The eco-modulation of producers' financial obligations for WEEE in the UK

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Acronyms

Acronym	Explanation
AATF	Approved authorised treatment facility
Defra	Department of food, environment and rural affairs
DRS	Deposit Return System
EOL	End-of-Life
EPR	Extended Producer Responsibility
EEE	Electric and Electronic Equipment
GHG	Greenhouse gas
PCS	Producer Compliance Scheme (see also PRO)
POM	Placed on Market
PRO	Producer Responsibility Organisation (see also PCS)
WEEE	Waste Electrical and Electronic Equipment
WG	WEEE generated

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Executive Summary

The purpose of this study was to explore, with supporting evidence, the mechanics and systems elements required to create an eco-modulation system in the UK that can facilitate and reward the eco-design of electrical and electronic equipment (EEE) in a cost-effective manner. Any UK system must work in accordance with the current Extended Producer Responsibility (EPR) legal framework and the UK's existing waste management strategies on recycling and would seek to reward resource efficiency at the design phase by enabling the reduction of waste generated and reducing negative environmental externalities through, inter alia, the use of less environmentally harmful substances and the extension of products' lifetime. In the last two decades, the EU has sought to incentivise the eco-design of EEE through multiple policy packages, notably the WEEE Directive, the Eco-design Directive, and the Waste Framework Directive. All three Acts were introduced in the 2000s and have since been amended and recast to expand their scope and level of ambition. The Waste Framework Directive in its three iterations to date has restated the need for Extended Producer Responsibility (EPR) to support the eco-design of products to minimise the impact of waste management systems on the environment. These Directives form part of the EU laws retained since the UK's departure from the European Union.

EPR states that the financial and organisational burdens of managing the end-of-life (EOL) of products sit with the producer. Whilst some theories regard EPR as a wider policy tool to decrease the overall impact of a product, over the last decades the main operational exploitation of the principle has been linked with EOL management: based on the "polluter pays" principle, EPR is expected to internalise costs, associated with WEEE arising and management, within product costs, relieving governments of the financial and administrative burdens of managing the end-of-life (EOL) of WEEE. In addition, it aims at reducing the environmental impacts associated with WEEE management through increased recycling rates. This study restricts the focus of analysis on the recycling costs as opposed to the lifecycle of products.

The modulation of the EOL compliance costs that producers pay into the producer compliance schemes, known as eco-modulation, has increasingly been proposed as an incentive mechanism to overcome the failure of EPR in encouraging producer eco-design. Such eco-modulation systems see producers' EPR fees and obligations adjusted based on the level of eco-design integrated within their products, while also leading to a differentiated distribution of costs among producers based on their alignment with modulation requirements.

Methodology and main findings

To understand how this might work for the UK, this study first gained insights and best practices from other countries where eco-modulation has already been implemented – namely France, Italy, Taiwan and the Canadian province of Ontario. France's eco-modulation system for EEE is the most mature, having been functional for 10 years it is the most advanced in thinking and practice. The evaluation of these existing eco-modulation systems in section 2 includes the mechanisms and modulation criteria utilised. Whilst this study aims to stay within the parameters of the UK, it uses these findings (#finding) to develop a broad understanding of previous and current frameworks established on eco-modulation and further evaluate their separate components. The French system was found to be complicated to audit, creating an extensive administrative burden and proved to be ineffective as a driver for design decisions. This was echoed in the experiences shared by the Italian system, whilst the Taiwan and Ontario systems are too early in their infancy to draw any robust conclusions.

This desk research was supported by the collation of confidential UK waste data so that data modelling and analysis could be done to explore the scenarios and levels of waste that might be reduced through eco-modulation and subsequent financial savings. Such quantitative work was then underpinned by one-to-one interviews and a stakeholder workshop to offer crucial insights on practical implementation and gain qualitative viewpoints. Interviews were conducted with two France-based producers, three UK-based AATFs (approved authorised treatment facilities), two PROs (one based in France and the other in Canada) and a major UK trade association (techUK) which has over 850 members including large brand technology producers. A workshop was conducted for this report, which was attended by a range of stakeholders including ten EEE producers, five European PROs, four UK compliance schemes and numerous WEEE recyclers.

The exploration of suitable eco-modulation criteria to incentivise change in EEE product design involved analysis of more than 350 criteria used for EEE eco-modulation in four jurisdictions: South Korea, Taiwan, France, and Ontario, Canada. It was then combined with experiences shared during interviews with three UK-based AATFs that recycle/repair different product categories including small WEEE, large domestic appliances and fridge/freezers. The resulting criteria were then grouped under three categories based on the lifecycle stage to which they are relevant: design, use and end-of-life and are expounded upon in section 2.5.

To understand the role of eco-modulation that is in congruence with the UK's current eco-design legislation, an assessment is made of the products and criteria used in eco-design legislation to see how they compared to that of eco-modulation. Several EEE product categories are both within the scope of the eco-design regulation and could be potentially affected by eco-modulation criteria. The Eco-design Regulation already stipulates a series of measures relevant to resource efficiency, including the availability of specific spare parts, the ban of certain hazardous substances like cadmium and halogenated flame retardants, repairability, and design for disassembly. Most of those criteria are also currently used in some of the other jurisdictions as a basis for eco-modulation. In addition to that, existing internationally recognized voluntary standards like EPEAT or TCO are also based on a similar set of criteria. Both producers and consumers are already conforming to demonstrate the environmentally conscious design of their products; these standards are also seen as an existing and valid alternative to eco-modulation as representing: (i) market-based instruments, (ii) known to consumers, and (iii) internationally recognized, harmonized and standardised. This is explored further in section 2.6.

The broad evaluation of potential metrics for eco-modulation (section 3) focuses on weight and units placed on the market (POM) as the major metrics both previously utilised by eco-modulation systems, whilst also aligning with measurements used to measure EPR responsibility within the UK and other jurisdictions. Data on appliances placed on the market (POM) - either in weight or units - has the main advantage of being available (reported in National Registers established under EPR regulations as well as in trade statistics) as well as a good proxy for overall impact on waste management.

Regarding the mechanism of implementation, the three mechanisms of (i) adoption of modulated POM fee, (ii) modulation of market share obligations and (iii) Deposit Return System (DRS), are studied based on the mechanisms deployed globally and that fit within the potential of the UK's EPR framework. Out of the three options, the most promising and fitting to the existing UK system appears to be the second option. As producers remain responsible for the collection and treatment of waste, based on the share of products they placed on the market which is corrected (decreased for products meeting the criteria and increased otherwise) using coefficients that will preserve the total amount of products to be recovered.

Finding 1

Simulations revealed correction coefficients are varying between 42% and 114% depending on product type, with an estimated presence of 20% of "green", eco-designed products on the market, enabling treatment cost reduction between 12% and 23%.

In section 4, this study examines the relationship of fees to changes in the recycling cost and life expectation caused by eco-modulation, with these pricing constraints being identified based on modulation systems utilised in other jurisdictions and being two mechanisms that are attached to the product's end-of-life impact.

Simulations were conducted to estimate the potential economic benefits of eco-designed products and the potential to justify eco-modulation. To do this, two aspects were considered: (i) the potential savings in the treatment costs due to less hazardous and easier to dismantle products and (ii) the potential savings connected with the lower generation of waste linked to products being more durable and repairable. The resulting savings shown in section 5 were used to calculate the potential reduction of end-of-life fees or the equivalent reduction of POM obligations for producers entitled to claim the eco-modulation benefits. The study did not consider aspects such as the use of new types of materials, such as bio-based plastics, or reduced number of materials for lack of meaningful, comprehensive and accessible data to design for future scenarios.

To assess the impact of treatment costs for the main products placed on the UK market and thus evaluate the share of those costs that could be potentially impacted by eco-modulation the average treatment cost reported by different PROs in the UK was considered.

Finding 2

The cost associated with recycling of all fridges POM (27.3 £m/year), flat panels, televisions & monitors (17.2 £m/year), and printers (6.7 £m/year) had the highest economic impact.

This means that eco-modulation intervention on those products has more potential to eventually influence producers' eco-design decisions.

Furthermore, it was assessed if eco-designed products could lead to a reduction in net treatment costs. The higher the variation in costs for each type of appliance, the bigger the space for fee modulation between eco-designed products and standard ones.

Finding 3

Fridges and freezers were found to have the highest potential for eco-modulation, despite the absolute value of the cost reduction (2.23 £/unit and 1.85 £/unit) appearing to be not high enough to justify or trigger design changes; this was followed by washing machines (0.79 £/unit) and other products had potential lower than 0.5 £/unit. It should be noted that although the figure indicates a small degree of opportunity for eco-modulation, this analysis does not account for the producers' costs of changing the design of products.

It should also be considered that the presence of costs associated with changing product design would further erode the overall incentive space for producers, resulting in fewer incentives to support eco-modulation measures.

To understand the theoretical impact of life extension of products, for example, through more durable products, increased repair or availability of spare parts, and the theoretical benefits on waste reduction that would justify lower fees for products meeting those criteria, various scenarios were modelled. This provided insights into whether the introduction of products with an extended life would lead to lower quantities of waste being generated and the potential savings associated with the reduction of WEEE generated (WG) that could justify lower fees for those eco-designed products.

Finding 4

With the example of a washing machine, it can be observed that the arrival on the market of extended lifetime products in 2010 (with a 20% market share) does not have an immediate impact on the quantities of waste generated. The impact only becomes significant 5-6 years after the product is put on the market. According to our modelling, the overall reduction in waste over the period 2020-2030 is 12%.

This means that eco-modulation intervention on those products has more potential to eventually influence producers' eco-design decisions.

Furthermore, it was assessed if eco-designed products could lead to a reduction in net treatment costs. The higher the variation in costs for each type of appliance, the bigger the space for fee modulation between eco-designed products and standard ones.

Finding 5

Overall, the potential reduction over a 10 year period is close to 1Mt with the most significant reductions for washing machines, fridges and flat-panel displays; the savings on treatment costs amount to £71m. The impact on waste generated varies among products, which is related to the evolution of POM up until 2018 (increasing, constant or decreasing) as well as to whether products are rather long- or short-lived.

In conclusion, the impact of lifetime extensions is highest for products with a rapidly increasing market share and relatively shorter lifetimes, and lowest for products with stable POM and long-baseline lifetimes.

Finding 6

In terms of savings expressed as £/t, it was observed that flat panel displays and laptops give rise to the highest savings – 184 £/t and 136 £/t respectively – due to the high impact on the volume of waste generated and high treatment costs; considering the total potential savings over a ten year period, fridges (approximately £23m) and flat panels (approximately £20m) are the biggest contributors. While the potential waste generated reduction is significant, the potential room to eco-modulate the fees for different products is varying but is also limited in absolute terms (from 0.55 £/unit in the best-case scenario of fridges, 0.49 £/unit for air conditioners, 0.33 £/unit for TVs down to 0.05 £/units for desktops and laptops).

Whilst the reduction of EOL fees appears a straightforward mechanism in those countries where producers pay upfront fees for each appliance placed on the market, the definition of a coefficient to reduce POM – as done in countries like Italy or Ontario – triggers the corresponding reduction of the collection and recycling obligations appears to be a more viable mechanism in the UK as it aligns with the UK's existing system. The mechanism is simple: a reduction coefficient is applied to POM for "green" products, whilst an increased coefficient is applied to POM for "baseline" products. Coefficients are calculated considering the differential in the total treatment cost of "green" products versus the baseline, adjusting the POM based on the weighted average of treatment costs. This ensures that the total revenues from EPR fees remain constant, thus safeguarding the ability to cover the real, current, collection and treatment costs.

Finding 7

Simulations carried out, assuming 20% of "green" products placed on the market, showed that the coefficients to reduce POM are relatively stable across product types and categories: overall, producers of standard products would be "penalized" by a 13-14% increase in POM, and producers of "green" products "rewarded" by a 40-50% reduction in POM. This would result in producers receiving a malus paying up to a 63% fee differential, relative to one receiving a bonus.

Such a mechanism could be easily implemented in the current UK system provided that the coefficients are annually reviewed to reflect the changes in the quantity of "green" products arising in the waste generated and the cost difference in the collection and treatment.

The role of consumer behaviour represents an important factor and is discussed in section 6. This dimension is not captured by modelling efforts when assessing the temporal dynamics of eco-modulation relating to waste generated yet could jeopardise the success of the system. Although producers can facilitate extensions in product lifetime in response to eco-design related measures, it is not guaranteed that a consumer will respond correspondingly and use the product until the end of its technological lifespan. Consumers dispose of EEE for multiple reasons and not all products which are disposed of by consumers are broken- this is known as functional WEEE. Consumers are therefore not exhausting the use-phase of their products and disposing of them before the end of their technological lifetime by choice.

Another consumer-related aspect of eco-modulation is its role as a "signalling function", allowing consumers to identify products which are more environmentally friendly. Theoretically, one would expect a malus to indicate lower environmental performance, and a bonus to indicate the better environmental performance of a given product. Theoretically, this could drive demand for more sustainable products, providing an incentive to producers in the form of a competitive advantage. But research shows that visible eco-modulation fees had a negligible impact on sustainable product market share and consumers' purchasing decisions. There is even evidence in one country that consumers associate a lower price with lower quality, which is the opposite of what eco-modulation seeks to achieve and is, therefore, a perverse effect.

A viable alternative to eco-modulation is the use of consumer-facing eco-labels, well known for some of the voluntary standards (e.g., EPEAT, TCO), but also very well known to UK consumers for energy efficiency or being developed in France for repairability: those labels demonstrate product environmental performance. Research from other countries highlighted how consumers typically consider a mix of factors when purchasing products, for example, product practicalities, brand, price, energy efficiency and design characteristics. Overall, consumer behaviour represents an under-addressed area in the context of eco-modulation more broadly yet is arguable of the utmost importance as an enabling lever in developing an effective system for eco-modulation.

Recommendations

Evidence collected during the study, data and simulations carried out as well as interaction with stakeholders allows us to summarize the success factors for the implementation of an eco-modulation system in the UK.

The system should be:

- **Simple:** striving for simplicity in the design of a system for eco-modulation is seen as paramount to its success, as well as its ability to synergise with the existing eco-design regulation in the UK. Experiences and evidence from modulations implementation in France suggest that an overcomplicated set-up is counter-productive and gives rise to sub-optimal environmental benefits;
- **Transparent:** criteria should be easily verifiable and sufficiently flexible enough to embrace changes in product design, innovation and reflect the development of policy and standards;
- **Harmonized:** definitions and criteria should be aligned with existing laws and standards, particularly the proposed EU Eco-design Directive and Sustainable Products Regulation as manufacturers make products on a global, or at least regional, market and misaligned criteria are expensive to comply with.

Those three conditions will allow a minimum reduction in the administrative burden for companies when having to declare products that will benefit from eco-modulation incentives; the burden will also be reduced by adopting a system with self-declaration and sample audits – similarly to RoHS – rather than mandatory third-party verification.

Producers have unanimously expressed the view that eco-design related incentives should be regulated by one single policy instrument, typically Eco-design regulations. They also favoured measures such as labelling as they are consumer-facing instruments that have proved to be a more powerful incentive to trigger previous design changes. There is the option to plug in the current UK WEEE management system eco-modulation adjusting the POM figures with specific coefficients; this way producers remain responsible to finance the management of waste corresponding to their market share, under the current set-up. Such a mechanism would result in minimal change to the existing EPR system, reducing the impact of integrating modulation on producers and compliance schemes that would otherwise have to realign with new EPR mechanisms.

The value of such coefficients can be reviewed annually based on updated figures on products meeting the specific criteria that are placed on the market, their share in waste generated and the savings obtained in the treatment processes. Anchoring the economic value of the eco-modulation to the potential savings in the end-of-life costs – either linked to reductions of the treatment costs due to more environmentally friendly products, or to potential reduction of waste generated through more durable and repairable products – will anyway provide only limited space (no more than few GBP for those products having higher recycling costs of being large and heavy) to really influence designers' decisions. In this respect, to really identify the most meaningful design changes that could increase the cost-effectiveness or facilitate the treatment phase, producers flagged the need to improve communication and collaboration with recyclers.

1 Introduction to eco-modulation

1.1 Introduction to EPR

The central aspect of Extended Producer Responsibility (EPR), first conceptualised by Swedish academic Thomas Lindhqvist[1], is that the financial and organisational burdens of managing the end-of-life (EOL) of products sit with the producer. Based on the "polluter pays" principle, EPR internalises recycling costs within product costs to relieve governments of the financial and administrative burdens of managing EOL. In addition, it aims at reducing the environmental impacts associated with EOL through increased recycling rates[2]. EPR systems are also intended at encouraging producers to integrate environmental considerations within the design of their products. The theoretical rationale of EPR is that, by placing the burden of EOL management on producers, they have a motivation to modify the design of their products to reduce the fees that they pay.

EPR systems are made possible by legislation that mandates their application to specific material streams and often the threshold for the fees that are levied. There are now over 400 EPR systems globally[3], which range in design and scope from individual – in which individual producers are made responsible for the EOL of their products – to collective and from monopolistic to competitive. In a collective system, for example, producers join a producer responsibility organisation (PRO) - also known as producer compliance scheme in the UK - which collects EPR fees and manages communication and reporting to public authorities.

Since the introduction of EPR systems in Germany and Sweden during the 1990s, there has been significant success in shifting EOL burdens from governments to producers[4]. However, this progress has been accompanied by criticism of their lack of effectiveness at encouraging producers to design environmentally friendly products[5,6]. The most notable amongst these criticisms is the fact that in collective EPR systems, producers pay fees based on product weight or the number of units placed on the market (POM) and on the average recycling costs for specific waste streams. Such systems ignore differences in treating products at the EOL, with some products being easier to refurbish, reuse, and recycle than others because of how they were designed. Existing EPR systems offer little consideration of product eco-design within their fees. The fee does not stimulate manufacturers to volunteer to make their products more durable or repairable[7].

In the last two decades, the EU has sought to incentivise the eco-design of EEE through multiple policy packages, like the WEEE Directive, the Eco-design Directive, and the Waste Framework Directive. All three were introduced in the 2000s and have since been recast more than twice each to expand their scope and level of ambition. The Directive 2002/96/EC on WEEE explicitly set out to incentivise the eco-design of EEE through EPR in both its preamble and Article 4:

1 Lindhqvist, Thomas, and Karl Lidgren. 1990. "Model for Extended Producer Responsibility." 7-44. Stockholm, Sweden: Swedish Ministry for Environment.
2 Araujo, Ariel, et al. 2021. "Extended Producer Responsibility and Ecomodulation Fees." Berlin, Germany: Ecologic Institute.
3 Laubinger, Frithjof, et al. 2021. "Modulated fees for Extended Producer Responsibility schemes." OECD Environment Working Papers No.184. Paris, France: OECD.
4 OECD. 2016. "Extended Producer Responsibility: Updated Guidance for Efficient Waste Management." Paris, France: OECD Publishing.
5 Pouikli, Kleoniki. 2020. "Concretising the role of extended producer responsibility in European Union waste law and policy through the lens of the circular economy." ERA Forum 20 (4): 491-508.
6 Micheaux, Helen and Franck Aggeri. 2021. "Eco-modulation as a driver for eco-design: A dynamic view of the French collective EPR Scheme". Journal of Cleaner Production
7 Laubinger, Frithjof, et al. 2021. "Modulated fees for Extended Producer Responsibility schemes." OECD Environment Working Papers No.184. Paris, France: OECD.

"The establishment, by this Directive, of producer responsibility is one of the means of encouraging the design and production of electrical and electronic equipment which take into full account and facilitate their repair, possible upgrading, reuse, disassembly and recycling."[8]

However, anecdotal evidence as well as formal evaluations[9] of its effectiveness at promoting eco-design have found that Directive 2002/96/EC on WEEE had failed in this regard in virtually all Member States. To make up for this shortcoming, the Waste Framework Directive in its three iterations to date has restated the need for EPR to support the eco-design of products to minimise the burden on waste management systems. In its latest recasting dating from 2018, Article 8a (4) of the Waste Framework Directive committed the European Commission to develop guidelines for eco-modulation that are applicable across all Member States to achieve a harmonised system that incentivises the eco-design of products and packaging; these guidelines have not yet been published. The modulation of the EPR fees that producers pay into the producer compliance schemes, known as eco-modulation, has increasingly been proposed as an incentive mechanism to overcome the failure of EPR in encouraging producer eco-design. In 2010, France became the first Member State of the European Union to integrate eco-modulation within its EPR system for Electrical and Electronic Equipment (EEE)[10]. Since then, five other jurisdictions have introduced some form of eco-modulation for EEE: Italy, the province of Ontario in Canada, Taiwan, Singapore, and South Korea.

Such eco-modulation systems see producers' EPR fees adjusted based on the level of eco-design integrated within their products, while also leading to a differentiated distribution of costs among producers based on their alignment with modulation requirements. The main differences between the adoption of eco-modulation in the case of packaging versus EEE is (a) the sheer number of materials and components in the latter, (b) the considerably longer lifetime of EEE, (c) the wide-reaching environmental footprint of WEEE and (d) the lower share of the EPR fee in an EEE product's price.

In its working paper "Modulated fees for EPR schemes"[11], the OECD differentiates between basic fee and advanced fee mechanisms within EPR systems. A basic fee is often used by collective EPR schemes and does not use modulation, with fees being based on average product treatment cost at their EOL per unit, weight, or material. This sees all products within a product category having the same EPR modulation fee regardless of their integration of eco-design. Meanwhile, advanced fee modulation establishes a bonus or a malus to encourage greater eco-design, by charging producers based on criteria like the recyclability, repairability, or reusability of their products. These fees differ from producer to producer and from product to product. The OECD recommends the use of advanced fee mechanism (modulation) over the use of a basic fee system for reasons that include:

- a more accurate distribution of EPR fees among producers;
- lower costs of EPR implementation in the long term if the system is successful at instigating eco-design;
- the reduction of product environmental impacts beyond EOL.

