Final report for the project

Differentiated producer responsibility fees – case study for electrical and electronic equipment

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Differentiated producer responsibility fees – case study for electrical and electronic equipment

Miljödifferentierad producentansvarstaxa - fallstudie för elektronik

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Table of content

Summary

To differentiate producer responsibility fees is on the EU agenda and for example mentioned in the EU Strategy for Plastics in the Circular Economy[1] as a measure towards resource-efficiency. In theory, differentiation of fees within extended producer responsibility (EPR) schemes could favour more reusable and recyclable products as producers are rewarded or penalised with lower or higher producer responsibility fees in correspondence to compliance or non-compliance with certain criteria, which incentivises changes in product development.

The project group has found one large-scale example, France, where differentiated producer responsibility fees are used for electrical and electronic equipment (EEE) within EPR schemes. The differentiation is based on a bonus-malus approach where products get a financial reward or a penalty depending on fulfilment of certain criteria. The project group has not found any indications that the differentiation of fees in France has led to change of product design and more environmentally sound products. The reason for the lack of impact could be difficulties with implementing differentiation on a single market as well as how the differentiation model is structured. There are also challenges with evaluating the effects of a differentiated fee system. The bonuses or penalties according to compliance or non-compliance with criteria are in the French system based on percentages of the basic level of fees being withdrawn or added.

It is doubtful that implementation of differentiated fees within producer responsibility for EEE in Sweden or any single- market will lead to changes in product design. The main reason is that the EEE sector often operates globally, thus reducing the incentives to modify the product design for a single market. Differentiated producer responsibility fees for electronics, could thus favour product development towards more reusable and recyclable products. However, such a differentiation likely benefits from being implemented and harmonised on the EU level. Challenges such as the criteria base to build the differentiation upon, control of compliance with criteria, developing a differentiation model in financial terms not only taking bonus and penalties' percentages into account, but also the fee levels, still need to be solved.

In a differentiated system, inspiration for criteria could be taken from existing criteria within ecolabels and green public procurement. The criteria used in such systems are mainly focused on the same aspects within reuse, recycling, and hazardous substances. For reuse there is a strong focus on lifetime extension such as warranties, availability of spare parts, replaceability of components as well as upgradability, capacity expansion and repairability. For recycling the focus is mainly on marking of plastic components, manual disassembly of certain parts, content of recycled plastics and reduction of the polymer types. Hazardous substances are commonly included by restricting the use of substances in line with current legislation and beyond.

[1] A European Strategy for Plastics in a Circular Economy. COM (2018) 28 final.

The producer responsibility fees for electronics are set to achieve the targets outlined in the WEEE Directive, which all are met for the studied product groups. The fees cover the current costs within the EPR schemes to reach the minimum targets in the WEEE Directive. More ambitious reuse and recycling practices, including more cost-intensive recycling processes, would require an elevation of fees or higher EU targets. PROs compete for member producers. If one PRO takes the lead and elevates the fees with the motivation that more technologically advanced recycling processes with better recycling results are offered they risk losing customers. Similarly, recyclers offering advanced recycling processes to a higher cost than their competitors risk losing the PRO contracts.

The objective of this project was to evaluate *if* differentiated fees for electrical and electronic products (EEE) could give incentives to producers of EEE to design more reusable and recyclable products. The project specifically looked at five product groups of EEE; smartphones, TVs, laptops, refrigerators/freezers and washing machines. Focus areas considered were prevention of waste, reuse and recycling, in line with the WEEE Directive. The project was conducted by IVL Swedish Environmental Research Institute, Chalmers Industriteknik, and The International Institute for Industrial Environmental Economics (IIIEE) at Lund University. Electrolux, El-Kretsen, El-Giganten, Recipo, Samsung, Sims Recycling Solutions and TCO Development functioned as the project's reference group. The project was financed by Vinnova (Sweden's innovation agency) and Energimyndigheten (Swedish Energy Agency) within the research programme RE:Source.

Sammanfattning

Differentierade producentansvarsavgifter är på agendan inom EU och nämns exempelvis i EU: s strategi för plast i en cirkulär ekonomi[2] som en åtgärd för ökad resurseffektivitet. I teorin skulle en differentiering av producentansvarsavgifter inom ramen för producentansvar kunna gynna mer återanvändbara och materialåtervinningsbara produkter eftersom producenterna belönas eller straffas med lägre respektive högre producentansvarsavgifter om de uppfyller eller inte uppfyller vissa kriterier, vilket stimulerar förändringar i produktutveckling.

Projektgruppen hittade ett storskaligt exempel, Frankrike, där differentierade producentansvarsavgifter används för elektronik. Differentieringen baseras på bonus-malus där producenter får ett ekonomiskt påslag eller avdrag beroende på om vissa kriterier uppfylls. Projektgruppen fann inga indikationer på att differentieringen i Frankrike har lett till förändringar i produktdesign, vilket kan bero på svårigheter att genomföra en differentiering på en enskild marknad, liksom på hur differentieringsmodellen är strukturerad. Det finns också utmaningar med att utvärdera effekter av differentierad producentansvarstaxa. Det ekonomiska påslaget eller avdraget görs i det franska systemet med hjälp av procentsatser på avgifternas basnivå.

Det är tveksamt om en differentiering av avgifter inom producentansvaret för elektriska och elektroniska produkter i Sverige eller annan enskild marknad skulle leda till förändringar i produktdesign. Huvudskälet är att elektronikbranschen ofta är verksam globalt och därigenom minskar incitamenten att ändra produktdesignen för en enskild, mindre marknad. Differentierade producentansvarsavgifter för elektronik kan gynna produktutveckling mot mer återanvändbara och materialåtervinningsbara produkter. Det är dock sannolikt att en differentiering gynnas av att implementeras och harmoniseras på EU-nivå. Utmaningar som är förknippade med att implementera differentierade producentansvarsavgifter är att utveckla kriterier som differentieringen ska baseras på, att kontrollera och bedriva tillsyn över kriteriernas efterlevnad samt att utforma differentieringsmodellen i finansiella termer, inte bara med hänsyn till påslag och avdrag på avgifter i form av procentsatser, utan också grundnivåerna på producentansvarsavgifterna.

Inspiration till kriterier kan hämtas från befintliga kriterier inom miljömärkningar och grön offentlig upphandling. Kriterierna som används i sådana system är huvudsakligen inriktade på samma aspekter inom återanvändning, materialåtervinning och farliga ämnen. För återanvändning finns det ett starkt fokus på att förlänga livstiden på produkter, såsom garantier, tillgång till reservdelar, utbytbarhet av komponenter samt uppgraderbarhet, kapacitetsutbyggnad och reparerbarhet. För materialåtervinning är fokus främst på märkning av plastkomponenter, manuell demontering av vissa delar, innehåll av materialåtervunnen plast och minskning av antal plasttyper. Farliga ämnen ingår vanligtvis genom att användningen av vissa ämnen begränsas enligt gällande lagstiftning eller enligt hårdare krav.

[2] A European Strategy for Plastics in a Circular Economy. COM (2018) 28 final.

Producentansvarsavgifterna för elektronik är utformade för att täcka de nuvarande kostnaderna inom producentansvarssystemet för att nå minimi-målen i WEEE-direktivet. Samtliga återvinningsmål uppfylls för de studerade produktgrupperna. Mer ambitiös återanvändnings- och återvinningspraxis, inklusive mer kostnadskrävande återvinningsprocesser, skulle kräva en höjning av avgifter eller högre EU-mål. Producentansvarsorganisationer konkurrerar om medlemmar (producenter). Om en producentansvarsorganisation höjer avgifterna med motivationen att mer tekniskt avancerade återvinningsprocesser med bättre återvinningsresultat erbjuds riskerar de att förlora kunder. På samma sätt riskerar återvinningsföretag som erbjuder avancerade återvinningsprocesser till en högre kostnad än sina konkurrenter att förlora kontrakten med producentansvarsorganisationerna.

Syftet med projektet var att utvärdera om differentierade producentansvarsavgifter för elektriska och elektroniska produkter (EEE) skulle kunna ge incitament till producenter av elektronik att utveckla mer återanvändbara och materialåtervinningsbara produkter. Projektet tittade specifikt på fem produktgrupper; smartphones, TV, bärbara datorer, kylskåp/frysar och tvättmaskiner. Fokusområden som beaktades var förebyggande av avfall, återanvändning och materialåtervinning, i enlighet med WEEE-direktivet. Projektet genomfördes av IVL Svenska Miljöinstitutet, Chalmers Industriteknik och Internationella Miljöinstitutet (IIIEE) vid Lunds universitet. Electrolux, El-Kretsen, El-Giganten, Recipo, Samsung, Sims Recycling Solutions och TCO Development fungerade som projektets referensgrupp. Projektet finansierades av Vinnova och Energimyndigheten inom det strategiska forskningsprogrammet RE-Source.

1. Introduction

Waste of electrical and electronic equipment (WEEE) is one of the fastest growing waste streams in the EU, growing at 3-5% per year[3]. Around 9 million tonnes of WEEE was generated in 2005, and the waste stream is expected to grow to more than 12 million tonnes by 2020. Due to its complex nature, WEEE may cause environmental and health issues if not properly managed. In order to improve environmental management, increase resource-efficiency, and to contribute to a circular economy, the WEEE Directive (2002/96/EC) came into force in 2003, and a recast of the directive (WEEE Directive 2012/19/EU) in 2012.[4]

The purpose of Directive 2012/19/EU on waste electrical and electronic equipment (WEEE)[5] *is to contribute to sustainable production and consumption by, as a first priority, the prevention of WEEE and, in addition, by the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of valuable secondary raw materials.*

The WEEE Directive is based on the principle of extended producer responsibility (EPR) to create a link between the production phase and the waste phase of a product and concerns various actors involved in the life cycle of electrical and electronic equipment (EEE), such as producers, distributors, consumers and operators of treatment plants. In more detail, it is stated in the directive that *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.* The term "extended producer responsibility", as well as its concept as a preventative environmental protection strategy was first used and defined by Lindhqvist and Lidgren in a report for the Swedish Ministry of the Environmental and Natural Resources in 1990. The English translation of the definition reads as follows.

Extended Producer Responsibility is an environmental protection strategy to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product.[6]

Producers commonly join producer responsibility organisations (PROs) to fulfill their obligations towards the producer responsibility obligations stated in the directive. PROs charge their member producers fees in relation to the kind and

[3] Eurostat (2018). Waste electrical and electronic equipment (WEEE). http://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee
[4] DG Environment (2017). Waste Electrical & Electronic Equipment (WEEE). http://ec.europa.eu/environment/waste/weee/index_en.htm
[5] Hereafter referred to as the WEEE Directive.
[6] Lindhqvist, T, Lidgren, K (1990). Model for Extended Producer Responsibility]. In Ministry of the Environment, From the Cradle to the Grave – six studies of the environmental impacts of products. Stockholm: Ministry of the Environment. (DS1991:9).

amount of products they put on the market. The structure of the fees varies depending on the individual PRO. The fees are, however, commonly not differentiated based on the products' environmental impact why it can be argued that the producer responsibility obligations do not give incentives to the producers to develop products that are in line with the purpose of the directive.
In the EU, the EPR approach is also introduced in the End-of-Life Vehicles (ELV) Directive 2000/53/EC, and in the Batteries Directive 2006/66/EC.

Differentiation of fees, also called fee modulation, can be designed to reward better designed products and penalise poorly designed products from an environmental perspective. Fees can be differentiated according to a range of product design criteria such as toxicity, durability, reusability, repairability and recyclability. Labelling, public awareness and communication campaigns supporting collection and treatment high up in the waste hierarchy can also be focus for criteria.[7] Differentiated fees could therefore work as an incentive for producers to develop and manufacture more environmentally friendly products in terms of recyclability and reusability.

In a background report to the European Strategy for Plastics in a Circular Economy it is suggested to base differentiation of fees for plastic packaging on recyclability of plastics, for example on the existence of technology to sort and/or recycle the packaging, which requires that best available technologies are regularly reviewed. Other aspects that could form basis for criteria on recyclability is the use of composite packaging (how possible it is to separate and recycle different layers of packaging), packaging format design, and existence of markets for the secondary raw materials. To use recyclability as basis for differentiation thus requires a common definition of recyclability within the EU.[8] As EEE to a high extent constitutes of plastics, and existing criteria to favour recycling within several ecolabels and EU GPP very much focus on plastics, it is likely that criteria development for differentiation of plastic packaging benefits from collaboration with criteria development for EEE.

1.1 Objective

The objective of the project was to evaluate *if* differentiated fees for electronics could be a suitable way of giving incentives to producers of EEE to design more reusable and recyclable products. If found that differentiated fees are likely to have a positive effect on the reusability and recyclability of products, a second aim was to investigate how a differentiation model could be structured and implemented. The objective would be achieved by answering the following questions:

1. In which countries and for which product groups are differentiated fees implemented in the EU?
2. What are the results and experiences from producer responsibility schemes or PROs using differentiated fees?

[7] E. Watkins, S. Gionfra, J-P. Schweitzer, M. Pantzar, C. Janssens and P. ten Brink (2017) EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging.
[8] E. Watkins, S. Gionfra, J-P. Schweitzer, M. Pantzar, C. Janssens and P. ten Brink (2017) EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging.

3. How are differentiated fees on a larger scale expected to be received by actors in the value chains?
4. If differentiated fees are likely to have a positive effect on product design, how can criteria to build the differentiation upon be structured?
5. What is the impact of different countries in the EU introducing differentiated fees with different criteria and technical ways to measure?
6. What would a differentiated fee at EU level look like, what product design aspects should be rewarded with lower fees? What specific criteria should be looked at?
7. What minimum level of market surveillance or controls is needed to make a differentiated fee system workable?
8. How can the developed criteria be implemented on the EU level?
9. Are the results for EEE applicable on other product groups?

2. Method

The project work was divided into four activities (excl. management and reporting):

1. Knowledge base
2. Development of criteria for WEEE - including dismantling tests
3. Implementation of the criteria
4. Transferability to other producer responsibilities

1. Knowledge base

Activity 1 had a primary focus on investigating existing initiatives where differentiated fees are used in producer responsibility schemes targeted on various product groups with focus on EEE. The activity was carried out as a desktop study where both scientific and non-scientific literature was covered. Literature was complemented with contact with project members and European industry organisations to further identify examples where differentiated fees are used. The focus in the activity was to document experiences and results from existing initiatives.

2: Development of criteria for WEEE - including dismantling tests

Results from activity 1 served as basis for the proposal of criteria for how the fees could be differentiated. Activity 2 included development of draft criteria to base the differentiation upon. Before developing criteria the study was limited to a number of product groups and focus areas, you can read more about these limitations in Chapter 2.1. Dismantling tests were carried out to give input to the criteria regarding recyclability. It was seen as important not to overlap with legislation already implemented.

3: Implementation of the criteria

If differentiated producer responsibility fees for electronics seem promising, a crucial point is how implementation of the criteria should be dealt with. A small analysis was made regarding the possibilities to implement producer responsibility fees on the EU level.

Another key aspect of this task was to create more knowledge about how differentiated fees for EEE would be accepted within the Swedish producer responsibility system. Interviews were carried out with eight producers of EEE.

4: Transferability to other producer responsibilities

Synergies and parallels to other product groups than EEE were briefly investigated, both in terms of experiences from differentiation of fees of other product groups, as well as knowledge gathered in this project that could be applicable on other product groups.

This project was conducted by IVL Swedish Environmental Research Institute, Chalmers Industriteknik, and The International Institute for Industrial Environmental Economics (IIIEE) at Lund University. Electrolux, El-Kretsen, El-Giganten, Recipo, Samsung, Sims Recycling Solutions and TCO Development functioned as a

reference group. The project was financed by Vinnova and Energimyndigheten within the research programme RE-Source.

2.1 Selection of products groups and focus areas

As EEE represents a high number of different products, the project group decided that the focus of the study needed to be limited to certain products. When limiting the study to a number of product groups the following aspects were taken into consideration:

- The product groups should be put on the market in a high volume or weight.
- There should be difference in the design of products within the product groups, for example their recyclability.

The choice fell on the following five product groups:

1. Smartphones
Reasoning: Around 3.8 million of smartphones are put on the Swedish market every year.[9] The recycling industry is experiencing a difference in the design when it comes to, for instance, how easily batteries can be dismantled. Furthermore, smartphones have a second-hand value.

2. Laptops
Reasoning: Laptops include both screens and batteries. The battery must be removed according to the WEEE Directive and NFS 2005:10[10] and the conditions to do so differ between brands and models. Laptops, as smartphones, have a second-hand value.

3. TVs
Reasoning: TVs are subject to some of the highest producer responsibility fees compared to other EEE. TVs require manual dismantling due to its possible content of mercury-containing lamps, but also to gain fractions that are possible to recycle with good quality.[11]

4. Refrigerators and freezers
Reasoning: Refrigerators and freezers are also subject to some of the highest producer responsibility fees compared to other EEE, which can be explained by their size and weight and the fact that the coolant in the refrigerators needs to be removed and treated as hazardous waste. The existing producer responsibility fees also vary depending on the type of coolant.[12]

[9] Ernstsson, B (2017). Personal communication with Bengt Ernstsson, Elektronikbranschen.
[10] Naturvårdsverkets föreskrifter om yrkesmässig lagring, förbehandling och återvinning av avfall som utgörs av elektriska eller elektroniska produkter.
[11] Benson, F (2018). Personal communication with Fredrik Benson, El-Kretsen.
[12] Benson, F (2018). Personal communication with Fredrik Benson, El-Kretsen.

