time needed to implement' estimates for each policy lever – Product groups with a wide range in performance

Policy lever	A	B	C	D	E	F
MEPS (includes enforcement)	3	1.5	2	3	1.5	2
Mandatory label (includes enforcement)	3	1.5	2	3	1.5	2
Voluntary endorsement label	1	1	1	1	1	1
Obligation scheme	4	2.5	1	3.5	2	0.5
Public procurement	4	2.5	1	3.5	2	0.5
Communications campaign	4	2.5	1	3.5	2	0.5
Advice/aid in implementation	4	2.5	1	3.5	2	0.5
Grants, subsidies, loans	4	2.5	1	3.5	2	0.5
Taxes on poor performing products	4	2.5	1	3.5	2	0.5
Technology deployment/diffusion	4	2.5	1	3.5	2	0.5

Table 3.9 Assumptions used to develop indicative 'time needed to implement' estimates for each policy lever – Product groups that have 'clear winners'

Policy lever	A	B	C	D	E	F
MEPS (includes enforcement)	3	1.5	2	3	1.5	2
Mandatory label	3	1.5	2	3	1.5	2
Voluntary endorsement label	3	1.5	2	3	1.5	2
Obligation scheme	1	1	1	0.5	0.5	0.5
Public procurement	1	1	1	0.5	0.5	0.5
Communications campaign	1	1	1	0.5	0.5	0.5
Advice/aid in implementation	1	1	1	0.5	0.5	0.5
Grants, subsidies, loans	1	1	1	0.5	0.5	0.5
Taxes on poor performing products	1	1	1	0.5	0.5	0.5
Technology deployment/diffusion	1	1	1	0.5	0.5	0.5

Assumptions (years)

3	Time to develop brand new mandataory meps/labelling (and standards)
1.5	Time to complete meps/labelling/standards underway (either new or revision)
2	Time for GB to initiate/complete revision of existing meps/labelling/standards (1yr for study, 1 yr for policy making)
1	Time to implement new non-mandatory MEPs/labelling policy lever
0.5	Time to include product group into existing non MEPS/labelling policy lever

There are three drivers of the time estimate allocations related to each specific product group:

- Type of product group (see Section 3.4.3.1 for details).
- Status of MEPS/ labelling/ measurement standards or transitional methods of measurement (TMM) related to each product group (see 0 for details);
- Existence of related policy lever in the UK (see 0 for details).

The assumptions here are intended to allow for comparative analysis between different policy levers and product group combinations. Assumptions were made based on judgements of typical time required to develop harmonised standards, time needed to develop an evidence base and draft mandatory and voluntary policy levers. Actual time required to design and implement a policy lever will depend on Government priorities and resources.

Time required to develop standards can also vary based on the complexity of a product group, and the type of standard being developed.

3.4.5 Potential trade-offs

3.4.5.1 Trade-offs between energy efficiency and the circular economy

Whilst improved energy efficiency and resource efficiency can both contribute to limiting the environmental impacts of products, there is a potential for conflicting impacts due to the different outcomes of energy-related policy levers and shortlisted horizontal measures included in Task 4. Examples of potential trade-offs are presented in Table 3.10, but those which were examined in Task 4 were specific to the shortlisted horizontal measures.

Table 3.10 Illustrative trade-offs with impacts on product performance

Improvement	Key benefit	Key trade-offs
Improved energy efficiency	Reduced energy consumption	Potential increased raw material usage, use of hazardous materials, reduction in consumer experience, additional cost outweighs value of benefits
Improved water efficiency	Reduced water consumption (and energy consumption where water is heated)	Potential reduction in user experience although this is not inevitable and will depend on how reduced water consumption is achieved
Reuse, repair	Lifetime extension	Older, potentially less energy efficient products continue to be used
Modularisation of products	Allows for replacement of components	Potential impact on design or durability if designed for component upgrades
Material efficiency, light-weighting of products	Decreased raw material usage, lower transportation costs, lower disposal costs	Potential impact on durability

The shortlisted horizontal circular economy measures are listed as follows:

- Requirements for material content and declaration
- Repairability measures – modular design
- Product support and extension of Ecodesign “November package” resource efficiency measures[14]

14 In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

- Mandatory minimum warranty/guarantee

Requirements for material content and declaration are information requirements that also enable future limiting of the environmental footprint of products by setting requirements in respect of the material contents of products e.g., % recycled / hazardous substances / critical raw materials (CRM). Depending on the material contents limited, there is potential for a conflicting impact on energy-related policy levers. There are many options to limit the environmental footprint of a product. Specific trade-offs depend on the specific material that is limited. Identification of the specific materials for each product group is beyond scope of this study. The trade-off examined here is limited to provision of information requirements only.

A mandatory minimum warranty/guarantee is not expected to have a trade-off with energy performance, as this measure is intended to help ensure that a product remains in use for its expected lifetime.

Product support measures and extension of Ecodesign November package measures[15] are intended to ensure that manufacturers and/or distributors provide the necessary means for products to be kept in use for as long as possible. They also intend to ensure products are designed to be repairable.

3.4.5.2 Any product group specific trade-offs relating to the policy levers and shortlisted horizontal measures are highlighted in the factsheets. Policy lever impacts – distributed costs and benefits

A second type of trade-off that was examined is the potential for different impacts on different product groups when considering each energy-related policy lever and horizontal measure. Impacts are not necessarily uniform due to variations in the market for each product group. Typical distributions of costs and benefits for each policy lever are included in Table 3.11. Each factsheet will state if there is a potential to diverge from this typical distribution of costs and benefits.

The parties that incur the costs and benefits should be clear. Costs incurred by society are only associated with obligation schemes because energy suppliers are likely to meet the cost of their obligations through increases to energy prices. Because this cost is not limited to purchasers or end users of the products, these costs have been allocated to society. Retailers have been included in costs around voluntary endorsement labels and advice/aid in implementation. This is because there are opportunities for specific policy levers that involve retailers training staff or improving information provision at the point of sale. Although it could be assumed that the costs could be passed on via higher prices of all goods sold (and therefore assigned to society), we have assumed that these costs would not be significant, and typical pricing drivers will continue to be most important in a retail establishment.

Related to benefits, we have assumed that Government, in addition to society, will incur benefits related to all policy levers, as they all help achieve Government CO2e emissions

[15] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products “the November Package”, which included resource efficiency measures.

reduction targets which reduces the need for other emission reducing policy levers in other sectors.

Table 3.11 Typical distribution of costs and benefits

Energy related policy lever & horizontal measures	Costs						Benefits			
	Government	Manufacturer	Retailers	Energy	End-users	Society	Manufacturer	Government	End users/	Repairers/
MEPS (includes enforcement)	x	x			x			x	x	
Obligation scheme				x	x	x		x	x	
Public procurement[16]	x							x	x	
Mandatory label (includes enforcement)	x	x			x			x	x	
Voluntary endorsement label		x	x					x	x	
Communications campaign	x							x	x	
Advice/aid in implementation	x		x					x	x	
Grants, subsidies, loans	x						x	x	x	
Taxes on poor performing products[17]					x			x	x	
Technology deployment/diffusion	x	x					x	x	x	
Requirements for material content and declaration		x						x	x	x
Repairability measures - modular design		x			x			x	x	x
Product support & extension of Ecodesign November package measures[18]		x			x			x	x	x
Mandatory minimum warranty/guarantee		x			x			x	x	x

[16] Manufacturers of more efficient products would benefit from public procurement requirements
[17] Manufacturers of more efficient products would benefit from taxes on less efficient products.
[18] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

3.5 Evidence sources

ICF carried out research to pull together lists of EU based evidence and research and compiled lists of existing Ecodesign regulations, preparatory studies, review studies, Ecodesign workplan preparatory studies. We investigated the associated research papers to pull out product group information and underlying evidence.

We identified equivalent studies in the RoW. Several RoW related research papers on standards and labelling regulations around the world have been summarised here. Further research was undertaken to identify underlying evidence feeding into the existing regulations (and new candidate product groups). In addition, academic research papers and peer reviewed journal databases were searched to identify additional evidence sources.

3.5.1 Ecodesign regulation

Table 3.12 List of existing Ecodesign Regulations[19]

Product Group	Implementing Measure
Air conditioners	(EU) No 206/2012
Air heating products, cooling products, high temperature process chillers and fan coil units	(EU) 2016/2281
Circulators (glandless standalone circulators and glandless circulators integrated in products)	(EU) No 622/2012
Computers	(EU) No 617/2013
Servers and data storage products	(EU) No 2019/424
Domestic ovens, hobs and range hoods	(EU) No 66/2014
Electric motors	(EU) No 4/2014 (EU) No 2019/1781 (From 01/07/2021)
Electrical lamps and luminaires	(EU) No 2015/1428 (EU) No 2019/2020 (From 01/09/2021)

[19] EU Regulations in effect before 1 January 2021 were retained in GB and continue to apply. Existing and future EU regulations will continue to apply in Northern Ireland subject to the terms of the Northern Ireland Protocol. Following a consultation, BEIS intends to implement UK regulations to implement the new Ecodesign requirements for displays, household refrigeration, commercial refrigeration, washing machines/washer dryers, dishwashers. Subject to consultation BEIS also intends to implement new Ecodesign requirements for lighting.

Product Group	Implementing Measure
Electronic displays and televisions	(EU) No 801/2013 (EU) No 2019/2021 (From 01/03/2021)
External power supplies (no-load condition electric power consumption and average active efficiency of external power supplies)	(EC) No 278/2009 (EU) No 2019/1782 (From 01/04/2020)
Fans driven by motors with an electric input power between 125 W and 500 kW	(EU) No 327/2011
Household dishwashers	(EU) No 1016/2010 (EU) No 2019/2022 (From 01/03/2021)
Household refrigerating appliances	(EC) No 643/2009 (EU) No 2019/2019 (From 01/09/2021)
Household tumble driers	(EU) No 932/2012
Household washing machines	(EU) No 1015/2010 (EU) No 2019/2023 (From 01/03/2021)
Local space heaters	(EU) No 2015/1188 (EU) No 2015/1185
Professional refrigerated storage cabinets	(EU) No 2015/1095
Refrigerating appliances with a direct sales function	(EU) No 2019/2024
Residential ventilation units	(EU) No 1253/2014
Simple set-top boxes	(EC) No 107/2009
Small, medium and large power transformers	(EU) No 2019/1783 amending (EU) No 548/2014

Product Group	Implementing Measure
Solid fuel boilers and packages of a solid fuel boiler, supplementary heaters, temperature controls and solar devices	(EU) No 2015/1189
Space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device	(EU) No 813/2013
Standby and off mode electric power consumption of electrical and electronic household and office equipment	(EU) No 801/2013
Vacuum cleaners	(EU) No 666/2013
Water heaters, hot water storage tanks and packages of water heater and solar device	(EU) No 814/2013
Water pumps	(EU) No 547/2012
Welding equipment	(EU) No 2019/1784

3.5.2 List of Ecodesign IMs under review

Table 3.13 List of existing Ecodesign Regulations under review

Product group	Existing IM	Consultation Forum date	Stakeholders consulted
Circulators	(EU) No 622/2012	13 June 2019	EHI / HHIC / BPMA / Member State (MS) comments
Air conditioners	(EU) No 206/2012	9 September 2019	FETA / APPLiA / Eurovent / MS comments
Local space heaters	(EU) No 2015/1188 (EU) No 2015/1185	10 September 2019	BEAMA / MS comments
Tumble dryers	(EU) No 932/2012	18 September 2019	APPLiA / AMDEA / MS comments

Product group	Existing IM	Consultation Forum date	Stakeholders consulted
Water pumps	(EU) No 547/2012	29 October 2019	BPMA / MS comments
Vacuum cleaners	(EU) No 666/2013	30 October 2019	APPLiA /AMDEA / MS comments
Imaging Equipment	SRI/ VA	12 December 2019	MS comments

3.5.3 Pipeline of New Ecodesign implementing measures based on preparatory studies being prepared or completed

Table 3.14 Pipeline of products under consideration for future Ecodesign implementing measures

Lot	Product Group	New Regulation
ENTR Lot 4	Industrial ovens (Inactive)	Voluntary agreement possible
ENER 33	Smart Appliances	Study complete. No regulatory action yet. Inclusion of EV chargers is important
ENER 37	Lighting Systems	Study complete. No regulatory action yet. Would take Ecodesign from products to systems, as installation very important
ENTR 7	Steam Boilers (Inactive)	Study complete. Insufficient traded quantity for Ecodesign to apply.
ENER	Rechargeable electrochemical batteries with internal storage	Study completed in March 2020.
ENTR 8	Power cables (Inactive)	Study complete. No action on regulation (wiring regulations would be better)
GROW 11	Lifts	Study completed in October 2019. Concluded that EPBD would be more suitable than Ecodesign for establishing MEPS.
GROW 12	Hand Dryers	Study completed in May 2020.

Lot	Product Group	New Regulation
ENER 24	Professional wet appliances and dryers (Inactive)	Inactive
ENER 27	Uninterruptible power supplies	Study completed. No regulatory action yet.
ENER 28	Pumps for wastewater	Considered as input to 2019 review of pumps regulation. Not included in MEPS
ENER 29	Large pumps and pumps for pools, fountains and aquariums	Considered as input to 2019 review of pumps regulation. Not included in MEPS
ENER 31	Compressors	CF took place on 11 Sept 2019
ENER 32	Window Products (Inactive)	Inactive
ENER	Building automated control systems (BACS)	Study underway. Would take Ecodesign into systems, with installation highly important to performance
JRC	Solar Photovoltaic modules, inverters and systems	Study completed in December 2019. Recommendations include Ecodesign MEPS for modules and inverters, and energy labelling, Ecolabelling, voluntary agreements and green public procurement as policy options.
	Refrigerated containers	Study underway
JRC	High Pressure Cleaners	Study completed in June 2019. Recommended that durability and repairability of domestic products would result in greatest energy and emission savings. MEPS and labelling could be most effective in the professional sector and based on cleaning performance and motor-pump requirements.
JRC	Taps and shower heads	Study completed in 2014 and updated in 2019. Considering a Voluntary Agreement based on the European Water Label

Lot	Product Group	New Regulation
JRC/ Lot 3	Computers	Study completed in July 2018. Concluded that rate of technological progress makes it hard to regulate this product group.
JRC (on behalf of ENER)	Cooking appliances (formerly domestic ovens, hobs and range hoods)	Study ongoing. 2nd stakeholder meeting took place in May 2020. New draft report published in April 2021.
ENER Lot 1	Space and combination heaters	Study completed in July 2019. New impact assessment follow-up study ongoing and to be finalised in 2021.
ENER Lot 2	Water heaters	Study completed in July 2019. Included in the follow-up study mentioned for space and combination heaters.

3.5.4 Existing regulations where a review is due or pending

Table 3.15 Regulations where a review is due or pending

Product Group	Review Date
Air heating products, cooling products, high temperature process chillers and fan coil units	January 2022
Fans driven by motors with an electric input power between 125 W and 500 kW	March 2015
Professional refrigerated storage cabinets	May 2020

3.5.5 Energy Labelling Delegated Acts

Table 3.16 lists the current suite of 18 EU Energy Labelling delegated acts[20] – 16 vertical and two horizontal acts.

Table 3.16 List of Energy Labelling Delegated Acts

Product Group	Regulation
Air conditioners	(EU) No 626/2011
Domestic ovens, hobs and range hoods	(EU) No 65/2014
Electrical lamps and luminaires	(EU) No 874/2012 (EU) No 2019/2015 (From 01/09/2021)
Electronic displays and televisions	(EU) No 1062/2010 (EU) No 2019/2013 (From 01/03/2021)
Household combined washer-driers	96/60/EC (EU) No 2019/2014 (From 01/03/2021)
Household dishwashers	(EU) No 1059/2010 (EU) No 2019/2017 (From 01/03/2021)
Household refrigerating appliances	(EU) No 1060/2010 (EU) No 2019/2016 (From 01/03/2021)
Household tumble driers	(EU) No 392/2012
Household washing machines	(EU) No 1061/2010 (EU) No 2019/2014 (From 01/03/2021)
Local space heaters	(EU) No 2015/1186

[20] EU Regulations in effect before 1 January 2021 were retained in GB and continue to appl. Existing and future EU regulations will continue to apply in Northern Ireland subject to the terms of the Northern Ireland Protocol. New EU labelling requirements for displays, household refrigeration, washing machines/washer dryers and dishwashers will apply automatically as they took effect before the end of transition period. Subject to consultation, BEIS intends to introduce regulations to implement new labels for commercial refrigeration and lighting. EU energy labelling regulations will continue to apply automatically in Northern Ireland.

Product Group	Regulation
Professional refrigerated storage cabinets	(EU) No 2015/1094
Refrigerating appliances with a direct sales function	(EU) 2019/2018 (From 01/03/2021)
Residential ventilation units	(EU) No 1254/2014
Solid fuel boilers and packages of a solid fuel boiler, supplementary heaters, temperature controls and solar devices	(EU) 2015/1187
Space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device	(EU) No 811/2013
Water heaters, hot water storage tanks and packages of water heater and solar device	(EU) No 812/2013
Labelling of energy-related products on the internet	(EU) No 518/2014
Use of tolerances in verification procedures	(EU) 2017/254

3.6 Products assessed but without regulation in Europe

3.6.1 Ecodesign Workplans

Ecodesign has progressed through four workplans to date:

- The Transitional Period (2005-2008);
- The First Workplan (2009-2011)[21];
- The Second Workplan (2012-2014)[22]; and
- The Third Workplan (2016-2019)[23]

Table 3.17 provides a summary of the product groups featured in each of the four workplans.

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0660
[22] https://ec.europa.eu/docsroom/documents/9952/attachments/1/translations/en/renditions/pdf
[23] https://ec.europa.eu/docsroom/documents/20375

Table 3.17 Product groups in Ecodesign Workplans

Transition Period 2005-2008	**First Workplan 2009-2011**	**Second Workplan 2012-2014**	**Third Workplan 2016-2019**
Heating and water-heating equipment (boilers and water heaters only)	Air-conditioning and ventilation systems (commercial and industrial)	Window products*	Building Automated Control Systems
Electric motor systems	Electric and fossil-fuelled heating equipment	Steam boilers8 (< 50MW)*	Electric kettles
Lighting in the domestic and tertiary sectors	Food preparing equipment	Power cables*	Hand dryers
Domestic appliances	Industrial and laboratory furnaces and ovens	Enterprise servers, data storage and ancillary equipment*	Lifts
Office equipment in both the domestic and tertiary sectors	Machine tools	Smart appliances/meters*	Solar panels and inverters
Consumer electronics	Network, data processing and data storing equipment	Wine storage appliances (c.f. Ecodesign regulation 643/2009)*	Refrigerated containers
HVAC systems (domestic)	Refrigerating and freezing	Water-related products*	High pressure cleaners
Standby	Sound and imaging equipment	Positive displacement pumps	
	Transformers	Fractional horsepower motors under 200W	
	Water-using equipment	Heating controls	

Transition Period 2005-2008	First Workplan 2009-2011	Second Workplan 2012-2014	Third Workplan 2016-2019
		Lighting controls/systems	
		Thermal insulation products for buildings	

*Indicates a priority product group within the second workplan

The transitional period (2005-2008) contained eight broad product groups, which were broken down and delivered via 26 different preparatory studies.

The first workplan (2009-2011) contained ten new product groups, which resulted in a further 11 preparatory studies. The second workplan (2012-2014) contained a distinct priority and conditional list. Those which were priorities are marked with an asterisk in the table above. The third workplan (2016-2019) workplan[24] contained new product groups for which preparatory studies would be launched.

Originally, this list was based on a longer list of product groups which had been shortlisted by the preceding European Commission preparatory study for the "Ecodesign Workplan 3"[25]. The final list is included in the table above. The Commission's Communication announcing the third Ecodesign workplan also highlighted the following ICT products for more in-depth assessment with a view to their possible inclusion in the Ecodesign workplan. An ICT Impact study was completed in July 2020[26].

- Base stations
- Gateways (home network equipment)
- Mobile / smart phones

The products with existing Implementing Measures were originally identified in the transitional period and the First Working Plan. With the exception of servers and data storage equipment (regulated in March 2019)[27], no products from the Second Working Plan (except enterprise servers) have been regulated to date; however preparatory studies are underway, and several have been completed.

3.6.2 European Commission preparatory study for the Fourth Work Plan

The fourth work plan preparatory study kicked off in 2020 and the first three draft task reports have been published.

[24] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1486046599700&uri=CELEX%3A52016DC0773
[25] http://ec.europa.eu/DocsRoom/documents/20374/attachments/5/translations/en/renditions/pdf
[26] https://circabc.europa.eu/ui/group/1582d77c-d930-4c0d-b163-4f67e1d42f5b/library/b6884364-4e14-44a1-9e23-03a7fed002af
[27] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0424&from=EN

Products remaining from Working Plan 2016 – 2019 included in Task 2[28] are:

- Uninterruptible Power Supplies
- Professional laundry appliances
- Professional dishwashers
- Window products
- Non-tertiary coffee machines

New product groups included in Task 2 are:

- Interconnected home audio and video
- Small home/ office networking equipment
- Low temperature emitters
- Air curtains
- Small-scale cooking products
- Unmanned aircraft (drones)
- Water softeners
- Base stations and subsystems
- Industrial sensors
- Hair dryers
- Tertiary hot beverage equipment including free standing hot beverage vending machines
- Greenhouse covers
- Patio heaters

New horizontal measures included in Task 2 are:

- Lightweight design
- Durability
- Post-consumer recycled content
- Universal external power supplies
- Universal batteries for battery driven products
- Ecological profile

[28] https://www.ecodesignworkingplan20-24.eu/documents

- Horizontal innovative solutions for improved market surveillance

3.7 Products under regulation outside of Europe

A 2018 study 'Improving global comparability: how do Europe's S&L policies stack up'[29] covered nine major economies Australia, China, the European Union, India, Indonesia, Mexico, Russia, South Africa and the United States and more than 100 products across eight different product areas. The study found the EU has the largest number of MEPS, and the most ambitious MEPS and energy labels for more than half the comparable MEPS and label measures.

Table 3.18 Products covered by Standards and labelling by economy for all products analysed

Country	MEPS	Labels	MEPS or Labels
US	47	40	70
European Union	62	35	67
China (PRC)	39	42	51
Australia	35	18	41
Mexico	23	23	33
India	5	14	16
Russia	8	9	14
Indonesia	7	8	10
South Africa	2	8	9
TOTAL:	228	197	311

A 2013 study, Energy Standards and labelling programs throughout the world in 2013 (published May 2014)[30] provides high level statistics on standards and labelling programmes throughout the world. The countries with the most active national programs are:

- China with 100 measures.
- USA with 86 measures.
- Korea with 78 measures.
- All EU countries with 76 measures.
- Canada with 65 measures.

[29] https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2015/7-appliances-product-policy-and-the-ict-supply-chain/improving-global-comparability-how-do-europe8217s-sl-policies-stack-up/2015/7-411-15_Weyl-Reeves-rev.pdf/

[30] https://www.iea-4e.org/document/343/energy-standards-labelling-programs-throughout-the-world-in-2013

- New Zealand with 54 measures.
- Australia with 51 measures
- Other key statistics from the study are included in the table below.

Table 3.19 Key statistics from a 2013 global assessment of standards and labelling programmes (compared against 2004)

Description	2013	2004
Countries with standards and labelling programmes	81	50
Number of products subjected to mandatory energy performance standards	55	42
Number of energy performance standard measures	1,453	431
Comparative labels	1,149	354
Endorsement labels	1,002	435

The 2013 study summarised standards and labelling by geographical region as well, presented in Table 3.20 below.

Table 3.20 Summary of measures by measure type and geographical region (2013)

Selected Countries	Energy Performance Standards	Comparative Labels	Endorsement Labels	Total Measures
Europe	939	652	708	2299
Asia Pacific	243	228	195	666
North America	92	44	82	218
Central/South America	43	88	16	147
Middle East	79	78	0	157
Africa	57	59	1	117
Total	1453	1149	1002	3604

The study identified the most regulated products worldwide, summarised here.

Refrigerators (75 countries with 185 separate measures).

Room air conditioners (73 countries with 152 measures).

Lamps or ballasts (67 countries with lamps alone, accounting for some 358 separate measures across all lamps types).

Televisions (47 countries with 135 measures, most of which are now mandatory from a base of just 21 countries with 41 voluntary measures in 2004).

Some of the reports mentioned here are dated, so the CLASP NGO policy database will be a first point of research to identify products being regulated in the RoW. Resource efficiency/circular economy evidence sources

3.8 Resource efficiency/circular economy evidence sources

The research team carried out initial research as part of the assessment of horizontal measures and their suitability for future use. Table 3.22 includes a list of evidence sources (updated in January 2021).

Various sources enabled the collection of considerable evidence. Despite this, a lack of scientific/robust evidence at product level was found. Because of this, assumptions were made on material content (e.g., Critical Raw Materials and Hazardous Substances content) based on presence of components in products and presented in the product factsheets.

It was also noted that the naming conventions of product groups covered by different sources were not aligned, which made it more difficult to cross reference data and evidence. For example, naming conventions used in Ecodesign Regulations (Table 3.12) are not aligned with the Waste Electrical and Electronic Equipment (WEEE) categories and Environmental Agency statistic (see Table 3.21).

More evidence will be needed at a product level to establish the extent of resource efficiency and circular economy potential.

Table 3.21 Categories of EEE covered by the WEEE regulation (schedule 1) and used by the Environmental Agency to report WEEE collected in the UK.

Category Name WEEE regulation	Category Name Environmental Agency[31]
1) Large Household Appliances	1) Large Household Appliances
2) Small Household Appliances	2) Small Household Appliances
3) IT and Telecommunications Equipment	3) IT and Telecoms Equipment
4) Consumer Equipment and Photovoltaic Panels	4) Consumer Equipment
5) Lighting Equipment	5) Lighting Equipment

[31] For each compliance year EEE producers need to report products that are put on the market to the environmental regulator in one of these 14 categories.

Category Name WEEE regulation	Category Name Environmental Agency[31]
6) Electrical and Electronic Tools (with the Exception of Large-Scale Stationary Industrial Tools)	6) Electrical and Electronic Tools
7) Toys, Leisure and Sports Equipment	7) Toys Leisure and Sports
8) Medical Devices (with the Exception of all Implanted and Infected Products)	8) Medical Devices
9) Monitoring and Control Instruments	9) Monitoring and Control Instruments
10) Automatic Dispensers	10) Automatic Dispensers
	11) Display Equipment
	12) Cooling Appliances Containing Refrigerants
	13) Gas Discharge Lamps and LED Light Sources
	14) Photovoltaic Panels

Table 3.22 Resource efficiency/circular economy evidence sources

Title	Author	Date Published
25 Year Environment Plan	Defra	January 2018
Access to Critical Materials post note	UK Parliament	September 2019
BIO Intelligence Service (2013), Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP), Part 1: Material Efficiency for Ecodesign – Draft Final Report	European Commission - DG Enterprise and Industry	December 2013
Circular Economy & Sustainability in Critical Minerals podcast and resources	The Critical Minerals Association'	September 2017
Commission Staff Working Document - Sustainable Products in a Circular Economy - Towards an EU Product Policy Framework contributing to the Circular Economy	European Commission	March 2019
COMMUNICATION FROM THE COMMISSION Ecodesign Working Plan 2016-2019 COM/2016/0773 final - Contribution to the circular economy	European Commission, DG for Internal Market, Industry, Entrepreneurship and SMEs	November 2016
COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND	European Commission	September 2020

Title	Author	Date Published
THE COMMITTEE OF THE REGIONS Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability COM/2020/474 final		
Consumers and repair of products – European Parliament briefing	European Parliamentary Research Service, Nikolina Šajn	September 2019
Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study	European Commission, Joint Research Centre) Bobba, S., Carrara, S., Huisman, J., Mathieux, F., Pavel, C.	2020
CRM Recovery programme	WRA, KTN, Wuppertal Institute, ERP UK Ltd and EARN	2016
Design for a circular economy – Reducing the impacts of the products we use	Green Alliance	November 2020
Development of an approach for assessing the reparability and upgradability of Energy-related Products	Mauro Cordella, Javier Sanfelix, Felice Alfieri	2018
Documentation of changes implemented in the ecoinvent database v3.7 – 9 Waste sector	Ecoinvent Association	September 2020

Title	Author	Date Published
	Moreno Ruiz E., Valsasina L., FitzGerald D., Symeonidis A., Turner D., Müller J., Minas N., Bourgault G., Vadenbo C., Ioannidou D., Wernet, G.	
Ecodesign as Part of Circular Economy – Implications for Market Surveillance – Discussion paper	ECOS	November 2018
Ecoinvent 3.7	Ecoinvent Association	September 2020
Electronic products and obsolescence in a circular economy	European Environment Agency - European Topic Centre Waste and Materials in a Green Economy	June 2020
Electronic Waste and the Circular Economy – First Report of Session 2019-21	House of Commons Environmental Audit Committee	2020
Electronics and the Circular Economy	ERP/Edie	September 2020
Environment Bill 2019-21	Defra	
Environmental assessment of the durability of energy-using products: method and application	Fulvio Ardente, Fabrice Mathieux	July 2014

Title	Author	Date Published
Environmental Footprint And Material Efficiency Support For Product Policy	Talens Peiro Laura and Ardente Fulvio	2015
Environmental Labelling and Information Schemes (ELIS)	OECD	2016
EU Green public procurement criteria for imaging equipment, consumables and print services	European Commission	July 2020
ICT Impact study – Final report	European Commission, Directorate-General for Energy	July 2020
IEC – Preparing the Circular Economy report (2019) and ACEA workshops – circular economy and Material Efficiency initiatives	ACEA	October 2019
IEC – TC 111 Environmental Standardization for electrical and electronic products		October 2018
Improving material efficiency in the life cycle of products: a review of EU Ecolabel criteria	Cordella, M., Alfieri, F., Sanfelix, J. et al.	March 2019
ITU-T SG5: Environment, climate change and circular economy (2017-2020)	International Telecommunication Union	
JRC Technical Report - Analysis and development of a scoring system for repair and upgrade of products	Cordella Mauro, Alfieri Felice and Sanfelix Forner Javier Vicente	2020

Title	Author	Date Published
JRC Technical Report - Guidance for the Assessment of Material Efficiency: Application to Smartphones	Cordella Mauro, Alfieri Felice and Sanfelix Forner Javier Vicente	2020
JRC Technical Report - Methods for the Assessment of the Reparability and Upgradability of Energy-related Products: Application to TVs	Sanfelix Forner, Javier Vicente, Cordella Mauro and Alfieri Felice	2019
Longer Product Lifetimes Summary Report	Defra – ERP Jackie Downes, Bernie Thomas, Carina Dunkerley and Howard Walker (Bridge Economics)	2011
MEPS push for limited 'right-to-repair' on consumer devices	Eszter Zalan	October 2020
Minerals UK – Centre for sustainable mineral development		
Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024	European Commission - DG GROW	2020
Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC	European Commission - DG Enterprise and Industry	2015
Raw materials Information System (RIMS)	European Commission Joint Research Centre (JRC)	

Title	Author	Date Published
Reducing UK emissions: Progress Report to Parliament	Committee on Climate Change	June 2020
– indice de réparabilité et indice de durabilité – loi anti-gaspilage pour une économie circulaire	Ministère de la Transition écologique	January 2010
Resources and waste strategy for England	Defra	December 2018
Review of the Future Resource Risk Faced by the UK Business and an Assessment of Future Viability	Defra	December 2010
Study to Support Preparation of the Commission's Guidance for Extended Producer Responsibility Schemes	Eunomia (Chris Sherrington, Joe Papineschi, Mark Hilton, Alex Massie, Peter Jones) for DG Environment of the European Commission	April 2020
The Effectiveness of Providing Labels and other Pre-Purchase Factual Information in encouraging more Environmentally Sustainable Product Purchase Decisions: Expert Interviews and a Rapid Evidence Assessment	WRAP	February 2019
UNEP (2010) Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials, A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management.	Hertwich, E., van der Voet, E., Suh, S., Tukker, A., Huijbregts M., Kazmierczyk, P., Lenzen, M., McNeely, J., Moriguchi, Y.	2010

Title	Author	Date Published
Waste electrical and electronic equipment (WEEE): evidence and national protocols guidance	Environmental Agency	
Why scaling repair is necessary right now	Sandra Goldmark	October 2020

4 Results of further analysis

4.1 Further analysis of product groups

The maximum technical potential energy and carbon savings that could be achieved with BAT have been estimated for the shortlisted products. These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each product and allow identification of product groups with the highest savings potential. These are presented in Table 4.1.

The figures presented below are high-level estimates of the maximum savings that could be achieved over a 10-year period if all units sold in the UK in one given year were BAT instead of average products. Savings were first calculated on a per unit basis over products' lifespan, then multiplied by average UK annual sales. Lifetime savings were then annualised and multiplied by 10 to allow for comparison between products with different lifespans.

In addition to presenting maximum BAT savings (e.g., what could be achieved if all units sold in the UK were BAT), Table 4.1 also presents the scaled down savings that could be achieved with a mix of policy levers (e.g., MEPS, mandatory label, voluntary endorsement label, obligation scheme, etc.). Section 3.4.2 provides further detail into the assumptions behind scaling down BAT savings to savings that could be achieved with a mix of policy levers.

Example of applying the methodology for estimating savings

Up to 42,000 units of non-domestic BACS are sold in the UK each year. These are installed in buildings which consume on average 109,000 kWh/year of gas and 67,000 kWh/year of electricity. The average lifespan of BACS is up to 18 years. With BAT BACS installed, these buildings can consume up to 71% less gas and 64% less electricity. The average proportion of BAT savings that can be achieved with a mix of policy levers is 40%.

For each unit of BAT BACS installed in a building, 109,000 x 71% = 77,400 kWh/year of gas and 67,000 x 64% = 42,900 kWh/year of electricity can be saved, meaning 120,300 kWh of energy could be saved per year.

Hence, if all units sold in the UK in one year were BAT BACS, savings could reach 42,000 x 120,300 = 5 TWh, which sums up to 50 TWh over 10 years. Savings that could be achieved with a mix of policy levers are 50 x 40% = 20 TWh. Carbon savings are estimated using default emission factors.

The Product Factsheets included in the Part B Annexes of this report provide further detail into the assumptions behind the estimates for potential savings. Additional research is required to confirm these estimates and provide more accurate saving figures.

Table 4.1 Highest BAT Potential Savings from the Task 4 Shortlisted Products

	Maximum technical potential savings (with BAT)		Savings that can be achieved with a mix of policy levers	
Product Group	**Energy (TWh)**	**Carbon (MtCO2e)**	**Energy (TWh)**	**Carbon (MtCO2e)**
Non-Domestic Building Automated Control Systems	50.50	9.67	20.30	3.89
Domestic Building Automated Control Systems	25.63	4.76	10.30	1.91
Curtains, blinds, doors and covers for refrigerated display cabinets	15.40	3.16	8.29	1.70
Hobs	10.87	2.02	3.13	0.58
Servers	7.92	1.62	3.18	0.65
Space Heaters	7.65	1.44	1.67	0.32
Refrigerating appliances with a direct sales function	5.99	1.23	3.23	0.66
External Power Supplies	5.50	1.13	2.21	0.45
Water Pumps	4.59	0.95	1.84	0.38
Standard air compressor	1.66	0.34	0.67	0.14

4.1.2 Estimated energy and carbon savings for the top 10 shortlisted product groups

The savings for non-domestic Building Automated Control Systems (BACS) are calculated assuming these systems can save up to 71% of a building's gas consumption and up to 64% of its electricity consumption. This leads to the highest energy and carbon savings across shortlisted product groups when considering the average energy consumption of buildings in the UK and the number of systems that could be installed or upgraded. The potential savings that can be achieved by domestic BACS are proportionally lower – up to 26% savings to gas consumption and 8% savings to electricity consumption – but the average energy consumption of buildings and the number of systems that could be installed or upgraded in the UK also lead to a large savings potential. The Benefit to Cost Ratio (BCR) for achieving BAT savings is higher than one for both domestic and non-domestic BACS, suggesting that the benefits created by installing or upgrading these systems outweighs the costs.[32]

Savings for retrofit measures for Refrigerated Display Cabinets (RDCs) have been calculated assuming that curtains, blinds, doors or covers are installed in these units, which can reduce the energy consumption of a unit. Maximum energy savings are up to 40% with the installation of doors specifically, which are the most efficient retrofit measures. The BCR for achieving BAT savings is greater than one for these measures suggesting that the benefits created by retrofitting an RDC outweighs the retrofit costs.

The savings for professional hobs are mostly attributable to switching to induction hobs, which can be up to 53% more efficient than solid plate / cast iron hobs and up to 81% more efficient than gas hobs. The BCR for achieving BAT savings is greater than one for both cast iron/hot plate and gas hobs, suggesting that the benefits created by switching from these technologies to induction hobs outweigh the costs. Although future emission savings are available from fuel switching, these emission savings rely on timelines to decarbonise electricity. As the analysis undertaken did not include a time-series element, this impact was excluded from the analysis for all product groups.

The space heaters product group includes space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar devices. For estimating energy savings, these have been split into two specific products: gas boiler space heaters and heat pump space heaters. Most of the savings that can be achieved for this product group (84%) relate to gas boilers as these have large average sales figures (around 1.7 million units per year) and consume a considerable amount of energy (up to 12,500 kWh per year per unit). Highly efficient gas boiler space heaters can consume up to 3% less energy than average products. However, the BCR for achieving BAT savings is lower than one, suggesting that the costs for achieving savings might outweigh the benefits.

The server's product group has been split into two: distributed IT servers and datacentre servers. Most of the savings that can be achieved for this product group (87%) relate to the datacentre servers as these have large average sales figures (around 1 million units per year). BAT servers can consume up to 30% less energy than average products. The BCR for distributed IT servers is slightly lower than one and the BCR for datacentres' servers slightly higher than one, suggesting that costs outweigh benefits for the former, but not the latter.

Refrigerating appliances with a direct sales function include refrigerated display cabinets (RDCs), beverage coolers and ice cream freezers. Most of the savings that can be achieved for this product group (91%) relate to RDCs as these have the larger average annual energy

[32] 0 provides further detail on the BCR.

consumption (up to 28 MWh/year). BAT RDCs can consume up to 50% less energy than average products. The BCR for achieving BAT savings is greater than one for these refrigerating appliances, suggesting that the benefits created outweigh their costs.

The external power supplies (EPS) product group has been split into large EPS (for laptops, scanners, inkjet printers and power tools – power greater than 50W) and small EPS (for other smaller electronics, such as portable audio, DECT and mobile phones, tablets, power tools, electric toothbrushes – power lower than 50W). Most of the savings that can be achieved for this product group (61%) relate to the small EPS as these have large average UK sales figures (up to 72 million units per year). BAT small EPS can consume up to 47% less energy than average products. The BCR for both small and large EPS is lower than one, suggesting that the increased cost of a BAT unit might outweigh the energy and carbon savings created.

Savings that can be created from UK sales of BAT water pumps have been calculated assuming that these units can be up to 28% more efficient than average ones. The BCR for achieving BAT savings is greater than one, suggesting these would be cost-efficient savings.

Savings attributable to UK sales of standard air compressors have been calculated assuming that these units can be between 4 – 20% more efficient than average ones, depending if product or system efficiency is improved. The BCR for achieving BAT savings is slightly higher than one for standard air compressors, suggesting that the benefits created by upgrading these products outweigh the costs.

Benefit Cost Ratio

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving technical savings. A simplified BCR has been estimated for shortlisted products through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M).

A BCR greater than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient. Although the values estimated in this study are high-level estimates, they should give some indication of the size of the benefits that can be achieved compared to the cost of achieving them. The Table 3.2 presents specific products with the highest BCRs, where savings can be achieved at the lowest costs.

Table 4.2 Highest Benefit to Cost Ratios for the Task 4 Shortlisted Products

Specific Product	Benefit Cost Ratio
Non-domestic Building Automated Control Systems (Electricity)	27.9
Refrigeration compressors	15.4

Specific Product	Benefit Cost Ratio
Water pumps	15.3
Non-domestic Building Automated Control Systems (Gas)	9.5
Refrigerated Display Cabinets	8.6
Electric storage water heaters	8.6
Hobs (Cast iron/Hot plate)	8.4
Ice cream freezers	6.0
Space heaters (heat pumps)	4.7
Hobs (Gas)	3.7

4.2 Further analysis of circular economy related horizontal measures

The purpose of Task 4 was to carry out further analysis of the shortlisted horizontal measures and the outputs presented in the form of case studies. At the time of writing, the preparation of the horizontal measure case studies is on-going, and the outcome will be published later in a separate report.

The horizontal measure case studies present a description of each horizontal measure, applicability to product groups, potential impact, and scale of opportunities within policies, legislation, and standards, enablers for implementation, identify the main initiatives and best practices already in place, the key stakeholders and challenges, opportunities and proposed next steps and recommendations.

4.3 Further analysis of energy related horizontal measures: Standby and off-mode energy consumption

4.3.1 Products in scope of current regulation

A horizontal EU Ecodesign regulation is in place in the UK to provide minimum energy performance criteria affecting a product’s standby mode energy consumption. Regulation (EU)

No 801/2013 amended the original standby regulation (EC) No 1275/2008[33]. The 2008 regulation placed requirements for standby and off mode electric power consumption of "electrical and electronic household and office equipment". These products are split into four main groups: Household appliances, Information technology equipment for domestic use, Consumer electronics equipment and toys, leisure, and sports equipment.

The original regulation covered imposed off-mode and standby mode maximum limits noted in Table 4.3.

Table 4.3 Standby Regulation No 1275/2008 maximum consumption requirements

Implementation date	Off-mode power	Standby mode	Standby mode with information or status display
01 Jan 2009	1.00 W	1.00 W	2.00 W
01 Jan 2013	0.5 W	0.5 W	1.00 W

The 2013 update to the Network Standby regulation[34] provided requirements to standby mode of products connected to the internet. The maximum limits for network standby consumption ranges from 3 to 12 Watts based on the type of network connectivity.

Table 4.4 Network Standby Regulation No 801/2013 maximum consumption requirements

Implementation date	HiNA equipment Networked standby	Non-HiNA equipment Networked standby
01 Jan 2015	12 W	6 W
01 Jan 2017	8 W	3 W
01 Jan 2019	No change	2 W

A distinction is made for "networked equipment with high network availability" (HiNA), meaning equipment with one or more of the following functionalities, but no other, as the main function(s): router, network switch, wireless network access point, hub, modem, VoIP telephone, video phone. Stricter limits are set for non-HiNA networked equipment.

[33] Ecodesign Standby regulation No 1275/2008 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R1275&from=EN
[34] Ecodesign Networked Standby No 801/2013 https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:225:0001:0012:en:PDF

4.3.2 Products excluded from the current regulation

The regulation currently has some exemptions. These are:

- Products equipped with electric motors operated by remote control
- Products placed in the market with low voltage external power supplies
- Professional equipment (white goods and IT)
- Other office equipment not stated in Annex I (e.g., business equipment).

Large printing systems are included in the Network Standby regulation but are exempt from the maximum standby consumption requirement. Other products such as televisions have unique standby requirements included in product specific Ecodesign regulations.

Products equipped with electric motors operated by remote control

This category applies to adjustable furniture and local building controls. The technology used to activate electric motors requires a similar amount of power compared to current standby levels. The 2017 review study on the Standby regulation found that 76% of the sampled adjustable furniture already met a standby consumption under 1W. Local building controls can meet the network standby consumption values without incurring significant cost. Local building controls market share is estimated to grow by 5% a year. The review study estimated there was a case to add these products to the standby requirement list.

Low voltage external power supplies (LV EPS)

The standby regulation does not apply to equipment placed on the market with a low voltage external power supply. These appliances are subject to the External Power Supply (EPS) regulation, which provides a “no-load” requirement that is stricter than the standby regulation. However, there is an increased number of devices (such as mobile phones) that fall into this exemption. There are currently few data points available to determine if these technologies can meet the standby criteria. Although the energy savings opportunity is estimated to be low, the review study recommended to include an information requirement for these products to gather data for future policy.

Professional white goods

Professional white goods need to harmonise low power modes with a test standard to measure the current performance of these goods. Until this takes place, it is not recommended to include them into the regulation. Because this product group has the potential to include additional low power modes into the definition of “Standby”, the review study suggested that regulating standby consumption should be done as part of an Ecodesign regulation on these products rather than being added to the scope of the horizontal measure.

Professional IT equipment

This category is mainly composed of imaging equipment and display products intended for office use. There is already a voluntary agreement for imaging equipment, which does not include a standby requirement, but does include an estimation on Typical Energy Consumption (TEC). This is an all-inclusive measure of annual consumption. For electronic displays, the Ecodesign regulation was updated in 2019 with standby limits as follows: off-mode 0.3W, standby mode 0.5W and network standby mode of 2W, along with additional allowances for special features. Subject to Parliamentary approval, these requirements will be implemented in GB in 2021. The research team determined that there was insufficient data on professional IT equipment to make a horizontal policy recommendation.

Office equipment not included in standby regulation

Products such as paper shredders, laminating machine, binding machines, are not included in the current standby regulation. The review study estimated the potential savings to be small as the products already have a low standby consumption and are estimated to diminish in offices as workspaces move away from paper.

Large format printing equipment

The study showed that most of the larger format printing equipment would be able to comply with the standby/off-mode requirements of 0.5W and the requirements from the network standby regulation. However, the savings resulting from their inclusion in the regulation are estimated to be small due to limited stock (below 0.01 TWh/year in the EU by 2030).

4.3.3 Potential changes to the current regulation

Current requirements for off-mode and standby mode consumption are both limited to a maximum of 0.5W (up to 1W with a status/information display). According to the review study, most products currently in scope would be able to meet a revision of off-mode and standby consumption from 0.5W to 0.3W. In September 2017, a Commission regulation draft was put forward, which proposes to lower off-mode consumption to 0.3W.

For the networked standby consumption of non-HiNA equipment to meet 2W by 2019, the review study determined that this was a challenging target for some of the product types. Based on data collected, the study concluded industry would be able to meet this requirement. As this requirement to networked standby has only come into effect in 2019, it is advised to gather further data before considering a further review of networked standby consumption. Networked equipment is included in the September 2017 draft regulation, such that their off-mode consumption maximum to be reduced to 0.3W.

4.3.4 Recommendations

BEIS should consider the following measures to enhance energy savings from the Standby regulation:

For the products in scope of the current regulation, BEIS should consider limiting off-mode consumption from 0.5W to 0.3W. Following the study results, this requirement could also be extended to standby consumption.

The standby review study recommends extending the scope of the regulation to products equipped with electric motors operated by remote control. The study recommends only applying the existing standby regulation of 0.5W rather than push to 0.3W. The draft EC regulation from 2017 included these products into the scope of the regulation at 0.5W for standby and 0.3W for off mode. Further data gathering is recommended before including further technologies into the extended scope.

The review study recommended that network standby requirements not be enhanced at this time. Data should first be collected on the effectiveness of the 2W limit implemented in 2019.

The study also recommended that clarifications to the following terms should be made in the regulation: 'reactivation function', 'main function', 'intended use' and 'deactivation of wireless network'. This is to avoid problems with interpretation.

4.4 Discussion of energy related horizontal measures: Smart appliances

4.4.1 Defining smart appliances

In the 2018 Smart Appliances Consultation, BEIS uses the term 'smart appliances' to mean those which are connected and are able to modulate their electricity consumption in response to signals, such as price. This definition focuses on appliances that have the greatest opportunity for demand side response (DSR). DSR is the way that consumers can engage with the energy system, turning up or down their consumption in response to signals, such as price.

PAS 1878 was published by the British Standards Institution in May 2021 specifying the requirements for an Energy Smart Appliance (ESA). An ESA must be "communications-enabled and able to respond automatically to price and/or other signals by shifting or modulating its electricity consumption and/or production". The PAS details requirements in ESA architecture, communications, cyber security, general functioning, and specific requirements for EV, battery storage and HVAC applications.

A broader definition used by the ETL programme describes smart technologies as technologies or products that are communications enabled and have at least one of the following capabilities: respond automatically to signals by shifting or modulating their energy consumption; adapt and control their operation to optimise energy consumption according to user needs and local conditions; and provide operational information to users and owners such as fault detection and maintenance requests.

4.4.2 Policy landscape

There are currently no regulations on smart functionalities. Developments within the energy industry and flexibility markets however are happening at pace. There are regulations and codes (for example The Electricity Capacity Regulations 2014, Grid code and Distribution Code) that define and refer to DSR. The core activities on smart technologies to date are from the British Standards Institute (BSI), Ecodesign and the Smart Readiness Indicator. The 'Automated and Electric Vehicles (AEV) Act 2018' gives Government powers through secondary legislation to mandate that all EV charge points sold and installed in the UK to have smart functionality and meet minimum device-level requirements.

The BSI Energy Smart Appliances Programme covers research into smart EV charge points and smart domestic appliance standards to support the establishment of a testing and certification regime. The Publicly Available Standard (PAS) 1879 was developed by the programme for the demand side response operation of energy smart appliances. A further PAS 1878 was released in May 2021 detailing Energy Smart Appliances – System functionality and architecture specifications.

The Ecodesign Preparatory Study on Smart Appliances (Lot 33) analysed the technical, economic, market and societal aspects that are relevant for a broad market introduction of smart appliances. In 2018, the study was completed with several proposed policy option recommendations for smart appliances. Notable recommendations are the addition of an energy smart icon to labels, information requirements, privacy protection, interface flexibility and interoperability recommendations.

Smart Readiness Indicator (SRI) is an instrument for rating the smart readiness of buildings. This voluntary scheme will assess the technological readiness of buildings to interact with their occupants and with connected energy grids and to operate more efficiently.

With the focus to increase smart grid capabilities, BEIS and Ofgem published the Smart Systems and Flexibility Plan (SSFP) in 2017[35]. With regards to smart technologies, this plan has delivered a cyber security risk assessment and the BSI PAS standard review on smart appliances. According to the plan, by 2022 all homes would be offered smart meters, cyber security would be regulated for smart products and a smart appliances regulation would be developed.

Other initiatives are contributing to the development of a "smart technology landscape". These are the Smart Data Strategy and Energy Data Taskforce and the Energy Networks Association (ENA) Open Networks Project.

4.4.3 Assessment of product groups with smart potential

Table 1.1 details the number of products from the Ecodesign workplan study which have a smart potential capability, from 30 to 42%.

[35] Upgrading our Energy System – smart systems and flexibility plan | Ofgem

Table 4.5 Proportion of product groups evaluated in this study with smart potential

	Products with smart potential	Total number of products listed	Percentage (%)
Task 2 Long List	81	262	30%
Task 3 Short List	63	187	34%
Task 4 Further Analysis	11	26	42%

The products with smart potential included in Task 4 are:

- Standard air compressors
- Low pressure air compressors
- Oil free air compressors
- Air conditioners
- Space heaters
- Water heaters
- Building Automated Control Systems
- Servers
- LED lamps and luminaires
- Water pumps
- Refrigerating appliances with a direct sales function
- Refrigerated containers
- Professional dishwashers

4.4.4 Energy saving potential

The energy savings potential of smart technologies can be classified into two categories: energy optimisation and DSR.

Energy optimisation metric is not entirely a “smart” capability as it helps optimise operating products. For example, HVAC systems could be optimised using an appropriate Building Automated Control System (BACS) is installed. This system does not necessarily need to be connected to the internet to function.

However, internet connectivity via a smart appliance would enable energy consumption to be optimised by remote control. For example, a residential BACS system or smart appliance would allow a user to turn off their heating system when they are not home, saving energy. In addition, in built functionality would remove the need to install local hardware to control devices.

DSR requires smart appliances to enable a response to grid conditions, ramping up or down local consumption based on external signals. Although this does not necessarily provide an energy saving, changing the time of use can provide the energy system with efficiencies from reducing peak load power demand, reducing storage requirements, and curtailing energy system loses.

Estimating DSR and smart appliance specific energy savings is challenging, and would require assumptions around uptake of smart appliances, participation in smart energy tariffs and occurrences of remote signalling and durations of responses.

Energy Star has identified the Smart Home Energy Management System (SHEMS) program which has recognized smart thermostats, lighting, and appliances to deliver energy savings for domestic users.

4.4.5 Trade-offs

A key trade-off from smart functionality would be on the increased standby energy consumption of the smart appliance. Under Network Standby Regulation No 801/2013, devices connected to the internet may have a “networked standby consumption” defined for “HiNA” or “non-HiNA” equipment. “HiNA” are networked equipment with a high network availability that provide connectivity services such as a router, network switch, wireless network access point, hub, etc. These devices have an allowance of 8W.

Non-HiNA equipment are any other device with an internet connection, which have a standby consumption allowance of 2W. For products without a network connection, the maximum allowed standby consumption is 0.5W (or up to 1W if the device has an information or status display). Most smart appliances are classed as “non-HiNA”. The switch to smart appliances therefore is likely to increase the standby consumption of devices. This is expected to be small compared to the unlockable benefits from DSR, however a further study should review these benefits to determine comprehensive trade-offs.