The use of eco-modulation criteria that are applicable across multiple products, such as the system that Italy uses (see section 2.3), brings the advantage of simplicity and clarity by only using five criteria across all EEE categories. Furthermore, if the fee per product is communicated publicly, it can trigger a signalling effect that can, for instance, enable public authorities to incorporate such considerations in their procurement decisions (section 6.2).

8 Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electric and electronic equipment". 2003. Official Journal L27, p. 24.
9 Ecologic, IEEP. 2009. "A report on the implementation of Directive 2002/96/EC on WEEE". https://ec.europa.eu/environment/archives/waste/reporting/pdf/WEEE_Directive.pdf
10 Micheaux, Helen and Franck Aggeri. 2021. "Eco-modulation as a driver for eco-design: A dynamic view of the French collective EPR Scheme". Journal of Cleaner Production 289: 125714.
11 Laubinger, Frithjof, et al. 2021. "Modulated fees for Extended Producer Responsibility schemes." OECD Environment Working Papers No.184. Paris, France: OECD.

An overall examination of existing schemes reveals that EPR fees for EEE tend to represent only a marginal ratio (often less than 1%) of the product cost, for which reason consumers often times deemed insignificant. This is unlike in the case of packaging, where EPR fees are sizable relative to the cost of packaging. This leads to EPR EEE fees not being a distinct driver in influencing consumer choices (section 6). Furthermore, the modulation of EPR fees for EEE oftentimes happens on relatively small amounts that are capped to the average cost of recycling of a given product, so the impact on producers' decisions has also been called into question (section 5.1 and 7.1.3).

Analysis of existing eco-modulation schemes and interviews with experts have also identified the fact that, in order for modulation criteria to be effective at influencing the design decisions made by global EEE producers, a harmonisation of the criteria among jurisdictions is necessary. In order for producers to invest in eco-design across EEE value chains, which are often global, the incentives to do so need to be sizable and the size of the markets where those are applicable needs to be considerable. Therefore, while it is encouraged that the characteristics of the local market be taken into account when designing eco-modulation schemes, it is also advisable that the schemes take into account existing policies in other countries. For that reason, this report presents four case studies in section 2 below, looking at policy design and documenting market impacts where data is available.

1.2 Methodology of the report

The analysis undertaken focused on options to implement eco-modulation for EEE in the UK, considering in particular the use of eco-modulation as a tool to reduce the environmental impact of WEEE and/or the quantity of waste generated. The aim was to explore how eco-design can be rewarded through the use of eco-modulation to extend the life of a product and thus reduce waste. For this reason, analysis of the 'use-phase' of product criteria was used, as detailed in section 2.5.2.

This study adopted both a qualitative and quantitative approach, starting with desk-based research of existing eco-modulation systems and research existing studies available. This was then complemented by the gathering of UK waste data to allow for data modelling to be conducted. This work was then supported by interviews and a stakeholder workshop to offer crucial insights on practical implementation and gain qualitative viewpoints.

One to one interviews were conducted with two France-based producers, three UK-based AATFs, two PROs (one that based in France and the other in Canada) and a major UK trade association (techUK) which has over 850 members including large brand technology producers. Three stakeholder workshops were held in March and May 2022 and attended by a range of stakeholders including ten EEE producers, five European PROs, four UK compliance schemes and numerous WEEE recyclers. Throughout the study we sought to obtain the input of professional stakeholders, however, these opinions and experiences do not represent the collective opinion of their respective industries, rather offering a small sample of the opinion held by a stakeholder within the sector.

Within our evaluation of existing eco-modulation systems, we offer a broad overview of jurisdictions that have implemented eco-modulation (section 2), including the mechanisms and modulation criteria utilised. This was based on literature research and stakeholder engagement, and although this study aims to stay within the parameters of the UK, it uses these findings to develop a broad understanding of previous frameworks established on eco-modulation and further evaluate their separate components. To understand the potential function of eco-modulation alongside the UK's current eco-design legislation, we broadly outline the UK's current eco-design framework as the permeators of an eco-design system (section 2.6).

Within our broad evaluation of potential metrics for eco-modulation (section 3), we focussed on weight and units of POM as the major metrics both previously utilised by eco-modulation systems, whilst also aligning with measurements used to measure EPR responsibility within the UK and other jurisdictions. Data on POM (either in weight or units) has the main advantage of being available (reported in National Registers established under national WEEE legislation as well as in trade statistics) as well as a good proxy for overall impact on waste management.

Regarding the mechanism of implementation (section 4), the three mechanisms of DRS (Deposit Return System), POM fee and market share obligations were studied based on the three major EPR mechanisms deployed globally and that fit within the potential of the UK's EPR framework. This study examines the attachment of fees to changes in the recycling cost and life expectation caused by eco-modulation (section 5), with these pricing constraints being identified based on modulation systems utilised in other jurisdictions and being two mechanisms that are attached to the product's end-of-life impact.

More broad considerations for eco-modulation, including reducing the environmental impact of obtaining raw materials, through process such as the mining of criterial minerals, are not considered within this study as they do not directly relate to the impact of EEE's waste management. Carbon footprints were also considered as potential metric for eco-modulation (section 3.3), however reliable and comprehensive LCA data for all EEE product categories could not be collected within the framework of the current study. This shall however be included in the extended study to be conducted. Although this was not a part of our original scope, the role of consumer behaviour is an important factor to consider (section 6). This was further corroborated by the responses gained from the workshop and requires further exploration.

2 Analysis of existing eco-modulation schemes

Ex-post analyses of eco-modulation for EEE are limited in scope and number. Most eco-modulation schemes are relatively recent and have not been sufficiently evaluated. Furthermore, in the fast-evolving market of EEE, it is difficult to pinpoint changes in product design to a single factor that drove them (like eco-modulated fees) and, therefore, to isolate the impact of fee eco-modulation on the eco-design initiatives of producers.

This section provides a brief overview of the eco-modulation systems implemented in France, Taiwan, Italy, and the Canadian province of Ontario to demonstrate how these systems work in practice and how different eco-modulation criteria interact in existing systems. These four cases were selected out of the six eco-modulation systems identified for EEE operating globally. The rationale behind their selection was based on the fact that they include a broad number of product criteria specifically aimed at improving product environmental impact, whilst having also been implemented at a state-wide (or province-wide in the case of Canada) level. Furthermore, the systems offer a clear distinction between potential mechanisms and frameworks for which eco-modulation can function. The more recent system in Ontario is also the most similar to the current EPR system for WEEE in the UK. While its implementation is still being rolled out, the case was included because it is indicative of the early stages of an obligation-based modulation system. It was possible to conduct a more comprehensive analysis of the French and Italian systems based on longevity and available data. Analysis of the Taiwan and Ontario, Canada systems was constrainted by lack of available data and infancy of system.

Despite multiple eco-modulation systems operating globally, the majority of producers participating in the workshop indicated that they did not have experience with eco-modulation, where the minority that did were subject to a malus. Additionally, some participants felt existing systems are not working. Furthermore, they indicated that alignment with other internationally leading eco-modulation and eco-design standards was a key consideration in maximising engagement.

Bonus/Malus

Bonus: All producers whose products fulfil modulation criteria are rewarded through lower product EPR fees. An example would be a 10% reduction in the EPR fee for all the products that meet one or a series of criteria related to recyclability, durability, repairability, and others.

Malus: All producers whose products fail to meet modulation criteria are given an increased EPR fee for the non-compliant product. Such can be reflected with an increase of EPR fees by 15% for products that contain hazardous chemicals, for example.

2.1 France

France was the first country in Europe to implement an eco-modulation system for EEE in 2010[12], aiming to promote product design that supports the principles of repair, reuse, renovation and reconditioning. The French system relies on a bonus/malus mechanism[13] which is determined based on specific criteria proposed by PROs, upon consulting their producer members, on a yearly basis. A bonus is issued to reward producers when the fulfilment of criteria is deemed as being best practice, whilst a malus is given to penalise producers whose failure to fulfil criteria is deemed to be against commonly held knowledge and is therefore unjustified. An example of the eco-modulation of three products can be seen in Table 1. These demonstrate the bonus and malus criteria, whilst also demonstrating the irregularity in ever fulfilling one or several criteria.

Eco-modulation in France was implemented progressively throughout the years, first with the introduction of six product categories in 2010, which focused on discouraging the use of hazardous chemicals. A second phase was then implemented in 2015 to cover nine household product categories[14], and expand modulation criteria to cover extended product lifespans and strengthen the recyclability of EEE[15]. In 2020, household and professional EEE were differentiated, to have relevant criteria and declaration requirements. Professional EEE are only subject to bonus criteria as opposed to penalties for household EEE, all professional EEE but one (i.e. ink cartridges) are modulated, whereas 14 of the 28 product type of household EEE are modulated. Currently, the system prevents eco-modulation fees to exceed 100% of the products recycling cost, however, new measures will allow PROs to charge modulation fees up to 20% of the products retail price before VAT (Value Added Tax)[16].

The criteria and the declaration method for 2023 of household equipment are under review. French WEEE PROs are engaging in discussions with the relevant stakeholders, including producers, to align on proposals for a revised system. The new proposals were submitted in June 2022 to the PRO committee and are currently being discussed with the public authorities for final approval by January 2023. The new system will then be applicable starting in July 2023. Speaking to a representative from one of the largest PROs for WEEE revealed that, up until now, it has not been possible to identify the criteria based on which producers were applying for a malus.

Household equipment

The eco-modulation system for household equipment differentiates based on the type of products examined. In the case of a bonus, all product criteria must be met to receive a reduced fee, whilst for a malus, meeting one of the criteria is enough to receive an increased fee. For example, laptop computers, seen in Table 1, needs to comply with all three criteria in order to qualify for a bonus.

12 "BAREME MENAGER ECOLOGIC APPLICABLE AU 1ER JUILLET 2016". 2016. Ecologic-France.com, https://www.ecologic-france.com/images/bareme-ecologic-menager-2016.pdf.
13 Micheaux, Helen and Franck Aggeri. 2021. "Eco-modulation as a driver for eco-design: A dynamic view of the French collective EPR Scheme". Journal of Cleaner Production 289: 125714.
14 "BAREME MENAGER ECOLOGIC APPLICABLE AU 1ER JUILLET 2016". 2016. Ecologic-France.com, https://www.ecologic-france.com/images/bareme-ecologic-menager-2016.pdf.
15 Micheaux, Helen and Franck Aggeri. 2021. "Eco-modulation as a driver for eco-design: A dynamic view of the French collective EPR Scheme". Journal of Cleaner Production 289: 125714.
16 "Law No. 2020-105 Of February 10, 2020, Relating To The Fight Against Waste And The Circular Economy". 2020. French Government.

Product	Weight in kg	Criteria	Base fee (Euro)	Bonus/ malus	Eco-modulated fee (Euro)
Laptop	0 to 2 kg Above 2,0001 kg	Absence of paint and coatings incompatible with recycling and reuse on plastic parts >100g **and** Incorporation of post-consumer recycled plastic (minimum threshold of 10%) **and** Product upgrade with standard tools, including memory drives, chips and cards	€0.30 €0.42	**Bonus** -20%	€0.24 €0.34
Printer	0 to 5 kg 5,001 to 10 kg Above 10,001 kg	Complete disassembly capability with commercially available standard tools **and** Provision of essential parts for equipment use for 5 years	€0.42 €0.75 €1.50	**Bonus** -20%	€0.34 €0.60 €1.20
Refrigerators/ Freezer / Combined	0 to 40 kg 40,001 to 80 kg Above 80,001 kg	Presence of refrigerant with GWP>15 **or** Failure to provide technical documentation for electrically authorised repairers **or** Unavailability of essential spare parts for equipment use	€8.33 €15.33 €19.17	**Malus** +20%	€10.00 €18.00 €23.00

Table 1: Example of French modulation criteria and fees for household EEE (January 1st, 2022)[17]

The results of two studies revealed the following changes in the share of EEE receiving a bonus or a malus between the years 2010 and 2016 (Table 2)[18].

PROs:	Results:	
Ecologic, Soren, eco-system and Recylum	**Malus:** Change in share of products (+ a percentage increase, - a percentage decrease) receiving a malus (penalty):	
	Phase 1 (2010-2012): • Vacuum cleaners (-2%) • TVs (-13%) • Laptops (+13%), • Refrigerators (+5%) • Phones (+3%)	Phase 2 (2013-2016): • Vacuum cleaners (+2.5%) • Phones (+12.5%) • Refrigerators (+1.5%) • Tablets (-6%) • Game Consoles (-0.63%).
	Bonus: Change in share of products (+ a percentage increase, - a percentage decrease) receiving a bonus: Data from 2010 to 2016: • Lamps (+51%)	• Printers (+1.13%) • Coffee makers (+5.62%) • TVs (+9.38%) • Washing machines (-3.5%) • Laptops (-0.75%)

Table 2: Change in the issuing of bonuses and maluses by French PROs for EEE from 2010 to 2016

17 Ecologic. 2022. "Household EEE Financial Contribution, 2022". Paris, France. https://www.ecologic-france.com/images/medias/document/18380/ecologic-household-weee-financial-contribution-2022.pdf

18 Laubinger, Frithjof, et al. 2021. "Modulated fees for Extended Producer Responsibility schemes." OECD Environment Working Papers No.184. Paris, France: OECD.

Looking at the results of the analysis we can observe that the number of producers claiming a bonus for lamps changed significantly between 2010 and 2016, warranting a 51% increase in the number of lamps receiving an EPR bonus: this is mainly linked with the adoption of LED technology and the market penetration observed. The results for other products were mixed, which could be indicative either of trends in product design or of the increased implementation of EPR eco-modulation during the reporting years (or both). The extent to which the increase in bonus claims can be attributed exclusively or mainly to eco-modulation remains hard to ascertain.

Research in 2021 in France published in the Journal of Cleaner Production shows that it is difficult to establish causality in the case of changes in EEE design[19], also notably because the awarding of a bonus or a malus is contingent upon the fulfilment of several criteria for each product – for example the availability of spare parts **and** the presence of recycled material. Whether a producer applies for a bonus thanks to the former rather than the latter is, again, hard to ascertain.

Furthermore, producers do not always have full control of these design considerations, seeing how registered producers in France do not only include manufacturers, but also importers, distance sellers, and assembly companies[20]. The available data therefore does not indicate how the change in the percentage of products receiving a bonus or a malus resulted in tangible impacts on WEEE generated and waste prevention.

Professional equipment

The criteria for professional equipment are less complex than those for household appliances. This is because this modulation entered into force later and so it was possible to learn from household EEE experience and thus use a simpler approach. The type of products, producers and usage is also different and so the model reflects this. Producers can only obtain a bonus and to do so, they need to comply with at least one of the three following criteria: i. integration of >20% recycled plastic; ii. No brominated flame retardants in plastic parts; iii. Spare parts availability[21]. Producers complying with one criterion get 20% discount, those compliant with any two criteria get 30% discount whilst those compliant with all three criteria get 40% discount. The discount rates are reviewed every year by the PRO, as reflected in the table below. Whilst according to a French PRO, the system is still too new to have concrete data, with less than 1% asking for a bonus, 0% are claiming all 3 criteria, 1.1% for 2 criteria and 1% are for 1 criteria.

Year/ Number of criteria	1	2	3
2020-2021	10%	15%	20%
Starting in 2022	20%	30%	40%

Table 3: Bonuses for professional EEE in France by the number of criteria with which the product is compliant[22]

19 "Micheaux, Helen and Franck Aggeri. 2021. "Eco-modulation as a driver for eco-design: A dynamic view of the French collective EPR Scheme". Journal of Cleaner Production 289: 125714.
20 "Environmental Code". 2020. Vol. 541-10. Paris, France: Government of France.
21 ecosystem. 2022. "Professional EEE Cost Grid For 2022". Paris, France: ecosystem. https://www.ecosystem.eco/upload/media/download/0001/02/deeecc5ed41715bfc1be8888821d80c83262768c.pdf.
22 Ecologic. 2022. "Professional EEE Financial Contribution, 2022". Paris, France. https://www.ecologic-france.com/images/medias/document/18380/ecologic-household-weee-financial-contribution-2022.pdf

Administrative process

The eco-modulation scheme in France uses self-declaration by producers, who are required to complete and sign standardised declaration forms. The auditing of eco-modulation bonus claims is done at the same time as the compliance audits for producers and conducted by a third party. There is a legal obligation on PROs to audit 20% of the weight of the total POM declared by the producers registered with their PRO scheme[23]. In practice, for one French PRO interviewed, this means around 50 producers out of the 4500 registered, are audited every year. Of these, not all apply for eco-modulation, so an even smaller number have their eco-modulation paperwork checked. The logic of the declaration and the evidence supplied to prove the criteria is checked during the audit as well as ensuring there is a consistent reporting method for continuity. The same PRO revealed that eco-modulation auditing typically takes 10 weeks for a team of 2-3 auditors with audits taking between half a day to 4 days, depending on size of company. If a deviation of more than 2% compared to the fees paid is detected during an audit, the audited producers will be re-invoiced or refunded the difference. It was noted in the interview that audits demonstrated that many producers have difficulty understanding the declaration process and those filling in the declarations might not be competent to define if and which criteria can be applied or be able to access the necessary technical design data.

The France-based producers interviewed, when expressing their views on the system of eco-modulation, argued that it was not the right tool for the objectives set. They argued it aimed to charge a fee to be paid for products put on the market today but to be recycled only in the future, while today old appliances are still being recycled. One producer pointed out that they considered the legislative Proposal for a Sustainable Product Initiative, published by the European Commission on 30 March 2022, a more promising approach to influencing current designs for products placed on the market today to be more efficient to recycle in the future, when they become waste[24]. This was a perspective echoed in the workshop, with one producer citing a poor experience with existing schemes in France and Italy.

2.2 Taiwan

In Taiwan, EPR requirements for EEE were established under the Waste Management Act in 1998 and were expanded in 2017 to cover more products[25]. Across all relevant EEE products, the Fee Rate Review Committee sets two EPR recycling fee rates paid by producers. This includes a 'regular' price for products that are non-compliant with modulation criteria and a second, lower fee for compliant products that receive a 'green-mark' to demonstrate compliance to consumers. For each product category, as seen in Table 4 producers must comply with all product-specific criteria to be eligible for the lower 'green-mark' fee. These different fees have been set for products across five separate modulation criteria, including energy efficiency, hazardous materials, repairability, noise emissions and disassembly. Recovered EPR fees are used to subsidise recycling systems, reward recycling activity, and pay towards the auditing and certification of products. Table 4 summarises some of the criteria for different products.

23 « Decree No. 2020-1455 Of November 27, 2020 Reforming Extended Producer Responsibility". 2020. Vol. 541-128. Paris, France: Government of France.
24 European Commission. "Sustainable Product Policy". Accessed 31 March 2022. https://joint-research-centre.ec.europa.eu/scientific-activities-z/sustainable-product-policy_en.
25 Tsai, Wen-Tien 2020. "Recycling Waste Electrical and Electronic Equipment (WEEE) and the Management of Its Toxic Substances in Taiwan—A Case Study". Toxics, 8 (3).

Product:	Criteria:	Regular fee for each unit (TWD)	'Green-mark' fee for compliant products for each unit (TWD)	Bonus/Malus
Printer Inkjet types **Printer Laser type** **Printer Dot-matrix type**	1. Energy Efficiency (must meet ENERGY STAR program criteria) 2. Disassembly (can be disassembled) 3. Noise Emissions (must be compliant with individual noise level criteria) 4. Hazardous Substances (14 separate criteria)	$175 (£4.37) $193 (£4.82) $188 (£4.70)	$167 (£4.17) $184 (£4.60) $179 (£4.47)	**Bonus** -5%
Washing machine	1. Energy Efficiency (must meet ENERGY STAR criteria) 2. Noise Emissions (Cleaning: ≦50 dB (A); Water removal: ≦53 dB (A) 3. Hazardous Substances (12 separate criteria)	$357 (£8.92)	$304 (£7.60)	**Bonus** -16%
Portable PC Notebook **Portable PC Tablet**	1. Energy Efficiency (must meet ENERGY STAR criteria) 2. Disassembly (can be disassembled) 3. Hazardous Substances (10 separate criteria)	$39 (£0.97) $25.3 (£0.63)	$34 (£0.84) $22 (£0.55)	**Bonus** -14%

Table 4: Example of Taiwan modulation criteria and fees per product unit in Taiwan Dollar (TWD), exchange rate accurate as of March 1st, 2021

2.3 Italy

In Italy, like in most countries, PROs define the EOL fees and then charge producers based on their POM, this is calculated ever through weight-based (€/t POM) fees or unit-based (€/unit POM) fees, depending on each individual PRO. In most cases the fees are the same for all the products belonging to the same waste stream (e.g. refrigerators and air conditioners, or printers, vacuum cleaners and tools).

In 2016, the government introduced a new legislative decree (Decreto 10 June 2016, n. 140) on the eco-modulation of fees for EEE as a complementary measure to the general eco-design principles contained in Directive 2012/19/EU on WEEE. Through the new decree, Italian authories sought to:

- promote the cooperation between producers and waste management operators;
- support the eco-design of EEE and promote waste prevention;
- foster the market of secondary raw materials for EEE.

Five criteria for assessment have been identified by authorities, without defining specific KPIs or indicators: (i) a score for the lifecycle impacts of the product; (ii) a score for the end-of-life impacts; (iii) scores for repairability, (iv) disassembly, and the (v) number of ISO certifications. The criteria and scores are outlined in Table 5 below.