5. Washing machines
Reasoning: Washing machines, together with other white goods and TVs, are subject to the highest producer responsibility fees compared to other EEE. Similar to refrigerators/freezers and TVs they are costly to transport due to their weight. Washing machines and refrigerators/freezers belong to category 1 in the WEEE directive, *large household appliances*, whereas smartphones and laptops to category 3, *IT and telecommunications*. TVs belong to category 4, *consumer equipment and photovoltaic panels.* For WEEE falling within category 1 and 3 the targets according to the WEEE directive is that 85 % shall be recovered (preparation for reuse, recycling and energy recovery) and 80 % shall be prepared for reuse and recycling (based on collected amounts). The latest official Swedish recycling and recovery figures from 2015 for the two categories reported to Eurostat are listed in Table 1. The targets were met. There is no official recycling statistics where the categories are split into more detailed sub-groups.

Table 1. Sweden's reported recovery and recycling and reuse figures for category 1, 3 and 4 for 2015.[13]

	Category 1: Large household appliances	**Category 3:** IT and telecommunications	**Category 4:** Consumer equipment
Recovery (%)	89.5	92.9	96.7
Recycling and reuse (%)	84.4	85.6	83.6

From the 15th of August 2018, all EEE shall instead be classified within the categories set out in Annex III in the WEEE directive. Refrigerators and freezers are to be classified as *Category 1: Temperature exchange equipment*, TVs and laptops as *Category 2: Screens, monitors, and equipment containing screens having a surface greater than 100 cm*^{2}, washing machines as *Category 4: Large equipment*, and smartphones as *Category 6: Small IT and telecommunication equipment.* The targets for reuse and recycling for refrigerators/freezers and washing machines remain the same as for the old categorisation of EEE whereas the targets for TVs are lowered from 80 to 70% and from 80 to 55% for smartphones.

The achievement of the targets shall be calculated, for each category, "by dividing the weight of the WEEE that enters the recovery or recycling/preparing for reuse facility, after proper treatment in accordance with Article 8(2) with regard to recovery or recycling, by the weight of all separately collected WEEE for each category, expressed as a percentage". The targets are input based, meaning that the calculation shall be based on WEEE that enters the recovery or recycling/preparing for reuse facility.[14]

Data used for calculating the national recovery and recycling rates are reported to the national WEEE registers by the producers and PROs. The producers and PROs receive data from their contracted sorting and recycling facilities, but it is unknown

[13] Eurostat (2018). http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
[14] European Commission (2015). Study on WEEE recovery targets, prepairation for reuse targets and on the method for calculation of the recovery targets. Final Report.

whether the facilities around Europe use the same basis for calculation. WEEE Forum, an association of WEEE producer responsibility organisations, has thus developed a common reporting routine called WF-RepTool to determine treatment results for WEEE in a transparent and comparable way[15]. The data reported to the national authorities is thus often not subject to any continuous supervision why discrepancies might exist. Weaknesses and differences in reporting routines are also important to consider when comparing recycling and recovery statistics with other countries reporting to Eurostat, not only the Nordic countries.

2.2 Focus areas

It was decided that the project should put emphasis on the following focus areas (incl. examples of sub-categories), which was meant to form a possible basis for differentiation. The reasoning behind these focus areas is the purpose of the WEEE directive and the Swedish ordinance (2005:209) on producer responsibility for electrical and electronic equipment. Focus areas, and examples of more detailed sub-categories, were chosen to:

- Reuse
  - Product life time
  - Guarantees
  - Repair possibilities
  - Availability of spare parts

- Recycling
  - Dismantling for recycling
  - Number of plastic components
  - Use of hazardous substances (described in a separate sub-chapter)
  - Marking of plastics
  - Use of recycled plastics

2.3 Product groups

2.3.1 Smartphones

Over the last years around 3.8 million smartphones have been sold annually in Sweden.[16] In 2016, 1.5 billion smartphones were sold globally.[17] Although the real-life expectancy of a mobile phone is believed to be ranging from 3.5 years[18] to 4.7

[15] WF-Reptool (2018). https://www.wf-reptool.org/index.php/home
[16] Ernstsson, B (2017). Personal communication with Bengt Ernstsson, Elektronikbranschen.
[17] https://www.statista.com/statistics/263437/global-smartphone-sales-to-end-users-since-2007/ [Accessed 2018-03-06]
[18] Puustinen, R., & Zadok, G. (2010). The Green Switch: Designing for Sustainability in Mobile Computing. Paper presented at the Proceedings of the First USENIX conference on Sustainable information technology, San Jose, CA.)

years[19] before the device's performance starts degrading remarkably, mobile phone users worldwide change their devices at an average frequency of 18 months[20].

Smartphones are powerful devices in that they contain advanced electronics and strong computational power. Some examples of components and contents:

- Powerful CPUs (computational processing units) and data storage
- Several sensors, such as:
    - microphones
    - cameras
    - lighting and proximity sensors
    - gyro
    - compass
    - accelerometer
    - GPS
- Connectivity in the form of:
    - mobile data
    - Wi-Fi
    - Bluetooth

Since smartphones contain high value electronics and advanced components they also contain precious metals, such as, gold, silver, platinum and palladium, rare earth elements that are e.g. used in displays and magnets, cobalt in batteries, and comparatively large amounts of copper used for wiring, among others, and aluminium often used for the casing.

The high sales number, the short lifecycles due to frequent replacements and the content of high-value elements make smartphones a suitable product type for this study.

2.3.2 Laptops

Laptops have gone through a process of becoming slimmer and more lightweight over time. When recycling laptops the possibility to easily separate the battery and the screen is important. Representatives from the recycling industry mean that the battery is removed before shredding, and that separation of batteries becomes more difficult since laptops are slimmer and the batteries often glued. There are laptops which have several thin batteries spread out leading to a demanding separation processes.

According to the interviews conducted in the project, prolonging the battery capacity is a focus area of improvement and a current trend within laptop development. Available ports differ between producers and models. The plastic components are often treated with flame retardants.

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[19] https://www.cta.tech/News/Blog/Articles/2014/September/The-Life-Expectancy-of-Electronics.aspx [Accessed 2018-03-06]

[20] Bossuet, L. (2014). Sustainable electronics: On the trail of reconfigurable computing. Sustainable Computing: Informatics and Systems, 4(3), 196-202.

A laptop is generally constructed of the following components[21]:

- Battery
- RAM memory
- Motherboard
- Hard drive
- Circuit board
- Graphics board
- Processor
- Fan
- Video camera
- Plastic housing
- Screen (LCD with/without mercury)
- Speaker
- Keyboard
- Touchpad
- AC adapter
- Ethernet port
- USB port
- HDMI port
- Central processing unit

2.3.3 TVs

There are many types of televisions (TVs) and technological advances make techniques more or less favourable at different times. This means that the recycling flow is constituted of different types of devices. According to El-Kretsen[22] collected cathode ray tube TVs (CRTs) are declining in numbers. In 2015, 98% of TVs on the Swedish market was LCDs.

In 2012, the sales of TVs in Sweden reached 840 000 to a value of 5.4 billion SEK.[23] The development is heading towards larger screens. Almost all of the LCDs on the market are sold using LED as backlight, meaning a high energy performance product. Since 2010 television are included in the European Eco-design and energy labelling requirements.

On a general level a modern TV is constructed of the following components[24]:

- Circuit board
- Capacitor
- Resistor
- Speaker
- Screens (LCD with/without mercury-containing backlight technology)
- Housing (often made of plastics)

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[21] http://net.trinitechconsulting.com/ftp/class/Week2/Introduction%20to%20Computer%20Hardware%20and%20Components.pdf

[22] http://www.el-kretsen.se/sites/el-kretsen_se/files/pressrelease_2016.pdf

[23] Upphandlingsmyndigheten (2018). TV. http://www.upphandlingsmyndigheten.se/hallbarhet/stall-hallbarhetskrav/it-och-telekom/av-produkter/tv/

[24] http://www.audiolabga.com/pdf/37LC7D.pdf

- AC adapter
- Plastic stand or wall mounting
- Remote control
- Metallic screws

The plastic components in TVs are generally treated with flame retardants.

2.3.4 Refrigerators and Freezers

In 2016 more than 610,000 refrigerator and freezers were sold in Sweden. The average annual sales during the period 2010-2015 were around 560,000 units.[25] On a European level it was estimated that around 19.5 million units were sold in the EU-28 in 2015. This means that the sales in Sweden represent slightly less than 3 percent of total sales. According to data used in the final report of the preparatory review study of the existing Ecodesign and Energy Label regulations for household refrigeration appliances, the total product life of the average refrigerating appliance is around 16 years. Commonly this age can be divided in two phases where it takes 12-13 years up to first replacement (in the kitchen) followed by 3-4 years in secondary use. Data also show that the product life time varies across different countries in the EU.[26]

Refrigerators and freezers come in several different types and of varying size. They can be of the type built-in or stand-alone, and specifically freezers are produced both as upright and of chest-type, where the latter is top-mounted. There are also compact (small) versions. Refrigerators and freezers can also be combined to form either combi tops or side-by-sides depending on the setup. For both types the refrigerator and freezer part each have their own compartments (separate external doors). However, regardless of type and size, the basic design, components and materials used are commonly the same. In an environmental declaration by a white goods manufacturer active on the global market, a components and materials content of an up-right standardised refrigerator representative for the product group is given as that seen in Table 2. The total weight of the refrigerator is 68 kg.[27]

Table 2. Components and materials content of a refrigerator produced by a global white goods manufacturer[28].

Components and materials		Percentage (wt%)
Iron and steel		45-62
Copper		1
Aluminium		1-2
Zink		<0.1
Glass		2.5-3.5
Polymers:	Isolation (PUR)	8-12
	Others	8-12
Rubber		<0.1
Electronics		<0.4

[25] Ernstsson, B. (2018). Personal communication with Bengt Ernstsson, EHL.
[26] Preparatory/review study; Final report - Commission Regulation (EC) No. 643/2009 with regard to ecodesign requirements for household refrigeration appliances and Commission Delegated Regulation (EU) No. 1060/2010 with regard to energy labelling of household refrigeration appliances (2016).
[27] Miljödeklaration (Environmental product declaration) Electrolux Kylskåp - ERC37320W.
[28] Miljödeklaration (Environmental product declaration) Electrolux Kylskåp - ERC37320W

Compressor	16-20
Isolation gas/blowing agent	0.2-0.3
Refrigerant/cooling agent	<0.1

The standard materials content of a compressor as that presented in the table above is seen in Table 3.

Table 3. Materials content of a standard compressor used in a refrigerator[29].

Materials content of a refrigerator compressor	Percentage (wt%)
Iron and steel	80
Copper	12
Aluminium	3
Oil	4
Plastics	1

Recently there have been fridges and freezers showing up on the global market with touch screen displays integrated in the doors and also cameras placed inside the cabinets. This exemplifies what "smart" household cooling appliances can look like as it is also possible to connect such products to the Internet and therefore interact with them using e.g. smartphones. This means that more electrical components are added to the products. The addition of such electrical components might lead to a more demanding and thus more time-consuming recycling process when these products reach their end of life. If the screens are of LCD type and has a surface area larger than 100 cm^2 they should according to the WEEE Directive be removed from collected refrigerators before the rest of the products proceed down the recycling production line.

2.3.5 Washing machines

According to the definition given by Commission Delegated Regulation No. 1061/2010[30] and Commission regulation No. 1015/2010[31] a "'household washing machine' is an automatic washing machine which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes."

According to the Prodcom data, the total volume of produced household clothes washing and drying machines in EU28 declined from 27.7 million units in 2007 by 26 percent to 20.5 million units produced in 2013. Poland, Italy and Germany are the main Member States (for which data are available) producing "clothes washing and drying machines", followed by Spain and France.[32]

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[29] Miljödeklaration (Environmental product declaration) Electrolux Kylskåp - ERC37320W.

[30] Commission Delegated Regulation (EU) No 1061/2010
of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household washing machines

[31] Commission Regulation (EU) No 1015/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines

[32] Boyano Larriba, A., Cordella, M., Espinosa Martinez, M., Villanueva Krzyzaniak, A., Graulich, K., Rüdinauer, I., Alborzi, F., Hook, I. and Stamminger, R., Ecodesign and Energy Label for household washing machines and washer dryers, EUR 28809 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74183-8, doi:10.2760/029939, JRC109033

In 2012, Whirlpool was the number 1 global player manufacturing white goods. The European white goods industry was dominated by seven major players. BSH Hausgeräte ranked number one in Europe followed by Electrolux as number 2 (both at European and global level). Indesit (later bought by Whirlpool) and Whirlpool were number 3 and 4, respectively, in Europe. These four players were followed by Samsung, LG and Miele. When it comes to washing machines only, the key manufacturers in Europe are Arcelik Group, BSH Group, Electrolux Group and Whirlpool-Indesit Group.[33]

The composition and design of washing machines differ among brands and markets. They can be front-loaded or top-loaded where front-loaded washing machines are the most common on the European market. There are, however, a number of basic design structures that are common for most washing machines. For example washing machines are (on a weight basis) almost entirely made of metal (steel, copper, aluminium, stainless steel and their alloys), diverse plastics and other organic materials. In addition to metals and plastics, washing machines contain low-value printed wire boards (PWB) and electronics containing precious and platinum-group metals. The balance weight, often composed of concrete, also represent a significant share of the weight of the washing machine. An average composition of a washing machine from UNEP is presented in Boyano Larriba et al. (2017)[34], however without specifying geographical and technical representativeness.

Table 4. An average composition of a washing machine[35].

Material	Percent (%)
Iron and steel	52.1
Copper	1.2
Aluminium	3.1
Stainless steel	1.9
Brass	0.1
Plastics	6.8
Rubber	2.8
Wood	2.6
Other organic material	0.1
Concrete	23.8
Other inert material	1.9
PWB	0.4
Cables (internal / external)	1.1
Other materials	2.2
Total	100

Differences that can have an impact on the material composition are for example the balance weight. Washing machines require some kind of weight to keep the machines stable during centrifugation. An average front-loaded washing machine

[33] Boyano Larriba, A., Cordella, M., Espinosa Martinez, M., Villanueva Krzyzaniak, A., Graulich, K., Rüdinauer, I., Alborzi, F., Hook, I. and Stamminger, R., Ecodesign and Energy Label for household washing machines and washer dryers, EUR 28809 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74183-8, doi:10.2760/029939, JRC109033
[34] Ibid
[35] Ibid

weighs between 65-75 kg of which 25 kg is concrete block. The concrete blocks are usually placed under the tub at the front and on top. If the balance weight is made of steel instead of concrete, the content of ferrous metals increase, and correspondingly the content of concrete decrease. There are, however, alternatives to concrete and metal. Researchers in the UK have for example developed a plastic counterweight to replace the concrete blocks. The plastic counterweight is hollow until delivery and then filled with water. This solution could save fuel during transportation, cut carbon emissions and reduce back injuries according to the researchers. [36] There are also examples when the weight is made of steel.

Another difference that can influence the weight of the washing machine is if a permanent-magnet synchronous motor (PMSM) is applied, which reduces the weight of the washing machine by a few kilos. In cases where heat pumps are used about 10 kg of additional components are required such as copper pipes, a compressor system with an electric motor, a heat-exchanger and a control unit.

A washing machine has two steel tubs. The inner tub holds the clothes, and is perforated with holes to make the water leave when the tub spins. The outer tub seals in the water and is bolted to the washing machine's body. The inner drum is sometimes covered with porcelain to prevent corrosion.[37]
There are commonly two water inlets, and the water is heated by a radiator. A drainage pump makes sure waste water is pumped out through a water outlet.
The following trends in the washing machine sector can be expected for the next years:[38]

- The trend moves towards washing machines with a capacity over 8 and up to 13 kg that replace washing machines with lower capacity.
- Less water consumption.
- Shorter durability
- Greater attention on exterior design
- More features of the programmes offered in the machines.

2.4 Dismantling study of smartphones

As part of the project a dismantling study of smartphones present in the Swedish WEEE stream was performed. The study was based on the possibility to access and remove batteries used in smartphones. The study was carried out at El-Kretsen's facility in Arboga (Sweden) where statistics on the Swedish WEEE stream is generated. Annually, 1.5-2% of the Swedish WEEE stream flows through the facility to be characterised. In total 538 smartphones were examined. The study was based on two dismantling criteria, namely;

[36] BBC News (2017). http://www.bbc.com/news/uk-40821915
[37] Recycle Nation (2015). https://recyclenation.com/2015/02/how-to-recycle-washing-machines/
[38] Boyano Larriba, A., Cordella, M., Espinosa Martinez, M., Villanueva Krzyzaniak, A., Graulich, K., Rüdinauer, I., Alborzi, F., Hook, I. and Stamminger, R., Ecodesign and Energy Label for household washing machines and washer dryers, EUR 28809 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74183-8, doi:10.2760/029939, JRC109033

1. Can the battery be reached without the need of any tools?
2. Can the battery be easily removed by hand (i.e. without the need to pull the battery loose)?