Smart devices would also increase data transmission on the telecoms grid. Although this is not of concern to the end user, it could increase the energy footprint of the country as power is required to operate the modems, hubs, cables and datacentres. However, improvements in telecoms technology suggest that the energy cost per unit of information transmitted is very small and decreasing (has been calculated as 0.06 kWh/GB in 2015, an estimated decrease since 2000 by a factor 170). Because of this, there is unlikely to be a trade-off related to the telecoms related energy consumption of smart appliances.

4.5 Energy related policy lever assessments

An understanding of existing UK energy efficiency related policy levers that cover energy-related products was needed to help assess the potential for applying levers to the shortlisted product groups. We focused on national level policies and excluded any local authority or municipal policy levers. The search also focussed on non-MEPS and labelling policy levers, since there is already a good understanding of these levers from other work.

After identifying relevant policies, we identified the sectors affected, the specific participants, the proportion of the sector/market affected, its status (operating or ended) and its location. We then identified the products covered to identify the shortlisted product groups that were already included. This helped to form judgements used in the factsheets around the time to either implement new policy levers or to include shortlisted products into existing policy levers.

We then carried out additional research to identify if evaluation studies had been completed that would allow us to assign potential impacts related to a new policy lever being applied to a product group.

Table 4.6 provides a summary of this research. We identified 30 different existing policies in the UK, GB or its constituent countries which corresponded to the different policy levers identified for energy-related products. Only 17% of these policies had associated evaluation studies, and just five contained impacts at a product level. The coloured cells highlight where impact data were found and where data were found that could potentially be used as proxy information for product groups. The actual policies and associated details are contained in 0.

Table 4.6 Summary of UK policy levers

Policy lever	UK Policies	Impact data	Impact data that can be used as a proxy?
MEPS	2	1	0
Mandatory label	2	0	0
Voluntary endorsement label	2	0	0
Obligation scheme	3	2	2
Public procurement	3	1	0
Communications campaign	3	0	0
Advice/aid in implementation	4	1	0
Grants, subsidies, loans	8	3	3
Taxes on poor performing products	1	0	0
Technology deployment/diffusion	2	0	0

Policy lever	UK Policies	Impact data	Impact data that can be used as a proxy?
Totals	30	8	5

As mentioned in Section 3.4, we also carried out research to identify policies in the rest of world (RoW) to help with understanding policy levers and their potential impacts if applied to the UK or its constituent countries. Evaluation studies were sought to help assess future potential impacts of the policy levers on the shortlisted product groups. The results of this effort are summarised in Table 4.7. 56 policies were identified, and impacts were identified for 30% of them. The coloured cells highlight where impact data were found and where data were found that could potentially be used as proxy information for product groups. However, impacts were not reported in a way that they could be used to inform assumptions on potential impacts of shortlisted product groups and policy levers.

Table 4.7 Summary of RoW policy levers

Policy lever	RoW Policies	Impact data	Impact data that can be used as proxy?
MEPS	12	4	0
Mandatory label	16	5	0
Voluntary endorsement label	3	0	0
Obligation scheme	1	1	0
Public procurement	5	0	0
Communications campaign	0	1	0
Advice/aid in implementation	8	1	0
Grants, subsidies, loans	9	3	0
Taxes on poor performing products	3	2	0
Technology deployment/diffusion	7	2	0
Totals	64	19	0

Evaluation studies related to policy levers in the UK and RoW were primarily available at a policy level, sector level, or building level. Policy level impact reporting means that only aggregate emission savings were reported, and because most policy levers influence a range of products, including those that were not shortlisted (e.g., insulation measures), it was not possible to disaggregate the savings into component products. The same issue was found in evaluation studies that reported savings with more granularity, such as those that reported sector-based savings, or building based savings.

Where impact estimates were reported at a product level, two of the three examples related to the 'Grants, subsidies and loans' policy lever were related to energy generation technologies via the Renewable Heat Incentive and the Smart Export Guarantee, so were unable to be used as proxy data since these studies focused on renewable energy related policy levers. Only the Salix Finance loan scheme[36] reported on energy efficient products and noted that 50% of the schemes were related to lighting, and 10-20% of savings reported were due to these lighting measures.

Product level impacts were found for two obligation schemes: ESOS[37] and ECO[38]. The ESOS evaluations suggested that only 2-9% of installations of energy efficient products were directly attributable to ESOS, with 12% of the installations related to external lighting and 10% attributable to LED replacements. The ECO scheme evaluation study reported that of all measures installed to 2020, 64% were insulation based and 36% were related to new boiler or other heating products. Only 6% of the lifetime emission savings due to ECO were attributed to boilers.

As a result of the limited evidence identified, it was not possible to assign potential impacts due to product group and policy lever combinations in the factsheets. 'Not found' was therefore attributed to the impact column in the policy lever suitability table contained in each factsheet.

Despite this general lack of insight, a few useful findings were identified relating to the impacts reported for ESOS, ECO and Salix Finance. The main finding is that these policy levers covered only a small proportion of the non-domestic market, which would limit the scope of savings potential compared to MEPS and mandatory labelling measures, which cover the entire market. The evaluation studies also found that direct attribution of savings to a non-mandatory policy lever is challenging, especially for policy levers that require provision of information or reporting of information.

These findings indicate that future analysis of the proportion of technical savings potential that could be achieved would immediately scale down by the market coverage of a policy lever, and then scale down further based on assumptions of proportion of savings that are cost-effective.

36 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730976/Public-sector-energy-efficiency_loan_scheme_evaluation_Interim_Report_Final.pdf

37 https://www.gov.uk/guidance/energy-savings-opportunity-scheme-esos

38 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/937748/Headline_Release_-_HEE_stats_26_November_2020.pdf
https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-headline-release-november-2020
https://www.ofgem.gov.uk/system/files/docs/2019/03/energy_company_obligation_eco2_csco_final_report.pdf

It would then scale down even further based on estimates of savings that are directly attributable to a policy lever.

4.5.2 Summary of stakeholder feedback related to policy levers

A Task 3 question asked, “What policy levers should be attributed to the shortlisted product groups?” Task 4 requested more general feedback on the report, which included feedback on policy levers. A summary of general stakeholder responses has been included here. Product specific feedback is included in the factsheets.

A few themes emerged from the feedback. Stakeholders acknowledge the importance of MEPS for many, but not all product groups, particularly the groups that are components of complex systems. In these cases, views expressed that MEPS may not be the best intervention when system wide savings are available. Test standards and market surveillance were also mentioned as critical to the success of MEPS. Stakeholders said MEPS should also be technology neutral.

Fiscal incentives at all levels were popular and could incentivise manufacturers and purchasers to invest in developing and purchasing energy efficient equipment.

Building related policy levers were also suggested as ways to improve the uptake of more efficient products. Indeed, building related policy levers could be suitable for complex products. Several stakeholders referred to the Future Homes and the Future Buildings Standards under development by the Ministry of Housing Communities and Local Government (MCLG). These two standards, once implemented, will set out requirements for a low carbon future for domestic and non-domestic buildings.

A summary of the responses by stakeholder type are provided below:

11 Manufacturers and 1 importer responded. They indicated a variety of views, including a preference for voluntary levers and supplier focused incentives as well as MEPS as they ensure a level playing field. They also expressed that MEPS only make sense with effective market surveillance and indicated a preference for point-of-sale information online and in store rather than product labelling. Related to MEPS and market surveillance, manufacturers also expressed the importance of test standards. Grants to upgrade products used in commercial buildings were also proposed. Manufacturer feedback also indicated that policy levers should focus on emission reductions rather than energy efficiency and that MEPS should be technology neutral. A few manufacturers also highlighted the risk of regulatory divergence with the EU, considering that it is common for manufacturers to serve both markets and divergence could increase costs to consumers. A manufacturer also stated that divergent legislation should come from a very strong evidence base and that the default position should be to align with future EU MEPS.

6 Trade associations responded. In addition to product specific comments, they provided a variety of more general comments on policy levers. Some recommended a strong focus on improving market surveillance as non-compliance with existing regulations can affect energy saving projections. Another mentioned the importance of setting material efficiency

requirements on a product-by-product basis rather than a horizontal approach. This, they argued, would help avoid pitfalls related to a one-size fits all approach. This association also recommended adopting a voluntary endorsement label that is widely used in other markets. The importance of setting appropriate timelines for new regulations requiring product redesign was also raised. A trade association suggested that two years is needed for consumer electronics to avoid disrupting market access and innovation.

3 Consultants responded. They fed back that MEPS are the most powerful policy tool and should form part of any policy mix. They also expressed support for labelling policy levers. They mentioned obligation schemes related to new build and refurbishment of homes and communication campaigns to support these measures. Another consultant supported MEPS that are fuel neutral.

1 Environmental NGO responded. They mentioned that mandatory labelling linked to MEPS are ten times more effective than voluntary schemes not linked to MEPS.

1 Public sector stakeholder also suggested mandatory and voluntary information provision and labelling schemes alongside MEPS. They said information provision should be around expected product lifetimes. The stakeholder also mentioned Government and non-SME purchasing of efficient products should be mandatory, with SME purchasing being voluntary.

Stakeholders responding to the BEIS ErP Call for Evidence[39] expressed the most support for the following policy levers. A stakeholder noted the lack of impact evidence of these types of policy levers from the literature review and recommended that a trial and test approach be taken with any new policy levers.

Public procurement including improved reporting (15 responses)

Fiscal incentives to promote business investment, VAT reductions, and measures to support purchases of energy efficient equipment (15 responses)

Communication campaigns related to purchasing equipment, retailer training, recycling promotion, and explaining existing fiscal incentives (12 responses)

Obligation schemes (9 responses)

Technology deployment and diffusion (6 responses)

4.6 Policy lever discussion

This section summarises key themes which came from the policy lever analysis.

Policy levers that are technology neutral (e.g., those that provide an energy or emissions reduction target only) will almost always be fulfilled by the lowest cost interventions. This

[39] https://www.gov.uk/government/consultations/energy-related-products-call-for-evidence

usually relates to building fabric improvements, particularly different forms of insulation. Insulation is low cost, relatively quick to install and has a long lifetime.

In nearly all cases, horizontal measures related to material content and declaration and minimum warranty/guarantee periods, are deemed relatively quick to implement, as they are independent of other policy levers. However, there are costs associated with this which should be better understood.

Public procurement programmes may need to improve their reporting to understand impacts from Government Buying Standards. In any case, adding additional products to the list, and reviewing and revising existing standards to reflect the current state of play are low-cost measures that would bring additional benefit to the public sector.

Voluntary endorsement labels only identify the best performing technologies, so are best suited for products with a range of energy performance or energy saving add on technologies such as doors on refrigerated display cabinets.

Space and water heating products, as well as other components in a heating system, have considerable scope for energy efficiency improvements, but there are many complexities due to the systems nature of these products. A holistic approach should be considered with long-term ambitions clearly spelled out. There are also many stakeholders and policy makers that can influence the energy performance of heating systems across all sectors. Building level policy levers could be a good candidate for future policy levers as heating system efficiency ultimately depends on the building itself. Any new systems related policy levers much consider the Future Homes and Future Buildings Standards that are under development. It is recommended that BEIS and MCLG work together to ensure the compatibility and additionality of a new systems related policy lever.

Targeted policy levers that focus on specific sectors in the economy have the potential to initiate change more rapidly for specific product groups. Industry engagement is important to determine the most suitable levers, but fiscal incentives, advice/aid in implementation, technology deployment/diffusion policy could all be suitable candidates for improving energy performance quickly.

Possibly due to the nature of the four shortlisted horizontal measures, no potential trade-offs were thought to be likely in terms of achievement of energy efficiency savings. Conceptually, repairability and modular design imply that lifetime extension could keep poorer performing products on the market longer than if the horizontal measures were not present. However, it could be argued that repairing or replacing certain modules could also improve the energy performance of a product. So, the actual potential for a trade-off really depends on the part of the product that fails and needs repair or replacing.

On distributed impacts of select policy levers along supply chains, it was not thought that the distribution would change across different product groups. Any new mandatory policy lever that requires new legislation would investigate this further through a regulatory impact assessment.

On voluntary measures or policy levers that don't require a change in law, engagement with stakeholders should still take place, and views on these impacts should be sought.

4.7 Evidence gaps

This study identified a long list of products, consolidated, and then scored each product group against a set of evaluation criteria. This scoring exercise provided BEIS and Defra information to select several products to carry out further research and analysis. 26 products were shortlisted using the evidence based scoring and other priorities and further analysis was carried out on these product groups. The information was presented in factsheets and case studies that can be used by Government and stakeholders to help select product groups and policy levers to focus on in the future. Due to the large number of products assessed during the study (e.g., 184 products in Task 3 and 26 in Task 4), limited evidence and simple assumptions underpin the analysis undertaken. This reduced the robustness of the analysis, which can be considered a limitation to the study. Further research is recommended to fully evidence technology specific policy options.

Detailed studies involving primary research with industry and stakeholders will almost certainly be needed to understand better energy and material consumption, savings potential and the impact on carbon emissions for shortlisted products that are focused on in the future. This research should also focus on the potential impacts on industry, end-users and other stakeholders before new policy levers are rolled out.

Market information was generally available for shortlisted product groups or could be derived using simple assumptions. However, shortlisted product groups that are not covered by existing policies (e.g., heat emitters and printer cartridges) had little literature available to provide evidence on energy performance or material composition.

The literature review undertaken to support the policy lever analysis also found little evidence on a product group level to assist with the assessment of potential impacts for different combinations of product groups and policy levers. Indeed, little evidence was discovered on high level impacts of policy levers, both in the UK and RoW. Therefore, it was not possible to make reasonable assumptions to inform the proportion of the technical savings potential that could be achieved through new policy levers. For example, some evaluation studies identified challenges in providing quantitative estimates of impacts and others reported metrics that were not suitable for this study. A good example of this is the evaluation of the Big Energy Saving Network, an advice/aid in implementation policy lever in England and Wales completed in 2014. The study reported outreach numbers in terms of vulnerable persons contacted and did not focus on the outcomes of the contact, or the associated energy/ emission savings.

There are significant future opportunities to realise emission savings through reduced energy and resource consumption across many types of product groups. The potential to add horizontal measures to this policy mix is high, and a coordinated effort to apply new policy levers in both areas should be taken. It's worth noting that there is considerable potential for additional benefits of non-shortlisted horizontal measures, and further research into these opportunities should certainly take place.

Annex 1 Task 3 Scoring criteria – Product groups

Task 3 scores were calculated based on the following sub-criteria. The sub-criteria are presented below alongside information on how scores were attributed to each sub-criterion. To ensure maximum comparability between product group scores, scoring guidance sought to keep scoring objective. The aim of this was to ensure that the research team could attribute scores to product groups in a consistent and systematic manner.

A few of the sub-criteria are somewhat subjective in nature. Where this is the case, a small team of researchers populated the scores for the entire list of product groups to help ensure a consistent approach to scoring.

Where no evidence was available and reasonable proxy data was not available, a ‘not available’ score was attributed to exclude the sub-criteria from the criteria average. It is recognised that a high score in a single criterion, combined with ‘not available’ scores entered in other criteria would result in scores that are biased towards that single criteria. To account for this, only scores with at least 2/3 criteria completed were considered for the shortlisting exercise.

To enable maximum flexibility of the Task 3 product group matrix, sub-criteria weighting, and in/out criteria selection functionality were implemented into the matrix. This allows analysts to prioritise a sub-set of criteria when considering different questions.

A1.1 Market based score

UK Imports	1	2	3	4	5	n.a.
Average units imported into the UK per year: HS6/HS8 trade data will be used with typical price per unit (PRODCOM?) to estimate units.	<10k/yr	10-100k/yr	101-200k/yr	201-500k/yr	>500k/yr	no information
UK Exports	1	2	3	4	5	n.a.
Average units exported from the UK per year: HS6/HS8 trade data will be used with typical price per unit (PRODCOM?) to estimate units.	<10k/yr	10-100k/yr	101-200k/yr	201-500k/yr	>500k/yr	no information
UK Production	1	2	3	4	5	n.a.
Average units produced in the UK per year: If multiple years are available, use the most recent data point. PRODCOM/COMEXT is potential source for this.	<10k/yr	10-100k/yr	101-200k/yr	201-500k/yr	>500k/yr	no information
UK annual sales	1	2	3	4	5	n.a.
Annual UK Sales Identify estimates of annual sales and allocate per scoring guidance below. Use EUP or ETL model input workbooks if available. If using prep studies (Task 2), scale from EU to UK using population for domestic (11%) or GDP for non-domestic (15%). Or use web searches.	<10k/yr	10-100k/yr	101-200k/yr	201-500k/yr	>500k/yr	no information
Market growth	1	2	3	4	5	n.a.
Market growth potential between 2020 and 2050: If prep study exists, use Task 2 report. EU growth as proxy for UK. For mature products, using historical data may be suitable for projections Otherwise rely on web searches to find market projections, near term ones as proxy okay.	High negative growth (>10% per year)	Low negative growth (<10% per year)	Static (no growth)	Low growth (< 10% per year)	High growth (>10% per year)	no information
Existing measures in place	1				5	n.a.
Are there existing energy efficiency measures in place in the UK? Measures can be mandatory (like minimum energy performance standards or building regs) or voluntary like ETL.	Measures in place				No measures in place	no information
Typical price per unit	1	2	3	4	5	n.a.
Typical price per unit of a typical product in this product group Base cases in prep study (Task 4 or 5) easiest source. Some models will have this. If the product group consists of many different actual products, give more weight to the products with large market size. No need to calculate actual sales weighted averages, estimates okay. Use evidence spreadsheet to record back-of-envelope calcs.	£0 < £10	£11 < £100	£101 < £500	£500 < £2000	> £2000	no information

A1.2 Resource consumption (in-use phase of life cycle) scores

Energy Consumption	1	2	3	4	5	n.a.
Market average annual energy consumption per unit (kWh/yr): Task 4 or 5 prep study for base case or use literature review data if available. If the product group consists of many different actual products, or different end-use (domestic vs commercial) give more weight to the products with large market share. No need to calculate precise sales weighted averages, estimates okay. Use evidence spreadsheet to record back-of-envelope calcs.	<250 kWh/yr	251-500 kWh/yr	501-1000 kWh/yr	1,001-1,500 kWh/yr	>1,500 kWh/yr	no information
Energy Source	1	2	3	4	5	n.a.
What fuel is consumed by the product? If the product generates electricity, score a 1. Otherwise scoring is based on carbon intensity of fuel.	Generates electricity or consumes biofuel	Electricity	Natural Gas	Diesel & other fossil fuels	Coal	no information
Water Consumption	1				5	n.a.
Market average annual water consumption per unit This is a binary score, either it consumes water or it doesn't.	No water consumption				Water consumption	no information
Other Resources Consumption	1				5	n.a.
Does the product consumes any other resources (e.g. paper, filters, toners, etc.) - please specify what it is in the comment. This is a binary score, either it uses consumables or it doesn't.	No other resources consumed				Resource consumption	no information

A1.3 Circular economy related scores (whole life of resource efficiency)

Materials	1	2	3	4	5	n.a.
What is the weight of the product? Examples: iPhone 172 grams; 32-inch TV 11-14 kg; escalator up to 8 tonnes; industrial boiler 165 tonnes	Low impact - less than 500gr	Low-Med impact - between 0.5 < 5kg	Medium impact - 5 < 100kg	Med-High impact - 100 < 1000kg	High impact - > 1 tonne	no information
CRM	1	2	3	4	5	n.a.
How relevant is the use of CRM in manufacturing the product? An approach based on grouping products with similar CRM characteristics will be taken based on evidence available.	No CRM content		Moderate CRM		High CRM	no information
Lifespan	1	2	3	4	5	n.a.
What is the product's lifespan? Lifespan is the expected period of time during which a product remains useful to the average user (the end user chooses to purchase a new product, not when it fails). Other terms used: lifetime, longevity, product life, service life, duration of use, life cycle. Use model inputs if possible. For products with a prep study this info can be found in the End-of-life section (task 4 or 5). For other products, search product specifications or consumers studies.	Long lifespan (>15yrs)	Long lifespan (10-15yrs)	Medium lifespan (7-10yrs)	Medium lifespan (4-7yrs)	Short lifespan (<4yrs)	no information
End of Life - guarantee	1	2	3	4	5	n.a.
How long is the duration of the guarantee? Guarantee means any undertaking by the retailer or a manufacturer to the consumer, regarding quality/lifespan with a promise to reimburse the price paid; or replace, repair or handle appliances in any way if they do not meet the specifications set out in the guarantee statement or in the relevant advertising. Web searches for a few (3) products on the market should give you this information.	long guarantee (>5 years)	medium guarantee (1-5 years)	medium guarantee (1-12 months)	short guarantee (30 days)	no guarantee	no information

A1.4 Technical improvement potential score

Energy consumption	1	2	3	4	5	n.a.
Maximum potential to reduce market average per unit energy consumption. Base this on Best Available Technology (BAT) performance or maximum savings possible based on combination of improvements in Task 6 report. We are concerned with technical potential, so do not consider costs at this point. Use web searches or BAT components (such as motors) as proxy if no data on product.	No potential	Low potential (<10%)	Medium potential (11-20%)	High potential (21-30%)	Very high potential (>30%)	no information
Energy source	1		3		5	n.a.
Potential for fuel switching to electricity.	No potential to switch to electricity		Partial switch to electricity		Can switch to electricity	no information
Water consumption	1	2	3	4	5	n.a.
Potential to reduce water consumption. <u>If product doesn't consume water, input n.a.</u> Same thresholds used as energy savings. There may not be much evidence here. If no evidence, input n.a.	No potential to reduce consumption	Low potential (<10%)	Medium potential (11-20%)	High potential (21-30%)	Very high potential (>30%)	no information

A1.5 Technical improvement cost & combined scores

Energy consumption	1	2	3	4	5	n.a.
BAT cost or cost to achieve maximum savings potential	High (>50% additional cost)	Med/High (30-50%)	Medium cost (20-30%)	Low - Medium cost (10-20%)	Low cost (<10%)	no information
Energy source	1	2	3	4	5	n.a.
Potential for fuel switching to electricity. If no potential for fuel switching, input n.a. Consider cost of cheapest way to fuel switch. If components cannot be swapped out, and product switching is needed, consider marginal cost of switching to the electricity fuelled product (i.e. the additional cost of a hybrid heat pump compared to gas boiler).	High (>50% additional cost)	Med/High (30-50%)	Medium cost (20-30%)	Low - Medium cost (10-20%)	Low cost (<10%)	no information
Water consumption	1	2	3	4	5	n.a.
If product doesn't consume water, input n.a. If there is no cost evidence, input n.a.	High (>50% additional cost)	Med/High (30-50%)	Medium cost (20-30%)	Low - Medium cost (10-20%)	Low cost (<10%)	no information
GHG Emissions impact - use phase ***(sales x energy consumption x fuel)***	Scores are calculated automatically. For GHG emissions, higher scores mean higher emissions and for Cost Efficiency higher scores mean higher cost efficiency. Other scores to be determined.					
Cost Efficiency of energy consumption improvement ***(Maximum improvement potential x Maximum improvement cost)***						
Likelihood of lifetime extension **((6-price)*lifetime*guarantee)**						

Annex 2 Task 3 Scoring criteria – Horizontal measures

The initial Task 3 scores were calculated based on the following criteria. The criteria are presented below alongside information on how scores were attributed. To ensure maximum comparability between horizontal measures scores, a small team of researchers populated the scores for the entire list of horizontal measures to help ensure a consistent approach to scoring. Where no evidence was available, a ‘no information’ score was attributed to exclude the sub-criteria from the criteria average. It is recognised that a high score in a single criterion, combined with ‘no information’ scores entered in other criteria would result in scores that are biased towards that single criteria.

Considerations from stakeholders and policy makers will also contribute to this exercise.

A2.1 Horizontal scores

Coverage	1	2	3	4	5	n.a.
Proportion of product groups that could be covered by a horizontal measure (to be taken from the products matrix)	<10%	11<25%	26-49%	50-74%	>75%	no information
Existing examples	1		3		5	n.a.
Horizontal measure being implemented? This might include examples in other countries/ regions or for other products	Not planned		Being considered		Planned or implemented	no information
Costs	1		3		5	n.a.
What is the per unit cost of implementing the horizontal measure?	High		Medium		Low	no information
Benefits	1		3		5	n.a.
Potential benefits of the implementation of the horizontal measure to reduce resources and energy demand	Low		Medium		High	no information

The coverage and existing examples criteria were assessed based on evidence collected by the research team. The coverage criteria assessed the overall potential of the horizontal measure being implemented for each product in the consolidated long list and the existing examples were based on an extensive literature review and policy analysis in the UK and other countries.

The potential costs and benefits criteria scores were based on the potential impact that the implementation of the horizontal measures might have across the supply chain and the use of resources and energy. Evaluating actual costs of implementation of horizontal measures will require a whole-system approach that would be more complex and would include a wider range of stakeholders and therefore, this analysis was based on existing references and studies, per measure and product group, supported by previous experience from the research team by engaging with different stakeholders and policy related studies. A high, medium, or low score was assigned to identify potential increasing of cost for producers/manufacturers and consumers based on an increased product price. Horizontal measures were prioritised where they might have a direct impact on use of raw materials and energy as well as other measures that will be relevant for raising awareness for future regulation and/or implementation of other measures.

Annex 3 Stakeholder feedback

A3.1 Task 2 feedback & recommendations

The following list of product groups were suggested by stakeholders to include in the Task 2 longlist. In most cases, the products were already included in the longlist of product groups. A rationale for actions has been provided. The 'Suggestions Count' for product groups with a single instance of being suggested were left blank.

Stakeholder suggested additions to Task 2 long list	Action	Suggestions Count
Battery chargers/batteries	Already included	
Bio-liquids for domestic heat application	Out of scope as this project examines products, not fuels.	
Boiling water taps	Excluded as they are marketed as energy and water saving compared to electric kettles. High upfront cost relative to electric kettles.	
Circulating fan >125W (man coolers)	Not included as not recommended by multiple stakeholders. Could be assessed as part of a review of the existing fans regulation.	
Demand controlled kitchen ventilation	Already included	
Dishwashers	Already included	
Domestic printers	Similar performance characteristics as printer component of an MFDs. If MFD shortlisted, then printers will be looked at separately.	2
EV charge points	Already included	
Gas fired patio heaters	Already included	

Stakeholder suggested additions to Task 2 long list	Action	Suggestions Count
Ground and water source heat pumps	Already included in space heater product group. Categorisations attempted to map to existing Ecodesign regulation categories.	4
Headphones/earphones	Not included as not recommended by multiple stakeholders.	
Heat pumps <400kW	Already included	
Hot tubs and home swimming pools	Heaters already included.	
Hybrid air coolers	Not included as not recommended by multiple stakeholders.	
Hydrogen boilers	Not commercially available	
In home displays	Already included	
Infrared space heaters	Already included	
Multi-functional cooking pans	Use hobs for energy	
Nondomestic dishwashers	Already included	
Nondomestic wine chillers	Already included	
Other types of compressors (standard-air)	Already included	
Overhead radiant tube heaters	Already included	
Portable battery packs	Already included	
Pressure cooking pans	Use hobs for energy	
Projectors	Not included as not recommended by multiple stakeholders.	
Refrigerators	Already included	

Stakeholder suggested additions to Task 2 long list	Action	Suggestions Count
Software products	Not included as not recommended by multiple stakeholders.	
Standard mixer showers	Already included	
Televisions	Already included	
Toys	Not included as scope is too wide to be meaningfully assessed.	
Tumble dryers	Already included	
Variable speed circulators	Already included	
Vehicles	Out of scope	
Ware washing equipment	Already included	
Washer dryers	Already included	
Washing machines	Already included	
Wastewater heat recovery system	Already included	2

A3.2 Task 3 feedback & recommendations

Stakeholder responses to the 4 questions on Task 3 outputs are summarised and included in both the main body report and individual factsheets.

Annex 4 Policy lever suitability criteria

The following criteria were used to help inform judgements on including or excluding a policy lever from the factsheets.

Policy lever	Pre-requisite for inclusion in analysis	Exclude from policy lever analysis	Include - potential	Include - higher potential
Minimum performance standards (includes Enforcement)	Must not apply to an energy saving add-on as they don't consume energy directly. If standards exist, then higher rating	Energy saving add-on product	Significant consumption or market size, standards in place or under development.	MEPS in place or being considered, energy performance standards exist or under development
UK Technology deployment and diffusion	Small or concentrated market that can be targeted. Market not mature or need for commercialisation assistance.	Mature technology and market. No new transformative technologies available or on horizon.	Market is small, concentrated (few suppliers or end-users) or in its infancy. Transformative technologies not yet commercially available.	Market is small, concentrated (few suppliers or end users) or in its infancy. Transformative technologies already available.
Grants, subsidies, loans	Need to understand which products are most efficient so needs labelling or to be clear technology winners.	Unable to differentiate between performance.	Labelling in place or clear technology winners available, already good uptake in market.	Labelling in place and clear technology winners available, poor uptake in market.
Tax programmes	Mandatory labelling to identify poor performers or poor performers are clearly known. Cannot be a regressive tax.	Unable to differentiate between performance.	Labelling in place or clear technology winners available, price not directly proportionate to efficiency.	Labelling in place or clear technology winners available, price directly proportionate to efficiency.

Policy lever	Pre-requisite for inclusion in analysis	Exclude from policy lever analysis	Include - potential	Include - higher potential
Public procurement	Requires labelling of some kind or clear technology winners.	Product group not used in public sector and unable to differentiate between performance.	Product group somewhat used in public sector and a type of labelling in place or clear technology winners available.	Product commonly used in public sector and a type of labelling in place or clear technology winners available.
Communications campaigns	Residential sector products only. Requires labelling of some kind or clear technology winners.	Non-domestic sector product. Unable to differentiate between performance	Domestic sector product without labelling but standards exist or under development.	Domestic sector product and a type of labelling in place or clear technology winners available.
Energy labelling – mandatory information labels	No prerequisites, but mostly suitable for domestic products. May not be suitable to an energy saving add-on product. If standard exists, then higher suitability.	No variation in energy performance or a clear winner. No standards exist.	Wide range in energy performance, but no energy performance standards exist	Wide range in performance, energy performance standards in place or under development
Energy labelling – voluntary endorsement labels	No prerequisites. May not be suitable to an energy saving add-on product. If standard exists, then higher suitability.	No variation in energy performance or a clear winner. No standards exist.	Wide range in energy performance, but no energy performance standards exist	Wide range in performance, energy performance standards in place or under development
Obligation schemes	Residential sector products only. Need to understand which products are most efficient so needs labelling of some kind or clear technology winners.	Not residential sector product.	Residential sector product, but non-essential. No labelling or standards exist.	Residential sector product, but essential (e.g., lighting, heating, cooking, refrigeration). Labelling or standards exist.

Policy lever	Pre-requisite for inclusion in analysis	Exclude from policy lever analysis	Include - potential	Include - higher potential
Implementation aid and advice programmes	Could be applied to residential owner/occupiers/landlords or commercial sector building managers. Could also target specific industry sectors. May need labelling or involve clear technology winners.	Unable to differentiate between energy performance of product groups.	Labelling in place or clear technology winners available.	Labelling in place or clear technology winners available, can be easily added to existing scheme.

Annex 5 Status of performance measurement standards for shortlisted products

Outputs of performance standard review. Informed policy lever time required to implement.

Sector	Sub-sector	Product group	Energy performance standards exist	Standard	Notes
Non-domestic	Commercial/Industrial	Standard air compressors Low pressure air compressors Oil free air compressors	Yes, in part		Safety, noise standards exist and other primary/secondary performance parameters. Some products regulated in USA and China and working through EC regulation. So, they will be under development or exist.
Non-domestic	Commercial/Industrial	Curtains, blinds, doors and covers for refrigerated display cabinets	In part	BS EN ISO 23953-2:2015	There is no specific test standard for this technology, but the RDC standard can be adapted for use.
Non-domestic	Commercial/Industrial	Refrigeration compressors	Yes	BS EN 12900:2013 BS EN 13771-1:2016	These are the two standards within the ETL technology criteria for refrigeration compressors

Sector	Sub-sector	Product group	Energy performance standards exist	Standard	Notes
Domestic	Consumer electronics	Electronic displays and televisions	Yes, in part	IEC 62087-3:2016 BS EN 62301:2005 / BS EN 50564:2011	62087 covers power consumption. 62301 / 50564 covers standby. A mandate is being prepared by the EC, a draft of which has been published. CLASP have published excerpts of the TMM https://www.clasp.ngo/research/all/transitional-test-method-for-ecodesign-and-energy-labelling-requirements-for-electronic-displays/
Non-domestic	Cooking	Hobs (all technologies)	No		EFCEM, the European Federation of Catering Equipment Manufacturers, has produced an industry standard for "open flamed burners" e.g., gas. No induction hob standard. Stakeholders also recommended BS EN 203-2-1 Gas heated catering equipment. Specific requirements. Open burners and wok burners and cited the BSI standard development committee GSE/19 for gas hobs.
Multi-sector	Generation, conversion, supply, storage	External power supplies	Yes	BS EN 50563:2011 +A1:2013	This is the harmonised standard for the Ecodesign regulation
Multi-sector	Heating, Ventilation, Cooling	Air conditioners	Yes	See comment adjacent	Depends on the size and scope of the AC, but harmonised standards are published by the European Commission (EC) for the ACs in scope of 2011 Energy labelling and 2012 Ecodesign regulations https://ec.europa.eu/energy/topics/energy-efficiency/energy-

Sector	Sub-sector	Product group	Energy performance standards exist	Standard	Notes
					efficient-products/list-regulations-product-groups-energy-efficient-products_en?redir=1
Multi-sector	Heating, Ventilation, Cooling	Space heaters, etc.	Yes	See link in adjacent cell	Various standards exist associated with the Ecodesign and Energy labelling regulations https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-products/list-regulations-product-groups-energy-efficient-products_en?redir=1
Multi-sector	Heating, Ventilation, Cooling	Water heaters, etc.	Yes	See link in adjacent cell	Various standards exist associated with the Ecodesign and Energy labelling regulations https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-products/list-regulations-product-groups-energy-efficient-products_en?redir=1
Multi-sector	Heating, Ventilation, Cooling	Patio heaters	No	specification and safety only	BS EN 14543:2017 - TC BS EN 14543:2017 - TC. Tracked Changes. Specification for dedicated liquefied petroleum gas appliances. Parasol patio heaters. Flueless radiant heaters for outdoor or amply ventilated area use.
Multi-sector	ICT	Computers and laptops	Mandate M545 indicates none exist. Being developed		A standardisation request M545 was published by the EC in 2016 covering the Ecodesign computers regulation 617/2013. https://ec.europa.eu/growth/tools-

Sector	Sub-sector	Product group	Energy performance standards exist	Standard	Notes
					databases/mandates/index.cfm?fuseaction=search.detail&id=566
Non-domestic	ICT	Servers	Mandate M573 indicates none exist. Being developed	ETSI EN 303 470:2019 EN 50672:2017	The EC has published a mandate (M573) in Jan '21 to the European Standardisation Organisations to develop standards for the ecodesign reg. 303470 covers active state efficiency and idle state power in response to an earlier mandate (M462). 50672 covers internal power supply efficiency and power factor in response to an earlier mandate (M545).
Non-domestic	Motor driven	Water pumps	Yes, in part Mandate M498 indicate none exist on water pump efficiency	BS EN ISO 14414:2019	This standard is for a pump system energy assessment. It sets the requirements for conducting and reporting the results of a pumping system energy assessment that considers the entire pumping system, from energy inputs to the work performed as the result of these inputs.
Non-domestic	Refrigeration	Refrigerating appliances with a direct sales function	Yes	BS EN ISO 23953-2:2015 BS EN 16902:2016	N/A

Sector	Sub-sector	Product group	Energy performance standards exist	Standard	Notes
Non-domestic	Refrigeration	Refrigerated containers	No	N/A	Check out the Task 1 Scope document from the Prep Study www.eco-refrigerated-containers.eu. The current Professional Refrigeration Review Prep Study stated standards still needed to be done, but component standards exist for safety, box construction, box insulation and cooling unit compressors.
Multi-sector	Small appliances	Vacuum cleaners	Yes	BS EN 60312-1:2017 BS EN 60335-2-2:2010 BS EN 60335-2-69:2012 BS EN 60704-2-1:2015	
Non-domestic	White goods	Professional dishwashers	Yes, in part	BS EN IEC 63136:2019 DIN SPEC 10534	63136 covers energy consumption and cleaning performance. Both the DIN SPEC and NSF/ANSI standards cover hygiene / sanitisation. The fourth and final element of the standards suite is for rinse.

Sector	Sub-sector	Product group	Energy performance standards exist	Standard	Notes
				NSF/ANSI 3-2019	There is no published standard for rinse, but one is being developed in Europe.
Domestic Non-domestic	Heating, Ventilation, Cooling	Building automated control systems (BACS)	No		draft standard for comment, published Jan 2021. BS EN 14908-9.BS EN 14908-9. Open Data Communication in Building Automation, Controls and Building Management. Control Network Protocol. Part 9. Wireless Communication in ISM bands
Multi-sector	Heating, Ventilation, Cooling	Heat emitters	Yes	BS EN 442-2:2014	Part 2 covers test methods and rating. There is also a part 1 (specification and requirements) and part 3 (evaluation of conformity)

Annex 6 Summary of energy related UK policies

Full list of UK policy levers identified during this study. Note that Ecodesign MEPS and Energy Labelling are excluded from this table.

Policies related to resource efficiency are contained in each case study.

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
1	Advice/aid in implementation	Simple Energy Advice website (formerly known as Energy Saving Advice Service)	Domestic	All	100%	Operating	England/Wales	Space heaters Water heaters Building automated control systems (BACS) Heat emitters
2	Advice/aid in implementation	Home Energy Scotland	Domestic	All	100%	Operating	Scotland	Space heaters Water heaters Building automated control systems (BACS) Heat emitters
3	Advice/aid in implementation	Welsh Government	Domestic	All	100%	Operating	Wales	Space heaters Water heaters

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
		Warm Homes Nest scheme						
4	Advice/aid in implementation	Big Energy Saving Network (2013-14) -	Domestic	Disadvantaged	11%	Ended	England/Wales	not necessarily linked to a particular shortlisted product but rather an information website/campaign
5	Communications campaign	Energy Saving Trust '20% Campaign (2005) -	Domestic	All	100%	Ended	UK	not necessarily linked to a particular shortlisted product but rather an information website/campaign
6	Communications campaign	Big Energy Saving Week (2020) - annual event	Domestic	All	100%	Operating	UK	not necessarily linked to a particular shortlisted product but rather an information website/campaign
7	Communications campaign	Big Energy Saving Winter - annual event	Domestic	All	100%	Operating	UK	not necessarily linked to a particular shortlisted product but rather an

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
								information website/campaign
8	Grants, subsidies, loans	Boiler scrappage scheme (2010) - ended	Domestic	Households	125k vouchers	Ended	England	Space heaters
9	Grants, subsidies, loans	Green Deal policy (effectively closed, but still on gov.uk) -	Domestic	Homeowners	100%	Ended	GB	Space heaters Heat emitters
10	Grants, subsidies, loans	Green Homes Grant	Multi-sector	Homeowners + landlords	100%	Operating	England	Space heaters Water heaters Building automated control systems (BACS) Heat emitters
11	Grants, subsidies, loans	Renewable Heat Incentive	Multi-sector	Homeowners	100%	Operating	GB	Space heaters Water heaters

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
12	Grants, subsidies, loans	Smart Export Guarantee	Domestic	Homeowners	100%	Operating	UK	none
13	Grants, subsidies, loans	Winter Fuel Payments, Warm home discount, Cold Weather payments	Domestic	Vulnerable	11%	Operating	UK	none
14	Grants, subsidies, loans	Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme	Non-domestic	Public sector	17%	Operating	GB	Air conditioners Space heaters Building automated control systems (BACS) Electrical lamps and luminaires Taps and shower heads Building automated control systems (BACS) Heat emitters

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
15	Grants, subsidies, loans	Salix public sector finance - Loan scheme	Non-domestic	Public sector	17%	Operating	GB	compressors Electronic displays, TVs Air conditioners Space heaters Water heaters Building automated control systems (BACS) Computers and laptops Servers Electrical lamps and luminaires Taps and shower heads Professional dishwashers Building automated control systems (BACS) Heat emitters
16	Grants, subsidies, loans	Enhanced capital allowances	Non-domestic	All	100%	Ended	UK	Refrigeration compressors Space heaters Water heaters Electrical lamps and luminaires

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
17	Voluntary endorsement label	Energy Technology List – ongoing	Non-domestic	All	Top 20% is targeted	Operating	UK	Refrigeration compressors Space heaters Water heaters Electrical lamps and luminaires
18	Mandatory label - buildings	Energy Performance certificate	Domestic	Homeowner + landlord	100%	Operating	UK	Space heaters Water heaters Electrical lamps and luminaires Heat emitters
19	MEPS	Potential future Ecodesign MEPS (considered, under development or recently passed).	Multi-sector	All	100%	Operating	UK	Indicated in factsheets
20	MEPS	Domestic private rented property: minimum energy	Domestic	Landlords	20%	Operating	England/Wales	Space heaters Water heaters

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
		efficiency standard						Electrical lamps and luminaires
21	Obligation scheme	Energy Company Obligation (ECO) Affordable Warmth Obligation	Non-domestic	Disadvantaged	11%	Operating	GB	Space heaters Water heaters Heat emitters
22	Obligation scheme	CRC Energy Efficiency Scheme - (Streamlined Energy and Carbon Reporting)	Non-domestic	half hourly meter + 6GWh per year usage	10%	Ended	UK	Electronic displays, TVs Air conditioners Water heaters Building automated control systems (BACS) Electrical lamps and luminaires
23	Obligation scheme	ESOS	Non-domestic	>250 employees	34%	Operating	UK	lighting, heating system, computers and IT, cooling systems, hot water system - but all

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
								voluntary and non-prescriptive
24	Public procurement	Sustainable procurement: The Government Buying Standards (GBS)	Non-domestic	Public sector	17%	Operating	UK	Curtains, blinds, doors and covers for refrigerated display cabinets Air conditioners Water heaters Electrical lamps and luminaires Electronic displays, TVs Computers and laptops
25	Public procurement	National Procurement Strategy for Local Government in England 2014 (Local Government	Non-domestic	Public sector	39%	Operating	England	excluded as local authority level

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
		Association 2014)						
26	Public procurement	Re-Fit (via Local Partnerships)	Non-domestic	Public sector	39%	Operating	England/Wales	excluded as local authority level
27	Taxes on poor performing products	NONE FOUND	Multi-sector	ALL	100%			none found
28	Technology deployment/diffusion	Hydrogen for Heat demonstration trialling hydrogen heating	Non-domestic	technology specific				none found
29	Technology deployment/diffusion	Nondomestic smart energy management innovation competition (NDSEMIC)	Non-domestic	technology specific		Ended		none found
30	Voluntary endorsement label	Energy Saving Trust Register	Domestic	ALL	100%	Operating	UK	Space heaters Water heaters

No.	Policy Type	Policy name	Sector affected	Specific participant	% of specific market affected	Operating/ Ended	Location	Shortlisted product groups included
								Heat emitters Building automated control systems (BACS)
31	Voluntary endorsement label	BREEAM	Multi-sector	ALL	100%	Operating	UK	Space heaters Water heaters Building automated control systems (BACS) Electrical lamps and luminaires

Annex 7 Summary of international energy related policies

List of international policy levers identified during this study.

No.	Policy Type	Policy name	Coverage	Country of origin
1	Advice/Aid in Implementation	National Standard Practice Manual for Energy Efficiency Cost-Effectiveness - Utility System Benefits and Benefit Cost Reform	State/Utility	USA
2	Advice/Aid in Implementation	Home Energy Ratings. Disclosure, Labels	State/Utility	USA
3	Advice/Aid in Implementation	Home Energy Reports	Local/ Municipal	USA
4	Advice/Aid in Implementation	U.S. Department of Energy Better Buildings Challenge	National	USA
5	Advice/Aid in Implementation	ENERGY STAR for Industry - Industrial Focuses and Energy Performance Indicators (EPIs)	National	USA
6	Advice/Aid in Implementation	Sustainable Energy for All's Building Efficiency Accelerator (BEA)	International	International
7	Communications campaign	ENERGY STAR Day	National	USA

No.	Policy Type	Policy name	Coverage	Country of origin
8	Communications campaign	Behaviour Change Programs	National	International
9	Communications campaign	Community Based Outreach Strategies in Residential Energy Upgrade Programs	National	USA
10	Communications campaign	Utility Marketplaces	Regional/ State	USA
11	Demonstration project, Grants and subsidies	ENERGY STAR Retail Products Platform	State/Utility	USA
12	Endorsement label	E-standby Program	National	Korea
13	Endorsement label	Electronic Product Environmental Assessment Tool (EPEAT) Multi-attribute Environmental Specification	International	USA
14	Energy Label	Commercial Building Benchmarking Ordinances	State/Utility	USA
15	Energy Label	Ecodesign and Energy Labelling	Regional/ State	EU
16	Energy Label	Standards and Labelling Program	National	India
17	Energy Label	China Energy Label (CEL)	National	China
18	Energy Label	Energy Efficiency Standards and Labelling Policies	International	India, Korea, Switzerland, United States

No.	Policy Type	Policy name	Coverage	Country of origin
19	Energy Label	Taiwan Energy Efficiency City Index	Local/ Municipal	Taiwan
20	Energy Label	China Green Low-Carbon Cities Index (GCLCCI)	National	China
21	Energy Label	EPA ENERGY STAR Label	National	USA
22	Energy Label	Blue Angel	National	Germany
23	Energy Label	Energy Efficiency Label/ Unified Energy Conservation Label	National	Japan
24	Energy Label	Benchmarking/disclosure ordinances	Local/ Municipal	USA
25	Energy Label	EnerGuide for Products	National	Canada
26	Energy Label, Auditing	(Various) Home Energy Efficiency Policies: Ratings, Assessments, Labels, and Disclosure	Local/ Municipal	USA
27	Energy Label, Minimum energy performance standards (MEPS), Endorsement label	Equipment Energy Efficiency (E3) Program - Energy Rating Label	National	Australia / NZ
28	Grants and subsidies	Self-financed efficiency incentives using the Lawrence Berkeley National Laboratory (LBNL) Energy Efficiency Revenue Analysis (LEERA) model	National	Mexico
29	Grants and subsidies	ENERGY STAR rebates for products	National	USA

No.	Policy Type	Policy name	Coverage	Country of origin
30	Grants and subsidies	Alberta Sector-specific Industrial Energy Efficiency (SIEE) Grant Program	Regional/ State	Canada
31	Grants and subsidies	25% subsidy for efficient HVAC and Water Heating	National	International
32	Grants and subsidies	50% subsidy for efficient HVAC and Water Heating	National	International
33	Grants and subsidies, Minimum energy performance standards (MEPS), Energy Label, Advice/Aid in Implementation, Technology deployment and diffusion	Policies for emerging technologies: solid state lighting examples from SSL Annex member countries	International	SSL Annex Countries (Australia, China, Denmark, EU, France, Japan, Korea, Sweden, USA)
34	Grants and subsidies, Public procurement (Govt Buying Standards)	Korea Energy Agency (KEA) High-Efficiency Appliance Certification	National	Korea
35	Minimum energy performance standards (MEPS)	Minimum Product Standards	State/Utility	USA

No.	Policy Type	Policy name	Coverage	Country of origin
36	Minimum energy performance standards (MEPS)	Minimum Product Standards	National	USA
37	Minimum energy performance standards (MEPS)	SmartRegs Program	Local/ Municipal	USA
38	Minimum energy performance standards (MEPS)	Top-Runner Program	National	Japan
39	Minimum energy performance standards (MEPS)	Canada's Product Energy Efficiency Regulations	National	Canada
40	Minimum energy performance standards (MEPS)	Super-efficient Equipment and Appliance Deployment (SEAD) Initiative	National	International
41	Minimum energy performance standards (MEPS)	US DOE MEPS Program - What does the next generation of MEPS look like?	National	USA
42	Minimum energy performance standards (MEPS)	Best Available Technology (BAT) Scenario for MEPS in 13 Major World Economies	National	International

No.	Policy Type	Policy name	Coverage	Country of origin
43	Minimum energy performance standards (MEPS)	Sufficiency Policy	National	Germany
44	Minimum energy performance standards (MEPS), Energy Label	Energy Efficiency Label and Standard Program	National	Korea
45	Obligation schemes	Energy Efficiency Resource Standard	State/Utility	USA
46	Public procurement (Govt Buying Standards)	Sustainable Public Procurement	National	International
47	Public procurement (Govt Buying Standards)	"Federal Energy Management Program (FEMP)- Energy Efficient Product Purchasing (established by executive order under President Obama)"	National	USA
48	Public procurement (Govt Buying Standards)	Environmentally Preferred Purchasing, Environmentally Preferred Purchasing (EPP)	National	USA
49	Public procurement (Govt Buying Standards)	Federal Acquisition Regulation: High Global Warming Potential Hydrofluorocarbons	Regional/ State	USA

No.	Policy Type	Policy name	Coverage	Country of origin
50	Tax on least efficient products	Ecological Tax Reform	National	Germany
51	Tax on least efficient products	Comparison of Energy Subsidies and Taxes	International	International (EU)
52	Technology deployment and diffusion	Energy Management Systems	National	USA, Canada, South Africa
53	Technology deployment and diffusion	Financial Incentives	National	International
54	Technology deployment and diffusion	ENERGY STAR Emerging Technology Award and/or ENERGY STAR Most Efficient	National	USA
55	Technology deployment and diffusion	Golden Carrot/Efficiency Awards to Manufacturers (China Refrigerator Project example)	Local/ Municipal	China
56	Technology deployment and diffusion	2030 District (Pittsburgh, Pennsylvania)	Local/ Municipal	USA

Annex 8 Commercial/Industrial: Low Pressure Air Compressors

A8.1 Introduction

Commercial/industrial sub-sector includes all non-residential sector related products with end uses such as office or public sector buildings and production, storage and selling of goods and materials.

A compressor is a machine that compresses either a gas or a mixture of gases, e.g., air. Just as pumps are used to move liquids, compressors are used to move gases. The component that does the compressing is called the “compressor element” or the “air end”. Other key components include the motor, (possibly equipped with a variable-speed drive), transmission, drives or switchgear, and elements for air treatment (dryer, filter) and cooling. Since the compressor contains many components, it is sometimes referred to as the “compressor package”, which is the term used in the European Commission (EC)’s 2019 draft Ecodesign proposal for low pressure air compressors (and oil free air compressors). There are three separate fact sheets on compressors, which is intended to separate out the assessment of compressors consistent with the approach taken by the EU preparatory studies (and initial Ecodesign draft working documents separated the technologies).

ISO document ISO/TR 12942:2012 Compressors – Classification – Complementary information, which provides complementary information to BS ISO 5390:1977 defines a compressor as: “a machine or apparatus converting different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher-pressure values above atmospheric pressure with pressure-increase ratios exceeding 1.1”.

Low-pressure air compressors are defined in the 2017 Ecodesign preparatory study as compressors with an absolute discharge pressure of approximately 1.1 to 5 bar (a) and a maximum volume flow rate of 4,167 l/s at standard inlet conditions[40]. Information provided in this fact sheet relates to medium sized compressors. The EC’s 2019 draft Ecodesign proposal keeps the same absolute pressure discharge range and lowers the maximum volume flow rate to 4,150 l/s. The explanatory memorandum accompanying the 2019 draft Ecodesign proposal indicates that the compressors in scope are powered by electric motors and operate according to either “positive displacement” or “turbo-machinery” technical principles.

Low Pressure Air Compressors have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

[40] Preparatory study on Low pressure & Oil-free Compressor Packages, Final Report, VHK, 7 June 2017, available here

A8.2 Market information

The global market for air compressors is expected to reach USD 47.9 billion by 2024, at a compounded annual growth rate (CAGR) of 3.6% during 2019–2024 and the low pressure accounted for a foremost share in the compressor market[41]. According to trade data supplied by an industry association, annual UK sales of low-pressure compressors amounted to approximately 1,950 units in 2020[42].

Leading global players in the industrial air compressor market include Atlas Copco AB (Sweden), Doosan Infracore Co. Ltd. (South Korea), Gardner Denver, Inc. (U.S.), Ingersoll-Rand plc (Ireland), and Hitachi Ltd (Japan)[43].

A8.3 Energy performance information

The energy consumption of an average unit ranges between 39 and 48 MWh per year[44].

Applications for low-pressure compressors include wastewater treatment, pneumatic conveying, flue gas desulphurisation oxidation air, aeration reactors, filter flushing, air blast, jet milling, sprinkler systems and air knives.

There is potential to improve product efficiency and achieve up to 4% product savings and 20% system savings (primarily from a reduction in air leaks).

There are three ways in which this improvement potential might be realised to achieve Best Available Technology: (i) improving the efficiency of the compressor package itself, (ii) utilising variable speed drives (VSDs), and/or (iii) heat recovery. Improving the efficiency of the compressor package could drive up costs, potentially reducing market offerings, and VSDs would be of benefit only in applications with significant part load conditions or fluctuating air demand.

A promising option, with potentially the highest savings, is heat recovery – if there is a demand for heat and that it matches the supply of recovered heat, so that a match can be made (in size, in location, in distribution profile, etc.). Also, heat recovery often requires additional equipment and modifications to the compressor unit.