	Score		
Lifecycle analysis (LCA) score	Sufficient = 1 point	Average = 2 points	Optimal = 3 points
Product EOL score	Sufficient = 1 point	Average = 2 points	Optimal = 3 points
Repairability	Yes = 1 point	No = 0 points	
Disassembly	Yes = 1 point	No = 0 points	
ISO certifications	1-2 certifications = 1 point	3-5 certifications = 2 points	Over 5 certifications = 3 points

Table 5: Criteria used for EEE eco-modulation in the Italian EPR system[26]

To substantiate their claims for lower EPR fees, producers are asked to submit a dossier to the Italian environment agency for each model of EEE product placed on the market that is eligible for a reduction of the amount of products declared as placed on the market. The reduction is valid only for one year only. The dossier needs to include:

- an LCA of the product;
- a description of EOL management that indicates the benefits of eco-design on the EOL of the product;
- a list of ISO certifications;
- disassembly instructions;
- maintenance and repair specifications.

The Italian Environment Agency evaluates the dossiers and calculates the POM reduction coefficient (R value) based on the information provided by producers. Based on this assessment, if a producer's total score is between 1 and 3 points they are entitled to a reduction in their POM responsability of 5%. Producers scoring between 3 and 6 points can utilise a 10% reduction, whilst those with a score above 7 receive a 20% POM reduction.

Type of product	POM (t)	Score obtained (Table 5 criteria)	POM reduction coefficient	2021 EOL Fee (€/t POM)	POM declared (t)	Payment to PRO (€)	Saving (€)
Refrigerator	500 (approx. 10,000 units of a single model)	0	baseline	137	500	68,500	
		2	5 %		475	65,075	- 3,425
		5	10 %		450	61,650	- 6,850
		9	20 %		400	54,800	- 13,700

Table 6: Example of a potential reduction of POM; for a producer (Source: dss+)

To date, no producers have applied for the bonus. The table below estimates the minimum number of products (of the same model) that a producer would need to place on the market only to offset the administrative cost of performing a standard LCA (assumed to have a market cost of €20,000).

26 "Decree 10 June 2016, No. 140". Vol. 171. 2016. Rome, Italy: Official Gazette of the Italian Republic. vol. 171.

Type of product	Waste stream (collection category/ WEEE Directive)	Average fee 2021 (€/t POM)	Average weight of a product (kg)	Standard fee (per product)	Equivalent savings through eco-modulation (20% reduction of POM)	Number of products to be placed on the market to offset LCA cost
Refrigerator	Cat. 1	137	47	6.44 €	1.29 €	15,530
Washing machine	Cat. 4	65	59	3.84 €	0.77 €	26,076
Laptop	Cat. 2	275	2.5	0.69 €	0.14 €	145,455
Mobile phone	Cat. 6	25	0.2	0.01 €	0.00 €	20,000,000
Vacuum cleaner	Cat. 5	29	4	0.12 €	0.02 €	862,069
TV	Cat. 2	275	17	4.68 €	0.94 €	21,390

Table 7: The number of products a producer needs to place on the Italian market to offset the cost of complying with eco-modulation requirements (Source: dss+)

The benefit of the Italian system's use of "reduction (or increase) of product market share" (see section 4.2) rather than the adoption of bonus/malus fee system is that it is able to recover all end-of-life costs associated with the management of the share of responsibilities allocated to each individual producer through their market share. The system is influencing the relative market share of the producers that are applying for the eco-modulation, without changing the individual fees they are paying to the PROs. The overall responsibility of the PROs is then levelled among the other producers that are not applying for the eco-modulation and the total end-of-life cost are recovered. This mechanism is simulated for the UK market in section 5.3.

The Italian PRO also commented that the uptake of eco-modulation among producers has been low. Factors causing this include the complicated and expensive compliance requirements, which are elaborated upon in section 3 of this report, have led to this outcome. In turn, this state of affairs makes it difficult to assess the effectiveness of the eco-modulation scheme and calls into question whether its design could be improved to facilitate its uptake. Evidence from more than five years of implementation reveals that the administrative burden to lodge a claim for a bonus is too high compared to the potential financial benefits for producers, who have yet to take advantage of the policy and applied for a reduction.

2.4 Ontario, Canada

In Ontario, Canada, a system of eco-modulation called reduced management requirements for EEE was introduced through the Electrical and Electronic Equipment Regulation 2020[27]. Having come into force in January, 2021, the new EPR system covered information technology, telecommunications and audio-visual equipment (ITT/AV). Starting in January 2023, the EPR system will be extended to lighting equipment.

Products classed as ITT/AV:

Computers; Printers (desktop and floor-standing), including printer cartridges; Video gaming devices; Telephones, including cellular phones; Display devices; Radios and stereos, including after-market vehicle stereos; Headphones; Speakers; Cameras, including security cameras; Video recorders; Drones with audio or visual recording equipment; Peripherals and cables used to support the function of information technology, telecommunications and audio-visual equipment, including charging equipment; Parts of information technology, telecommunications and audio-visual equipment sold separately, such as hard drives; Handheld point-of-sale terminals or devices; Musical instruments and audio recording equipment.

Under these new EPR measures, producers of ITT/AV are responsible for the financing of collection and recycling of the total weight of the eligible products they place on the market. The purpose of these obligations is for producers to cover the cost of the collection, storage, processing, and communication of an amount of WEEE equivalent to a share of the weight of the EEE POM (from 55% to 70% for ITT/AV and from 30% to 50% for lighting). Compared to other EPR systems utilising modulation, the use of producers' POM weight is somewhat similar to the UK EPR system insofar as it does not levy a fee, but rather obligates producers to pay for the costs arising from end-of-life management.

This system is regulated by the RPRA (Resource Productivity and Recovery Authority), which enforces producer obligations, ensuring producers accurately register and report their POM weight, alongside fulfilling their obligated EOL commitments based on their corresponding POM weight. Resource recovery fees are not mandatory, with producers not being obligated to introduce visible fees and the RPRA does not collect fees to cover EOL costs. It is the responsibility of producers to collect and treat their total POM weight reported, whether this is directly through their own actions or is completed through third-party partners, such as a PRO. Furthermore, producers are required to pay a registration fee to support the RPRA's operations. In 2021, producers whose POM was less than 6,500 kg of EEE were exempt from this fee, whilst each kg of EEE over 6,500 was charged at CA$0.034 per kg.

Producers can reduce their requirement to report and recover their total weight POM by 50% through fulfilling one or more product criteria, which include: the percentage of post-consumer recycled materials in their products; the length of product warranty; and the repair options for products. Furthermore, by reducing the reported weight of EEE POM, producers also benefit from a corresponding decrease in the registry fees paid to the RPRA.

The presence of post-consumer glass or plastics materials, alongside recycled content in batteries, can see an overall reduction in producers' POM management requirements. Producers whose products have used recycled content can reduce the weight of their POM data by the equivalent weight in recycled content used.

27 "The Resource Recovery And Circular Economy Act, 2016". 2020. Vol. 52220. Ontario, Canada: Government of Ontario.

Post-consumer Content	
Management Reduction Requirement:	Total POM weight equivalent to post-consumer recycled content weight.
Example:	A producer placing 1,000 washing machines on the market that contain on average 13kg of plastics (0.65kg from post-consumer plastic each) is eligible to reduce their supplied data and WEEE management responsibility by 650kg (0.65kg x 1000 washing machines).

Table 8: Calculation of post-consumer content to reduce POM weight reported in Ontario

Producers that provide free warranty for one year or more can also benefit from a reduction in weight POM. The warranty period is used as a measure of the durability and quality of products. Producers that meet warranty requirements can reduce their reported POM weight by 5% for each full calendar year of warranty provided.

Product Warranty	
Management Reduction Requirement:	The number of warranty years.
Example:	The producer of a TV that has a one-year warranty will receive 5% off their reporting requirement, whilst that of a TV with a 5-year warranty would receive 25% off their reporting requirements.

Table 9: Calculation of product warranty to reduce POM weight reported in Ontario

Products must be considered repairable by the consumer through the provision of tools, information, and parts that are available either at no charge or on a cost-recovery basis. These must be available at the time the producer reports the data. If a producer fulfils this requirement, they can reduce the POM weight of their EEE by 10%.

Repairability	
Management Reduction Requirement:	10% of reported POM weight for the provision of tools, information, and spare parts.
Example:	The provision of spare parts, tools, and information for the repair of a camera when the producer is reporting this information can result in the reduction of the reported weight by 10%.

Table 10: Calculation of product repairability to reduce POM weight reported in Ontario

2.5 Application of criteria

This section outlines the eco-modulation criteria to incentivise change in EEE product design. These were selected through an analysis of a total of 371 criteria used for EEE eco-modulation in four jurisdictions: South Korea, Taiwan, France, and Ontario, Canada; as Italy has no specific KPIs but the assessment of performance is done on a case-by-case basis by environment agency, Italy has been excluded from the totals. These criteria were identified through relevant legal texts and databases for the respective countries and later grouped under three categories based on the lifecycle stage to which they are relevant: design, use and end-of-life and are expounded upon in sections 2.5.1 to 2.5.3.

Of the 371 criteria analysed, 126 concerned hazardous substances used in different EEE in Taiwan, which uses its EPR eco-modulation legislation to control for a series of chemicals, some of which are banned in the UK. These include mercury, lead in plastics and photo-sensitive material, cadmium in plastics and batteries, hexavalent chromium, polybromobiphenyls (PBBs), polybromodiphenyl ether, selenium, and others. In total, 135 criteria concerning hazardous substances were identified across the five jurisdictions. Aside from hazardous substances, recycled content, repairability and durability (using extended warranty as a proxy) were the leading criteria with 90, 31, and 13 instances respectively. The total number of criteria appearances by circular economy theme is outlined in Table 11. This table – without having a statistical significance – gives an overview of the current criteria used and adopted.

Circular economy theme	Number of mentions
Hazardous chemicals	205
Recycled content	90
Repairability	31
Durability	13
Energy efficiency	11
Disassembly	6
Others (incl. recyclability, noise levels, total weight POM, energy consumption, and upgradability)	15

Table 11: Classification of criteria by theme

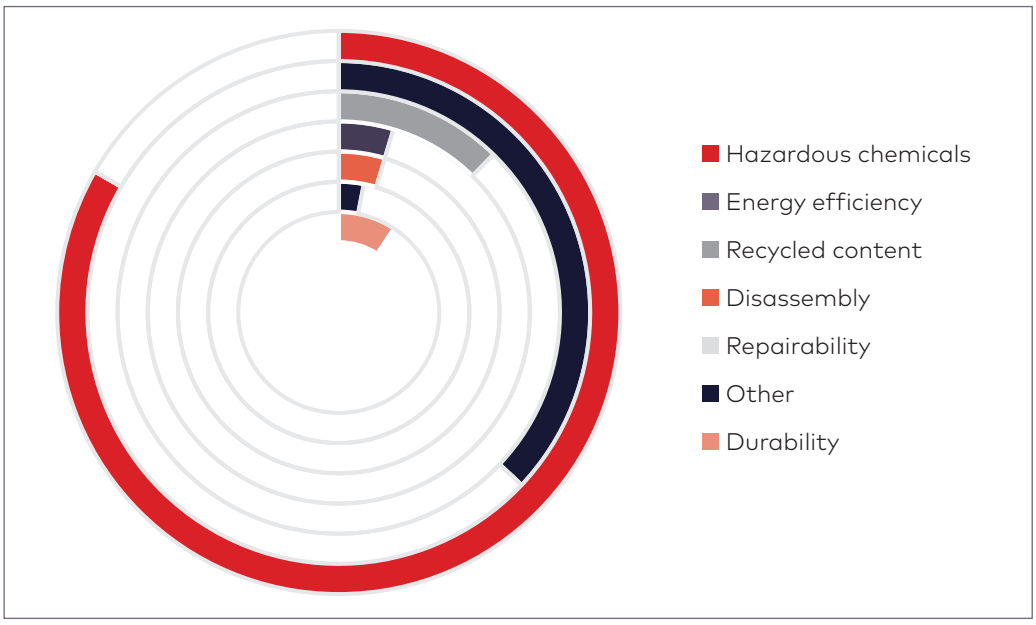
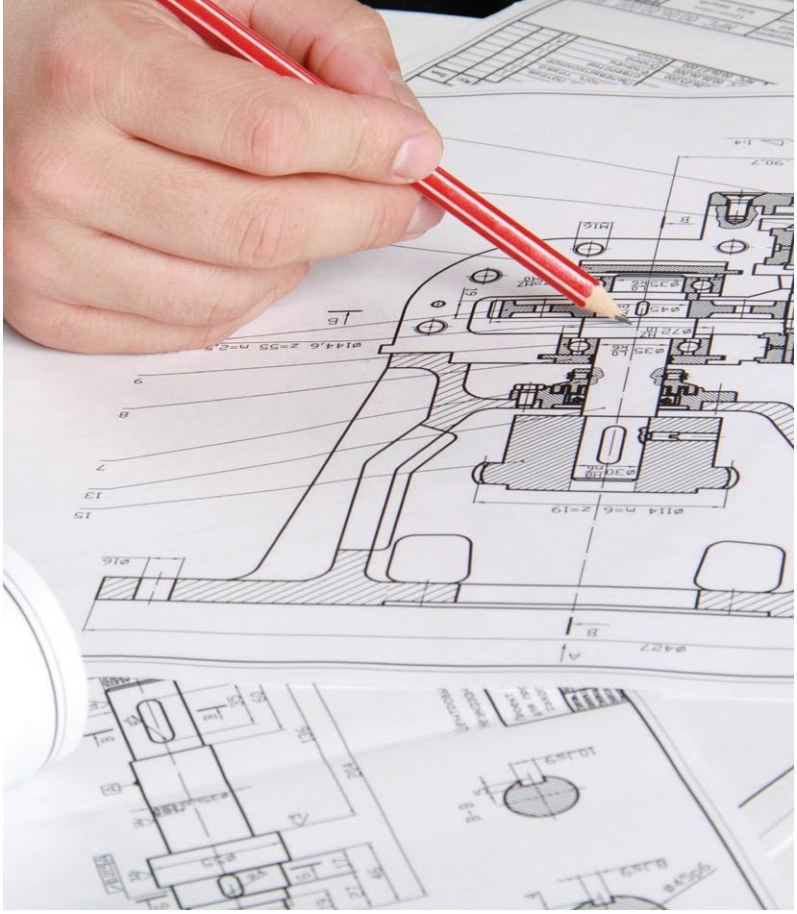


Figure 1: Percentage of each criteria by theme



Based on findings from relevant legal texts and databases for the respective countries, as previously outlined, France is the jurisdiction with the most criteria identified (190), followed by Taiwan (151), Ontario, Canada (26), and South Korea (11). Nearly all of the household EEE products were large household appliances. These include washing machines (22), refrigerators (18), printers (22), desktop PCs (19), air conditioners (16), vacuum cleaners (16), LED displays (17), driers (14), and microwaves (15). The two exceptions are:

- mobile phones (7 criteria identified in Ontario, France, and South Korea – specifically upgradability, the availability of a standard charger, warranty period, repairability, and recycled content)
- and laptops (19 criteria).

In addition, 157 of the 379 criteria were associated with professional EEE deriving from France, which accounted for 41% of the total. These criteria cover a highly diverse array of product types.

An important caveat is to note is that all the criteria below are relevant to the design of products, regardless of the lifecycle stage under which they are categorised and that there is significant overlap between the different criteria. For instance, although durability impacts the length of use of a product and has therefore been allocated to the use-phase category, it is pertinent to earlier lifecycle stages considering durability is determined at the design stage. Several of these criteria implemented in existing eco-modulation systems are linked to the fulfilment of other product-specific criteria to benefit from modulation, as noted in the cases of France and Taiwan (sections 2.1 and 2.2 above). However, for the purposes of this analysis, each criterion was considered separately.

The criteria detailed in the following sections are therefore a summary of those drawn out of desk research and experiences shared during interviews with three UK-based AATFs (approved authorised treatment facility) that recycle/repair different product categories including small WEEE, large domestic appliances and fridge/freezers.

2.5.1 Design criteria

Design criteria in eco-modulation are being used as potential mechanisms to encourage environmentally conscious design within EEE products across different phases of their lifecycle. These include the use of less environmentally damaging materials in the manufacturing of the product, alongside the reduction of energy in the use-phase. In the workshop conducted, producers indicated the biggest barrier to implementing design criteria, as well as use-phase and end-of-life criteria, as being a lack of homogeneity in eco-modulation at an international level, in addition to the financial costs of compliance.

Design criteria			
Criterion	**Definition**	**Aim**	**Potential performance indicators**
Recycled content	The % of post-consumer recycled content in new products. This criterion often manifests itself as a minimum threshold expressed as a % of weight comprising recycled content.	Encouraging producers to use more recycled material to minimise the environmental impacts associated with virgin material extraction and processing.	An increase in the demand for recycled materials, as more producers work to comply with the criterion.
	Example In France, new PCs, dishwashers, washing machines, and laptops that contain at least 10% of post-consumer recycled plastics and meet other product-specific criteria can benefit from their 20% reduction in EPR fee. **Anecdote** One producer flagged the regulatory challenges of manufacturing their products abroad using post-consumer recycled content as a result of legal barriers in those countries. This may influence the success of this criterion.		
Energy efficiency	This criterion measures the energy performance of EEE during its use-phase through requirements specified in the EPR legislation.	To reduce use-phase energy use from EEE.	The increase in the uptake of the most energy efficient models of EEE.
	Example In Taiwan, printers benefit from a 5% lower EPR fee if their energy consumption values, energy saving mode settings, and recovery times from energy saving modes meet the requirements of the ENERGY STAR label. For laptop computers, the fee is reduced by 13% if they meet the ENERGY STAR requirements.		
Restrictions on single-use products	Products that are designed without taking into consideration circular economy principles, e.g. single-use products.	To make sure producers reconsider designing products that have a minimum pre-defined lifespan.	Reduce number of single-use products on the market.
	Anecdote A UK-based recycler flagged the issue of single-use e-cigarettes are an example of a new type of device with a very short lifetime, (comparable to a pack of cigarettes), after which the product is disposed of – often into general waste despite containing a lithium battery. This is a new design versus having a main reusable unit.		
Discouraging the use of difficult-to-recycle polymers and additives	The use of an increasing number of different polymers and additives makes their recycling more complicated and reduce recycling yields.	Reducing the complexity in polymers and additives used in EEE plastics would improve WEEE plastic recycling yields.	Increase in the uptake of more easily recyclable products.
	Anecdote A UK-based recycler suggested that use of defined list of plastics in the production of new appliances would allow for more economically and environmentally viable recycling.		

Table 12: Modulation criteria previously utilised to shape product design in existing eco-modulation systems

2.5.2 Use-phase criteria

These modulation criteria aim to encourage producers to extend the lifespan of products and thereby reduce the overall quantities of materials required for new products. This objective is achieved by reducing the number of products on the market with a short lifespan and ensuring that products can fulfil their intended purpose for an extended period. By decreasing the consumption and production of new products, the use of materials can be reduced, and the wider environmental impact associated can be minimised. During the workshop, producers indicated the criteria in the use-phase as their biggest opportunities to enhance the environmental performance of their products.

Use-phase criteria			
Criterion	**Definition**	**Aim**	**Potential performance indicators**
Durability	The modulation of EPR fees based on the predicted lifespan of products.	Incentivising producers to make longer lasting EEE that will be in use for extended periods of time.	A decrease in the amount of WEEE by weight 5 years after the introduction of the eco-modulated fee.
	Example In Ontario, Canada, the length of product warranty is used as a proxy for durability, based on the assumption that producers only offer longer-term warranty for products they consider as being durable. EEE with a warranty of over 1 year, including printers, PCs, vacuum cleaners, mobile phones, refrigerators, batteries, dishwashers, microwaves, washing machines, dryers, LED displays, laptops, and air conditioners are eligible for an eco-modulated fee. **Anecdote** One AATF raised the issue of thickness of plastic coatings used in trays of dishwashers which tend to rust if the coating is not a good quality or not applied properly. If parts of the appliance are rusty the appliance cannot be re-sold on the second-hand market. The feet of some domestic appliances such as tumble driers are a 'weak feature' that are easily damaged in transit. Since the feet are not a separate part but are included in the base unit, they cannot be replaced, which makes the appliance unsuitable for re-sale.		

<table>
<tr><th colspan="4">Use-phase criteria</th></tr>
<tr><th>Criterion</th><th>Definition</th><th>Aim</th><th>Potential performance indicators</th></tr>
<tr><td rowspan="2">Repairability</td><td>Repairability criteria assess the ease with which products can be affordably and easily repaired.</td><td>Reducing the amount of WEEE and the demand for new products by enabling longer use of existing products through repair.</td><td>For further discussion.</td></tr>
<tr><td colspan="3">Example
In France the failure to provide technical documentation on how to repair refrigerators and vacuum cleaners is subject to a 20% EPR fee increase, whilst the failure to provide such information for laptops is penalised with a 30% fee increase. In Ontario, Canada, a 10% EPR fee reduction is offered if consumers have access to free information on product repair for the following products: printers, vacuum cleaners, mobile phones, refrigerators, batteries, microwaves, dishwashers, washing machines, dryers, LED displays, laptops, and air conditioners.

Anecdote
One AATF that repairs large domestic appliances for resale cited that lack of access by an engineer to parts that can be replaced is a barrier. Another point they raised was the need to be able to replace the front panel of appliances that might have “cosmetic” damage. The front appearance plays a key part in the appeal that an appliance has for customers and makes re-sales of refurbished appliances less appealing.