3. Experiences of using environmentally differentiated fees

The project group barely found any research in which experiences of environmentally differentiated fees were compiled or investigated. In the initial stage of the study, WEEE Forum was contacted for a first brief overview of the situation in Europe regarding modulated producer responsibility fees for EEE. It soon became clear that France is a clear exception as the only country in the EU and Europe that applies modulations of the producer responsibility fees for EEE. There are furthermore examples where differentiated producer responsibility fees to promote environmentally friendly products are under discussion within the EU. In the following chapter the focus is therefore put on experiences from the French modulation fee system for WEEE together with experiences from a Danish study carried out on behalf of the Danish EPA about implementing differentiated fees for EEE. In addition, examples and experiences from differentiated producer responsibility fees for other product groups under producer responsibility obligations, in this case packaging, are presented.

The Circular Plastics Platform has issued a position paper regarding the subject regarding packaging where they highlight important aspects to consider when introducing a differentiated fee system[39]. They stress among other things that fee modulation should be based on clear identifiable parameters and that the reporting should be easy without extra cost burden. The differentiation criteria need regular review due to constant technological advances. Factors to be assessed should be common across different countries so that producers do not have different incentives in different countries. A fee modulation must be applicable to all competing EPR schemes in the country, and when choosing criteria for the fee modulation it is important to consider and to maintain the functionality of packaging such as legal constraints regarding health and safety, and that common cost still must be fairly allocated to all packaging materials. The reporting should be reasonable for the producers without adding extra administrative- or cost burdens.

The idea of having differentiated fees (or modulation of fees) is also highlighted in the so-called EU plastic strategy[40] launched by the EU Commission in January 2018. The Commission will according to the strategy provide guidance on how to ensure effective modulation of fees paid by producers. Modulation of fees for plastic packaging is specifically mentioned as an example. The Commission states that modulation of fees only can lead to results if it provides “meaningful financial reward in return for more sustainable product design choices”. Commission guidance on the “eco-modulation” of EPR fees is planned for 2019 according to the strategy.

[39] CPP Position Paper Fee Modulation System in EPR Schemes for Packaging, October 2017.
[40] A European Strategy for Plastics in a Circular Economy. COM (2018) 28 final.

3.1 France

The French system with fee modulations first came into force in 2010 after discussions in 2008 and 2009 by the different stakeholders, including PROs, an environmental NGO, producer representatives and recyclers. This first phase of the system contained six product types, namely, refrigerators/freezers, vacuum cleaners, mobile phones, tablets, TVs and lamps. The French EPA (environmental protection agency) (ADEME) had the final say about the criteria used in the first version. After being used for five years, an updated version of the system was launched in 2015 and seven more product types were added to the initial six. Product types added were washing machines, dishwashers, coffee makers/kettles/tea makers, computers (both laptops and desktops), printers, electric drills/screwdrivers and game consoles. Along with the new product types also a set of new criteria was implemented. The second phase will continue until 2020.

The modulation system is based on a bonus-malus approach (rewarding and penalizing) where producers who meet certain requirements (criteria) pay a lower fee whereas those who do not pay a higher fee. Specific percentages are used for the modulation. In the WEEE Directive 2012/19/EU one can read in the Preamble and Recital 23 that *"Collective schemes could provide for differentiated fees based on how easily products and the valuable secondary raw materials that they contain could be recycled"*.[41] The purpose of the French modulation system is in short to encourage producers to place easily recyclable and repairable products on the market and reduce the environmental impact of these products when they reach their end of life.[42] The criteria used in the system are based on the following overall aspects:

- Product repairability and reuse potential
- Content of hazardous substances in product
- Product recyclability
- Product durability and life time

In France there are currently three PROs for WEEE; Eco-systèmes, Ecologic and Récylum. Récylum only deals with lamps whereas the other two handles EEE with the exception of lamps. There is also a fourth PRO focused on photovoltaics (PVs), PV CYCLE, but PVs is not a product type included in the current modulation system. Eco-systèmes is the largest WEEE PRO with a market share of 75 percent of EEE put on the market.[43] The producer responsibility fee is in the French system called éco-participation. In 2015 Eco-systèmes audited more than 15 percent (based on weight) of the products declared by its member producers in 2013 and 2014. The share of 15 percent is also the minimum level that should be audited each year.[44] In 2015 a total of 27 companies were screened which together represented 21 percent

[41] European Commission (2012). Directive 2012/19/EU on on waste electrical and electronic equipment (WEEE). http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0019&from=EN. [Accessed on 2018-03-26]
[42] Eco-systèmes (2016). Eco-systèmes annual report 2015 (Rapport annuel 2015)
[43] WEEE Forum (2017). "The EPR journey in France", Alain Grimm-Hecker. WEEE Forum Conference 2017. http://www.weee-forum.org/system/files/news/day_two_alain_grimm-hecker_epr_journey_in_france.pptx. [Accessed on 2018-03-26]
[44] Assimon, P-M. (2018). Personal communication with Pierre-Marie Assimon, Eco-systèmes.

(based on weight) of the products put on the market. The audit was carried out by EY[45]. The most frequent errors found was that the gross weight (product together with packaging, instructions and batteries) was declared instead of the product net weight, differences between the éco-participation to be paid for products and what éco-participation that was actually paid, and finally that the scale for the modulated fees was poorly applied. To help audited member companies improve their declarations and become more reliable, Eco-systèmes followed up the auditing by producing an individual report for each company to help them better understand and apply the reporting and regulation procedures. Eco-systèmes also has a team that supports its member producers with compliance-related issues and keep them informed on regulatory developments etc. In addition, Eco-systèmes develops various informative tools for producers to use when they develop new products. For example, there is a tool on recyclability.

Whether or not the system with modulated fees has made producers change their design of products covered by the system is too early to say. The first version of the system was comparatively narrow and the second version which contains more product categories and criteria has only been running for 2.5 years. To be able to detect a shift in the market requires more time and the criteria which are used at present need to be maintained before possible trends can be expected. Market dynamics also need to be considered which could mean that changes might be more clearly visible for products which are developing quickly and/or have relatively short use phases (e.g. smartphones) compared with products that develop more slowly and are usually kept for a longer time by users before being replaced (e.g. white goods). A second thing is that for some product categories it is enough to meet one out of two or more criteria to fulfill the requirements needed to be awarded with a bonus. It can also be the other way around, that it if one out of two or more criteria is not met, that results in a penalty. The point is that it can be difficult to distinguish which of the criteria used that primarily lead to changes in product design. Another important aspect is that even though France is a relatively large market, the incentive for producers to make changes in how they design products is believed to be much bigger if the system was implemented on an EU level.[46]

Table 5 and Table 6 show the criteria used in the French system for the five product categories focused on in this study, as well as the modulations and fees applied.[47][48] According to French law, fees should be visible to consumers, however, the fees are shown in their "unmodulated" form (i.e. the fees that apply when criteria are not met). As an example, the fee shown to a consumer for a mobile phone will therefore be 0.04 Euro which is the fee applied when one or both of the criteria for this product category apply.

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[45] Eco-systèmes (2016). Eco-systèmes annual report 2015 (Rapport annuel 2015)
[46] Assimon, P-M. (2018). Personal communication with Pierre-Marie Assimon, Eco-systèmes.
[47] OCAD3E (2015). Technical report Application of environmental contribution modulation criteria. https://www.ecologic-france.com/component/cck/?task=download&file=seb_media_document&id=15398. [Accessed on 2017-10-12]
[48] Eco-systèmes (2017). Eco-systèmes contribution scale - Household EEE. https://www.eco-systemes.fr/uploads/documents/hidden/English%20eco-fee%20scale/ContributionScale_01032017.pdf [Accessed on 2017-10-12]

Table 5. Criteria and modulated fee percentages in the French system for the five product categories focused on in this study.

Criteria	Refrigerator	Washing machine	Computer*	TV	Mobile phone
1	Presence of refrigerant with GWP>15	Provision of essential parts for equipment use for 11 years	Absence of paint and coatings incompatible with recycling and reuse on plastic parts >100g,	Provision of technical documentation for electrically authorised repairers and essential parts for equipment use (electronic boards) for 5 years	Lack of standardised connections (charger and other connections)
2	**or** Failure to provide technical documentation for electrically authorised repairers	**or** Incorporation of post-consumer recycled plastic (minimum threshold of 10%)	**and** Incorporation of post-consumer recycled plastic (minimum threshold of 10%)	**or** Incorporation of post-consumer recycled plastic (minimum threshold of 10%)	**or** Lack of mutually compatible software updates, essential for the basic use of the device
3	**or** Unavailability of essential spare parts for equipment use		**and** Product upgrade with standard tools, including memory drives, chips and cards		
Contribution modulation	**+ 20%**	**- 20%**	**- 20%**	**- 20%**	**+ 100%**
Criteria application rules	*If **one (or more) of the 3 criteria applies/apply** to the EEE, the contribution is increased by +20%*	*If the EEE **meets one of the 2 criteria or both**, the contribution is reduced by -20%*	*If the EEE **simultaneously meets the 3 criteria**, the contribution is reduced by -20%*	*If the EEE **meets one of the 2 criteria or both**, the contribution is reduced by -20%*	*If **one (or both) of the criteria applies/apply** to the EEE, the contribution is increased by +100%*

Table 6. Producer responsibility fees for fulfilled and not fulfilled criteria in the French system for the five product categories focused on in this study.

	Refrigerator			Washing machine	Computer	TV					Mobile phone
Net weight (kg) or screen size (")	> 80 kg	<= 80 kg and > 40 kg	<= 40 kg		Laptop >= 7"	> 25 kg	<= 25 kg and > 17 kg	<= 17 kg and > 12 kg	<= 12 kg and > 7 kg	>= 7 kg and >= 7"	
Fulfilled – amount (€ excl. VAT)	16.67	13.33	6.67	6.00	0.34	10.00	7.34	4.66	3.34	2.00	0.02
Not fulfilled – amount (€ excl. VAT)	20.00	16.00	8.00	7.50	0.42	12.50	9.17	5.83	4.17	2.50	0.04
	+ 20%			- 20%	- 20%	- 20%					+ 100%
	…one (or more) of the 3 criteria applies/apply…			*…meets one of the 2 criteria or both..*	*…simultaneously meets the 3 criteria…*	*…meets one of the 2 criteria or both…*					*…one (or both) of the criteria applies/apply…*

3.2 Italy

The Ministerial Decree 140[49], enforced since august 2016, defines "criteria and ways for pushing the eco-design and manufacturing of EEE". The main theme is the mechanism to reward producers of EEE that put EEE on the market, which has low environmental impacts. This theme was managed in a bureaucratic way as the reward that can be obtained is not high enough if compared to the documental effort needed to demonstrate the eco-design, and in a way not harmonized at European level. Additionally the differentiation model in the Decree for calculating the differentiated fee was wrong considering it could lead to a situation in which every producers can benefit of the reduced fee. In that case there would not be enough money to cover the recycling activities in the whole country. The result of this complicated Decree is that, since 2016, there was no EEE Producer that applied for having a differentiated fee.[50]

3.3 Denmark

The Danish EPA conducted a review published in 2014 regarding a potential implementation of an environmentally differentiated allocation of waste treatment cost for WEEE in Denmark[51]. The intention was to influence the design of products and thus promoting more environmentally sound products as well as phasing out products with poor environmental performance.

The following approach was proposed in the review:

- The yearly costs for collection and treatment of each of the WEEE categories would be calculated (excluding the income from sales of material after treatment).
- The environmental criteria for the differentiation would be decided; the market development over the coming years would also be evaluated and taken into consideration when setting the criteria.
- The size of the differentiation would be decided.
- Producers and importers would report the amounts and number of products put on the market to the Danish producer responsibility system.
- The costs for collection and treatment of WEEE would be distributed between the producers and importers depending on the number of products put on the market, and how they are evaluated in the differentiated allocation.

Some potential problems identified were:

- Rapid technological development has a tendency to quickly out-phase static allocation criteria.

[49] http://www.gazzettaufficiale.it/eli/id/2016/07/23/16G00150/sg
[50] Campadello, L (2018). Personal communication with Luca Capadello, Ecodom, Italy.
[51] Danish EPA (2014). Ressourcepræmie og miljødifferentieret betaling for elektronikaffald - Analyse af to styringsmidler til at reducere miljøbelastningen fra udvalgte typer småt elektronikaffald , Miljøprojekt nr. 1560, 2014.

- To increase the incentive for manufacturers to produce more environmentally friendly products the economic incentive would need to be quite large. Due to the fact that the fees only entail costs for collection and treatment, the overall economic incentive with a differentiation would be limited.
- An isolated differentiated fee for Denmark would lead to a limited environmental impact because the producers work on a global market where Denmark constitutes only a limited turnover of products.

A problem that was raised in the review was also that raw material market prices often result in a net profit for the producers due to sales of the treated material. To create an economic incentive in the system the profits made from sales of the treated material cannot be taken into account. Instead the system needs to focus on the costs for collection and treatment. However the economical driver would still be low since the waste management cost of the products constitutes only a fraction of the total costs.

The conclusions from the review were that an isolated Danish system would not have the desired effects. Solutions that were proposed instead were:

- A European legislation of differentiated fees would have the possibility to make an impact due to the larger market in Europe.
- Introducing a labelling system that sends a clear message to consumers about which products that are more environmentally friendly than others.

3.4 Packaging

The project group has found two examples of systems where differentiated fees for packaging are used, CITEO in France and CONAI in Italy. The structure of the systems are briefly explained below followed by the plans of Förpacknings- och tidningsinsamlingen's, the largest PRO for packaging in Sweden, to introduce differentiated fees for plastic packaging.

3.4.1 CITEO, France

In France the organisation CITEO (previously Eco-Emballages) is responsible for the French national system for household packaging. CITEO has introduced a bonus-penalty system for packaging. The purpose is to encourage producers to design packaging that is more environmentally sound, but also to raise consumer awareness regarding the importance of source-separation of packaging.[52]

The bonus is given depending on four different main criteria: On- and off-packaging awareness information and reduction at source or recyclability (listed in Appendix 1). Additional bonus is granted if the measures implemented are published in the good practice catalogue. The bonus is given only for household packaging and only applies for the first year that it is placed on the market meaning a measure implemented one year is only applicable for bonus for that particular year.
The on-packaging awareness means that the household packaging should entail sorting guidelines. The information must be visible when purchasing or consuming

[52] Eco Emballages Declaration Manual 2016

the product, or on a leaflet or user instruction. The off-packaging awareness can for example be in the form of a QR code with guidelines on a linked website or awareness raising as a media campaign.

3.4.2 CONAI, Italy

CONAI (Consorzio Nazionale Imballaggi), the National Packaging Consortium in Italy is a private non-profit consortium where packaging producers and packaging users have joined in order to achieve the legal recycling and recovery target of packaging waste. CONAI works with recycling of six packaging materials; steel, aluminium, paper, wood, plastic and glass. For plastic packaging, a differentiation fee in Italy referred to as Contribution Diversification has been decided and started to apply from the 1st of January 2018[53].

The Italian producer responsibility system is based on companies paying a contribution (fee) depending on the type of packaging put on the market. By using the contribution as a lever CONAI hopes to encourage a reduction of the environmental impact of plastic packaging by promoting the use of more sortable and recyclable packaging.[54]

The guiding principles for the contribution diversification are: Sortability, Recyclability and the Main target (household or commerce & industry). Specific criteria are presented in Appendix 3.

In order to keep up with the technological advances in the sorting and recycling systems, a permanent technical assessment committee has been established. They will make sure that the system is up-to-date and suggest changes when needed.

3.4.3 Förpacknings – och tidningsinsamlingen in Sweden

Förpacknings- och tidningsinsamlingen (FTI) is the largest EPR system in Sweden for packaging. FTI works on behalf of the producers to help them meet their producer responsibility obligations, and provides a national collection system for packaging waste.

FTI has recently published guidelines targeted on producers of plastic packaging about how to design plastic packaging in order to facilitate recycling. The basis is that plastic packaging should be produced of polymers that can be sorted and recycled in the existing sorting and recycling systems, and that there should be a market for the polymers as recycled material. Similar guidance is planned for paper and metal packaging.

FTI is planning to differentiate their packaging fees for plastic packaging from April 2019. The basis is that producers fulfilling certain conditions that facilitate recycling of plastic packaging (in terms of raw materials, market for the recycled plastic type,

[53] Conai (2017). Contribution diversification decided for plastic packaging. http://www.conai.org/en/businesses/environmental-contribution/contribution-diversification/
[54] Conai (2017). Contribution Diversification for Plastic Packaging. http://www.conai.org/wp-content/uploads/2017/02/Technical_Guide_Contribution_diversification_for_plastic_packaging.pdf

use of glue, ink etc.) are rewarded with a lower producer responsibility fee.[55] At the time of writing it is not known how the differentiation will be structured in detail.