Beyond realising the improvement potential of the compressor package itself, there are also energy savings to be made through taking a systems approach, rationalising the use of compressed air and sizing the system appropriately and managing air leakage via regular distribution network energy audit and corrective actions.

[41] “Global Compressor Market is Expected to Reach USD 47.9 billion by 2024, Observing a CAGR of 3.6% during 2019–2024: VynZ Research”, Globe Newswire, available here, accessed 6 April 2021

[42] Data supplied by an industry association, 31 March 2021.

[43] “Industrial Air Compressor Market”, Markets and Markets, available here, accessed 6 April 2021

[44] The 2017 Ecodesign preparatory study on low-pressure compressors and oil-free compressors defines a typical low pressure air compressor as having a rated power of 16.5 kW, a mass of 605kg, and an annual energy consumption of 43 344 kWh. A +/- 10% margin has been applied to the latter.

Table A8.1 Energy performance information

	Low pressure air compressors	Air Compressors Total (low pressure, oil free and standard)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.59 - 1.32	8.57 - 14.85
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.01 - 0.05	0.41 - 2.72
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0 - 0.02	0.16 - 1.09
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.08 - 0.26	1.77 - 2.98
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0 - 0.01	0.08 - 0.55
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	lower than 0.01	0.03 - 0.22
Benefit Cost Ratio of BAT Savings	0.4	n.a.

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units. In this case, a BAT unit is assessed by only improvements at a product (not system) level.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a low-pressure air compressor is 11 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.02 - 0.04 TWh of energy could be saved as well as up to 0.01 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.01 - 0.02 TWh of energy and up to 0.004 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A8.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £6,200 to £29,000. Most low-pressure air compressor are available approximately at £19,000.
- **Product weight:** approximately 605 to 6800 kg (1.5 bar to 5 bar pressure range)
- **Lifespan:** 8.4 to 13.2 years (up to 20 for centrifugal types)
- **Typical duration of the warranty:** 6 - 7 years
- **% currently recycled (where available):** Metal and electronic components, accounting for over 85% of each product, are recycled due to high scrap

A8.4.1 Composition of typical product

A typical product has a rated power of 16.5 kW and weighs 605 kg. Material composition data exist for the whole product but not for components.

Table A8.2 Composition of a typical low pressure air compressor

Main materials	Weight (kg)	% of total product	Notes
High Alloy steel	18	3.0%	Recycled due to high scrap value
Low Alloy steel	18	3.0%	Recycled due to high scrap value
Unalloyed steel	266	44.0%	Recycled due to high scrap value

Main materials	Weight (kg)	% of total product	Notes
Cast iron	133	22.0%	Recycled due to high scrap value
Aluminium	54	8.9%	Recycled due to high scrap value
Copper	18	3.0%	Recycled due to high scrap value
Plastics	12	2.0%	Incinerated
Insulation materials	60	9.9%	Landfilled due to being inert materials
Electronics	12	2.0%	Recycled for precious metal content
Others (misc. incl. cardboard)	12	2.0%	Recycled
Assumed powder coating	1	0.2%	Recycled with metals
Assumed rubber	1	0.2%	Landfilled
Assumed chromium plating	0.0012	0.002%	Recycled with metals
TOTAL	605	100%	

Table A8.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Permanent Magnets in motors (Not all compressors have this type of motor)	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all types of products have Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	Modern compressors do have more electronics in them than before. PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Beryllium	Copper alloys	Recycling rate for beryllium is high ~20% during the manufacturing of beryllium products. Recovery of beryllium from copper beryllium alloys is difficult because of the small size of the components; difficulty of separation; overall low beryllium content per device; and the low beryllium content in the copper beryllium alloy	No

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A8.5 Information on select policy levers and horizontal measures

Ecodesign MEPS are being considered. An EC Ecodesign consultation forum took place on 11 September 2019. It is estimated that product groups with EC MEPS under development will require < 1.5 years to put in place in GB, and that new policy levers (that are not mandatory MEPS or labelling) require 1 year to develop. If a new mandatory policy is developed, it is assumed 3 years is required to prepare it.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

Existing energy related policy levers in UK

- No existing regulations related to MEPS and labelling. Compressors are under consideration (ENER 31) at EU level and a consultation forum took place in 2019.
- Currently, some types of compressors are covered by the “**Salix public sector finance - Loan scheme**”.
- Previously, before their suspension the “**CRC Energy Efficiency Obligation Scheme**” also covered to an extent this product group.

Existing circular economy related policy levers

- None identified.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A8.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[45]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	<1.5 (Under consideration)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate given on-going work in EU. Keep track of progress[46].
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Not suitable as this is a product for industrial customers who would rely more on a mandatory product information sheet than a mandatory label.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards in other countries.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	None found	Not suitable option for energy supplier to provide to residential customer.
Public procurement	N/A	Prohibit poor efficiency products / Energy savings	N/A	Not suitable as not typically used in public sector.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	Not suitable as product not sold to domestic sector.
Advice/aid in implementation	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate for targeted advice. Can be based on standards in use in other countries.

[45] Further detail on assumptions contained in Section 3.4.4.
[46] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36806

Policy lever	Indicative time needed to implement (years)[45]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	N/A	Not suitable as there's no accepted UK standard or label to identify high efficiency products.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	N/A	Not suitable as there's no accepted UK standard or label to identify high efficiency products.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	<1.5	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[47]	<1.5	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[47] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A8.6 Summary of stakeholder feedback

An industry trade association suggested (for all types of compressors) that MEPS are considered for the compressor element of the package. They have also proposed an obligation scheme for standard air compressors where manufacturers publish the specific energy requirements of the compressor package and that this should be measured at a consistent point in the package and backed by a mandatory testing regime (e.g., the Compressed Air and Gas Institute (CAGI) testing program in the US). This information should allow purchasers to directly compare products. A trade association indicated that they have this prepared for the UK market and indicated that a similar scheme could be prepared for low pressure compressors.

During the BEIS Call for Evidence, a stakeholder suggested that air compressors be considered for future regulation.

A8.7 Discussion & next steps

A trade association provided sales data of their own, and validated other sales data, that show that the UK market for compressors is gradually growing. A indicated in its feedback, there is increasing interest in the industry in an obligation on manufacturers to publish the specific energy requirements of compressor packages, backed up by a testing regime like the CAGI's in the United States, to allow purchasers to directly compare compressor packages. This obligation would complement the MEPS obligation.

MEPS regulations in China and the United States have not changed since the 2017 Ecodesign preparatory study on compressors, meaning that EC MEPS defined in the EC's draft Ecodesign proposal for compressors would be the most stringent internationally.

When considering generating regulation, it should be kept in mind that a minority of compressed air systems are associated with essential services and so are designed to be robust rather than efficient.

As noted in the 2017 Ecodesign preparatory study, much larger energy savings are possible through making improvements to the compressed air system, e.g., the piping that carries the compressed air and the equipment that uses it or controls it, than through improving the efficiency of the compressor package. Improvements to the system could be quite simple, such as utilising pipes that have a more appropriate (larger) diameter, upgrading the vent traps and moisture control system, or maintaining/ replacing filter elements more frequently. Such improvements need not necessarily involve equipment-specific regulation. Leak management also has an impact in this area.

A8.8 Evidence sources

Title	Author	Date Published or date accessed
Preparatory study on Low pressure & Oil-free Compressor Packages	Van Holsteijn en Kemna B.V. (VHK)	7 June 2017
Ecodesign Preparatory Study on Electric motor systems/ Compressors (Part 1 and Part 2)	Van Holsteijn en Kemna B.V. (VHK)	3 June 2014
Global Compressor Market is Expected to Reach USD 47.9 billion by 2024, Observing a CAGR of 3.6% during 2019–2024: VynZ Research", Globe Newswire	Globe Newswire	Published 4 February 2020, Accessed 6 April 2021
UK Sales data provided by a trade association	Trade association	31 March 2021
Industrial Air Compressor Market by Type, Markets and Markets	Markets and Markets	Published October 2016, Accessed 6 April 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 9 Commercial/Industrial: Oil Free Air Compressors

A9.1 Introduction

Commercial/industrial sub-sector includes all non-residential sector related products with end uses such as office or public sector buildings and production, storage and selling of goods and materials.

A compressor is a machine that compresses either a gas or a mixture of gases, e.g., air. Just as pumps are used to move liquids, compressors are used to move gases. The component that does the compressing is called the “compressor element” or the “air end”. Other key components include the motor, (possibly equipped with a variable-speed drive), transmission, drives or switchgear, and elements for air treatment (dryer, filter) and cooling. Since the compressor contains many components, it is sometimes referred to as the “compressor package”, which is the term used in the EC 2019 draft Ecodesign proposal for low pressure air compressors and oil free air compressors. There are three separate fact sheets on compressors, which is intended to separate out the assessment of compressors consistent with the approach taken by the EU preparatory studies (and initial Ecodesign draft working documents separated the technologies).

ISO document ISO/TR 12942:2012 Compressors – Classification – Complementary information, which provides complementary information to BS ISO 5390:1977, defines a compressor as: “a machine or apparatus converting different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher-pressure values above atmospheric pressure with pressure-increase ratios exceeding 1.1”.An oil-free compressor contains no oil-based lubricants in the compression elements. In most compressors, oil is used as a lubricant to reduce friction and therefore heat; however, in such compressors, there is a risk that the oil might contaminate the air.

Oil-free air compressors are defined in the 2017 Ecodesign preparatory study as compressors with (i) no oil inserted in the compression chamber, (ii) an absolute discharge pressure of approximately 5 to 15 bar (a), i.e., the same as standard air compressors[48], and (iii) a maximum volume flow rate of 3,333 l/s at 8 bar(a)[49]. The EC’s 2019 draft Ecodesign proposal keeps the same absolute pressure discharge range and raises the maximum volume flow rate to 3,500 l/s. The explanatory memorandum accompanying the 2019 draft Ecodesign proposal indicates that the compressors in scope are powered by electric motors and operate according to either “positive displacement” or “turbo-machinery” technical principles.

[48] This means compressors that a compressor that contains no oil-based lubricants in the compression elements, but that has an absolute discharge pressure of approximately 1.1 to 5 bar (a) and a maximum volume flow rate of 4,167 l/s at standard inlet conditions, is categorised as a low-pressure air compressor (see Annex 8)

[49] Preparatory study on Low pressure & Oil-free Compressor Packages, Final Report, VHK, 7 June 2017, available here

Oil-free Air Compressors have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A9.2 Market information

Globally, the oil-free air compressor market size was valued at USD 11.24 billion in 2018 and is expected to register a Compounded Annual Growth Rate (CAGR) of 4.8% till 202550. According to trade data supplied by an industry trade association, annual UK sales of oil-free compressors amounted to approximately 150 units in 2020[51].

Leading global players in the global oil-free compressor market are Atlas Copco AB (Sweden), Ingersoll Rand plc (Ireland), Aerzen, Kaeser (Germany), Gardner Denver, General Electric, Kobelco, Sullair (United States), Nanjing Compressor (China), Fusheng (Taiwan), and Mitsui, Hitachi, Anest Iwata (Japan)[52].

A9.3 Energy performance information

The energy consumption of an average unit ranges between 103 and 126 MWh per year.

Oil free compressors are used in specialist applications where a high purity of air is needed, such as food and drink, medical pharmaceuticals, chemical, automotive (painting), and for measurement equipment.

There is potential to improve product efficiency and achieve up to 4% savings and 20% system savings (primarily from a reduction in air leaks).

There are three ways in which this improvement potential might be realised in order to achieve Best Available Technology: (i) improving the efficiency of the compressor package itself, (ii) utilising variable speed drives (VSDs), and/or (iii) heat recovery. Improving the efficiency of the compressor package could drive up costs, potentially reducing market offerings, and VSDs would be of benefit only in applications with significant part load conditions or fluctuating air demand.

A promising option, with potentially the highest savings, is heat recovery – if there is a demand for heat and that it matches the supply of recovered heat, so that a match can be made (in size, in location, in distribution profile, etc.). Also, heat recovery often requires additional equipment and modifications to the compressor unit.

Beyond realising the improvement potential of the compressor package itself, there are also energy savings to be made through taking a systems approach and rationalising the use of

[50] Oil Free Air Compressor Market Size, Share & Trends Analysis Report, Grand View Research, accessed 6 April 2021, available here

[51] Data supplied by an industry association, 31 March 2021.

[52] Oil-Free Compressor Market 2021, KSU – The Sentinel Newspaper, accessed 6 April 2021, available here

compressed air and sizing the system appropriately, and managing air leakage via regular distribution network energy audit and corrective actions.

Table A9.1 Energy performance information

	Oil free air compressors	Air Compressors Total (low pressure, oil free and standard)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.05 - 0.25	8.57 - 14.85
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0 - 0.01	0.41 - 2.72
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	lower than 0.01	0.16 - 1.09
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	lower than 0.01	1.77 - 2.98
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	lower than 0.01	0.08 - 0.55
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	lower than 0.01	0.03 - 0.22
Benefit Cost Ratio of BAT Savings	3	n.a.

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units. In this case, a BAT unit is assessed by only improvements at a product (not system) level.

For Oil Free Air Compressors, the low sales (135-160 units per year) and low savings potential (2%-4%) result in very low energy consumption and savings in TWh, and consequently low carbon emissions and savings in MtCO2e. On a per unit basis, energy consumption ranges between 516-1,603 MWh/year and maximum technical potential savings with BAT range between 10-64 MWh/year.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of an oil free air compressor is 9 years[53] and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, up to 0.01 TWh. Savings that could be achieved with a mix of policy levers would be up to 0.004 TWh of energy. Carbon savings are lower than 0.01 MtCO2e and thus not captured in the scale used in this study. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A9.4 Baseline resource efficiency information

Resource footprint

- **Average price**: from £11,949 to £62,062. Most oil-free air compressors are available approximately at £18,734. (Average price is calculated by taking weighted average with sales)
- **Product weight**: from 1070 kg to 3360 kg (rated power ranges from 37kW to 160 kW)
- **Lifespan:** 5.0 to 12.7 years
- **Typical duration of the warranty**: 3 - 10 years
- **% currently recycled (where available):** Metal and electronic components, accounting for over 89% of each product, are recycled due to high scrap.

[53] Lifespans can be extended to 15 – 25 years from reselling on second-hand markets.

A9.4.1 Composition of typical product

A typical product has a rated power of 37.3 kW and weighs 1070 kg. Material composition data exist for the whole product but not for components.

Table A9.2 Composition of a typical oil free air compressor

Main materials	Weight (kg)	% of total product	Notes
High Alloy steel	32	3.0%	Recycled due to high scrap value
Low Alloy steel	32	3.0%	Recycled due to high scrap value
Unalloyed steel	471	43.9%	Recycled due to high scrap value
Cast iron	236	22.0%	Recycled due to high scrap value
Aluminium	96	8.9%	Recycled due to high scrap value
Copper	32	3.0%	Recycled due to high scrap value
Plastics	21	2.0%	Incinerated
Insulation materials	107	10.0%	Landfilled due to being inert materials
Electronics	21	2.0%	Recycled for precious metal content
Others	21	2.0%	Recycled
Assumed powder coating	2	0.2%	Recycled with metals
Assumed rubber	2	0.2%	Landfilled
Assumed chromium plating	0.0021	0.0%	Recycled with metals
TOTAL	1,073	100%	

Table A9.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Permanent Magnets in motors (Not all compressors have this type of motor)	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all of these products contain Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	Modern compressors do contain more electronics than older variants.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Beryllium	Copper alloys	Recycling rate for beryllium is high ~20% during the manufacturing of beryllium products. Recovery of beryllium from copper beryllium alloys is difficult because of the small size of the components; difficulty of separation; overall low beryllium content per device; and the low beryllium content in the copper beryllium alloy	No

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A9.5 Information on select policy levers and horizontal measures

Ecodesign MEPS are being considered. An EC consultation forum took place on 11 September 2019. It is estimated that product groups with EC MEPS under development will require < 1.5 years to put in place in GB, and that new policy levers (that are not mandatory MEPS or labelling) require 1 year to develop. If a new mandatory policy is developed, it is assumed 3 years is required to prepare it.

Existing energy related policy levers in UK

- No existing regulations related to MEPS and labelling.
- Compressors are under consideration at EU level (ENER 31) and a consultation forum took place in 2019.
- No other policies were identified that focus specifically on Oil Free Air Compressors, but some types of compressors are covered by the "**Salix public sector finance - Loan scheme**"

Existing circular economy related policy levers

- No available ones.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A9.4 Information on select policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[54]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	<1.5 (Under consideration)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate given on-going work in EU. Keep track of progress[55].
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Not suitable as this is a product for industrial customers who would rely more on a mandatory product information sheet than a mandatory label.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards in other countries.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	None found	Not suitable option for energy supplier to provide to residential customer.
Public procurement	N/A	Prohibit poor efficiency products / Energy savings	N/A	Not suitable as not typically used in public sector.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	Not suitable as product not sold to domestic sector.
Advice/aid in implementation	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate for targeted advice. Can be based on standards in use in other countries.

[54] Further detail on assumptions contained in Section 3.4.4
[55] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36806

Policy lever	Indicative time needed to implement (years)[54]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	N/A	Not suitable as there's no accepted UK standard or label to identify high efficiency products.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	N/A	Not suitable as there's no accepted UK standard or label to identify high efficiency products.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	<1.5	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[56]	<1.5	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[56] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A9.6 Summary of stakeholder feedback

An industry association has suggested that MEPS should be considered for oil-free air compressor packages (and standard air compressor packages) via the data sheet scheme only. They have also proposed an obligation scheme where manufacturers publish the specific energy requirements of the compressor package and that this should be measured at a consistent point in the package and backed by a mandatory testing regime (e.g., the Compressed Air and Gas Institute (CAGI) testing program in the US). This information should allow purchasers to directly compare products. An industry association indicated that industry have this prepared for the UK market.

During the BEIS Call for Evidence, a stakeholder suggested that air compressors be considered for future regulation.

A9.7 Discussion & next steps

An industry association has provided sales data of their own, and have validated other sales data, that show that the UK market for compressors is gradually growing. As indicated in its feedback, there is increasing interest in the industry in an obligation on manufacturers to publish the specific energy requirements of compressor packages, backed up by a testing regime like the CAGI's in the United States, in order to allow purchasers to directly compare compressor packages. This obligation would complement the MEPS obligation.

MEPS regulations in China and the United States have not changed since the 2017 Ecodesign preparatory study on compressors, meaning that EC MEPS defined in the EC's draft Ecodesign proposal for compressors would be the most stringent internationally.

When considering generating regulation, it should be kept in mind that a minority of compressed air systems are associated with essential services and so are designed to be robust rather than efficient.

As noted in the 2017 preparatory study, much larger energy savings are possible through making improvements to the compressed air system, e.g., the piping that carries the compressed air and the equipment that uses it or controls it, than through improving the efficiency of the compressor package. Improvements to the system could be quite simple, such as utilising pipes that have a more appropriate (larger) diameter, upgrading the vent traps and moisture control system, or maintaining/ replacing filter elements more frequently. Such improvements need not necessarily involve equipment-specific regulation. Leak management also has an impact in this area.

A9.8 Evidence sources

Title	Author	Date Published or date accessed
Preparatory study on Low pressure & Oil-free Compressor Packages	Van Holsteijn en Kemna B.V. (VHK)	7 June 2017
Ecodesign Preparatory Study on Electric motor systems/ Compressors (Part 1 and Part 2)	Van Holsteijn en Kemna B.V. (VHK)	3 June 2014
Oil Free Air Compressor Market Size, Share & Trends Analysis Report	Grand View Research	Published February 2019 Accessed 6 April 2021
UK Sales data provided by an industry association	Industry association	31 March 2021
Oil-Free Compressor Market 2021	KSU – The Sentinel Newspaper	Published 2 February 2021 Accessed 6 April 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 10 Commercial/Industrial: Standard Air Compressors

A10.1 Introduction

Commercial/industrial sub-sector includes all non-residential sector related products with end uses such as office or public sector buildings and production, storage and selling of goods and materials.

A compressor is a machine that compresses either a gas or a mixture of gases, e.g., air. Just as pumps are used to move liquids, compressors are used to move gases. The component that does the compressing is called the “compressor element” or the “air end”. Other key components include the motor, possibly equipped with a variable-speed drive), transmission, drives or switchgear, and elements for air treatment (dryer, filter) and cooling. Since the compressor contains many components, it is sometimes referred to as the “compressor package”, which is the term used in the European Commission’s 2019 draft Ecodesign proposal for standard air compressors. There are three separate fact sheets on compressors, which is intended to separate out the assessment of compressors consistent with the approach taken by the EU preparatory studies (and initial Ecodesign draft working documents separated the technologies).

ISO document ISO/TR 12942:2012 Compressors – Classification – Complementary information, which provides complementary information to BS ISO 5390:1977, defines a compressor as: “a machine or apparatus converting different types of energy into the potential energy of gas pressure for displacement and compression of gaseous media to any higher-pressure values above atmospheric pressure with pressure-increase ratios exceeding 1.1”.

Within a standard-air compressor, the air is pressurized to 7–15 bar above atmospheric pressure. This is the most commonly available type of compressor and used in a diverse range of applications. The 2014 Ecodesign preparatory study states that the compressors are in scope are powered by three phase electric motors and operate according to either positive displacement or to rotary technical principles. The EC’s 2014 draft Ecodesign proposal includes both and sets volume flow rates of between 2 to 64 l/s for positive displacement (piston) compressors and between 5 and 1280 l/s for rotary compressors. However, the 2019 draft Ecodesign proposal restricts its scope to rotary compressors, keeping the volume flow rate range of between 5 and 1280 l/s.

Standard Air Compressors have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A10.2 Market information

The global market for air compressors is expected to reach USD 47.9 billion by 2024, at a compounded annual growth rate (CAGR) of 3.6% during 2019–2024 and the low pressure accounted for a foremost share in the compressor market[57]. According to trade data supplied by an industry association), annual UK sales of standard air compressors amounted to approximately 16,410 units in 2020[58]. The current market is still recovering from the effects of the economic crisis started in 2008 and sales are now close to what they were before the economic crisis. The current industry forecasts assume a constant increase in sales volume.

Leading global players are Atlas Copco AB (Sweden) is the leading air compressor manufacturer in the world, followed by Doosan Infracore Co. Ltd. (South Korea), Gardner Denver, Inc. (U.S.), Ingersoll-Rand plc (Ireland), and Hitachi Ltd (Japan)[59].

A10.3 Energy performance information

The energy consumption of a typical positive displacement unit ranges between 2.6 and 3.1 MWh per year, and the energy consumption of a typical rotary compressor unit ranges between 80 and 89 MWh per year[60]. A purely theoretical average unit would thus have an energy consumption of between 41 and 46 MWh.

A standard-air compressor is the most commonly available type of compressor and used in a diverse range of applications. Some of the more popular options are tools: e.g., hand tools such as nailers, impact wrenches, sanders; cutting machines, robots, packaging, pneumatics, and paint sprayers.

There are two methods of achieving air compression: positive and dynamic displacement. Positive displacement air compressors force air in a chamber where the volume is decreased to compress the air. Dynamic displacement compressors (used in turbo compressors which are oil free by design) utilize a rotating blade powered by an engine to generate airflow. The air is then restricted to create pressure, and the kinetic energy is stored within the compressor.

There is potential to improve product efficiency and achieve up to 4% savings and 20% system savings (primarily from a reduction in air leaks).

There are three ways in which the improvement potential might be realised in order to achieve Best Available Technology: (i) improving the efficiency of the compressor package itself, (ii) utilising variable speed drives (VSDs), and/or (iii) heat recovery. Improving the efficiency of the compressor package could drive up costs, potentially reducing market offerings, and VSDs

[57] “Global Compressor Market is Expected to Reach USD 47.9 billion by 2024, Observing a CAGR of 3.6% during 2019–2024: VynZ Research”, Globe Newswire, available , accessed 6 April 2021
[58] Data supplied by an industry association, 31 March 2021.
[59] “Industrial Air Compressor Market”, Markets and Markets, available here, accessed 6 April 2021
[60] Preparatory study on Compressors, Final Report, VHK, 3 June 2014, available here

would be of benefit only in applications with significant part load conditions or fluctuating air demand.

A promising option, with potentially the highest savings, is heat recovery – if there is a demand for heat and that it matches the supply of recovered heat, so that a match can be made (in size, in location, in distribution profile, etc.). Also, heat recovery often requires additional equipment and modifications to the compressor unit.

Beyond realising the improvement potential of the compressor package itself, there are also energy savings to be made through taking a systems approach and rationalising the use of compressed air and sizing the system appropriately and managing air leakage via regular distribution network energy audit and corrective actions.

Table A10.1 Energy performance information

	Standard air compressors	Air Compressors Total (low pressure, oil free and standard)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	7.93 - 13.28	8.57 - 14.85
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.4 - 2.66	0.41 - 2.72
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.16 - 1.07	0.16 - 1.09
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	1.69 - 2.72	1.77 - 2.98
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.08 - 0.54	0.08 - 0.55
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.03 - 0.22	0.03 - 0.22
Benefit Cost Ratio of BAT Savings	1.4	n.a.

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units. In this case, system level saving potential has been used as BAT to illustrate system level saving potential.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a standard air compressor is 15 years[61] and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.3 - 1.66 TWh of energy could be saved as well as 0.07 - 0.34 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.12 - 0.67 TWh of energy and 0.03 - 0.14 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A10.4 Baseline resource efficiency information

Resource footprint

- **Average price***:* from £3400 to £5300.
- **Product weight:** approximately 150 kg to 540 kg
- **Lifespan:** 13-16 years
- **Typical duration of the warranty:** 6 - 10 years
- **% currently recycled (where available):** Metal and electronic components, accounting for over 85% of each product, are recycled due to high scrap.

[61] Industry feedback suggests the range is more like 8-12 years with proper maintenance. This includes replacements of small piston technology every 3-4 years.

A10.4.1 Composition of typical product

A typical product has a rated power of 10 kW and weighs 265 kg. Material composition data exist for the whole product but not for components.

Table A10.2 Composition of a typical standard air compressors

Main materials	Weight (kg)	% of total product	Notes
High Alloy steel	8	3.0%	Recycled due to high scrap value
Low Alloy steel	8	3.0%	Recycled due to high scrap value
Unalloyed steel	116	43.8%	Recycled due to high scrap value
Cast iron	58	21.9%	Recycled due to high scrap value
Aluminium	24	9.1%	Recycled due to high scrap value
Copper	8	3.0%	Recycled due to high scrap value
Plastics	5	2.0%	Incinerated
Insulation materials	26	9.8%	Landfilled due to being inert materials
Electronics	5	1.9%	Recycled for precious metal content
Others (misc. incl. cardboard)	5	1.9%	Recycled
Assumed powder coating	1	0.4%	Recycled with metals
Assumed rubber	1	0.4%	Landfilled
Assumed chromium plating	0.0005	0.002%	Recycled with metals
TOTAL	265	100%	

Table A10.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Permanent Magnets in motors (Not all compressors have this type of motor)	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all types of this product group have Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	Modern compressors do have more electronics in them than before.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Beryllium	Copper alloys	Recycling rate for beryllium is high ~20% during the manufacturing of beryllium products. Recovery of beryllium from copper beryllium alloys is difficult because of the small size of the components; difficulty of separation; overall low beryllium content per device; and the low beryllium content in the copper beryllium alloy	No

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A10.5 Information on select policy levers and horizontal measures

Ecodesign MEPS are being considered. An EC consultation forum took place on 11 September 2019. It's estimated that product groups with EC MEPS under development will require < 1.5 years to put in place in GB, and that new policy levers (that are not mandatory MEPS or labelling) require 1 year to develop. If a new mandatory policy is developed, it is assumed 3 years is required to prepare it.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Existing energy related policy levers in UK

- No existing regulations related to MEPS and labelling.
- Under consideration at EU level and an EC consultation forum took place in 2019.
- No identified UK policies that focus specifically on Standard Air Compressors, but some types of compressors are covered by the "**Salix public sector finance - Loan scheme**".

Existing circular economy related policy levers

- No available ones.

Table A10.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[62]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	<1.5 (Under consideration)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate given on-going work in EU. Keep track of progress[63].
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Not suitable as this is a product for industrial customers who would rely more on a mandatory product information sheet than a mandatory label.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards in other countries.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier to provide to residential customer.
Public procurement	N/A	Prohibit poor efficiency products / Energy savings	N/A	Not suitable as not typically used in public sector.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	Not suitable as product not sold to domestic sector.
Advice/aid in implementation	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate for targeted advice. Can be based on standards in use in other countries.

[62] Further detail on assumptions contained in Section 3.4.4
[63] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36806

Policy lever	Indicative time needed to implement (years)[62]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	N/A	Not suitable as there's no accepted UK standard or label to identify high efficiency products.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	N/A	Not suitable as there's no accepted UK standard or label to identify high efficiency products.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	<1.5	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[64]	<1.5	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[64] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A10.6 Summary of stakeholder feedback

An industry association has suggested that MEPS should be considered for standard air compressor packages (and oil-free air compressor packages) via the data sheet scheme only. They have also proposed an obligation scheme where manufacturers publish the specific energy requirements of the compressor package and that this should be measured at a consistent point in the package and backed by a mandatory testing regime (e.g., the Compressed Air and Gas Institute (CAGI) testing program in the US). This information should allow purchasers to directly compare products. An industry association indicated that have this prepared for the UK market.

Feedback from an industry association during Task 2 resulted in the inclusion of standard air compressors in the shortlist as they were mistakenly omitted from the long list of products.

During the BEIS Call for Evidence, a stakeholder suggested that air compressors be considered for future regulation.

A10.7 Discussion & next steps

An industry association has provided sales data of their own, and have validated other sales data, that show that the UK market for compressors is gradually growing.

As indicated in its feedback, there is increasing interest in the industry in an obligation on manufacturers to publish the specific energy requirements of compressor packages, backed up by a testing regime like the CAGI's in the United States, in order to allow purchasers to directly compare compressor packages. This obligation would complement the MEPS obligation.

MEPS regulations in China and the United States have not changed since the 2017 Ecodesign preparatory study on compressors, meaning that EC MEPS defined in the EC's draft Ecodesign proposal for compressors would be the most stringent internationally.

When considering generating regulation, it should be borne in mind that a minority of compressed air systems are associated with essential services and so are designed to be robust rather than efficient.

As noted in the 2017 Ecodesign preparatory study, in relation to low-pressure and oil-free compressor but the point is true for standard air compressors as well, much larger energy savings are possible through making improvements to the compressed air system, e.g., the piping that carries the compressed air and the equipment that uses it or controls it, than through improving the efficiency of the compressor package. Improvements to the system could be quite simple, such as utilising pipes that have a more appropriate (larger) diameter, upgrading the vent traps and moisture control system, or maintaining/ replacing filter elements more frequently. Such improvements need not necessarily involve equipment-specific regulation. Leak management also has an impact in this area.

A10.8 Evidence sources

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Ecodesign Preparatory Study on Electric motor systems/ Compressors (Part 1 and Part 2)	Van Holsteijn en Kemna B.V. (VHK)	3 June 2014
Preparatory study on Low pressure & Oil-free Compressor Packages	Van Holsteijn en Kemna B.V. (VHK)	7 June 2017
Global Compressor Market is Expected to Reach USD 47.9 billion by 2024, Observing a CAGR of 3.6% during 2019–2024: VynZ Research", Globe Newswire	Globe Newswire	Published 4 February 2020, Accessed 6 April 2021
UK Sales data provided by an industry association	Industry association	31 March 2021
Industrial Air Compressor Market by Type, Markets and Markets	Markets and Markets	Published October 2016, Accessed 6 April 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020
Waste management Life Cycle Assessment: the case of a reciprocating air compressor in Brazil	Journal of Cleaner Production	2014

Annex 11 Commercial/Industrial: Refrigeration Compressors

A11.1 Introduction

Commercial/industrial sub-sector includes all non-residential sector related products with end uses such as office or public sector buildings and production, storage and selling of goods and materials. Commercial refrigeration typically covers a temperature band of -30oC to +5oC, with industrial refrigeration systems sometimes requiring even lower temperature freezing to -50oC.

Refrigeration compressors are products that are specifically designed to raise the pressure, temperature and energy level of a refrigerant vapour by mechanical means as part of a "vapour-compression, economised vapour compression or trans-critical R744 (CO2) refrigeration cycle. Compressors drive the circulation of a refrigerant. They range in size from those used in refrigerated display cabinets used in shops and supermarkets, to those used in large industrial refrigeration systems in breweries. Refrigeration compressors are available in a range of different designs and efficiencies, and can be manufactured as fully hermetic, semi-hermetic or open products.

A11.2 Market information

A rising number of supermarkets, hypermarkets and the pharmaceutical industry requiring HVAC systems will result in the increasing proliferation of refrigeration compressors in the market. The global refrigeration compressor market was 210 million units in 2019, in which the largest share was of China, followed by Southeast Asia, USA, India and Europe. The last three contributors are Japan, Brazil and Middle East, accounting for approximately 4% of the total sales[65]. According to the Fortune Business insights, global compressor market is expected to show a Compounded Annual Growth Rate (CAGR) of 4.1% from 2018 till 2026. In 2016, the BSRIA reports the sales of refrigeration compressors to be 329,443 in the UK. It assumes an average annual growth rate of 3% till 2020 and then it is assumed to drop to 1% post 2020. Annual imports of around 1.5m units and exports 600k have been seen in recent years.

Globally manufacturers such as GMCC (Barcelona and Poland), Zhuhai Landa (China), Embraco (factories in China, Mexico and Slovakia, as well as business offices in Italy, Russia and the United States), Panasonic, LG, RECHI Group, Samsung, Johnson Controls-Hitachi, Emerson, Highly, Secop, Tecumseh, FISCHER, Carlyle Compressors, FRASCOLD, Bitzer, Hanbell, Fusheng Industrial GEA Bock and many others are contributing to market growth[66].

[65] https://www.statista.com/statistics/1192033/refrigeration-compressor-sales-worldwide/
[66] https://apnews.com/press-release/wired-release/d2f7956599d24bbb0dfdd4045466e4a2

A11.3 Energy performance information

The typical energy consumption of a unit ranges between 50 and 54 MWh per year based on energy consumption from cold storage applications with an average cooling capacity of 34-36kW to compressors with low cooling capacity of 12 kW (used in industrial applications).

Below is a description of how the technology works and its usage patterns.

When a compressor starts, it draws refrigerant fluid (in vapour form) from the evaporator. The compressor increases the refrigerant fluid's pressure and temperature up to superheated levels.

The hot, compressed gas leaving the compressor enters a condenser (e.g., external metal coils (tubes) on the back or bottom of the refrigerator), which transfers heat to the ambient and condenses the fluid to liquid.

In a vapour-compression cycle, the liquid gas continues to flow through the system until it reaches an expansion valve.

After passing through the expansion device, the pressure is reduced because the compressor is removing gas from the end of the evaporator. This lowers the boiling temperature of the refrigerant. The lower temperature absorbs heat from the air passing over the evaporator and converts the liquid to a gas. The gas then passes into the compressor and the cycle repeats until the refrigerator temperature has returned to its set point.

There is potential to improve product efficiency and achieve up to 4% savings. A key improvement option is the use of inverter compressors. Compared to the traditional single speed compressor, the inverter compressor can run at a number of desired speeds, depending on how the refrigerator is being used by the consumer. This provides options for quick pull down or freezing, or to run at a very low speed once the cabinet is at a steady state, thereby significantly reducing energy consumption. However, in using an inverter compressor the cooling load requirement of the cabinet must be considered, as well the pressures and temperatures of the compressor, particularly at low speeds, in order to maintain the durability and reliability of the compressor.

Table A11.1 Energy performance information

	Refrigeration compressors
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	19.8 - 32.85
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.4 - 1.31

	Refrigeration compressors
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.22 - 0.71
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	4.08 - 6.75
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.08 - 0.27
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.04 - 0.15
Benefit Cost Ratio of BAT Savings	15.4

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a refrigeration compressor is 14 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.34 - 0.88 TWh of energy could be saved as well as 0.07 - 0.18 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.18 - 0.47 TWh of energy and 0.04 - 0.1 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A11.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £394 to £889.
- **Product weight:** approximately 9.6 kg to 38.6 kg
- **Lifespan:** 12-15 years
- **Typical duration of the warranty:** 3 - 5 years
- **% currently recycled (where available)**: No information is available

A11.4.1 Composition of typical product

Table A11.2 Composition of a typical refrigeration compressor

Main materials	Weight (kg)	% of total product
Cast iron	19	55%
Steel	12	35%
Copper	3	8%
Alloy	0.5	1%
TOTAL	35	100%

Table A11.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Permanent Magnets in motors	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredding. As a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	Modern compressors do have more electronics in them than before.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Beryllium	Copper alloys	Recycling rate for beryllium is high ~20% during the manufacturing of beryllium products. Recovery of beryllium from copper beryllium alloys is difficult because of the small size of the components; difficulty of separation; overall low beryllium content per device; and the low beryllium content in the copper beryllium alloy	No

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Potential presence of refrigerants, such as R744.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A11.5 Information on select policy levers and horizontal measures

Ecodesign MEPS do not exist for this product group. If a new mandatory policy is developed, it is assumed 3 years is required to prepare it.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

Existing energy related policy levers in UK

- Currently, refrigeration compressors are partially covered by the “Sustainable procurement: the Government Buying Standards (GBS) for Commercial Refrigeration”.
- Refrigeration compressors are listed on the Energy Technology List.

Existing circular economy related policy levers

- None identified.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A11.4 Information on select policy leers and horizontal measures

Policy lever	Indicative time needed to implement (years)[67]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	3	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate. Standards already in place.
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Good candidate due to existing standards, but uncertain benefits as labelling typically for domestic products.
Voluntary endorsement label	2	Information provision / Energy savings	None found	Good candidate due to existing standards.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier to provide to residential customer.
Public procurement	N/A	Not suitable as this is a mature product group.	N/A	Not suitable as not typically used in public sector.
Communications campaign	N/A	Not suitable as this is a mature product group.	N/A	Not suitable as product not sold to domestic sector.
Advice/aid in implementation	1	Not suitable as this is a mature product group.	N/A	Good candidate for targeted advice based on standards or endorsement label.
Grants, subsidies, loans	1	Increase accessibility of high efficiency products / Energy savings	None found	Candidate based on standards or endorsement label.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	N/A	Not suitable as there is no mandatory label to identify poor performers.

[67] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[67]	Policy objective/ impact	Scale of impact	Suitability comments
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[68]	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A11.6 Summary of stakeholder feedback

No stakeholder feedback was received on this product group during this study or the BEIS Call for Evidence.

A11.7 Discussion & next steps

There is increasing proliferation of refrigeration compressors in the market. In 2016, UK sales were over 329,000, with annual growth rate of 3% till 2020 and then 1% post 2020. However,

[68] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

the global compressor market is expected to grow at over 4% per year through 2026. No unique features are associated with the UK market compared to RoW.

Key energy saving option is the use of inverter technology, which is readily available on the market.

No existing policy measures associated with this product, although introduction of MEPS or industry voluntary agreements are feasible as measurement standards are available.

A large UK retailer is currently collaborating with a UK university to investigate a more holistic approach towards energy savings which captures the whole store energy consumption and more importantly how it can be influenced by seasonal changes and the external ambient temperatures. Refrigeration compressors are a key component of refrigeration appliances and, so, are part of the suite of technologies that support a whole store energy consumption approach.

A11.8 Evidence sources

Title	Author	Date Published or date accessed
https://www.fortunebusinessinsights.com/industry-reports/commercial-refrigeration-compressor-market-101651	Fortune Business Insights	18th March 2021
https://www.statista.com/statistics/1192033/refrigeration-compressor-sales-worldwide/	Statista	18th March 2021
https://apnews.com/press-release/wired-release/d2f7956599d24bbb0dfdd4045466e4a2	AP News	18th March 2021
https://inventory.tecumseh.com/~/media/Asia/Files/Marketing-Brochure/General-Catalogue-2017-2nd-Edition.pdf	Tecumseh	18th March 2021
https://www.climatecare.com/blog/how-long-can-an-ac-compressor-or-refrigerant-last-in-your-ac/#:~:text=The%20short%20answer%20is%20that,efficiently%20for%20its%20entire%20lifespan.	Climate Care	18th March 2021
Valpro Commercial Refrigeration Warranty T&C	Valpro	2017

Title	Author	Date Published or date accessed
https://www.indiamart.com/proddetail/vertical-refrigerator-3yrs-compressor-warranty-7575881288.html	India Mart	18th March 2021
Energy consummation and environmental emissions assessment of a refrigeration compressor based on life cycle assessment methodology	Tao Li, Hong-Chao Zhang, Shi-Tong Peng, and Zhi-Chao Liu	May 2015
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 12 Consumer Electronics: Electronic Displays and TVs

A12.1 Introduction

Consumer electronic products are generally purchased for personal rather than commercial use. Examples include televisions, game consoles, Blu-ray players and home theatre equipment.

The term television (TV) refers to a wide spectrum of products depending on the system boundaries applied. The term has come to refer to all the aspects of television from the television devices (TV-set), television related equipment (e.g., TV/video combinations), up to the complete television broadcasting and receiving system including:

An image source - this may be a camera for live pick-up of images or a flying spot scanner for transmission of films.

A sound source.

A transmitter, which modulates one or more television signals with both picture and sound information for transmission.

A receiver (television) which recovers the picture and sound signals from the television broadcast.

A display device, which turns the electrical signals into visible light and audible sound.

The definition of electronic displays is intended primarily to cover standard monitors designed for use with computers. An electronic display is defined as an electronic product with a screen and its associated electronics encased in a single housing that can display output information from a computer via one or more inputs, such as VGA, DVI, and/or IEEE 1394. The electronic display usually relies upon a light-emitting diode (LED), organic light-emitting diode (OLED), quantum dots (QLED), liquid crystal display (LCD) or other display device.

A12.2 Market information

The total annual sales in 2020 in the UK market for TVs is around 5,700,000 units. Electronic displays have annual sales of 2,690,000 units.

The market growth in the UK has been 37% between 2007-2013.

Trade information was found on the imports, exports and production of monitors and projectors (not incorporating television reception apparatus) in the UK market 2019 are the following:

- Imported units:
- Monitors and projectors = 7,625,956
- Exported units:
- Monitors and projectors = 1,264,831
- Produced units:
- Monitors and projectors= 73,979

A12.3 Energy performance information

The typical energy consumption of a unit is around 0.03 MWh per year.

TV technology works by receiving broadcast transmissions, processing these received transmissions, and display the resulting image while reproducing the accompanying sound. The signal is provided via antenna, satellite, cable, or other broadband access. The pictures are recovered and displaying by the monitor, and the speaker enables the reproduction of audio signal.

For television screens the potential to improve product efficiency can achieve up to 28% savings. For computer monitor displays, these savings are estimated at 8%.[69]

The Best Available Technology for this product group relates to reduction of power consumption and long-term resource efficiency. It comprises an unspecific set power supply design measures with the target of improving average power supply efficiency towards 85%. Also, design measures that support the recovery of genuine material fractions at the product's end-of-life is a general requirement. Product prices have dropped in some market segment by up to 50% since 2007, this drop in product price shows that BAT options did not add additional costs.

Table A12.1 Energy performance information

	TVs	Displays
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	1.35 - 2.09	0.35 - 0.54
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.3 - 0.57	0.02 - 0.04

69 These saving estimates are appropriate for 2020, before the MEPS from Directive 2019/2021 which increases performance standards in March 2021 and March 2023.

	TVs	Displays
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.2 - 0.38	0.01 - 0.03
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.27 - 0.44	0.05 - 0.12
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.06 - 0.12	0 - 0.01
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.04 - 0.08	0 - 0.01
Benefit Cost Ratio of BAT Savings	n.a.	n.a.

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

For electronic displays and TVs, the BCR is not calculated as costs are set to zero because energy savings are not necessarily associated with increased costs. In some cases, more expensive products can consume more energy.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a display is 6 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.06 - 0.07 TWh of energy could be saved as well as 0.01 - 0.02 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.04 - 0.05 TWh of energy and 0.01 - 0.01 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a TV is 10 years. If all units sold annually in the UK in a given year were BAT technologies, 0.45 - 0.52 TWh of energy could be saved as well as 0.07 - 0.11 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.3 - 0.35 TWh of energy and 0.05 - 0.07 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A12.4 Baseline resource efficiency information

Resource footprint

TVs

- **Average price:** from £621 to £760.
- **Product weight:** approximately 5 kg to 14 kg
- **Lifespan:** 9-11 years
- **Typical duration of the warranty:** 1-3 years
- **% currently recycled (where available):** Not available

Electronic Displays

- **Average price:** from £203 to £831.
- **Product weight:** approximately 5 kg to 14 kg
- **Lifespan:** 5-6 years
- **Typical duration of the warranty:** 1-3 years
- **% currently recycled (where available):** Not available

A12.4.1 Composition of typical product

Table A12.2 Composition of typical TV

Main component	Main materials	Weight (g)	% of total product
Body	Steel, cooper	6,931	50.6%

Main component	Main materials	Weight (g)	% of total product
	Cooper	52	0.4%
	EPS	1,550	11.3%
	PMMA	1,013	7.4%
	PET	977	7.1%
	PC	869	6.3%
	PE	91	0.7%
	Other plastics	6	0.0%
	Glass	2,065	15.1%
Electronics	Electronics	145	1.1%
TOTAL		13,699	100%
Packaging	Paper	1,202	8.07

Table A12.3 Composition of typical electronic displays

Main component	Main materials	Weight (g)	% of total product
Body	Steel	4,300	51.8%
	Cooper	30	0.4%
	EPS	561	6.8%
	PMMA	694	8.4%
	PET	673	8.1%
	PC	577	6.9%
	PE	64	0.8%

Main component	Main materials	Weight (g)	% of total product
	Other plastics	4	0.0%
	Glass	1,321	15.9%
Electronics	Electronics	84	1.0%
TOTAL		8,308	100%
Packaging	Paper	791	8.69

Table A12.4 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes
Yttrium, Terbium, Europium, Gadolinium, Lanthanum,	Displays/ Screens (Fluorescent powder)	No substitute available for yttrium. Primary REEs are produced almost exclusively in China and have low price and this price decreased after the peak in 2011[70]. Therefore, there	No

[70] Rare Earth Elements: Overview of Mining, Mineralogy, Uses, Sustainability and Environmental Impact

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Cerium		are not many recycling technologies available. Large amounts of investment are needed for this type of (R&D) and subsequent scaling up and infrastructure, and this process takes many years. Solvay closed its REE separation plant in 2016 and there has not been any other industrial recycling facility in Europe since. REEs powders are being sent to landfill.	
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium, Silicon, Platinum and Rare Earth Elements (REEs)	Display use LEDs Liquid-crystal displays (LCD) Semiconductors	No substitute available for indium, and gallium. No recycling of indium from EoL products. High demand of indium by indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. LCDs have been displaced by LED-backlit LCD displays containing less REEs – market moving to Organic LED TVs (represents approximately 84% of total global indium consumption)	Technically feasible but with recycling rates below 1%. Recycling of REEs have not reached the commercial scale.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		Recyclability of displays is focused on the recycling of metal and glass and not the REEs.	

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Polyvinyl chloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A12.5 Information on select policy levers and horizontal measures

Ecodesign MEPS were recently updated as part of the November Package of Ecodesign regulations[71] . If a new revision is developed, it is assumed 2 years is required to prepare it.

Regarding the horizontal measures, it is assumed that 2 of the 4 measures in the table can be implemented independently of MEPS regulations, whilst the others would be simplest to implement alongside MEPS.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Existing energy related policy levers in UK

- Updated Ecodesign requirements came into force in the EU and Northern Ireland and are due to enter into force in GB later in 2021. Re-scaled Energy Labels have also come into force across the EU and UK.
- Currently, electronic displays are covered by the "**Salix public sector finance - Loan scheme**".
- Previously, before its end the "**CRC Energy Efficiency Obligation Scheme**" also covered to an extent this segment.

Existing circular economy related policy levers

- New Ecodesign requirements are being introduced to encourage greater dismantling, recycling, and recovery. Certain plastic components will be marked. Products will be designed for repair and reuse.

[71] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

Table A12.5 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[72]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Recently updated (2)	Remove poor efficiency products / Energy savings	Depends on new MEPS levels	Recently updated in November package[73] .
Mandatory label (includes enforcement)	Recently updated (2)	Information provision / Energy savings	None found	Recently updated in November package[74] .
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards.
Obligation scheme	N/A	Not suitable as this is a mature product group.	N/A	Not suitable option for energy supplier to provide to residential customer.
Public procurement	Already included (0.5)	Prohibit poor efficiency products / Energy savings	None found	Good candidate for updating. Need to understand effectiveness of this measure.
Communications campaign	0.5	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate, low cost/effort to include in existing/new campaigns.
Advice/aid in implementation	0.5	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate, low cost/effort to include in existing/new policy lever.

[72] Further detail on assumptions contained in Section 3.4.4
[73] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.
[74] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

Policy lever	Indicative time needed to implement (years)[72]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	N/A	Not suitable policy lever as product is non-essential.
Taxes on poor performing products	1	Reduce purchases of low efficiency products / Energy savings	None found	Good candidate due to existence of labelling to identify poor performers.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[75]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[75] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A12.6 Summary of stakeholder feedback

A trade association objected to Displays being included within the Task 3 shortlist. They were surprised that products so recently regulated by the EU, and negotiated by the UK, were still shortlisted. They argued such products should have less weighting compared with those that have not been subject to recent regulation.

A trade association recommended the following policy measures for displays - Ecodesign and Energy Labelling requirements (aligned to those forthcoming in the EU), tailored online information and improved market surveillance.

A trade association indicated that for any material efficiency or performance requirements, a product-specific approach should always prevail, as it is the most effective and robust approach, and to avoid the pitfalls of a one-size-fits-all approach to product policy. They urge that dedicated studies should consider the specific opportunities to each product group, and in respect to B2B and B2C products. Specifically, for electronic display and televisions: Ecodesign and labelling requirements should be implemented in alignment with those forthcoming in the EU as well as a tailored online information system. Also, improved market surveillance mechanisms should be implemented.

There was no reference to this product group within the summary of responses to the ErP Call for Evidence.

A12.7 Discussion & next steps

Electronic displays, including televisions, are subject to new Ecodesign and Energy Labelling requirements being rolled out across the EU and the UK during 2021.

The product group could potentially be a candidate for further circular economy and resource efficiency measures. Existing communication campaigns and aid/advice policy levers could be widened to promote uptake of more efficient electrical consumer products, including televisions and displays.

A12.8 Evidence sources

Title	Author	Date Published or date accessed
TVs | Televisions | Argos	Argos	18/03/2021
EUPP Post RC_displays_corrected_stck model	ICF modelling	Unpublished

Title	Author	Date Published or date accessed
PostRC_Displays_SUM DomDisplaysMonitorv1.6postRC, DomDisplaysSecondTVsv1.3postRC, DomDisplaysTVsv1.3postRC, ComDisplaysMonitorsv1.6postRC	ICF modelling	unpublished
Preparatory Studies for Ecodesign Requirements of EuPs Televisions	Fraunhofer IZM	02/08/2007
2014-11-eu-electronic-displays-paper.pdf (unepdtu.org)	CLASP European Programme	18/03/2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020
Production technologies of CRM from secondary resources – D4.2	Solutions for Critical Raw materials - a European Expert Network SCRREEN project	31 January 2018

Annex 13 Cooking: Non-domestic Electric and Gas Hobs

A13.1 Introduction

Cooking products prepare food in various ways (usually via heat) in either a residential or commercial environment. Related equipment such as extract hoods are included here.

Hobs are part of the cooking and warming product group and are one of the main appliances used in professional food service outlets for the preparation and provision of food. Hobs are products which have heat generation mechanisms in their internal structure which generate and transfer heat towards their top surface. Their top surface is used as a base for pans and other food holding items to be placed. Food is cooked or warmed up through the heat transferred to those.

Different hob types exist which use different heat generating processes and as a result the internal structure and the top surface of hobs differs in terms of materials used and the heat transfer mechanisms that they operate with. There exist electric and gas hobs with the electric hobs being split into two different types for the professional foodservice industry. These are induction and the solid plate or cast-iron hobs. Heat generation and transfer in hobs takes place using electromagnetic fields, conduction, and for gas hobs combustion which translates into convection.

A13.2 Market information

The total annual sales in the UK market for professional hobs is around 30,000 units. The sales are split among the different product types. Induction hobs have annual sales of 6,700 units (~20%) and solid plate or cast-iron hobs 9,500 units (~30%). Gas hobs have the highest annual sales being about 17,500 units (~50%).

The market growth has been static for professional hobs, with a small negative growth (e.g., shrinkage) rate of -0.9% over the last 5 years. The forecast projections for the different types of hobs between 2020-2025 and 2025-2030 have been estimated and are the following. The growth in sales for induction hobs for 2020-2025 and 2025-2030 is estimated to be 3.2% and 9.3% respectively. For solid plate hobs, sales are estimated to grow by 4.5% and 7.2%. For gas hobs sales growth is expected to be 3.8% and 8.3%. The above forecast estimates that the growth within the next 5 years will be lower than the second half of this decade with an increase after 2025.

No trade information was found on the imports, exports, and production of professional hobs in the UK market.