Another example cited was the need for standardisation of fixing bolts that remain with a washing machine (such as in a pouch at the back). Fixing bolts prevent damage of internal parts of the device during transport and currently come in different shapes and sizes – and are often lost. The standardization of these bolts would greatly foster giving a second life to such appliances.</td></tr>
<tr><td rowspan="2">Availability of spare parts</td><td>The ease with which consumers can access spare parts for products allows them to repair and replace broken components, increasing the lifespan of EEE. This can include the possibility of using 3D printed parts within the product, based on the availability of data files for free or at an affordable rate.</td><td>Allowing consumers to extend the lifespan of products without the need for large product stockpiles, as broken components can easily be created and replaced.</td><td>For further discussion.</td></tr>
<tr><td colspan="3">Example
In France, the failure to provide essential spare parts for printers for at least 5 years, refrigerators and electronic displays for at least 10 years, and dishwashers and washing machines for at least 11 years is subject to a 20% EPR fee increase. A report by Eunomia on behalf of the European Commission emphasised the potential to modulate the availability of 3D printable files, allowing consumers and repairers to create new parts easily and cheaply without the need to stockpile.

Anecdote
The experiences shared by the AATF that repairs domestic appliances included needing to know which spare parts are suitable to be used in which products. They had wasted time ordering a certain spare part, not knowing that the same kind of part is readily available from another device on site.</td></tr>
</table>

Use-phase criteria			
Criterion	**Definition**	**Aim**	**Potential performance indicators**
Use of soft lithium batteries	Lithium batteries are used extensively throughout EEE products but are very unstable and if they leak, are highly flammable.	Reduce the risk of fire from lithium batteries during the recycling process.	For further discussion.
	Example The problem of fires being caused by lithium batteries is well documented. Designing products that use different types of batteries that are safe and stable would reduce the cost and complexity of handling these items once they become WEEE. **Anecdote** All of the AATFs interviewed invest heavily annually (£100,000 was one cost given) in fire prevention activities, training and systems at their sites. This is a real risk to personnel and sites.		
Upgradability	The possibility to upgrade EEE or its parts – for example, to increase the memory storage capacity of devices like mobile phones.	A reduction in WEEE by enabling users to repurpose and adapt devices as technology evolves.	For further discussion.
	Example In France, the upgradability of PCs and laptops with standard tools like new memory drives, chips, and cards receives a 20% decrease in EPR fees.		

Table 13: Modulation criteria previously utilised to encourage extended product lifespan in existing eco-modulation systems

2.5.3 End-of-life criteria

End-of-life criteria within eco-modulation aims to increase the ease with which products can be recycled whilst also reducing the cost of their recycling. They aim to ensure that such products are more easily recyclable, by decreasing the time, effort and cost needed to recycle a product.

<table>
<tr><th colspan="4">End-of-life criteria</th></tr>
<tr><th>Criterion</th><th>Definition</th><th>Aim</th><th>Potential performance indicators</th></tr>
<tr><td rowspan="2">Recyclability</td><td>The ease with which a product can be recycled, based on specific features outlined in compliance legislation, such as size, materials, or colour.</td><td>Increasing the proportion of recycled waste and decreasing that of landfilled material. Also, reducing the cost of recycling services.</td><td>A decrease in the percentage of landfilled WEEE.</td></tr>
<tr><td colspan="3">Example
In France, the presence of paints and coatings that are incompatible with recycling in quantities over 100g in PCs and laptops being subject to a 20% EPR fee increase.

Anecdote
Recyclability challenges cited by AATFs included the use of shatterproof glass that can only go into aggregate rather than recycled into new glass or the tops of domestic appliances being chip board with a veneered coating glued which means it cannot be recycled but the glue makes it too toxic to go to waste to energy.</td></tr>
<tr><td rowspan="2">Disassembly</td><td>EEE can be taken apart into components that can be recycled, refurbished, and/or reused.</td><td>Lower recycling costs and greater ease and profitability with which products can be dismantled for reusable spare parts.</td><td>An uptake in the percentage of products that are easier to disassemble.</td></tr>
<tr><td colspan="3">Example
In Taiwan, printers, PCs, dishwashers, and LED displays that can be disassembled are subject to an EPR fee reduction of 5% for printers, 13% for laptops and 15% for LED displays. In France, printers are subject to a 20% fee reduction based on their complete disassembly capability with commercially available standard tools.

Anecdote
A practical example cited by an AATF was the challenge they face to remove and degas compressors as some are built-in and so require complex manual dismantling prior to degassing. The use of uniform screw heads in all components of a product and reusable fixings rather than glue for casings were other disassembly suggestions.</td></tr>
<tr><td rowspan="2">Removal of batteries</td><td>The ease with which batteries can be removed from EEE products.</td><td>Preventing the incidence of fires at recycling plants, particularly since more and more EEE products include lithium-ion batteries.</td><td>A decrease in the incidence of fires at recycling plants.</td></tr>
<tr><td colspan="3">Example
This criterion is not currently incorporated in any of the known EPR WEEE schemes that employ eco-modulation.

Anecdote
Interviews with AATFs have revealed that the ability to easily remove batteries would have the biggest positive economic impact on their operations (one example was a cost of £30-40,000 to recycle 10 tonnes of batteries) and reduce risk of fire (for one recycler, 30% of the batteries removed are lithium ion which are a high fire risk).</td></tr>
</table>

End-of-life criteria			
Product labelling	Products can be labelled to show their CRM (Critical Raw Materials) content	Identification of CRM containing devices makes CRM recycling easier in the future.	An uptake in recovery of CRM from WEEE.
	Anecdote One AATF noted that if they knew which items contained CRM materials, they could be set aside for specialised dismantling and reclaim and would be worth investing in the infrastructure to do so.		
Hazardous content	Producers going beyond compliance to eliminate not only banned substances, but other substances that make recycling more difficult.	Reducing the risk of contamination in the recycling process, the limitations associated with hazardous content disposal, and the demand for specialised recycling processes.	An uptake of WEEE that does not contain substances of concern.
	Example In France, a 100% EPR fee increase is exacted for vacuum cleaners, tablets, portable game consoles, home game consoles for the presence of bromine in all plastic parts containing flame retardants. **Anecdote** Old smoke alarms can contain radioactive material. The detection, sorting and separate treatment of these implies extra effort and costs to the facility. Penalizing such devices could reduce the environmental and financial burden they impose.		

Table 14: Modulation criteria previously utilised to increase the ease with which products can be recycled in existing eco-modulation systems

Stakeholder viewpoints

During dedicated workshops and consultations with producers key elements were raised in respect of the different criteria that should or could be adopted in UK:

- Regarding design and use-phase, the functionality and performace requirements of the great variety of products sold makes it difficult to define common criteria. For example, a product's robustness or waterproofing of their outer casing might be conflicting design requirement when considering removability of batteries.
- Some criteria, such as marking parts for easier identification and using common sized screws, are already practices utilised by producers.
- Criteria focusing on repairability and accessibility to repair services versus self-repair need to be carefully assessed as not all repair activities should be done by consumers. This identifies the need to share the right level of technical knowledge about the product to the repairer. The cost of sharing this knowledge through hosting training session or creating manuals was flagged as a concern.
- Concern surrounding the additional cost of stringent criteria surpassing the financial benefit of reduced recycling fees.
- If the criteria used was too stringent, there was a concern that large companies would incur costs to comply, allowing free riders to offer cheaper, non-complaint products and would undercut the market.

2.6 Compatibility of eco-modulation with existing eco-design legislation in the UK

EEE sold in the UK is already subject to a range of eco-design criteria. The UK's existing EEE eco-design legislation, which was a transposition of the EU Eco-design Directive through the introduction of the Eco-design for Energy-Related Products and Energy Information Regulations 2021, henceforth referred to as the Eco-design Regulation, and the Eco-design for Energy-Related Products and Energy Information (Lighting Products) Regulations 2021. It is essential that any eco-modulation system supports the existing legislation in order to avoid duplication and yet ensure that all the levers that can effectively drive eco-design are used.

Table 15 below outlines the criteria laid out in the eco-design regulation associated with the top 12 most common WEEE product categories in the UK by weight. This is further supplemented by other eco-design regulations beyond the top 12 threshold.

Product	POM 2018 (% of total weight)	Regulation(s)	Criteria (Contained in Regulation)
Refrigerators	20.6%	UK Eco-design (2021) + EU Eco-design Directives (Nos 640/2009, 643/2009, 1016/2010, 1275/2008, 642/2009)	**Presence of hazardous substances** (displays only): Labelling indicating presence of Cadmium, ban on Halogenated Flame Retardants in enclosure and stand, use of other flame retardants must be marked. **Product lifespan:** Availability of spare parts, repair standards, material efficiency, repairability in terms of repair information and dismantlability with common tools. No guidance on warranty, durability, or design for repair and reuse. **Recyclability (Displays only):** Plastic components heavier than 50g must be labelled with type of polymer. **Energy Efficiency:** Specific requirements for different types of products, energy efficiency standards, programme and functional requirements. **Water Consumption (Dishwashers only):** Standards around consumption. **Consumer Awareness:** Energy efficiency labelling
Freezers	3.8%		
Household dishwashers	5.0%		
Household washing machines and dryers	23.1%		
Electronic displays (monitors)	2.5%		
Flat panel display TVs	4.7%		
Desktop PC	2.8%	EU Eco-design Directives (Nos 617/2013, 42/1992)	**Energy Efficiency:** Specific requirements for different types of product, energy efficiency standards, programme, and functional requirements. **Consumer Awareness:** Energy efficiency labelling.
Central heating (boilers)	6.9%		
Printers (scanners, multifunctional, faxes)	6.6%	(EC report on voluntary eco-design scheme for Imaging Equipment)	**Consumer Awareness/Energy Efficiency:** Voluntary ENERGY STAR programme labelling relating to energy efficiency.

Product	POM 2018 (% of total weight)	Regulation(s)	Criteria (Contained in Regulation)
Microwaves	9.5%	Not addressed by regulation	Not applicable
Speakers	2.2%		
Video (including DVD players)	2.5%		
Light sources and separable control gears	Products that fall beyond top 12 threshold by weight POM, but also governed by eco-design regulation	The Eco-design for Energy-Related Products and Energy Information (Lighting Products) Regulations 2021	**Energy efficiency:** Specific energy efficiency requirements, functional requirements. **Product Lifespan:** Lumen maintenance factor and survival factor.
Domestic Ovens, hobs and range hoods		EU Eco-design Directives (Nos 66/2014, 2019/1781, 327/2011, 2019/1782, 107/2009, 548/2014, 1253/2014, 547/2012)	**Energy efficiency:** Specific energy efficiency requirements, airflow requirements, functional requirements.
Electric Motors			
Fans (Industrial fans driven by motors)			
Power Supplies			
Set-top boxes			
Transformers			
Ventilation Units			
Water pumps			
Heating and cooling appliances (air conditioners and comfort fans, Air heating products, cooling products, high temperature process chillers, and fan coil units)		EU Eco-design Directives (Nos 206/2012, 813/2013, 2016/2281)	**Energy efficiency:** Specific energy efficiency requirements, functional requirements **Presence of hazardous substances:** Requirements relating to NOx emissions per kWh of fuel.
Vacuum Cleaners		EU Eco-design Directive No 666/2013	**Energy efficiency:** Specific energy efficiency requirements **Product lifespan:** Hose durable so still useable after 40,000 oscillations under strain, operational motor lifetime shall be greater than or equal to 500 hours.
Welding Equipment		EU Eco-design Directive No 2019/1784	**Energy efficiency:** Specific energy efficiency requirements **Product lifespan:** Availability of spare parts, repair standards, repairability in terms of repair information and dismantlability with common tools. No guidance on warranty, durability, or design for repair and reuse.

Table 15: The criteria laid out in the eco-design regulation associated with the top 12 most common WEEE product categories in the UK by weight. This is further supplemented by other eco-design regulations beyond the top 12 threshold.

Several EEE product categories are within the scope of the Eco-design Regulation and could theoretically, i.e. notwithstanding the caveats in this study, be made subject of eco-modulation criteria that go beyond minimum eco-design requirements, if we consider refrigerators, freezers, household dishwashers, household washing machines and dryers, electronic displays (monitors), flat panel display TVs, desktop PCs, central heating equipment (boilers) and printers. The Eco-design Regulation stipulates a series of measures relevant to resource efficiency for these products, including the availability of specific spare parts, the ban of some hazardous substances like cadmium and halogenated flame retardants, repairability, and design for disassembly. Although the removability of batteries is not covered under separate eco-design legislation, provisions are made under Article 11 of the Batteries and Accumulators Regulations, outlining those appliances that incorporate batteries must be designed to ensure that the end-user can safely remove the battery, or where not possible, ensuring this can be done by a professional.[28]. Some of these criteria are also currently used in some of the other jurisdictions as the basis for eco-modulation, as shown by the examples of modulation criteria used in other countries next to the equivalent UK eco-design regulation in table 16.

Country	Product	Criteria	UK Eco-design Regulation 2021
France	Refrigerators and Freezers	Failure to provide technical documentation for electrically authorised repairers or Unavailability of essential spare parts for equipment use	Availability of spare parts, repair standards, material efficiency, repairability in terms of repair info and dismantlability with common tools. No guidance on warranty, durability, or design for repair and reuse.
Taiwan	Washing Machine	12 separate criteria on the inclusion of Hazardous Substances to obtain a lower EPR fee.	Presence of hazardous substances (displays only): Labelling indicating presence of Cadmium, ban on Halogenated Flame Retardants in enclosure and stand, use of other flame retardants must be marked.

Table 16: Example of alignment between French and Taiwan modulation criteria and UK eco-design criteria

However, the existing legislation does not provide guidance regarding the durability for all products (e.g. warranty period). For light sources, governed under the UK Eco-design for lighting products regulation 2021, stipulations dictate requirements relating to lumen maintenance and survival factor. Additionally, for vacuum cleaners, the 2013 EU Eco-design requirements impose specific conditions relating to the durability of the motor and hose. The remaining UK eco-design regulations largely address design considerations relating to recycled content, and design for repair and reuse. For example, the Eco-design Regulation does currently not include guidance for desktop PCs, boilers, and printers, for which the energy efficiency is already covered by previous Eco-design Directives. Whilst the conclusion might be to cover these three product categories through an eco-modulation scheme, for example by using specific criteria as exemplified in section 3 and excluding existing ones – in this case energy efficiency – this could further enhance policy fragmentation and increase administrative burden. It is therefore important to carefully weigh and balance whether the aim should be to complement the current list of measures under Eco-design rather than creating overlapping ones through the introduction of a competing system, thereby leading to further policy fragmentation.

When considering incentives or reward of eco-design efforts from producers, it is worth bearing in mind voluntary eco-labelling certifications have also become widely accepted standards for eco-designed products sold in the UK. Such eco-labels are seen with TCO Certified and EPEAT, certifications which cover a range of EEE products, however, these two are primarily focused on consumer technology.

28 Government Guidance Notes. Department for Business, Innovation and Skills. 2014. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/390443/bis-14-778-batteries-and-accumulators-placing-on-the-market-regulations-2008.pdf. [Last accessed: 14th April 2022]https://assets.publishing.service.gov.uk/go

The criteria contained within EPEAT and TCO are particularly comprehensive (Table 17), also addressing a range of measures extending beyond product eco-design which is typically seen in regulations. For example, these include the provision of product carbon footprint and LCA, organisational carbon footprint, use of conflict materials, labour standards in manufacture as well as specific measures surrounding the packaging design to better manage EOL impact (some of these have been omitted from Table 17 as they are out of scope of this project).

Voluntary standards also offer an insight into the types of criteria some producers are already conforming with in order to demonstrate the environmentally conscious design of their products, which could be seen as an existing and valid alternative to eco-modulation as represent: (i) market-based instruments, (ii) known to consumers, and (iii) internationally recognized, harmonized and standardised.

Product	Standard	Criteria contained in standard
Electronic displays (monitors)	**EPEAT** (IEEE Standard for Environmental and Social Responsibility Assessment of Computers and Displays[29]) **TCO** (TCO Certified Generation 9 for Displays[30]) (TCO Certified Generation 9 for all-in-one PCs[31]) (TCO Certified Generation 9 for Desktops[32])	**Hazardous substances:** • Conformity with RoHS • Restricted use: Cadmium, Mercury, Beryllium, Bromine and Chlorine in plastic components, Lead, Halogens, Non-halogenated substances, plasticisers • REACH: Avoidance or elimination of substances on Annex XIV, reduction of substances on SVHC list • Batteries: compliance with EU battery directive • Chemical assessment and selection • Evidence product does not contain substance thresholds set out in IEC62474 • Reduce fluorinated gas emissions (for flat panel display manufacturing and semi-conductor production) **Recycled Content:** • Product composed of post-consumer plastic or bio-based plastic content • Recyclability: • Identification of materials requiring separate treatment • Plastic parts must be separable and compatible with recycling **Product Lifespan:** • Service support and publicly available service information • Long life rechargeable battery (specific lifetime metrics) and battery replacement + information removable lithium-ion batteries • Spare parts (standards vary), TCO go into depth specifying critical replaceable components • Provision of warranty (standards vary) • Repairable with commonly used tools (aligning with ISO standards) • Energy efficiency: • Conformance with ENERGY STAR program requirements • Low power mode (specific standard set), energy efficiency for internal power supplies (standards set) **Carbon footprint:** • Provision of LCA and product carbon footprint • Developing carbon footprint in line with recognised, reputable standards **Noise:** • Requirements surrounding noise and rating based on performance
Desktop PCs		

29 IEEE Standard for Environmental and Social Responsibility Assessment of Computers and Displays, IEEE, EPEAT. https://ieeexplore.ieee.org/document/8320570. [Last accessed 30th March 2022]

30 TCO Certified Generation 9 for Displays, TCO. https://tcocertified.com/files/certification/tco-certified-generation-9-for-displays-edition-3.pdf . [Last accessed: 30th March 2022]

31 TCO Certified Generation 9 for all-in-one PCs, TCO. https://tcocertified.com/files/certification/tco-certified-generation-9-for-all-in-one-pcs-edition-3.pdf . [Last accessed: 30th March 2022]

32 TCO Certified Generation 9 for Desktop PCs, TCO. https://tcocertified.com/files/certification/tco-certified-generation-9-for-desktops-edition-3.pdf . [Last accessed: 30th March 2022]

Product	Standard	Criteria contained in standard
Flat panel display TVs	**EPEAT** (IEEE Standard for Environmental Assessment of Televisions[33]) **TCO** (TCO Certified Generation 9 for Displays)	**Hazardous substances:** • Conformity with RoHS • Restricted use: Cadmium, reporting on Mercury content, absence of mercury, Lead, Reducing BFR/CFR/PVC content of external plastic casings and circuit boards, Halogens, Non-halogenated substances, plasticisers • REACH: Reduction of substances under candidate list SVHC • Batteries: EU Battery Directive compliance • Reduce fluorinated gas emissions (for flat panel display manufacturing) **Recycled Content:** • Declaration of post-consumer recycled content and minimum requirement • Bio-based content declaration and minimum standards **Recyclability:** • Ease of disassembly • Single plastic type for larger parts, plastic type markings and notification of materials with special handling needs, metal/plastic blends separable, restriction of materials not compatible with reuse and recycling and rates aligning with EU WEEE Directive **Product Lifespan:** • Upgradeable firmware • Readily available service information • Early failure process, Provision of warranty (standards vary) • Spare parts (standards vary), TCO go into depth specifying critical replaceable components • Repairable with commonly used tools (aligning with ISO standards) **Energy efficiency:** • ENERGY STAR conformity or exceed this • Low power mode to certain standard, automatic sleep mode **Carbon footprint:** • Provision of LCA and product carbon footprint • Developing carbon footprint in line with recognised, reputable standards **Noise:** • Requirements surrounding noise and rating based on performance
Printers (scanners, multifunctional, faxes)	**EPEAT** (IEEE Standard for Environmental Assessment of Imaging Equipment[34])	**Hazardous substances:** • Conformity with RoHS • Restricted use: Cadmium, reporting on Mercury content, absence of mercury optional, Reducing BFR/CFR/PVC content of external plastic casings and circuit boards • REACH: Reduction of substances under candidate list SVHC • Batteries: Compliance with EU battery directive • Reduce fluorinated gas emissions (for flat panel display manufacturing) • Evidence product does not contain substance thresholds set out in IEC62474 **Recycled Content:** • Declaration of post-consumer recycled content and minimum requirement • Bio-based content declaration and minimum standards **Recyclability:** • Ease of disassembly • Recyclable plastics for certain weights, and restriction on materials not compatible with reuse and recycling • Notification of components with special handling needs • Minimum recyclability/reusability based on EU WEEE Directive

33 IEEE Standard for Environmental Assessment of Televisions, IEEE, EPEAT. https://ieeexplore.ieee.org/document/6331499 . [Last accessed: 30th March 2022}
34 IEEE Standard for Environmental Assessment of Imaging Equipment, IEEE, EPEAT. https://ieeexplore.ieee.org/document/6330972 . [Last accessed: 30th March 2022]

Product	Standard	Criteria contained in standard
		Product Lifespan: • Minimum product life: clear protocol surrounding product failure in terms of coverage and process • Product upgradability • Provision of spare parts **Energy efficiency:** • ENERGY STAR conformity • Minimum low-power mode standards **Carbon footprint:** • Provision of LCA or product carbon footprint
Video (incl. DVD, Projectors)	**TCO** (TCO Certified Generation 9 for Projectors[35])	**Hazardous substances:** • Restricted use: Aligns with EU RoHS, although mercury not permitted for use in lamps, limits or bans on certain halogens, limits on non-halogenated substances, bans or limits on plasticisers **Recycled Content:** • Declaration of post-consumer recycled content (classed based on content levels) **Recyclability:** • Coding of different types of plastics **Product Lifespan:** • Minimum product life: clear protocol surrounding product failure in terms of coverage and process • Product upgradability • Provision of spare parts **Energy efficiency:** • Alignment with EU directive with requirements relating to on, eco, standby and off modes. **Carbon footprint:** • Provision of product carbon footprint • Developing carbon footprint in line with recognised, reputable standards **Noise:** • Requirements surrounding noise and rating based on performance

Table 17: Example of voluntary criteria under EPEAT and TCO schemes for in-scope EEE

Stakeholder viewpoints

During the workshops, producers suggested that eco-modulation could offer potential synergy with eco-design requirements provided that it is harmonised with other international regulations. One of the main reasons identified was the link with the worldwide remit and perspective of design departments, especially in big organizations.