4. Possible criteria as basis for differentiation

To look for possible criteria that could form a basis for differentiation, the project group took inspiration from existing criteria within existing differentiation systems presented in Chapter 3, as well as criteria used for several ecolabels, namely for TCO Certified, the Nordic Swan, and the Blue Angel, together with criteria used within EU Green Public Procurement (EU GPP). Existing criteria that favour more easily reusable and recyclable products were compiled and analysed rather than developing completely new criteria. The reason was that developing criteria on a detailed level to form basis for differentiation would require multiple stakeholder interventions and targeted research, which was not possible within the scope of this project. The criteria used within the different ecolabels as well as in EU GPP have been established and analysed in cooperation with various stakeholder groups.
A discussion about which criteria that could be suitable for differentiation is found in Chapter 6.

Besides identifying existing criteria used as basis for differentiation, variations within the selected product groups were looked into. This was made by interviewing the actors participating in the project. In addition, a desktop study was carried out to identify variations within product groups including filmed dismantling tests. The desktop study was limited to products currently put on the market.

4.1 Criteria in ecolabelling and in EU Green Public Procurement (GPP)

All product groups in focus of the study can be marked with several ecolabels. The ecolabels do not only take reuse and recycling aspects into consideration, but environmental aspects in a broader sense, for example content of hazardous chemicals, emissions to air, water and soil, energy efficiency, water usage and waste management. Aspects from production to use and end-of-life management are often taken into consideration.

It is possible to achieve the Nordic Swan Ecolabel for all product groups of focus in the study except for smartphones. The Blue Angel can be achieved for laptops and TVs. TCO Certified is aimed at IT products why smartphones and laptops are possible to certify.

Also, the European criteria for green public procurement (EU GPP) figured as example of criteria possible to use as basis for differentiation. There are currently criteria for laptops within EU GPP. The criteria are divided into *Selection criteria* and *Award criteria. Selection criteria* are used to select and exclude tenderers, and

[55]Carlsson K (2017). PPT from presentation held on Avfall Sverige's autumn meeting on November 15.

Award criteria are used for evaluating and comparing tenderers.[56] Both *selection* and *award criteria* are divided into *Core criteria* and *Comprehensive criteria. Core criteria* are designed to allow for easy application of GPP, focusing on the key area(s) of environmental performance of a product and aimed at keeping administrative costs for companies to a minimum, whereas *comprehensive criteria* take into account more aspects or higher levels of environmental performance.[57]

Of the eco labels studied, white goods, including washing machines and refrigerators, can only be marked with The Nordic Swan Ecolabel. Version 5.4 of the Nordic Ecolabelling requirements for white goods (refrigerators and freezers, dishwashers, washing machines and tumble dryers) is valid until December 31st 2020. According to the Nordic Swan Ecolabel the greatest environmental impact caused by a white good comes from its use why the criteria are focused on white goods' use phase[58]. Criteria for the German environmental label "Blue Angel" for household washing machines was published in January 2013, but is no longer valid as the interest from the industry of ecolabelling washing machines was scarce[59].

Laptops and TVs can achieve the Nordic Swan Ecolabel and the Blue Angel Ecolabel, as well as becoming certified according to TCO Certified. The current criteria focusing on recycling for laptops, TVs and smartphones within the certification systems are summarised in Appendix 1.

There are currently no laptops marked with the Nordic Swan Ecolabel. Two companies; Philips Professional Display Solutions and Samsung Electronics Nordics AB, have TVs marked with The Nordic Swan Ecolabel.

4.1.1 EU Green Public Procurement

Green Public Procurement (GPP) is defined by the EU as "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured".[60]

Green public procurement (GPP) can help stimulate demand for more sustainable products. In the EU Action Plan for the Circular Economy, public procurement is recognised as a key driver in the transition towards a circular economy. The action plan sets out actions for the EU Commission to take to integrate a circular economy perspective, for example integrating circular economy aspects into the EU GPP criteria.[61]

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[56] European Commission (2016). Buying green! A handbook on green public procurement. 3rd Edition.
[57] European Commission (2016). Commission staff working document. EU GPP Criteria for Computers and Monitors.
[58] http://www.svanen.se/en/Criteria/Nordic-Ecolabel-criteria/Criteria/?productGroupID=2
[59] German Environment Agency (2018). Personal communication with Elke Kreowski.
[60] European Commission (2017). Public procurement for a circular economy. Good practice and guidance.
[61] European Commission (2017). Public procurement for a circular economy. Good practice and guidance.

In June 2010 a new process for the EU GPP criteria was implemented to make the process more transparent to stakeholders, and to create synergies between different product-related policy instruments. It is the Joint Research Centre's Institute for Prospective Technological Studies, JRC-IPTS), based in Seville, that leads the process for criteria development. The process starts from an annual work plan, which is coordinated with the work plan of The EU Ecolabel. This work plan is approved in consultation with an informal advisory group within EU GPP named GPP AG. GPP AG acts as a consulting body on behalf of the EU Commission in general procurement politics, and for the development for EU GPP's criteria. GPP AG consists of one representative from each member state together with five stakeholder representatives (civil society, industry, SMEs, public procurement and a local authority).[62]

EU GPP's process is to a high extent following the EU Ecolabel's process for criteria development. Stakeholders are invited to comment on documents and drafts during several steps in the process. All information about the development of new criteria and revision of existing criteria is provided by JRC-IPTS, and is based on product groups.[63]

EU GPP includes criteria for a number of product categories, for example computers. There are criteria for the areas "product lifetime extension", "hazardous substances" and "end-of-life management". The end-of-life management section consists of criteria focusing on plastic casings, enclosures and bezels where components greater than 100 grams in mass with a surface area greater than 50 cm^2 shall be marked in accordance with ISO 11469 and ISO 1043-1. Paints and coatings on plastic casings, enclosures and bezels "shall not significantly impact upon the resilience of plastic recyclate produced from these components upon recycling and when tested according to ISO 180 12 or equivalent". "Parts shall not contain moulded-in or glued-on metal inserts unless they can be removed with commonly available tools. Disassembly instructions shall show how to remove them." Besides, there is a criterion awarding points for the time-efficient manual dismantling and extraction of PCBs (printed circuit boards) with a surface area larger than 10 cm^2, rechargeable batteries and HDD (hard disk drives) and optical drives (excluding SSD – solid-state drive) from portable computers. The maximum time required to extract them shall not exceed 600 seconds.[64]

In Sweden, The National Agency for Public Procurement (Upphandlingsmyndigheten) provides support for public procurement by providing knowledge, tools and methods. The agency's criteria are ready-to-use requirements that can be used by the public sector in order to accomplish more sustainable procurements. The criteria are voluntary to use and are developed to facilitate the procurement process as they are harmonized with procurement rules and current

[62] European Commission (2016). Process for setting criteria. http://ec.europa.eu/environment/gpp/gpp_criteria_process.htm
[63] European Commission (2016). Process for setting criteria. http://ec.europa.eu/environment/gpp/gpp_criteria_process.htm
[64] European Commission (2016). COMMISSION STAFF WORKING DOCUMENT EU GPP Criteria for Computers and Monitors. Brussels, 21.10.2016. SWD(2016) 346 final.

legal praxis. They are also meant to be a driving force meaning that they put higher requirements than what is required by law. The criteria are divided into three levels: basic, advanced and cutting-edge.

The National Agency for Public Procurement's criteria are focused on energy efficiency, but has an interest in looking at possibilities to include a circular perspective to a higher extent. The criteria are developed in cooperation with expert groups including procuring authorities, retailers, manufacturers, researchers, expert public agencies, representatives from ecolabels, and other stakeholders. There is a dialogue about what areas should be subject to criteria, and what areas that are possible to put requirements on. Among the product groups studied, the agency provides criteria for a sustainable procurement of TVs and laptops, but not for the reuse and recycling aspects. For the time being, criteria for computers and monitors are under consideration until January 30th 2018. In this case, the criteria are based on criteria set by the EU, where both reuse and recycling is included.

4.2 Criteria for reuse

According to the waste hierarchy, reuse is the second-best option after waste prevention and reduction. Reuse is closely linked to product features such as upgradability, replaceability, repairability and durability. These features can all be seen as measures for product lifetime extensions. Hardware upgradability and repairability are both dependent on replaceability. Repairability concerns the possibility of repairing products and their components and parts if they break. The access to spare parts is therefore an important aspect. To favour repair, components and parts need to be replaceable, at least by professionals and repair workshops, and batteries to be should be easily replaceable, which is often mentioned in ecolabelling. The durability of a product reveals if it is built with a potential to last long if handled normally.

Upgradability concerns both hardware and software (when applicable) and is about being able to increase the capacity of a e.g. laptop by supplying it with more RAM and, among other things, install new updates of the operative system. Warranty could perhaps be something that, at least on a general level, could be used to get a hint of what the brand owners believe about the lifetime of products they put on the market.

4.2.1 Criteria favouring reuse in ecolabelling, EU Green Public Procurement

The existing criteria favouring reuse and life time extension within The Nordic Swan Ecolabel, The Blue Angel and TCO Certified are listed in this sub-chapter, together with criteria in EU Green Public Procurement (EU GPP) and the French EPR system for EEE.

Washing machines and refrigerators

The Nordic Swan Ecolabel is the only ecolabel investigated that provides criteria for white goods; washing machines, refrigerators and freezers. Compliance with the criteria listed in Table 7 are required in order to achieve The Nordic Swan Ecolabel for refrigerators/freezers and washing machines. However, there are currently no washing machines or refrigerators/freezers marked with The Nordic Swan Ecolabel. Criteria for EU Green Public Procurement are not available for white goods.

Table 7. Criteria linked to reusability to be fulfilled by refrigerators and washing machines to achieve The Nordic Swan Ecolabel

Nordic Swan Ecolabel	Refrigerator /freezer	Washing machine
Warranty The manufacturer is to provide a warranty that the white good will work for at least two years. The warranty is to apply from the day that the machine is delivered to the customer.	X	X
Replacement parts The availability of replacement parts shall be guaranteed for 10 years from the time that production ceases.	X	X

Laptops, TVs and smartphones

Among the three ecolabels, the Blue Angel has the most recently updated criteria for mobile phones and laptops, dating back to July and January 2017, respectively. The Blue Angel and TCO Certified do not have criteria for TVs. The Nordic Swan, which has criteria for TVs and computers (including laptops), but not for mobile phones, had its latest criteria versions for these product types introduced in 2013. For laptops, the Blue Angel has twice as many criteria connected to reuse as each of the other two ecolabels. However, the criteria connected to reuse used by the ecolabels are all closely related and the most common are further described below.

EU GPP has criteria for computers, and therefore also laptops, but neither for TVs nor for smartphones. Criteria favouring reuse in EU GPP fall under the category "Product lifetime extensions", which is one out of four distinct categories used. The specific criteria favouring reuse of laptops, TVs and smartphones are due to their high numbers listed in Appendix 1.

4.2.2 Availability of spare parts and repair/repairability – Lifetime extension

All ecolabels have criteria that require that spare parts should be available for a certain time after the production of a product has ended. For TVs the Nordic Swan requires that "the availability of compatible electronic replacement parts shall be guaranteed for seven years from the time that production ceases". The Nordic Swan does not have a similar criterion for laptops. For mobile phones and laptops, TCO Certified demands that brand owners guarantee the availability of spare parts for at least three years from the time the production ceases. The Blue Angel requires in turn a period of at least three years for mobile phones and at least five years for laptops. Both TCO Certified and the Blue Angel specify what to consider as relevant spare parts in this context. TCO defines spare parts as such parts that have the potential to fail during normal use of the product. Parts that usually live longer than the average usual life of the product do not need to be categorized as spare parts. When the cost for replacing a broken part exceeds the cost for replacing the whole product, the part does not have to be considered a spare part according to TCO. The Blue Angel has the same angle to it and defines spare parts as those "parts which, typically, may fail

or break down within the scope of the ordinary use of a product, especially batteries, displays and front glasses". The criterion for mobile phones states further that "mobile phones shall be so designed as to enable qualified specialist workshops to replace such spare parts with reasonable effort". From what is said about spare parts for laptops it is clear that laptops do not tend to break as easily and/or as often as mobile phones. A special emphasis is put on batteries, which is the type of laptop spare part that the Blue Angel demands must be available for at least five years following the end of production.

EU GPP has a criterion on repairability and replacement of components and parts, which is further divided into three sub-criteria. The criterion states that "the tenderer shall guarantee the availability of spare parts […] for at least three years from the date of purchase". There is also a baseline of what spare parts that as a minimum should be included. For computers there are three parts that "shall be easily accessible and replaceable by the use of universally available tools […]". A second criterion asks of the tenderer to provide a price list for spare parts and the labour for performing reparations. This is to assure that repair operations are economically attractive.

4.2.3 Warranty

When it comes to warranties, or commercial guarantees, which is the term used by the Nordic Swan, the ecolabel requires for TVs that "the manufacturer shall offer a commercial guarantee to ensure that the product will function for at least two years". The guarantee shall be valid from the date of delivery to the customer. The Nordic Swan does not have a similar criterion for laptops. For mobile phones and laptops, TCO Certified demands that brand owners shall provide a product warranty for at least one year on all markets where the product is sold. The Blue Angel does not have a warranty criterion for laptops but does have one for mobile phones that states that "the applicant undertakes to offer a free minimum two-year warranty on the mobile phone, except for the batteries". When it comes to the battery, "the applicant shall offer a free minimum 1-warranty on the battery which covers a remaining capacity of at least 90%, provided that the phone is properly used and charged with the manufacturer's own or another suitable charging device".

EU GPP states that a minimum two-year warranty shall be provided and become effective from the delivery of the product. Except that the warranty shall cover repairs and replacements, it shall also include a service agreement for pick-up and return or on-site repairs. There is also an "awarding" criterion that awards warranty periods that go beyond the minimum level of two years.

4.2.4 Replaceability of the battery

Both TCO Certified and the Blue Angel have criteria that batteries should be replaceable. For TCO the criterion concerns mobile phones but not laptops. The battery in a mobile phone should be possible to replace by the end-user or a qualified professional. The Blue Angel applies this type of criterion both for mobile phones and laptops. Mobile phones should be designed in a way that allows the user to replace the battery without special expert knowledge and without damaging the phone. When it comes to laptops their design should allow for an easy replacement of batteries without the need for expert knowledge.

The third sub-criterion to the criterion on repairability and replacement of components and parts in EU GPP (mentioned in section 4.2.2) states that rechargeable batteries shall be easy to replace and not be glued or soldered into portable products. It shall be possible for a professional user or repair service provider to replace the battery.

4.2.5 Upgradability/capacity expansion

This type of criterion concerns laptops and is brought up by the Nordic Swan and the Blue Angel but not TCO Certified. The Nordic Swan requires as a minimum that primary memory (often denoted as rapid access memory (RAM)) expansions must be possible. The Blue Angel gives some general information on what to ask of the design of laptops regarding this matter and states that laptops (computers) must provide the expansion options of: (i) replacement or expansion of RAM (if any); and (ii) replacement or expansion of the mass storage (if any).

4.2.6 Other criteria favouring reuse

The remaining criteria from the Blue Angel are about battery capacity, battery durability, software updates and data deletion. The battery capacity should be measured according to a standard procedure outlined in the criteria document. This concerns both mobile phones and laptops. In general terms the criterion requires that batteries deliver an actual performance in accordance to what the manufacturers state they should. Battery durability is about that batteries must achieve a minimum of 500 full charge cycles. Also, after 500 full charge cycles the battery must have in a fully charged state a remaining capacity of at least 90 percent of the nominal capacity if it is a mobile phone battery and at least 80 percent of the nominal capacity if it is a laptop battery.

Software updates and data deletion concern only mobile phones. When it comes to the criterion on software updates the applicant undertakes to offer security updates for the operating system for at least four years from the time productions ceases. It should also be free of charge for the user to update the operating system. The data deletion is about to enable the user to completely and in a safe way delete all personal data without the help of any software. This is clearly to allow reuse of devices. Devices should also include a software function that makes it possible to reset devices to their factory settings.

Just like the Blue Angel, EU GPP has a criterion on battery durability. The more cycles the higher the points awarded. In addition, there are also two criteria on the durability of hard disk drives used in laptops (notebooks) and the durability of the actual laptop and its screen when subjected to physical impact via e.g. accidental drop.

4.2.7 Criteria favouring reuse in the French modulation fee system

All product groups in focus of the study are covered in the French modulation fee system. There is a total of seven criteria focused on reusability and life time extension for the five product types in focus of the study (Table 8 and Table 9). None of the product types share the same criteria even though refrigerators/freezers and washing machines both have a criterion on essential spare parts for equipment use.

Table 8. Criteria on reusability and life time extension for refrigerator/freezer and washing machine in the French modulation fee system.

[Refrigerator/freezer and washing machine]	Refrigerator/freezer	Washing machine
Failure to provide technical documentation for electrically authorized repairers (malus)	X	
Unavailability of essential spare parts for equipment use (malus)	X	
Provision of essential parts for equipment use for 11 years (bonus)	-	X

Table 9. Criteria on reusability and life time extension for laptop, TV and smartphone in the French modulation fee system.