The professional hobs that end up in the UK market are mainly manufactured in the USA, in European countries and in China, where, depending on the manufacturer, different qualities of product exist. One of the UK manufacturers of induction, solid plate and gas hobs was stated to have a good market share for all three hob types in the UK market. Feedback received via a trade association suggested UK equipment manufacturers are well placed to meet specific sector requirements in the transition to Net Zero.

A13.3 Energy performance information

The typical energy consumption of an induction hob ranges between 14 and 20 MWh per year. The typical energy consumption of cast iron/hot plate hob ranges between 27 and 42 MWh per year. The typical energy consumption of a gas hob ranges between 48 and 106 MWh per year. These figures have been computed considering 4 ring hobs and a total of 330 operational days for all cases. The daily operational hours per hob type was varied to match the actual operational hours per day for each type as estimated from the industry.

Induction technology cooks food using an electromagnetic field. For the electromagnetic field to be generated a pan with a magnetised base has to be used where the magnetic field causes it to be heated directly. Upon the removal of the pan from the hob, the electromagnetic field automatically stops being generated and the hob is turned off.

Solid plate or cast-iron hobs have metallic plates on the top surface of the hob, where heating elements exist underneath it. Current is used to heat the elements and the heat generated is transmitted to the solid plate. One manufacturer stakeholder was able to provide estimations on the efficiency ratings of the three hob types, stating that this hob type is about 80% efficient but since no test standards and associated data have been identified, this should be considered an estimate. Solid plate hobs have the longest pre-heat times of all types of hobs.

For gas, small nozzles in the top surface of the hob release the gas. Using a spark, fire is ignited, and the heat generated is transferred to the pan’s surface. The pre-heat time for gas hobs is not considered, as heat is generated from the moment the source is lit. The stakeholder estimated that gas hobs are 50% efficient, again, this should be considered an estimate.

There is potential to improve product efficiency and achieve up to 81% savings in annual energy consumption for the case of gas hobs. In this case both the fuel switch and the higher energy efficiency lead to less energy consumption and a reduction of the carbon footprint of hob cooking activities. The potential energy saving to be achieved is dependent on the type of product being replaced by induction hobs, the Best Available Technology.

The Best Available Technology for this product group is considered to be induction hobs for a number of reasons. The product efficiency as stated from one manufacturer stakeholder is about 90-95%, almost negligible pre-heat times and the ability to be turned off automatically when the top surface is clear of metallic pans. To achieve BAT performance, the replacement of any other type of hob with induction technology has to take place which comes along with increased purchase costs depending on what it is replacing. The following table presents the annual energy consumption of different hob types and the estimated price increase to achieve BAT performance.

Table A13.1 Energy performance information

	Induction	Solid Plate / Cast Iron	Gas
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.64 - 1.8	1.84 - 5.28	4.41 - 15.86
Maximum technical potential energy savings that can be achieved with BAT (TWh)	n.a.	0.92 - 2.8	2.34 - 11.1
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	n.a.	0.26 - 0.81	0.67 - 3.2
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.16 - 0.36	0.4 - 1.08	0.81 - 2.86
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	n.a.	0.2 - 0.57	0.43 - 2
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	n.a.	0.06 - 0.16	0.12 - 0.58
Benefit Cost Ratio of BAT Savings	n.a.	8.4	3.7

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

Induction hobs are assumed to have a very high efficiency (90-95%), so no energy savings are attributed to this specific product. For gas hobs and cast iron/hot plate hobs, the energy and carbon savings are estimated based on two factors. Firstly, a technology switch to induction hobs. Secondly, a change in user practice, allowing products to switch off when not in use. The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The carbon savings for hobs are estimated based on the lower energy consumption of induction hobs when compared to gas or cast iron/hot plate hobs. As these are high-level estimates and not timebound, the effect of the difference between the natural gas and electricity emission factors has not been taken into account into these estimates as the electricity emission factor for the grid in the UK is expected to fall down below the emission factor for natural gas only in 2028, which means that in the short-term a switch from gas to electricity would not increase carbon savings. However, any realistic timescale for implementing future policy for cooking appliances would quickly pass this transition point after which point carbon savings from using electric induction hobs instead of gas hobs would rapidly increase. A timebound assessment of impacts of switching from gas appliances to low carbon alternatives should take this into consideration.

The Saving Energy Through Better Products and Appliances report, published in 2009 by Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a gas hob is 11 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 2.65 - 8.54 TWh of energy could be saved as well as 0.48 - 1.54 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.76 - 2.46 TWh of energy and 0.14 - 0.44 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a cast iron/hot plate hob is 10 years. If all units sold annually in the UK in a given year were BAT technologies, 1 - 2.33 TWh of energy could be saved as well as 0.25 - 0.48 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.29 - 0.67 TWh of energy and 0.07 - 0.14 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A13.4 Baseline resource efficiency information

Resource footprint

Induction Hobs

- **Average price:** from £3,000 to £6,000. Most Induction hobs are priced at approximately £4,500.
- **Product weight:** approximately 40 kg to 140 kg (depending if the product is countertop or freestanding)
- **Lifespan:** 7 - 10 years
- **Typical duration of the warranty:** 1 - 2 years
- **% currently recycled (where available):** Not available

Solid Plate / Cast Iron Hobs

- **Average price:** from £1,000 to £3,600. Most Solid Plate hobs are priced at approximately £2,300.
- **Product weight:** approximately 30 kg to 90 kg (depending if the product is countertop or freestanding)
- **Lifespan:** 8 - 12 years
- **Typical duration of the warranty:** 1 - 2 years
- **% currently recycled (where available):** >90% recycled for metallic parts (steel, copper, aluminium) which compose ~92% of the product. Percentage of recycled non-metallic parts not available.

Gas Hobs

- **Average price:** from £761 to £1800. Most Gas hobs are priced at approximately £2,560.
- **Product weight:** approximately 20 kg to 70 kg (depending if product is countertop or freestanding)
- **Lifespan:** 9 - 13 years
- **Typical duration of the warranty**: 1 - 2 years
- **% currently recycled (where available):** >90% recycled for metallic parts (steel, copper, aluminium) which compose ~90% of the product. Percentage of recycled non-metallic parts not available.

A13.4.1 Composition of typical product

Table A13.2 Composition of typical induction hobs

Main component	Main materials	Weight (g)	% of total product
Entire Induction Hob	Bulk Plastics	5,400	7%
	Technical Plastics, other	1,160	1%
	Ferrous metals (Stainless steel)	64,300	78%
	Non-ferrous metals	5,100	6%
	Electronics	500	1%
	Miscellaneous. (mineral fibre, insulation)	6,120	7%
TOTAL		82,580	100%

Table A13.3 Composition of typical solid plate / cast iron hobs

Main component	Main materials	Weight (g)	% of total product
CASING Including			
Top shelf	Ferrous metals (Stainless steel)	7,100	8.9%
Frame rear sheet	Ferrous metals (Stainless steel)	1,800	2.2%
Frame side sheets	Ferrous metals (Stainless steel)	8,400	10.5%
Control panel	Ferrous metals (Stainless steel)	800	1%
Feet casing holders	Ferrous metals (Stainless steel)	1,400	1.7%
Door	Ferrous metals (Stainless steel)	3,400	4.2%
Other elements	Ferrous metals (Stainless steel)	14,400	17.9%
HEATING ELEMENTS Including			

Main component	Main materials	Weight (g)	% of total product
Electric resistance	Ferrous metals (Stainless steel)	2,200	2.7%
Resistance support	Ferrous metals (Stainless steel)	12,000	15%
Heated plate	Ferrous metals (Stainless steel)	16,400	20.5%
CONTROL TECHNOLOGY Including			
Thermal sensor	Miscellaneous	120	0.15%
MISCELLANEOUS Including			
Knobs	Technical Plastics (Polyamide 6)	40	0.05%
Handle	Technical Plastics (Polyamide 6)	120	0.15%
Thermoplastic polymers	Bulk Plastics	5,400	6.7%
Elastomers	Technical Plastics (Rigid Polyurethane)	1,000	1.2%
Aluminium	Non-ferrous metals (Aluminium sheet/extrusion)	1,200	1.5%
Stainless steel	Ferrous metals (Stainless steel)	4,300	5.4%
TOTAL		80,080	100%

Table A13.4 Composition of typical gas hobs

Main component	Main materials	Weight (g)	% of total product
CASING Including			
Top shelf	Ferrous metals (Stainless steel)	6,600	11.3%
Frame rear sheet	Ferrous metals (Stainless steel)	1,100	1.9%
Frame side sheets	Ferrous metals (Stainless steel)	4,500	7.7%

Main component	Main materials	Weight (g)	% of total product
Control panel	Ferrous metals (Stainless steel)	1,700	2.9%
Pan holders	Ferrous metals (Cast iron)	24,000	41.2%
Other elements	Ferrous metals (Stainless steel)	2,700	4.6%
HEATING ELEMENTS Including			
Burners	Ferrous metals (Cast iron)	6,400	11%
Other elements	Non-ferrous metals (Aluminium sheet/extrusion)	2,000	3.4%
MISCELLANEOUS Including			
Knobs	Technical Plastics (Polyamide 6)	40	0.07%
Handle	Technical Plastics (Polyamide 6)	120	0.2%
Thermoplastic polymers	Bulk Plastics (Polypropylene)	5,100	8.8%
Elastomers	Technical Plastics (Rigid Polyurethane)	500	0.86%
Iron	Ferrous metals (Steel tube/profile)	3,500	6%
TOTAL		58,260	100%

Table A13.5 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium, Silicon, Platinum and Rare Earth Elements (REEs)	Display use LEDs Liquid-crystal displays (LCD) Semiconductors	No substitute available for indium, and gallium. No recycling of indium from EoL products. High demand of indium by indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. LCDs have been displaced by LED-backlit LCD displays containing less REEs – market moving to Organic LED TVs (represents approximately 84%	Technically feasible but with recycling rates below 1%. Recycling of REEs have not reached the commercial scale.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		of total global indium consumption) Recyclability of displays is focused on the recycling of metal and glass and not the REEs.	

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Polyvinyl chloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A13.5 Information on select policy levers and horizontal measures

Ecodesign MEPS do not exist for this product group.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group. Any measure which encourages the transition from gas to electric and/or hydrogen would need to consider the current use of gas in speciality cooking (e.g., chargrilling and wok cooking) and address the resulting industry concerns about the impact the transition would have on the taste/production of these foods. In addition to the above, it has been reported from stakeholders that the electricity capacity on-site can be limited in some circumstances, making the foodservice outlets with this limitation not able to transition completely to electricity without the need to upgrade their sites. This would increase the costs of such a transition. For some building types, such as pre-existing and/or older buildings, these supply upgrades are likely to be harder to achieve.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Existing energy related policy levers in UK

- No regulations related to MEPS and labelling.
- No identified additional UK policies that focus specifically on this segment.
- MEPS exist for domestic hobs.
- Existing circular economy related policy levers
- None identified.

Table A13.6 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[76]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	EC Consultants recommend an EC Preparatory study 2-4	Remove poor efficiency products / generate energy savings	Depends on MEPS levels	Good candidate. Keep track of progress in EU.
Mandatory label (includes enforcement)	EC Consultants recommend an EC Preparatory study 2-4	Information provision / Energy savings	None found	Good candidate. Keep track of progress in EU.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to an industry standard for open flamed burners.
Obligation scheme	1	Provision of energy saving technologies / Energy savings	None found	Not suitable option for energy supplier to provide to residential customer.
Public procurement	1.5	Prohibit poor efficiency products / generate energy savings	None found	Good candidate after label developed. Need to understand effectiveness of this measure.
Communications campaign	N/A	Not suitable as this is a mature product group.	N/A	Not suitable as product not sold to domestic sector.
Advice/aid in implementation	1.5	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate for targeted advice based on technology switching to induction hobs.

[76] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[76]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	1.5	Increase accessibility of high efficiency products / Energy savings	None found	Good candidate based on endorsement label.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	None found	Potential candidate if made technology specific (instead of label class). Could be used to target removal of solid plate / cast iron hobs, to promote induction technology.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Good candidate. The product group is mature, but induction technology currently only occupies 20% of sales in the non-residential market. Transition to induction is considered BAT.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[77]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material	None found	Good candidate. Need to understand costs.

[77] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

Policy lever	Indicative time needed to implement (years)[76]	Policy objective/ impact	Scale of impact	Suitability comments
		and resource consumption		

A13.6 Summary of stakeholder feedback

There was no feedback or participation relating to this product group resulting from the Task 2 or Task 3 stakeholder consultation and the policy study's first stakeholder consultation meeting. However, feedback was received on behalf of manufacturers via a trade association, in response to the draft final report.

Manufacturer feedback considered an alternative approach to establishing Best Availability Technology for hobs than presented above in section A.13.3. They favoured a technology agnostic approach, allowing end-users to make informed choices on solutions that suit their needs. This would permit continued use of gas, recognising electricity supply issues already raised in the discussion section below.

There was one question in the ErP Call for Evidence which asked if better MEPS, than those which currently apply, could be set for cooking appliances. Some responses felt that the scope of current Ecodesign and Energy Labelling regulations could be broadened beyond domestic ovens and hobs to include professional cooking appliances.

In a separate BEIS study on the Professional Foodservice Equipment sector in 2020, the industry provided their individual views on a future transition to hydrogen in cooking processes. They stated that such a transition should happen at a slow pace to allow manufacturing operations to adapt to the change and the development of new designs for products where needed. Also, manufacturers requested that the introduction of hydrogen is aligned with the EU to avoid the need for producing different products solely for the UK market. There were also safety concerns expressed due to the high flammability of hydrogen gas. Concerns were also expressed about any possible impact from the use of hydrogen gas on the taste of food. However, the trade association stated they have member manufacturers designing and producing hydrogen cooking appliances. Furthermore, they stated there are no safety issues in the use of low-pressure hydrogen as a replacement for natural gas and dismissed concerns about the use of hydrogen impacting on food taste.

As stated from the industry, at the moment, limited energy efficiency training is provided for kitchen operators. There is room for improvement by introducing energy efficiency behaviour change programmes in the industry which could have a large potential in optimising energy usage and the efficient use of cooking equipment. The expenses and the high turnover of staff in the hospitality industry though act as barriers to the introduction of such programmes.

Financial incentives to support both the transition to BAT and from gas to electricity cooking processes were stated as being key, given anticipated costs by industry for the transition.

A13.7 Discussion & next steps

Fuel switching and technology transition is a key theme for the future of the hobs product category. The phase out of older forms of electric hob cooking (e.g., solid plate or cast-iron hobs) and the transition from gas to electricity, all point to the adoption of induction cooking (Best Available Technology).

A separate BEIS study on the Professional Foodservice Equipment sector in 2020 concluded that uptake of induction hobs is held back in sites which have limited electricity capacity and the preference of gas use to cook certain styles of food (e.g., chargrilling or wok cooking). Additionally, the purchase costs of induction hobs are higher compared to other hob types and this is another factor which contributes to their limited uptake. The trade association added that many commercial catering businesses operate within rented premises, where landlords may be reluctant to invest in upgrading from gas to electricity. The trade association reported that 20% of UK gas demand is likely to remain to support end use applications which are hard to electrify.

With the high cost of gas ventilation systems and strict regulations surrounding gas safety, the view that electric products are cleaner, as well as the cheaper overall running and maintenance cost of electricity, are all drivers of a trend towards electric cooking. The latter though, along with energy efficient practices, is something that needs to be communicated to operators and end users further, as it is something many of them lack awareness of.

The UK has a very engaged group of stakeholders covering the full supply chain, including manufacturers, suppliers, distributors, designers, and operators and end-users. The associations that represent these stakeholders would be willing to engage on discussion of future measures. Feedback from the trade association pointed to a well-established second-hand market in the UK, with dealers reconditioning equipment for re-sale.

A13.8 Evidence sources

Title	Author	Date Published or date accessed
EELWP Task3 Professional cooking appliances draft.pdf	Viegand Maagøe A/S Oeko-Institut e.V. et al.	5 March, 2021
ETL Annual Submission 2020	ICF	unpublished

Title	Author	Date Published or date accessed
BEIS Study on PFSE Sector	ICF	unpublished
Lot_23_Task_4_Final.pdf	VIO Intelligence Service	5 March, 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 14 Generation, Conversion, Supply, Cooling: Rechargeable Batteries

A14.1 Introduction

Generation, conversion, supply, storage product groups all relate to products that handle electricity and enable it’s use with other products.

A battery is an electrochemical system that can convert chemical energy into electrical energy to power and/or conserve energy for different electrical applications. Rechargeable batteries are also called secondary batteries and can be recharged for multiple uses providing electrical energy over a longer lifetime. This study focuses on portable rechargeable batteries, notably on the chemistries of Nickel–metal hydride (NiMH) and Lithium ion (Li-ion).

A Nickel–metal hydride (NiMH) cell has a voltage like that of single use AA/AAA batteries, and hence is the chemistry used for rechargeable AA/AAA batteries. As the name describes, the main material components of these batteries are Nickel (usually in the form of Nickel Oxide Hydroxide), and a Hydrogen-absorbing alloy. This alloy is an intermetallic compound, which could be a combination of a rare-earth metals with Nickel, Cobalt, Manganese or Aluminium. Some higher capacity batteries may use Titanium, Vanadium or Zirconium. These intermetallic compounds are used as a replacement to Cadmium which was removed due to health concerns. The metal electrodes are in an alkaline electrolyte, usually a solution of Potassium hydroxide. These batteries require an external charger to be recharged.

Lithium-ion battery technology provides the higher energy and power densities in terms of weight and volume. They have a higher cell voltage and a lower self-discharge rate making them a perfect match for e-mobility (high power, high energy), ICT (high volumetric energy density) and stationary (long lifetime and low self-discharge) applications. As the name suggests, these batteries contain Lithium, however it should be noted that this is not in metallic Lithium form. The positive side of the battery is typically a metal oxide of Lithium, Cobalt, Manganese, which may also be complimented with Nickel, Aluminium or Iron. The negative side of the battery is a substrate material with Lithium intercalated. The substrate is typically Graphite, but Silicon and Lithium Titanate can also be used.

A14.2 Market information

The estimated annual sales in the UK market for Li-ion batteries is 61,840,000 (often within electronics devices) and for NiMH is 1,350,000. The forecast for the battery market growth potential in sales is estimated to be 5-10% between 2020 and 2025. However, it is estimated to decrease for NiMH batteries by 3% per Annum.

The overall market for batteries in the UK is estimated to grow, as Li-ion batteries are tied to consumer electronic sales. However, for rechargeable NiMH AA/AAA batteries, the market is diminishing as the Li-ion technology replaces NiMH.

The UK has little to no manufacturing of batteries, though there are some activities around the assembly of batteries, these do not include the chemical cell manufacture. There has been some recent investment in the UK to potentially manufacture EV batteries in the UK in the future.

Countries who were identified to manufacture significant quantities of rechargeable batteries are European countries being Germany, and Sweden, as well as the U.S., Japan, and China.

Trade information was found under the HS code 27.20.23.00 for “Nickel-cadmium, nickel metal hydride, lithium-ion, lithium polymer, nickel-iron and other electric accumulators” in the UK market are the following:

Imported units: not available

Exported units: not available

Produced units (from 2018): 1,848,777

A14.3 Energy performance information

The energy efficiency of a battery is the difference in energy required to charge the battery and the energy recovered during discharge. Due to the energetic electric losses during charging, discharging and storage and since the discharge voltage is lower than the charge voltage, the battery cell efficiency is not 100%. It is also possible that more current is needed to charge a cell than can be discharged.

No energy performance information has been estimated for rechargeable batteries. This product group has been included in the shortlist due to the materials and circular economy criteria.

A14.4 Baseline resource efficiency information

Resource footprint

NiMH

- **Average price:** from £1.73 to £2.11.
- **Product weight:** Smaller than 0.3 kg
- **Lifespan:** 3-5 years
- **Typical duration of the warranty:** Not applicable
- **% currently recycled (where available):** 30%

Li-ion (laptops)

- **Average price:** from £20.02 to £136.50.
- **Product weight:** approximately 0.5 kg to 2 kg
- **Lifespan:** 4.5-5.5 years
- **Typical duration of the warranty:** Not applicable
- **% currently recycled (where available):** 30%

Li-ion (portable audio, DECT and mobile phones, tablets, power tools, electric toothbrushes)

- **Average price:** from £4.10 to £23.67
- **Product weight:** under 0.2 kg
- **Lifespan:** 1.4-5.5 years
- **Typical duration of the warranty:** 6 months
- **% currently recycled (where available):** 30%

A14.4.1 Composition of typical product

Table A14.1 Composition of typical NiMH battery

Main component	Main materials	Weight (g)	% of total product
Nickel	as nickel hydroxide nickel oxide nickel powder	8.1-13.5	30-50
Potassium Hydroxide		<1.35	<5
Cobalt	as cobalt metal cobalt oxide cobalt hydroxide	0.68-1.62	2.5-6
Sodium Hydroxide		<0.81	<3
Zinc	as zinc metal zinc oxide zinc hydroxide	<0.81	<3
Mercury		0-0.00014	0-0.0005
Lead	as lead metal lead oxide	0-0.00108	0-0.004
Cadmium	as cadmium metal cadmium oxide cadmium hydroxide	0-0.00054	<0.002
Hexavalent Chromium		0-0.00135	0-0.005
TOTAL		11-18	100%

Table A14.2 Composition of typical Li-ion battery (40g smartphone)

Main component	Main materials	Weight (g)	% of total product
Cathode	Active material- Co, Ni, Mn, Al, Li, O	11.6	31.0%
	Conductor- Carbon	0.6	1.6%

Main component	Main materials	Weight (g)	% of total product
	Binder- PVDF	1.9	5.1%
	Collector- Al foil	1.7	4.5%
Anode	Active material-Graphite	6.5	17.4%
	Binder 1- SBR	0.6	1.6%
	Binder 2- CMC	0.5	1.3%
	Collector- Cu foil	3.6	9.6%
	Heat resistant layer- Al	0.3	0.8%
Electrolyte	Formulated electrolyte	4.1	11.0%
	Fluid- LiPG6	0.7	1.9%
	Solvent 1- EC	1.7	4.5%
	Solvent 2- DMC	1.7	4.5%
	Solvent 3- EMC	0.9	2.4%
Separator	PE/PP/PP	1.0	2.7%
TOTAL		37.4	100%
Packaging	Tab with film- Al film	0.3	1%
	Exterior covering- PET/Ny/Al/PP	0.3	1%
	Collector- Al/Cu/Plastic fasteners	0.2	0%
	Cover- Valve, rivet term	1.0	3%
	Case- Ni planting Iron	0.8	2%

Table A14.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Antimony, Cadmium, Cobalt, Lead, REEs, Lithium, Graphite, Phosphorus and Nickel[78]	Anode Cathode	The EU produces only 1% of all battery raw materials overall. For lithium-ion batteries (Li-ion) batteries, used in smart phones, Cobalt in the cathode can be collected and reused/recycled. In batteries, the recovery procedure is efficient and these secondary sources of cobalt cost less than raw cobalt extraction. For the Li-ion batteries, there are environmental, political and social impacts of mining activities where most of the world's cobalt is sourced from. Recycling rate for lithium is less than 1%. The REEs from NiMH batteries can be concentrated in a residue after smelting (Umicore[79]) Battery Directive 2006/66/EC includes target for member states for minimum collection rates of 45% by 26 September 2016. The EU collection	Yes, for NiMH batteries and most of Li-ion batteries used in electronics, that are easy to separate manually. For some products not feasible for consumers to separate batteries because they are built in.

[78] Annex VII of the WEEE Directive requires the removal of batteries because they are considered hazardous waste.

[79] Battery recycling Umicore

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		rate was 43.6% with the UK achieving 44%[80] Additional information for batteries not in our scope: For lead acid batteries (for cars, not reviewed in this study)– relatively cheap and increasingly well-established methods for recycling lead-alloys. For lead acid, or non-rechargeable batteries shall be broken mechanically and drained to collect acid/alkaline to avoid environmental damages.	

Hazardous substances content

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

Potential presence of hazardous in the batteries (nickel, cadmium, cobalt, lithium, mercury, and graphite).

Li-ion batteries can cause significant waste fires if they are punctured or damaged during transit (during end-of-life processes).

Lead acid and non-rechargeable batteries contain acidic or alkaline liquids which can be harmful if not treated appropriately.

[80] Evaluation report of the Batteries Directive, April 2019.

The EU batteries Directive 2006/66/EC has placed limitations on the content of mercury (no more than 0.0005% by weight) and cadmium (no more than 0.0002% by weight).

Batteries, accumulators, and button cells containing more than 0,0005 % mercury, more than 0,002 % cadmium or more than 0,004 % lead, shall be marked with the chemical symbol for the metal concerned: Hg, Cd or Pb.

A14.5 Information on select policy levers and horizontal measures

Existing energy related policy levers in UK

- No identified UK policies focused on rechargeable batteries.

Existing circular economy related policy levers

- Sustainable Batteries are under consideration in the new proposed regulation "Modernising the EU's batteries legislation".

Energy related policy levers have been excluded from this analysis as this product group is more suitable for circular economy related horizontal measures.

Regarding the horizontal measures, 2 of the 4 measures are not suitable since small batteries are single celled and cannot be repaired.

A few of the energy related policy levers assessed in other product groups could be suitable here. For example, public procurement schemes could ban single use batteries from use in the public sector. Also, a communications campaign can promote the use of rechargeable batteries and can inform consumers of the cost savings associated with rechargeable batteries. Similarly grants or subsidies on rechargeable batteries could work well to improve their uptake, and an additional tax on single use batteries could deter purchases of these products.

The new EU initiative, Modernising the EU's batteries legislation[81] aims to address social, environmental and health impacts generated by the increased demand and use of batteries in several products:

Become more sustainable, high-performing and safe along their entire life cycle (e.g., lowest environmental impact, using materials from responsible sources, extend lifespan, and suitable for repurposed, remanufactured or recycled at EoL).

Set up requirements for all batteries (responsibly sourced materials, restrict use of hazardous substances, minimum content of recycled materials, carbon footprint, performance and durability and labelling, as well as meeting collection and recycling targets.

[81] Modernising the EU's batteries legislation

Minimising environmental impacts: only rechargeable industrial and electric vehicles batteries placed on the market from 1 July 2024; new requirements and targets on the content of recycled materials and collection, treatment, and recycling; and the use of new IT technologies to increase traceability throughout their life cycle.

Table A14.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[82]	Policy objective/ impact	Scale of impact	Suitability comments
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	N/A	Extend lifetime / reduction in material and resource consumption	None found	Small batteries use a single cell and cannot be repaired. Measures requiring replacement of batteries would be required in the products they are used in. Hence modular design may not be suitable for this product group.
Product support & extension of Ecodesign November package measures[83]	N/A	Extend lifetime / reduction in material and resource consumption	None found	See above comment. Small batteries use a single cell and cannot be repaired.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A14.6 Summary of stakeholder feedback

During Task 2, 2 stakeholders raised concerns with regards to the battery review. The first was that portable battery packs (also known as power banks) which provide charge “on-the-go” to

[82] Further detail on assumptions contained in Section 3.4.4

[83] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

electronics have little to no standards or regulation monitoring them. The second point was for batteries and charger performance to be considered for both the charge and discharge efficiencies, considering the entire usage cycle of the device. Efficiency analysis is often prescribed solely on the discharge process of the battery. This focus on the discharge process detracts attention to the optimisation of the charging process.

A trade association has been actively engaged and have provided feedback. Their feedback has been mainly oriented towards the horizontal measure of universal batteries. They pointed out that interoperable batteries are already a market reality for relevant applications (e.g., power tools, gardening equipment). The interoperability ensures the functionality of the equipment over the expected use time until the next charging cycle (where a device may need to be used all day, hence having a spare battery is necessary to continue using the device throughout the day). The stakeholder objected to the measure being imposed on ICT equipment, where the charge capacities of batteries are designed to outlast the expected demand for operation until the next charging cycle.

Regarding the use of rechargeable batteries instead of single use batteries, industry stakeholders noted the joint industry statement presented to the EU when considering the restricting of primary batteries in Europe in September 2020. The statement presents evidence of how a ban of primary batteries would have a negative impact on the environment. It states that primary batteries are more efficient for usage in low-drain application (such as sensors, meters, smoke alarms, and hearing aid button batteries) due to their low self-discharge rate and durability.

A14.7 Discussion & next steps

This study did not consider lead-acid car batteries, UPS or large batteries such as Li-ion batteries for Electric Vehicles, or for energy storage systems. Non-rechargeable batteries (also known as “primary batteries”) were not included in this analysis.

Comparing NiMH rechargeable to non-rechargeable batteries, it should be noted that due to their reusable nature, NiMH are more sustainable than their non-rechargeable equivalents. This is notably the case for high discharge products (e.g., digital cameras, uninterruptible power supplies, power tools, patient monitor). However, evidence provided by stakeholders indicates that this sustainability advantage does not apply for low drain product applications.

Therefore, policy levers could be aimed to encourage the use of rechargeable batteries instead of non-rechargeable ones in suitable products. Potential policy levers could be for public procurement to mandate rechargeability of batteries in high power equipment, or for a communications campaign to encourage the public to purchase rechargeable batteries in relevant products (which also have a net benefit to the consumer due to cost savings). One could also mandate high power devices to be provided with rechargeable batteries.

With regards to circular economy considerations, a policy on material content and declarations would be well suited for rechargeable batteries. Li-ion batteries are rarely recycled in their entirety and focus on Cobalt recovery. There are many different chemistries of Li-ion batteries which don’t allow for adequate recovery processes.

Policy levers on modular designs and product support are not suitable for portable batteries, as these are often single cell products which cannot be repaired. There is potential for these policy levers to be effective on large batteries with many cell packs such as the kind for EVs and energy storage systems. However, due to their sizes, chemistries and markets, it is important to distinguish portable batteries, EV batteries and energy storage systems as separate technologies requiring separate policies.

A driver for a universal battery horizontal measure would be the improved recyclability of li-ion batteries. Their collection and recycle levels are currently very low as the material recuperation technique is quite difficult and the chemistries of Li-ion batteries vary greatly. However, mandating a particular Li-ion chemistry could damage innovation, as the industry is continuously researching and changing the battery chemistry makeup to improve performance parameters.

A14.8 Evidence sources

Title	Author	Date Published or date accessed
nickelmetalhydride_appman.pdf (energizer.com)	Energizer	2018
Ecodesign preparatory Study for Batteries	VITO, Fraunhofer, Viegand Maagøe	08/2019
NiMH Nickel Metal Hydride Battery Material Safety Data Sheet	ESP Special Batteries Ltd	01/2017
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Title	Author	Date Published or date accessed
Batteries - modernising EU rules	European Commission	Accessed 30 March 2021
Nickel Metal Hydride Batteries Market Report 2020	Research and markets report	Accessed 08 April 2021
Joint industry statement on the impact of restricting primary batteries in Europe	Digital Europe	Accessed 30 June 2021; Published 15 September 2020

Annex 15 Generation, Conversion, Supply, Storage: External Power Supplies

A15.1 Introduction

Generation, conversion, supply, storage product groups all relate to products that handle electricity and enable it's use with other products.

An external power supply is defined in the Preparatory Studies for Ecodesign Requirements of EuPs, as a single voltage external ac-dc / ac-ac power supply with the following characteristics:

- It is designed to convert line voltage ac input into lower voltage dc output / into lower voltage ac output;
- is able to convert to only one dc / ac output voltage at a time;
- It is sold with, or intended to be used with, a separate end-use product that constitutes the primary load;
- It is contained in a separate physical enclosure from the end-use product;
- It is connected to the end-use product via a removable or hard-wired male/female electrical connection, cable, cord, or other wiring;
- Does not have batteries or battery packs that physically attach directly (including those that are removable) to the power supply unit;
- Does not have a battery chemistry or type selector switch and an indicator light or state of charge meter (e.g., a product with a type selector switch and a state of charge meter is excluded from this specification; a product with only an indicator light is still covered by this specification); and
- Has nameplate output power less than or equal to 250 watts.
- Market information

The estimated annual sales in the UK market for the EPS >50W (laptops, scanners, power tools) is around 16,128,000 - 22,272,000 units and for the EPS < 50W for other smaller electronics is 60,060,000 – 71,940,000 units.

The forecast for the market growth potential in sales is estimated to be <10% per year as they are proportional to the different electronics (laptops, portable audio, DECT and mobile phones, tablets, power tools, electric toothbrushes).

The UK market for external power supplies is tied to consumer electronics (often sold as package to end user) and is expected to continue growing along with population and GDP. The UK market is not expected to be different from other developed nations.

The UK has no significant external power supply manufacturers.

Following the HS6 code, 27.11.50.40, trade information was found for 2015 on the imports, exports and production of external power supplies in the UK market are the following:

- Imported units: 27,701,656
- Exported units: 5,544,328
- Produced units: 397,653
- These values may not track with the estimated sales values as trade codes may not account for the external power supplies packaged with other goods.

A15.2 Energy performance information

The typical energy consumption of a unit is between 0.01 and 0.02 MWh per year.

External power supplies are connected to the end-use product via wiring and are without batteries. They convert high incoming voltage alternating current (AC) to low voltage direct current (DC) or low voltage AC. The end-use product is an important aspect as it dictates the technical specifications of an EPS. These devices are usually left connected at all times, even when not being used to power another device. This will result in a small "no-load" consumption.

There is potential to improve product efficiency and achieve up to 47% savings. External power supplies can have an increased efficiency for their conversion process whilst running and the "no-load" power consumption.

Improvements are made through better engineering design for improved energy conversion, or through the use of improved materials with greater electrical or magnetic conductance properties. For higher wattage power supplies (>50W for laptops), these improvements can lead to a 38-47% decrease in the annual consumption of the device. For smaller power supplies (<50W), BAT could lead to a 7-47% improvement in annual consumption.[84]

With regards to materials, Best Available Technology can lead to a reduction in the Bill of Materials (BOM), which assumes 10% reduction and lifetime extension (standardisation of interfaces).

A15.3 Despite BAT price increases, improvements could lower life cycle costs.

[84] BAT savings estimates are compared to performance level required from Ecodesign MEPS regulation 2019/1782 which came into force in April 2020. The wide window of consumption and potential savings are due to the wide variety of products supported by EPS.

Table A15.1 Energy performance information

	For laptops, scanners, inkjet printers and power tools (>50W)	For other smaller electronics: (portable audio, DECT and mobile phones, tablets, power tools, electric toothbrushes, etc.) (<50W)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.8 - 2.52	0 - 3.17
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.3 - 1.18	0 - 1.49
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.12 - 0.47	0 - 0.6
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.15 - 0.5	0 - 0.66
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.06 - 0.24	0 - 0.31
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.02 - 0.1	0 - 0.12
Benefit Cost Ratio of BAT Savings	0.9	0.8

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a small EPS is 4 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, up to 3.24 TWh of energy could be saved as well as up to 0.68 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be up to 1.3 TWh of energy and up to 0.27 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a large EPS is 5 years. If all units sold annually in the UK in a given year were BAT technologies, 0.76-2.12 TWh of energy could be saved as well as 0.11-0.42 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.31-0.85 TWh of energy and 0.04-0.17 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A15.4 Baseline resource efficiency information

Resource footprint

EPS >50W

- **Average price:** from £24.9 to £30.5.
- **Product weight:** approximately <0.5 kg
- **Lifespan**: 5-5.6years
- **Typical duration of the warranty:** 4-6 years
- **% currently recycled (where available)**: 5%

EPS <50W

- **Average price:** from £4.10 to £23.67.
- **Product weight:** approximately <0.5 kg
- **Lifespan:** 3.6-4.4 years
- **Typical duration of the warranty:** 4-6 years
- **% currently recycled (where available):** 3%

A15.4.1 Composition of typical product

Table A15.2 Composition of typical EPS>50 W (for laptops)

Main component	Main materials	Weight (g)	% of total product
Housing	Upper case and lower case (PC)	47.885	18.1%
Electronic assembly	PVB	7.212	2.7%
	Capacitors (electrolytic)	18.076	6.8%
	Capacitor (film) + ceramic	3.935	1.5%
	Coils + transformer	44.040	16.7%
	Slot 230V	5.245	2.0%

Main component	Main materials	Weight (g)	% of total product
	IC (THT) + SMD	0.505	<0.0%
	SMD capacitors	0.105	<0.0%
	SMD resistors + transistor	0.268	<0.0%
	SMD diodes	0.093	<0.0%
	THT resistors + transistors + diodes + rectifier	5.945	2.2%
	THT fuse	0.290	<0.0%
	THT ferrite	0.265	<0.0%
	THT bridge, jumper (copper)	0.090	<0.0%
	Solder (SnAG)	0.837	<0.0%
Cables	Copper wire	34.125	12.9%
	PVC	34.125	12.9%
	Plug THT	3.215	1.2%
	Plug low voltage	6.190	2.3%
Miscellaneous	Adhesive (silicone) + Spacer + tape	7.335	2.8%
	Screws + metal mountings	1.515	0.6%
	Al heat sink	22.735	8.6%
	Heat sink with copper	22.800	8.6%
	Shield (plastic)	2	<0.0%
	Intern wire - Cu	0.405	<0.0%
	Intern wire PVC	0.810	<0.0%

Main component	Main materials	Weight (g)	% of total product
TOTAL		270	100%

Table A15.3 Composition of typical EPS <50 W (DECT and mobile phones)

Main component	Main materials	Weight (g)	% of total product
Housing	Upper and bottom case - Polycarbonate	18	6.9%
	Upper and bottom case - Polyphenyloxide	16.1	6.2%
	Plug (Copper- Zinc)	2.0	0.8%
	Plug; pin support and label (PVC)	1.1	0.4%
Electronic assembly	PVB	1.5	0.6%
	Capacitors (electrolytic)	1.1	0.4%
	Coils + transformer	187.9	71.9%
	DC/DC regulator	0.3	0.1%
	SMD capacitors (electrolytic)	0.5	0.2%
	SMD Capacitor (film) + ceramic	0.1	0.04%
	SMD resistors + filters	1.5	0.6%
	Diodes	0.5	0.2%
	Internal wire	0.3	0.1%
	Contacts	0.4	0.2%
	Solder	1.2	0.5%
Cables	Copper wire	13.8	5.3%

Main component	Main materials	Weight (g)	% of total product
	PVC	11.9	4.6%
	Plug	3.1	1.2%
TOTAL		261	100%
Packaging	Cardboard	17.7	
	Master carton	20.0	
	Plastic bag	1.0	

Table A15.4 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A15.5 Information on select policy levers and horizontal measures

Existing energy related policy levers in UK

- Ecodesign measures were recently updated for this product group.

Existing circular economy related policy levers

- None identified.

Ecodesign requirements were recently updated for this product group in the November Package Regulations through Regulation (EU) 2019/1782 which repealed and replaced Regulation (EC) No 278/2009[85]. There was an expansion of scope to include active power over Ethernet injectors, and lighting convertors, and importantly, an update of the MEPS, which are now aligned to USDOE regulation (2016). The MEPS update tightened the no-load and active efficiency requirements of EPS. These were brought into force in April 2020 and the requirements were retained in GB on 1 January 2021. If a new revision is desired, it is assumed 2 years is required to prepare it.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations. However, it should be noted that industry stakeholders noted health and safety concerns (e.g., risk of fire and electric shock) regarding modularity and other repairability measures targeted to a do it yourself (DIY) audience. Their view was that measures should be aimed at improving repairability for professionals.

[85] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A15.5 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[86]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Recently updated (2)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Recently updated.
Mandatory label (includes enforcement)	N/A	Information provision / Energy savings	N/A	Often bundled with products at point of sale. Unlikely to inform consumer decision making.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards. Can demonstrate environmental credentials of producer of other product.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier to provide to residential customer.
Public procurement	2	Prohibit poor efficiency products / Energy savings	None found	Often bundled with products with GBS. Endorsement label could enable addition to procurement specifications.

[86] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[86]	Policy objective/ impact	Scale of impact	Suitability comments
Communications campaign	N/A	Not suitable as this is a mature product group.	N/A	Often bundled with products at point of sale. Unlikely to inform consumer decision making.
Advice/aid in implementation	N/A	Not suitable as this is a mature product group.	N/A	Often bundled with products at point of sale. Unlikely to inform consumer decision making.
Grants, subsidies, loans	N/A	Not suitable as this is a mature product group.	N/A	Often bundled with products at point of sale. No label to identify highest performers.
Taxes on poor performing products	N/A	Not suitable as this is a mature product group.	N/A	Often bundled with products at point of sale. Not suitable as there's no mandatory label to identify poor performers.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Potential hazards for user safety should ensure measure is aimed at professional repairers.
Product support & extension of Ecodesign	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.

Policy lever	Indicative time needed to implement (years)[86]	Policy objective/ impact	Scale of impact	Suitability comments
November package measures[87]				
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A15.6 Summary of stakeholder feedback

Stakeholders indicate that for any material efficiency or performance requirements, a product-specific approach should always prevail, as it is the most effective and robust approach, and to avoid the pitfalls of a one-size-fits-all approach to product policy. They urge that dedicated studies should consider the specific opportunities to each product group, and in respect to B2B and B2C products. Specifically, for external power supplies, improved market surveillance mechanisms should be implemented.

A trade association has also come back strongly opposed regarding the horizontal measure of universal chargers. They indicate that, where in 2009, there were many proprietary chargers supplied on the market per phone, a Memorandum of Understanding and voluntary International Standardisation between manufacturers has reduced this such that consumers may now charge an increasing number of devices with the same charger. This is indicated by the development of the USB Type-C, born out of a second MoU, providing interoperable charging and data transfer capabilities. The industry has pointed out that mandating a single charger for laptops and smartphones is likely to increase material consumption to devise a new EPS capable of handling both power requirements (which is unlikely to be efficient at both power levels) and would need to replace existing USB-C infrastructure. The stakeholder advised that rather than mandating a single EPS, common charging interoperability should be championed.

A15.7 Discussion & next steps

The energy consumption of EPS is tied to the products it converts power for. As the EPS converts power, it has conversion losses. More efficient EPS therefore would transmit more power from the grid to the end device. Efficiency of an EPS will vary according to the load it is

[87] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

transmitting, which is why it is preferred to tailor an EPS to an end device. EPS also consume power if plugged in but not actively converting power. These are referred to as “no-load” power consumption.

Because MEPS were recently updated in 2020, a voluntary endorsement label could be a good candidate as a policy lever. There are existing standards to the technology that can be used as benchmarks. This can demonstrate environmental credentials to a consumer electronics provider seeking an EPS of a certain label quality. This has been applied in the US under Energy Star and therefore can be reproduced in the UK. This could then be tied into a public procurement scheme for electronics.

EPS are considered good candidates for the material efficiency measures: recommendations for material content and declaration, reparability measures (such as modular design), product support extending of Ecodesign November package measures[88] (with the provision of spare parts) and the enactment of a mandatory minimum warranty period. These measures would increase the durability, repairability and component reuse of EPS. EPS are typically composed of electronic components (diodes, capacitors, solenoids), which can be replaced by a professional, if information on the parts to replace, access into the device and adequate parts are provided. Some power supplies are harder to open due to welding, hence some measures may be needed to ensure EPS are designed such that they can be opened. No other adverse impacts are foreseen by the implementation of these 4 material efficiency measures if adequate safety measures are considered to aim these towards professionals. It would be necessary to start with the policy of material content declaration to then enable the development of reparability measures and product support through the provision of spare parts. Modular design of reparability should be enacted in tandem with product support policies to ensure that the required parts are readily available for repair. Mandatory minimum warranty would require some further analysis to understand the costs associated.

The “active lifetime” of most EPS units is limited by the lifetime of the end product that it serves. This is due to compatibility and the fact that each new end product comes with a new power supply unit. Therefore, the main opportunity to reduce material extraction and disposal related to EPS rests in reducing the need for individual EPSs to be placed on the market with mobile devices. This could be achieved through a common/universal connector (or interoperability criterion) that allow the reuse of such accessories, which was consulted upon during and EU impact assessment study in 2019. The benefits of this approach would be for a common connector providing convenience to users and reducing waste impacts from redundant chargers. Existing EN standards could provide the basis for requirements related to common EPS design to be included in a revision of the Ecodesign measure. However, a universal EPS may compromise the energy efficiency, as the EPS will be designed for the highest output and will be less efficient for lower outputs.

[88] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A15.8 Evidence sources

Title	Author	Date Published or date accessed
Preparatory Studies for Ecodesign Requirements of EuPs: Lot 7 Battery chargers and external power supplies	Bio Intelligence Service, Fraunhofer IZM, CODDE	23/01/2007
ETL product research data	ICF	unpublished
Using the modelling from m InputWkBk_Dom_EPS_Large_NewPol_v2.1 and InputWkBk_Comm_EPS_Large_NewPol_v2.1 InputWkBk_Dom_EPS_NewPol_v5.1 prepared in 2019 for ecodesign regulation	ICF modelling	unpublished
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
European Commission Ecodesign regulation; Regulation (EU) 2019/1782	European Commission	Published October 2019 Accessed 24 March 2021
Impact assessment Study on Common Chargers of portable devices	European Commission	Published December 2019 Accessed May 2021

Annex 16 Heating, Ventilation, Cooling: Building Automation and Control Systems (BACS)

A16.1 Introduction

Heating, ventilation, and cooling sub-sector encompasses all residential and non-residential product groups that provide sanitary hot water, heating, cooling or ventilation (or a means to control them) to improve comfort levels in buildings and their surroundings.

Building Automation and Control Systems (or BACS) are defined in EN15232 as: “system, comprising all products, software and engineering services for automatic controls (including interlocks), monitoring, optimization, for operation, human intervention, and management to achieve energy–efficient, economical, and safe operation of building services.” This is sometimes referred to as a Building Management System (BMS).

In effect a BACS will control different aspects of a building operation, such as the heating, ventilation, air conditioning, lighting, auxiliary power, etc. An example of a BACS would be for it to control the heating to be turned on or off if a sensor reaches a desired temperature. In this analysis, we have reviewed the market for domestic and non-domestic BACS.

Building Automated Control Systems have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A16.2 Market information

Sales of BACS are estimated on a “per-site” basis. In the UK, it is estimated that 34-41k sites are fitted with BACS each year. In the domestic market, this is estimated to 620-758k households. Over the domestic and non-domestic markets, BACS are expected to continue growing 2-7% annually. No trade information or HS6 code is available for this technology as the technology is niche and overlaps with other products (sensors, cables, etc.).

It is important to understand that although this technology is constructed around a key product, the controller, this technology is a system which relies on multiple stakeholders for delivery. The system requires the following components to function:

field devices (sensors, actuators, etc.) which will measure the building performance and act to change the building performance.

controllers which will gather the field devices information, analyse this data and provide commands on how to respond to maintain building environment. (it should be noted that some new technologies rely on remote control facilities)

hardware (communication cables and gateways) which will connect field devices and controllers.

software development to ensure devices are adequately connected and provide adequate control capabilities.

All of these components are reliant on an installer to adequately install and commission devices and provide the software to integrate devices. This may require reprogramming for existing control systems to be tied with new systems.

The basic functions of the domestic and non-domestic technologies are the same. However, procurement and usage of the markets are different. Non-domestic clients are likely to want a flexible installation process, as there are likely to be multiple systems to tie together and for cyber-security reasons. The domestic market is more likely to fit an “all-in-on” security, relying on Wi-Fi and remote-control capabilities.

For non-domestic BACS, the market leader in the UK is Trend controls (49%) followed by Schneider Electric (10%) and Honeywell and Siemens in a combined 3rd place (6%). However, Honeywell owns Trend Controls, Centraline and Tridium, resulting in a final share of 57%. Bigger suppliers are capable of providing all aspects of BACS service, dominating notably in the provision of hardware. However, market competition is more diverse for the provision of software products and field level controllers.

A16.3 Energy performance information

The typical energy consumption of a domestic building ranges between 3.2 and 3.9 MWh of electricity and 9.6 and 11.8 MWh of gas per year. The typical energy consumption of a non-domestic building ranges between 6.5 and 67.5 MWh of electricity and 17.1 and 109.4 MWh of gas per year.

This technology is an energy enabling technology, it controls building functions to limit its consumption. This will entail turning on and off devices as they are needed, using a minimum amount of resources whilst maintaining the building environment conditions. The highest consumption and savings to be delivered are on heating, ventilation, and air conditioning.

The baseline typical estimates below are the average electricity and gas consumption of an average building. The BAT energy consumption figures estimate the consumption of a building assuming that BACS are installed (Class C for the minimum and Class A for the maximum savings estimates), and that all major equipment in the building are connected to the BACS. The price increase considered in the calculations are the costs of the BACS, which includes the installation of additional sensors and software review, notably the need for presence and demand detection sensors.

Baseline consumption and saving potential for both domestic and non-domestic have wide windows under our model. This is due to the need to represent the potential savings across a wide range of building types (such as terraced houses compared to flats, or offices compared to warehouses) and to the differences between savings that can be achieved with Class C and Class A BACS.

Table A16.1 Energy performance information (Domestic)

	Electricity consumption (Domestic)	Gas consumption (Domestic)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	20 - 59.8	59.8 - 178.8
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.6 - 4.78	5.38 - 46.49
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.24 - 1.92	2.16 - 18.69
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	4.2 - 12.6	11 - 32.8
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.13 - 1.01	0.99 - 8.53
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.05 - 0.41	0.4 - 3.43
Benefit Cost Ratio of BAT Savings	2	1.8

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

Table A16.2 Energy performance information (Non-Domestic)

	Electricity consumption (Non-Domestic)	Gas consumption (Non-Domestic)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	1.76 - 50.76	4.72 - 82.26
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.37 - 32.49	0.76 - 58.4
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.15 - 13.06	0.31 - 23.47
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.4 - 10.44	0.88 - 15.12
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.08 - 6.68	0.14 - 10.74
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.03 - 2.69	0.06 - 4.32
Benefit Cost Ratio of BAT Savings	27.9	9.5

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a building (in kWh/year) by the lifespan of BACS (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming BACS units sold in the UK are installed in buildings.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

BACS are energy saving add-ons. The sales figures considered for the estimates correspond to the average number of BAT BACS being installed in buildings in the UK each year. Baseline typical gas and electricity consumption is presented for average buildings. For domestic buildings, there is a potential to achieve up to 26% savings on gas consumption, and up to 8% on electricity consumption. For non-domestic buildings, there is potential to achieve up to 71% savings on gas consumption, and up to 64% on electricity consumption. This saving potential is the maximum assumption, when assuming that a domestic building has no control systems in place, and then installs BAT BACS on HVAC, domestic hot water and lighting controls. The low-end BAT savings assumption is if a building with no controls installs a BACS with average functionalities (designated as class C under the EN 51232 designation) to HVAC, domestic hot water and lighting.

The average lifespan of a domestic BACS is 15 years and the savings presented in the table are estimated for BAT BACS being installed in the UK in one given year over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If 620k – 760k BAT BACS were installed in domestic buildings in the UK in a given year, 0.6 - 2.39 TWh of electricity (and 0.13 - 0.5 MtCO2e) could be saved as well as 5.4 - 23.24 TWh of gas (and 0.99 - 4.26 MtCO2e), over 10 years. Savings that could be achieved with a mix of policy levers would be 0.24 - 0.96 TWh of electricity (and 0.05 - 0.2 MtCO2e) as well as 2.17 - 9.34 TWh of gas (and 0.4 - 1.71 MtCO2e), over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a non-domestic BACS is 13 years. If 34k – 42k BAT BACS were installed in non-domestic buildings the UK in a given year, 0.42 - 18.05 TWh of electricity (and 0.11 - 3.71 MtCO2e) could be saved as well as 0.96 - 32.45 TWh of gas (and 0.18 - 5.96 MtCO2e), over 10 years. Savings that could be achieved with a mix of policy levers would be 0.17 - 7.26 TWh of electricity (and 0.04 - 1.49 MtCO2e) as well as 0.39 - 13.04 TWh of gas (and 0.07 - 2.4 MtCO2e), over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A16.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £230 to £1,370 for domestic systems, from £420 to £6,090 for non-domestic systems
- **Product weight:** typically, a controller would be under 0.5kg, weight can be higher for large systems with many cables, sensors, controller devices, possibly totalling up to tens of kilograms of materials for big buildings.
- **Lifespan:** 10-20 years for domestic buildings; 8-18 years for non-domestic buildings
- **Typical duration of the warranty:** product doesn't come with warranty but often comes as an ongoing service.

A16.4.1 Composition of typical product

The consultants delivering the BACS European Commission preparatory study, in agreement with the Commission, did not provide a Bill of Materials (BOM) breakdown in their analysis, reasoning that "there is no evidence that a higher functionality BACS has different transportation needs than a lower functionality BACS and hence it does not make sense to model it". Extensive online searches have also failed to yield example BOMs for BACS products. The components and hence materials for BACS can vary extensively. An entry level domestic BACS could simply be a smart thermostat communicating with a boiler via Wi-Fi (provided as part of a space heating package or added on as a separate technology). For non-domestic BACS, these may be extensive array with dozens of sensors, controllers, and a centralised controller per floor, along with interconnecting cables. This makes average materials analysis difficult to establish.

Table A16.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium, Silicon, Platinum and Rare Earth Elements (REEs)	Display use LEDs Liquid-crystal displays (LCD) Semiconductors	No substitute available for indium, and gallium. No recycling of indium from EoL products. High demand of indium by indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. LCDs have been displaced by LED-backlit LCD displays containing less REEs – market moving to Organic LED. Recyclability of displays is focused on the recycling of metal and glass and not the REEs.	Technically feasible but with recycling rates below 1%. Recycling of REEs have not reached the commercial scale.