Additionally, during the workshops and consultations, the need for an eco-modulation system to be simple and involve minimal administrative burden was flagged. Simplicity is mainly connected with the desire of EU-wide harmonization of a limited number of criteria, taking into account the large variety of EEE products and their individual attributes and design key requirements.

Producers expressed concerns on the capability of (i) complying, (ii) ensuring limited administrative burden, or (iii) providing evidences to prove compliance with too complex criteria. Several producers reported how excessive complexity might be the reason to decide not to apply for eco-modulated fees, even when they have the right to do so.

35 TCO Certified Generation 9 for Projectors, TCO. https://tcocertified.com/files/certification/tco-certified-generation-9-for-projectors-edition-3.pdf [Last Accessed: 30th March 2022]

Most of the participants in the workshops also expressed the preference for a mechanism where self-declarations combined with ad-hoc audits are in place. This is in contrast with a system with independent, third party assessment resulting in higher costs for the system with negative impacts also on product prices.

While recognizing the goal of eco-modulation as a concept, producers agreed that eco-design regulations could be a better and more suited policy tool to fulfil such ambitions as the eco-modulation potential benefits are exploited only at the EOL stage.

3 Exploring potential metrics for eco-modulation in the UK

This section examines the case for eco-modulation in the UK by waste stream and product category, looking at three separate metrics: **weight, units and carbon footprint** of EEE.

Given the fact that POM is reported to UK authorities according to 14 product categories, the analysis at product level is based on data obtained from trade and production statistics according to the "apparent consumption" approach also adopted in the EU's **Common Methodology**[36].

EEE not only represents a highly complex group of products from a design and materials perspective, but also a vastly diverse one. However, irrespective of the metric used, it can be noted how a subset of products usually makes up most of the total POM, with the remaining product types occupying far smaller percentages individually: this is the case for all three metrics (weight/units/carbon footprint). Tackling the leading product types would result in a greater tangible impact on the quantities of waste generated and their associated lifecycle environmental impacts.

Subjecting the remaining products to eco-modulation will result in diminishing returns in terms of environmental benefits versus the cost of setting up a modulation scheme for them. The following sections (3.1 and 3.2) illustrate the product types which make up 80% and 90% respectively of the total weight and number of units of EEE product categories.

3.1 Metric 1 - Weight of EEE placed on the market (POM)

To analyse the potential prioritisation of products within the 14 categories used in UK, trade data from international statistics was used, which was based on the "apparent consumption" methodology and dataset[37]. The trend that emerged was that a series of products consistently occupied the largest proportions of total waste POM by weight, a fact that needs to be taken into consideration when designing a future eco-modulation scheme.

The main categories of EEE POM in the UK in 2018, based on weight, are: large household appliances (623 kt, 34% of total), cooling appliances containing refrigerants (349 kt, 19% of total), small household appliances (269 kt, 15% of total), lighting equipment (161 kt, 9% of total), IT and telecoms equipment (144 kt, 8% of total), consumer equipment (98 kt, 5% of total), and display equipment (73 kt, 4% of total). These categories represented 93% (1.7 million tonnes) of the total POM (1.8 million tonnes) in the UK for the year 2018.

17 types of products, together, correspond to more than 80% of the weight of EEE placed on the UK market. Adding 7 other products types, results in an amount exceeding 90% of the EEE placed on the market in the UK (Table 18).

36 European Commission. 2017 "Commission Implementing Regulation (EU) 2017/699". Accessed 31st March 2022. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R0699.
37 Statistics Netherlands. Accessed 30th March 2022. https://github.com/Statistics-Netherlands/ewaste

Equipment type	Tonnes POM, 2018 (kt)	% of total weight POM
Washing Machines	234.8	12.7%
Fridges	209.8	11.3%
Household Luminaires	142.8	7.7%
Small equipment for food preparation	106.3	5.7%
Large kitchen equipment	101.8	5.5%
Microwaves	96.9	5.2%
Other small household equipment	72.8	3.9%
Professional Cooling equipment	72.8	3.9%
Central Heating equipment	69.8	3.8%
Printers	66.6	3.6%
Household Heating & Ventilation	54.5	2.9%
Vacuum Cleaners	51.2	2.8%
Dish washers	50.8	2.7%
Flat Display Panel TVs	48.1	2.6%
Household Tools	43.9	2.4%
Music Instruments, Radio, Hi-Fi	42.4	2.3%
Freezers	38.9	2.1%
80% threshold		**81.2%**
Desktop PCs	28.1	1.5%
Small equipment for hot water preparation	27.9	1.5%
Video equipment and projectors	25.7	1.4%
Flat Display Panel Monitors	25.3	1.4%
Speakers	22	1.2%
Laptops & tablets	20.2	1.1%
Photovoltaic Panels	19.2	1.0%
90% threshold		**90.3%**

Table 18: Main types of products based on tonnes POM in 2018

The products identified based on this metric might be prioritised in an eco-modulation scheme, because material use and flows tend to correlate with the weight of the waste resulted from products. It is noteworthy, however, that two important categories of consumer products would not be accounted for when using weight as a metric – laptops and mobile phones. Separate consideration needs to be given to these two product categories due to their complexity and ubiquity.

Furthermore, it should be noted that, although wider environmental footprint of products tend to increase with their weight, the relation is not linear and impacts may vary substantially across products of similar weight, e.g. depending on the amount of electronic components in them. Indeed, products rich in complex electronics need consideration because of the size of their environmental footprint, in particular production and demand for resource intensive extraction.

3.2 Metric 2 - Units of EEE placed on the market

The main types of EEE POM in the UK in 2018, based on the number of units per product category, are: lighting equipment (394 million units, 34% of total), gas discharge lamps and LED light sources (279 million units, 24% of total), small household appliances (160 million units, 14% of total), IT and telecommunications equipment (109 million units, 9% of total), consumer equipment (69 million units, 6% of total), monitoring and control instruments (39 million units, 3% of total), and toys (35 million units, 3% of total). These categories represent 92.5% of the total number of units POM in the UK for the year 2018.

13 types of products together correspond to an 80% threshold of units POM. These products are listed in the table below. To reach a threshold of 90% of units POM, 8 other product types need to be taken into consideration.

Equipment type	Units POM, 2018 (M units)	% of total units POM
Household Luminaires	378.1	32.2%
LED Lamps	121.8	10.4%
Compact Fluorescent Lamps	109.6	9.3%
Other small household equipment	68.5	5.8%
Small IT equipment	52.7	4.5%
Equipment for food preparation	42.7	3.6%
Household Monitoring & Control equipment	35.6	3.0%
Professional Medical equipment	27.1	2.3%
Personal Care equipment	25.4	2.2%
Straight Tube Fluorescent Lamps	24.7	2.1%
Special Lamps	22.7	1.9%
Small Consumer Electronics	22.1	1.9%
Toys	21.1	1.8%
80% threshold		**81.2%**
Video and projectors	18.1	1.5%
Music Instruments, Radio, Hi-Fi	15.8	1.3%
Professional Luminaires	15.3	1.3%
Small equipment for hot water preparation	14.2	1.2%
Game Consoles	13.5	1.2%
Household Tools	12.1	1.0%
Printers	11.5	1.0%
Laptops	11.2	1.0%
90% threshold		**90.3%**

Table 19: Main products based on units POM in 2018

3.3 Metric 3 - Carbon footprint of EEE

This measure estimates the average carbon footprint of each EEE product category. This reflects greenhouse gas (GHG) emissions throughout the product lifecycle, accounting for those associated with manufacturing, use, and disposal. In the research process, the main barrier to assessing the feasibility of carbon footprint as a metric is the lack of comprehensive and publicly available data, particularly in a UK context. The GHG emissions of a product reflected in the use-phase can be different on an international basis as a result of different carbon intensities of electricity grids. Although some data is available for certain products, it lacks the breadth and consistency necessary to conduct an accurate, representative analysis. Research involved conducting web-based searches, consulting publicly available documentation, academic journals and LCA databases.

From a theoretical perspective, prioritising products for eco-modulation on the basis of this metric might have limited potential for a number of reasons:

- A carbon-intensive process in the production or in the use of the products might not necessarily generate lesser quantities of waste than a less carbon-intensive one (assuming waste reduction is one of the main objectives of eco-modulation).
- The carbon footprint of a given product only reflects its climate impact, as opposed to other environmental pressures it generates related to resource depletion, pollution, waste, biodiversity impacts, and others.
- The carbon footprint is also dictated by the composition of the materials used to manufacture the product in question, in addition to the means through which they are manufactured (BSI 2014).

If the purpose of eco-modulation is to reward eco-design efforts that are leading to less waste generated, or less hazardous waste to treat, or even products lasting longer, there is a limited link with using product carbon footprint. Studies conducted in the context of Energy Efficiency Labelling, inter alia co-ordinated by the Joint Research Centre, have demonstrated the trade-off between replacing energy inefficient products by energy efficient models (thus resulting in less greenhouse gas emissions and carbon footprint at the expense of more WEEE) and keeping energy inefficient products in longer usage, thus saving on the extraction of materials at the expense of the carbon footprint of the products[38]. This could also be argued to apply more broadly, in the context of other environmental pressures associated with EEE throughout its lifecycle. There will be points, that will vary depending on the product, where replacing an old inefficient model with a new efficient one may be justified even when considering the additional environmental impacts of producing a new product. However, as the grid decarbonises and given the major energy efficiency advances already realised for many products, this will become less and less relevant.

Furthermore, for many of the products in question, the use-phase of the product represents a larger portion of the lifetime emissions than those associated with production and disposal, which reduces the importance of materials and circular economy in the overall environmental impact of the EEE. The risk of using carbon footprint in prioritizing products for eco-modulation measures is that some products are carbon-intensive but not particularly resource-intensive, or vice versa. Here again, grid decarbonization and energy efficiency improvements will continue decreasing the share of the use-phase in the overall lifetime emissions of products.

However, due to a lack of widely available data on product-level carbon impact it was so far not possible to develop an in-depth, data-driven, evaluation of the ranking of products having higher potential for eco-modulation based on carbon footprints.

38 European Commission. "Sustainable Product Policy". Accessed 31 March 2022. https://joint-research-centre.ec.europa.eu/scientific-activities-z/sustainable-product-policy_en.

Stakeholder viewpoints

During the conducted workshops and consultations, stakeholders highlighted several important aspects regarding the selection and prioritization of products subject to eco-modulation criteria:

- Obligations and eco-modulation criteria should be fair across all types of WEEE and should not single out a limited number of products. Such an example is products/businesses placing seasonal products in large quantities on the market (e.g., Christmas tree lights), many of which have an exceptionally low collection rate.
- The system should work in the context of the existing WEEE system, which is well established, known and accepted by stakeholders. Irrespective of the metric used and selected, some of the stakeholders perceived the eco-modulation system as an added cost to do business in the UK.

The use of carbon footprint was not considered as a suitable metric as no simple and commonly agreed standards applicable across all products was identified. Although producers reported using carbon footprint and LCA analysis as part of their internal eco-design processes, alongside efforts to reduce the overall carbon footprint of companies and products, the complexity of standardizing this process across Industry was reported as being too high and costly. The cost of conducting such a study to identify a single product's carbon footprint can exceed £80,000. This cost could (i) be too high for SMEs and (ii) impact on the final product price if products are sold in small numbers.

3.4 Definition of metric to be adopted for prioritising products

There are several ways in which the environmental impacts of EEE could be tackled throughout its lifecycle, dependent on the core objective of the eco-modulation measures and the prioritization of intervention. Any metric that is selected will require making trade-offs between the type of environmental pressures (resource consumption versus presence of hazardous chemicals versus use of critical or scares metals versus market penetration) that can be addressed. This can be exemplified via the case of GHG emissions from EEE throughout its lifecycle. As the desired effect of introducing eco-modulation measures largely focuses on fostering waste prevention and driving the shift towards a circular economy, selecting products based on total weight is seen like the most relevant metric, at this stage. As highlighted by OECD, when assessing the broader environmental pressures associated with a given material flow, greater volumes or weights of material are typically associated with greater environmental impact[39]. For this reason, prioritisation based on weight might be more relevant. It is also the metric for which the data is easiest to collate.

Regarding utilising the number of units POM as a metric, this arguably offers limited potential on the basis that a higher number of units of a product does not necessarily equate to greater resource consumption and waste. For example, although LED lamps represent 10% of total units POM, they account for just 0.4% of weight POM, whereas washing machines, which account for just 0.3% of units POM, account for 13% of total weight POM. Units as a metric is less effective a proxy for environmental impact than weight, particularly when the goal is waste prevention. Despite the factual basis of this conclusion, during the workshop conducted, participants also indicated other potential metrics to be evaluated in order to prioritise products to be subject to eco-modulation; options included also the complexity of recycling process.

39 OECD. 2008. "MEASURING MATERIAL FLOWS AND RESOURCE PRODUCTIVITY (Vol 1)". The OECD Guide. Paris, France: OECD.

Stakeholder viewpoints

Regarding the prioritisation of products, producers expressed a more holistic perspective. The intended outcome should be aligned with the focus, whether it is (i) avoiding damage to the environment, (ii) improving recyclability, (iii) encouraging ease of repair, (iv) reducing cost at end of life or (v) reducing products being sent to landfill/ incineration.

Consideration needs to be given to the extent by which individual EEE types can technologically be improved. For example, certain products such as refrigerators, have been subject to significant improvement over the last few decades, especially regarding energy efficiency or phasing out of hazardous substances such as Ozone Depleting Substances.

One suggested starting point was to look at key products from each category of EEE, ensuring a fair distribution of impacts across the whole sector is assured.

4 Mechanisms for implementation

The analysis conducted in the previous section allowed for the identification of the metric most appropriate to identify products in scope for eco-modulation, paving the way for assessing the implementation of eco-modulation system. This section utilises quantitative data to outline and examine separate charging mechanisms for eco-modulated fees in the UK.

In the current UK system every year, through their membership of a Producer Compliance Scheme, producers finance the management of a quantity of WEEE which is proportional to product share that the producer placed on the market, with the total cost for the activities of the compliance scheme (£) being allocated among the producers based on the compliance scheme's rules. In some cases, producers might have individual take-back operations that will contribute to the achievement of such targets in a more cost-effective way (e.g. via individual take-back in-store or via retailers). This means that in some cases different producers might have a different economic impact (£/t) when fulfilling their obligations (i.e. tonnage to be collected) for the same type of product.

The reward for products fulfilling eco-modulation criteria could be applied following different routes. If one of these producers is "green" (while the others are not) there are multiple possible methodologies to modulate fees in order to give the "green" producer an advantage. Irrespective of the mechanism adopted, the recovery of total end-of-life cost (£/year) should be paramount to ensure financial stability for the system; two options are possible, from a theoretical standpoint:

- reduce the fee the producer pays to the compliance scheme or recycling cost and increase the contributions of other producers;
- do not change the fee the producer pays to the compliance scheme or for end-of-life and increase the contributions for other producers.

With the first option the system will trigger a reduction in responsibility of fee paid by compliant producers transferred to non-compliant producers (as one producer is paying less and others are paying more); with the second option fees will increase for producers placing on the market "non-green" products, overall seeing no producer pay less than before. These would therefore ensure that total recovered fees are ever equal to, or greater than, the total end-of-life treatment cost for each product waste catergory.

In order to ensure that eco-modulation continues to recover the total end-of-life cost of each products waste category, there are three potential fee mechanisms that could be utilised: (i) adoption of (modultated) fees per product placed on the market, (ii) reduction of the POM figures, and (iii) implementation of Deposit-Return-System (DRS) approaches. The study of a DRS system was requested during the report's formation, however, such a system does not function on the same principles as a POM fee or marketshare system, as it aims to increase collection rather than obtain EPR fees.

4.1 POM fees

The POM fees approach is a system in which the EPR fee producers pay to their PRO or compliance scheme is modulated through the implementation of a malus (increased fee) or bonus (reduced fee). This is effectively the approach adopted in France, with the fulfilment of criteria causing producers to ever be charged a lower fee, whilst in other cases a failure to comply with criteria can cause the issuing of a higher fee. Without the issuing of such fees inline with a change in the product's recycling cost, due to criteria fulfilment or non-fulfilment as shown in section 5.1, the issuing of the change in fee level could cause the recovery of EPR fees to be greater or less than the total end-of-life cost.

A more broadly balancing system could be developed through the issuing of two separate prices, such as seen in Taiwan, in which a higher (generic) EPR fee level is given to products that do not fulfil criteria, whilst a reduced EPR fee level is given to criteria compliant products. This allows for the funding gap caused by the reduced fees to be added to the higher fee paid by non-compliant producers, this will ensure the total EPR fees recovered equals the total end-of-life cost across the product waste category. Such a system relies on annual fee adjustments to ensure the overall increase in EPR fees aligns with the overall reduction in EPR fees from criteria compliant producers. Whilst the difference in fee level must be aligned with individual PROs to ensure there is not a misalignment between the level of funding received by different recycling schemes. Without this, certain schemes might coincidently have a large proportion of producers that are non-compliant and in return would receive high levels of funding, whilst schemes with a larger proportion of compliant sellers would receive low levels of funding. Although modulated POM fees aims to create incentive for producers to design more environmentally friendly products, participants engaged in the eco-modulation workshop indicated that even where impacted by a malus, would not be a key driver in influencing the design of their products.

A POM fee system is not in full alignment with the UK's current EPR system, in which producers are responsible for the proportion of units that they placed on the market during the end-of-life process. Producers are given a choice of how to fulfil this responsibility, either to offset their obligation through their own collections, to rely entirely on collections undertaken by their compliance scheme or a combination of both. For this system to work in the UK's EPR regime, authorities would need to set product-specific EPR fees to allow for individual product fee modulation, rather than having market share responsibility.

4.2 Reduction (or increase) of product market share

A reduction/increase of product market share approach requires producers, either directly or through their membership of a PRO or compliance scheme whose products do not align with modulation criteria and are therefore deemed to have a greater environmental impact, are made financially responsible for the take-back and recycling of a larger amount of WEEE. This sees their costs for end-of-life treatment to exceed the costs that would normally be associated with their market share. Conversely, producers whose products are deemed to have a lesser environmental impact will be paying the costs associated with a smaller market share.

To ensure the total end-of-life cost recovery, such a system can be "self-balancing" as seen in Italy based on POM weight. The total percentage of POM responsibility reduction from producers that fulfil criteria, is then divided between non-compliant producers. As a result, the total increased and decreased POM responsibility equals the total end-of-life costs that would have otherwise been recovered. This was particularly emphasised by an Italian PRO, who supported the system's ability to recover all end-of-life costs, ensuring the financial stability of the wider recycling system. Reduced POM was the preferred implementation mechanism with those that attended the eco-modulation workshop, although producers suggested this would not be a significant factor on whether they would change the design of their products.

The modulation of costs through market share adjustment already aligns with the UK's current EPR system, in which producers are responsible for the total collection and treatment of equal products to what they placed on the market. As a result, the total units of POM responsibility can be integrated within the UK's current EPR system, in which market responsibility can be divided between modulation criteria compliant and non-compliant producers, allowing for the total product end-of-life to be recovered.

It is important to note that the specificities of the UK system need to be considered, such as with eco-modulation being applied at product category level. If products, rather than categories of products, are eco-modulated, the situation could occur in which a producer making a certain product, such as microwaves, could obtain a reduced market share obligation, whilst producers making other products in the same category that are not subject to eco-modulation criteria, such as toasters, are unable to benefit from reduced responsibility. Whilst such producers would not have the chance to reduce their obligation, they could also see an increase in their obligation in response to a signficant number of microwave producers having applied the criteria in their category. To avoid such a situation, the application of the reduction/increase coefficient – which is described in detail in section 5.3 – should always be applied at product level, considering the share of the selected products in the waste stream. This way the correction of POM only applies to producers placing on the market products covered by the measure.

4.3 Deposit Return Scheme (DRS)

While technically speaking a Deposit Return Scheme (DRS) is mainly aimed at increasing the collection rate and incentivising consumers, it could be also potentially considered as an alternative to reward products meeting certain eco-design criteria. A DRS approach would implement a fee charged at the moment of EEE purchase, which would be returned once the product is brought back to a designated collection point. The OECD defines the deposit as "a system that consists of setting up an overcharge in addition to the base price of potentially polluting products. When pollution is avoided by returning the product or its residues, the overload initially paid for is returned." Historically, deposit systems have been applied to reusable packaging (mainly glass bottles, gas bottles), and have gradually extended to recyclable packaging (plastics, aluminium). These systems, widely used in the 1960s and 1980s for consumables, have been phased out.

The question arises as to the relevance of a system initially developed for packaging, and potentially applied to waste streams like EEE having different intrinsic economic value and particularly variable depending on the types of materials and substances used.