[Laptop, TV and smartphone]	Laptop	TV	Smartphone
Product upgrade with standard tools, including memory drives, chips and cards (bonus)	X	-	-
Provision of technical documentation for electrically authorised repairers and essential parts for equipment use (electronic boards) for 5 years (bonus)	-	X	-
Lack of standardized connections (charger and other connections) (malus)	-	X	-
Lack of mutually compatible software updates, essential for the basic use of the device (malus)	-	-	X

4.3 Criteria for recycling

The existing criteria favouring recycling within The Nordic Swan Ecolabel, The Blue Angel and TCO Certified are listed in this sub-chapter, together with criteria within EU GPP and in the French fee modulation system for EEE. When analysing the criteria from the various sources it becomes clear that criteria favouring recycling are focused on four main aspects; dismantling possibilities, marking of plastics components, exclusion of metal inlays or paint on plastic components, and limiting the number of plastic types used. These four aspects are further looked into at the end of this sub-chapter.

4.3.1 Criteria favouring recycling in ecolabelling, EU Green Public Procurement

The Nordic Swan Ecolabel is the only ecolabel investigated that provides criteria for white goods; washing machines, refrigerators and freezers. Compliance with the criteria listed in Table 10 are required in order to achieve The Nordic Swan Ecolabel for refrigerators/freezers and washing machines. The criteria have a focus on marking of plastic components and marking of the type of refrigerant used. However, there are currently no washing machines or refrigerators/freezers marked with The Nordic Swan Ecolabel. Criteria for EU Green Public Procurement are not available for white goods.

Table 10. Criteria to be fulfilled by refrigerators/freezers and washing machines to achieve The Nordic Swan Ecolabel.

Nordic Swan Ecolabel	Refrigerator/freezer	Washing machine
Plastic parts that weight 50 grams or more must be marking in accordance with ISO 11469. (Cables and plastic parts with a smooth surface of less than 200 mm^2 are excluded from the requirement).	X	X
Type of refrigerant that is used shall be marked on marking plate to ease future recycling.	X	-

Criteria to favour recycling of laptops are available within the Nordic Swan Ecolabel, TCO Certified, the Blue Angel and within EU GPP. TVs can only achieve the Nordic Swan Ecolabel, and smartphones only TCO Certified. The criteria favouring recycling of laptops, TVs and smartphones are due to its high number listed in Appendix 1. Both the Nordic Swan Ecolabel and the Blue Angel provide eight recycling criteria for laptops, TCO Certified one and EU GPP four. TVs have three criteria in the Nordic Swan Ecolabel, and none in the other systems. There is one criterion for smartphones in TCO Certified and two in the Blue Angel.

4.3.2 Criteria favouring recycling in the French modulation fee system

All product groups in focus of the study are covered in the French modulation fee system. There are three criteria focused on recyclability for two of the product groups in focus, namely refrigerators/freezers and laptops. For each product type in the modulation system there are between two to three criteria and both refrigerators/freezers and laptops each have three criteria (Table 11).[65]

Table 11. Criteria on recyclability for refrigerator/freezer and washing machine in the French modulation fee system.

The French modulation fee system	Refrigerators/freezers	Laptops
Presence of refrigerant with GWP>15	X	-
Absence of paint and coatings incompatible with recycling and reuse on plastic parts >100g	-	X
Incorporation of post-consumer recycled plastic (minimum threshold of 10%)	-	X

4.3.3 Marking of certain plastic components

The obligation to mark plastic components according to ISO 11469 and ISO 1043 parts 1-4 to achieve the above mentioned ecolabels are in place for all product groups, and also within EU GPP. For washing machines and refrigerators the limit is set to plastic components with a mass exceeding 50 grams whereas for laptops and TVs the limit is 25 grams and for smartphones 5 grams. There are, however, exceptions made. Cables and plastic parts in washing machines and refrigerators with a smooth surface of less than 200 mm^2 are excluded from the requirement; extruded plastic materials and plastics for light emitters in flat screens are exempted in TVs

[65] Technical report Application of environmental contribution modulation criteria - technical-report-contribution-modulation17042015uk.pdf

according to the Blue Angel, and printed wiring board laminates in laptops, TVs and smartphones according to TCO Certified.

ISO 11469:2016 *Plastics — Generic identification and marking of plastics products* specifies a system of uniform marking of products from plastics materials. The marking system is intended to facilitate handling, waste recovery or disposal. The standard does not specify the minimum size of the item to be marked, and the size of the lettering.[66] Plastic products are defined as articles or stocks shapes of plastic materials for any type of application. ISO 11469 states that markings are to be made during moulding giving the appropriate symbol included in the mould design or by embossing, by melt imprinting or by other legible and indelible marking of the polymer.

The generic identification of the plastics is provided by the symbols and abbreviated terms given in ISO 1043-1, ISO 1043-2, ISO 1043-3 and ISO 1043-4, also set as an obligation in order to achieve ecolabels. The different parts of ISO 1043 represent the following:

- ISO 1043-1, Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics
- ISO 1043-2, Plastics — Symbols and abbreviated terms — Part 2: Fillers and reinforcing materials
- ISO 1043-3, Plastics — Symbols and abbreviated terms — Part 3: Plasticizers
- ISO 1043-4, Plastics — Symbols and abbreviated terms — Part 4: Flame retardants

For components made from a single polymer the marking would be the abbreviated term for the polymer enclosed by > and <. If a mixture (blend or alloy) of polymers is used, the abbreviated terms for the different polymers would be separated by a "+", with the main component in first place. This would then be followed by the other components in the order of their decreasing mass fractions. Products that comprise of two or more components, should preferably be marked so that the primary visible material is identified first, followed by the identification of the other material(s), with the individual materials separated by a comma, for examples laminates. Underlining is used to identify the main component by mass. In many cases, plastics contain additives such as fillers, plasticizers and flame retardants. Therefore, the correct marking may consist of abbreviated terms for the base material(s) plus symbols for the additives described above. Figure 1 exemplifies the marking.

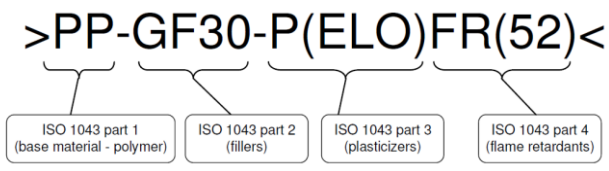

Figure 1. Example of marking according to ISO 1043, parts 1-4.

[66] https://www.iso.org/standard/63434.html

The purpose of the above mentioned ISO standards is primarily to help recyclers identify different plastic types when the products are manually sorted. However, in a Danish study[67] carried out on behalf of the Danish EPA to recommend criteria to be inserted into the Ecodesign Directive several drawbacks of this measure were identified. One main drawback was that manual sorting is only used to a limited extent, and before inserting such a criterion into the Ecodesign Directive it should be examined how future waste treatment of the product groups in question may look like. Marking systems suitable for automatic sorting systems were also seen as relevant to further explore, such as having tags on the products to facilitate automatic sorting. Also, in this project the benefits of having plastics markings have been questioned. Manual sorting was confirmed to only take place to a very limited extent, at least in the Swedish recycling industry, why markings are not helpful. For larger plastic components, such as for TV back panels and drawers in refrigerators/freezers, plastic markings could, however, serve its purpose and help increase recycling.

4.3.4 Manual disassembly

To achieve the Nordic Swan Ecolabel laptops and TVs must be easy to disassembly. This is also a criterion for laptops within the Blue Angel. The criteria might concern specific components to be separated, and type of connections and tools to be used. In a study about development of the Ecodesign Directive from 2015 it was concluded that it was not possible to evaluate whether or not requirements for manual disassembly favours recycling of electrical and electronic equipment. The reason for the doubt was that manual disassembly is being replaced by automatic or more "destructive" processes such as shredding processes in many developed countries why the benefit of being able to manually disassembly the products can be questioned.[68] Some components are still manually dismantled if they contain resources where the value exceeds the extra cost for taking the time to dismantle the item. Some hazardous components are also manually dismantled due to regulations in the WEEE directive.

One hazardous component that needs separate handling is batteries. According to the WEEE Directive batteries have to be removed separately from any separately collected WEEE. This is also valid according to the Swedish regulations on professional pre-treatment of WEEE (NFS 2005:10). The recycler in the project confirms that easier disassembly of batteries would be very useful. The recycling industry experiences difficulties in dismantling batteries as they are often glued or very tightly attached to the product. If not dismantled, the batteries pose a risk in the further treatment as lithium batteries can cause fires. The Blue Angel ecolabel has a criterion for laptops stating that batteries must be possible to remove without tools or with the use of universal tools.

Another criterion that was discussed in the project was facilitation of manual disassembly of printed circuit boards (PCBs) in laptops and smartphones. After shredding, a PCB-rich fraction is currently sent to metal recyclers that extract gold

[67]Bundgaard, A, Remmen, A. & Overgaard Zacho, K. (2015). Ecodesign Directive version 2.0: From Energy Efficiency to Resource Efficiency.
[68] Bundgaard, A.; Remmen, A. & Overgaard Zacho, K. (2015). Ecodesign Directive version 2.0: From Energy Efficiency to Resource Efficiency.

and other valuable metals from the fraction. According to Sims Recycling Solutions it is unlikely that a product design favouring manual disassembly of PCBs would actually lead to manual disassembly as the automated shredding and sorting processes generates a fraction of such quality that the high-value metals can be extracted in the following recycling processes.

Dismantling study of smartphone battery replaceability

Since the possibility to manually remove and replace batteries in smartphones has decreased over the years, the project members thought it would be interesting to investigate to which extent this feature was still present in older smartphones. Today, the share of smartphones put on the Swedish market with batteries possible to remove by hand (without the need of tools) is close to non-existent.[69][70] At the same time, replaceability of batteries in smartphones is something brought up both by TCO Certified and Blue Angel among their range of criteria.

Out of the 538 smartphones examined, 252 contained a battery that could be reached by hand without the need of any tools. Of these 252, eight smartphones contained a battery that would not be removed without being pulled loose, however, still by hand. 56 smartphones were marked with the year they were manufactured (10.4%), which gave a mean age of 5.5 years whereas the median was 6 years. Figure 2 gives an overview of the dismantling study and presents the its outcome.

[69] Oscarsson, J. (2017) ”Mobiler med utbytbara batterier – en utdöende art”. Online article https://surfa.se/utbytbart-batteri-utdoende-art/. [Accessed on 2017-08-22]
[70] Oscarsson, J (2017). Personal communication with Joel Oscarsson, Surfa.

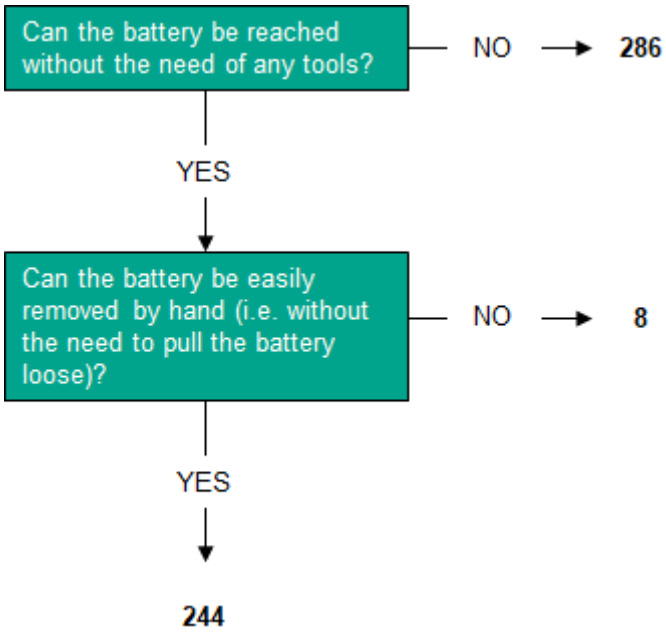

Figure 2. Outcome of the dismantling study in which the possibility to manually remove batteries in smartphones present in the Swedish WEEE stream was investigated.

The dismantling study showed that since year 2012 the product design feature of easily removable and replaceable batteries in smartphones put on the Swedish market has decreased from around 50% down to today's absence. As previously mentioned, not being able to easily remove batteries used in smartphones obstructs the selective treatment of materials and components in WEEE as part of the pre-treatment. Among all parts in a smartphone the battery is the part that primarily is worn and will face capacity degradations. When batteries in smartphones are worn out and cannot be easily replaced there is a risk that their users instead choose to replace the complete phone rather than the battery. If so, this reduces the time a smartphone will be in use from the time it is purchased by its first user to when it is replaced by the same person.

4.3.5 Reduce the number of polymers

Another focus in ecolabelling is to reduce the number of polymers used in the products. In the Nordic Swan Ecolabel plastic components in laptops heavier than 25 grams must be comprised of one polymer or compatible polymers. In addition, the components heavier than 25 grams must not be painted or metallised (with some exceptions). A similar criterion exists in the Blue Angel ecolabel where it is stated that metallic coatings are not permitted in plastic housing parts (exception notebook computers), and that a maximum of four types of plastics may be used in plastic parts greater than 25 grams in mass. The plastic housings may consist of two separable polymers or polymer blends at the most.

The electronics industry is a relatively large consumer of plastics. 2.8 million tonnes of plastics were consumed by the EU electrical and electronics industry in 2016 representing 5.8 percent of total plastics demand in the EU. The most commonly used plastics in electrical and electronics are polypropylene (PP) and polystyrene

(PS), but also a high number of specialised engineering plastics. [71] The mass share of plastics in WEEE is estimated to about 21 percent by weight, but there are great differences among the WEEE categories. Large household appliances have a plastic share of around 19 percent.[72]

The amount of plastics in the collected WEEE in the EU is around 1.2 million tonnes annually. Technology is available to generate RoHs and REACH compliant recycled polymers from WEEE. According to European Electronics Recyclers Association (EERA), the WEEE recycling industry in Europe is capable of taking care of 50 percent of the plastics from the collected WEEE and turn it into post-consumer recycled plastics. The other half needs to be taken care of by for example energy recovery as a result of its content of so called legacy substances, e.g. certain brominated flame retardants and cadmium. However, the European recycling industry has only a capacity of taking care of 250 000 tonnes of plastics annually. The rest is exported from Europe. It is estimated that well over 75 percent of the WEEE plastics are exported from Europe. The large number of plastics in the WEEE waste stream requires a complicated recycling process to arrive to the separation of sufficiently pure polymers that can be extruded and compounded to REACH and RoHS compliant secondary resources, and the complexity of the separation processes require a recycling facility to be of a fairly large size.[73]

The idea behind reducing or limiting the number of polymers used in the products is that mixtures of different plastics can decrease the plastic properties and therefore the use of the produced recycled plastics. Automated shredding processes mix the different plastics why separation is needed, which could be both technically difficult as well as costly. In the Danish evaluation of the Ecodesign Directive[74] it was recommended that these kinds of requirements should be supplemented with a dialogue with stakeholders from the recycling industry.

4.3.6 Recycled plastics content

Differentiation of fees could be considered based on the amount of recycled plastic content in EEE placed on the market. This has been proposed to be one of the focus areas for differentiation of fees for plastic packaging within the EU, proposed in the EU Plastic Strategy. Using recycled plastics in new products can help creating a demand and a market for recycled plastics.[75]

Challenges within incorporating criteria regarding recycled content is the lack of a definition of recycled content, quality standards and a system of traceability for recycled material. This is needed to ensure and validate that the material declared is

[71] PlasticsEurope (2017). Plastics the facts 2017. http://www.plasticseurope.org/Document/plastics---the-facts-2016-15787.aspx?FolID=2
[72] Wäger P.A, Hischier R. Life cycle assessment of post-consumer plastics production from waste electrical and electronic equipment (WEEE) treatment residues in a Central European plastics recycling plant. Science of the Total Environment 529 (2015).
[73] European Electronics Recyclers Association (2017). EERA's comments and proposals for the EU Plastics Strategy 2017
[74] Bundgaard, A. Remmen, A. & Overgaard Zacho, K. (2015). Ecodesign Directive version 2.0: From Energy Efficiency to Resource Efficiency.
[75] E. Watkins, S. Gionfra, J-P. Schweitzer, M. Pantzar, C. Janssens and P. ten Brink (2017) EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging.

actually recycled.[76] Another challenge when setting criteria for recycled content is the absence of reliable technologies for an analytical assessment of the recycled content in products. This implies that verifications are dependent on supplier declarations.[77]

In the French producer responsibility system there is a condition that 10 percent of the plastics used in EEE should be of recycled origin. According to Bundgaard et al. (2015)[78] it is important to assess if producers of recycled materials can satisfy increased demands that the requirement would create. They suggest setting declaration requirements first and then tightening them continuously by setting threshold requirements. A comment from the stakeholders in the project group is that the requirement of declaration or threshold should be on post-consumer plastics as post-consumer plastics represent the major challenge in terms of recycling, or that using post-consumer recycled plastics at least should be more rewarding than using pre-consumer recycled plastics.