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A16.5 Information on select policy levers and horizontal measures

Ecodesign MEPS do not exist for this product group. A European Commission preparatory study identified that as an energy saving technology, their consumption is very small and hence MEPS would not be suitable for BACS. However, the study concluded that functionality and operability requirements may be suitable, such as: improved control accuracy, minimum calibration certificates for sensors, individual room control, adaptive room setpoint scheduling, demand orientated controls and adaptive generation sequencing. Follow progress in EU.

In its recent consultation on The Future Buildings Standard[89], MCLG has proposed a specification of Class A BACS as part of the requirements.

Regarding the horizontal measures, it is assumed that 3 of

Existing energy related policy levers in UK

- No Ecodesign MEPS or energy labelling.
- BACS are required by Building Regulations Part L.
- Currently, controls similar to BACS are covered by the advice in implementation schemes "**Simple Energy Advice website (formerly known as Energy Saving Advice Service)**" and "**Home Energy Scotland**".
- Additionally, when it comes to grants and loans BACS are covered by the "**Green Homes Grant**", the "**Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme**", the "**Salix public sector finance - Loan scheme**".
- BACS are also covered to an extent by the voluntary **BREEAM** endorsement label.
- Previously, before its end the "**CRC Energy Efficiency Obligation Scheme**" also covered to an extent this segment.

Existing circular economy related policy levers

- None identified.

[89] report See 3.10.17 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956037/Future_Buildings_Standard_consultation_document.pdf

the 4 measures in the table can be implemented independently of MEPS regulations, whilst modular design requirements are not suitable to BACS, they are inherently modular.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group. However, an issue of split incentives can occur for non-domestic BACs where building owners incur costs and tenants incur benefits.

Table A16.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[90]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	N/A	Remove poor efficiency products / Energy savings	N/A	Unsuitable as energy classes depend on installation, not able to define at point of sale.
Mandatory label (includes enforcement)	N/A	Information provision / Energy savings	N/A	Unsuitable as energy classes depend on installation, not able to define at point of sale.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Label could be associated with equipment needed to meet highest energy classes.
Obligation scheme	0.5	Provision of energy saving technologies / Energy savings	None found	Suitable option for energy supplier to provide to residential customers.
Public procurement	(Indirectly included) 0.5	Prohibit poor efficiency products / Energy savings	None found	Could be directly included. Current inclusion via BREEAM requirements. Need to understand

90 Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[90]	Policy objective/ impact	Scale of impact	Suitability comments
				effectiveness of this measure.
Communications campaign	0.5	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate, low cost/effort to include in existing policy lever.
Advice/aid in implementation	0.5	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate, low cost/effort to include in existing policy lever.
Grants, subsidies, loans	1	Increase accessibility of high efficiency products / Energy savings	None found	Would require verification of installation.
Taxes on poor performing products	N/A	Not suitable as this is a mature product group.	N/A	Not suitable as mandatory labels needed to identify poor performers are unsuitable.
Technology deployment & diffusion	1	Encourage uptake of new product / Energy savings	N/A	Suitable for domestic BACS or highest energy class of Non-domestic BACs.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	N/A	Extend lifetime / reduction in material and resource consumption	None found	Not suitable. BACS are inherently modular products.

Policy lever	Indicative time needed to implement (years)[90]	Policy objective/ impact	Scale of impact	Suitability comments
Product support & extension of Ecodesign November package measures[91]	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate for product support. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A16.6 Summary of stakeholder feedback

There was no feedback or participation relating to this product group resulting from the Task 2 or Task 3 stakeholder consultation and the policy study's first stakeholder consultation meeting. As part of the Task 4 consultation, a trade association noted that the MCLG proposed new Building Regulation Part L requirements for Class A BACS (based on EN15232) in non-domestic buildings could significantly reduce the additionality of savings through products policy.

A few stakeholders from the HVAC sector noted that installation of a fully integrated and automated BACS system in a domestic premise is highly unlikely.

There was no reference to this product group within the summary of responses to the ErP Call for Evidence.

A16.7 Discussion & next steps

The emphasis for this product group is less on the product itself, but rather how it is installed and commissioned - particularly in non-domestic settings. The new standard BS EN 15232 considers a systems approach to the integration of a building's control strategy and its HVAC, lighting and other services. Implementation of the currently voluntary standard delivers an A, B, C, D class assessment of the performance of the building. Any encouragement of measures should therefore target this aspect. Building regulations cover the use of controls in buildings and could be a vehicle for delivering future measures. Whilst the European Commission preparatory study concluded that MEPS would not be suitable for BACS, Ecodesign

[91] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

functionality requirements could complement building regulations by facilitating better functionality and operability of BACS.

A shift towards the installation of simple BACS has already started in the domestic market under the Boiler Plus standard (2018) which ensured new boilers would have load and weather compensation controls at installation.

In parallel to this activity, recommendations have been delivered to BEIS to introduce voluntary, endorsement labelling for Building Energy Management Systems under the Energy Technology List.

It is important that communication protocols are open, allowing full system integration and future proofing its continued integration.

A next step could be a study on the likely take-up of BACS within the domestic sector.

A16.8 Evidence sources

Title	Author	Date Published or date accessed
EU BACS prep study	European Commission Directorate-General for Energy	Accessed: March 2021
English Housing survey	Gov.uk	Accessed: March 2021
ETL modelling for Building Environment Zone controls	ICF modelling	unpublished
ECUK	Gov.uk	Accessed: March 2021
BS EN 15232-1:2017	BSI standards	2017
Building Automation and control systems, UK, BSRIA 60589/7	BSRIA	March 2018
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021

Title	Author	Date Published or date accessed
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 17 Heating, Ventilation, Cooling: Electric and Gas Patio Heaters

A17.1 Introduction

Heating, ventilation, and cooling sub-sector encompasses all residential and non-residential product groups that provide sanitary hot water, heating, cooling or ventilation (or a means to control them) to improve comfort levels in buildings and their surroundings.

A patio heater is a radiant heating appliance for generating thermal radiation for outdoor use. Patio heaters can either use propane or electricity as a fuel. Propane patio heaters direct flames at a metal screen and heat is radiated around the appliance. Electric patio heaters emit heat generated in electric heating elements. Designs focus on infrared radiative transmission to reduce heat losses to surrounding air (transparent to radiation).

A17.2 Market information

Annual sales are estimated to be 12,500 – 18,000 and 4,500 – 6,500 units per annum for propane and electric patio heaters, respectively. Given the increase in outdoor socialising and dining as a result of the Covid-19 pandemic, the market is expected to grow.

No trade information was found for this product group.

No information on the countries of manufacture/assembly of patio heaters was found. There is a suggestion that many manufacturers are based in the US.

A17.3 Energy performance information

The typical energy consumption of a unit ranges between 1.2 and 9.5 MWh per year.

A patio heater is a radiant heating appliance for generating thermal radiation for outdoor use. In a propane patio heater, gas is released from a canister and directed up the pole of the heater to the burners. The burners ignite the propane and the heat produced is used to heat the radiant reflective dome at the top of the patio heater. The radiant element emits heat to the surrounding objects.

Electric patio heaters emit heat through infrared radiative transmission. Electricity is passed into a heating element which converts the energy to infrared heat. This heat is transmitted through the air via electromagnetic waves (radiative heating) until it reaches an object. It is then absorbed and heats the object.

Both types of patio heaters are estimated to be used for an average of 12 hours a week, although it is likely there will be significant seasonal variation.

There is potential to improve product category efficiency and achieve up to 85% savings though switching to electric heaters.

There are few options for improving the energy performance of a patio heater as the mechanism of operation is simple. It is assumed inclusion of smart controls or standby modes could give a modest efficiency improvement of 1% at little cost. The primary method for reducing energy consumption of patio heaters is to switch fuel from propane to electric patio heaters. This gives a primary energy saving of 70-85%.

Table A17.1 Energy performance information

	Propane Patio Heaters	Electric Patio Heaters
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.27 - 1.19	0.03 - 0.07
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.19 - 1.01	n.a.
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.08 - 0.41	n.a.
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.06 - 0.28	n.a.
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.04 - 0.24	n.a.
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.02 - 0.1	n.a.
Benefit Cost Ratio of BAT Savings	1.2	n.a.

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

No energy savings have been attributed to electric patio heaters as the potential to improve efficiency is very marginal (up to 1%). For propane patio heaters, the energy and carbon savings have been estimated assuming a technology switch electric patio heaters.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a propane patio heater is 5 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.7 - 1.45 TWh of energy could be saved as well as 0.14 - 0.34 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.28 - 0.58 TWh of energy and 0.06 - 0.14 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A17.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £150 – 600 for electric patio heaters. From £250 – 550 for propane patio heaters.
- **Product weight:** approximately 18 kg to 55 kg
- **Lifespan:** 3 – 7 years
- **Typical duration of the warranty:** up to 1 year.
- **% currently recycled (where available):** not available.

A17.4.1 Composition of typical product

No information was found on the composition n of electric or propane patio heaters.

Table A17.2 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinyl chloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A17.5 Information on select policy levers and horizontal measures

Ecodesign MEPS do not exist for this product group. Regarding the horizontal measures, it is assumed that all 4 measures in the table can be implemented independently of MEPS regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group. However, if new sales of these products were banned, costs could be incurred by the restaurant/leisure sector who could lose custom during winter months due to lack of patio heaters[92].

Existing energy related policy levers in UK

- There are no identified Ecodesign MEPS measures for this segment.

Existing circular economy related policy levers

- None identified.

Table A17.3 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[93]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	3	Remove poor efficiency products / Energy savings	N/A	Suitable for MEPS.
Mandatory label (includes enforcement)	3	Information provision / Energy savings	N/A	Suitable for mandatory labelling. Alternatively, could ban poor performers outright.
Voluntary endorsement label	N/A	Information provision / Energy savings	None found	Not suitable as there are no energy performance measurement standards.

[92] https://www.reuters.com/article/uk-climate-change-france-idUKKCN24S1HJ
[93] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[93]	Policy objective/ impact	Scale of impact	Suitability comments
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	None found	Not suitable option for energy supplier to provide to residential customer.
Public procurement	N/A	Prohibit poor efficiency products / Energy savings	N/A	Not suitable. Use of all patio heaters should not be encouraged in public sector.
Communications campaign	N/A	Not suitable as this is a mature product group.	N/A	N/A
Advice/aid in implementation	N/A	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	N/A
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	N/A	N/A
Taxes on poor performing products	1	Reduce purchases of low efficiency products / Energy savings	None found	Tax on entire product group could be considered to discourage uptake.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	N/A
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.

Policy lever	Indicative time needed to implement (years)[93]	Policy objective/ impact	Scale of impact	Suitability comments
Product support & extension of Ecodesign November package measures[94]	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A17.6 Summary of stakeholder feedback

Little stakeholder feedback was received for this product group. In Task 2 feedback, a single stakeholder indicated more attention should be paid to gas fired patio heaters.

Feedback from a stakeholder mentioned BioLPG as an alternative fuel and a potential renewable energy solution for LPG products, including patio heaters.

A17.7 Discussion & next steps

Patio heater demand is higher in the UK than in many other countries due to its climate and large portion of the year with temperatures between 10 and 20°C.

Patio heaters are already very efficient and there is limited room for technical improvement within the categories. Decarbonisation potential lies in electrification.

Products compete with smart architecture design that enables higher comfort levels in a patio/ garden. Actual usage profiles and scenarios need further research, it is possible that with a decreasing smoking population the demand for patio heaters will also decrease.

Further research should seek to improve the evidence base and to consider impacts of different fuels on the emission savings potential of product switching.

[94] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A17.8 Evidence sources

Title	Author	Date Published or date accessed
Portablefireplace.com	Megan Meyer	March 2016
Global Outdoor Heater Market Outlook 2021	Research Reports	December 2020
EU Bid to Freeze Out Patio Heaters	The Guardian	March 2020
https://www.thisismoney.co.uk/money/experts/article-5611715/How-does-cost-run-patio-heater.html		April 2018
https://patiomate.co.uk/faq/how-much-does-it-cost-to-run-patio-heater/		March 2020
Patio heater, fire pit or a bigger jumper? How to stay warm while relaxing outside this winter	The Guardian	October 2020
Home Heating and Cooling		March 2021
Herschel's Guide to Outdoor Heating		March 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 18 Heating, Ventilation, Cooling: Space Heaters

A18.1 Introduction

Heating, ventilation, and cooling sub-sector encompasses all residential and non-residential product groups that provide sanitary hot water, heating, cooling or ventilation (or a means to control them) to improve comfort levels in buildings and their surroundings.

Space heaters are heat sources to provide heating to central heating systems for buildings. This category includes gas boilers within a hydronic heating system and heat pumps (either air or ground source). Heat pumps work by pumping or moving heat from one place to another by using a compressor and a circulating structure of liquid or gas refrigerant, through which heat is extracted from outside sources and pumped indoors.

Space heaters have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A18.2 Market information

Annual sales of gas boilers in the UK are estimated at around 1.68 million (BSRIA, 2020) and of heat pumps are estimated at nearly 37,000 (BSRIA, 2021). The gas boiler market is expected to remain largely stable, with the heat pump market expecting a CAGR of 29% over the next five years.

Around 70% of gas boilers sold in the UK are manufactured domestically, with a small export market, while only around 30% of heat pumps sold in the UK are manufactured domestically, but there is a strong and growing export market capturing 0.5% of the NW Europe market and 0.6% of the rest of the world (BEIS, 2020).

Approximately 93% of fossil fuel fired boiler production in the EU and the UK takes place in 7 countries: Italy, the UK, Germany, the Netherlands, France, Poland, and Slovakia. The largest heat pump producing nations in the Europe are the UK, Germany, Sweden, and France. Energy performance information

A18.3 Energy performance information

The typical energy consumption of a gas boiler ranges between 11 and 12.5 MWh per year[95]. Typical heat pump energy consumption is around 3.6 to 4.4 MWh per year[96].

Space heating can be provided by different technologies. Based on present and future market share, the two most important ones are gas-fired boilers and air source heat pumps. All space heaters supply heat to hydraulic central heating systems in buildings. Heat is generated via natural gas combustion or a reversed refrigeration cycle (powered electrically). Space heating demand is correlated with the outside temperature with peak demand in winter months.

There is potential to improve product efficiency and achieve up to 3% savings for gas boilers[97] and 40% savings for heat pumps. Whilst boilers above 92% seasonal space heating efficiency are available on the market, it is recommended that there is further investigation as to how boilers achieve these higher efficiencies in practice.

Potential for improvements in boiler technology is limited, as this is a mature technology. There is some room for improvement by increasing heat exchanger size and using smarter control strategies. Potential for heat pumps is higher as these are more complex systems that could be expanded and optimised – new working fluids could be used, multi-stage design, compressor design and heat exchanger sizing are all valid R&D directions.

Table A18.1 Energy performance information

	Gas Boiler	Heat Pumps
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	147.82 - 346.5	1.8 - 3.24
Maximum technical potential energy savings that can be achieved with BAT (TWh)	1.48 - 10.4	0.54 - 1.3
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.32 - 2.28	0.12 - 0.28

95 The values have been calculated from the Space and combination heaters Ecodesign and Energy Labelling - Task 7 report (2019). The annual load for non-condensing and condensing boilers was divided by the total stock (kWh/unit), and multiplied by the associated minimum and maximum efficiencies to obtain the reported range.
96 The heat pump values were based on a range created using the annual energy consumption of a standard electric heat pump as reported in a BEIS 2016 report: Heat_Pumps_Combined_Summary_report_-_FINAL.pdf (publishing.service.gov.uk)
97 SSHEE efficiency. The ETL list contains boilers <70kW and reports maximum efficiencies of 94% based on a review in 2018. However, a manufacturer reported a 95% efficiency boiler during the 2016 research programme. Future research should validate the reported efficiency. https://etl.beis.gov.uk/product-search/sub-technology/hot-water-boilers?page=0&keywords=&listingStatus=current&feature13-1=Condensing%20(%3C%3D70kW)&sort=feature13-10%2Cdesc

	Gas Boiler	Heat Pumps
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	27.2 - 63.75	0.45 - 0.72
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.27 - 1.91	0.14 - 0.29
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.06 - 0.42	0.03 - 0.06
Benefit Cost Ratio of BAT Savings	0.1	4.7

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient. No cost data was found in the literature relating to BAT heat pumps. For the purpose of the BCR calculation, a 10-15% uplift in cost was assumed. This assumption will need further exploration by future research.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a heat pump space heater is 17 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.3 - 0.72 TWh of energy could be saved as well as 0.09 - 0.16 $MtCO_2e$ over 10 years. Savings that could be achieved with a mix of policy levers would be 0.07 - 0.16 TWh of energy and 0.02 - 0.04 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a gas boiler space heater is 12 years. If all units sold annually in the UK in a given year were BAT technologies, 1.74 - 6.93 TWh of energy could be saved as well as 0.32 - 1.28 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.38 - 1.52 TWh of energy and 0.07 - 0.28 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A18.4 Baseline resource efficiency information

Resource footprint

Gas Boilers & heat pumps:

- **Average price:** from £1,050 to £1,150 for gas boilers. From £3,570 to £6,400 for heat pumps. Excludes installation costs.
- **Product weight:** approximately 35 kg to 42 kg for gas boilers and 500 kg to 850 kg for heat pumps.
- **Lifespan:** the life span for gas boilers is 8.5 to 15 years and for heat pumps is 15 to 18 years.
- **Typical duration of the warranty:** for gas boilers a warranty typically lasts 5 to 10 years and for heat pumps 2 to 10 years (noting 10 years for general parts only, not the whole heat pump/ compressor).

A18.4.1 Composition of typical product

Table A18.2 Composition of typical product – Gas Boiler

Main component	Main materials	Weight (g)	% of total product
Boiler unit	PP	64	0.2
	PVC	5	0.01
	ABS	1171	3
	flexalen PUR (pre-insulated plastic pipe system)	115	0.3
	Steel sheet galv.	22879	59.1
	Stainless steel coil	6736	17.4

Main component	Main materials	Weight (g)	% of total product
	Diecast aluminium	1905	4.9
	Copper wire	74.4	0.2
	Copper tube/sheet	2290	5.9
	Brass cast	3215	8.3
LCD screen	LCD	3	0.01
Controller board	Controller board	248	0.6
TOTAL		38705.4	100%

Table A18.3 Composition of a typical product – Air Source Heat Pump

Main component	Main materials (weight if available)	Weight (g)	% of total product
Heat pump unit	HDPE	500	0.2%
	PVC	1600	0.8%
	flexalen PUR (pre-insulated plastic pipe system)	16000	7.5%
	Steel tube/profile	120000	56.%
	Aluminium sheet extr.	32000	14.9%
	Copper tube/sheet	36600	17.1%
Refrigerant	R134a	4900	2.3%
Misc.	Polyester oil	2700	1.3%
TOTAL		214300	100%

Table A18.4 Composition of typical product – Ground Source Heat Pump

Main component	Main materials (weight if available)	Weight (g)	% of total product
Heat pump unit	LDPE	4700	0.9%
	HDPE	250000	47.9%
	PVC	1000	0.2%
	flexalen PUR (pre-insulated plastic pipe system)	10000	1.9%
	Steel tube/profile	75000	14.4%
	Aluminium sheet extr.	20000	3.8%
	Copper tube/sheet	22000	4.2%
	Brass cast	6600	1.3%
Refrigerant	R134a	3090	0.6%
Misc.	Polyester oil	1.7	0.0%
	Ethylene glycol	130000	24.9%
TOTAL		522392	100%

Table A18.5 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in motors NdFeB-magnets may be used in both main and other motors such as in pumping motors,	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets).	Technically feasible, but the economic feasibility may be critical under the current economic conditions.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
	cooling ventilations, water distribution valves and feeding valves.	Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium, Silicon, Platinum and Rare Earth Elements (REEs)	Display use LEDs Liquid-crystal displays (LCD) Semiconductors	No substitute available for indium, and gallium. No recycling of indium from EoL products. High demand of indium by indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. LCDs have been displaced by LED-backlit LCD displays containing less REEs – market moving to Organic LED TVs (represents approximately 84% of total global indium consumption) Recyclability of displays is focused on the recycling of metal and glass and not the REEs.	Technically feasible but with recycling rates below 1%. Recycling of REEs have not reached the commercial scale.

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Asbestos may be found on gas and electrical installations in the form of lagging and coating on large boilers and pipe work.

Potential presence of refrigerant (heat pumps)

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Polyvinyl chloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A18.5 Information on select policy levers and horizontal measures

Ecodesign MEPS and labelling exist for this product group. An EC impact assessment study of the Ecodesign and Energy Labelling measure for space heater is underway and scheduled to complete by November 2021.

Because energy labelling is already in place, most of the policy levers assessed in this study were deemed suitable for this product group.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations.

Except for obligation schemes, a literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

Existing energy related policy levers in UK

- There are Ecodesign MEPS measures and an impact assessment is underway.
- Boiler Plus standards require MEPS for domestic gas boilers at 92% ErP.
- Building Regulations Part L – Conservation of fuel and power also set requirements.
- Dwelling based MEPS such as the “**Domestic private rented property: minimum energy efficiency standard**” cover this segment.
- Currently, space heaters are covered by the aid in implementation schemes “**Simple Energy Advice website (formerly known as Energy Saving Advice Service)**”, “**Home Energy Scotland**”, and “**Welsh Government Warm Homes Nest scheme**”.
- When it comes to grants and loans heat pumps were covered by the “**Green Homes Grant**” (now closed), and are currently covered by “**Renewable Heat Incentive**”, “**Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme** “, “**Salix public sector finance - Loan scheme**”.
- Boilers are also covered by the “**Energy Company Obligation (ECO) Affordable Warmth Obligation**”, by the mandatory label “**Energy Performance certificate**”, and by the voluntary labels “**Energy Saving Trust Register**” and “**BREEAM**”.
- Space Heaters are listed on the **Energy Technology List**.
- Previously, they were also covered to an extent by the “**Green Deal policy**”.

Existing circular economy related policy levers

- None identified.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group as measures would only apply to newly sold boilers. However, extending lifetimes of gas fuelled boilers may conflict with future electrification of heat or hydrogen fuelled boiler programmes.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group. However, an issue of split incentives can occur for space heating where building owners incur costs and tenants incur benefits. This has been partially addressed by policy levers such as Domestic private rented property: minimum efficiency standards in England and Wales[98].

Table A18.6 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[99]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Already exist (2)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate for revision. Impact assessment to be published in Nov 2021, which is reviewing impact of existing MEPS, and providing in-depth analysis of certain topics, including hydrogen as an alternative fuel for boilers, the testing and calculation method for heat pumps.
Mandatory label (includes enforcement)	Already exist (2)	Information provision / Energy savings	None found	Good candidate for revision. Impact assessment to be published in Nov 2021, which is reviewing impact of existing labelling measure, and providing in-depth analysis of certain topics.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards.

[98] https://www.gov.uk/guidance/domestic-private-rented-property-minimum-energy-efficiency-standard-landlord-guidance

[99] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[99]	Policy objective/ impact	Scale of impact	Suitability comments
Obligation scheme	Already exist	Provision of energy saving technologies / Energy savings	Low[100]	Suitable option for energy supplier to provide to residential customers.
Public procurement	Already exist	Prohibit poor efficiency products / Energy savings	None found	Potential need to update for Boiler Plus. Need to understand effectiveness of this measure. Ecodesign MEPS and labelling also apply. See above.
Communications campaign	Already exist	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Already exist. Potential to increase focus on upgrades in addition to reducing energy bills.
Advice/aid in implementation	Already exist	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Already exist.
Grants, subsidies, loans	Already exist	Increase accessibility of high efficiency products / Energy savings	None found	Already exist.
Taxes on poor performing products	1	Reduce purchases of low efficiency products / Energy savings	None found	Suitable but likely to disproportionately affect low-income populations.
Technology deployment & diffusion	1	Encourage uptake of new product / Energy savings	None found	Suitable for technology switching only.

[100] Evaluation studies on ECO indicate that only 6% of CO_2e savings are due to boilers, remaining due to installation of insulation measures. With ECO3 only applying to vulnerable populations (comprising 11% of population), a low rating has been assigned.

Policy lever	Indicative time needed to implement (years)[99]	Policy objective/ impact	Scale of impact	Suitability comments
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[101]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A18.6 Summary of stakeholder feedback

Stakeholders have indicated that the decarbonisation of heat is a complex, multi-faceted issue which will encompass significant efforts with regards to considering consumer engagement, funding, incentives and systemic capacity issues together with dealing with the energy efficiency of the UK's building stock. They suggested that Ecodesign on its own, or any other isolated policy won't provide an adequate solution. A few stakeholders noted the importance of considering lower operating temperatures and system balancing using thermostatic radiator valves in the wet primary circuit in future policy options. This extends to related impacts on heat emitters.

Stakeholders have raised that an Ecodesign regulation for space and water heating is currently undergoing work at EU level and thus an update which results from considerable industry inputs and oversight should be expected shortly. They have also indicated that they would

[101] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

have confidence in the pragmatic outcome of this work, which should influence regulations to be adopted in the UK.

Feedback also noted that energy labels are important to help consumers understand the different performance levels of heat pumps.

A stakeholder noted that the uncertainty of typical industry/ test laboratory measurement instruments, the efficiencies measured using the ErP methodology would need a tolerance in the region of 2 percentage points. This would need to be accounted for during market surveillance activities and could potentially negate benefits of increasing MEPS.

Another stakeholder noted that industry has taken on board circular economy measures and introduced a working group to implement horizontal standards into the boiler test standard (BSEN15502-1xx).

A stakeholder also recommended that hydrogen ready space heaters be within scope of future research.

Boilers and heat pumps were covered extensively in the BEIS Call for Evidence (CfE). Feedback highlighted all the major challenges to the decarbonisation of heat and technology switching, including the existing gas dominated heat market, grid capacity issues around moving to an electricity based heat market, low awareness of alternative technologies, the low-temperature suitability of the GB building stock, need to consider systems approach, affordability of new technologies, inadequate testing procedures, and the low potential for improving efficiency further for gas boilers (whilst noting that reducing boiler cycling and wider modulation are important considerations).

Responses to the CfE also indicated that technology switching via MEPS alone is not necessarily the best approach, as there are other issues like building fabric, geographic location, and the system itself should be considered.

CfE feedback on heat pumps indicated that products currently on the market are more efficient than required by existing Ecodesign regulations, and future MEPS should be made more ambitious. CfE feedback also noted that test procedures could be improved.

A18.7 Discussion & next steps

The main efficiency and decarbonisation gain is expected to come from the technology switching moving from fossil fuel systems, such as boilers to low carbon systems such as heat pumps or potentially heating appliances that have a clean fuel supply.

The analysis has shown that there is still a significant potential for absolute energy savings through performance improvement in gas boilers and increasing the share of heat pumps in the market. This is reflected in a review study of Ecodesign and Energy Labelling for space heating boilers and combination heaters (July 2019), which proposed updated Ecodesign limits and energy efficiency classes.[102] Feedback via the Call for Evidence illustrated the wide variety of other considerations with improving efficiency of heating systems.

Further to this, space heating is subject not only to product-related policy, buildings-related policies are significant for the market (that includes topics like Part L of Future Homes, Future Building Standards, standard Building Regulations, Standard Assessment Procedures), as well as other tools – like zone planning, infrastructure development (gas boilers requiring NG grid). The effort should be well coordinated to avoid sending mixed signals to the public.

Within its Ten Point Plan for a Green Industrial Revolution[103], UK Government signalled its intentions to transition from fossil fuelled boilers to lower carbon more efficient heating alternatives over the next 15 years. Within the Ten Point Plan, UK Government stated its aim for 600,000 heat pump installations every year by 2028. The next significant policy milestone affecting space heating will be the publishing of the Government's Heat and Buildings Strategy, due this year.

Further research should look at heat pump price analysis segmented by product efficiency. UK market share analysis by heat pump efficiency should also take place to help establish a baseline of typical heat pump efficiencies.

A18.8 Evidence sources

Title	Author	Date Published or date accessed
Space and combination heaters Ecodesign and Energy Labelling - Task 5	VHK, Delft (NL)	01/07/2019
Space and combination heaters Ecodesign and Energy Labelling - Task 7	VHK, Delft (NL)	01/07/2019
BSRIA 102184/17 Report United Kingdom Heat pumps 2021.	BSRIA	03/2021
BSRIA 100953/24 Report Domestic boilers market analysis United Kingdom 2020	BSRIA	04/2020
Space and combination heaters Ecodesign and Energy Labelling - Task 2	VHK, Delft (NL)	01/07/2019

[102] https://www.ecoboiler-review.eu/Boilers2017-2019/study-boilers-2017-2019.htm

[103] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

Title	Author	Date Published or date accessed
Evidence Gathering – Low Carbon Heating Technologies	BEIS	Published 11/ 2016. Accessed 28/04/2021
Cost of installing heating measures in domestic properties	BEIS	09/2020
Hybrid Heat Pumps Study	BEIS	04/2018
Energy Technology List - Hot Water Boilers	ICF modelling	unpublished
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020
Heat pump manufacturing supply chain research project	Eunomia for BEIS	November 2020

Annex 19 Heating, Ventilation, Cooling: Water Heaters

A19.1 Introduction

Heating, ventilation, and cooling sub-sector encompasses all residential and non-residential product groups that provide sanitary hot water, heating, cooling or ventilation (or a means to control them) to improve comfort levels in buildings and their surroundings.

Water heaters are used to provide hot water to be used in showers, baths and taps at around 40 to 60 °C. This section provides information on three types of electric powered water heaters: electric instantaneous, electric storage and heat pump water heaters. Electric instantaneous water heaters are typically smaller devices that use electrical resistance to heat water directly for use. Electric storage water heaters use a similar heating process but with the addition of a storage tank, typically used in larger applications. Heat pump water heaters use electricity to move heat from one place (e.g., heat from the surrounding air or ground) to another (water tank) instead of generating heat directly.

Most of the domestic hot water in the UK is generated by fossil fuelled combi boilers (providing both space and water heating). In line with existing product policy, combi boilers are covered by the space heaters section.

Water heaters have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A19.2 Market information

Annual sales of electric instantaneous water heaters (including electric showers) are between 1,200,000 and 1,300,000 per year, of electric storage water heaters is between 120,000 and 130,000 per year and electric heat pump water heaters is approximately 1,800 per year. The market for electric instantaneous, electric storage and heat pump water heaters have a CAGR of 1%, 1% and 15% respectively.

No PRODCOM based import/export/UK production information was found for water heaters.

The main producing countries of electric instantaneous water heaters in the EU and the UK are Germany, Italy, Poland, and the UK. Whereas the main producing countries of electric storage water heaters are France, Germany, and Italy. A trade association noted that the majority of electrically heated water heaters for the UK market are produced in the UK[104].

A19.3 Energy performance information

The typical energy consumption of a unit[105] ranges between 0.4 and 0.5 MWh per year for electric instantaneous water heaters, 0.9 and 1.4 MWh per year for heat pump water heaters, and 1.9 to 3.8 MWh per year for electric storage water heaters.

Instantaneous electric heaters are usually connected to a single outlet such as a shower or a tap and their usage pattern follows strictly the usage profile of hot water at the outlet. Their advantage is that they minimise the amount of water wasted as the hot water is available on demand, without any need to discard water cooled in pipes while the outlet was not used.

Electric storage heaters provide an opportunity to disconnect the water usage pattern from the electricity usage profile. This allows users to heat water using cheaper off-peak electricity and potentially to participate in demand side response schemes. Heat-pump driven water heaters share the same advantages as electric storage heaters, but additionally they offer higher efficiencies due to utilisation of ambient heat (via reversed refrigeration cycle).

There is potential to improve product efficiency and achieve up to 3% savings[106] for electric instantaneous water heaters, 9% savings for electric storage water heaters and 10% savings for heat pumps water heaters[107].

Direct electric heating systems have a very limited potential for performance improvements. The primary cost effective and technically feasible option is supplementing the devices with smarter controls to reduce losses. Heat pump driven water heaters offer more improvement potential in relative terms, but in absolute terms the analysis presented below does not reflect that potential due to the current market size.

[104] A trade association noted UK instantaneous products are limited to single point shower use due to power limitations of a single-phase supply, whereas EU units are often 3 phase high power output units able to supply multiple hot water outlets.

[105] Values based on evidence from the Ecodesign water heaters and storage tanks review study (VHK, 2019)

[106] Based on available products with an energy factor (EF) of 99%.
https://www.stiebel-eltron-usa.com/sites/default/files/pdf/are-you-ready-doe-new-wh-standard.pdf
https://www.energy.gov/energysaver/estimating-costs-and-efficiency-storage-demand-and-heat-pump-water-heaters

[107] Note that this is based on currently available technologies as reported in the Ecodesign space and water heaters review study (2019). Future potential savings could be assessed with further research.

Table A19.1 Energy performance information

	Electric Instantaneous Water Heaters (including electric showers)	Electric Storage Water Heaters	Heat Pump Water Heaters
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	8.25 - 11.52	3.45 - 8.82	lower than 0.01
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.08 - 0.35	0.14 - 0.79	lower than 0.01
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.02 - 0.08	0.03 - 0.17	lower than 0.01
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	1.65 - 2.34	0.75 - 1.8	lower than 0.01
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.02 - 0.07	0.03 - 0.16	lower than 0.01
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0 - 0.02	0.01 - 0.04	lower than 0.01
Benefit Cost Ratio of BAT Savings	0.6	8.6	0.7

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

For Heat Pump Water Heaters, the low sales (around 1,800 units per year) and low energy consumption (900-1,400 kWh/year) result in very low energy consumption and savings in TWh, and consequently low carbon emissions and savings in MtCO2e. On a per unit basis, energy consumption ranges between 14-28 MWh over product lifespan and maximum technical potential savings with BAT range between 0.1-2.8 MWh.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of an electric instantaneous water heater is 17 years[108] and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.06 - 0.19 TWh of energy could be saved as well as 0.01 - 0.04 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.01 - 0.04 TWh of energy and up to 0.01 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of an electric storage water heater is also 17 years. If all units sold annually in the UK in a given year were BAT technologies, 0.08-0.44 TWh of energy could be saved as well as 0.02-0.09 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.02-0.10 TWh of energy and up to 0.02 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A19.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £215 to £3,100. Electric showers are typically priced at £100 to £250.
- **Product weight:** approximately 0.5 kg to 56 kg
- **Lifespan:** 15-20 years
- **Typical duration of the warranty:** 1-5 years

[108] Estimate derived from multiple sources including Ecodesign review study (VHK, 2019).

A19.4.1 Composition of typical product

Table A19.2 Composition of an electric heat pump water heater

Main component	Main materials (weight if available)	Weight (g)	% of total product
Electric Heat Pump water heater	LDPE	1200	2.14%
	HI-PS	2400	4.28%
	PVC	200	0.36%
	Rigid PUR	2600	4.63%
	St sheet galv.	42700	76.11%
	Stainless steel coil	100	0.18%
	Aluminium sheet/extrusion	2100	3.74%
	Copper tube/sheet	2600	4.63%
	Brass cast	900	1.60%
	Powder coating	1300	2.32%
TOTAL		56100	100%

Table A19.3 Composition of an electric instantaneous water heater

Main component	Main materials	Weight (g)	% of total product
Electric Instantaneous water heater	PS	100	9.1%
	PVC	100	9.1%
	PA 6	500	45.5%
	St sheet galv.	100	9.1%
	Copper wire	100	9.1%
	Copper tube/sheet	100	9.1%

Main component	Main materials	Weight (g)	% of total product
	Brass cast	100	9.1%
TOTAL		1100	100%

Table A19.4 Composition of an electric storage water heater

Main component	Main materials	Weight (g)	% of total product
Electric Storage Water Heater	HI-PS	2000	5.03%
	Rigid PUR	2100	5.28%
	St Sheet galv.	31100	78.14%
	Copper tube/sheet	2600	6.53%
	Powder coating	1900	4.77%
	Controller board	100	0.25%
TOTAL		39800	100%

Table A19.5 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in motors (Mostly applicable to heat pump water heaters). NdFeB-magnets may be used in both main and other motors such as in pumping motors,	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
	cooling ventilations, water distribution valves and feeding valves.	treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available

Hazardous substances content

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A19.5 Information on select policy levers and horizontal measures

Ecodesign MEPS and labelling exist for this product group. An impact assessment study is underway and scheduled to complete by November 2021.

Because energy labelling is already in place, most of the policy levers assessed in this study were deemed suitable for this product group.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group. However, an issue of split incentives can occur for water heating

Existing energy related policy levers in UK

- There are Ecodesign MEPS and energy labelling measures for this segment and an impact assessment is underway.
- Building Regulations Part L – Conservation of fuel and power
- MEPS such as the “**Domestic private rented property: minimum energy efficiency standard**” cover this segment.
- Currently, water heaters are covered by the aid in implementation schemes “**Simple Energy Advice website (formerly known as Energy Saving Advice Service)**”, “**Home Energy Scotland**”, and “**Welsh Government Warm Homes Nest scheme**”.
- When it comes to grants and loans water heaters are covered by “**Salix public sector finance - Loan scheme**”.
- They are also covered by the public procurement scheme “**Sustainable procurement: the Government Buying Standards (GBS)** “, the “**Energy Company Obligation (ECO) Affordable Warmth Obligation**”, by the mandatory label “**Energy Performance certificate**”, and by the voluntary labels “**Energy Saving Trust Register**” and “**BREEAM**”.
- Water heaters are listed on the **Energy Technology List**.
- Previously, they were also covered to an extent by the “**Green Deal policy**” and the “**CRC Energy Efficiency Scheme (Streamlined Energy and Carbon Reporting)**”.

Existing circular economy related policy levers

where building owners incur costs and tenants incur benefits. This has been partially addressed by policy levers such as Domestic private rented property: minimum efficiency standards in England and Wales.

Table A19.6 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[109]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Already exist (2)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate for revision. Keep track of progress in EU. Impact assessment to be published in Nov 2021.
Mandatory label (includes enforcement)	Already exist (2)	Information provision / Energy savings	None found	Good candidate for revision. Keep track of progress in EU. Impact assessment to be published in Nov 2021.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards.
Obligation scheme	Already exist	Provision of energy saving technologies / Energy savings	None found	Unlikely to be deployed due to low utilisation of product.
Public procurement	0.5	Prohibit poor efficiency products / Energy savings	None found	Good candidate due to existing labelling and standards. Need to understand effectiveness of this measure.
Communications campaign	Already exist	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Already exist. Potential to increase focus on upgrades in addition to reducing energy bills.
Advice/aid in implementation	Already exist	Information provision – usage and purchasing	None found	Already exist.

[109] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[109]	Policy objective/ impact	Scale of impact	Suitability comments
		high efficiency products / Energy savings		
Grants, subsidies, loans	Already exist	Increase accessibility of high efficiency products / Energy savings	None found	Already exist.
Taxes on poor performing products	1	Reduce purchases of low efficiency products / Energy savings	None found	Suitable but likely to disproportionately affect low-income populations.
Technology deployment & diffusion	1	Encourage uptake of new product / Energy savings	None found	Suitable for technology switching only.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[110]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[110] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A19.6 Summary of stakeholder feedback

Stakeholders have raised that an Ecodesign regulation for space and water heating is currently undergoing work at EU level and thus an update which results from considerable industry inputs and oversight should be expected shortly. They have also indicated that they would have confidence in the pragmatic outcome of this work, which should influence regulations to be adopted in the UK.

Stakeholders also indicated the importance of working with MCLG, who are developing the Future Homes and Future Buildings Standards, to ensure any new policy levers are compatible and provide additionality.

A stakeholder also queried the energy performance and lifetime values used in the study and recommended future research examine these numbers more closely.

A stakeholder queried the exclusion of indirect hot water storage tanks from the analysis and recommended its inclusion.

Stakeholders have indicated that the decarbonisation of heat is a complex, multi-faceted issue which will encompass significant efforts with regards to considering consumer engagement, funding, incentives, and systemic capacity issues together with dealing with the energy efficiency of the UK’s building stock. They suggested that Ecodesign on its own, or any other isolated policy won’t provide an adequate solution. This sentiment was also echoed in the BEIS Call for Evidence responses.

A19.7 Discussion & next steps

The highest emissions reduction potential is available from technology switching rather than incremental improvement to individual technologies. This is reflected in a review study of Ecodesign and Energy Labelling for water heaters and tanks (July 2019), which proposed updated Ecodesign limits and energy efficiency classes.[111]

However, switching from simple electric to heat-pump water storage might not always be feasible. Heat-pump systems require a low temperature heat source (like ambient or ventilation air), and access to such sources may be prohibitively difficult in some building layouts. Stakeholder feedback pointed out that continued decarbonisation of the electricity supply could mean that traditional electric water heaters could be considered a low carbon option, reducing the need for technology switching.

Electric storage water heaters are often used in UK in buildings with electric heat emitters used for space heating. Upgrading both water and space heating at the same time may offer some

[111] https://www.ecoboiler-review.eu/Waterheaters2017-2019/documents-waterheaters-2017-2019.htm

benefits of scale and coordination between the upgrades is worth considering with future policy levers.

Future research should include a review of indirect hot water storage tanks as part of a hot water heating system. It should also use UK based evidence and stakeholder inputs to update the energy performance and lifetime values (currently based on the EU review study of water heater and storage products).

Significant benefits of technology development exist in 'smart' functionality and enabling dynamic demand side response. However, the impacts of this can be difficult to quantify.

Given most of the domestic hot water in the UK is generated by fossil fuelled combi boilers, it is important to consider the policy context from the UK Government's Ten Point Plan for a Green Industrial Revolution[112]. The Government signalled its intentions to transition from fossil fuelled boilers to lower carbon more efficient heating alternatives over the next 15 years. The next significant policy milestone will be the publishing of the Government's Heat and Buildings Strategy, due this year.

A19.8 Evidence sources

Title	Author	Date Published or date accessed
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020
Water Heaters and Storage Tanks Ecodesign and Energy Labelling - Task 2	VHK, Delft (NL)	1 July 2019

112 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

Title	Author	Date Published or date accessed
Water Heaters and Storage Tanks Ecodesign and Energy Labelling - Task 5	VHK, Delft (NL)	1 July 2019
Water Heaters and Storage Tanks Ecodesign and Energy Labelling - Task 7	VHK, Delft (NL)	1 July 2019
Evidence Gathering – Low Carbon Heating Technologies	BEIS	Published 11/ 2016. Accessed 28/04/2021

Annex 20 Heating, Ventilation, Cooling: Split System Air Conditioners

A20.1 Introduction

Heating, ventilation, and cooling sub-sector encompasses all residential and non-residential product groups that provide sanitary hot water, heating, cooling or ventilation (or a means to control them) to improve comfort levels in buildings and their surroundings.

A split system air conditioner is defined as a refrigeration system fixed on two or more mountings to form a matched unit. The system consists of an indoor and outdoor unit connected by a pipe which transfers the refrigerant. The refrigerant absorbs heat at the indoor unit and passes to the outdoor unit. Here a compressor condenses the refrigerant from a gas to a liquid and heat is released. Split systems can be single or multi-split. A multi-split system has several indoor units connected to a single outdoor unit. Air conditioners are used to cool the indoor environment of a building via the refrigeration cycle to a comfortable temperature for occupants. AC units considered in this category are less than 12 kW (of cooling capacity).

Air Conditioners have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A20.2 Market information

Annual sales for split system air conditioners are estimated to be 170,000 – 190,000 units per annum. The market was previously growing with a CAGR of 3%. However, the impact of the Covid-19 pandemic has seen sales of split air conditioners down 8% (BSRIA).

Trade data for window or wall air conditioning systems, self-contained or split systems (28.25.12.20) shows 260,000 units imported to the UK and 40,000 units exported annually. The average number of units produced in the UK annually is 300,000 units.

Most split system air conditioners are manufactured in Japan, Korea, and China. Production is strengthening in US and Europe (Czech Republic, Spain, Italy, and UK).

A20.3 Energy performance information

The typical energy consumption of a unit ranges between 0.6 and 1.4 MWh per year.

Air conditioners are used to cool an inside environment to a comfortable temperature. As such use throughout the year is inconsistent; they are used more in the summer months when temperatures are higher.

There is potential to improve product efficiency and achieve up to 36% savings.

The improvement options available for this technology are as follows. The potential reduction in kWh/yr (%) is shown for each design option. The replacement of refrigerant R410A with R32 would decrease the greenhouse warming potential of the split air conditioning unit. Use of a higher efficiency rotary compressor to one with an Energy Efficiency Ratio (EER) of 3.4 or to use a 3.4 EER rotary compressor with improved oil management (6-8%). This enables the compressor to operate at a lower compression ratio. There is the option to increase the UA value (UA value is defined as the product of the overall heat transfer coefficient and the heat transfer area) of the indoor (8-15%) and outdoor (7-11%) heat exchangers. Use of a micro-channel heat exchanger is also possible for split system air conditioners (2%). Finally, the use of low power modes, such as standby, are options to improve energy efficiency of the product (1%).

Table A20.1 Energy performance information

	Split (Single, Multi and VRF included)
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	1 - 3.24
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.1 - 1.17
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.07 - 0.79
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.2 - 0.72
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.02 - 0.26
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.01 - 0.18
Benefit Cost Ratio of BAT Savings	0.1

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a split air conditioner is 11 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.1 - 0.97 TWh of energy could be saved as well as 0.02 - 0.22 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.07 - 0.66 TWh of energy and up to 0.01 - 0.15 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A20.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £600 to £5,000. Most split system air conditioners approximately at £1,000.
- **Product weight:** approximately 27 kg to 82 kg
- **Lifespan:** 10 – 12 years
- **Typical duration of the warranty:** 5 – 7 years
- **% currently recycled (where available):** Not available. High potential to be recycled due to metal and plastics content (65% metal-based, 18% plastic-based products).

A20.4.1 Composition of typical product

Table A20.2 Composition of typical product – split system air conditioners

Main component	Main materials	Weight (g)	% of total product	Notes
Air Conditioner	Bulk Plastics	5600	15.84%	Breakdown by weight or component not available. Average weight of 35 kg assumed.
	Technical Plastics	700	1.98%	
	Ferrous	15750	44.55%	
	Non-ferrous	8400	23.76%	
	Coating	0	0.00%	
	Electronics	1050	2.97%	
	Misc.	3850	10.89%	
TOTAL		35350	100%	
Packaging	Cardboard			No information on packaging weight found.
	Polystyrene			

Table A20.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in motors	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets).	Technically feasible, but the economic feasibility may be critical under the current economic conditions.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Fluorspar Helium	Cooling mechanisms Refrigeration systems	Helium occurs in small amounts in natural gas deposits and cannot be recovered once lost to the atmosphere. F	No

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Potential presence of refrigerant such as R410A with R32 and others.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A20.5 Information on select policy levers and horizontal measures

This product group is subject to existing Ecodesign and Energy labelling regulations. These regulations are under review and an EC consultation forum took place on 9 September 2019. A revision to this policy could happen relatively soon.

Because energy labelling is already in place, most of the policy levers assessed in this study were deemed suitable for this product group.

It's estimated that product groups with EC MEPS that are being revised will require < 2 years to revise in GB, and that new policy levers (that are not mandatory MEPS or labelling) require 1 year to develop.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

Existing energy related policy levers in UK

- There are Ecodesign and energy labelling rules for this segment and a revision is expected soon.
- Currently, when it comes to grants and loans air conditioners are covered by the "**Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme**", and the "**Salix public sector finance - Loan scheme**".
- They are also covered by the public procurement scheme "**Sustainable procurement: the Government Buying Standards (GBS)**".
- Previously, they were also covered to an extent by the "**CRC Energy Efficiency Scheme (Streamlined Energy and Carbon Reporting)**".

Existing circular economy related policy levers

- None identified.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A20.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[113]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	< 2 (Revision underway)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate for revision. Keep track of progress in EU.
Mandatory label (includes enforcement)	< 2 (Revision underway)	Information provision / Energy savings	None found	Good candidate for revision. Keep track of progress in EU.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards.
Obligation scheme	1	Provision of energy saving technologies / Energy savings	None found	Unlikely to be deployed due to low utilisation of product.
Public procurement	Already implemented	Prohibit poor efficiency products / Energy savings	None found	Need to understand effectiveness of this measure.
Communications campaign	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate, low cost/effort to include in existing/new policy lever.
Advice/aid in implementation	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate, low cost/effort to include in existing/new policy lever.
Grants, subsidies, loans	1	Increase accessibility of high efficiency products / Energy savings	None found	Unlikely to be deployed due to low utilisation of product.

[113] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[113]	Policy objective/ impact	Scale of impact	Suitability comments
Taxes on poor performing products	1	Reduce purchases of low efficiency products / Energy savings	None found	Unlikely to be deployed due to low utilisation of product.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings.	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	< 2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[114]	< 2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A20.6 Summary of stakeholder feedback

In Task 3, stakeholders were asked to comment on a short list of products. One stakeholder thought that air conditioners should not be on the short list. This is because they think most of the carbon impact of the product comes from installation and operation during its life. They see

[114] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

little benefit in introducing resource efficiency measures at this stage and consider it more important to focus on the performance of the product throughout its lifecycle.

In the BEIS Call for Evidence (CfE), stakeholders were asked if better MEPS than those which currently apply could be set for space cooling to save more energy in the UK and facilitate a transition towards net zero. Eleven responses came from a range of stakeholders, including a trade association, a manufacturer, a research organisation, an NGO, and members of the public. Nine out of eleven respondents thought there was room for improvement, with most citing 3-5 years for improvement. Feedback from stakeholders indicated that the UK's exit from the EU presented an opportunity to introduce more ambitious MEPS. It was suggested that the UK should adopt some of the measures currently being considered in the review of EC air conditioning and comfort fan regulation. One stakeholder mentioned that energy efficiency of air conditioners could be improved by using flammable refrigerants paired with new and improved safety measures and components. Two stakeholders did not consider there was room for improving MEPS, citing improved performance of the sector over the past 10 years.

Stakeholders were also asked in the CfE if better resource efficiency measures could be set under Ecodesign regulations. Out of seven respondents, six responded yes. The PAS 2050 resource efficiency related standard was raised as an example, and a stakeholder noted that components of air conditioners such as refrigerants, non-ferrous metals and rare earth metals have potential to be recycled. It was noted that similar resource efficiency requirements as those which exist for washing machines and dishwashers should be introduced for air conditioners. It is expected introduction of these measures would take up to 5 years.

A20.7 Discussion & next steps

The UK is a relatively small portion of the global air conditioning market, with many countries much more interested in the technology due to climate conditions (with Japanese and US companies leading). The UK typically has a short season for air conditioning compared to countries in warmer climates.

Preliminary proposals of updated regulations were issued in July 2019, with recommendations to widen the scope to include ventilation exhaust air-to-air heat pumps and air conditioners with heating or cooling capacity under 12kW[115]. Increased MEPS and energy efficiency class ambition levels and sound power restrictions are also being proposed.

Many air conditioners (almost all sold in the UK) have an option for reverse operation as a heat pump. Users in the UK may use heating more than the cooling function. Detailed usage profiles of various end-user groups should be analysed to improve the evidence base.

There is an ongoing significant regulatory change regarding F-Gas usage that impacts devices performance, cost structure and maintenance habits. Future policy levers need to take the F-Gas regulatory developments into account.

[115] https://www.eceee.org/ecodesign/products/airco-ventilation/

A20.8 Evidence sources

Title	Author	Date Published or date accessed
BSRIA Split Systems Air Conditioning Report (2017)	David Garwood	February 2018
Air Conditioners and Comfort Fans Preparatory Study	Viegand Maagøe and ARMINES	May 2018
BSRIA Split Systems Air Conditioning Report (2020)	BSRIA	April 2020
Daikin Product Website		March 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 21 Heating, Ventilation, Cooling: Heat Emitters

A21.1 Introduction

Heating, ventilation, and cooling sub-sector encompasses all residential and non-residential product groups that provide sanitary hot water, heating, cooling or ventilation (or a means to control them) to improve comfort levels in buildings and their surroundings.

A heat emitter is a convector (commonly known as a radiator) consisting of a metal frame which heated water or oil is passed through. The frame is usually made from steel, aluminium or cast iron. As the fluid is passed through the structure, its heat is transferred to the environment via convection. Heat emitters are used to heat indoor spaces and provide a comfortable temperature of the indoor environment. This assessment only considers heat emitters that are part of a central heating system that is fed by gas boilers or heat pumps. Standalone heaters are not included.

A21.2 Market information

Annual sales of heat emitters fed by gas boilers are 7,600,000 – 8,000,000 units. For heat emitters fed by heat pumps, annual sales are 300,000 – 370,000 units. The market is slowly growing with a CAGR of 3.8%.

Around 75% of the UK's radiators were imported from Turkey, with the remainder manufactured mostly in the UK, Poland, and China[116].

A21.3 Energy performance information

As heat emitters do not directly consume energy and are part of the wider heating system, there are challenges in isolating energy savings which can be attributed directly to heat emitters. For this reason, estimates of baseline energy consumption have not been included.