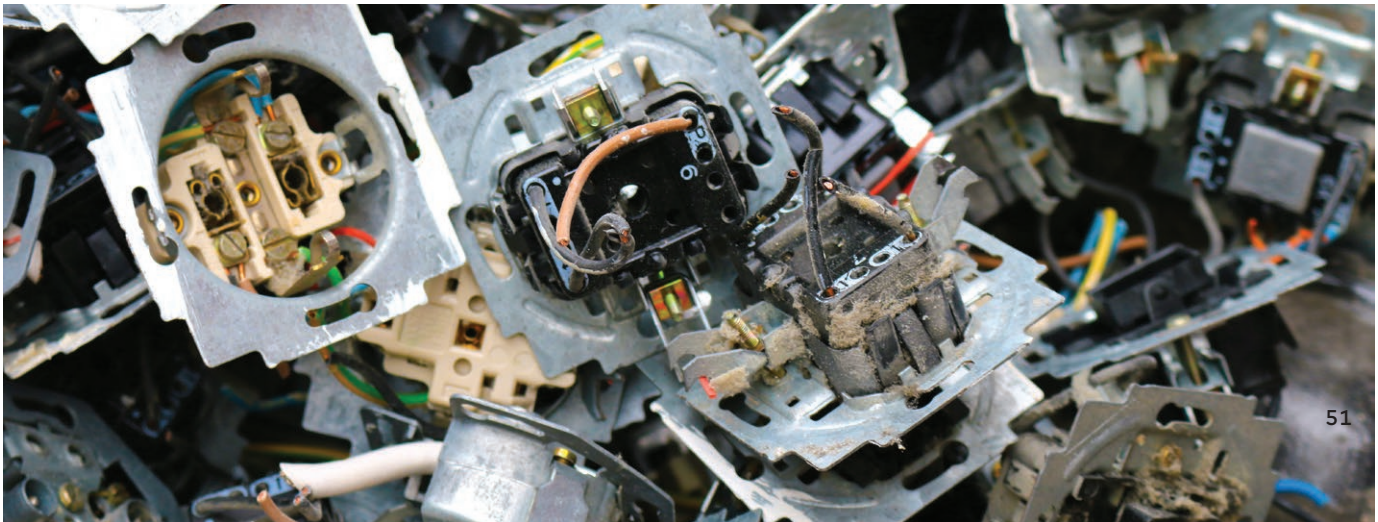
The use of DRS for EEE has previously been investigated regarding the return of old mobile phones. In April 2019, the French government in its roadmap on the circular economy (FREC) proposed a measure (FREC Measure 31) to develop a financial mechanism to encourage the return of old mobile phones for recycling or reuse. DRS are sometimes cumbersome and expensive to implement, for more complex products. In the case of WEEE, past experiences in South Korea from 1992 to 2003 (TV sets, washing machines, refrigerators, air conditioners) and Austria from 1992 to 2005 (mercury-containing lamps, refrigeration equipment) have subsequently been abandoned. The reasons behind these systems' failure was their high administrative costs, the creation of a financial surplus due to the low rate of deposits claimed (<25% in Austria and <10% in Korea) considered unfair to consumers, the proven lack of impact on collection rates, and insufficient deposit amounts to create a real incentive (initially set at €70 in Austria, the deposit was gradually reduced to €7 to avoid cash accumulation within the deposit system, before being completely abandoned). High administrative costs could be further impacted by the introduction of modulation for producers and compliance schemes, with the further complexity caused by modulated fees.

Furthermore, implementation of DRS could also create a risk of "waste tourism", and therefore create an additional cost of enforcement, as a return fee attracts external waste to enter the country to obtain return fees. This has been seen with the deposit system on beverage packaging in Denmark, which has rapidly attracted flows of packaging from abroad for which the deposit had not been paid, resulting in the establishment of an expensive and restrictive control system (distribution of stamps with invisible ink, installation of machines with optical readers at collection points, etc.). In addition, the Danish press reported the emergence of a foreign population of informal waste collectors, attracted by this new source of income. DRS might also have a limited effect when it comes to targeting the deposits of old worthless appliances that have been stored for years in users' drawers.

However, due to the limited data and experience regarding DRS system for EEE in general and some evidence from countries that abandoned such system for EEE, there is currently little room to imagine the implementation of such mechanism also considering the WEEE system in UK is based on the allocation of responsibilities to producers and does not foresee payment of upfront fees.

Furthermore, it has to be considered that application of DRS mechanism to EEE would mean a potentially high amount of funds stockpiled – given the number of different appliances held by consumers in UK and the need to set the amount of the deposit high enough to trigger the action of the consumer returning the product; in addition, there is a risk that for appliances with a long-lifetime, the amount of deposit decided today might not necessarily reflect the cost of recycling appliances in the future.

All in all it appears that a DRS system is not fit for purpose in the case of reward of eco-design effort from producers but, if a DRS approach was desirable, a more detail analysis of DRS for EEE products and the mechanism for eco-modulation would need to be carried out.



5 Economic potential for eco-modulation

In this chapter simulations were carried out to estimate the potential economic benefits of eco-designed products and the potential to justify eco-modulation considering:

- The potential savings in the treatment costs due to less hazardous and easier to dismantle products;
- The potential savings connected with lower generation of waste linked to products more durable and repairable;

Those savings were used to calculate the potential reduction of end-of-life fees or the equivalent reduction of POM obligations for producers claiming the eco-modulation benefits.

5.1 Eco-modulation potential linked to treatment cost

The treatment cost approach, based on modelling of UK data, describes the potential impact of eco-designed products on reducing end-of-life treatment costs and therefore creating the financial buffer to justify a reduction of the fees for those products compared to others. Theoretically, there are two dimensions that require fulfilment in order for eco-modulation of fees to have an impact on producer design choices. Firstly, fulfilment of given criteria relating to the eco-design of a product must yield a notable impact on treatment costs relative to a non-eco-designed product. Secondly, the magnitude of this gap needs to be considered in the context of the total product price and what proportion of this can be occupied by the fee. In essence, the fee needs to equate to enough of the total price, within which, the benefit of designing in an eco-friendlier manner creates a large enough financial incentive. To perform this assessment, UK data on the main products based on tonnes of POM (as discussed in section 4.1) was gathered through data requests to compliance schemes in the UK (in total five of them) as well as considering data available in international databases.

Figure 2 below provides insights on the potential impact of eco-modulation on manufacturers' behaviour. The horizontal axis (X) represents the impact of net treatment costs on average product price, while the vertical axis (Y) represents the share of tonnes placed on the UK market. It was expected that the higher the impact of net treatment costs on product price, the higher the potential impact of eco-modulation on industry behaviour. Ideally, the products with a highest potential for eco-modulation would be located on the top right side of the figure. Considering a threshold of 1% (impact of net treatment costs on product price), for example, only fridges and freezers would be good candidates for eco-modulation regulation. If there is an additional threshold of at least 20% of the share of POM, only fridges would be modulated.

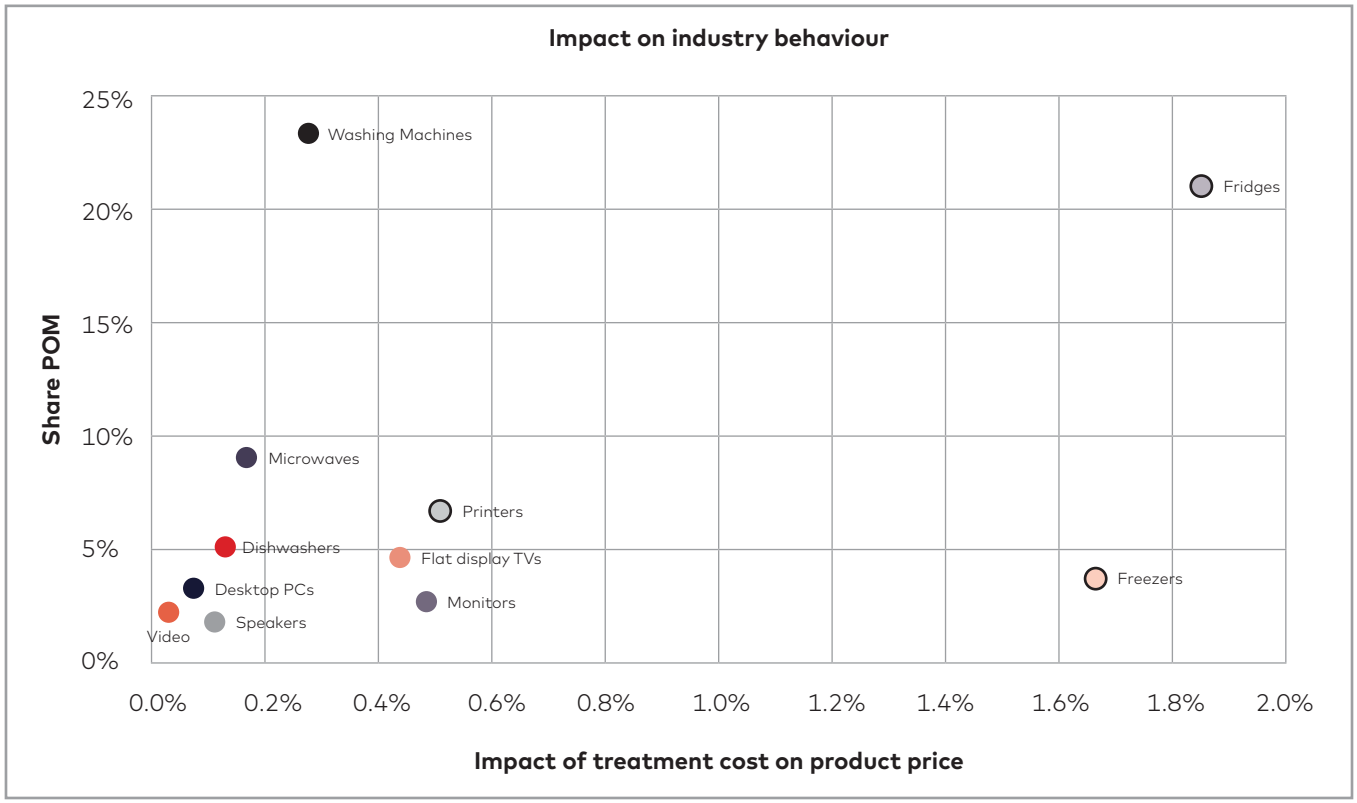


Figure 2: Impact of eco-modulation on industry behaviour

The potential impact of changes in the treatment costs charged to producers was also estimated to assess the room to trigger eco-design changes from producers or have greater impact on product price; Figure 3 below summarises the findings: the percentages indicate the incidence of maximum cost gap (maximum cost – minimum cost) on the average product price. Fridges and freezers have the highest potential for eco-modulation, despite the relevance on product price remains limited and, for majority of products considered, totally negligible.

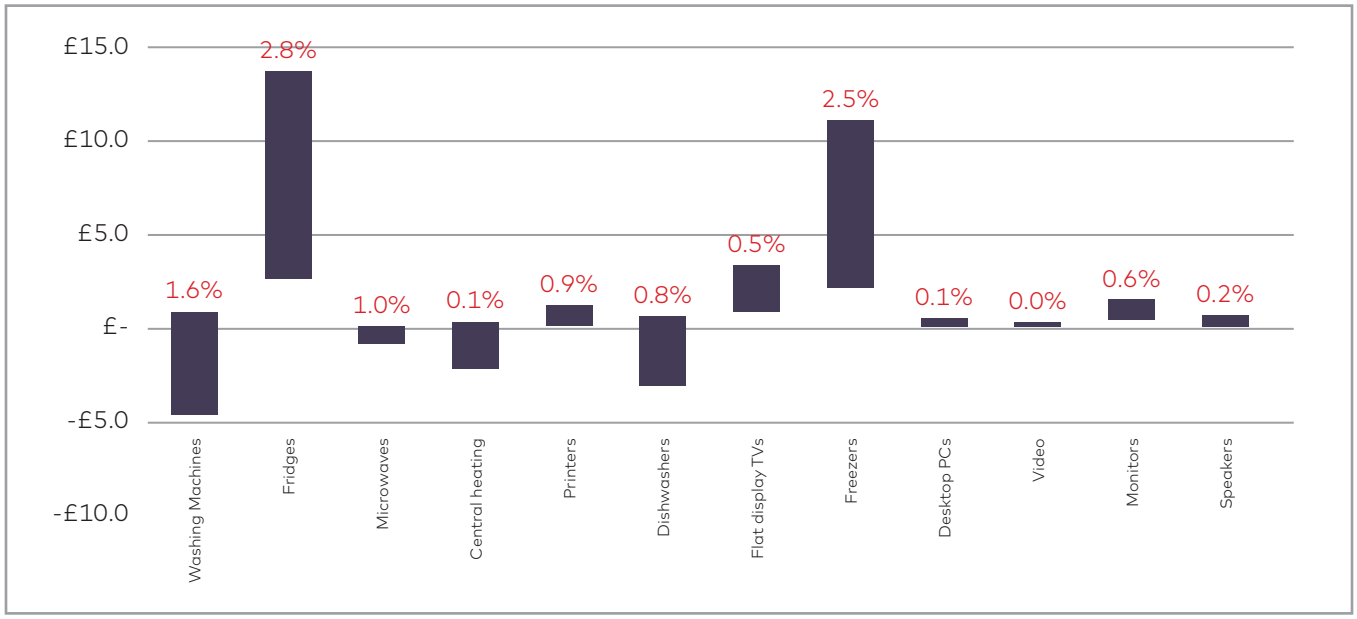


Figure 3: Gap between 30% reduction and 30% increase in recycling costs (PROs) per unit. Numbers in red represent the incidence of gap on product price

To assess the impact of treatment costs for the main products placed on UK market and thus evaluate the share of those costs that could be potentially impacted by eco-modulation the average treatment cost reported by different PROs in the UK was considered. Table 20 summarises the economic space calculated for each product. Negative values represent a profit from recycling. According to this methodology, the cost associated with recycling of video equipment, monitors, flat display TVs, and printers has the highest economic impact. This means that eco-modulation on those products has on the one hand, the potential to influence producers' eco-design choices, but, on the other hand, leverage to balance bonus/malus to make sure the total value of financial contribution of producers covers the financial needs for collection and treatment of those products.

Product	Absolute net treatment costs, £ in millions
Washing machines & Dryers	-£3.4
Refrigerators	£27.3
Microwaves	-£1.4
Printers	-£1.0
Dishwashers	£6.7
Flat display TVs	-£0.7
Freezers	£11.3
Desktop PCs	£5.1
Video	£2.8
Monitors	£2.6
Speakers	£5.9

Table 20: Economic incentive space based on estimated absolute treatment costs for the UK market (£ in millions)

Furthermore, it was assessed if eco-designed products could lead to a reduction in net treatment costs. Simulations have been done considering the technical treatment costs reported by EERA (European Electronics Recyclers Association) members and assuming that eco-designed products could lead to:

- reduction of de-pollution costs (-50% due to easier dismantling) and
- reduction of disposal of hazardous fractions from de-pollution activities (-100%, assuming a best-case scenario involving the complete phase-out of hazardous substances, although this is challenging to achieve for specific products/fractions due to intrinsic material composition and chemical properties of some substances).

The higher the variation in costs, the bigger the space to justify a fee modulation (reduction) for those products able to deliver recycling cost benefits.

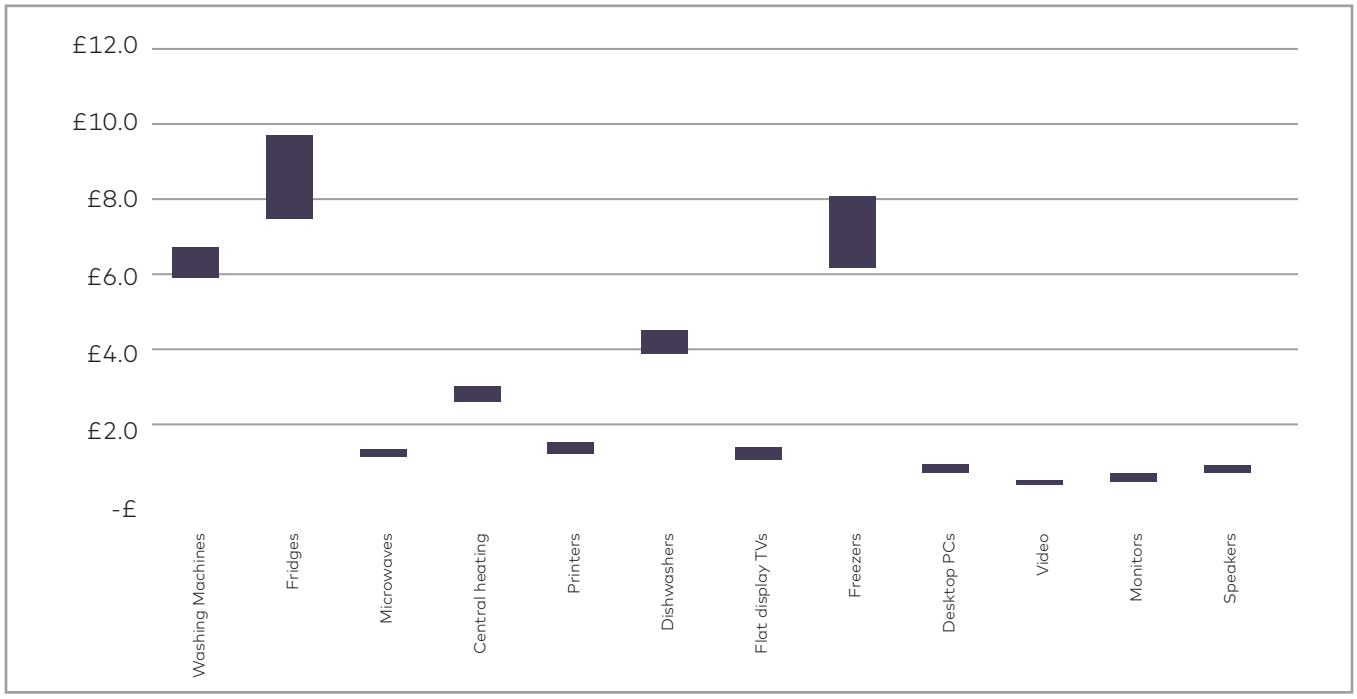


Figure 4: Gap between average recycling costs and "green" products scenario (EERA) per unit

Figure 4 above summarises the findings and indicates that fridges and freezers have the highest potential for eco-modulation, but for most of the products the potential is limited in £/unit. Furthermore, the potential exploitation of the reduction of recycling cost benefits should also consider the costs associated with separation of products (if required): as example fridges containing CFC/HCFC are representing a still relevant share of the waste generated with higher treatment costs compared to those having HC as refrigerant and blowing agent in the PU foam; despite newer fridges – provided that they are treated in compliance with applicable quality standards – might have lower recycling costs, recycling operations are currently not sorting and invoicing to PROs/Producers separately for the two different streams.

5.2 Eco-modulation potential linked to life extension

In order to understand the theoretical impact of life extension of products, for example through more durable products, increased repair or availability of spare parts, and the theoretical benefits on waste reduction that would justify lower fees for products meeting those criteria, various scenarios were modelled. The modelling provided insights into whether the introduction of products with extended lifetime would lead to lower waste generated and what are the potential savings connected with the reduction of waste generated that could justify lower fees for those eco-designed products. The data that informs this analysis was derived from existing POM and Weibull parameters to estimate the waste generated derived from the WEEE Generated Methodology adopted by the European Commission[40]. It is acknowledged that research has been conducted around the phenomenon that some products will be used until they break whilst other products will be replaced for other reasons, for example cosmetics, efficiency, or functionality, and that the extension of the life of a product depends a great deal on the regulatory framework, i.e., on the extent to which circular business models are being adopted.

40 European Commission. 2017. "COMMISSION IMPLEMENTING REGULATION (EU) 2017/699". Annex II.

The following simplifying assumptions were made for the modelling:

- Products with an extended life have an average lifespan 50% longer than conventional, business-as-usual products.
- Products with an extended lifetime were introduced on the market in 2010, with a 20% market share that stays constant over the years. Simulating such an early market entry is due to the delayed effects caused by the relatively long lifetime of most electrical and electronic appliances. Sufficient time is needed for changes in POM to have a notable effect of WEEE Generated. If "green" products, with an extended lifetime, were introduced on the market today, the impact on waste generation would only be visible after 5-20 years depending on the type of product.
- Sales after 2018 remain at a constant level, both for baseline products and products with a 50% life extension.
- The stock remains constant over time, meaning that there is no increase in the installation rate (e.g., number of fridges per household). As a longer lifespan with the same POM values would lead to an increase of stock, POM is here corrected (downwards) to ensure that the stock stays constant.

This approach is illustrated below for the case of washing machines: figure 5 below shows the lifetime profiles for baseline products and products with an extended lifetime; it shows the impact on WEEE generated (WG) for the period 2010-2030. It can be observed that the arrival on the market of extended lifetime products in 2010 (with a 20% market share) does not have an immediate impact on the quantities of waste produced. The impact only becomes really significant 5-6 years after the product is put on the market. Overall, the reduction in waste over the period 2020-2030 is forecast at 12%.