4.4 Hazardous substances

Another area of possible focus for differentiation of fees for EEE is content of chemicals and hazardous substances. When looking into this aspect two different pathways have been identified. One pathway is to have a "positive" list of chemicals in which approved chemicals to use in EEE are listed. The other pathway is to go for a list of banned chemicals. Pros and cons of these pathways are further described below as well as examples of criteria regarding hazardous substances in ecolabelling and in EU GPP.

Hazardous substances in EEE are to some extent already regulated through EU legislation. Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP) and Regulation (EU) No 1907/2006 concerns the registration, evaluation, authorisation and restriction of chemical substances (REACH) both apply to EEE. The REACH Regulation with reference to the ECHA (European Chemical Agency) Candidate List[79] contains a list of hazardous substances defined as Substances of Very High Concern (SVHC). Listing of a substance as a SVHC on the so-called Candidate list by ECHA is the first step in the procedure for authorization of use of a chemical. Substances on the candidate list can be used in mixtures and articles, but there is obligation to provide information about use in articles to ECHA and to users. After a two-step regulatory process, SVHCs may be included in the Authorization List (Annex XIV) and become subject to authorization. These substances cannot be placed on the market or used after a given date, unless an authorization is granted for their specific use, or the use is exempted from authorization.

[76] Ibid
[77] Bundgaard, A, Remmen, A. & Overgaard Zacho, K. (2015). Ecodesign Directive version 2.0: From Energy Efficiency to Resource Efficiency.
[78] Ibid
[79] https://www.echa.europa.eu/candidate-list-table

Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHs) aims at reducing the risks to human health and the environment by replacing and restricting hazardous chemical substances in electric and electronic equipment. RoHs also aims to improve the prospects of cost-effective and sustainable recycling of waste from electronic and electronic equipment, and applies to categories 1-11 in the WEEE directive. Member States shall, from 1 July 2006, ensure that new electrical and electronic equipment released onto the market does not contain:

- Lead
- Mercury
- Cadmium
- Hexavalent chromium
- PBB and/or PBDE

The limits for the hazardous substances listed above are 0.1% by weight in homogenous material, with the exception of cadmium, with a limit of 0.01% by weight in homogenous material. Homogeneous material means material that cannot be mechanically broken down into different materials, e.g. by crushing. Chemicals to be regulated shortly within the RoHs legislation (July 22, 2019) are; phthalates DEHP, BBP, DBP and DIBP that are used as plasticizers[80].

4.4.1 The Nordic Swan

To achieve The Nordic Swan Ecolabel the manufacturers of white goods (washing machines and refrigerators/freezers) must compile a list of the chemicals used in final assembly of white goods and in surface treatment including safety data sheets. For a white good to carry the ecolabel there are also criteria (thus with exemptions) stating that[81]:

- Certain flame retardants cannot be used in plastic and rubber parts
- That metals may not be plated with cadmium, chromium, nickel, zinc or alloys of these
- That the following substances must not be actively added to the chemical products used (for example, cleaning products, paints, lacquers, adhesives, sealants used in final assembly of white goods and surface treatment):
    - lead (Pb)
      - mercury (Hg)
      - hexavalent chromium (CrVI)
      - cadmium (Cd) and their compounds
      - halogenated organic substances
    - alkylphenols, alkylphenol ethoxylates or other substances that may form alkyphenols or alkylphenol ethoxylates
    - phthalates
    - volatile organic compounds at more than 1% by weight

[80] KEMI, RoHs-direktivet, Mars 2016

[81] The criteria can be viewed in full here: http://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=003

- volatile organic compounds (VOCs**) at more than 5% by weight in surface
- treatment agents

For a laptop and a TV to carry The Nordic Swan Ecolabel there are criteria (thus with exemptions) stating that[82]:

- Certain flame retardants cannot be used in plastic and rubber parts
- Laptop: The enclosure and chassis must not contain chlorine-based plastics.
- TV: Plastic parts >25g must not contain chlorinated polymers.
- The external power cable delivered with the product must not contain a list of phthalates.
- Laptop: Background lighting in all displays must not contain mercury.
  TV: Background light in TV screens must not contain mercury.
- Laptop: Nano particles/materials, for example nano silver, nano gold and nano copper, shall not actively have been added to, or be part of, the surface of the product.

4.4.2 The Blue Angel

The Blue Angel has requirements regarding plastic components in computers and keyboards[83]. Halogenated polymers are not allowed in chassis or chassis parts. Halogenated organic substances are in addition not allowed as flame retardants. Flame retardants classified according to CLP Regulation as carcinogenic Category Carc. 2 or as hazardous to water Category Aquatic Chronic 1 are also not allowed. Other requirements from the Blue Angel refer to the candidate list in REACH and to CLP regulation, and prohibit the use of certain classified substances that through legislation (REACH and CLP) might only be registered with certain risks to human, health or environment or have some restrictions in use for different circumstances: "Plastic in chassis and chassis parts must not contain, as constituent components, any substances with the following characteristics:

1. Substances that have been identified as SVHC according to: (EC) No. 1906/2006 (REACH) and are included in the candidate list[84].
2. Substances that have been classified under CLP Regulation (Regulation (EC) No 1272/2008 in the following hazard categories or which meet the criteria for such classification:

• Carcinogenic or category carc. 1A or Carc. 1B,
• Mutagenic of category Muta. 1A or Muta. 1B
• Reproductive of category Repr. 1A or Repr. 1B."

Companies aiming for the Blue Angel ecolabel must declare that they comply with the rules and show declarations from plastic manufacturers.

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[82] The criteria can be viewed in full here. Laptop: http://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=048
TV: http://www.nordic-ecolabel.org/product-groups/group/?productGroupCode=071
[83] Der Blaue Engel, Basic Criteria for Award of the Environmental Label-Computers and Keyboards, RAL-UZ 78, Edition of January 2017
[84] https://echa.europa.eu/candidate-list-table

The Blue Angel also prohibits the use of biocidal silver on touchable surfaces. Exempted from the requirements are:

- fluoroorganic additives (as, for example, anti-dripping agents) used to improve the physical properties of plastics, provided that they do not exceed 0.5 weight percent;
- plastic parts weighing 25 grams or less, where - with regard to keyboards - the total weight of all key caps shall be the decisive factor in determining the mass.

Almost identical requirements are set by the Blue Angel for plastics in housing and housing parts for TVs[85] referring to the CLP regulation and REACH candidate list. Allowing exempts for: process-related, technically unavoidable impurities; fluoroorganic additives (as, for example, anti-dripping agents) used to improve the physical properties of plastics, provided that they do not exceed 0.5 weight percent and plastic parts less than 25 grams in mass.

4.4.3 TCO Certified

The criteria in TCO Certified for laptops and smartphones state that the products cannot contain:

- Heavy metals: cadmium, mercury, lead and hexavalent chromium (harmonised with RoHs requirements, but to carry TCO Certified lamps cannot contain mercury).
- Halogenated flame retardants (stricter than RoHS requirement)
- Bromine and chlorine included in plastics
- Certain phthalates (laptops)
- Non-halogenated substances (Using GreenScreen™ for Safer Chemicals)

The criteria can be viewed in full on the TCO Development website.[86]

4.4.4 EU Green Public Procurement

The EU GPP criteria for procurement of computers (laptops in this case) favour tenderers who can demonstrate "implementation of a framework for the operation of Restricted Substance Controls (RSCs) along the supply chain for the products to be supplied". In addition, points shall be awarded tenderers with halogen-free main Printed Circuit Boards. The motivation for awarding tenderers with halogen-free PCBs is to recognise the potential for toxic emissions from improper disposal of PCBs outside of the EU.[87]

4.4.5 Pathway 1: A negative list of banned substances

As seen in chapter 4.4.1-4.4.4 the current criteria's approach regarding hazardous substances is to prohibit substances that are not desirable. The criteria are generally

[85] Blue Angel, Basic Criteria for Award of the Environmental Label, Televisions Sets, RAL-UZ 145, July 2012
[86] www.tcocertified.com
[87] European Commission (2016). Commission Staff working document. EU GPP criteria for computers and monitors.

based on current legislation, but with additional/stricter requirements. A major disadvantage of this approach is that a few substances would be banned/restricted while thousands of potentially hazardous substances are accepted, but not yet restricted.

If the chosen approach is to have a negative list of banned substances one way could be to use the so-called SIN (Substitute it Now) List. The SIN List is developed by ChemSec (International Chemical Secretariat)[88]. The list consists of chemicals that have been identified as SVHCs (Substances of Very High Concern) based on the criteria for these defined within REACH Article 57, but the substances are not yet included in the candidate list.

In addition to speeding up the REACH process, the SIN List aims at looking at the substances that may be subject to restriction in the near future. History tells us that the SIN List has been good at predicting which substances that will eventually end up on the candidate list. According to ChemSec, they have named 94 percent of all SVHC's regulated under REACH today, ahead of the authorities[89]. The SIN List are for example used by companies to identify chemicals to substitute ahead of legislation, and by investors and financial analysts to avoid investing in companies producing chemicals that are likely to be banned[90].

The SIN list is often used when looking at substances that in the near future will need substitution. The substances on the SIN list are grouped into 31 groups. The list is based on publicly available information from databases, studies and new research. The SIN List is publicly available in a free of charge database[91].

4.4.6 Pathway 2: A positive list of approved substances

The other pathway is to avoid having negative lists of banned substances, but instead communicate the approved substances. GreenScreen is a screening method created by the organisation Clean Production Action [92]. The idea is to instead of banning chemicals present chemicals that are approved for use through a screening method. To be listed as an approved chemical the chemical needs to go through an evaluation based on 18 categories. The result is a benchmark between 1-4 where:
1= Avoid, chemical of high concern, 2= Use, but search for safer substitutes, 3= Use but still opportunity for improvement, 4= Prefer, safer chemical, U= Unspecified, too many data gaps to position in the benchmarks.

One organisation using GreenScreen is TCO Development providing the TCO Certified label[93].They have chosen to focus on flame retardants because there is available data about these chemicals. Available data for plasticizer or process chemicals is more difficult to find. TCO Development uses GreenScreen for non-halogenated flame retardants. They have developed a TCO Certified approved list of non-halogenated flame retardants, where there are currently 15 subjects listed with

[88] http://chemsec.org/business-tool/sin-list/about-the-sin-list/
[89] ChemSec (2017). http://chemsec.org/business-tool/sin-list/
[90] ChemSec (2017). http://chemsec.org/business-tool/sin-list/sin-list-faq/
[91] ChemSec (2017). http://sinlist.chemsec.org/.
[92] https://www.greenscreenchemicals.org/
[93] http://tcocertified.com/news/greenscreen-for-safer-chemicals-faq/

benchmarks 2-4 included. If manufacturers want to use a non-halogenated flame retardant not listed they must go to a licensed tester from the CPA website. If the chemical is approved, it will be added to the approved list.

Towards the next generation of criteria TCO Development are looking over the possibility of using GreenScreen also for plasticizers. One option is to use TCO Certified's approved list that is public. At present, however, as previously stated, it only covers non-halogenated flame retardants. For more stringent usage benchmark 3-4 can be used. In the case of our criteria, to only use a positive list of non-halogenated flame retardants is somewhat limiting, as there are many other chemicals to be considered.

4.4.7 Tax on chemicals in certain electronics ("Kemikalieskatten")

On 1 July 2017, a new tax on the chemical content in electrical and electronic equipment was introduced in Sweden. The purpose of the tax is to reduce the content and use of certain groups of flame retardants in such products. Via the tax, the ambition of the Swedish parliament is to influence future product design by favouring the choice of using more environmentally friendly and less hazardous substances.

The tax is calculated based on product weight without packaging (gross weight) and amounts to 8 SEK per kilogram for white goods and SEK 120 per kilogram for other EEE. There is a limit corresponding to a maximum tax amount of 320 SEK per product. As an example, a white goods product that weighs more than 40 kilograms will therefore not face a tax amount higher than 320 SEK.

Not all electrical and electronic equipment are subject to the tax. The products on which tax on chemicals in certain electronics is payable are defined using the division of the Customs Tariff into CN numbers (Combined Nomenclature). All product types of focus in the study are subject to the tax. Certain deductions can be made from the tax and at the Swedish Tax Agency's website the following information can be found: *"It is possible to make a deduction from the tax if a product does not contain certain listed groups of flame retardants. The deduction is 50 percent or 90 percent of the amount of the tax depending on which group of flame retardants the product does not contain."*[94] At the same time this means that all taxable electronics have to be paid for (10 percent of the tax) even though a product does not contain any of the listed groups of flame retardants.

The information in Table 12 is gathered from the Swedish Tax Agency's website and describes what criteria that must be met in order to have the right to do a deduction of either 50 or 90 percent.

[94] Swedish Tax Agency (2017). "Tax on chemicals in certain electronics". https://www.skatteverket.se/servicelankar/otherlanguages/inenglish/businessesandemployers/payingtaxesbusinesses/taxonchemicalsincertainelectronics.4.5c281c7015abecc2e2019351.html. [Accessed on 2018-03-26]

Table 12. Criteria to be met to have the right to do tax deductions under the tax on chemicals in certain electronics.

50 percent tax deduction	90 percent tax deduction
One can make a deduction of 50 percent of the gross tax on an electronic product if the product does not contain any bromine or chlorine compound added as an additive that makes up a proportion higher than 0.1 per cent by weight of the homogeneous material in: • a circuit card, with the exception of the components of the card; or • a plastic part weighing more than 25 grams.	You can make a deduction of 90 per cent of the gross tax on an electronic product if the product does not contain: • any bromine, chlorine or phosphorus compound added as an additive that makes up proportion higher than 0.1 per cent by weight of the homogeneous material in - a circuit card, with the exception of the components of the card, or - a plastic part weighing more than 25 grams; or • any bromine or chlorine compound added as a reactant that makes up proportion higher than 0.1 per cent by weight of the homogeneous material in - a circuit card, with the exception of the components of the card, or - a plastic part weighing more than 25 grams.

Since the tax is new many of the producers that were interviewed draw parallels between the tax and differentiated producer responsibility fees, regarding what the tax has brought in terms of an added administrative burden.

4.5 Compliance with criteria

A critical aspect of introducing differentiated fees for electronics is how to control compliance with the selected criteria. Ensuring fair competition requires a clear framework with set rules, surveillance and enforcement measures and transparency. In a report about how to introduce resource-efficiency criteria under the Ecodesign Directive, it is suggested to review how the ecolabels work on verification and market surveillance to possibly transfer the methods to future requirements under the Ecodesign Directive[95]. This project has not included any in-depth analysis of how compliance of criteria is verified in the ecolabels studied. It can thus be concluded that compliance with criteria is generally based on producer declaration in combination with test reports, sample checks, site visits etc. The criteria documents in the Nordic Swan, the Blue Angel and TCO Certified include information about how the compliance of criteria is verified. Each criterion under EU GPP is followed by information about how the criteria should be verifiable.

[95] Ecodesign Directive version 2.0 – From Energy Efficiency to Resource Efficiency

In the French system for WEEE the largest PRO Eco-systèmes audited in 2015 more than 15 percent (based on weight) of the products declared by its member producers in 2013 and 2014. In total 27 companies were screened, which together represented 21 percent (based on weight) of the products put on the market. The audit was carried out by the company EY. Two of the most frequent errors found were differences between the eco-participation to be paid for products and what eco-participation that was actually paid, and secondly that the scale for the modulated (differentiated) fees was poorly applied. To help audited member companies improve their declarations and become more reliable, Eco-systèmes followed up the auditing by producing an individual report for each company to help them better understand and apply the reporting and regulation procedures.

5. Acceptance of differentiated fees among producers and retailers

In order to evaluate whether differentiated fees for EEE would have the desirable effects, i.e. promote design for reuse and recycling, a qualitative interview study with manufacturers of EEE was carried out. The project group has not verified the results from the survey by other sources of information. The questions posed in the interviews are listed in Appendix 4. The results from the survey are compiled below.

The results from the interviews are similar. The interviewed stakeholders believe to various extent that differentiated fees could be an instrument to favour more reusable and recyclable electrical and electronic products. They strongly emphasise that any criteria used to differentiate the producer responsibility fees paid by the producers should be harmonised between EU Member States to provide consistent incentives and rewards to manufacturers. If different member states adopt different criteria it will create a patchwork, which is unlikely to generate incentives to drive changes in product design. Such an approach would create a large administrative burden for producers instead of environmental improvements. Implementing a differentiation on a limited market as Sweden will not have the effect a differentiation aims for. One company mentions that even though the company would get several hundred SEK in bonus per product it would not be worth it for a single and small market like Sweden's. The limitation in having single-market differentiation of fees is also highlighted in a report from OECD about EPR systems where the authors mean that multinational producers play an increasing role in certain product markets. Producers that design and market identical products at a global level will be less motivated to change product designs for a specific market why the results of having the differentiated fees are limited.[96]

When setting criteria to be fulfilled it is important to be aware that the companies will have costs associated with collecting data and administrating the criteria, in addition to the cost of changing the design and the following production. To calculate if it is "worth" fulfilling the criteria and accepting the bonus both the administrative costs as well as the production costs should be looked into. One company representative mentions that changes in design happens often so production units are used to making changes. Three interviewed stakeholders highly familiar with the French system mean that the differentiated fees have not incentivised them to make any changes in the design of products they sell in France.