Whilst heat emitters are not energy consuming products in and of themselves, they have a key role to play in the overall efficiency of a heating system. Improving the performance of heat emitters has the potential to reduce the energy demand of the connected gas boiler or heat pump. This would lead to overall lower carbon emissions from the heating system.

Designing a low temperature heating system with suitable heat emitters provides efficiency improvements to the whole system for both boilers and heat pumps. For condensing boilers, by

116 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/976021/beis-dhds-final-report__1_.pdf

operating at low temperature, the return temperature is maintained at a level to maximise the time the boiler spends in condensing mode. For heat pumps, lowering the flow temperature reduces the difference between the source temperature of the heat pump and therefore increases the coefficient of performance (COP).

Heat emitters can contribute to efficiencies to the whole heating system by being able to effectively distribute heat at lower temperatures. With a more effective convector (e.g., new smaller convectors are designed to have greater surface area, and lower water content), they heat up more quickly, reducing the heat source (boiler or heat pump) operational time and associated energy consumption, thus improving efficiency.

A21.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £50 to £400.
- **Product weight:** approximately 20 kg to 50 kg
- **Lifespan:** 20-50 years
- **Typical duration of the warranty:** 10 - 15 years
- **% currently recycled (where available):** no exact information. Expect 90-95% of the heat emitter to be recycled as is composed of cast iron, steel, and copper components.

A21.4.1 Composition of typical product

No information found on the typical composition of a heat emitter.

Hazardous substances content

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Potential presence of Bisphenol A (BPA) in pipes.

A21.5 Information on select policy levers and horizontal measures

Ecodesign MEPS and labelling do not exist for this product group. They are under consideration in the latest EC Ecodesign Workplan study.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group. However, an issue of split incentives can occur for space heating where building owners incur costs and tenants incur benefits. This has been partially addressed by policy levers such as Domestic private rented property: minimum efficiency standards in England and Wales.

Existing energy related policy levers in UK

- Although it is under consideration, there are no Ecodesign rules for this segment.
- Currently, heat emitters are covered by the aid in implementation schemes "**Simple Energy Advice website (formerly known as Energy Saving Advice Service)**", and "**Home Energy Scotland**".
- When it comes to grants and loans heat emitters are covered by the "**Green Homes Grant**" (now ended), "**Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme**", and the "**Salix public sector finance - Loan scheme**".
- They are also covered by the mandatory label "**Energy Performance certificate**" and the "**Energy Company Obligation (ECO) Affordable Warmth Obligation**" as they are part of a heating system.

Existing circular economy related policy levers

- None identified.

The time estimates related to the policy lever are based on an assumption that it is necessary to have performance standards or labelling in place to select the best performing heat emitters. However, its acknowledged that some products can be considered 'clear winners' (such as underfloor heating versus wall mounted radiators). Having 'clear winners' could reduce down the time needed to develop and implement new policy levers.

Table A21.1 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[117]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Potential candidate. Keep track of progress in EU.
Voluntary endorsement label	1.5	Information provision / Energy savings	None found	Potential candidate but needs energy performance test standards.
Obligation scheme	0.5	Provision of energy saving technologies / Energy savings	None found	Suitable option for energy supplier to provide to residential customers.
Public procurement	2-4	Prohibit poor efficiency products / Energy savings	None found	Requires MEPS or labelling. Need to understand effectiveness of this measure.
Communications campaign	2-4	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Requires MEPS or labelling. Good candidate, low cost/effort to include in existing/new policy lever.
Advice/aid in implementation	2-4	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Requires MEPS or labelling. Good candidate, low cost/effort to include in existing/new policy lever.
Grants, subsidies, loans	0.5	Increase accessibility of high efficiency products / Energy savings	None found	Relevant alongside space heating measures as technology switching may require upgrades to heat emitters.
Taxes on poor performing products	4	Reduce purchases of low efficiency	N/A	Requires MEPS or mandatory labelling. Suitable but likely to

[117] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[117]	Policy objective/ impact	Scale of impact	Suitability comments
		products / Energy savings		disproportionately affect low-income populations.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[118]	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A21.6 Summary of stakeholder feedback

In Task 3, one stakeholder felt that local space heaters should have been included on the short list. They noted that they anticipate a dramatic increase in uptake of heat pumps to replace gas boilers. This is something we have considered through separation of heat emitters into gas boiler fed and heat pump fed units.

[118] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

In Task 4, stakeholder feedback noted the exclusion of underfloor heating (UFH) from this analysis. They highlighted the importance of considering UFH as part of future analysis due to their lower operating temperatures (commonly 35 deg C) and usefulness as a thermal store.

Heat emitters were covered in the BEIS Call for Evidence with stakeholders noting that they are critical to the performance of heating systems. A focus on low temperature heat emitters as components of more efficient heating systems was stressed, and that lowering maximum flow temperatures could bring big saving.

A21.7 Discussion & next steps

The UK's building stock is relatively old with most buildings designed to be heated with a high temperature medium. Redesigning the systems to accommodate low-temperature (35-45°C) heating systems could prove challenging and incur additional costs (new heat generator, piping, fitting larger emitters). Emitters have a long lifespan, so a long-term strategy is needed.

There are significant installation costs, particularly when transitioning from a wall-based system to an UFH based system. However, costs can be mitigated if UFH systems are installed as part of a larger home renovation or construction of a new build home.

There is significant inter-dependence with space heaters policy, and it is recommended to explore policies linking these two categories of products. Emitters are part of the larger heating system and it is important to keep in mind that in isolation, they do not offer any savings potential. Efficiency depends on correct system specification and sizing, correct installation, regular maintenance and use of controls. Further research, inclusive of UFH, would need to be undertaken to assess if MEPS or other ecodesign requirements would be a suitable option.

It is important to consider the policy context from the UK Government's Ten Point Plan for a Green Industrial Revolution[119]. The Government signalled its intentions to transition from fossil fuelled boilers to lower carbon more efficient heating alternatives over the next 15 years. This will clearly influence the heat emitters product group. The next significant policy milestone will be the publishing of the Government's Heat and Buildings Strategy, due this year.

A21.8 Evidence sources

Title	Author	Date Published or date accessed

119 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/936567/10_POINT_PLAN_BOOKLET.pdf

Domestic Heat Distribution Systems: Evidence Gathering	BEIS Research Paper 2021/015	February 2021
Radiator and Boiler Manufacturing in the UK	IBIS World	October 2020
Global Heating Radiator Market	Grand View Research	August 2019
World Heating: Radiators & Underfloor Heating 2018/19	BSRIA	2018
https://www.nottinghamshire.gov.uk/waste-and-recycling/recycling-and-disposing-of-waste/how-to-recycle-or-dispose-of-common-waste-items		April 2021
ETL – Hot Water Boilers	ICF modelling	unpublished
How Often Should Radiators be Replaced?	Ant Langston	June 2018
Regulation 811/2013	European Commission	February 2013
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 22 ICT: Servers

A22.1 Introduction

Information and communication technologies (ICT) product groups can be used in residential and non-residential end uses. They enable the use and transfer of digital and analogue information. They also include the ancillary equipment needed to operate and maintain ICT equipment (apart from power requirements).

A computer server is defined as a computing product which provides services and manages networked resources for client devices (such as other computers, smartphones or tablets). Server computers do not have direct user input devices, such as a keyboard or a mouse, and are controlled by client devices via network connections.

Servers are by definition connected to the internet and hence have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A22.2 Market information

The UK annual sales of server computers are estimated 1.2 million units. This market is expected to continue growing at a rate of 3-5% a year.

3 codes have been identified as potentially containing server products (these could also be used as components to other products):

- 26.20.14.00 Digital data processing machines: presented in the form of systems:
- Import: 3,169,081
- Export: 820,408
- Production: 2,312

26.20.15.00 Other digital automatic data processing machines whether or not containing in the same housing one or two of the following units: storage units, input/output units:

- Import: 8,056,486
- Export: 5,633,968
- Production: 384,401

26.20.16.60 Other input or output units, whether or not containing storage units in the same housing:

- Import: 82,393,282
- Export: 9,234,456

- Production: 1,034,088

Many servers will be running in dedicated facilities, with dedicated internet connectivity, power supply and temperature control. These facilities are commonly referred to as Datacentres. Other servers in non-dedicated facilities such as offices, are denominated as “distributed IT”. The two major trends of the server industry have been for centralisation (the move to dedicated server centres), and the maximisation of server usage, minimising the idle time of the servers.

Servers permit the running of the digital economy, which in 2013 was estimated at 10% of the UK GDP. One of the notable industries supported by this development of data capability is the financial industry. Approximately 60% of Europe’s data services are held in the UK, with London seen as the second largest data centre cluster in the world, after Virginia. London benefits from first mover advantage as the industry started developing here 18 years ago.

The global manufacturing market for enterprise servers is dominated by five key manufacturers: HPE, Dell, Lenovo, Cisco and IBM (in that order). Together, they account for approximately 66% of the global server market. The UK proportion of the global server manufacturing market is consequently very modest and mainly an SME market serving a more bespoke, high-end market. Two examples are “Broadberry Data systems” and “Novatech”.

A22.3 Energy performance information

The typical energy consumption of a unit ranges between 1.1 and 2.1 MWh per year.

Server computers are continuously “on”, either in an “idle” state where they are not delivering any work, or actively computing providing calculations, answering internet queries, or storing information. It is therefore crucial for servers to be always connected to a power source and have a continual internet connection.

As servers are computer devices, they are under constant performance improvement under Moore’s law. This means the average device is becoming more powerful, or capable of performing more calculations. Although this means that the device is likely to also consume more power, this relationship is not linear. In this fashion, as the technology improves, each machine delivers more calculations, which results in more work done, per unit of energy spent. For this reason, servers have a short average lifecycle as devices are being continually replaced with new products capable of delivering more work for less power.

Servers can also benefit from using the most efficient components, such as Central Processing Units (CPUs), and power supplies. They can also benefit from features to ramp down energy use at low workloads.

There is potential to improve product efficiency and achieve up to 30% savings. It is important to note that this estimate is based on the average consumption of a server on a product basis. Total energy consumption of data processing can be further improved with better utilisation techniques (such as virtualisation) along with server host facilities consumption on cooling, communication equipment and power conversion.

Table A22.1 Energy performance information

	Distributed IT	Datacentres
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.92 - 2.04	6.16 - 13.8
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.03 - 0.61	0.18 - 4.14
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.01 - 0.25	0.07 - 1.66
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.2 - 0.42	1.28 - 2.82
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.01 - 0.13	0.04 - 0.85
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0 - 0.05	0.02 - 0.34
Benefit Cost Ratio of BAT Savings	0.9	1.3

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a distributed IT server is 5 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.06 - 1.02 TWh of energy could be saved as well as 0.02 - 0.21 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.02 - 0.41 TWh of energy and 0.01 - 0.08 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a datacentre server is 5 years. If all units sold annually in the UK in a given year were BAT technologies, 0.45 - 6.9 TWh of energy could be saved as well as 0.1 - 1.41 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.18 - 2.77 TWh of energy and 0.04 - 0.57 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A22.4 Baseline resource efficiency information

Resource footprint

- **Average price:** Distributed IT servers from £926 - £4,547; Datacentre servers from £1,428 - £24,461
- **Product weight:** approximately 10 kg to 190 kg
- **Lifespan:** 4 to 6 years
- **Typical duration of the warranty:** 3 years
- **% currently recycled (where available):** 5 – 45% [120]

A22.4.1 Composition of typical product

Table A22.2 Composition of typical product – rack servers

Main component	Main materials	Weight (g)	% of total product
Chassis	Metal body (steel)	12265	53.07%
	Plastics (ABS)	348	1.51%
	Plastics (PC)	282	1.22%

[120] Server recyclability may be difficult to define as B2B industry stakeholders have increased circularity traits, recovering particular elements from servers when upgrading systems.

Main component	Main materials	Weight (g)	% of total product
	Aluminium	249	1.08%
	Copper	179	0.77%
	Electronic components (capacitors, inductors, printed circuit, resistors, transformers, transistors)	131	0.57%
Fans	Steel	386	1.67%
	Copper	78	0.34%
	Iron based	55	0.24%
	Plastic (PBT-GF30)	296	1.28%
	Plastic (PCABSFR40)	21	0.09%
	Plastic (undefined)	200	0.87%
HDDs	Steel	12	0.05%
	Low alloyed steel	222	0.96%
	Aluminium	1335	5.78%
	PCB (electronics)	179	0.77%
ODD	Low alloyed steel	115	0.50%
	Copper	7	0.03%
	Aluminium	1	<0.00%
	High Density Polyethylene (HDPE)	28	0.12%
	Acrylonitrile-Butadiene-Styrene (ABS)	12	0.05%
	Polycarbonate (PC)	7	0.03%
	Electronic components (capacitors, inductors, printed circuit, resistors, transformers, transistors)	8	0.03%
	Solder	2	0.01%

Main component	Main materials	Weight (g)	% of total product
	PCB (electronics)	9	0.04%
Mainboard	Electronic components (capacitors, inductors, printed circuit, resistors, transformers, transistors)	1667	7.21%
PSUs (2)	Low-alloyed steel	1027	4.44%
	Chromium steel	66	0.29%
	Brass	42	0.18%
	Copper	9	0.04%
	Zinc	7	0.03%
	Aluminium	491	2.12%
	High Density Polyethylene (HDPE)	184	0.80%
	Polyvinylchloride (PVC)	92	0.40%
	Paper	50	0.22%
	Electronic components (capacitors, inductors, printed circuit, resistors, transformers, transistors)	1101	4.76%
	Solder	31	0.13%
	PCB	326	1.41%
PCB (expansion card/other)	Electronic components (capacitors, inductors, printed circuit, resistors, transformers, transistors)	349	1.51%
Cables	Brass	7	0.03%
	Copper	81	0.35%
	Zinc	96	0.42%
	High Density Polyethylene (HDPE)	104	0.45%
	Polyvinylchloride (PVC)	145	0.63%

Main component	Main materials	Weight (g)	% of total product
	Polyurethane (PUR)	2	0.01%
	Synthetic rubber	35	0.15%
CPUs (2)	Copper	30.5	0.13%
	Gold	0.4	<0.00%
	PCB	21.2	0.09%
	IC	1.9	0.01%
CPU Heat Sinks	Copper	442	1.91%
	Steel	140	0.61%
Memory	PCB	97	0.42%
	IC	38	0.16%
TOTAL		23110	100%
Packaging	Cartons	3629	packaging not accounted for in % analysis
	HDPE/ other plastics	78	
	Styrofoam	1,026	

Table A22.3 Composition of typical product – Blade System

Main component	Main materials (weight if available)	Weight (g)	% of total product
Chassis	steel	87000	55.49%
4 x PSU	Low-alloyed steel	4981	3.18%
	Chromium steel	319	0.20%
	Brass	202	0.13%
	Copper	43	0.03%
	Zinc	32	0.02%

Main component	Main materials (weight if available)	Weight (g)	% of total product
	Aluminium	2384	1.52%
	High Density Polyethylene (HDPE)	894	0.57%
	Polyvinylchloride (PVC)	447	0.29%
	Paper	245	0.16%
	Electronic components (capacitors, inductors, printed circuit, resistors, transformers, transistors)	5343	3.41%
	Solder	149	0.10%
	PCB	1581	1.01%
6 Fans	Steel	964	0.61%
	Copper	194	0.12%
	Iron based	137	0.09%
	Plastic (PBT-GF30)	515	0.33%
	Plastic (PCABSFR40)	52	0.03%
	Plastic (undefined)	499	0.32%
8 Blade Servers, Top and Bottom Chassis, Drive cage, system board tray	Steel	33600	21.43%
Mainboards	Electronics	6451	4.11%
CPUs (16)	Copper	244.1	0.16%
	Gold	3	0.00%
	PCB	170	0.11%
	IC	15	0.01%
CPU heat sinks	Copper	1688	1.08%

Main component	Main materials (weight if available)	Weight (g)	% of total product
	Steel	560	0.36%
Memory	PCB	773	0.49%
	IC	307	0.20%
HDDs (8*2 per server)	Steel	47	0.03%
	Low alloyed steel	888	0.57%
	Aluminium	5341	3.41%
	PCB	717	0.46%
TOTAL		156785.1	100%
Packaging	Cartons	14969	packaging not accounted for in % analysis
	HDPE	321	
	Styrofoam	4233	

Table A22.4 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in Hard disc drive	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Content in Hard Disc Drive (in mass): 60 mg Dy; 1 044 mg Nd; 145 mg Pr [121]. For the liberation of NdFeB-magnets from Hard disc drive, Hitachi developed a process[122] in Japan. In the EU, so far, no specific pre-treatment processes are in practice for WEEE containing NdFeB-magnets. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available).

[121] Preparatory study for implementing measures of the Ecodesign Directive 2009/125/EC DG ENTR Lot 9 - Enterprise servers and data equipment – Task 5: Environment & Economics
[122] Rare-earth Magnet Recycling

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinyl chloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A22.5 Information on select policy levers and horizontal measures

This product group is subject to existing Ecodesign regulations but does not have comprehensive test standards. A mandate to create one was issued in January 2021 (M573).

It’s estimated that product groups with EC MEPS would require 2 years to revise in GB, and that new policy levers (that are not mandatory MEPS or labelling) require 1 year to develop.

Regarding the horizontal measures, it is assumed that ‘Requirements for material content and declaration’ and a ‘Mandatory minimum warranty/guarantee’ can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, ‘Modular design’ and ‘Product support requirements’ would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

Existing energy related policy levers in UK

- There are established Ecodesign rules for this segment.
- Currently, servers are covered by the “**Salix public sector finance - Loan scheme**”.

Existing circular economy related policy levers

- Ecodesign regulation mandates that manufacturers ensure product can be disassembled for repair/reuse, functionality for secure data deletion and firmware availability.

There are seemingly no direct trade-offs anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group. However, there could be an indirect effect on energy performance of servers as increased lifetime could lead to a lower product replacement rate. This could result in the use of less efficient servers, as their performance increases significantly on a year-on-year basis.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A22.5 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[123]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Recently updated (2)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Recently updated.
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	No existing standards. Uncertain suitability as non-domestic end-use.
Voluntary endorsement label	1.5	Information provision / Energy savings	None found	No existing standards. Could be suitable to enable other policy levers.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier to provide to residential customers.
Public procurement	2	Prohibit poor efficiency products / Energy savings	None found	Requires labelling of some sort. Need to understand effectiveness of this measure.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings.	N/A	Not suitable option as it's a non-domestic product.
Advice/aid in implementation	1	Information provision – usage and purchasing high	None found	Candidate for sector specific new policy lever.

[123] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[123]	Policy objective/ impact	Scale of impact	Suitability comments
		efficiency products / Energy savings		
Grants, subsidies, loans	Already exist	Increase accessibility of high efficiency products / Energy savings	None found	Already exist
Taxes on poor performing products	4	Reduce purchases of low efficiency products / Energy savings	None found	Candidate but requires mandatory labelling to identify poor performers.
Technology deployment & diffusion	1	Encourage uptake of new product / Energy savings	None found	Relates to innovative methods for cooling servers.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[124]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[124] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A22.6 Summary of stakeholder feedback

A trade association objected to Servers being included within the Task 3 shortlist - they were surprised that products so recently regulated by the EU, and negotiated by the UK, were still shortlisted. They argued such products should have less weighting compared with those that have not been subject to recent regulation.

A trade association recommended the following policy measures for servers - adoption of Energy Star and revisiting EU Ecodesign minimum standards.

On the latter, a trade association noted that the current Ecodesign measure for servers posed a challenge going forward due to the mandatory minimum Idle Power thresholds that have been imposed and considered to be an energy efficiency parameter. The industry has previously emphasised that Idle Power is not a good proxy for energy efficiency of server technology and requested its removal from the regulation. A trade association stated that because idle power was not removed some very efficient server products have been withdrawn from the European market. Industry would recommend the issue of Idle Power is revisited and studied not on the premise that too many servers sit “Idle” for a substantial amount of time and therefore are “wasting energy” but on an up to date understanding of a typical server deployment that takes into account the whole market.

Stakeholders indicate that for any material efficiency or performance requirements, a product-specific approach should always prevail, as it is the most effective and robust approach, and to avoid the pitfalls of a one-size-fits-all approach to product policy. They urge that dedicated studies should consider the specific opportunities to each product group, and in respect to B2B and B2C products.

There was no reference to this product group within the summary of responses to the ErP Call for Evidence.

A22.7 Discussion & next steps

Servers and data storage products are subject to Ecodesign requirements which were published in 2019. In line with the new regulation, the suite of accompanying existing standards need to be updated to align with the new requirements. That is the task covered by the recent new standards mandate issued by the Commission, M573.

The main point of contention in the existing Ecodesign regulation 2019/424 is the idle power requirement. Industry have voiced that improving idle power requirements detracts from the larger potential gains from active efficiency. However, this view may not account for Distributed IT performances which do not use the latest technologies or power management techniques.

As denoted in the category introduction, servers are operated as “Distributed IT” for servers in non-dedicated facilities or operated from dedicated server facilities of “datacentres”. For servers in “distributed IT”, their operation is likely to not be tracked individually, with their energy consumption, internet connection and temperature control likely to be covered under the rest of the facilities consumption. For servers operated in datacentres, all aspects of their operation are monitored: their operation state, their energy consumption, their internet connection and temperature. This is critical for energy consumption, as it is the largest contributor to the operating costs of datacentres, varying from 25-60% of the data centre running costs. Most of this consumption is from the servers and cooling the premises, which are both directly related to the efficiency of individual servers, as servers using more energy will release more heat. Datacentres will therefore prioritise efforts to optimise the performance of their servers and the cooling of their buildings. Therefore, datacentre operators are incentivised to purchase newer more efficient servers, and use “virtualisation” of servers which reduces the idle time of each device, hence increasing energy efficiency.

Energy Star, the voluntary energy efficiency label in the US, already has a performance label for servers. The SERT (Server Efficiency Rating Technology) methodology in the US was developed for Energy Star to measure the energy efficiency of servers in active delivery.

As the MEPS are quite recent, their review should only be considered once their effects have been verified. This is critical for the idle performance requirements of current MEPS, which were included to increase the efficiency of “Distributed IT” but, as is argued by some may decrease the efficiency of datacentres. If this upward trend towards datacentres continues, idle power should be reviewed. Rather than developing policy options for servers, greater efficiencies could be found by improving the cooling (or recuperating the heat) from datacentres.

Due to the short lifecycle, growing market and critical raw materials content for servers, material efficiency measures could be considered to increase the recuperation and material recycling of servers.

As indicated in the market information section, the UK is a world leader in datacentre technology, to which servers are integrally linked. One of the reasons for this is because of the reliance of the financial industry on data, which allowed the UK to benefit from “first mover advantage”. The UK datacentre market is therefore ahead of other countries, with efficiency trends such as the shift towards datacentres and virtualisation more developed than in other countries. However, as the EU has a requirement for data to be stored within the EU, datacentre capabilities are starting to develop in the EU to account for the departure of the UK from the block. This is unlikely to lead to a decrease of datacentre market and capabilities of the UK in the short term but may result in increased competition from EU countries.

A22.8 Evidence sources

Title	Author	Date Published or date accessed
The 4.2 Trillion Opportunity: The Internet Economy in the G-20 https://www.bcg.com/documents/file100409.pdf	Boston Consulting Group	2013
Ecodesign preparatory study on enterprise servers and data equipment https://op.europa.eu/en/publication-detail/-/publication/6ec8bbe6-b8f7-11e5-8d3c-01aa75ed71a1	Deloitte	2016
Silver Linings: The implications of Brexit for the UK Data Centre Sector. http://www.techuk.org/insights/reports/item/9554-silver-linings-the-implications-of-brexit-for-the-uk-data-centre-sector	Tech UK	2018
IDC dataset https://www.idc.com/getdoc.jsp?containerId=prUS41969816	IDC	2018
Energy Star Enterprise servers https://www.energystar.gov/products/data_center_equipment/enterprise_servers	Energy Star	2021
Servers Ecodesign, EUPP modelling 2018	ICF modelling	unpublished
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020
Regulation on ecodesign requirements for servers and data storage products EU 2019/424	Official Journal of the European Union	18.3.2019

Annex 23 ICT: Smart Phones

A23.1 Introduction

Information and communication technologies (ICT) product groups can be used in residential and non-residential end uses. They enable the use and transfer of digital and analogue information. They also include the ancillary equipment needed to operate and maintain ICT equipment (apart from power requirements).

The main technical feature of smart phones is the radio interface. It allows for voice and data communication over a cellular radio network, which is provided by a telecommunication network operator. To get access to the telecommunication network, a subscriber identity module (SIM) must activate in the mobile device.

Smart phones can serve a non-quantifiable amount of functions, including: gaming, navigation, recording, editing and playing videos, music, and other audio, dictation, messaging, data storage of any kind, chemical and biochemical analysis, level, distance measurements, noise level measurements, object recognition, online purchases, interior planning, engineering planning, home and other automation control, office programs, tracking of contacts to control spread of diseases, torch, mirror, magnifying glass, microscopy and many more.

The use is highly individual since the customer can select and adjust specific functionalities by installing application software (apps) from various sources (app stores, etc.). The individual software configuration may influence the energy consumption and battery life but does not change the main function which is the basic voice and data communication over a cellular radio access or other wireless telecommunication network.

A23.2 Market information

The total annual sales in the UK market for smart phones is around 14,040,000 units.

The market growth rate is expected to be approximately 3% in 2021 and 2022, but under 1 % in 2024 and 2025.

Manufacturers of registered smart phones include Apple and Samsung are registered in several EU countries: Belgium, Finland, France, Germany, Netherlands, Poland, Portugal, Spain, and Sweden.

Trade information was found under HS6 code: 26.30.22.00 “telephones for cellular networks or for other wireless networks”. Imports, exports, and production for the UK are as follows:

Imported units: 28,868,499

Exported units: 5,918,220

Produced units (latest data from 2018): 252,997

A23.3 Energy performance information

No energy performance information has been estimated for smart phones. This product group has been included in the shortlist due to the materials and circular economy criteria. Task 6, of the European Commission Ecodesign preparatory study finished in March 2021, identified three energy Design Options: Extended battery endurance per full charge (through battery size and energy-efficiency measures of the smartphone) and Eco-DECT (which reduces the radiation power of a handset based on demand or distance to base station). The preparatory study did not model for these design options under task 7 modelling under the assumption that most smart phones are already optimised in these ways by market incentive. Task 2 of the preparatory study indicated that the leading purchasing criteria for smartphones is a “long-lasting battery life”, supporting the market incentive for efficiency.

A23.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £297 to £364.
- **Product weight:** approximately 0.112 kg to 0.328 kg
- **Lifespan:** 3-4 years
- **Typical duration of the warranty:** N/A
- **% currently recycled (where available):** 1.5%

A23.4.1 Composition of typical product

Table A23.1 Composition of typical product – smart phones

Main component	Main materials	Weight (g)	% of total product
Body	Aluminium	22.18	13.86%
	Copper	15.12	9.45%
	Plastics	9.53	5.96%
	Magnesium	5.54	3.46%
	Cobalt	5.38	3.36%
	Tin	1.21	0.76%

Main component	Main materials	Weight (g)	% of total product
	Iron (steel)	0.88	0.55%
	Tungsten	0.44	0.27%
	Silver	0.31	0.19%
	Neodymium	0.05	0.03%
	Gold	0.03	0.02%
	Tantalum	0.02	0.01%
	Palladium	0.01	0.01%
	Praseodymium	0.01	0.01%
	Indium	0.01	0.01%
	Yttrium	0.0004	<0.00%
	Gallium	0.0004	<0.00%
	Gadolinium	0.0002	<0.00%
	Europium	0.0001	<0.00%
	Cerium	0.00003	<0.00%
	Others (ceramics, semiconductors)	99.29	62.05%
TOTAL		160.0111	100%

Table A23.2 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Antimony, Cadmium, Cobalt, Lead, Lithium, Graphite,	Anode Cathode	The EU produces only 1% of all battery raw materials overall.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Phosphorus and Nickel[125]		For lithium-ion (Li-ion) batteries, used in smart phones, Cobalt in the cathode can be collected and reused/ recycled. In batteries, the recovery procedure is efficient and these secondary sources of cobalt cost less than raw cobalt extraction. For the Li-ion batteries, there are environmental, political and social impacts of mining activities where most of the world's cobalt is sourced from. Recycling rate for lithium is less than 1%. Battery Directive 2006/66/EC includes target for member states for minimum collection rates of 45% by 26 September 2016. The EU collection rate was 43.6% with the UK achieving 44%[126]	
Gold, Silver, Bismuth, Palladium, Gallium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that	Yes

125 Annex VII of the WEEE Directive requires the removal of batteries because they are considered hazardous waste.

126 Evaluation report of the Batteries Directive, April 2019.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters. Gallium is used in semiconductors in integrated circuits (about 40 %), in smartphones or wireless communication. No effective substitutes for gallium in semiconductors because other components do not meet the high performance of the actual systems.	
Indium	Displays/ Screens (Organic LED)	OLED displays are commonly used in smart phones. OLEDs use organic molecules to emit light instead of Rare Earth Elements. These are expected to eliminate the need for CRM except for indium. Indium is used in indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. No recycling of indium from EoL products.	No. A few candidates to replace indium in ITO, but not yet commercially available.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Antimony	Plastic casing and flame retardants.	Antimony used in flame retardants is not recoverable as it is diffused in the product. Antimony is particularly hard to substitute in its main application as a flame retardant.	No

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins

Potential presence of Bisphenol A (BPA) in the screen, and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

Potential presence of hazardous in the batteries (lead, cadmium, lithium, mercury, and graphite).

Li-ion batteries can cause significant waste fires if they are punctured or damaged during transit (during end-of-life processes).

A23.5 Information on select policy levers and horizontal measures

Smart phones have been excluded from the energy related policy lever analysis as they are already optimised for energy efficiency. Regarding the horizontal measures, it is assumed that all 4 shortlisted measures can be implemented independently.

Modular design, product support and mandatory minimum warranty/guarantees would all benefit this product group as longer lifetimes are the most important aspect to reduce overall environmental impacts[127]. This should also be applied to the ancillary equipment such as charging port, headphones and earbuds. Engagement with industry will be critical when designing measures as the small size of equipment has a direct impact on the ability to improve repairability.

Existing energy related policy levers in UK

- Currently, there are no identified UK policies focusing on smart phones.

Existing circular economy related policy levers

- None identified.

[127] https://www.sustainably-smart.eu/app/download/8884555582/ModularSmartphones.pdf?t=1574689220

Table A23.3 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[128]	Policy objective/ impact	Scale of impact	Suitability comments
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	< 2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[129]	< 2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A23.6 Summary of stakeholder feedback

During the Q&A session in the first stakeholder meeting, two questions were brought up on smart phones, the first regarding the increasing energy consumption of smart phones, pointing at 5G consumption. The second regarding the efficiency of wireless charging systems.

A trade association indicated that for any material efficiency or performance requirements, a product-specific approach should always prevail, as it is the most effective and robust approach, and to avoid the pitfalls of a one-size-fits-all approach to product policy. They urge that dedicated studies should consider the specific opportunities to each product group, and in respect to B2B and B2C products. Specifically, for smart phones: Ecodesign and labelling requirements should be implemented in alignment with those forthcoming in the EU as well as

[128] Further detail on assumptions contained in Section 3.4.4
[129] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

a tailored online information system. Also, improved market surveillance mechanisms should be implemented.

Stakeholders have indicated that the EC started an Ecodesign preparatory study for smartphones in April 2020, which finished in March 2021. Stakeholders urge the UK to await the outcome of this work before regulating a minimum energy performance standard and energy labelling. The study had a strong focus on circular economy potential of smartphones, more than energy efficiency.

During the BEIS Call for Evidence, four respondents, including NGOs and trade associations suggested electronic devices such as laptops, tablets and smartphones could save additional energy and resources through Ecodesign measures. One reason given by a stakeholder was that these products are being replaced at an increasing rate, meaning as more are made, more waste and emissions are produced. One respondent cited research that has found mobile phones should last 25 years which is much longer than the current average lifetime of 3 to 4 years. It was suggested that the UK government should consider criteria such as durability, repairability and component reuse.

A23.7 Discussion & next steps

Smartphones are reliant on a telecom's infrastructure to function. Therefore, the consumption of smartphones is not the only energy consumption in the system. The use of 5G is likely to increase energy consumption, to a lesser extent on a per phone basis due to portability requirements, but also from base stations. Currently it is estimated that 5G base stations would consume more power on a per station basis but reduce consumption per bit processed.

Energy efficiency considerations for smart phones were not reviewed. Task 4 of the European Commission preparatory study report identified energy consumption efficiency measures (e.g., power management options, data compression, adapted Wi-Fi sensing, frame rate adjustments, brightness, etc.) but Task 6 did not analyse them and focused on reviewing battery size improvements, extra external memory settings and idle state performance design options. The preparatory study found that most smart phones are already sufficiently optimised in terms of their energy efficiency due to the portable nature of devices.

However, there are multiple measures for material efficiency which may be appropriate for smart phones. The European Commission Ecodesign preparatory study identified measures around reliability, operating system reparability, use of materials, second use, recycling, and manufacturing biproducts. These recommendations align with the recommendations for material content and declaration, reparability measures (such as modular design), product support and extension of Ecodesign November package measures[130] (with the provision of spare parts) and the enactment of a mandatory minimum warranty period.

[130] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

Task 2 of the European Commission Ecodesign preparatory study indicated that the average life expectancy for smartphones is of 3 years. Yet Task 3 survey results indicate that 64% of respondents would like to keep their current digital devices for at least 5 years. This mismatch between average life expectancy and consumer expectations is illustrated by a survey of the prompt to purchase a new device: 37% of the time due to break of existing device and 19% due to certain applications or software stopped working on the old device. The study also reviewed attitudes towards repair, showing only 11% of users would repair a broken phone, whereas 59% would replace with a new device. The main barrier for repair was shown to be the cost of repair. The market is therefore compelled to replace their device rather than repair. Therefore, it is expected that measures which would reduce the cost of repair or provide software upgrades would increase the average life expectancy of smartphones.

No adverse impacts are foreseen by the implementation of these 4 material efficiency measures. It would be necessary to start with the policy of material content declaration to enable the development of reparability measures and product support through the provision of spare parts. Modular design of reparability should be enacted in tandem with product support policies to ensure that the required parts are readily available for repair. Mandatory minimum warranty should not be difficult to enact as many manufacturers already offer this (however an exception is made for battery performance which is dependent on usage patterns).

A23.8 Evidence sources

Title	Author	Date Published or date accessed
Ecodesign preparatory study on mobile phones, smartphones and tablets	Fraunhofer IZM, Fraunhofer ISI, VITO	02/2021
https://www.sustainably-smart.eu/app/download/8884555582/ModularSmartphones.pdf?t=1574689220	Fairphone, Fraunhofer	Accessed: 28/03/2021
https://www.statista.com/statistics/619788/average-smartphone-life/	Statista	Accessed: 18/03/2021
https://www.tomsguide.com/uk/us/smartphones-best-battery-life,review-2857.html	Philip Michaels	Accessed: 15/03/2021
https://www.techspot.com/news/84490-global-smartphone-shipments-experienced-biggest-decline-history-last.html	Shawn Knight	Accessed: 20/03/2021

Title	Author	Date Published or date accessed
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 24 ICT: Computers and Laptops

A24.1 Introduction

Information and communication technologies (ICT) product groups can be used in residential and non-residential end uses. They enable the use and transfer of digital and analogue information. They also include the ancillary equipment needed to operate and maintain ICT equipment (apart from power requirements).

Computers are defined as a device, which performs logical operations and processes data. Computers are composed of, at a minimum:

A central processing unit (CPU) to perform operations;

User input devices such as a keyboard, mouse, digitizer, or game controller; and

A display screen to output information.

For the purposes of this specification, computers include both stationary and portable units, including desktop computers, integrated computers, and workstations.

Laptops are defined as a computer designed specifically for portability and to be operated for extended periods of time without a direct connection to an ac power source. Laptops must utilize an integrated monitor and be capable of operation off and integrated battery or other portable power source. In addition, most laptops use an external power supply and have an integrated keyboard and pointing device, though tablets use touch sensitive screens. Laptops are typically designed to provide similar functionality to desktops except within a portable device. For the purposes of this specification, laptops include notebooks, thin client, integrated thin client and portable all-in-one.

A24.2 Market information

The total annual sales in 2020 in the UK market for computers is 1,366,660 units. Laptops have annual sales of 4,755,000 units.

The market growth has been 2% between 2020-2030. The computers market is expected to continue growing, as it is tied to population and GDP growth. The UK market is not expected to be different from other developed nations.

The UK has no significant computer manufacturers.

Trade information was found with two HS6 codes, 26201100 for “laptops PCs and palm-top organisers”, and 26201300 for “Desktop PCs”. The trade figures extracted are:

For 26201100, the values reported are:

- Imported units: 20,829,598
- Exported units: 3,509,774
- Produced units:159,402

For 26201300, the values reported are:

- Imported units: 866,190
- Exported units: 489,666
- Produced units:157,821

A24.3 Energy performance information

The typical energy consumption of a unit ranges between 0.02 and 0.10 MWh per year.

Computers use electricity to “performs logical operations and processes data, is capable of using input devices and outputting information to a display, and normally includes a central processing unit (CPU) to perform operations.” Where a desktop computer is intended to be powered from a fixed location, it relies on a constant power source. Laptops, as portable computers, are equipped with their own in-built screens, keyboards, touchpads, and batteries, allowing them to be used when not directly connected to a power source. The usage pattern for these devices in a professional sphere is mainly on a 9 to 5 basis on weekdays. In the domestic sphere, computers may also be used at any other time for personal purposes (e.g., internet browsing, gaming, etc.).

There is potential to improve product efficiency and achieve up to 40% savings. Computers on the market are continuously being improved without price impact due to Moore’s law, which predicts that processing speed continuous to increase. This results in computers performing more complex operations, which may result in an overall power increase of the device but has a reduced energy consumption per operation made. On a component level, improvements can be made in the efficiency of the power supply unit, the central processing unit, the motherboard (or Printed Circuit Board), Random Access Memory, storage and Graphic processing units. Software used can improve the energy consumption through power management standards such as the Advanced Configuration and Power Interface (ACPI) specification. BAT components for desktop computers, from an energy efficiency aspect, are not necessarily the most expensive when compared to other desktop components. For laptops, improvements to energy performance can be made to the integrated display, component selection and power management features. These aspects are highly prioritised by manufactures as laptop battery performance is a key selling feature.

No major technology changes are expected in the industry at the moment other than the continued improvement in performance linked to Moore’s law, and the shift from Hard Drive Disks to Solid State Drives which is ongoing.

Table A24.1 Energy performance information

	Computers	Laptops
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.66 - 0.99	0.45 - 0.56
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.17 - 0.4	0.11 - 0.22
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.07 - 0.16	0.04 - 0.09
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.12 - 0.2	0.1 - 0.11
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.03 - 0.08	0.03 - 0.04
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.01 - 0.03	0.01 - 0.02
Benefit Cost Ratio of BAT Savings	0.4	n.a.

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

For laptops, the BCR is not calculated as there no robust evidence on the increased costs to achieve savings was found in the research.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a computer is 6 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.25 - 0.6 TWh of energy could be saved as well as 0.05 - 0.12 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.1 - 0.24 TWh of energy and 0.02 - 0.05 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a laptop is 5 years. If all units sold annually in the UK in a given year were BAT technologies, 0.25 - 0.4 TWh of energy could be saved as well as 0.05 - 0.08 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.1 - 0.16 TWh of energy and 0.02 - 0.03 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A24.4 Baseline resource efficiency information

Resource footprint

Computers

- **Average price:** from £951 to £1,163.
- **Product weight:** approximately 2 kg to 10 kg
- **Lifespan:** 6-6.6 years
- **Typical duration of the warranty**: 1-5 years
- **% currently recycled (where available):** 65%

Laptops

- **Average price:** from £867 to £1,060.
- **Product weight:** approximately 2 kg to 5 kg
- **Lifespan:** 5-5.6 years
- **Typical duration of the warranty:** 1-5 years
- **% currently recycled (where available)**: 65%

A24.4.1 Composition of typical product

Table A24.2 Composition of typical product – Desktop computers

Main component	Main materials	Weight (g)	% of total product
Body	LDPE	246	2.35%
	ABS	381	3.64%
	PA	138	1.32%
	PC	264	2.52%
	Epoxy	98	0.94%
	Flex PUR	2	0.02%
	Steel sheet galvanized	6312	60.28%
	Steel tube	107	1.02%
	Cast iron	483	4.61%
	Stainless 18/8 coil	10	0.10%
	Aluminium sheet	315	3.01%
	Aluminium diecast	15	0.14%
	Copper winding wire	257	2.45%
	Copper wire	334	3.19%
	Copper tube	67	0.64%
	Powder coating	2	0.02%
	Big caps & coils	483	4.61%
	Slots/ ext. Ports	310	2.96%
	Integrated circuits 5% Silicon, Gold	69	0.66%
	Integrated circuits1% Silicon	96	0.92%

Main component	Main materials	Weight (g)	% of total product
	SMD & LEDs avg	194	1.85%
	PWB ½ lay 3.75 kg/m2	78	0.74%
	PWB 6 lay 4.5 kg/m2	163	1.56%
	Solder Alloy (SnAg4Cu0.5)	48	0.46%
TOTAL		10472	100%
Packaging	Cardboard	2,287	

Table A24.3 Composition of typical product – laptops

Main component	Main materials	Weight (g)	% of total product
Body	LDPE	43	1.51%
	ABS	142	4.98%
	PA6	281	9.85%
	PC	267	9.36%
	Epoxy	3	0.11%
	PMMA	36	1.26%
	Steel sheet galvanized	489	17.14%
	PP	4	0.14%
	PS	3	0.11%
	EPS	50	1.75%
	Aluminium sheet	38	1.33%
	PVC	23	0.81%
	LCD screen m2	63	2.21%

Main component	Main materials	Weight (g)	% of total product
	Copper wire	60	2.10%
	Copper tube	15	0.53%
	Powder coating	122	4.28%
	Big caps & coils	501	17.56%
	Slots/ ext. Ports	133	4.66%
	Integrated circuits 5% Silicon, Gold	47	1.65%
	Integrated circuits1% Silicon	31	1.09%
	SMD & LEDs avg	50	1.75%
	PWB ½ lay 3.75 kg/m2	5	0.18%
	PWB 6 lay 4.5 kg/m2	77	2.70%
	Solder Alloy (SnAg4Cu0.5)	7	0.25%
	Glass for lamps	1	0.04%
	Glass for LCD	362	12.69%
TOTAL		2853	100%
Packaging	Cardboard	921	

Table A24.4 Critical Raw Material content and feasibility of recovery – Desktop computers

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate.	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in Hard disc drive	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). For the liberation of NdFeB-magnets from Hard disc drive, Hitachi developed a process[131] in Japan. In the EU, so far, no specific pre-treatment processes are in practice for WEEE containing NdFeB-magnets. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available).

131 Rare-Earth Magnet Recycling

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	
Yttrium, Terbium, Europium, Gadolinium, Lanthanum, Cerium	Displays/ Screens (Fluorescent powder)	No substitute available for yttrium. Primary REEs are produced almost exclusively in China and have low price and this price decreased after the peak in 2011[132]. Therefore, there are not many recycling technologies available. Large amounts of investment are needed for this type of (R&D) and subsequent scaling up and infrastructure, and this process takes many years. Solvay closed its REE separation plant in 2016 and there has not been any other industrial recycling facility in Europe since. REEs powders are being sent to landfill.	No
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium,	Display use LEDs	No substitute available for indium, and gallium.	Technically feasible but with recycling rates below 1%.

[132] Rare Earth Elements: Overview of Mining, Mineralogy, Uses, Sustainability and Environmental Impact

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Silicon, Platinum and Rare Earth Elements (REEs)	Liquid-crystal displays (LCD) Semiconductors	No recycling of indium from EoL products. High demand of indium by indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. LCDs have been displaced by LED-backlit LCD displays containing less REEs – market moving to Organic LED TVs (represents approximately 84% of total global indium consumption) Recyclability of displays is focused on the recycling of metal and glass and not the REEs.	Recycling of REEs have not reached the commercial scale.

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins

Potential presence of Bisphenol A (BPA) in the screen, and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

Table A24.5 Critical Raw Material content and feasibility of recovery – Laptops

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Antimony, Cadmium, Cobalt, Lead, REEs, Lithium, Graphite, Phosphorus and Nickel[133]	Anode Cathode	The EU produces only 1% of all battery raw materials overall. For lithium-ion (Li-on) batteries, Cobalt in the cathode can be collected and reused/recycled. In batteries, the recovery procedure is efficient and these secondary sources of cobalt cost less than raw cobalt extraction. For the Li-ion batteries, there are environmental, political and social impacts of mining activities where most of the world's cobalt is sourced from. Recycling rate for lithium is less than 1%. Primary REEs, present in the NiMH batteries, are produced almost exclusively in China and have low price and this price decreased after the peak in 2011[134].	Yes, for NiMH batteries and most of Li-ion batteries used in electronics, that are easy to separate manually. For some products not feasible for consumers to separate batteries because they are built in.

133 Annex VII of the WEEE Directive requires the removal of batteries because they are considered hazardous waste.

134 Rare Earth Elements: Overview of Mining, Mineralogy, Uses, Sustainability and Environmental Impact

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		The REEs from NiMH batteries can be concentrated in a residue after smelting (Umicore[135]) Solvay closed its REE separation plant in 2016 and there has not been any other industrial recycling facility in Europe since. REEs powders are being sent to landfill. Therefore, there are not many recycling technologies available. Large amounts of investment are needed for this type of (R&D) and subsequent scaling up and infrastructure, and this process takes many years. Battery Directive 2006/66/EC includes target for member states for minimum collection rates of 45% by 26 September 2016. The EU collection rate was 43.6% with the UK achieving 44%[136] Additional information for batteries not in our scope: For lead acid batteries (for cars, not reviewed in this study)– relatively cheap and increasingly well-established methods for recycling lead-alloys. For lead acid, or non-rechargeable batteries shall be broken	

135 Battery recycling Umicore
136 Evaluation report of the Batteries Directive, April 2019.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		mechanically and drained to collect acid/alkaline to avoid environmental damages.	
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in Hard disc drive	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). For the liberation of NdFeB-magnets from Hard disc drive, Hitachi developed a process[137] in Japan. In the EU, so far, no specific pre-treatment processes are in practice for WEEE containing NdFeB-magnets.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength

[137] Rare-Earth Magnet Recycling

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	(no other similar strong magnets are available).
Antimony	Plastic casing and flame retardants.	Antimony used in flame retardants is not recoverable as it is diffused in the product. Antimony is particularly hard to substitute in its main application as a flame retardant.	No
Yttrium, Terbium, Europium, Gadolinium, Lanthanum, Cerium	Displays/ Screens (Fluorescent powder)	No substitute available for yttrium. Primary REEs are produced almost exclusively in China and have low price and this price decreased after the peak in 2011[138]. Therefore, there are not many recycling technologies available. Large amounts of investment are needed for this type of (R&D) and	No

[138] Rare Earth Elements: Overview of Mining, Mineralogy, Uses, Sustainability and Environmental Impact

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		subsequent scaling up and infrastructure, and this process takes many years. Solvay closed its REE separation plant in 2016 and there has not been any other industrial recycling facility in Europe since. REEs powders are being sent to landfill.	
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium, Silicon, Platinum and Rare Earth Elements (REEs)	Display use LEDs Liquid-crystal displays (LCD) Semiconductors	No substitute available for indium, and gallium. High demand of indium by indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. LCDs have been displaced by LED-backlit LCD displays containing less REEs – market moving to Organic LED TVs (represents approximately 84% of total global indium consumption) Recyclability of displays is focused on the recycling of metal and glass and not the REEs.	Technically feasible but with recycling rates below 1%. Recycling of REEs have not reached the commercial scale.

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Indium	Displays/ Screens (Organic LED)	OLED displays are commonly used in laptops. OLEDs use organic molecules to emit light instead of Rare Earth Elements. These are expected to eliminate the need for CRM except for indium. Indium is used in indium-tin-oxide (ITO) thin-films present in flat screens and touch screens. No recycling of indium from EoL products.	No. A few candidates to replace indium in ITO, but not yet commercially available.

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins

Potential presence of Bisphenol A (BPA) in the screen, and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

Potential presence of hazardous in the batteries (lead, cadmium, lithium, mercury, and graphite).

Li-ion batteries can cause significant waste fires if they are punctured or damaged during transit (during end-of-life processes).

A24.5 Information on select policy levers and horizontal measures

This product group is subject to existing Ecodesign regulations. A review study was completed in 2018, and a proposal for Lot 3 products is underway with the Commission, CLASP and GTD working with other stakeholders to develop active mode efficiency metrics.

It's estimated that product groups with EC MEPS not revised will require 2 years to revise in GB, and that new policy levers (that are not mandatory MEPS or labelling) require 1 year to develop.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

Existing energy related policy levers in UK

- There are existing Ecodesign rules for this segment.
- Currently, computers and laptops are covered by the "**Salix public sector finance – Loan scheme**".
- **"Government Buying Standards"** exist for laptop computers and workstations.

Existing circular economy related policy levers

- None identified.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A24.6 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[139]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Already regulated 2	Remove poor efficiency products / Energy savings	Depends on MEPS levels	A review study completed in 2018. Further consultation is ongoing in the EU to develop an active efficiency metric.
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Review study concluded labelling is challenging due to configuration potential and rapid technical development.
Voluntary endorsement label	1.5	Information provision / Energy savings	None found	Existing voluntary labelling in other markets. Approach could be replicated in UK.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Unlikely to be deployed. Obligation schemes focus on heating improvements.
Public procurement	Already implemented	Prohibit poor efficiency products / Energy savings	None found	Need to understand effectiveness of this measure.
Communications campaign	2	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Candidate, but needs a label to point end-users in the direction of high efficiency products.
Advice/aid in implementation	2	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	Candidate, but needs a label to point end-users in the direction of high efficiency products.

[139] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[139]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	2	Increase accessibility of high efficiency products / Energy savings	N/A	Candidate, but needs a label to point end-users in the direction of high efficiency products.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	N/A	Same challenges as mandatory label.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[140]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

140 In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A24.6 Summary of stakeholder feedback

An industry association indicated that for any material efficiency or performance requirements, a product-specific approach should always prevail, as it is the most effective and robust approach, and to avoid the pitfalls of a one-size-fits-all approach to product policy. They urge that dedicated studies should consider the specific opportunities to each product group, and in respect to B2B and B2C products. Specifically, for computers and laptops: Ecodesign standards should be implemented in alignment with EC regulation, Energy Star should be adopted, and improved market surveillance mechanisms should be implemented. With the reviewed Ecodesign preparatory study on computers completed in 2017 and published in 2018, a trade association has suggested that the UK should align with the results from this study and upcoming Ecodesign review.

Industry association feedback on material efficiency concerns has urged for “a more coherent B2B collection framework, communications to householders on how and where to recycle, and clear government advice on how to reuse/recycle, focusing on how to clear data on devices at the end of use.” They also highlighted an opportunity to amend guidance from the UK government’s Information Commissioner’s Office, which currently includes laptop destruction as an option for secure data deletion.

Four respondents, including NGOs and trade associations, responded to the BEIS Call for Evidence to suggest that electronic devices such as laptops, tablets and smartphones could save additional energy and resources through Ecodesign measures. This is down to rapid replacement rates of these products resulting in more waste and emissions. Another respondent cited research that found laptops should last 20-44 years whereas average lifetime estimate is now of 5-6 years. It was therefore suggested that the UK government should consider durability, repairability and component reuse criteria in new measures. One stakeholder said computers should be required to use higher quality capacitors and other components designed to last a long time.

A24.7 Discussion & next steps

An Ecodesign preparatory study on computers was completed in 2017 and published in 2018. The study has concluded that due to the fast development of computer technologies, product classification and Ecodesign requirements can quickly become obsolete. Current Ecodesign classification is defined by the included hardware, such as number of CPUs, graphic cards, and system memory. Each category has separate maximum annual total energy consumption allowances. This complexity would be avoided if a performance-based metric were to be developed. Preparatory study modelling was performed along two scenarios: updating current existing Ecodesign requirements with maximum annual total energy consumption values for each computer category defined, and a scenario delayed by two years to allow for the development of an Energy Efficiency Index (which would provide a score for the ratio energy to performance) as a metric for MEPS and energy labelling. The first scenario, updating current Ecodesign requirements, was deemed easier to implement, with immediate benefits. However, it is estimated that the market would gradually move to more powerful computers, with higher energy allowances, resulting in an increase in energy consumption values per computer in the latter half of the decade. The second scenario, having a MEPS and label based on an Energy Efficiency Index metric, would be applicable across all computer categories, and hence would sustain efficiency savings regardless of a shift towards more powerful computers. Therefore, the second scenario models more savings in the long-term, a near doubling in savings by 2030 compared to the first scenario.

The development of a voluntary endorsement label has been marked as a potential policy measure which could unlock other policy levers. Indeed, computers are already on the Energy Star endorsement label of the US, indicating the policy lever would not be difficult to implement. An energy label would allow both domestic and non-domestic buyers to favour more efficient products. This label would then be capable of tying into an energy efficiency communications campaign to recommend the market move to more efficient devices. The effect on a public procurement scheme has not yet been established but one would need to rely on such a label to be put in place first. It could therefore be a further activity to review once label has been mainstreamed.