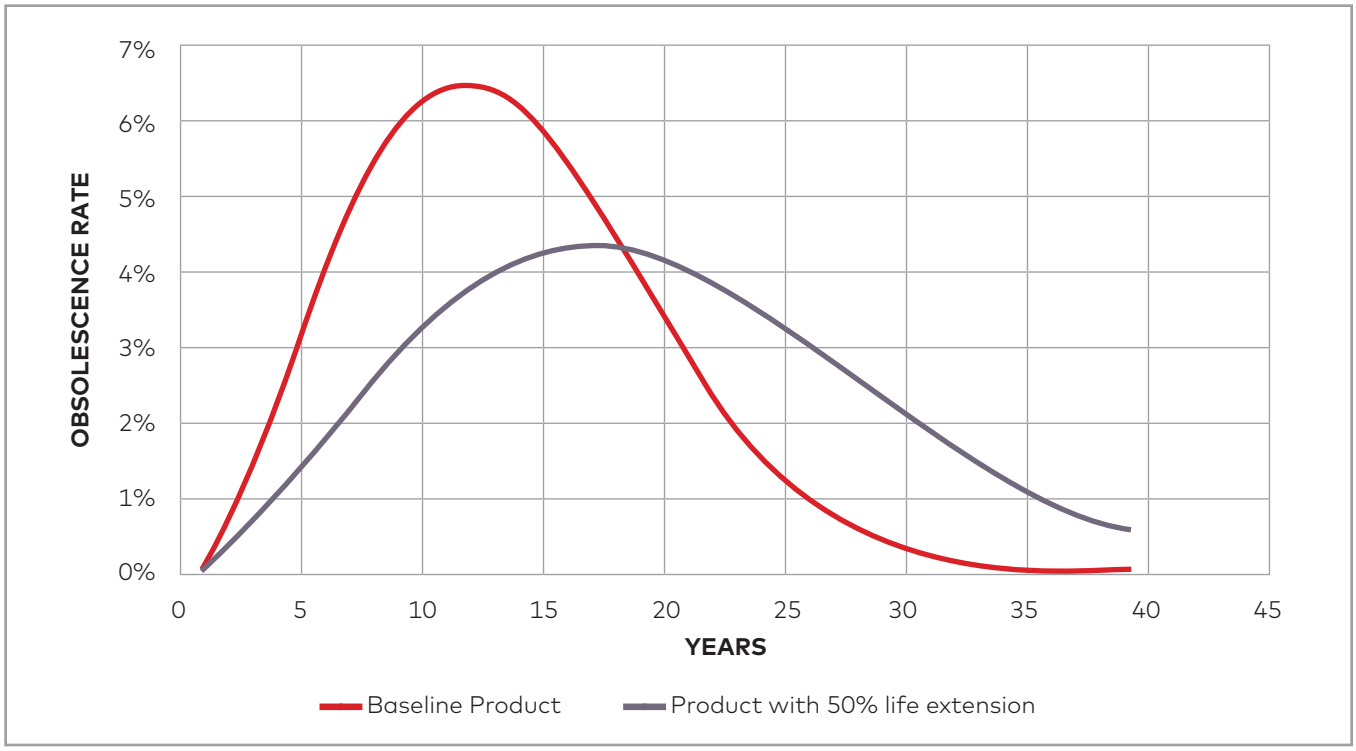


Figure 5: Weibull function for washing machines (baseline vs longer lifespan)

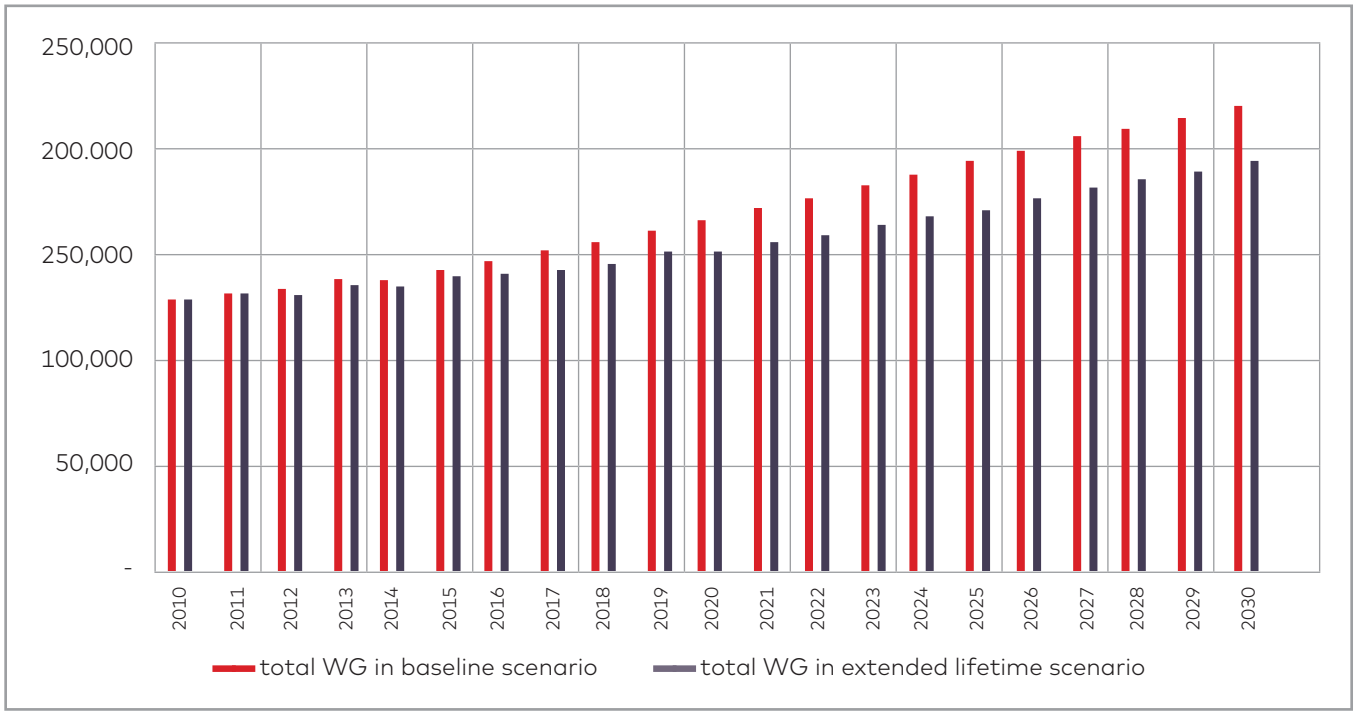


Figure 6: Reduction of waste generated linked to 20% of products having 50% longer lifespan, example for washing machines

Results for all equipment categories are given in Table 21. Impacts on WG (in tons and percent) and on treatment costs (per ton and in absolute terms, for the UK) were calculated, making it possible to calculate the potential savings (due to reduced quantities of waste) per ton of "green" products (with extended lifetime) put on the market.

The impact on WG varies among products, which has to do with the evolution of POM up until 2018 (increasing, constant or decreasing) as well as whether products are rather long- or short-lived. The product type with the highest decrease in WG, flat display TVs, has witnessed a drastic increase in POM between 2010 and 2018 (+500%) and have a baseline average lifetime of 10.4 years. In contrast, freezers, for which impact on WG is the smallest, have witnessed a modest increase in POM (+26% over 2010-2018) and have a baseline average lifetime of 21.5 years. In conclusion, impacts of lifetime extensions are highest for products with a rapidly increasing market share and relatively shorter lifetimes, and lowest for products with stable POM and long-baseline lifetimes.

Equipment	Impact on WG 2020-2030		Impact on treatment costs		Total POM (2020-2030)	Savings per ton & unit of "greener" product POM	
	in kilotons	in percent	Treatment costs, in £/ton	Total savings over 10 years, in £/million	in kilotons	in £/t POM of "greener" products	in £/unit POM of "greener" products
Central Heating	-67.4	-11%	-15	0.98	739.7	7	0.04
Dish washers	-44.7	-8%	-15	0.65	542.6	6	0.05
Washing Machines	-234.8	-11%	-15	3.43	2,725.1	6	0.08
Dryers	-36.9	-8%	-15	0.54	149.8	18	0.13
Fridges	-176.8	-9%	130	-23.00	2,353.0	-49	-0.55
Freezers	-16.2	-3%	130	-2.10	434.3	-24	-0.23
Air Conditioners	-15.7	-10%	130	-2.04	150.3	-68	-0.49
Microwaves	-56.0	-6%	101	-5.63	1,077.7	-26	-0.06
Vacuum Cleaners	-53.0	-10%	101	-5.33	591.5	-45	-0.05
Desktop PCs	-37.9	-11%	101	-3.81	248.1	-77	-0.05
Laptops (incl. tablets)	-25.4	-11%	235	-5.96	219.7	-136	-0.05
Printers	-34.9	-5%	101	-3.51	693.5	-25	-0.03
Mobile Phones	-3.2	-11%	101	-0.32	27.0	-59	0.00
Flat Display Panel Monitors	-10.6	-4%	235	-2.49	257.7	-48	-0.04
Video	-29.2	-10%	101	-2.94	288.2	-51	-0.01
Speakers	-22.2	-10%	101	-2.24	240.4	-47	-0.03
Flat Display Panel TVs	-73.5	-12%	235	-17.24	469.6	-184	-0.33
Total	**-938.4**			**-71.01**	**11,208.4**	**-32**	**-0.06**

Table 21: Impact of lifetime extension on WEEE generated and associated savings due to reduction of treatment costs

In terms of relative savings (due to diminished waste amounts), it was interesting to observe that highest savings in relative terms would be enabled for flat display TVs and laptops, due to relatively high impact on WG and relatively high treatment costs. On the other hand, for LHA (Large Household Appliances) which are characterized by negative treatment costs – i.e. revenues from recyclates exceed treatment costs – an extension in lifetimes would result in decreased revenues for waste management operators. Overall, relative savings would amount to £32 per ton of "green" product put on the market, of £76 per ton of waste generated (£71 million / 940 kt). It should be noted that the calculations below do not consider the cost of collection which might add up to 100-150 £/t of product (depending on product types) so the values might be considered like a lower bound.

While the potential waste generated reduction is significant, as the table above shows, the potential room to eco-modulate the fees for different products is varying but is also limited in absolute terms (few GBP per product, in the best-case scenarios). The main assumptions anyway potentially impacting the full exploitation of such potential benefits are the following:

- The cost paid made by producers to extend the lifetime of products, through design and manufacturing of more durable electronics, or through availability of spare parts to extend products' lifecycle, might exceed by far the potential savings obtained from the reduction of end-of-life costs. Recent statistics[41] shows that for Home Appliance products the share of repair costs linked to storage of spare parts vary between 29% (fridges) to 44% (small appliances) of the total.
- Even though products could be designed to last longer, the role that consumers play in the discard of appliances cannot be controlled. Various studies conducted in the last decade, highlighted how a relevant share of products are discarded not because of technical failure, but because consumers decide to replace them.

5.3 Implementation of eco-modulation through POM reduction coefficients

As discussed in section 4.2, while the reduction of fees appears a straightforward mechanism in those countries where producers pay upfront fees for each appliance placed on the market, the definition of coefficient to reduce the collection and recycling obligations appears to be a more viable mechanism in UK. The mechanism is simple: a reduction coefficient is applied to POM for "green" products, while an increase coefficient is applied to POM for "baseline" products. This ensures that the total revenues from EPR fees remain constant, thus safeguarding the ability to cover for real, current, collection and treatment costs and from a producer perspective, overall, the system is cost reflective of the waste management costs they are required to finance. The combination of the two coefficients also ensure that the total POM (in tonnes) is remaining constant and does not alter the total statistics.

To calculate the reduction of POM obligations for producers placing on the market "green" products (and thus leading to a reduction of the recycling costs), the following assumptions/steps were made:

1. The total cost to be incurred for the collection and treatment of the amount of waste targeted for the year is calculated considering the different cost for baseline products (no reduction) and "green" products (reduction exploitable). In the example of table below the exploitable cost reduction is equivalent to 17% of the treatment costs (133.05 £/t versus 150.59 £/t).
2. The total, average, resulting cost for collection and treatment is calculated (147.08 £/t) which might vary depending also on the share of "green" products in the waste stream (in the example below assumed equal to 10% of the total).
3. The corresponding total cost for each stream (baseline and "green" products) is divided by the average and compared with the original collection target to calculate the corresponding adjustment (increase/decrease) of the POM obligation. The resulting collection targets are different per stream, but the total is not affected, and so is the total POM resulting from those calculations: this means that from National Register perspective such mechanism is also neutral.
4. Table 22 below shows that producers of "green" products have a corresponding obligation equal to 45% of the original POM, while producers of standard products an obligation equal to 114%.

Product	Waste Stream	POM (t)	Collection Target (65% POM)	Total cost (£/t)	Share WG	Total Cost (£m)	Coeffi-cient POM	Adjusted POM	New Collection Target
	Total product	96,905	62,988	150.59		9.37		96,905	62,988
80%	Baseline	77,524	50,390	150.59	90%	8.53	114%	88,242	57,357
20%	"Green" products	19,381	12,598	133.05	10%	0.84	45%	8,663	5,631

Table 22: Parameters used to determine POM correction coefficients

41 APPLIA. "Statistical Report – 2019-2020". 2020. Lambert, Belgium. http://statreport2019.applia-europe.eu/pillar-1/index.html?target=_self&lightbox=0.

Table 23 below summarises the results obtained under the same assumptions (80/20 breakdown of standard/ "green" products at POM level, 90/10 breakdown in waste generated, and savings of recycling costs based on EERA calculations) the potential coefficients for the main products.

Equipment	Savings collection and treatment costs (%) of "green" products vs baseline	Coefficient POM – baseline products	Coefficient POM – "green" products
Washing Machines	12%	113%	48%
Fridges	23%	114%	42%
Microwaves	17%	113%	47%
Central heating	12%	113%	48%
Printers	17%	114%	45%
Dishwashers	12%	113%	48%
Flat display TVs	17%	114%	44%
Freezers	23%	114%	42%
Desktop PCs	17%	114%	45%
Video	17%	114%	45%
Monitors	17%	114%	44%
Speakers	17%	114%	45%

Table 23: Calculated POM correction coefficients for main products

Results show that, following the assumed market share (20% of "green" products in POM, 10% in waste generated) and estimated potential for cost reductions through eco-design, correction coefficients are relatively stable across product types and categories. Overall, producers of standard products would be "penalized" by a 13-14% increase in POM, and producers of "green" products "rewarded" by a 40-50% reduction in POM.

6 Consumer behaviour

The role of consumer behaviour represents a crucial factor for consideration in the design of a system for eco-modulation. This is a dimension which is not captured by modelling efforts when assessing the temporal dynamics of eco-modulation relating to waste generated yet could serve as an impeding factor to a successful system.

6.1 Consumer behaviour and product lifespan

As discussed in section 5.2 and from the perspective of theory alone, eco-modulation offers some potential in reducing waste generated via modulated fees relating to product lifespan. However, this analysis does not account for the role of consumer behaviour. Ultimately, although producers can facilitate extensions in product lifetime in response to eco-design related measures, in reality it is not guaranteed that a consumer will use the product until the end of its technological lifespan. For example, in the instance of repairability, a 2021 European Commission study[42] found that of the 9,929 participants, across 7 member states, just 16% opted to discard their broken EEE product because repair was not possible. 18% of participants wanted a new model, for 21% the product was obsolete and for 30%, it was too expensive to repair.

In essence, consumers dispose of EEE for several reasons, which may limit the ability of eco-modulation to reduce WEEE generated via product lifespan extension. Replacing an old or broken product on the basis of desire for a new one, in addition to the costs of conducting a repair were both identified as barriers to success of eco-modulation in the workshop. Conducting similar research in the UK to that done by the EU Commission would provide valuable insight into the magnitude and nature of the consumer behaviour barrier. These could be integrated into modelling efforts comparable to that of section 5.2 in order to try and quantify the impact.

It is also a reality that not all products which are disposed of by consumers are broken. This can be exemplified through research conducted by the Waste and Resources Action Programme (WRAP)[43], which investigated the reusability of certain WEEE products disposed at a UK recycling centre. Presenting findings relating to washing machines, fridges, TVs, laptops and vacuum cleaners, the results show potential for reusability of disposed products meeting or exceeding 40% of the total waste inspected. In the instance of washing machines, almost 80% of these could be reused easily, or with reused after repair. Consumers are therefore not exhausting the use-phase of their products and disposing of them before the end of their technological lifetime by choice.

On this basis, eco-modulation measures relating to extending product lifetime may offer further reduced potential in practice compared to the outputs of modelling presented in section 5.2. This limitation was also raised by participants in the workshop for this project. Further research into the prevalence of functional WEEE in the UK across all the relevant product groups would serve as a valuable consideration in the design of an effective system for eco-modulation.

42 The European Commission. 2021. "Consumer Study On The Impact Of Reparability Information Formats On Consumer Understanding And Purchase Decisions". Luxembourg City, Luxembourg: The European Commission.

43 WRAP. "Switched On To Value: Powering Business Change". Banbury, UK: WRAP. Accessed 30 March 2022. https://wrap.org.uk/sites/default/files/2021-03/WRAP-switched-on-to-value-powering-business-change.pdf.

Stakeholder viewpoints

When asked about the consumer's impact on product repair and durability, the experiences and views expressed from producers during the workshops and the consultation were similar, whether they were producing large domestic appliance, IT products or small domestic appliances:

- They cited the importance of storytelling and explaining to consumers the main features of a product and the pivotal role consumers play; the durability of products is often expected by consumers, alongside longer warranties to support it. At the same time proper communication on the use of recycled content is important, as while it is seen as a plus in many eco-modulation criteria, some consumers might perceive it as impacting negatively on the quality of products;
- The need to increase consumer awareness on recyclability and repairability, explaining to consumers what can be repaired by a consumer, what can be repaired by an engineer and what to do with a product at its end of life. Repairable products are not necessarily repaired if consumers decide not to, and even environmentally designed products can be improperly discarded by consumers.

A UK recycler involved in the repair and refurbishment of washing machines and dishwashers also highlighted that even minor "cosmetic" imperfections visible to consumers severely hinders the ability to resell the machine, even though they are fully functional.

It was also highlighted the high impact of cost of repair, and in particular the impact of labour cost of qualified engineers, which is higher than the cost of spare parts. This is in line with the figures provided in the latest APPLiA annual report[44] which highlights, on average, the impact of cost components for repair activities.

Cost	Small appliances	Large Appliances	Cooling & Freezing
Spare parts	44 %	39 %	29 %
Labour	33 %	44 %	30 %
Transport	15 %	16 %	16 %
Other	8 %	1 %	25 %

Table 24: Impact of repair costs components (% of the total cost)

Such trend and dynamics were also reiterated by a large domestic appliance producer who also flagged the lack of engineers in the UK as a major barrier to availability and affordability of repair. Furthermore, any delay in repair activity will affect the final decision of the consumer, which based on previous experience found consumers preferred to buy a new appliance rather than waiting for the repaired one. This trend was only bunked during the pandemic when buying new products was not possible, increasing the repair of existing products.

All those aspects illustrate how critical consumers are in determining life duration and thus environmental impact of a product, regardless of how it has been designed or made.

44 See: http://statreport2019.applia-europe.eu/pillar-1/index.html#p=23?target=_self&lightbox=0

6.2 Signalling function

It is argued eco-modulation can serve as a "signalling function" for consumers, allowing them to identify products which are more environmentally friendly (reports by OECD/Eunomia). In essence, it is argued a malus would indicate lower environmental performance, whereas a bonus would indicate better environmental performance of a given product. Furthermore, it is suggested that this can drive demand[45] for more sustainable products, providing incentive to producers in the form of competitive advantage.

Although from a theoretical perspective the impact of eco-modulation on consumer behaviour at point of purchase is promising, preliminary results from existing systems indicate otherwise. In the instance of France, visible eco-modulation fees had negligible impact of sustainable product market share and consumer buying decisions (Eunomia/OECD), presumably due to the fact that the difference in EPR fees was insubstantially small. Research conducted by WEEE Ireland and SENS eRecycling[46], PROs in Ireland and Switzerland, showed that although Irish consumers saw visible fees as a reassurance that old products would be disposed of correctly, they felt the concept of introducing a different fee for the same product was confusing. Furthermore, the research highlights the need for variation in price to be integrated into total product price. However, in the case of Switzerland, consumers state visible fees were not an influencing factor in purchase decision. Crucially, Swiss consumers associated more expensive products with better environmental performance, because "sustainability is expensive". In theory, this could mean rewarding products with worse environmental performance, creating an opposing force to eco-modulation efforts. This was a point raised as a limitation by producers in the workshop, although, they noted developing a concrete understanding of consumer behaviour in this respect as a crucial.

As an alternative to visible fees, both the OECD and Eunomia proposed that this could be solved through the application of eco-labels which demonstrate product environmental performance, comparable with the energy label ratings applied under EU eco-design regulation. Research conducted by WEEE Ireland and SENS eRecycling in 2021 echoed this suggestion, a point further highlighted by producers attending the study's workshops and consultations. In the instance of Swiss consumers, however, this was not a finding reflected for Irish consumers. This concept was brought out further in speaking to a large domestic appliance producer who cited that they saw it as a worthwhile investment of time and money in developing the score their products achieved in a Repairability Index that was shown to consumers on the product label. Even an increment as small as moving from 7.7 to 8.2 was seen invaluable as a means of competitive advantage in addition to brand reputation, quality and price.

The research conducted by WEEE Ireland and SENS eRecycling aimed to uncover the influencing factors in EEE purchase decisions for consumers by conducting 30 in-depth interviews with consumers who had bought a large household appliance in the previous 18 months. In the instance of Ireland, product practicalities, brand and price were ranked as the top three factors, whereas in Switzerland, practicalities, energy efficiency and brand were the top three. In Ireland, energy efficiency and design characteristics were the bottom ranked factors, whereas in Switzerland, it was design and price.