Several stakeholders mention that in combination with a bonus system it is essential that the companies are able to market and communicate that they are "best in class". Important to notice is that it is not only manufacturers of electronics that are producers in a formal sense (according to the WEEE Directive), it could also be the importers. Importers can have different relationships with the producers, and can be more or less involved in details about the manufacturing. It can thus be difficult for an importer to know whether a certain criteria is possible to fulfil or not and to what

[96] The OECD Global Forum (2014). The State of Play on Extended Producer Responsibility (EPR): Opportunities and Challenges. Global Forum on Environment: Promoting Sustainable Materials Management through Extended Producer Responsibility (EPR).

cost. If the relationship between the importer and the manufacturer is not "ideal", the importer might not even contact the manufacturer about the conditions and instead report to the PROs that the criteria are not fulfilled.

By whom the critera are set is another challenging question. It needs to be a credible body/organisation that can motivate the choice of criteria. Follow-up of the criteria is another challenging task. One interviewed stakeholder draws a parallel to the WEEE Directive and how it has been implemented in the EU member states. According to the stakeholder there are currently around 400 different EEE/WEEE categories used across the countries in the EU. This makes this type of environmental compliance a bit tricky and of course it would be easier if there were more countries that used the same kind of categories.

Some interviewees mean that implementing too strong policy instruments in one, single country could result in a situation that the producer abandons that particular market for others. One stakeholder mentions an example from Denmark where the government wanted to prohibit certain phthalates. In 2012, the Danish Government decided to ban the import and sales of electric and electronic products containing phthalates DEHP, DBP, BBP and DIBP. The ban was intended to be in effect in the Danish market from December 1st, 2014.[97] The ban was later put on hold for two years as it was considered it could lead to unnecessary competition and loss of Danish work places. The Danish Chamber of Commerce (Dansk Ehrverv) meant that a ban would have affected the supply of many electrical and electronic products in Denmark as the products are manufactured by large international companies that do not wish to change their production due to requirements on a small market like Denmark.[98]

Among the differentiation models proposed, a bonus system is preferred in order for the producers to be "best in class" and stand out from the rest. Malus systems are not preferred as penalties in general are regarded as negative. As some producers get money back from the PROs, a so-called kick-back, it is difficult to have penalty models as the system is already giving them "bonuses".

Increasing producer responsibility fees will lead to an increase of the consumer price. As the margins are limited it is the only option according to the interviewed stakeholders.

To the question of other possible policy instruments that can help favour prevention, reuse and recycling of electrical and electronic products, several stakeholders mention procurement, both public and private procurement as a strong tool. One stakeholder says that requirements come from the public and private sector, not from consumers. Another stakeholder mentions that strict limitations and bans on various elements and chemicals set out by regulations such as REACH and RoHS are important tools to favour recycling and reusability of EEE. The Ecodesign Directive is also mentioned as a strong tool to drive changes in product design. One stakeholder even means that the directive should be the only tool to improve

[97] FEHA and CECED (2012). Danish ban on phthalates.
[98] Dansk Ehrverv (2014). The new phthalate direction of the Ministers favours Denmark. Press release.

environmental performance of products put on the market. Different regulations dealing with the same topics are not ideal. Material efficiency standards are being developed by CEN, CENELEC and ETSI including test methods to determine recyclability, repairability and durability of products, as well as how to determine recycled content. Differentiation of fees could be based on such material efficiency standards.

5.1 Implementing differentiated fees

There are several challenges with implemented differentiated producer responsibility fees for EEE on the EU level. The following examples of challenges have been identified based on the Danish study from 2014[99], and recommendations for implementing differentiated fees on plastic packaging within the EU:

- A system of differentiated fees needs to be organized by a transparent and reliable organisation that can solve the task in cooperation with key stakeholders. This was also emphasised in the interviews carried out in the project.
- Simple, transparent and rational criteria should be developed, and tightened on a regular basis when at least 80 percent of the products meet the requirements.
- The criteria need to be developed in consultation with stakeholder groups.
- The criteria can quickly be out-of-date due to rapid technical development of the EEE market.
- The control of compliance of criteria. One possibility is to implement self-control in accordance with several other areas, and allow for spot-checks by authorities.
- A differentiation must target all actors with producer responsibility obligations to create an equal playing field, and to avoid competitive advantages for some actors.
- In general, assessing the effects of EPR schemes is difficult, for instance due to a lack of data and the difficulty of distinguishing EPR effects from other impacts. EPR schemes are structured in different ways making comparisons difficult.

Differentiated fees within EPR are already in focus for discussion in the EU, mostly for packaging. The discussion about implementing differentiated fees for electronics could as a first step be lifted within existing platforms such as WEEE Forum. WEEE Forum is a not-for-profit association of 34 WEEE PROs founded in 2002. The forum provides a platform for PROs to share ideas and best practices[100], and could act as an arena to bring the idea with differentiated fees forward within EU.

[99] Danish EPA (2014). Ressourcepræmie og miljødifferentieret betaling for elektronikaffald - Analyse af to styringsmidler til at reducere miljøbelastningen fra udvalgte typer småt elektronikaffald , Miljøprojekt nr. 1560, 2014.
[100] WEEE Forum (2018). http://www.weee-forum.org/what-is-the-weee-forum

The Working Plan under the ecodesign and energy labeling framework for 2016-2019101 sets out the Commission's working priorities for coming years. One priority is to strengthen the contribution of the Ecodesign Directive to a more circular economy. The focus in the Ecodesign Directive so far has been on energy efficiency improvements. In the future, the Directive should make a much more significant contribution to the circular economy, for example by tackling material efficiency issues such as durability (e.g. minimum life-time of products or critical components), repairability (e.g. availability of spare parts and repair manuals, design for repair), design for disassembly (e.g. easy removal of certain components), information (e.g. marking of plastic parts), and reusability and recyclability (e.g. avoiding incompatible plastics).

Another key European multi-stakeholder platform for discussion on EPR is "The EPR Club"[102] founded in 2012. The objectives are to bring together a variety of key stakeholders, including EU institutions, have a dialogue on policies and practical implementation of EPR, exchange of information and experiences, and to contribute to EU policy and legislation. It focuses on both existing EPR schemes and on future perspectives.

[101] COM(2015) 341 final
[102] www.eprclub.eu

6. Discussion and conclusions

Implementing differentiated producer responsibility fees within EPR systems is on the agenda in the EU, and for example mentioned as a measure in the EU Plastic Strategy for a Circular economy[103] in order to reach resource-efficiency. Plastic packaging is brought up as an area suitable for differentiated fees in the strategy, which represents a more homogenous material stream than EEE. Existing criteria to favour recycling in ecolabels are focused on plastics why there might be reason to find synergies and parallels for differentiation of fees for plastic packaging and EEE.

6.1 Differentiated fees for electronics – experiences from existing systems

The project group barely found any research exploring experiences with differentiated producer responsibility fees. Only one large-scale example was identified, France, where differentiated producer responsibility fees are used for EEE within EPR schemes. The differentiation in France is based on a bonus-penalty approach where products get a financial reward or a penalty depending on fulfilment of certain criteria. almost

In theory, differentiation of fees within EPR systems favour more reusable and recyclable products as producers are provided with incentives to manufacture more reusable and recyclable products. The project group has, however, not found any evidence, neither in research nor when contacting the largest French producer responsibility organisation in charge for the modulated fees, that the differentiation has led to change of product design and more environmentally sound products. The reason for the lack of results could be the weaknesses of implementing differentiation on a single market as well as how the differentiation model is structured. According to the French PRO it is not possible yet to see any cleareffects on product design even though modulated fees up to date have been in place in France for 8 years for six product groups. For seven additional product groups modulated fees have been in place for three years.

6.2 Possible criteria as basis for differentiation and control of compliance

Existing criteria found within ecolabels (The Nordic Swan and The Blue Angel), as well as within the French fee modulation system, the EU Green Public Procurement and TCO Certified are similar and focus on mainly the same aspects within reuse, recycling, and hazardous substances. For reuse there is a strong focus on lifetime extension such as warranties, availability of spare parts, replaceability of components as well as upgradability, capacity expansion and repairability. For recycling the focus is mainly on marking of plastic components, manual disassembly of certain parts, content of recycled plastics and reduction of the polymer types. Hazardous substances are commonly included by restricting the use of substances that are in line

[103] A European Strategy for Plastics in a Circular Economy. COM (2018) 28 final.

with current legislation and beyond. It is noticeable that some of the systems use a high number of criteria, on a detailed level.

The project group has not developed detailed suggestions of criteria to form basis for differentiation but suggests that inspiration is taken from existing criteria with underlying background reports for the above-mentioned systems.

Based on the screening of existing criteria to facilitate reuse of the product groups studied, the following criteria were identified and believed to positively influence the reuse of EEE:

- **Warranty**. A minimum of three years for all product categories in the study but should preferably be differentiated among the product categories. This is since a warranty period of three years is not that impressive if it concerns a refrigerator whereas it could definitely be more ground-breaking if it concerns a smartphone. The warranty should be provided by the brand owner.
- **Dual-SIM**. This is a criterion that only applies to smartphones of the product categories focused on in the study. A bit more on this type of criterion can be read below.

6.2.1 Warranty

Below follows a section that aims to describe the difference between warranty and what is provided via the Consumer Sales Act. Also presented is what the authors of this report believes could be positive side-effects of products covered by generous warranty periods. It should be noted that this is the view of the authors, and not the reference group.

About warranty

To provide a warranty for an article or product is totally optional. It is therefore up to the one who leaves the warranty to decide for how long it shall last. The warranty can also be designed to guarantee a certain property or component/part of the product. To provide a guarantee for a product means that the one who leaves the warranty is responsible for the product to be functional and that it maintains its quality throughout the whole warranty period.[104] Warranty terms must not affect the rights that the consumer has by law. In Sweden, one such example is the Consumer Sales Act (see below).

According to Konsument Europa (“Consumer Europe”), the average length of a warranty or insurance is one to five years. According to the same source, a more expensive product usually also has a longer warranty period. Commonly the warranty is linked to a specific part of a product.[105] In contrast to the Consumer Sales Act (more on this below), the warranty is product-specific, which means that it will

[104] Konsumentverket (2016). ”Frivilligt att lämna garanti”. http://www.konsumentverket.se/for-foretag/konsumentratt-for-foretagare/frivilligt-att-lamna-garanti/. [Accessed on 2018-03-26]
[105] Konsument Europa (2017). ”Reklamera en vara”. http://www.konsumenteuropa.se/sv/amnesomraden/handel-inom-eu/reklamera-en-vara/. [Accessed on 2018-03-26]

continue to be valid even if the product changes ownership. The warranty cannot be limited to the first owner.[106]

About the Consumer Sales Act

In Sweden, consumers have the right to make a complaint (submit a claim) for a product for up to three years from the date of purchase if it breaks down and the error that causes it has been there from the start.[107] Within the EU, the right of complaint is at least two years, but in the national legislation of the Member States there is a possibility to go further. This applies to Sweden with its three years.
The right of complaint follows the original buyer and not the product itself. This means that the right to complain is no longer valid for a product sold by the original buyer even if this is done within a three-year period from the time the product was purchased originally. In the Consumer Sales Act there is also something called the "six-month rule". This rule means that if an error occurs within the first six months following the sale of a product, the error is assumed to have been from the start (when the product was bought) unless the seller can prove that it is not so. After this period, it is up to the consumer to prove the fault is original.

Warranty for EEE

An important difference between the warranty and the consumers' right to make complaints is that during the complaint period the burden is on the consumer to prove that the fault was there at purchase (except during the first six months from the purchase date according to the six-month rule).[108] This means, that on a general level a warranty that lasts for one year from the date of purchase might be seen as an extension of the sixth-month rule by another six months. The reasoning behind this is that you as a customer do not need to prove the fault was present at the time of purchase. However, it applies only to those parts of a product covered by the warranty unless the complete product is covered. What is stated in the guarantee terms is also directly decisive.

Since the Consumer Sales Act and the right of making a complaint are mandatory and valid for three years in Sweden, you as a customer have a "lowest level" of protection when a product is found out to have an original fault and is discovered within this period. As a warranty does not affect the rights that a consumer has by law, you can never get a lower protection for a product that also has guarantee connected to it. Depending on the fact that the warranty terms for products on the market are likely to differ, even when it comes to products within the same type of category, both bigger and smaller "additions" can be expected on top of what falls under the Consumer Sales Act, which perhaps can be perceived as the base line. For the purpose of facilitating the use of a criterion such as warranty, three years may be used as a basic breakpoint, as that is when the Consumer Sales Act expires for a purchase done in Sweden. Due to the fact that the Consumer Sales Act is mandatory

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[106] KKV (2014). "Garanti". https://www.kkv.fi/sv/information-och-anvisningar/kop-forsaljning-och-avtal/garanti/. [Accessed on 2018-03-26]
[107] Hallå konsument! (2017). "Garanti". http://www.hallakonsument.se/klaga-angra-eller-anmala/dina-rattigheter-som-konsument/garanti/. [Accessed on 2018-03-26]
[108] Elgiganten (2014). "Din garanti, reklamation och servicevillkor". https://www.elgiganten.se/cms/20140304_094253/din-garanti-reklamation-och-servicevillkor-afs-0016/. [Accessed on 2018-03-26]

whereas the warranty is optional, it is only after three years that electronic products with a warranty period more than that starts to stand out from the crowd, as such "long" warranty periods are relatively uncommon for products on today's electronics market. What should be required in terms of time/length of a guarantee as a kind of lowest level can therefore in the first instance be that the guarantee period shall be a minimum of three years.

Some reflections on what other positive side effects “generous” warranty periods might bring about

To judge manufacturers and the products they put on the market based on the warranty period they provide on the products bring a number of interesting aspects except for the actual warranty itself. Below follow a few examples of what kind of positive climate and environmental benefits and characteristics that the authors to this report believe that generous warranty times may bring to electronics products concerning the way they are designed, manufactured and can be maintained during their lives.

6.2.2 Long life spans

Products with warranty periods that stand out from the crowd, because they are longer than the vast majority of the segment, probably convey a sense of good quality and increased durability to many consumers. It is also reasonable to imagine that manufacturers also believe in their products when they provide them with generous warranty periods. Products that do not last for at least their entire warranty period would quickly become an unfavourable deal for the manufacturers, so in many cases “offensive” warranty periods certainly also imply high quality products and thus increased durability and long life times. Properties that lead to increased product life expectancy give products good prerequisites to be used for a longer period of time before being replaced. If this is true, that means fewer products are consumed per time unit, which at the same time means that less resources are consumed and used. In addition, fewer products mean that fewer products will become waste, which leads to waste prevention. When products are made durable and can be used for a long time before they break or become obsolete for one reason or the other, there is also potential of increased resource efficiency.

Repairability contributes to lifetime extension

Generous warranty periods lead to that consumers are given good prerequisites for getting their products repaired if they brake. This also believed to be the case even after the warranty has expired because established repair channels increase the potential for a consumer to come into contact with a repairer. An increased opportunity for having repairs performed increases the likelihood that a product will be repaired instead of being replaced with a new one. This, in turn, increases the life of products with the same positive side effects as above. Long warranty periods and good repair channels should also be able to provide a good spare parts market where spare parts are made easier to access for consumers. One such example may be that manufacturers sell spare parts through their websites, as well as give tips on where consumers can go to get products repaired.

Demand for products on the reuse market

The remaining warranty period may make products particularly attractive on the reuse market. In the same way a generous warranty period provides a first consumer with an increased protection, it is also expected to provide protection for a second owner when a product with remaining warranty is sold on the reuse market. To buy from a former owner a used product that is still covered by the warranty may in many cases probably be something that a significant proportion of consumers consider to be very positive. If so, these types of products may be expected to be particularly attractive, which leads to increased reuse. If an owner of such a product knows that there is usually a strong demand, the likelihood is also that the owner chooses to try to sell it on the reuse market instead of handing it in for recycling.

Dismantlability might improve repairability and recyclability

For products with generous warranty times, one might think that the manufacturers have thought about a little extra to make repairs and component changes smooth. A part of such a strategy may be to design products in a way that makes them easy to disassemble and replace components. This makes repairs easier and faster. An increased disassembly can also be very positive when it comes to the time when it is time to recycle such a product. A good disassembly opens for easier and faster pre-treatment and a possible further disassembly of a product's components and materials. It provides good conditions for increased recyclability. In such a context, parts of a product may also be removed to be used as spare parts in the same way that for a long time has been the case within, for example, the car industry. High quality components in a product provide good opportunities for such components to be reused as spare parts.

An increased material separation in pre-treatment of WEEE can lead to increased recovery rates

If products are designed in such a way that components and parts are easy to remove (high disassembly), it is perhaps likely to think that the material separation often made during the pre-treatment of WEEE may be performed in a more efficient way. If a product can be more efficiently disintegrated by grinding or shredding, so that a larger proportion of different materials can be separated from each other, higher recovery and recycling rates can be expected. This means that the output material fractions might be of higher purity rates (more homogeneous) which in turn can lead to increased recycling rates.