A grants loans and subsidies scheme for more efficient computers could be effective to shift the market, however it would need to rely on the existence of a quality label first. There is also a concern that this might simply encourage the market to replace their devices faster, hence potentially raising material efficiency concerns. Also, as the UK doesn’t have any computer manufacturers, this scheme is unlikely to foster secondary benefits of industrial development.

Material efficiency policy measures have also been marked in our analysis as good candidates to take forward: recommendations for material content and declaration, reparability measures (such as modular design), product support and extension of Ecodesign November package measures[141] (with the provision of spare parts) and the enactment of a mandatory minimum warranty period. These measures would increase the durability, repairability and component reuse of smartphones, aligning with some of the stakeholder concerns. However, analysis is needed to review if the potential increase in product lifetime would counterbalance the increased environmental impact from the provision of additional parts.

Requirements for material content and declaration is a good candidate as it could lead to the increase of collection and recycling which is important as computers are rich in critical raw materials. Other measures to increase collection and recycling that should be considered in future are an improved collection framework, recycling communications campaign and clear advice for data deletion at end of product lifetime.

Mandating a modular design and other repairability measures would not be a big challenge for desktop computers, which are already mostly modular by design. This measure would increase material efficiency allowing for parts such as CPU/PSU/etc. to be replaced as the device ages allowing for better performing product and increased longevity. During replacement, the old part is isolated, which would also make it more likely for it to be reused/recycled. This policy

[141] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

however would be harder to implement for laptops, where a design element is required to reach compact requirements. However, this is not impossible as many laptops are already designed in such a way to replace/upgrade RAM capabilities.

Following the policy lever of modular design, product support measures are intended to ensure that spare parts remain available and that they are delivered within reasonable timelines. This would ensure that products are repairable, as having the spare parts available, or an alternative, allows for the product to extend its lifetime.

Mandatory minimum warranty should not be difficult to enact as many manufacturers already offer this. However, it should be noted that this may be dissociated from a warranty on the software products which are subject to licensing fees (as long as an operating system is always made available. An exception (or rather separate warranty timeline) should also be made for laptops with regards to battery performance which is dependent on usage patterns.

A24.8 Evidence sources

Title	Author	Date Published or date accessed
Preparatory study on the Review of Ecodesign Regulation 617/2013 (Lot 3) - Computers and Computer servers	Viegand Maagøe and VITO	02/2017
https://www.currys.co.uk/gbuk/computing/laptops/laptops/315_3226_30328_xx_xx/3_20/price-asc/xx-criteria.html	Currys	20/03/2021
Analysis of material efficiency aspects of personal computers product group.	Tecchio P., Ardente F., Marwede M., Clemm C., Dimitrova G. Mathieux F.	01/2018
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Title	Author	Date Published or date accessed
UK Information Commissioners Office	ICO	Accessed 30 June 2021

Annex 25 Lighting: LED Lamps and Luminaires

A25.1 Introduction

Lighting product groups focus on improving visibility in residential and non-residential spaces, with end uses being internal or external. Lighting includes lamps, luminaires, controls, and control gear required to ensure optimal operation of products.

This factsheet focuses on LED lamp technologies and the circular economy and resource efficiency topics. LEDs covering commercial, industrial, and domestic applications are included here.

LED luminaires are a complete lighting unit consisting of an LED lamp or lamps together with parts designed to distribute light, position and protect lamps and connect to the power mains.

A25.2 Market information

Annual sales of typical residential, commercial, industrial and street lighting LED lamps were approximately 100-140m units in 2020[142]. According to AMA Research, the LED lamp market is expected to grow as LEDs replace older lamp types and then will stabilise in 2024[143]. Annual sales of LED luminaires was estimated to be 11 million units in 2020. The market for LED luminaires is expected to grow as prices reduce and take-up of this technology becomes more common.

To derive the trade information, the Procom codes 27401100, 27401293, 27401295, 27401300, 27401490, 27401510, 27401530 and 27401550 were used. Looking at this data, an average of 63 million units are typically imported into the UK annually. Compared to imports, exports from the UK are approximately 30% of imports, or 18 million. Production numbers could not be derived from the trade data due to inconsistencies in the data.

USA, Germany, Austria, Netherlands, Ireland, Taiwan, South Korea, Japan are all leading countries of manufacture /assembly of LEDs[144].

[142] *ICF modelling, 2020*
[143] https://www.electricaltimes.co.uk/led-represents-14-per-cent-of-all-household-lighting-appliances/
[144] https://blog.technavio.com/blog/top-10-largest-led-lighting-manufacturers

A25.3 Energy performance information

LED lamp and luminaire energy performance has been omitted from this study because it has been assessed separately to this study. BEIS consulted stakeholders from November 2020 to January 2021 on potential for achieving additional energy savings from lighting products[145].

A25.4 Baseline resource efficiency information

Resource footprint (Luminaires)

- **Average price:** from £40 to £196 for luminaires, with lamps ranging from £1 to over £100 per unit, depending on end use.
- **Product weight:** Varies significantly by end use and size. Ranges from < 0.2 kg (domestic lamps) – 15 kg (street lamp luminaires)
- **Lifespan:** 9-12 years
- **Typical duration of the warranty:** 5 years for luminaires
- **% currently recycled:** Currently less than 50% of the materials in LEDs are recycled

A25.4.1 Composition of an example product

LEDs consists of semiconductors (LED-dice) assembled on a single or multi-chip LED module. Together this is called an LED array. These are connected to an electronic ballast and heat sink and integrated into lamps with an optical element and housing. Some retrofit lamps are designed with a 'filament' style, which removes the need for a heat sink.

The semi-conductors contain CRM including gallium and indium. Colour converter materials are also used to define the colour temperature (warm white to cold white). This contains silicon, phosphor particles and filler particles. Rare earth metals are also used, albeit in very small quantities.

Two examples of material composition are included here to demonstrate the range of products included in this product group. An LED lamp LCA and a street light LED luminaire LCA were used to populate the tables below.

[145] https://www.gov.uk/government/consultations/draft-ecodesign-and-energy-labelling-regulations-lighting-sources-2021

Table A25.1 Composition of typical LED lamp

Main component	Main materials	Weight (Kg)	% of total product	Notes
LED lamp	Aluminium, high density	0.07	41%	
	Resin compound	0.04	24%	
	Plastic	0.03	17.5%	
	Electronic components	0.03	17.5%	
	Non-ferrous metal	0.00		5g
	Ferrous metal	0.00		< 0.5g
	Glass	0.00		< 2g
TOTAL		0.17	100%	

Table A25.2 Composition of typical LED street light luminaire

Main component	Main materials	Weight (Kg)	% of total product	Notes
Street light LED luminaire	Aluminium, high density	3.98	72.5%	
	Steel	0.85	15.5%	
	Template glass	0.27	5%	
	Copper	0.21	4%	
	Paperboard	0.10	2%	
	Polystyrene	0.08	1%	
TOTAL		5.49	100%	

Table A25.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Phosphorus, Magnesium, Gallium, Arsenic, Germanium, Indium, Silicon, Platinum and Rare Earth Elements (REEs)[146]	Semi-conductors	No substitute available for indium, gallium and yttrium. Primary REEs are produced almost exclusively in China and have low prices. Prices decreased after peaking in 2011[147]. There are not many recycling technologies available. Large amounts of R&D investment are needed for this type of recycling and subsequent scaling up and infrastructure. This process takes many years. Solvay closed its REE separation plant in 2016 and there has not been any other industrial recycling facility in Europe since. As this technology is moving forward rapidly, many components at the end-of-life stage (EoL) are not able to be reused as they will not be compatible with the latest technology due to obsolescence. The heterogeneity of LED bulbs causes problems in recycling. REEs powders are being sent to landfill.	Technically feasible but with recycling rates below 1%. Recycling of REEs have not reached the commercial scale.

[146] A single LED bulb contains about 1g of phosphorescent powder in proportions containing 0.7mg of cerium and 450mg of yttrium.
[147] Rare Earth Elements: Overview of Mining, Mineralogy, Uses, Sustainability and Environmental Impact

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	LED chips and PCB	LED chips are mainly manufactured in China. PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA).

Potential presence of heavy metals.

A25.5 Information on select policy levers and horizontal measures

This product group is subject to existing Ecodesign and Energy labelling regulations, which were recently updated at EU level as part of the November Package of regulations[148]. Circular principles were supported in the EU Ecodesign Regulation, but no additional requirements were included that go beyond the EU WEEE Directive.

A definition for containing products was also included in the EU Ecodesign Regulation to help ensure that light sources can be removed for testing.

This product group was excluded from the energy related policy analysis as work already being undertaken in this area. A UK consultation took place from November 2020 to January 2021 and a Government response will be published in due course.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

Existing energy related policy levers in UK

- There are updated EU Ecodesign rules for this segment: Regulations (EU) 2019/2020 setting Ecodesign requirements and (EU) 2019/2015 setting Energy Labelling requirements for light sources (Sept 2021). Draft GB regulations are under preparation to reflect these EU regulations.
- Lamps and luminaries are also covered by dwelling based MEPS such as "**Domestic private rented property: minimum energy efficiency standard**".
- Currently, lamps and luminaries are covered by the "**Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme**" and "**Salix public sector finance - Loan scheme**".
- They are also covered by the public procurement scheme "**Sustainable procurement: the Government Buying Standards (GBS)**", the mandatory label "**Energy Performance certificate**" and to an extent by the voluntary label BREEAM.
- LED lamps are listed on the **Energy Technology List**.
- Now ended, they were also covered to an extent by the "**CRC Energy Efficiency Scheme - (Streamlined Energy and Carbon Reporting)".**

Existing circular economy related policy levers

- None identified in addition to the revised Ecodesign regulations.

[148] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A25.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[149]	Policy objective/ impact	Scale of impact	Suitability comments
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[150]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

Discussion on resource efficiency with a focus on critical raw materials

As part of European Union Ecodesign Regulation, halogens and CFLs are due to be phased out and LEDs are set to become even more popular, with LED lighting undergoing rapid evolution.

[149] Further detail on assumptions contained in Section 3.4.4

[150] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

LED lamps can have different chemical compositions, but mostly include a variety of critical raw materials (CRM). The next generation of LEDs are organic-LEDs (OLEDs) which use organic molecules to emit light instead of Rare Earth Elements[151]. These are expected to eliminate the need for CRM except for indium[152].

Projection of future materials demand identifies that REEs will increase dramatically. The supply risks related to extraction and processing of these materials are the main concern: China increasingly dominates the supply of these raw materials.

The low price of REEs has been a significant factor to a low recycling rate and the quantity of REE materials available for recycling is unknown. Its collection is also inefficient, and this waste is exported to developing countries reducing the REE potential available. Finally, the content of REE per application is low, which reduce the recycling systems and the recycling processes are currently complex, with no incentives for manufacturers and designers to develop recyclable products/REEs[153].

There is potential for more recovery of REEs, and technological advancements may make this process cheaper, but there is a need to rethink and investment in R&D to make viable recycling at an industrial scale.

A25.6 Summary of stakeholder feedback

Feedback on Task 2 related to lighting products indicated that emergency lighting should be excluded from this product group. Emergency lighting is already excluded from the existing Ecodesign regulations, and maintaining this exclusion is recommended due to the specific function and requirements for emergency lighting. Additional feedback highlighted the potential impacts of the existing Ecodesign lighting regulations on health and wellbeing related to humans, wildlife and ecology. Feedback suggested that this is due to replacement lamp technologies that cannot match the light quality offered by incandescent lamps.

Task 3 feedback mentioned that mandatory policy levers would help ensure a level playing field but highlighted the importance of effective market surveillance relating to mandatory requirements, particularly relating to online suppliers of lighting products.

This product group was covered extensively in the BEIS Call for Evidence and had significant stakeholder engagement. The main topics were around the importance of considering health impacts of lighting and lighting technologies (in particular around issues of flicker, colour temperature and glare from LEDs), consideration of lighting systems as a means to achieve greater energy savings, and support for improving the resource efficiency and circularity of lighting products via tax programmes, lighting as a service, take back schemes and recovery and reuse of CRM. Provision of better information at point of sale was also suggested.

[151] How OLEDs (organic LEDs) work, accessed 30 March 2021,
[152] Critical raw materials in lighting applications: Substitution opportunities and implication on their demand
[153] Production technologies of CRM from secondary resources SCRREEN Project

A25.7 Discussion & next steps

Updated Ecodesign and Energy Labelling requirements will be adopted in GB this year, subject to Parliamentary approval, which reflect those requirements that will apply in the EU and Northern Ireland from 1 September 2021. It will be important to ensure that these regulations have high rates of compliance as part of any future consideration of new policy levers. There are opportunities to increase the ambition levels the EU light sources regulation, as some types of lamps will continue to be sold despite more efficient options already being available at cost effective prices.

BEIS explored how to improve the policy beyond the updated Ecodesign and Energy Labelling requirements in a consultation published in November 2020. Whilst responses to the ErP Call for Evidence and elsewhere suggest the market is naturally moving towards LED lamps and luminaires, it remains evident that further carbon savings from lighting products may be achievable over a shorter time-horizon if the ongoing transition to LEDs is accelerated.

Potential health related impacts of LED lighting should be considered as part of any new policy lever to ensure only lamps with high quality light outputs are placed on the market which do not disproportionately impact those who are photosensitive.

Responses to the ErP Call for Evidence and elsewhere also reinforced the view that better installation and management of lighting controls offer the potential for significant energy savings. Consideration of a systems-based approach to lighting is recommended, which implies that lighting provision at a building scale may need consideration rather than at a product level. This implies that Building Regulations or building related policy levers could be a suitable option.

Ensuring that LED lamps meet their stated lifetimes, improving the repairability of luminaires and minimising waste at the end of life are also important for the future, as the market share of LEDs will only increase over time.

A25.8 Evidence sources

Title	Author	Date Published or date accessed
IEA Tracking Report - Lighting https://www.iea.org/reports/lighting	IEA	June 2020
Life cycle analysis of an OSRAM light-emitting diode lamp – Parathom Classic A	OSRAM Group	29 March 2021
LCA Case Study to LED Outdoor Luminaries	Lozano-Miralles J., Gago-Calderon A. et. Al.	25 December 2019

Title	Author	Date Published or date accessed
as a Circular Economy Solution to Local Scale		
Critical raw materials in lighting applications: Substitution opportunities and implication on their demand	Pavel, C, Marmier, A, Tzimas, E, Schleicher, T.	August, 2016
Critical review on life cycle inventories and environmental assessments of LED-lamps	Franz, M., Wenzl, F.	September, 2017
Preparatory study on light sources	VITO	December 2015
https://www.ledsmagazine.com/leds-ssl-design/modular-light-engines/article/16695809/lighting-as-a-service-poised-to-deliver-the-circular-economy-magazine		25 February, 2021
https://blog.technavio.com/blog/top-10-largest-led-lighting-manufacturers		12 March, 2021
How OLEDs (organic LEDs) work		30 March 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020
Production technologies of CRM from secondary resources – D4.2	Solutions for Critical Raw materials - a European Expert Network SCRREEN project	31 January 2018

Annex 26 Materials: Printer Cartridges – Inkjet and toner cartridges

A26.1 Introduction

The materials product group covers products that do not directly consume energy, but either affect the consumption of other products (typically HVAC ones) or the primary function of other products (printer cartridges).

A printer cartridge is a component of a printer that contains either ink or toner that gets deposited onto the paper during printing. Thus, depending on the type of material used, we disaggregate it into following two categories:

Ink Cartridge: An ink-based cartridge that is either dye-based or pigment-based and are used in inkjet printers. Dye-based inkjet cartridges are not waterproof and can be susceptible to smudging, whereas pigmented inkjet cartridges have a smoother finish and quicker dry-times than dye-based.

Toner cartridge: Contains a solid toner powder, a fine, dry mixture of plastic particles, carbon and black or other colouring agents and are used in laser printers.

A26.2 Market information

The global printer toner market is expected to grow from USD 3.90 billion in 2018 to USD 7.35 billion by 2028, representing a CAGR of 6.53%, whereas ink cartridges will show a decline in CAGR of 2.1% by 2023 from 2017 levels. Increasing consumer preference has moved to toners due to cost effectiveness and reduction in wastage, both of which are expected to drive the market[154]. Europe is the second largest shareholder after North America in terms of sales and revenue generated.

In the UK, over 900 companies employ over 5,000 workers to produce over 6 million cartridges every year[155]. The printer cartridges market in Europe is different from the ROW. The key OEMs in Europe such as Brother, Lexmark, Canon, Epson, HP, Kyocera, and Xerox, are implementing recycling programs. With the number of remanufactured cartridges sold now exceeding 1,500,000 each year, the remanufacturing industry now provides more cartridges to UK laser printer users than all bar one printer manufacturer[156].

[154] https://www.fiormarkets.com/report/printer-toner-market-by-type-genuine-or-oem-411499.html
https://www.fiormarkets.com/report/2018-2023-global-ink-cartridges-consumption-market-report-310876.html
[155] Study on the implementation of product design requirements set out in Article 4 of the WEEE Directive. Jan 2018
[156] https://www.ukcra.com/

Imaging products were modelled in 2012 by the Market Transformation Programmes (on behalf of Defra) to assess the impact of EU ENERGY STAR on the UK. Annual sales of domestic sector imaging products were estimated at 6-7 million compared to around 3.5 million in the non-domestic sector[157].

On trade data, the related PRODCOM code is 28.23.26.00 - Parts and accessories of printers of HS 8443 3 and the corresponding COMEXT code is 844399. While there is no data in PRODCOM, for 2019, the COMEXT dataset values are 49,000 tonnes of imports and 17,000 tonnes of exports for parts and accessories for printers. Because the code is for printer parts and accessories in general, the tonnage here includes other items as well. There is no additional information to estimate the proportions of tonnage specific to printer cartridges.

Several countries have been involved in the manufacturing of printer cartridges to meet the rising demand. Countries such as Bulgaria, France, Germany, Italy, Netherlands, Poland, Romania, Spain, Sweden, Switzerland, and the UK manufacture and remanufacture of inkjet and toner cartridges.

A26.3 Cartridge performance information

Inkjet printer cartridge[158] operates by dispensing ink through a narrow tube using a capillary action. When the printer circuit fires an ink droplet, it energizes two electrical contacts attached to a piezoelectric crystal. The energized crystal flexes outward against a membrane, which pushes against a hole in the ink dispenser. This increases pressure, forcing the waiting ink droplet from the tube to the paper.

A toner cartridge[159] is made of a toner hopper, developer, and drum assembly. On receiving a print command, the developer gathers positively charged toner particles from the hopper and brushes them past the drum assembly. An electrostatic image on the drum uses a negative charge to pull the toner from the developer onto the drum. The drum then moves over the paper. The paper pulls the toner particles off the drum in the shape of the electrostatic image. To affix the toner, the paper passes through fuser rollers, which are heated by internal quartz tube lamps. The heat melts the plastic in the toner particles, causing the toner to be absorbed into the paper fibres. Although the melted plastic sticks to the paper, it does not adhere to the heated fuser rollers because the rollers are coated with Teflon, a non-stick material.

[157] ENERGY STAR modelling (2012, Market Transformation Programme) EUP_ND_ICF_Print_SUM_New_v1-0-0 and EUP_D_ICF_Print_SUM_New_v1-0-0

[158] https://www.explainthatstuff.com/inkjetprinters.html#:~:text=The%20circuit%20activates%20each%20of,a%20bubble%20of%20ink%20vapor.

[159] https://tonerconnect.net/blog/how-do-toner-cartridges-work/

A26.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £10 (Inkjet) to £50 (toner). Larger office toner cartridges can cost £100-200.
- **Product weight:** approximately 0.15 kg to 1.2 kg (Laser toner cartridge). Larger office toner cartridges can weigh up to 2.6 kg.
- **Lifespan:** 1-2 years
- **Typical duration of the warranty:** up to 1 year (2 years for larger office toner cartridges).
- **% currently recycled (where available):** less than 30% are currently being recycled

A26.4.1 Composition of typical product

Table A26.1 Composition of a toner cartridge

Main component	Main materials	Weight (g)	% of total product
Rollers	Aluminium	76.66	7.9%
	Copper	0.55	0.1%
Wiper blade	Steel	387.76	40.0%
Case of toner cartridge	Polystyrene	449.69	46.4%
Cogwheels	Nylon	27.73	2.9%
Wiper blade	PVC	6.28	0.6%
Wiper blade	Polyurethane	19.94	2.1%
TOTAL		968.61	100%
Packaging	Corrugated board	482.93	33%
Packaging	LDPE	26.44	2%

Table A26.2 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB[160]	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinylchloride (PVC) a total of 6.28g of a total of 998g which is almost insignificant.

Printer ink toxicity is generally low. Recent studies have suggested that inhalation of printer toner nanoparticles can have health impacts[161], mostly related to heavy-duty use in print rooms.

[160] There is a tiny electronic circuit inside a printer cartridges.

[161] https://www.sciencedaily.com/releases/2020/02/200227114551.htm

A26.5 Information on select policy levers and horizontal measures

This product group is not subject to any Ecodesign or labelling regulations. Both new and remanufactured printer cartridges are considered WEEE if they contain an electronic chip. There is a voluntary agreement (VA) for imaging equipment in place in the EU and signatories via Eurovaprint are working with the EC to revise this VA.

This work is ongoing, with the latest draft VA published in October 2020[162]. An EC Consultation Forum took place in April 2021, but no new documents were made publicly available at time of writing. The latest draft VA includes cartridge and container commitments. This is a step in the right direction and partially captures the aim of the shortlisted horizontal measures. However, the European Toner and Inkjet Remanufacturers Association (ETIRA) feedback suggests that some of the exclusions inserted into the VA remove from scope a large part of the printer cartridge market.

Existing energy related policy levers in UK

- There are no Ecodesign rules for this product group and no identified additional UK policies focusing on printer cartridges.

Existing circular economy related policy levers

- None identified.

The horizontal measures assessed here are intended to supply information and extend lifetimes. It is assumed that the measures can be implemented independently of this VA, but there are potential efficiencies to gain from adopting a UK specific version of this VA.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

162 https://www.eurovaprint.eu/pages/voluntary-agreement/

Table A26.3 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[163]	Policy objective/ impact	Scale of impact	Suitability comments
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements. Keep track of VA developments in EU.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate although relates to refilling and/or re-manufacturing rather than repair. Keep track of VA developments in EU to see if a similar measure will be included.
Product support & extension of Ecodesign November package measures[164]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Keep track of VA developments in EU. Specific measures could be defined related to printer cartridges or printers themselves.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate, noting that these are typically offered already. Keep track of VA developments in EU.

A26.6 Summary of stakeholder feedback

No feedback was received on this product group during Task 2 or 3. This product group was not covered in the BEIS Call for Evidence. However, a few stakeholders recommended to include printers in Task 3.

An industry association indicated that for any material efficiency or performance requirements, a product-specific approach should always prevail, as it is the most effective and robust

[163] Further detail on assumptions contained in Section 3.4.4

[164] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

approach, and to avoid the pitfalls of a one-size-fits-all approach to product policy. They urge that dedicated studies should consider the specific opportunities to each product group, and in respect to B2B and B2C products. Specifically, for printer cartridges, improved market surveillance mechanisms should be implemented.

A26.7 Discussion & next steps

It is recommended to follow the on-going revisions to the existing VA on imaging equipment in the EU. Many other countries[165] have also developed their own VA with the imaging equipment product group, so an assessment of non-EU VAs is recommended to understand how printer cartridges are treated.

According to review study on imaging equipment, in 2018 UK was considered a best practice country in Europe on printer cartridge recycling and reuse rates, with nearly 70% collected and 40% reused/recycled. Engagement with this industry should take place to understand how these rates can be improved.

A26.8 Evidence sources

Title	Author	Date Published or date accessed
Study on the implementation of product design requirements set out in Article 4 of the WEEE Directive	Rachel Waugh, Harry Symington, David Parker, Maximilian Kling, Ferdinand Zotz	January 2018
https://www.fiormarkets.com/report/printer-toner-market-by-type-genuine-or-oem-411499.html	Fior Markets	12/3/2021
https://www.fiormarkets.com/report/2018-2023-global-ink-cartridges-consumption-market-report-310876.html	Fior Markets	12/3/2021
Cartridge Remanufacturing and Energy Savings	Sahil Sahni, Avid Boustani, Timothy Gutowski, Steven Graves	28/01/2010
Life Cycle Assessment of Toner Cartridge HP C4127X	Jonas Berglind & Henric Eriksson	Jan 2002

165 Including Canada, China, Taiwan, Hong Kong, India, Iran, Japan, Korea, Russia, Switzerland, Thailand, Turkey, Vietnam (see ‘Revision of Voluntary Equipment on Imaging Equipment Task 1-7, Final Report)

Title	Author	Date Published or date accessed
http://www.ukcra.com/why-is-ukcra-iimportant-for-our-industry.html	UKCRA	12/3/2021
https://www.explainthatstuff.com/inkjetprinters.html#:~:text=The%20circuit%20activates%20each%20of,a%20bubble%20of%20ink%20vapor.	Explain that stuff	24th March 2021
https://tonerconnect.net/blog/how-do-toner-cartridges-work/	Toner Connect	24th March 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 27 Materials: Taps and Showers

A27.1 Introduction

The materials product group covers products that do not directly consume energy, but either affect the consumption of other products (typically HVAC ones) or the primary function of other products (printer cartridges).

This category is split into domestic taps and domestic showers, which represent 92% of the market. A ‘tap’ is defined as a directly/indirectly, mechanically and/or automatically operated valve from which water is drawn. In a domestic setting, taps are found mostly in kitchens and bathrooms where running water is required. A ‘shower’ is defined as a shower system consisting of the shower valve, shower outlet and connecting hoses. The shower valve controls the release of water in the shower system. The shower outlet directs water from the system to the users and is either fixed or moveable. Showers are found in domestic bathrooms. They are also located in non-domestic environments where showering facilities are needed such as leisure centres, hotels and athletics facilities.

A27.2 Market information

Domestic taps have an estimated 11.5m unit sales per annum[166]. Domestic showers have an estimated 3.8 – 6.1m sales per annum. The markets for both taps and showers are static, both having a CAGR of 0.06% from 2020 – 2050.

Stakeholders mentioned moderate production of taps and shower systems in the UK, although most products are imported from Italy and China.

HS-6 code 28.14.12.35 trade information shows UK imports as 4.3 million units per annum. UK exports are 567,000 units per annum. The average number of units produced per annum are 1.4 million units.

Some UK water companies will distribute low flow water solutions such as aerators for taps or low flow shower heads for free in limited numbers per household.

China is a major producer of this product group, according to responses received in the BEIS Call for Evidence. European production mainly takes place in Germany, Italy and Portugal. There is moderate production in UK.

[166] Based on EU sales of taps and showers scaled to UK using a population factor (0.15). EU values taken from the JRC Taps and Showers Preparatory Study (see A27.8 Evidence sources).

A27.3 Energy performance information

A tap consists of a mechanical valve and casing. When the valve is opened, water flows out of the tap. A shower system consists of a mechanical valve and shower outlet. When the valve is opened, water flows from the shower outlet. Taps are used periodically throughout the day, with showers typically used in the early mornings and evenings due to domestic habits.

The options for reducing the energy consumption of taps relate to the heating system efficiency or low flow solutions. Improvements in heating systems efficiency would reduce the amount of energy required to heat the same quantity of water, thereby reducing energy consumption of the system. Low flow solutions such as aerators for taps or low flow shower heads for shower systems reduce the flow rate of water passing out of the tap. This in turn reduces the volume of water heated, hence reducing energy consumption of the tap/shower.

Given the on-going work in this area, no energy performance information has been estimated for taps and showers.

Recent analysis conducted by Energy Saving Trust looked at the costs and benefits of implementing water labelling options in the UK. Although the scope of this work extended beyond taps and showers and included toilets, water using products, washing machines and dishwashers, a taps and showers only analysis was also carried out. Four scenarios were modelled with the most favourable BCR projecting over 30 litres per day savings over a 25-year period. The scenarios assume that mandatory water labelling supported by MEPS would be implemented with requirements being added to building regulations. BCRs from all four scenarios exceeded 100:1, indicating that all ambition levels would be cost effective. Emission savings range between 27 – 36 $MtCO_2e$ cumulative savings over 25 years from energy and water related emission savings. It is worth noting that the saving estimates rely heavily on assumed behavioural impacts of the water label on water consumption.

A review study related to taps and showers was prepared by the Joint Research Council (JRC) in 2018. This study assessed potential EU level savings from five different water labelling scenarios. Each scenario considered covered different levels of harmonisation of (voluntary) energy and resource labelling, with the fifth category (entitled ‘maximum saving potential’) representing mandatory labelling. These are summarised here:

- Business as usual
- Industry-led harmonised label without a voluntary agreement with the EC (e.g., ‘Moderate harmonisation of labelling’ scenario).
- Voluntary agreement between EC and industry including a harmonised label (e.g., ‘Satisfactory harmonisation of labelling’ scenario).
- Mandatory label at EU level based on testing of functionalities (e.g., ‘Full harmonisation of labelling’ scenario).
- Maximum energy saving potential

Table A27.1 EU water and energy savings under five labelling scenarios (JRC, 2018)

Parameter	Year	1) Business As Usual (BAU)	2) Moderate harmonisation of labelling	3) Satisfactory harmonisation of labelling	4) Full harmonisation of labelling	5) Maximum saving potential
Water consumption (Gm3/year)	2015	24.9	0	0	0	0
	2030	23.2	0.1	0.3	0.4	2.5
	2050	22.6	0.3	0.6	1.3	4.9
Primary energy demand for water heating (PJ/year)	2015	2580	0	0	0	0
	2030	1670	10	20	40	250
	2050	1620	10	40	90	460

Looking at the JRC's 2030 saving projections, 33% greater water savings and 100% additional energy savings could be achieved through use of a mandatory labelling scheme (scenario 4) compared to the most ambitious uptake of a voluntary labelling scheme (scenario 3).

It is challenging to compare the two studies given the different analytical approaches taken, but both studies indicate that considerable savings can be made via a mandatory label versus a voluntary approach. The EST study estimates that benefits far outweigh costs, although each of their policy options assumes mandatory labelling backed by MEPS.

To consider policy levers specific to taps and showers, it is recommended to assess the underlying evidence and assumptions related specifically to those products to limit the scope of savings. It is also recommended to understand better how impacts of voluntary versus mandatory measures were allocated, and to understand the extent to which stakeholders were consulted on these outputs.

A27.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £35 to £500. Most taps approximately at £130.
- **Product weight:** approximately 1.6 kg to 4 kg
- **Lifespan:** 10-16 years
- **Typical duration of the warranty:** 1 - 5 years
- **% currently recycled:** Not available. High potential to be recycled due their metal content (90-95% metal-based products)
- In a typical household, water consumption of taps and showers as follows:
- Taps (washbasin) – 4 litres/p. person/day
- Taps (kitchen) – 4.5 litres/p. person/day

A27.4.1 Composition of typical product

Table A27.2 Composition of typical product – taps

Main component	Main materials	Weight (g)	% of total product
Body	Brass	1200	72.0%
	Nickel chrome plating	2	0.1%
	Plastic materials	73.5	4.4%
	Ceramic discs	21	1.3%
Handle	Zinc	216	13.0%
Pressure hoses	Plastic	154	9.2%
TOTAL		1666.5	100%
Packaging	Cardboard	565.5	N/A

Table A27.3 Composition of typical product – showers

Main component	Main materials	Weight (g)	% of total product
Valve – body	Brass	2226.5	54.3%
	Nickel chrome plating	2	0.0%
	Plastic materials	257	6.3%
	Ceramic discs	31.5	0.8%
Valve – handle	Zinc	353.5	8.6%
Outlet	Plastic	278	6.8%
	Brass	951	23.2%
TOTAL		4099.5	100%
Packaging	Cardboard (valve)	568	
	Plastic (outlet)	371	

Hazardous substances content

Critical Raw Material content – Not expected to be present in this product group.

Hazardous substances content – Not expected to be present in this product group. The only potential presence would be due to use of heavy metals.

A27.5 Information on select policy levers and horizontal measures

The policy lever analysis was excluded for taps and showers due to previous work having been completed for this product group.

The horizontal measures assessed here are intended to supply information and extend lifetimes. It is assumed that the measures can be implemented independently of a VA, but there are potential efficiencies to gain from adopting a UK specific version of this VA containing these horizontal measures.

The 2018 follow up study noted that the average lifetime of taps and showers is already satisfactory and is typically longer than the average bathroom renovation cycle.

On resource efficiency of taps and shower systems, respondents to the BEIS Call for Evidence were clear that there are often issues with recycling chrome plates plastic and galvanised components of taps and shower systems. One respondent felt that introducing similar resource efficiency requirements as those recently introduced under Ecodesign for washing machines and refrigerators could be useful.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Existing energy related policy levers in UK

- Taps and showers are covered by the “Salix public sector finance - Phase 2 Public Sector Decarbonisation Scheme” and “Salix public sector finance - Loan scheme”.
- Building regulations (Part G2) define maximum flow rates for showers.
- The Unified Water Label is an industry led voluntary labelling scheme.

Existing circular economy related policy levers

- None identified

Table A27.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[167]	Policy objective/ impact	Scale of impact	Suitability comments
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements. Keep track of VA developments in EU.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Keep track of VA developments in EU.
Product support & extension of Ecodesign November package measures[168]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Keep track of VA developments in EU.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Keep track of VA developments in EU.

A27.6 Summary of stakeholder feedback

Feedback from Task 2 of this study was limited. A stakeholder suggested that boiling water taps[169] should be included on the list but did not give any explanation. A manufacturer suggested the inclusion of standard mixer showers in this product group. This technology is already included here.

In feedback from Task 3 of this study, two stakeholders considered that taps and showers should not be included on the short list. One objected to the product group being named ‘taps and shower heads’, instead preferring ‘taps and showers’ as this is more representative of the products considered being a shower system consisting of a valve and shower head. The second stakeholder considered that investigation of taps and showers in this study could

[167] Further detail on assumptions contained in Section 3.4.4
[168] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.
[169] https://www.t3.com/features/best-boiling-water-tap

jeopardise existing research in this area, such as participation in an existing voluntary labelling scheme and ongoing work to standardise the metrics within the industry.

Stakeholders have indicated that Building Regulations part-G2 on water efficiency defines maximum shower fittings (e.g., flow rates of showers 10 l/min or 8 l/min) and that the Unified Water Label (UWL) assesses the water performance of products according to flow rates while also aiming to compare energy consumption according to methodologies and assumptions of usage. However, these assumptions do need to be reviewed according to current information in Building Regs, SAP (Standard Assessment Procedures) delivered by the BRE, and existing research conducted, for example, by the Energy Savings Trust. They have also mentioned that RIBA 2030 Climate Challenge Targets are: reducing potable water use by at least 40%, reducing operational energy demand by at least 75%, and reducing embodied carbon by at least 50-70%.

An industry association indicated that the UWL is an existing policy lever and that water, not energy is the primary metric used. Also, due to the extended lifetime of product, it is important to provide incentives for replacing the existing stock.

A manufacturer also recommended that the UWL be made mandatory to help consumers identify high efficiency products and to incentivise manufacturers to innovate.

Extensive feedback on this product group was received in the BEIS Call for Evidence (CfE). Stakeholders noted that introducing a minimum flow rate or a water and energy label could be effective steps in furthering policy in this area. There is debate over the effectiveness of a minimum standard based on flow rates, as this may be considered unacceptable by end users.

Introduction of a mandatory water and energy label was considered a highly effective route by stakeholders in the CfE. Australia’s Water Efficiency Labelling and Standards scheme or the industry led voluntary Europe/ Unified Water Label (UWL) water efficiency labelling scheme were mentioned as existing schemes for comparison.

In the CfE, stakeholders were asked based on existing technologies, what is the maximum amount of energy and water that could be saved from taps and showers. A study commissioned by an NGO assessing water and energy savings was highlighted by some respondents. The study was based on existing technologies, under a mandatory labelling scenario with minimum standards. It projected that up 21,000 MWh/year in energy and 705,000 Mlitres/year of water could be saved within 10 years.

A27.7 Discussion & next steps

There is on-going work and engagement with industry related to this product group. Assessments of potential energy and water savings related to mandatory labelling schemes are on-going. It is worth noting that attribution of savings due to labelling can be challenging to assess, due to the difficulties in projecting consumer behaviour in response to labelling.

The UWL is an industry led EU wide initiative to provide information to consumers. It was developed by the Bathroom Manufacturers Association (BMA) in the UK but is now being driven by the European Bathroom Forum. Industry is using this scheme to develop a proposed VA in the EU. Recommend continuing to follow this process and continuing to engage with UK industry to understand how this could form the basis of additional policy levers.

An important aspect of reducing water consumption is mitigating the potential trade off on consumer experience. Suitable standards must consider this and look to research to inform the minimum standards.

A27.8 Evidence sources

Title	Author	Date Published or date accessed
Taps and Showers Preparatory Study	JRC	2014
The influence of different water efficiency ratings of taps and mixers on energy and water consumption in buildings	Sebastian Englart and Andrzej Jedlikowski	2019
Measurement of Domestic Hot water Consumption of Dwellings	Energy Saving Trust	March 2008
BEUC Factsheet – Water Using Equipment	BEUC	December 2012
http://www.reducereuserecycle.co.uk/greenfreebies/free_water_saving_devices.php		March 2021
Building Regulations 2010 (2016 update) Sanitation, hot water safety and water efficiency Approved Document G: Requirement G2 Water efficiency	HMG	2016
Independent review of the costs and benefits of water labelling options in the UK EXTENSION PROJECT Technical Report - FINAL	Energy Saving Trust	2018
Water Labelling: Taps and Showers Only Comparison	Energy Saving Trust	2020

Annex 28 Motor Driven: Water Pumps

A28.1 Introduction

Motor driven product groups convert energy to mechanical force to drive machines with a multitude of end uses, including pumps, fans, and compressors other than those used in refrigeration.

Pumps are defined by the current Ecodesign regulation (EU 574/2012) as ‘the hydraulic part of a device that moves fluid by physical or mechanical action’. Their operational performance is characterised by two main parameters: the ‘head’ (the height in metres above a suction inlet that the pump can lift a fluid to the outlet); and the ‘flow’ (the volumetric flow rate in cubic meters per second of the fluid that is sucked through the pump from inlet to outlet). The power delivered to the fluid (P_out) is proportional to the net head (H), Volumetric flow rate ($\dot{Q}$), density of the fluid (ρ) and the gravitational acceleration (g): $P\_out=H\dot{Q}\rho g$. Suction head is also important as it drives design and material selection.

Water pumps have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A28.2 Market information

The current Ecodesign regulation regulates rotodynamic water pumps for pumping clean water, including where integrated in other products. The following designs are in scope: end suction own bearing (ESOB), end suction close coupled (ESCC), end suction close coupled inline (ESCCi), vertical multistage (MS-V), and submersible multistage (MSS) pumps.

Sales of water pumps in scope of the current Ecodesign regulation in the UK range between 113,000 and 186,000 units. Based on EU sales of pumps, it is estimated that increasing the scope to include other types of pumps could increase UK sales estimates to around 400,000 unit sales per year.

In Europe, sales of water pumps are forecasted to increase slightly between 2020 and 2025 and then stabilise until 2030. The pump manufacturing market in the UK is expected to decline at a compound annual rate of 1.8% through to 2022-2023 (IBIS, 2018) due to strong global competition and restricted demand.

The HS6 trade code for water pumps products is 28.13.14

Over 94% (£1,295 million in 2017) of the domestic demand for all types of pumps and pumps parts is supplied by import. UK manufacturers export approximately 94.3% of their pumps production. These values are artificially high due to the number of assemblers in the UK. Oil prices and value of pound drives demand for pumps significantly. UK key export destination is

US representing 15% of total export value in 2018. Key import partners are Germany and US representing 20% and 16% of UK imports by value, respectively.

The UK pump industry includes companies manufacturing, assembling, and distributing various types of centrifugal and positive displacement pumps. There are estimated to be over 200 manufacturers, distributors, and assemblers of pumps within the UK. Of these market players, there are around 50 manufacturers of pumps in the UK. The British Pump Manufacturers Association represents around 80 companies active in the UK pumps market.

A28.3 Energy performance information

The typical energy consumption of a unit ranges between 7.2 and 8.8 MWh per year.

Pump efficiency (η) is the ratio of energy imparted to the pumped fluid, to the mechanical energy provided by the pump motor. The pump efficiency varies with head and flow, with pumps designed to optimise efficiency at a 'Best Efficiency Point' (BEP), which is below the maximum head and flow capability of the pump. Overall pumping efficiency is also affected by the cross-sectional shape, pipe run geometry, use of diffusers and exit loss, and capacity of pipework fitted to pump inlet and outlet, and by the efficiency of the drive motor.

Running pumps at their Best Efficiency Point (BEP) by using Variable Speed Drives (VSD) in variable flow application has potential of reducing energy usage by up to 28% in the UK[170].

Potential to increase pumps efficiency at product level is limited with current Ecodesign regulation. The Extended Product Approach (EPA) can contribute to higher savings. Running pumps at their Best Efficiency Point (BEP) by using Variable Speed Drives (VSD) in variable flow application has potential of reducing energy usage.

Table A28.1 Energy performance information

	Pump + motor system
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	8.1 - 24.6
Maximum technical potential energy savings that can be achieved with BAT (TWh)	2.03 - 6.89
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.82 - 2.77
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	1.7 - 5.1

170 https://www.ecopumpreview.eu/downloads/Review_study_Water_pumps_547-2012_VM-VHK-ENER_Final_report.pdf

	Pump + motor system
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.43 - 1.43
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.17 - 0.57
Benefit Cost Ratio of BAT Savings	15.3

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a water pump is 13 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 2 - 4.59 TWh of energy could be saved as well as 0.43 - 0.95 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.8 - 1.84 TWh of energy and 0.17 - 0.38 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A28.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £400 to £2,800. Most water pumps are sold approximately at £950.
- **Product weight:** between 30 kg and 380 kg
- **Lifespan:** 10-15 years
- **Typical duration of the warranty:** 2-5 years
- **% currently recycled (where available):** 90%

A28.4.1 Composition of typical product

Table A28.2 Composition of a typical water pump

Main materials	Weight (g)	% of total product
Steel	64,310	41,67%
Cast iron	47,890	31.03%
Stainless steel	20,460	13.25%
Cardboard	9,410	6.10%
Aluminium die cast	5,590	3.62%
Copper winding wire	4,390	2.85%
Thermoplastic polycaprolactam (Polyamide 6 - PA6)	920	0.60%
LDPE	610	0.40%
Powder Coating	340	0.22%
Polyurethane	180	0.12%
Office paper	80	0.05%
Surface Mounted Device	60	0.04%
PVC	50	0.03%
Printed Wiring Board	30	0.02%

Main materials	Weight (g)	% of total product
Integrated Circuits	20	0.01%
TOTAL	154340	100%

Table A28.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in motors	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available). Recent developments in countries outside the EU have been reported but detailed information about the economic

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A28.5 Information on select policy levers and horizontal measures

This product group is subject to existing Ecodesign regulations. These regulations are under review and an EC consultation forum took place on 29 October 2019. A revision to this policy will likely happen soon. The revision is considering widening the scope to include additional products and to introduce an extended product approach (EPA) for certain types of pumps. The EPA was also looked at in the water pumps review study. It's noted that this systems-based approach would bring the largest opportunity for savings.

Existing energy related policy levers in UK

- There are existing Ecodesign rules for this segment, which are currently under review.
- No identified additional UK policies focusing on water pumps.
- Existing circular economy related policy levers
- None identified.

It's estimated that product groups with EC MEPS that are being revised will require < 2 years to revise in GB, while new mandatory policy levers would require 3 years to develop. New policy levers (that are not mandatory MEPS or labelling) are assumed to require 1 year to develop.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A28.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[171]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	< 2	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Revision underway in the EU. Good candidate for revision. Keep track of progress in EU.
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Candidate for new policy lever, but primarily non-domestic purchasing would limit the impact of this policy lever.
Voluntary endorsement label	1.5	Information provision / Energy savings	None found	Good candidate due to existing Ecodesign regulations.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings.	N/A	Unsuitable product for an energy supplier to provide to residential customers.
Public procurement	2	Prohibit poor efficiency products / Energy savings	None found	Would require a label to identify high efficiency products. Need to understand effectiveness of this measure.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	Not suitable as product not sold to domestic sector.
Advice/aid in implementation	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate for targeted advice on system efficiency.

[171] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[171]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	N/A	Not suitable as there's no label to identify high efficiency products.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	N/A	Not suitable as there's no label to identify poor performers.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen. Regular maintenance and repair is commonplace among end-users.
Product support & extension of Ecodesign November package measures[172]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen. Regular maintenance and repair is commonplace among end-users.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[172] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

A28.6 Summary of stakeholder feedback

Feedback indicated significant potential saving opportunities from carrying out energy audits on pumping systems according to the ISO 14414 pump system energy assessment standard. The stakeholder also mentioned that the addition of variable speed drives to both circulators and pumping systems would bring about significant savings.

A trade association noted the extensive body of evidence available via the preparatory studies for pumps and highlighted the importance of moving to the EPA. They also indicated that certain types of pumps such as agricultural pumps, swimming pool pumps and self-priming pumps is minimal.

Water pumps were covered extensively in the BEIS Call for Evidence. Feedback indicated support for the EPA from both industry and NGOs. Conflicting responses were received around the suitability of resource efficiency requirements for water pumps. Responses also indicated support for revising MEPS, with some preferring to align with the EC revisions and others suggesting there are opportunities to go beyond the EC in terms of strictness of future requirements and widening the scope of the regulation to include other pumps.

A28.7 Discussion & next steps

Recommend to closely follow developments with the revised draft EC Ecodesign regulation for pumps. The revision will likely expand the scope beyond the current regulation to include booster sets and multi-stage horizontal pumps. There are also opportunities to expand the scope further in line with proposals made in the review study.

The expansion of scope to additional pump types and the related MEPS values would depend on the availability of EPA related values for the pumps brought into scope. If these values are not available, the efficiency metrics currently being used could be applied to these pumps.

New information requirements are also being put forward in the revised regulation, which could be related to the requirements for material content and declaration, so it is recommended to track this aspect at the EU level. Discussions have also indicated that resource efficiency requirements will only be considered in the next iteration of the regulation. This may not be an issue as repair and servicing of water pumps is already commonplace.

A28.8 Evidence sources

Title	Author	Date Published or date accessed
Ecodesign Pump Review Study of Commission Regulation (EU) No. 547/2012 (Ecodesign requirements for water pumps)	VHK for the European Commission	December 2018
Appendix 5: Lot 11 - Water Pumps (in commercial buildings, drinking water pumping, food industry, agriculture).	AEA Group for the European Commission	February 2008
Post Brexit study	ICF	unpublished
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 29 Refrigeration: Refrigerating appliances with a Direct Sales Function

A29.1 Introduction

Commercial refrigerating appliances with direct sales function are designed to store and display chilled and/or frozen products (typically food and drinks) and are mainly used by commercial, institutional, or industrial facilities.

As described below, there are many different designs of refrigerated display cabinets, but all enable the customer to view the foodstuff stored in the cabinet, either through an opening in the cabinet, or through a transparent door, lid, or curtain.

Refrigerated display cabinets (RDCs) are normally used in supermarkets or grocery stores. They can be either plug-in (also knowns as integral - incorporating a compressor and condensing unit) appliances or connected to a remote refrigeration system (e.g., the compressor and condenser, or all or parts of the refrigeration system are located at a different location from the cabinet). The displayed products are usually perishable and stored at low temperatures.

Beverage coolers are cabinets usually designed to quickly lower the temperature of products that have been inserted at ambient temperature. They are used to store pre-packaged, non-perishable beverage products for sale to customers. Beverage coolers can be classified as plug-in, chilled, vertical, closed cabinets.

Small ice cream freezers[173] are also considered in this product category. It is important to note that the net refrigerated volume is usually smaller for ice cream freezers intended for merchandising when compared to their counterparts in the supermarket. But they often have storage compartments not for display at the bottom. Ice cream freezers can be classified as integral and plug-in, frozen, horizontal, closed cabinets.

Vending machines are excluded from this product category as they are responsible for only 5% of energy demand from 10% annual sales.

Linked to the RDC category, is the product group ‘Curtains, Blinds, Doors and Covers’, which can also be referred to as energy saving add-ons. These products are used as barriers that can be used to reduce the infiltration of ambient air (and heat flow) into refrigerated display cabinets, thereby reducing the energy consumption of the cabinet.

[173] A limit on volume of 500 litre has been proposed and has been considered appropriate, $V < 500$ litre, $TDA < 1.1\ m^2$

Refrigeration appliances with a direct sales function have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A29.2 Market information

Refrigerating appliances with direct sales function (e.g., RDCs, beverage coolers and small ice cream freezers) have an estimated combined total of 171,391 UK sales per annum with RDCs representing 20.4%, beverage coolers 49.2%, and ice cream freezers, 30.4%.

The estimated market growth rate for RDCs is 0.24%, while for beverage coolers and ice cream freezers the rate is 0.76% per annum, as per the JRC preparatory study update (2014) forecast growth rate to 2030.

Projected annual sales for the product group “Curtains, blinds, doors and covers for RDCs” are 123,834[174].

The market for strip curtains and chest freezer covers have decreased significantly and they are expected to decrease even further, particularly as strip curtains in supermarkets are no longer common.

Stakeholders have suggested a market split of 75% (new cabinet blinds) and 25% (retrofit blinds).

Various air flow management retrofit approaches are available to reduce air infiltration, including shelf edge technology and the use of multiple air curtains. These have the energy saving potentials ranging from 25 to 40%.

Major supermarkets, namely Sainsbury’s, Asda, Tesco, Morrisons, M&S and Waitrose, have already announced their decision to manufacturers that they will keep their cabinets open. As a result, manufacturers predict that the use of airflow management solutions for open fronted cabinets is likely to increase.

Currently in the UK, doors on cabinets are not the most preferred energy saving measure in large supermarkets even though the energy savings are well-documented in technical reports.

Door manufacturers have reported 20-30% of their sales to be for the retrofit market. This is likely to increase soon if end users decide to change their strategy or there is an external push for doors (e.g., Government policy).

[174] The annual sales estimate represents the number of refrigerated display cabinets that would be retrofitted with any of the energy-saving add-ons. These sales numbers are based on sales data and market share as provided by the current leading manufacturer in the retrofit market for cabinets, therefore any of the fluctuations in the results are directly linked to the manufacturer feedback.

Door manufacturers have highlighted that the current culture in the UK commercial refrigeration industry is different from what countries in Europe do in terms of the energy efficiency of refrigerated display cabinets.

UK supermarket operators are admittedly working in a highly competitive environment while retailers in France and Germany have managed to demonstrate 12 years of collaborative work with strong social responsibility at a corporate level.

Commercial refrigeration equipment is produced mainly in Japan, Western Europe, and the US.

The supermarket segment for remote RDC manufacturing is dominated by 5-7 manufacturers, representing ca. 70 % of the market. The plug-in segment is more fragmented, with over 50 manufacturers in the EU.

Major suppliers and manufacturers of RDCs in the UK are Carters (UK), Epta Group (Italy), Foster (UK), Gram (UK), Linde Carrier (US), Williams (UK), Purecold (cabinet importers from China), Koxka (Spain), Kaplanlar (Turkey) and others.

Suppliers and manufacturers of curtains, blinds, doors and covers for RDCs in the UK are Chiller Blinds (UK), Eis-kalt (UK), Kenfield Ltd (UK), SCHOTT (Germany), Rollatherm (UK), Thermasolutions International (UK).

A29.3 Energy performance information

The typical energy consumption of a unit ranges between 0.8 and 28.3 MWh per year.

In general terms, there are two types of RDCs – open, and closed display. They use refrigerants and a vapour compression cycle (a compressor and condensing unit) to cool a volume of space used in non-residential applications.

In an open RDC, an air curtain provides a barrier to prevent warm air infiltration into the cabinet, while for closed RDCs, doors provide a physical barrier to ambient air. The infiltration of warmer ambient air into the cabinet impacts both food quality and safety by increasing product temperature, and puts extra load on the compressor, thus increasing energy consumption. Air infiltration can account for 67-77% of the total heat load of a standard open RDC.

There is potential to improve product efficiency and achieve up to 50% savings.

The BAT savings are for all refrigerating appliances are calculated assuming that all units are sold with the electricity consumption associated with using Best Available Technology. For refrigerated display cabinets, the BAT scenario includes doors, but is not limited to this design option. That is, it also reflects the use of LED lighting (instead of fluorescents), parallel compression, electronic controls, and inverters. Consequently, the energy savings are a cumulation of each of these energy savings measures. BAT does not include blinds, curtains and covers, which provide an alternate and cheaper means to limit air infiltration, but are less efficient than doors.