45 The WRAP report on routes to net zero says that extending product lifecycle is a key step towards achieving net zero. There are a number of policy proposals to do that:
- Get consumers to buy the most eco-friendly product - through labelling
- Legislate minimum product lifespan for problematic EEE categories
- Force producers to give free extended warranties on problematic/short lifespan EEE categories
- Get producers to say how long the product has been designed to last for and how that compares to the average on a label – like energy efficiency - to influence customer choice
- Implement the suggested repair-ability index for repairs by the consumer with readily accessible tools
- Facilitate extending product lifecycle through modular design (although maybe this is covered under eco-design?)
- I noticed that single use e-cigarettes are now a thing – ban single use EEE
- Require producers to develop a plan for what will happen to their product at end of life to ensure that the resource remains in circulation
- Require producers to pay for investment in the necessary new infrastructure rather than just relying on what's there already. I guess this was the intention of the recycling/recovery targets but doesn't seem to be working

46 Visible Environmental Fees: Consumer awareness and behaviour. Elise Finidori, WEEE Ireland. Accessed 30th March 2022. https://www.weeeireland.ie/wordpress/wp-content/uploads/2021/10/Presentation-Visible-environmental-fees.pdf

These findings allow for the following conclusions:

- Firstly, consumer preference varies between nations prioritising different product attributes- most relevantly, the ranking of energy efficiency, although product design was the lowest ranked influencing factor for both samples. This means that evidence from other countries cannot necessarily be adopted as a proxy to inform the design of eco-modulation in the UK.
- Secondly, although the research was conducted with a relatively balanced sample group, the perspectives of 30 individuals is not an accurate reflection of perspectives of a national population. Naturally there are limits to sample size, however, future research in the UK should conduct this exercise at a larger scale, perhaps in a more quantitative manner. This will create provision for better informed conclusions in a UK context.
- Thirdly, this research was conducted solely in the context of large appliances, therefore, in designing a system for eco-modulation, consideration should be drawn to conducting similar research but in relation the products which serve as potential candidates for eco-modulation. The purchasing behaviours of consumers for a desktop PC may vary significantly compared to that of a washing machine, for example.

6.3 Conclusions relating to consumer behaviour

Consumer behaviour represents an under-addressed area in the context of eco-modulation more broadly yet is important as an enabling lever in developing an effective system for eco-modulation. It should be investigated from two angles:

- Impact of consumer behaviour on product lifetime extension: Failure to address this could render eco-modulation less impactful. To understand this fully, consumer behaviour in the UK must be researched in relation to disposal of devices before the end of their technological lifetime. Furthermore, integrating these findings into scenario-based modelling at a product specific level may serve as means of quantifying the ability of this factor to detriment an eco-modulation system. Once this is better understood, remedies can be developed, or alternate methods can be explored.
- The ability of eco-modulation to serve as a signalling mechanism: From the perspective of consumer behaviour, the visibility of eco-modulation to consumers and its influence on them is evidently unique on a national basis. Previous research therefore cannot be used as a proxy for the UK. The role of signalling should be investigated in a UK context, with a larger sample group than that of the WEEE Ireland and SENS eRecycling study and should be investigated across all potential candidate products for eco-modulation. Existing research in this context only addresses large appliances. As per the WEEE Ireland and SENS eRecycling study, the underpinning influencing factors relating to product attributes and the importance of environmental performance must also be understood. By doing this, the potential of eco-modulation can be better understood in relation to the pre-purchase/purchase stage of a product lifecycle.

7 Impacts of eco-modulation implementation on the Supply Chain

Drawing on stakeholder interviews with various system actors, and the three workshops conducted, key themes can be identified that relate to how eco-modulation has been experienced to date or might need to be considered in the future.

7.1.1 Administrative burden

Two France-based producers working under the French eco-modulation scheme highlighted the complexity of the evaluation, i.e., to check whether a product meets a criterion or not. The decision must be made not just on one single product type, but all the models and series of that product need to be examined (anecdotally, one producer shared that for a dishwasher there can be up to 400 different models). Evaluation of the criteria, the declaration, and the compilation of evidence to support declaration is a complex process, which the producers interviewed find time consuming because they do not have internal systems in place to access the data required. Some criteria are easy to evidence (such as availability of spare parts), but other such as recycled content and presence of hazardous substances require a more complicated investigation. Many times, producers must reach out to manufacturers and material suppliers to get specific product related data.

These insights have been further supported by an Italian based PRO, who suggested that the complexity of reporting has meant that this system has been unable to function adequately. Producers are expected to complete a significant amount of complex documentation each year to demonstrate their compliance, in which this information cannot be carried over to the next reporting year.

7.1.2 Impacts on end-of-life treatment

Various producers expressed the view that often time and effort spent by the producers interviewed to manage the process of evaluation, declaration, and evidencing internally to decide if they claim a bonus or malus does not seem to be worth the effort. Producers unanimously expressed the view that this is an artificial process which is not reaching the desired effect. The producers called on decision makers to reconsider the principle of eco-modulation: if the objective is to improve treatment of EEE at end-of-life, they advocated the need to improve communication and collaboration with recyclers to understand the products that are hard to recycle or repair and why.

This view was further supported by all the AATFs interviewed who highlighted a number of common challenges such as access to repairable parts or making it easier to identify lithium batteries inside products. It was also acknowledged that even if a product is designed to be "easy to recycle" at end-of-life, because it will be collected with a mix of other products in a large container of mixed WEEE, this benefit is lost at the treatment stage. To quote one producer "we are keen to find the solution, but it's about using the right tool".

7.1.3 Impacts on design decisions

While one producer interviewed stated that the administrative burden would be worth it if the French eco-modulation system achieved its aim to push producers to manufacture more sustainable products, the majority of producers interviewed stated that they did not make any design or other changes in their products to get a bonus or avoid receiving malus. They explained that there were more pressing elements that producers took into consideration when deciding on making changes to their products. This is a finding which was reflected in the workshop addressing eco-modulation.

Moreover, the fact that eco-modulation was in place only in France but not the rest of the EU countries, made it even less likely that it reached its goal. Producers declared they were not likely to invest in the efforts to make changes to their products for the sake of achieving economic benefits in one single market only. This was a reoccurring theme in the workshop, with participants expressing that fragmentation and a lack of homogeneity in regulations addressing eco-design and eco-modulation meant competing expectations between markets. It was unequivocally agreed of the need for homogeneity in regulations, with many highlighting that as producers typically design for a single, or global market, they opt to align design standards with the most influential market for them individually, with the highest standards for design.

The Repairability Index was cited as an effective tool to foster change in the design of the products. This initiative had triggered swift design changes to get better index score. Investing time to redesign products to gain even a small incremental increase (such as from 7.7 to 8.2) gives them advantage in other markets other than just in France. Getting the Repairability Index of their products higher is considered a priority because it is a visible, consumer-facing feature that can influence consumer's buying decision and is a non-economic competitive advantage. Regarding incentives for change, a producer stated that consumer labelling "is more powerful than money".

There are many conflicting demands on producers: retailers and consumers want products that are cheaper, but products must also be of good quality and built to last (and ideally be repaired); but price impacts on the quality of metal or thickness of coatings used on products which can in turn impact the durability of a product. Safety is a core design principle that determines a number of design decisions but might be in conflict with eco-modulation criteria (in the case of use of certain flame retardants, for example).

When it comes to use of recycled content, and plastic in particular, a few barriers were repeatedly cited as a major challenge during the workshops and consultations held during the project: there is a want to use recycled plastics, ideally from old products in new products – in order to be fully circular – but the production and uptake of recycled plastics from WEEE is hindered by a number of technical, economic and regulatory challenges. Currently, the recycled plastic used in EEE sector is typically from another single sources (packaging waste); producers also flagged the full-scale demand for plastics from EEE is currently not met by supply generated from WEEE. The time scale required to start using recycled content was also mentioned, indicating a time frame of 3-4 years to implement such a transition from design, to manufacture and securing suppliers of material.

For many eco-modulation criteria, the information is not readily available from the supply chain of the manufacturer. One producer explained that for brominated flame retardants, for example, suppliers of the materials used in a product were unable to provide information required on levels of persistent organic pollutants (POP). This means that even if the product in theory complies with the criteria, they cannot claim the bonus as they are not able to prove their compliance. To this end, the prospect of a Digital Product Passport that made information easier to obtain was supported by those interviewed.

This point was further emphasised by an Italian PRO, who suggested the lack of simple criteria meant that producers did not have the complex information needed to report their compliance, preventing them from reducing their POM share responsibility. Whilst a Canadian industrial compliance entity suggested that the data burden is further emphasised by the lack of manufacturing within Canada. Canadian administrative staff are given the responsibility to report the product's criteria compliance, nonetheless, these individuals are significantly detached from the product's manufacturing, lacking knowledge and data surrounding aspects including the product's materials and production process.

When it comes to declaration the producers interviewed were in favour of self-declaration as opposed to mandatory certification by third-party auditors. Self-declaration is a process most appliance manufacturers are familiar with from EU energy efficiency legislation. They emphasized, however, that measurement methodology standards should be in place to complete the declaration process and papers presented should be backed by evidence and access to that evidence should be secured. There are criteria where evidence is easily shown, e.g. the presence of online manuals or availability of spare parts, but others such as recycled content, are difficult to verify. Since there is not yet a verification system in place, there might be companies whose declaration is not reflecting the reality. The risk of getting caught is very low if a company is non complaint – this could be addressed if audits (to quote one producer) "shoot where the ducks are".

The experience shared was that every rule that is not properly implemented and checked created a disadvantage for large companies. Due to their visibility, large companies are the ones that are inspected and the cost of ensuring compliance means the product is more expensive, bringing about an economic disadvantage for larger companies. Smaller companies can gain economic benefits as they are less concerned about protecting their brand reputation and so can be more competitive on price.

The success of any compliance system is reliant on the extent to which verification of the claims is undertaken. In France yearly audits are in place to prevent producers from misusing the eco-modulation scheme. But this is largely academic as, for professional equipment, one of the biggest PROs in France found that less than 5% of its producers actually claim a bonus.

Alternative options to verify conformity and eligibility include:

- Self-declaration and audit by the compliance scheme: The producer declares that it is eligible for a bonus and the compliance scheme of which it is a member will conduct an audit to ascertain eligibility. This is similar to the scheme in France. For example, many electrical and electronic products in the EU are subject to self-declaration rules on conformity to energy efficiency requirements
- Third party certification: A third party verifies conformity with the rules and issues an attestation
- In advance control or inspection by the authorities, such as Defra: This is not considered likely given the time and resources this would require by the UK authorities

Insights gained on the French self-declaration system highlighted a change from a signed declaration form to the inclusion of a statement that the form has been completed to the best of the person's ability. This is to address the risk of inaccuracies being blamed on the PRO or the person completing the paperwork claiming they did not know how to complete the form. This demonstrates how critical it is that whoever completes the declaration has access to all the technical product design information needed. Whether or not a system is misused therefore depends greatly on the complexity of the declaration process, the evidence that needs to be provided and having a robust system for verification.

7.1.4 Producer definition

Another element flagged by producers is the current interpretation and the understanding of the ability of a "producer" to influence design choices over their product. The type of producers falling under the legal definition of "Producer" under the WEEE law in the UK[47] alongside respective legislation across Europe, does not equal "manufacturer". This also goes hand in hand with the burden associated with the role a producer. Table 25 outlines the different types of producers that are included under the definition and the areas subject to eco-modulation (exemplary high-level criteria). Below each criterion is an indication of the leverage that the specific type of producer is having in terms of control over the specific criteria. What becomes apparent is that the amount of leverage pertaining to being able to have control over a certain criterion can vary immensely depending on the type of producer looked at. This is mainly due to the fact that the current value chain of products includes a range of actors that are not a manufacturer in the traditional term, meaning they do not directly influence the design nor production phase of a product and therefore have little or no control over product associated criteria.

		Exemplary eco-modulation criteria (non-exhaustive)					
		Recyclability of products, inclusion of recycled content	**Repairability**	**Availability of spare parts**	**Durability**	**Energy efficiency**	**Product labelling**
Producer type	**Manufacture and sell EEE under your own brand in the UK**	Full control	Full control	Full control	Full control	Full control	Full control
	Resell equipment made by someone else under your own brand(if the maker's brand appears on the equipment, they are the producer)	Certain control via design and manufacturing agreements	Certain control via design and manufacturing agreements	Certain control via design and manufacturing agreements	Certain control via design and manufacturing agreements	Certain control via design and manufacturing agreements	Certain control via design and manufacturing agreements
	Import EEE on a commercial basis into the UK	No control	No control	No control, except specific agreements with supplier (depending on leverage/ negotiation power)	No control	No control	Limited control, in case of relabelling is done
	Are established outside of the UK and supply EEE directly to the UK market by distance selling (for example online, mail order, by phone)	Certain control, depending on the size of the player	Certain control, depending on the size of the player	Certain control, depending on the size of the player	Certain control, depending on the size of the player	Certain control, depending on the size of the player	Certain control, depending on the size of the player

Table 25: Different types of producer and their level of influence on criteria of a product

47 "Electrical And Electronic Equipment (EEE): Producer Responsibilities". London, UK: GOV.UK, accessed 29 March 2022, https://www.gov.uk/guidance/electrical-and-electronic-equipment-eee-producer-responsibility.

7.1.5 Harmonisation

techUK, a large UK trade association representing the views of some of the leading technology producers in the UK and across the globe, gave their view that the main priority should be to harmonise definitions and criteria with an evidence-based approach aligned to existing laws and standards. Alignment with EU laws (for example the proposed Eco-design for Sustainable Products Regulation) is highly recommended as manufacturers make products on a global basis and mis-aligned criteria are expensive to implement. The creation of new criteria for products must not undermine existing requirements, causing excessive complexity for producers attempting to comply with numerous environmental frameworks. As seen by section 2.6, the UK already has eco-design requirements for producers and to ensure the system effectively functions, the development of eco-modulation must be carefully formulated to support other requirements currently placed on producers.

An Italian PRO emphasised that few of their producer members only sell to consumers based in a single country level, rather harmonisation, at the minimal EU level, would be needed to ensure that producers are incentivised to invest in changing the design of their products to make the reduction in end-of-life expenditure financially worthwhile. This was further outlined by a Canadian industrial compliance entity who suggested that the creation of modulation criteria in small jurisdictions, including individual regions and countries, will not encourage change in producer behaviour, a producer's lack a financial and administrative incentive to change the design of their products for a single country. In line with previous comments, producers highlighted the importance of a harmonised approach when aiming at implementing eco-modulation criteria. The need to serve a customer base located in a globalised market raises the challenge of being faced with an already steep multitude of EPR obligations across various national markets.

This need had been identified by the European Commission in 2018 in its Directive 2018/851/EU amending Directive 2008/98/EC on waste, which introduced for the first time general minimum requirements for Extended Producer Responsibility (EPR) schemes to "introduce a level of harmonisation to improve the transparency, governance and cost-efficiency for all existing EU level and national level EPR schemes" of which there are more than one hundred in the EU.

In parallel to the transposition of that Directive, the European Commission has also set out its Sustainable Product Initiative (SPI). This legislative initiative seeks to ensure that all products placed on the European single market become increasingly sustainable and stand the test of circularity. The proposed Regulation is set to revise the Eco-design legislation and design sustainability requirements on a range of products. Upgradable, repairable, reusable, and recyclable products must become the norm.

Whilst the objectives of these laws and initiatives are broadly supported across continental Europe, stakeholders involved in putting the principles into practice and meeting the requirements have consistently alerted policymakers that the application across many policy areas of the eco-modulation framework must be clear and consistent across Europe to create the intended impact of sustainable circular business models and opportunities from a product lifecycle perspective. They are concerned that these conditions will not be in place.

A new draft set of Guidelines on the general minimum requirements for EPR schemes set out in Directive 2018/851/EU have also highlighted the need "[...] to facilitate the adaptation of EPR schemes to these new requirements by providing guidance to support their harmonised interpretation and application across the EU. Harmonised and effective implementation of these requirements should support level playing field and provide investment certainty, in particular, in separate collection, sorting and recycling, which will then go counter to the intended harmonisation and to increasing the effectiveness of such schemes across the Union."

7.1.6 Simplification

A need for system simplification was also shared by an Italian PRO regarding criteria selection. They believed that if criteria are easy for producers to understand and implement, the more likely they would encourage producers to pursue compliance. Such criteria could include the use of certain materials that could be easily identified and substituted within the production process. This sentiment was echoed by the France-based producers interviewed who found that the need to meet complex criteria made compliance very costly and time consuming. They also often felt pulled between opposing compliance demands (such as a safety need against fire but needing to avoid certain fire-retardant substances).

techUK also voiced support for simplification of implementation of eco-modulation, suggesting a phased approach of products in scope (i.e. a limited scope with gradual build-up of product categories).

More than ten years after the creation of the scheme in France, the OCAD3E, the accredited WEEE co-ordination body, in liaison with the producer's community as represented by the PROs, assessed the eco-modulation scheme:

'"[...] the study reveals certain limits to clearly identifying the levers and factors affecting the evolution of the number of products declared as eco-modulated per product family (declarative practices, design practices and/or market share of the different products, etc."'

And also:

'"Companies do not explicitly quantify the costs of changing the design or business practices for products that benefit from a bonus or avoid a malus within the eco-modulation system. In fact, changes may be the result of concomitant factors (as explained in the previous chapter: consumer/distributor demands, regulations, etc.) and may not be specific to eco-modulation, which makes precise costing difficult."'

The two main conclusions of the study are that the effect of an eco-modulation scheme on manufacturers' decision to make their products "greener" cannot be ascertained and there is an inherent tendency among decision-makers to overcomplicate the scheme. After ten years of an operational eco-modulation scheme, the limitations of eco-modulation are clear, yet some stakeholders in France also believe that the scheme can be improved.

7.1.7 Transparency and adaptation to current UK system

techUK also highlighted the need for any eco-modulation system to have transparency and a solid governance structure for how eco-modulation will be managed. They suggested that stakeholders (perhaps via a dedicated committee) should be able to take part in the revision process. This would allow the system to be flexible to account for changes in product design, innovation and to reflect development of policy and standards.

Based on our findings in section 4 and supported by interaction with stakeholders, a modulation system centred on reduction/increase of POM share responsibility would best fit within the UK's current EPR system, in which producers are responsible to finance the management of waste corresponding to their market share. Such a mechanism would result in minimal change to the existing EPR system, reducing the impact of integrating modulation on producers and compliance schemes that would otherwise have to realign with new EPR mechanisms.

The use of a POM fee system would need greater change to the UK's current EPR fee system, in which producers would pay EPR fees for each product. Whilst the adoption of DRS has been excluded based on its aim to increase collection rates, rather than collect EPR fees.

7.2 Recommendations for future studies

An in-depth qualitative study of UK consumer behaviour to better understand the relationship between eco-modulation and consumer behaviour would be recommended. The analysis in this report has mostly focussed on professional stakeholders, having drawn our findings on behaviour consumers from desk-based research and producer perspective. It would be valuable to have a qualitative study, including focus groups and surveys with UK consumers to better understand the impact the relationship between eco-modulation and consumer behaviour.

A future study would be recommended to analyse the effectiveness of eco-modulation criteria beyond those that primarily focus on reducing the end-of-life impact of EEE. Such could be seen with the use of eco-modulation to reduce the environmental impact of creating EEE products, such as studying the impact on decreasing the mining of precious metals and minerals used in EEE through modulation.

8 Conclusions

The purpose of this study was to explore, with supporting evidence, the mechanics and systems elements required to create an eco-modulation system in the UK that can facilitate and reward the eco-design of electrical and electronic equipment (EEE) in a cost-effective manner. Any UK system must work alongside the UK's current EPR framework and support existing waste management strategies on recycling, seeking to reward resource efficiency at the design phase by enabling the reduction of waste generated and reducing negative environmental externalities through, inter alia, the use of less environmentally harmful substances and the extension of products lifetime.

Evidence collected during the study, data and simulations carried out as well as interaction with stakeholders allows to summarize the success factors for the implementation of an eco-modulation system in the UK.

The system should be:

- **Simple:** striving for simplicity in the design of a system for eco-modulation is seen as paramount to its success, as well as its ability to synergise with the existing eco-design regulation in the UK. Experiences and evidence from implementation in France suggest that the overcomplexity of eco-modulation does not result in the wider adoption of higher environmental benefits. Most producers interviewed stated that complex systems, such as in France, did not result in any design or other changes in their products to get a bonus or avoid receiving malus.
- **Transparent:** criteria should be easily verifiable and flexible enough to embrace changes in product design, innovation and be able to reflect the development of policy and standards.
- **Harmonized:** definitions and criteria should be aligned to existing laws and standards, particularly EU Eco-design Directive and Sustainable Products Regulation as manufacturers make products on a global basis and misaligned criteria are expensive to implement. Producers declared they were not likely to invest in the efforts to make changes to their products for the sake of achieving economic benefits in one single market.

If those three criteria are met, it will also allow for the reduction in the administrative burden for companies when having to declare products that will benefit from eco-modulation incentives; the burden will also be reduced by adopting a system with self-declaration and sample audits – similar to RoHS – rather than third party verification.

Producers favoured the idea of eco-design related incentives or measures to be kept in one single policy instrument – typically Eco-Design regulations – and favoured measures like labelling as they are consumer-facing instruments that proved to be a more powerful incentive to trigger previous design changes.

There is the option to plug in the current UK WEEE management system some form of eco-modulation adjusting the POM figures with specific coefficients. Criteria to allow adjustment of POM should be ideally few only (e.g., presence of recycled content, or absence of specific hazardous substances), similar to what is happening in Ontario, or recently proposed in Sweden (only one criterion, based on the presence of hazardous substances).

With the proposed approach producers remain responsible to finance the management of waste corresponding to their market share, under the current set-up. Such a mechanism would result in minimal change to the existing EPR system, reducing the impact of integrating modulation on producers and compliance schemes that would otherwise have to realign with new EPR mechanisms.

The value of such coefficients can be reviewed annually based on updated figures on products meeting the specific criteria that are placed on the market, their share in waste generated and the savings obtained in the treatment processes. Anchoring the economic value of the eco-modulation to the potential savings in the end-of-life costs – either linked to reductions of the treatment costs due to more environmentally friendly products, or to the potential reduction of waste generated through more durable and repairable products – will anyway provide only limited space (no more than few GBP for those products having higher recycling costs of being large and heavy) to really influence designer's decisions. In this respect, to identify the most meaningful design changes that could increase the cost-effectiveness or facilitate the treatment phase, producers flagged the need to improve communication and collaboration with recyclers.

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