BAT includes various readily available measures, including doors (these can be made of Perspex or glass. The latter is a more expensive solution but more reliable and better quality. Glass doors can have single, double, or triple glazing. Reductions in the range of 23% to 73% are achievable), parallel compression (compresses the excess gas at the highest possible pressure level to improve the energy efficiency), electronic controls, LEDs (50% compared to older lighting forms, such as fluorescents; although this value depends on the location of the lighting, the amount of lighting, and external light sources), inverters (compared to the traditional single speed compressor, the inverter compressor can run at a number of desired speeds, depending on how the refrigerator is being used by the consumer. This provides options for quick pull down or freezing, or to run at a very low speed once the cabinet is at a steady state, thereby significantly reducing energy consumption.), shelf edge technology (these are fitted to the edge of each shelf in the cabinet, thus keeping the cold air in the cabinet with less cold-air spill in the aisle in front of the cabinet. It is claimed that they can achieve a 40% reduction in energy consumption and minimal maintenance. The aerofoils are made from 100% recycled aluminium).

Table A29.1 Energy performance information (Refrigerating appliances)

	Refrigerated display cabinets	Beverage coolers	Ice cream freezers
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	6.84 - 15.26	0.48 - 1	0.56 - 1.13
Maximum technical potential energy savings that can be achieved with BAT (TWh)	1.37 - 7.63	0.03 - 0.5	0.02 - 0.17
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.74 - 4.11	0.02 - 0.27	0.01 - 0.09
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	1.44 - 3.08	0.08 - 0.25	0.08 - 0.25
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.29 - 1.54	0 - 0.13	0 - 0.04
Maximum technical potential carbon savings that can be	0.16 - 0.83	0 - 0.07	0 - 0.02

	Refrigerated display cabinets	Beverage coolers	Ice cream freezers
achieved with a mix of policy levers (MtCO2e)			
Benefit Cost Ratio of BAT Savings	8.6	3.3	6

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

Table A29.2 Energy performance information (Curtains, blinds, doors and covers for RDCs)

	Curtains, blinds, doors and covers for RDCs
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	10.8 - 30.8
Maximum technical potential energy savings that can be achieved with BAT (TWh)	1.3 - 12.32
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.7 - 6.63
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	2.24 - 6.32
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.27 - 2.53
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.15 - 1.36
Benefit Cost Ratio of BAT Savings	2.2

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

Retrofit measures for RDCs are energy saving add-ons. The sales figures considered for the estimates correspond to the average number of RDCs being retrofitted each year. Baseline typical energy consumption is presented for average RDCs without a retrofit measure and savings are calculated assuming that the installation of curtains, blinds, covers or doors will reduce the energy consumption of these units by up to 40%.

The average lifespan of a retrofit measure for RDCs is 6 years and the savings presented in the table are estimated for RDCs units retrofitted in one given year in the UK over the lifespan of the retrofit measure. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If 110k - 130k RDC units were retrofitted in the UK in a given year, 3.24 - 15.4 TWh of energy could be saved as well as 0.67 - 3.16 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 1.74 - 8.29 TWh of energy and 0.36 - 1.7 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of an RDC is 12 years. If all units sold annually in the UK in a given year were BAT technologies, 1.6 - 5.45 TWh of energy could be saved as well as 0.32 - 1.1 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.86 - 2.93 TWh of energy and 0.17 - 0.59 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a beverage cooler is 10 years. If all units sold annually in the UK in a given year were BAT technologies, 0.06 - 0.4 TWh of energy could be saved as well as 0.01 - 0.1 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.03 - 0.22 TWh of energy and 0.01 - 0.05 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of an ice cream freezer is 10 years. If all units sold annually in the UK in a given year were BAT technologies, 0.04 - 0.14 TWh of energy could be saved as well as up to 0.03 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.02 - 0.08 TWh of energy and up to 0.02 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A29.4 Baseline resource efficiency information

Resource footprint

Refrigerated display cabinets (RDCs)

- **Average price:** from £3,192 to £3,894. Most RDCs approximately at £3,500.
- **Product weight:** approximately 775 kg to 680 kg
- **Lifespan:** 9-14 years
- **Typical duration of the warranty:** 1 - 2 years
- **% currently recycled:** 84% (large household appliances)

Beverage coolers

- **Average price:** from £750 to £865. Most beverage coolers approximately at £845.
- **Product weight:** approximately 90 kg to 150 kg
- **Lifespan:** 8-12.5 years
- **Typical duration of the warranty**: 1 - 2 years
- **% currently recycled:** 84% (large household appliances)

Ice cream freezers

- **Average price:** from £720 to £755. Most ice cream freezers approximately at £742.
- **Product weight:** approximately 75 kg to 280 kg
- **Lifespan:** 8-12.5 years
- **Typical duration of the warranty:** 1 - 2 years
- **% currently recycled:** 84% (large household appliances)

Curtains, blinds, doors and covers for RDCs

- **Average price (doors):** from £199 (installation of blinds) to £2,642 (installation of BAT doors). Most doors approximately at £1,670.
- **Product weight:** approximately 5 kg to 30 kg
- **Lifespan:** 4-8 years
- **Typical duration of the warranty:** n.a.
- **% currently recycled (where available):** usually accounted for in the "% currently recycled" for RDCs
- Doors and others are manually removed from the appliances as part of the pre-treatment stage of the recycling process.
- Glass parts particularly are extracted manually from doors and other parts of the appliances because they can damage the blades of the shredders. Some glass components with double glazing could be difficult to be manually extracted.

A29.4.1 Composition of typical product

Table A29.3 Composition of typical product – RDC: Vertical open chilled multideck (RCV2)[175]

Main component	Main materials	Weight (g)	% of total product
Included are:	Bulk Plastics	13938	2.27%
external housing	Tec Plastics	27,203	4.43%
foam insulation	Ferro	466,255	75.93%
shelves	Non-ferro	49,134	8.00%
lighting system	Coating	21,996	3.58%
components for assembling (screws, rivets, etc.)	Electronics	150	0.02%
evaporation module	Misc. (Blowing agent)	35,348	0.15%
expansion valve module	Misc. (Glass)		0.08%
anti-sweat heater	Misc. (Ballast)		0.19%
electric assembly	Misc. (Cardboard)		0.22%
packaging	Misc. (Paper)		0.17%
	Misc. (Wood)		4.94%
Miscellaneous electronic temperature control pipes in the refrigeration system others	Misc. (Other)		0.00%
TOTAL	614,023	100%	

175 Preparatory Studies for Ecodesign requirements of EuPs, Lot 12, Commercial refrigerators and freezers, Final Report, BIO Intelligence Service

Table A29.4 Composition of typical product – Beverage cooler24

<table>
<tr><th>Main component</th><th>Main materials</th><th>Weight (g)</th><th>% of total product</th></tr>
<tr><td rowspan="15">Included are:
external housing
foam insulation
shelves
door
lighting system
components for assembling (screws, rivets, etc.)
evaporation module
compression module
condenser module
expansion device module
electric assembly
packaging</td><td>Bulk Plastics</td><td>5,495</td><td>4.46%</td></tr>
<tr><td>Tec Plastics</td><td>8,756</td><td>7.11%</td></tr>
<tr><td>Ferro</td><td>68,915</td><td>55.97%</td></tr>
<tr><td>Non-ferro</td><td>12,804</td><td>10.40%</td></tr>
<tr><td>Coating</td><td>900</td><td>0.73%</td></tr>
<tr><td>Electronics</td><td>64</td><td>0.05%</td></tr>
<tr><td>Misc. (Ink)</td><td rowspan="9">26,189</td><td>0.06%</td></tr>
<tr><td>Misc. (Blowing agent)</td><td>0.44%</td></tr>
<tr><td>Misc. (Glass)</td><td>15.75%</td></tr>
<tr><td>Misc. (Ballast)</td><td>0.81%</td></tr>
<tr><td>Misc. (Ester oil)</td><td>0.24%</td></tr>
<tr><td>Misc. (Cardboard)</td><td>0.15%</td></tr>
<tr><td>Misc. (Paper)</td><td>0.05%</td></tr>
<tr><td>Misc. (Wood)</td><td>3.51%</td></tr>
<tr><td>Misc. (Refrigerant)</td><td>0.26%</td></tr>
<tr><td colspan="2">TOTAL</td><td>123,124</td><td>100%</td></tr>
</table>

Table A29.5 Composition of typical product – Ice cream freezers24

<table>
<tr><th>Main component</th><th>Main materials</th><th>Weight (g)</th><th>% of total product</th></tr>
<tr><td rowspan="3">Included are:
external housing
foam insulation</td><td>Bulk Plastics</td><td>3,509</td><td>4.71%</td></tr>
<tr><td>Tec Plastics</td><td>8,067</td><td>10.83%</td></tr>
<tr><td>Ferro</td><td>19,441</td><td>26.10%</td></tr>
</table>

Main component	Main materials	Weight (g)	% of total product
shelves door components for assembling (screws, rivets, etc.) evaporation module compression module condenser module expansion device module Electric assembly Packaging Miscellaneous Temperature control and display system pipes in the refrigeration system others	Non-ferro	6,568	8.82%
	Coating	23,709	31.83%
	Electronics	0	0.00%
	Misc. (Cardboard)	13,200	0.77%
	Misc. (Glass)		8.32%
	Misc. (Blowing agent)		0.54%
	Misc. (Ester oil)		0.37%
	Misc. (Wood)		5.75%
	Misc. (Paper)		0.27%
	Misc. (Refrigerant liquid)		0.30%
	Misc. (Unknown)		1.40%
TOTAL	74,493	100%	

Table A29.6 Composition of typical product – Door on a beverage cooler

Main component	Main materials	Weight (g)	% of total product
Door[176]	Gasket (Bulk Plastics)	690	0.56%

[176] The materials composition of doors is based on the BOM for beverage coolers which includes doors as a listed component.

	Handle and plastic cover (Bulk Plastics)	720	0.58%
	Hinges (Ferro)	100	0.08%
	Spring (Ferro)	100	0.08%
	Aluminium (Non-ferro)	4,201.1	3.41%
	Glass (Misc.)	19,123.6	15.53%
TOTAL (doors)		24,934.7	20.25%
TOTAL (beverage coolers)		123,124	100%

Table A29.7 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in motor	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available).

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain. In refrigerators where space is critical, NdFeB-magnets are used preferably also in main motors.	Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

Presence of refrigerant such as R134a and R404a (will be phased out by and would no longer be services in the EU after 2020).

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables

A29.5 Information on select policy levers and horizontal measures

This product group is subject to existing Ecodesign and Energy labelling regulations. These regulations were part of the November Package[177] of regulations passed in 2019 and the UK Government has announced it will implement them in GB in Summer 2021, subject to Parliamentary approval.

Because energy labelling is already in place, most of the policy levers assessed in this study were deemed suitable for this product group.

Regarding horizontal measures, it is assumed that 2 of the 4 measures can be implemented independently of MEPS regulations, whilst the others would be simplest to implement alongside revised MEPS for this product category.

Existing energy related policy levers in UK

- There are existing Ecodesign rules covering this segment, but there were no identified additional UK policies focusing on refrigeration appliances with a direct sales function.
- Existing circular economy related policy levers
- None identified.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

[177] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A29.8 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[178]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Recently regulated 2	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Candidate for uplifting the regulation as a method for encouraging more energy efficient technologies and components that can reduce air infiltration such as doors and curtains.
Mandatory label (includes enforcement)	Recently regulated 2	Information provision / Energy savings	None found	Recent regulation. Uncertain value in revisiting this policy.
Voluntary endorsement label	Already exist 1	Information provision / Energy savings	None found	Already exist for doors, curtains and blinds. Potential to expand to RDCs themselves.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier to provide to residential customers.
Public procurement	Already exist 1	Prohibit poor efficiency products / Energy savings	None found	May need revision based on MEPS and labelling. Need to understand effectiveness of this measure.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings.	N/A	Not suitable option as it's a non-domestic product.

[178] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[178]	Policy objective/ impact	Scale of impact	Suitability comments
Advice/aid in implementation	1	Information provision – usage and purchasing high efficiency products / Energy savings	N/A	Candidate for sector specific new policy lever.
Grants, subsidies, loans	1	Increase accessibility of high efficiency products / Energy savings	None found	Good candidate due to mandatory labelling.
Taxes on poor performing products	1	Reduce purchases of low efficiency products / Energy savings	None found	Good candidate due to mandatory labelling.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	N/A	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[179]	2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.

[179] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

Policy lever	Indicative time needed to implement (years)[178]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A29.6 Summary of stakeholder feedback

Stakeholder feedback collected during Task 3 indicates one manufacturer who thinks that professional storage cabinets are currently missing from the shortlist. Although products are large consumers of electricity and are in use 24/7 in hot environments, they are included within the Professional Refrigeration category.

No feedback received on this product group in the Call for Evidence.

A29.7 Discussion & next steps

The Commercial refrigeration study (BEIS) found that the UK retail sector, and in particular competition between supermarkets has become so highly competitive that there is a lack of collaboration, which instead of driving better productivity and innovation has had the opposite effect.

In the UK, the major decision-making process about what technology should be used and when it should be implemented is driven by capital costs and business performance rather than lifecycle costs.

New technologies are known by most retail stakeholders, but they are still perceived as not affordable.

The F-gas Regulation is closely linked to this product group, particularly in connection to expediting the transfer from HFCs to natural refrigerants. Importantly, a high leak rate of a high GWP refrigerant will mean a significant increase of the total CO2 emissions resulting from the use of the refrigeration system. As such, the F-gas regulation sets a target to reduce the CO2 equivalent of all gasses in use to 21% of the baseline (2009-12) by 2030.[180] There is some evidence to suggest that levels of training for natural refrigerants are low and establishing a rigorous certification process could be critical. By comparison, in Europe there is a legal requirement for engineers to be certified in F-gases while there is no such requirement for

[180] The UK government will be reviewing this regulation with a view to consulting on revised legislation in 2022.

natural refrigerants despite the fact that they present hazards including high pressure (CO_2), flammability (hydrocarbons) and toxicity (ammonia).

As far as energy saving add-ons designed for RDCs are concerned, the most popular retrofit measure currently in the UK market is the shelf edge technology which is a type of enhanced air flow management solution which optimises the energy performance of RDCs whilst keeping them open. Manufacturers predict that the use of airflow management systems is likely to continue to increase. As a result, it is expected that this could be closely linked to the increased use of night blinds during supermarkets' non-trading hours because they can be installed together with the enhanced air flow equipment for additional savings.

As per the Ecodesign preparatory study (2014), manufacturers stated that a great number of commercial refrigeration appliances are fully or partially remanufactured. Remanufacturing is preferable with regards to material resource efficiency when compared with new products, but remanufactured products could be less energy efficient.

There is a risk of leakages of refrigerant gases during the transport of commercial refrigerating appliances and/or accidental breakages of the refrigerant circuit.

There could be a possible mismatch on the characteristics of the appliances being recycled today and the ones currently commercialised.

Treatment of blowing agents in insulating foams is critical to the recycling process of commercial refrigerating appliances, mainly due to flammability risks.

There is scarce and incomplete data on the end-of-life treatment of commercial refrigeration appliances.

It is difficult to estimate the flow of appliances that are reused, collected as waste or recycled. According to recyclers, large supermarket refrigerators are under-represented in their waste flows.

One specific constraint is that, if there is any data available, it does not differentiate between used and new goods.

Due to the absence of recycling data, the JRC preparatory study (2014) refers to WEEE data for larger household appliances to draw some conclusions about commercial refrigeration appliances. It is noted that household and non-household refrigerators are usually recycled together.

Commercial refrigeration appliances can be collected and treated by manufacturers, professional users and recyclers; therefore, data should be collected from all sources.

Specific statistical data is absent on appliances that are fully or partially remanufactured.

A29.8 Evidence sources

Title	Author	Date Published or date accessed
InputWkBk_Comm_CommRefrigeration_RefrigeratedDisplayCabinets_v2.1 - product categories RVC2 and RHF4	ICF modelling	unpublished
InputWkBk_Comm_CommRefrigeration_BeverageCoolers_v2.1	ICF modelling	unpublished
InputWkBk_Comm_CommRefrigeration_IceCreamFreezers_v2.1	ICF modelling	unpublished
InputWkBk_Comm_ETLRefrigeration_CBDCDisplayCabinets_NP_v3	ICF modelling	unpublished
JRC, Ecodesign for Commercial Refrigeration - Preparatory study update, Final report	JRC	2014
Commercial refrigeration study (BEIS)	ICF	unpublished
Preparatory Studies for Ecodesign requirements of EuPs (TREN/D1/40-2005/LOT12/S07.56644), Lot 12, Commercial refrigerators and freezers, Final Report,	BIO Intelligence Service	2007
Retail Refrigeration – Making the Transition to Clean Cold, University of Birmingham	Professor Toby Peters	2017
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 30 Refrigeration: Refrigerated Containers

A30.1 Introduction

Refrigeration product groups use refrigerants and a vapour compression cycle to cool a volume of space used in residential or non-residential applications.

Refrigerated containers, also known as reefers, are 20- or 40-foot-long shipping and storage containers of perishable goods. They have integrated energy using refrigeration units and require an external power supply. These containers are used to ship perishable goods such as chilled foods, dairy, frozen foods, fruit, meat, seafood, and vegetables.

Refrigerated Containers have smart connectivity potential. This can lead to energy optimisation services, contents monitoring, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A30.2 Market information

The demand for perishable goods is growing across the world, with the rise in middle-class populations and income levels. This demand, along with the growth in containerized trade, is driving the growth of the reefer containers market. The global reefer market was 3,169.2 thousand 20-foot equivalent units (TEU) in 2019, and it is expected to grow at a compound annual growth rate (CAGR) of 8% from 2020 to 2030. By 2030, the global market is expected to be 7,063.3 TEU of reefers181. Assuming Europe’s 40% contribution in total stock and 3.47% in sales, the annual sales of reefers in the European market was 108 TEU in 2019 (assumption based in part on global importance of European operators).

The UK reefer market is categorised by various end user industries, such as fruits & vegetables; bakery & confectionary; dairy & frozen desserts; meat, fish, and sea food; drugs & pharmaceuticals; and others.

The UK’s online grocery market is the third largest in the world, with 6.1% of grocery sales occurring online, propelling the UK’s cold chain logistics market growth. Online grocery shopping has resulted in an increase in refrigerated containers and warehouses. Since export industries are dependent on the vital links that the cold chain system provides, businesses have invested in UK cold chain logistics to create an effective, efficient, and reliable system to minimise losses of capital and products.

[181] https://www.alliedmarketresearch.com/press-release/uk-cold-chain-logistics-market.html#:~:text=Furthermore%2C%20around%206.1%25%20of%20the,cold%20chain%20logistics%20market%20growth

The global container market has been dominated by China, which accounts for more than 90% of the world's container manufacturing, due to low labour cost advantages. CIMC, Singamas, CXIC, CEC are the largest reefer manufacturers and exporters in China. The USA is second position, with W&K Container Inc being the largest reefer manufacturer. Followed by Japan, Denmark, Singapore, UK, and India.

A30.3 Energy performance information

The typical energy consumption of a unit ranges between 6.0 and 7.4 MWh per year.

Reefers are air delivery units designed to distribute chilled air, via specific T-shaped decking, with the advantage of producing a consistent and uniform flow of air across the entire shipment, powerful enough to ensure a perfect air exchange with the goods. A Genset (or generator) provides the container with cooling/ electricity. It is a combination of a fuel-powered and electric powered generator because it is used on both transportations overseas and on the road by a truck[182].

Following are two types of cargo based on the type of air flow[183]:

Chilled Cargo- Air always must flow through the cargo so that heat and gases are removed, therefore the cartons used should have ventilation.

Frozen cargo- Air must flow around the cargo so there should be no gaps between the cargo and the walls and the cargo itself, so the cargo must be block stowed.

Several potential improvements on reefers are possible. The main option is better controls, which can result in up to 25 % improved energy efficiency, more efficient fans, incl. for evaporators, better insulation, and less air leakage from the reefer body.

Due to the lack of sales data, energy performance information has not been calculated for UK sales. Energy consumption of refrigerated containers ranges between 78 and 206 MWh over their lifespan, and potential savings that can be achieved per unit over their lifespan are between 12 and 52 MWh.

[182] https://container-xchange.com/blog/reefer-containers-meaning-and-how-they-work/
[183] https://www.shippingandfreightresource.com/what-is-a-reefer-container-and-how-does-it-work/#:~:text=Reefer%20containers%20are%20bottom%20air,air%20exchange%20with%20the%20goods

A30.4 Baseline resource efficiency information

Resource footprint

- **Average price:** from £4,642 to £5,755.
- **Product weight:** approximately 29,500 kg to 32,500 kg
- **Lifespan:** 13-28 years
- **Typical duration of the warranty:** 5-10 years
- **% currently recycled (where available):** No information is available.

A30.4.1 Composition of typical product

Table A30.1 Composition of a refrigerated container

Main component	Main materials	Weight (Kg)	% of total product	Notes
Reefer box	Exterior walls are made of low-grade stainless steel and the interior walls are made of food grade stainless steel. The space between the exterior and interior is filled with insulation foam of about 60 mm thickness. Ceiling and deck are made of aluminium.	29000-31000	95.8%	The weight of box is calculated from subtracting the total weight with the individual component.
Refrigerant compressor (50-500HP)	Stainless steel	200-500	1.5%	https://www.indiamart.com/proddetail/reefer-container-compressor-7811266730.html
Refrigerant	-R134A (mainstay refrigerant) -R404A (R404A will also be phased out by 2019 for its high global warming potential (GWP) and R404A would no	4.6	0.01%	https://www.daikinreefer.com/static/product-information/specifications/index.html

Main component	Main materials	Weight (Kg)	% of total product	Notes
	longer be services in the EU after 2020) -R513A -CO_2			
Diesel generator	Undermount generator Clip on generator	670-850	2.6%	https://www.mtcontainer.com/container-service/generators/
TOTAL		29875-32355	100%	

Table A30.2 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in motors	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand.	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available).

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	Recent developments in countries outside the EU have been reported but detailed information about the economic feasibility is not yet available

Hazardous substances content

Presence of refrigerant such as R134a, R404a (will be phased out by and would no longer be services in the EU after 2020) and R513a.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A30.5 Information on select policy levers and horizontal measures

Ecodesign MEPS are being considered and an EC preparatory study is due to be finalised in 2021. At this stage it is unclear if MEPS will be proposed or not, but if so, it is assumed it will take 3 years to develop. With the exception of labelling policy levers, all others have been assigned not applicable as some type of MEPS or labelling is needed to establish an agreed method of testing Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Existing energy related policy levers in UK

- Ecodesign measures for refrigerated containers are not part of the "**Draft Ecodesign and Energy Labelling Regulations 2021**".
- Refrigerated containers are not covered by the public procurement scheme "**Sustainable procurement: the Government Buying Standards (GBS)**".
- Refrigerated containers are not covered by the ETL, although relevant components are, such as fans, motors, professional refrigerated storage cabinets and blast cabinets.

Existing circular economy related policy levers

- None identified.

Table A30.3 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[184]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	Preparatory study underway 3	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate. Keep track of progress in EU.
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Uncertain suitability as non-domestic end-use.
Voluntary endorsement label	1.5	Information provision / Energy savings	None found	No existing standards, but standards on box, insulation, compressors and other components exist.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier to provide to residential customers.
Public procurement	N/A	Prohibit poor efficiency products / Energy savings	None found	Product group uncommonly used in the public sector.
Communications campaign	N/A	Information provision – usage and purchasing high efficiency products / Energy savings.	N/A	Not suitable option as it's a non-domestic product.
Advice/aid in implementation	N/A	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Unknown. Lack of evidence on energy performance and improvement options.

[184] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[184]	Policy objective/ impact	Scale of impact	Suitability comments
Grants, subsidies, loans	N/A	Increase accessibility of high efficiency products / Energy savings	None found	Currently unable to identify high efficiency products.
Taxes on poor performing products	N/A	Reduce purchases of low efficiency products / Energy savings	None found	Currently unable to identify poor efficiency products.
Technology deployment & diffusion	N/A	Encourage uptake of new product / Energy savings	None found	Not suitable as this is a mature product group.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[185]	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[185] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A30.6 Summary of stakeholder feedback

No feedback received on this product group.

A30.7 Discussion & next steps

The UK reefer market is categorised by various end user industries, such as grocery and drugs & pharmaceuticals. The former is growing significantly and propelling the UK's cold chain logistics market growth. However, there is little information on the sales of reefers in the UK, and consequently, accurate estimates of their total energy consumption contribution.

There is a lack of standardization pertaining to operating procedures, temperature, and measurement which highlights a lack of consistency and potentially poor efficiency across products used in the market. As such, it represents a good candidate for policy introduction, and there is a European Commission preparatory study being conducted to address this gap. This should be monitored for additional insights.

A30.8 Evidence sources

Title	Author	Date Published or date accessed
https://www.costowl.com/b2b/storage-containers-refrigerated-cost.html	Cost Owl	15th March 2021
Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC Task 3 Draft Final Report	European Commission, Directorate-General for Enterprise and Industry	12th Sep 2014
https://www.mordorintelligence.com/industry-reports/shipping-containers-market	Mordor Intelligence	15th March 2021
https://container-xchange.com/blog/container-manufacturers-new-built-and-used-containers/	Container Xchange	15th March 2021
https://www.tuscorlloyds.com/refrigerated-shipping-container-specifications/	Tuscor Lloyds	15th March 2021
Preparatory study on Refrigerated Containers	European Commission, Directorate-General for Energy	June 2020

Title	Author	Date Published or date accessed
Innovative energy-saving technology in refrigerated containers transportation	Dawidowicz, L.	September, 2018
https://www.indiamart.com/proddetail/reefer-container-compressor-7811266730.html	India Mart	15th March 2021
https://www.daikinreefer.com/static/product-information/specifications/index.html	Daikin	15th March 2021
https://www.mtcontainer.com/container-service/generators/	MT Containers	15th March 2021
https://www.alliedmarketresearch.com/press-release/uk-cold-chain-logistics-market.html#:~:text=Furthermore%2C%20around%206.1%25%20of%20the,cold%20chain%20logistics%20market%20growth	Allied Market Research	15th March 2021
https://container-xchange.com/blog/reefer-containers-meaning-and-how-they-work/	Container Xchange	23rd March 2021
https://www.shippingandfreightresource.com/what-is-a-reefer-container-and-how-does-it-work/#:~:text=Reefer%20containers%20are%20bottom%20air,air%20exchange%20with%20the%20goods	Shipping Freight	23rd March 2021
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 31 Small Appliances: Vacuum Cleaners

A31.1 Introduction

Small appliances are mainly small electrical goods that provide a variety of different functions, particularly mechanical and heat applications. Small appliances are used in both residential and non-residential applications.

This product group includes information about two products: Household Vacuum Cleaners (including cylinder, upright and handstick) and Cordless Vacuum Cleaners for household end use as they represent more than 80% of the total vacuum cleaner market.

Cordless vacuum cleaner means a vacuum cleaner powered by batteries. Cordless vacuum cleaners are used for cleaning floors from an upright standing position, including handhelds fitted with any tubes or attachments that makes it possible to use them for cleaning floor from an upright standing position.

Handheld vacuum cleaner means a lightweight cordless vacuum cleaner with cleaning head, dirt storage and vacuum generator integrated in a compact housing, allowing the cleaner to be held and operated whilst being held in one hand.

A31.2 Market information

Combined annual sales for household and cordless vacuum cleaners is 5.31 million. The annual sales for corded household vacuum cleaners are shrinking year on year whereas sales of cordless vacuum cleaners is growing.

Prodcom codes were used to identify trade information. The relevant HS-6 codes are 27512123 and 27512125. According to these codes, 8-9 million units are imported in the UK every year. Exports from the UK stands at approximately 10% of that to 0.8-0.9 million. Production information was not disclosed with the respective codes.

China, Hungary and Germany are leading countries of manufacture /assembly of vacuum cleaners.

A31.3 Energy performance information

Vacuum cleaners use an airflow created by an electrically powered vacuum generator or fan to remove and store soiled material from a surface before returning the cleaned suction air to the ambient surroundings. The typical energy consumption per unit is around 0.03 MWh per year.

Low-cost improvements to vacuum cleaners include maximising fan efficiency, improving airways and nozzle design, use of better seals, and minimising energy losses from filters.

Higher cost improvements include the use of universal motors, microprocessor controls, optimally designed centrifugal fan systems and use of HEPA filters.

According to the review study, most vacuum cleaners on the market exceed the minimum performance levels required by existing regulations. Future potential savings would be achieved mainly by expanding the scope of regulation to cordless vacuum cleaners.

Table A31.1 Energy performance information

	Domestic vacuum cleaners
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.88 - 1.39
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.16 - 0.31
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.05 - 0.09
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0.19 - 0.31
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0.03 - 0.07
Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0.01 - 0.02
Benefit Cost Ratio of BAT Savings	0.03

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 by Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies, and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of a domestic vacuum cleaner is 7 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, 0.18 - 0.4 TWh of energy could be saved as well as 0.05 - 0.09 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.05 - 0.12 TWh of energy and 0.01 - 0.03 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A31.4 Baseline resource efficiency information

Resource footprint

- Average price: £150.
- Product weight: approximately 3 kg to 10 kg
- Average Lifespan: 7 years
- Typical duration of the warranty: 1-2 years
- % currently recycled (where available): 29% of the plastics is considered to be recycled

A31.4.1 Composition of typical product

The composition of mains operated vacuum cleaners and cordless vacuum cleaners is similar. The major difference is the quantity of electronics, which is much greater in cordless versions. There will be more electronic waste and presence of hazardous materials and CRM due to the electronics.

Table A31.2 Composition of typical product

Main component	Main materials	Weight (g)	% of total product	Notes
Household mains operated vacuum cleaners	Bulk Plastics	3643	60%	The weight of components considered here is virgin + recycled as per preparatory study
	Technical Plastics	638	11%	
	Ferrous	863	14%	
	Non-ferrous	850	14%	
	Electronics	55	1%	
TOTAL		6049	100%	

Table A31.3 Composition of typical product

Main component	Main materials	Weight (g)	% of total product	Notes
Cordless vacuum cleaners	Bulk Plastics	1624	47%	The weight of components considered here is virgin + recycled as per preparatory study
	Technical Plastics	287	8%	
	Ferro	400	12%	
	Non-ferro	835	24%	
	Electronics	295	9%	
TOTAL		3441	100%	

Table A31.4 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Antimony, Cobalt, Lithium, Graphite and Nickel	Battery	Batteries – relatively cheap and increasingly well-established methods for recycling lead-alloys, particularly from lead-acid batterie	Yes, for NiMH batteries and most of Li-ion batteries used in electronics, that

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		If properly recycled, cobalt can be collected and reused/recycled. In batteries, the recovery procedure is efficient and these secondary sources of cobalt cost less than raw cobalt extraction. Batteries shall be broken mechanically and drained to collect acid to avoid environmental damages. Recycling rate for lithium is less than 1%. Other types of batteries such as NiMH batteries might contain cobalt. The EU produces only 1% of all battery raw materials overall.	are easy to separate manually. For some products not feasible for consumers to separate batteries because they are built in.
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that	Yes

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters. A big challenge occurs when EoL electronics are exported out of Europe.	
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in electric motors/drives	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with limited performance, size, and strength (no other similar strong magnets are available).

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	

Hazardous substances content

Hazardous from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

Potential presence of hazardous in the batteries (lead, cadmium, lithium, mercury, and graphite) of cordless vacuum cleaners.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins.

Polyvinylchloride (PVC) forms the coatings on wires and various plastic parts in electronic devices.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A31.5 Information on select policy levers and horizontal measures

Existing energy related policy levers in UK

- Ecodesign Regulations EU 666/2013
- Energy labelling regulation was annulled in 2018.
- There were no identified additional UK policies focusing on vacuum cleaners.

Existing circular economy related policy levers

- None identified.

The ability to apply new energy related policy levers to vacuum cleaners is limited due to the annulment of the Vacuum Cleaners Energy Labelling Regulation in 2018[186]. Because of this, there is no longer a way to distinguish high performing products from others.

For example, the only existing voluntary endorsement label (Germany's Blue Angel programme[187]) required A-class vacuum cleaners as the minimum performance to qualify for the label. Without the mandatory label, this judgement of energy performance is no longer possible, and the label is only effective for other parameters assessed.

Therefore, an uplift of the existing MEPS is the only suitable policy lever until a new test standard for testing energy performance is agreed. The 2018 review study looked at 3 different policy options and reported that the majority of savings in each scenario modelled is due to bringing cordless vacuums into scope of the regulation.

There is low scope to improve mains operated vacuum cleaners as most of them perform much better than existing MEPS. According to the review study, the impact of raising MEPS and scope extension is projected bring 1.76 TWh savings/yr in 2030 to the EU. Scaled to the UK, this could bring 1.76 GWh/yr in 2030.

Table A31.5 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[188]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	< 2 years (under review)	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Good candidate for revision. Keep track of progress in EU.

[186] https://www.ft.com/content/e3d518b0-e337-11e8-a6e5-792428919cee
[187] https://www.umweltbundesamt.de/en/publikationen/guide-on-green-public-procurement-vacuum-cleaners
[188] Further detail on assumptions contained in Section 3.4.4

Mandatory label (includes enforcement)	Annulled in 2018	Information provision / Energy savings	None found	New label proposed in EU. Keep track of progress.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate due to existing standards.
Public procurement	1	Prohibit poor efficiency products / Energy savings	None found	Good candidate with endorsement label, low cost/effort to include in public procurement requirements.
Communications campaign	1	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Good candidate with endorsement label, low cost/effort to include in a comms campaign.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	< 2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate to include in MEPS revision. Need to understand impacts.
Product support & extension of Ecodesign November package measures[189]	< 2	Extend lifetime / reduction in material and resource consumption	None found	Good candidate to include in MEPS revision. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

[189] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, “the November Package”, which included resource efficiency measures.

A31.6 Summary of stakeholder feedback

No feedback was received in Task 2 or 3 on the vacuum cleaner product group.

Vacuum cleaners were not in scope of the BEIS Call for Evidence and therefore no comments from stakeholders were provided.

A31.7 Discussion & next steps

An EC consultation forum took place in October 2019[190] and draft working documents for both Ecodesign and labelling regulations were proposed. Recommend that the UK follow this process closely to understand key issues coming out of the process. This will help decide if the UK wishes to adopt a revised Ecodesign regulation.

If an energy labelling regulation (and therefore new test standards) can be agreed, this would then open the door to other energy related policy levers.

It is also likely that resource efficiency requirements similar to the November Package[191] ones will be included in an updated Ecodesign regulation and could also be suitable for inclusion in a UK regulation.

The review study specifically mentioned increased recycled content of materials in production and increased recycling at the product's end of life are good candidates for vacuum cleaners. A few manufacturers are reaching a high recycled content of up to 70% for their plastics parts, indicating it is economical. It is possible then that Ecodesign measures set targets for a minimum recycled content for the plastic parts, and/or that it could be included as a parameter on the energy label.

Increasing product life is an option in the circular economy concept that aims to slow down the materials cycle of products. For instance, if the lifetime of mains household vacuum cleaners goes from 8 to 10 years, it is assumed that 25% less material resources would be needed. This can be done in multiple ways:

Increase the technical product-life of critical components such as the motor and hose;

Facilitate reparability by ensuring that spare parts are available for a sufficient time after the production of a model stops (Blue Angel suggests 8 years) and that critical parts are easy to replace;

There is a lot of uncertainty around testing and measurement standards for vacuum cleaners, particularly around testing at maximum power versus lower powers used in the real world and the difficulty of testing cordless input power.

[190] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=38391
[191] In Winter 2018/2019, updated Ecodesign requirements were agreed at EU level for a package of products, "the November Package", which included resource efficiency measures.

At the moment, no other policy levers are recommended for looking into in further detail, as the suitability depends on being able to distinguish the energy performance of different products at point of sale.

If new energy related test standards for labelling were to be agreed, the following policy levers could become suitable in future (communications campaigns, mandatory/voluntary labelling, public procurement).

A31.8 Evidence sources

Title	Author	Date Published or date accessed
Review study on vacuum cleaners https://ekosuunnittelu.info/wp-content/uploads/2019/05/Vacuum-cleaner-review_Draft-final-report-_Nov-2018.pdf	Rames M., Hansen P. et al	June, 2019
https://www.dyson.com/inside-dyson/terms/tools-warranty-terms	Dyson	12 March, 2021
https://www.miele.co.uk/c/miele-extended-warranty-25.htm	Miele	12 March, 2021
https://sharkclean.co.uk/warranty-&-returns-cms-page.customercare.warranty	Shark Clean	12 March, 2021
https://www.umweltbundesamt.de/en/publikationen/guide-on-green-public-procurement-vacuum-cleaners	German Environment Agency	November, 2016
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

Annex 32 White Goods: Professional Dishwashers

A32.1 Introduction

White goods are large, usually electrical products traditionally defined for residential end uses including washing and drying clothes and tableware. For this study, the definition has been expanded to include non-residential products that provide washing and drying services for clothes and tableware.

Professional dishwashing machines belong to the ware-washing product group which is one of the main mechanisms that enable professional food service outlets and kitchens in general to be effective.

Many ware-washing machines exist in this product category. The most common dishwashers are the Undercounter and the Hood or Door type dishwashing machines and this is due to their functionality, size and affordability.

Professional Dishwashers have smart connectivity potential. This can lead to energy optimisation services, improved maintenance services, remote control capabilities and/or Demand Side Response potential.

A32.2 Market information

The estimated annual sales in the UK market for undercounter dishwashers is around 7,900 and for the hood or door type washers 11,300. The forecast for the market growth potential in sales is estimated to be 1.7% between 2020 and 2050.

Countries who were identified to assemble and manufacture significant quantities of these types of dishwashers are Germany, Italy, and Sweden, as well as the U.S. and the UK.

A32.3 Energy performance information

The typical energy consumption of a unit ranges between 3.9 and 16.2 MWh per year.

A dishwashing machine operates through a series of stages to complete a cleaning operation. However, before placing within the dishwasher, items will likely be manually pre-scraped and possibly pre-scraped with an overhead water spray. The machine's cleaning cycle then starts with the pre-wash, moves to the cleaning stage and finally to the rinse phase. At pre-wash, water is sprayed on the items to remove large portions of food remains and in the cleaning stage chemicals are applied to clean the items. Finally, in the rinse stage hot water is sprayed on the items to remove the cleaning chemicals and other remains. A large portion of the energy consumption takes place in the heating process of the water hence energy consumption in these products is directly linked with the water usage per cycle.

The undercounter and hood / door type dishwashers operate in a very similar way as outlined above. The main difference in these two machines is their opening and closing mechanism to access the internal cavity. For an undercounter machine the machine's front surface is the door which is pulled to open the cavity. Whereas in the case of the freestanding hood / door type washer, a handle is used to pull up the external structure of the machine, exposing in this way the internal cavity trays.

Dishwashers are used extensively in commercial outlets over most of the daily shift. The cycles of professional dishwashers could range between 1 to 10 minutes with the most common cycle times expected to lie within this range. The total number of cycles for a dishwasher is dependent on the type of outlet and the number of people it feeds in a day.

There is potential to improve product efficiency and achieve up to 46% savings.

Advances in dishwashing machines include heat recovery processes, steam recirculation as well as integral water softening, and integral extraction and these functions are found in the Best Available Technologies. Processes such as the heat recovery and steam recirculation make the machine more energy efficient. To achieve BAT in undercounter and hood / door type dishwashers, there is an estimated price increase of 68% and 90% respectively. Below the baseline and the BAT typical energy consumption per year are presented along the estimated price increase percentage.

A32.3.1 Energy performance information

	Undercounter dishwashers	Hood / Door Type Dishwashers
Baseline typical energy consumption of UK annual sales over their lifetime (TWh)	0.14 - 0.99	0.48 - 1.8
Maximum technical potential energy savings that can be achieved with BAT (TWh)	0.05 - 0.46	0.17 - 0.72
Maximum technical potential energy savings that can be achieved with a mix of policy levers (TWh)	0.01 - 0.13	0.05 - 0.21
Baseline typical carbon emissions of UK annual sales over their lifetime (MtCO2e)	0 - 0.18	0.12 - 0.36
Maximum technical potential carbon savings that can be achieved with BAT (MtCO2e)	0 - 0.08	0.04 - 0.14

Maximum technical potential carbon savings that can be achieved with a mix of policy levers (MtCO2e)	0 - 0.02	0.01 - 0.04
Benefit Cost Ratio of BAT Savings	2.9	1.5

These are not precise estimates, but rather simple calculations undertaken to assess the order of magnitude of savings that can be achieved for each specific product over their lifespan if all units sold in the UK in one given year were BAT instead of average products or with a mix of policy levers.

The baseline typical energy consumption of UK annual sales over their lifetime is calculated by multiplying the energy consumption of a unit (in kWh/year) by its lifespan (in years) and by UK annual sales. The maximum technical potential energy savings that can be achieved with BAT is calculated assuming all units sold in the UK are BAT units.

The Benefit Cost Ratio (BCR) evaluates the value for money of achieving the technical savings through dividing the energy and carbon savings (in £M) by the additional cost of BAT units (also in £M). A BCR higher than 1.0 indicates that the benefits are greater than the costs and that BAT improvements are cost-efficient.

The Saving Energy Through Better Products and Appliances report, published in 2009 Defra presents indicative figures of the portion of maximum BAT energy savings that can be achieved through harnessing a mix of policy levers (e.g., MEPS, energy labelling, voluntary agreements, supplier obligations, subsidies and procurement). These figures are used to scale down BAT savings and present savings that could be achieved with a mix of policy levers.

The average lifespan of an undercounter dishwasher is 8 years and the savings presented in the table are estimated for UK annual sales over their lifespan. Because the lifespan of the shortlisted products varies, and to allow for comparing the savings achieved by these products, savings have also been estimated over a 10-year period. If all units sold annually in the UK in a given year were BAT technologies, up to 0.51 TWh of energy could be saved as well as up to 0.09 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0 - 0.15 TWh of energy and up to 0.03 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

The average lifespan of a hood/door type dishwasher is 8 years. If all units sold annually in the UK in a given year were BAT technologies, 0.36 - 0.8 TWh of energy could be saved as well as 0.07 - 0.16 MtCO2e over 10 years. Savings that could be achieved with a mix of policy levers would be 0.1 - 0.23 TWh of energy and 0.02 - 0.05 MtCO2e over 10 years. These are high level estimates, based on simple assumptions used to assess the order of magnitude of savings.

A32.4 Baseline resource efficiency information

Resource footprint

Undercounter Dishwasher

- **Average price:** from £1,200 to £1,500. Most Undercounter dishwashers approximately at £1,350.
- **Product weight:** approximately 70 kg to 80 kg
- **Lifespan:** 7 - 9 years
- **Typical duration of the warranty:** 1 - 3 years

Hood / Door Type Dishwasher

- **Average price:** from £2,500 to £3,000. Most Hood / hood type dishwashers approximately at £2,750.
- **Product weight**: approximately 125 kg to 145 kg
- **Lifespan:** 6 - 9 years
- **Typical duration of the warranty:** 1 - 2 years

A32.4.1 Composition of typical product

Table A32.1 Composition of typical product – Undercounter Dishwasher

Main component	Main materials (weight if available)	Weight (g)	% of total product
Entire Dishwasher Machine	Stainless steel	49,760	71.2%
	Polypropylene (PP)	4,565	6.5%
	Polyamide (PA)	500	0.7%
	Epoxy	1,000	1.4%
	Acrylonitrile Butadiene Styrene (ABS)	70	0.1%
	Pumps (copper)	2,500	3.6%
	Pumps (stack of sheets)	2,500	3.6%
	Pumps (stainless steel wave)	2,250	3.2%
	Pumps (Al)	2,250	3.2%

Main component	Main materials (weight if available)	Weight (g)	% of total product
	Cable (copper)	1,100	1.6%
	Cable sheath (PVC)	600	0.9%
	Cable sheath (silicone, EDPM)	300	0.4%
	Electronics (control)	500	0.7%
	Gaskets (EDPM)	2,040	2.9%
TOTAL		69,935	100%
Packaging	Polystyrene	500	
	Wood	6,000	
	Cardboard	2,750	

Table A32.2 Composition of typical product – Hood / Door Type Dishwasher

Main component	Main materials (weight if available)	Weight (g)	% of total product
Entire Dishwasher Machine	Stainless steel	93,090	79.1%
	Polypropylene (PP)	4,310	3.7%
	Polyamide (PA)	1,000	0.8%
	Epoxy	800	0.7%
	Acrylonitrile Butadiene Styrene (ABS)	70	0.1%
	Pumps (copper)	3,000	2.5%
	Pumps (stack of sheets)	3,000	2.5%
	Pumps (stainless steel wave)	2,500	2.1%
	Pumps (Al)	3,000	2.5%
	Cable (copper)	1,700	1.4%
	Cable sheath (PVC)	1,000	0.8%
	Cable sheath (silicone, EDPM)	500	0.4%

Main component	Main materials (weight if available)	Weight (g)	% of total product
	Electronics (control)	600	0.5%
	Gaskets (EDPM)	3,085	2.6%
TOTAL		117,655	100%
Packaging	Polystyrene	500	
	Wood	12,250	
	Cardboard	4,750	

Table A32.3 Critical Raw Material content and feasibility of recovery

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
Gold, Silver, Bismuth, Palladium, Antimony	PCB	PCBs (shredded, unshredded); CuPM granulate. The removal of PCBs of more than 10 cm2 is legally required (Annex VII of the WEEE Directive) because the boards consist of plastics that contain Brominated Flame Retardants. Removal of PCBs is driven by the recycling of Gold, Silver and Palladium in copper smelters.	Yes
Neodymium, Praseodymium, Dysprosium, Gadolinium, Terbium	Magnets in electric motors/drives	Magnets (the initial separation of NdFeB-magnets (Neodymium iron boron-magnets) prior to subsequent shredding is key to Nd recycling from magnets). Challenge: it is not possible to assume that all this type of	Technically feasible, but the economic feasibility may be critical under the current economic conditions. Possible component substitution, but with

Which CRM	Components with CRM	End of Life – requirements/ viable	Current economic and technical feasibility
		appliances has Nd, they might have as well other magnets like Rare Earth Elements (REEs) in electrical motors, which presents other challenges in pre-treatment. The use of NdFeB-magnets might change depending on the model and/or brand. The small NdFeB-magnets are difficult to remove from other components after shredded, as a result, almost all small NdFeB-magnets are lost into ferrous or nonferrous scrap. Manufacturer of NdFeB-magnets have been continuing to move to China where access to REEs remains cheapest and more secure. Only a few European players are found in the value chain.	limited performance, size, and strength (no other similar strong magnets are available).

Hazardous substances content

Hazardous substances from enclosures of electronic components such as circuit boards (Per- and polyfluoroalkyl substances (PFAS) and Halogenated Flame Retardants), which are considered easy to disassemble and are in limited quantity (around 1% of the total weight).

Potential presence of refrigerant such as R134a, R407C and others.

Plastic enclosures – potential presence of Phthalates and Chlorinated paraffins (35g of Polybutylene Terephthalate which represents 0.1% of a typical undercounter dishwasher)

Polyvinyl chloride (PVC) - 403g which represents 0.8% of a typical undercounter dishwasher.

Potential presence of Bisphenol A (BPA) and/or halogenated flame retardants and/or Perfluoroalkyl Sulfonate Substances (PFAS) in insulated cables.

A32.5 Information on select policy levers and horizontal measures

It's assumed that new MEPS will take 3 years to develop. Suitability of other policy levers would need labelling to identify the high efficiency products.

Regarding the horizontal measures, it is assumed that 'Requirements for material content and declaration' and a 'Mandatory minimum warranty/guarantee' can be implemented independently of MEPS regulations. This is because the two measures are assumed to require information provision or a warranty period. No product re-design would be required. The other two horizontal measures, 'Modular design' and 'Product support requirements' would be good candidates for inclusion in future Ecodesign regulations.

A literature review carried out during this study did not identify any product specific impacts related to the various policy lever evaluation studies found.

Existing energy related policy levers in UK

- Professional dishwashers are covered by the "Sustainable procurement: the Government Buying Standards (GBS)", and the "Salix public sector finance - Loan scheme".

Existing circular economy related policy levers

- None identified.

No trade-offs are anticipated between the energy related policy levers and horizontal measures. The horizontal measures assessed here are intended to supply information and extend lifetimes. None are anticipated to impact the energy performance of this product group. If water consumption was targeted for reduction by a measure, it should not be at the expense of the cleaning and rinsing performance of the product.

The distribution of costs and benefits explained in Section 3.4.5.2 of the main report are not expected to be different for this product group.

Table A32.4 Information on selection of policy levers and horizontal measures

Policy lever	Indicative time needed to implement (years)[192]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory MEPS (includes enforcement)	3	Remove poor efficiency products / Energy savings	Depends on MEPS levels	Potential candidate, but small market may limit savings. No rinse standard exists yet.

[192] Further detail on assumptions contained in Section 3.4.4

Policy lever	Indicative time needed to implement (years)[192]	Policy objective/ impact	Scale of impact	Suitability comments
Mandatory label (includes enforcement)	3	Information provision / Energy savings	None found	Potential candidate, but small market may limit savings. No rinse standard exists yet.
Voluntary endorsement label	1	Information provision / Energy savings	None found	Good candidate but no rinse standard exists yet. Could be suitable to enable other policy levers.
Obligation scheme	N/A	Provision of energy saving technologies / Energy savings	N/A	Not suitable option for energy supplier; these are non-domestic products.
Public procurement	1.5	Prohibit poor efficiency products / Energy savings	None found	Good candidate with labelling. Need to understand effectiveness of this measure.
Communications campaign	N/A	Not suitable as this is a mature product group.	N/A	Not suitable option as it's a non-domestic product.
Advice/aid in implementation	1.5	Information provision – usage and purchasing high efficiency products / Energy savings	None found	Candidate for sector specific new policy lever.
Grants, subsidies, loans	1.5	Increase accessibility of high efficiency products / Energy savings	None found	Good candidate with labelling.
Taxes on poor performing products	4	Reduce purchases of low efficiency products / Energy savings	None found	Candidate but requires mandatory labelling to identify poor performers.

Policy lever	Indicative time needed to implement (years)[192]	Policy objective/ impact	Scale of impact	Suitability comments
Technology deployment & diffusion	1	Encourage uptake of new product / Energy savings	N/A	Candidate for targeted deployment of specific heat recovery technology.
Requirements for material content and declaration	1	Information provision as a starter policy / foundation for future limits.	None found	Good candidate and necessary for future requirements.
Repairability measures - modular design	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Product support & extension of Ecodesign November package measures[193]	3	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. No adverse impacts foreseen.
Mandatory minimum warranty/guarantee	1	Extend lifetime / reduction in material and resource consumption	None found	Good candidate. Need to understand costs.

A32.6 Summary of stakeholder feedback

Two stakeholders requested the inclusion of commercial dishwashers during the Task 2 consultation, although the technology was already included on the long list.

All ware washing stakeholders who submitted feedback on the Task 3 consultation objected to this product group being shortlisted. None recommended consideration of any policy measures for this product group. Their main reasoning is the lack of a standard for measuring rinse performance. Stakeholders stated that since energy performance is tied so closely to the water consumed during the rinse mode of a wash cycle, without a measurement process it will be challenging to ascertain true energy performance and leave any potential measure open to abuse. Stakeholders also expressed concerns about the UK considering measures for this

[193] In November 2019, the Ecodesign regulations were update das part of “the November Package”.

product group when the EC was not. However, consultants delivering the EC Workplan 2020-24 for Ecodesign and Energy Labelling are likely to recommend the inclusion of professional dishwashers.

There was no reference to this product group within the summary of responses to the ErP Call for Evidence.

A32.7 Discussion & next steps

Professional dishwashers or ware washers have yet to be the subject of any energy efficiency regulatory measures in the EU, such as MEPS and labelling. This in part is because of the lack of standardisation covering energy performance, cleaning, hygiene and rinsing of these products. However, standards are now in place for three of these four aspects. With BS EN IEC 63136: 2019 covering energy and cleaning performance and hygiene standards such as DIN SPEC 10534 and NSF/ANSI 3-2019 being available. Rinsing, as identified by the stakeholder comments, is the final remaining element.

The consultants delivering the separate European Commission study informing the 2020-24 EU workplan for Ecodesign and Energy Labelling are also recommending that professional dishwashers are formerly included in the next workplan.

In parallel to this activity, recommendations have been delivered to BEIS to introduce voluntary, endorsement labelling for professional dishwashers under the Energy Technology List.

A32.8 Evidence sources

Title	Author	Date Published or date accessed
Lot 24: Professional Washing Machines, Dryers and Dishwashers	Öko-Institut e.V. Freiburg Head Office. et al.	8 February, 2021
Preparatory study for the Ecodesign and Energy Labelling Working Plan 2020-2024: Task 3 Preliminary Analysis of Product Groups and Horizontal Initiatives – Final Draft	Viegand Maagoe. Et al.	18 March, 2021
ETL Annual Submission 2020	ICF	unpublished
BEIS PFSE Research Study	ICF	unpublished
https://www.nisbets.co.uk/	Nisbets	16 March. 2021

Title	Author	Date Published or date accessed
D1.1. Baseline and Gap/Obstacle analysis of Standards and Regulations	Voluntary certification scheme for waste treatment - CEWASTE project	Published January 2020 Accessed 24 March 2021
Review of the Future Resource Risk Faced by the UK Economy	Eunomia	17 July 2020
European Commission, Critical materials for strategic technologies and sectors in the EU - a foresight study, 2020	European Commission, Joint Research Centre	3 September 2020

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