6.2.3 Dual-SIM

This criterion on double SIM card slots only concerns smartphones among the product types focused on in this study. Double SIM card slots in smartphones make it possible to have one smartphone with two subscriptions and two phone numbers, which might open up for having the same phone both at work and at home. This can potentially lead to that people who both have a smartphone at work and a private smartphone can downsize to have just one phone instead. If so, the result might be that fewer products are purchased per time unit, which at the same time means that less resources are used. In addition, fewer products mean that fewer products will become waste, which leads to waste prevention.

6.2.4 Possible criteria for recycling

Focus area to be developed further within recycling are for example:

- Marking of *certain* plastic components according to a standardised system such as ISO for certain larger components such as TV back panels and refrigerator drawers could facilitate recycling. Setting requirements to mark plastic components in general could be of no use as a limited number of components are manually dismantled in practice.
- Facilitating manual dismantling of batteries in laptops and smartphones.
- Limiting the number of polymers to be used in components. Exceptions could be looked into, for example components with a certain minimum weight.
- Making it clear which substances that are allowed to be used in the products in the form of a "positive list", the opposite in terms of restricting the use of certain substances, or a combination of both in the form of a positive and a negative list.

When it comes to hazardous substances both having "positive lists" and "negative lists" has its pros and cons. A negative of substances, pathway 1, poses a risk that harmful substances can be used as they are not yet evaluated. The SIN List, however, provides a wider red list than current legislation. Providing a list of approved substances in a positive list requires that substances have been evaluated according to GreenScreen or similar, which can be time-consuming and costly. On the other hand, it functions as a form of guarantee that the listed substances are of limited or no harm to use. A method using both of the approaches could be viable, for example to use a positive list to provide producers with a bonus, and the SIN list to provide penalties. This approach would, however, need more investigation and further analysis.

Work under the Ecodesign Directive could also be a beneficial arena for such criteria development. Stakeholder consultation with producers of EEE as well as the recycling sector is highly important to reach criteria that incentivise change in product design without demanding the impossible. A few highly motivated and well-founded criteria to be used as a start are recommended.

If differentiated fees are to be implemented within EPR for EEE the criteria should be set by a credible body/organisation with the possibility to motivate the choice of criteria. Experts and stakeholder groups need to be involved. The EPR systems for EEE are implemented differently across the EU, and lacks harmonisation in for example for the producer's reporting routines to the PROs. Producers with markets all over Europe face these differences, which lead to increased administrative costs. Implementing differentiated producer responsibility fees in the EPR schemes would put extra administrative burden on the producers, especially if it is not harmonised within the EU. As a first step the body/organisation in charge of the differentiation could aim for harmonisation across the EU before a possible differentiation is introduced.

6.3 Challenges with differentiated fees

In practice a differentiation of fees is followed by challenges; for example decision on the underlying criteria to be fulfilled by the producers, the differentiation model in

financial terms, and how to monitor and control the compliance of the criteria in order to reach a fair competition among the actors. Finding a differentiation model where a differentiation creates an incentive and "makes it worth" for the producer to change the product design pose a challenge.

Verifying compliance with criteria as basis for differentiated fees is challenging and administratively intensive for the controlling bodies. In the French modulation fee system, the PROs are responsible for the verification of compliance, which puts an administrative burden on the organisations.

6.3.1 Need for more discussion on size of fees, not only percentages

Providing financial bonuses or penalties according to compliance or non-compliance with criteria are, in the examples mentioned in the report, based on percentages of the fees being withdrawn or added. However, only percentages do not tell how much bonus or penalties mean in financial terms. A 100 percent bonus might have a very limited effect on the fee, if the basic fee is very low in the first place. A 100 percent increase in fee within the French modulation fee system represents around 0.02 euro in practice. Several products are not even subject to a fee as their material values are high enough to cover the recycling of them or even give revenues. Also, producers for certain product groups often get so-called kick-backs from the PROs at the end of the financial year due to lower collection and recycling costs than expected. It can also be that spot prices for materials contained in such products have been relatively high which balance the costs for recycling and can result in kick-backs.

6.3.2 Need for an equal playing field

The producer responsibility fees for electronics are set to achieve the targets outlined in the WEEE Directive. The targets set by the WEEE Directive are met for all product groups in focus for the study, which do not provide incentives for reaching more ambitious targets. The fees cover the current costs within the EPR system to reach the minimum targets in the WEEE Directive. More ambitious reuse and recycling practices, including more cost-intensive recycling processes, would require an elevation of fees or higher EU targets. Reasons for this might be that recycling targets stated in regulations are increased in the future but perhaps also complemented with targets that in contrast to weight are based on other factors e.g. environmental and climate benefits of recycling certain elements and compounds. With increased producer responsibility fees, increased incentives to produce products that are more environmentally friendly and/or have a lower climate impact, are more likely to be created due to differentiated fees within EPR systems. PROs compete for member producers. If one PRO takes the lead and elevates the fees with the motivation that more technologically advanced recycling processes with better recycling results are offered they risk losing customers to competitors. Similarly, recyclers offering advanced recycling processes to a higher cost than their competitors risk losing the PRO contracts.

6.3.3 The consumer perspective

Since producer responsibility fees are not stated on receipts and therefore not shown to consumers in Sweden, it is difficult for consumers to actively choose products with properties that give them a higher reusability and/or recyclability in front of products which lack these properties. To reach out to consumers, implementing differentiated fees could be combined with the possibility for producers to market their compliance with the criteria in the system. This market possibility could favour the acceptance of the differentiated fees. A possible way to market products that comply with the criteria could be to share the information via comparison shopping engine websites (e.g. www.prisjakt.se and www.pricerunner.se in Sweden) as well as similar websites but with the certain purpose to give consumers information about products that are comparatively environmentally friendly. An example is the website www.toptensverige.se operated by the Swedish Society for Nature Conservation, which lists the most energy-efficient products on the Swedish market. Top Ten Sverige is part of the Global Topten Network which currently involves 18 countries.

Potential penalty fees that producers will have to pay if differentiated fees within EPR systems are implemented will likely be covered for by being added to the product sales price and therefore paid by the consumers. Since producer responsibility fees paid for products are not shown to Swedish consumers, most of them will probably not be aware of the situation. A connection can be made to the tax on chemicals in certain electronics where producers have increased the sales prices for products to balance the added costs levied by the tax. For a smartphone that weighs around 100 grams, a tax of 12 SEK has to be paid. If the market price of the smartphone is 8 000 SEK (including the 12 SEK for the tax) the tax amounts to 0.15% of the total price. Consumers who are willing to buy a smartphone in that price segment will probably not refuse to buy the product even though the price includes a tax amount corresponding to 12 SEK. The point is that consumers' sensitivity to increased prices due to the tax is presumed in most cases to be low. The result is that no clear incentives to act differently neither for producers nor consumers are believed to be created. With the current producer responsibility fees for EEE it is supposed that a similar situation will occur if differentiated fees with EPR systems are introduced. However, the market of used EEE might be affected in a more significant way where prices are commonly lower than that of new products. In this case, and especially for what can be seen as heavier products, the tax on certain chemicals might become more notable as it constitutes a larger share of a product's market price.

6.4 Conclusions

The following conclusions are drawn from the project:

- Only one large-scale example was identified, France, where differentiated producer responsibility fees are used for EEE within EPR schemes. In France and Italy there is fee modulation for packaging.
- Based on an interview study with producers carried out in the project it is doubtful that implementation of differentiated fees within producer responsibility for EEE in Sweden or any other relatively small markets will

lead to changes in product design. The main reason is that the electrical and electronic sector often operates globally, thus reducing the incentives to modify the product design for a single market. The project group has not found any indications that the differentiation of fees in France has led to change of product design and more environmentally sound products. Differentiation likely benefits from being implemented and harmonised on the EU level.

- In theory, differentiation of fees within EPR systems favour more reusable and recyclable products as producers are provided with incentives, but in practice such a differentiation is followed by challenges; for example decision on the underlying criteria to be fulfilled by the producers, the setup of the differentiation model in financial terms, and how to monitor and control the compliance of the criteria in order to reach a fair competition among the actors. Worth mentioning is also the difficulties with evaluating the effect of differentiated fees. The same principles of differentiation could be applied on other product groups than EEE.
- More ambitious reuse and recycling practices, including more cost-intensive recycling processes, would require an elevation of fees or higher EU targets. Increased producer responsibility fees will boost the effect of the differentiated fees.
- Providing financial bonuses or penalties according to compliance or non-compliance with criteria are based on percentages of the fees being withdrawn or added. However, only percentages do not tell how much bonus or penalties mean in financial terms. A 100 percent bonus might have a very limited effect on the fee, if the basic fee is very low in the first place.

Appendix 1: Criteria in CITEO

Table A1. Reduction at source[109].

Reduction at source	Eligibility criteria					
Measure	Details	Iso- material	Iso- functionality	No transfer to multipack and transport packaging	No deterioration in the recyclability of the packaging	Eligibility threshold
Reduction in weight	Reduction in the weight of the packaging unit, for example by a reduction in the thickness of the material weight	X	X	X	X	Weight reduction of 2% of the packaging unit
Use of refills	Reduction in volume for example through concentration of the product and streamlining the packaging	X	X	X	X	Weight reduction of 2% of the packaging unit

[109] Eco Emballages Declaration Manual 2016

Reduction in volume	A refill is used to fill reusable packaging again with the same product and is not designed to be used alone		X	X		Weight reduction of 2% in relation to the fillable packaging
Removal of a packaging unit	Reduction in the number of packaging units constituting the consumer sales unit (CSU)	X	X	X	X	Weight reduction of 2% of the consumer sales units

Table A2. Improvement of recyclability[110].

Improvement of recyclability	Eligibility criteria				
Measure	Details	Iso- material	Iso- functionality	No transfer to multipack and transport packaging	No deterioration in the recyclability of the packaging
Removal of a non-main material from a multi-material packaging unit	This measure must not result in the packaging becoming heavier and the main material must remain	X	X	X	X

[110] Eco-Emballages (2016). Declaration Manual 2016. http://www.ecoemballages.fr/sites/default/files/files/resources/declaration_manual_2016_february2016.pdf

	the same				
Replacement of complex plastic tray with single resin trays improving their recyclability	The new packaging must not contain dye based on black carbon	X	X	X	X
Addition of a perforation on an plastic sleeve	This measure applies only to PET, HDPE or PP packaging with a sleeve covering more than 60% of the surface. A Perforation made in made up of 2 perforation lines on the sleeve	X	X	X	X
Removal of the black carbon dye in a plastic packaging item	Changing to a dark dye without black carbon is eligible for this bonus	X	X	X	X

The bonuses can be added to a maximum of 24 % according to the following distribution. On packaging awareness 8% +, off packing awareness 4 %+, Reduction at source or Recyclability 8 % +, Publication of measure in the good practices catalogue 4 %.

The penalties are:

- A fee increase of 50 % for disruptive packaging
- A fee increase of 100 % for packaging included in the sorting guidelines, but not having a recycling channel
-

Disruptive packaging is packaging that has a sorting guideline for source-separation, but cannot be recycled or has characteristics, which disrupts the sorting/recycling/end quality and significantly increases the cost of treatment. Examples are glass packaging with a ceramic stopper, drink cartons with paper/cardboard as the main material but with less than 50 % fibres, or PET bottles with disruptive association such as lids, labels, ink etc

Appendix 2: Criteria in CONAI

Packaging that meets all of the following conditions are considered sortable:

- Exceeds the minimum size to be sortable, min 5x5 cm to allow reading on the sorting belt
- Is identifiable on the sorting belt, the optical readers recognise the packaging surface
- Ensures minimum sorting quantities, a minimum and homogenous sorting quantity exceeding 2% of the total must be guaranteed because the effectiveness of the sorting process is decreased with low percentages of incoming material.

Packaging that meet all of the following conditions are considered recyclable:

- There are one or a higher number of recyclers (or lines designed on an industrial scale) that through a mechanical or chemical-organic process can produce a secondary raw material
- There are one or more companies (or lines designed on an industrial scale) that use the secondary raw material
- There is a minimum quantity, the quantity of sorted material must be sufficient to feed at least one industrial recycling line.
- Is compatible, thus packaging that is not compatible with relevant industrially known sorting and recycling technologies is not included.

All the above listed conditions must be met in order for the packaging to pass the sortability and recyclability requirement.

Appendix 3: Criteria to be fulfilled to achieve The Nordic Swan Ecolabel, TCO Certified or The Blue Angel

Table A3. Criteria linked to reusability and life time extension to be fulfilled by laptops, TVs and smartphones to achieve The Nordic Swan Ecolabel, TCO Certified or The Blue Angel.

Nordic Swan Ecolabel	Laptops [111]	TVs [112]	Smartphones N/A
Upgradability The design of category C (excluding slate) computers must permit performance expansions (upgrades). At a minimum, the following expansions must be possible: ▪ primary memory expansion	X	N/A	-
Repairability The manufacturer shall demonstrate that the product can be easily dismantled by professionally trained recyclers, using the tools usually available to them, for the purpose of: ▪ undertaking of repairs and replacements of worn-out parts ▪ upgrading older or obsolete parts To facilitate the dismantling: ▪ Fixtures within the products shall allow for this disassembly, e.g. screws, snap-fixes, especially of parts containing hazardous substances. An exploded diagram of the product labelling the main components as well as identifying any hazardous substances in components. This can be in written or audio-visual format.		X	-
Warranty The manufacturer shall offer a commercial guarantee to ensure that the product will function for at least two years. This		X	-

[111] Category C. Notebook computer (including slate)) (October 2013-June 2020
[112] June 2013-June 2020

guarantee shall be valid from the date of delivery to the customer. *(This shall be written in the electronic and/or printed product fact sheet.)*			
Availability of spare parts and repair The availability of compatible electronic replacement parts shall be guaranteed for seven years from the time that production ceases. *(This shall be written in the electronic and/or printed product fact sheet.)*		X	-
TCO Certified	**Laptops** (November 2015)	**TVs** (not available for this ecolabel but monitors are)	**Smartphones** (November 2015)
Replaceability of the battery Batteries shall be rechargeable and when necessary, replaceable by the end user or a qualified professional.	N/A		X
Warranty The brand owner shall provide a product warranty for at least one year on all markets where the product is sold.	X		X
Availability of spare parts and repair The brand owner shall guarantee the availability of spare parts for at least three years from the time that production ceases. Instructions on how to replace these parts shall be available to professionals upon request.	X		X
The Blue Angel	**Laptops** (January 2017)	**TVs** (not available for this ecolabel but monitors	**Smartphones** (July 2017)

		are)	
Replaceability of the battery **Mobile phones:** The mobile phone shall be designed so as to allow the user to replace the rechargeable battery without special expert knowledge and without damaging the telephone. **Computers:** The computers shall be designed to allow the easy replacement of the batteries/accumulators without the need for expert knowledge.	X		X
Battery/accumulator capacity *"Minimum discharge time for batteries"*	X		X
Durability of the battery/accumulator The battery must achieve a minimum of 500 full charge cycles. The minimum number of full charge cycles achievable shall be specified in the product documents. After 500 full charge cycles the battery must, in addition, have in a fully charged state, a remaining capacity (QRem): **Mobile phones:** of at least 90 percent of the nominal capacity (N) **Laptops (computers):** of at least 80 percent of the nominal capacity (N)	X		X
Warranty The applicant undertakes to offer a free minimum 2-year warranty on the mobile phone, except for the batteries. In addition, the applicant shall offer a free minimum 1-warranty on the battery which covers a remaining capacity of at least 90%, provided that the phone is properly used and charged with the manufacturer's own or another suitable charging device. The product documents shall provide details of such warranties.			X
Availability of spare parts and repair **Mobile phones:** The applicant undertakes to make sure that the availability of spare parts for device repair is guaranteed for at least 3 years from the time that production ceases. Spare parts shall be offered at reasonable prices by the manufacturer itself or a by third party. Spare parts are those parts which, typically, may fail or break down within the scope of the ordinary use of a product, especially batteries, displays and front glasses. The mobile phones shall be so designed as to enable qualified specialist workshops to replace such spare parts with reasonable effort. The product documents shall provide information on spare parts supply and repair services. **Laptops (computers):** The applicant undertakes to make sure that the availability of spare parts for appliance repair is guaranteed for at least 5 years from the time that production ceases. Especially batteries/accumulators, (if any) must be available for at least 5 years following the end of production. The spare parts must be offered at reasonable cost by the manufacturer itself or a by third party. Spare parts are functionally identical or compatible and functionally improved components or modules that may be exchanged during repair in the course of the life-cycle of a computer or keyboard to replace defect parts. Other parts which normally exceed the life of the product are not to be considered as spare parts. The product documents shall include detailed information on the provision of spare parts.	X		X
Software updates The device shall come with a free function to allow the user to update the operating system. The aim of these updates is,			X

above all, the closing of security holes, as well as other software updates, if applicable. The applicant undertakes to offer security updates for the operating system of the mobile phone to be ecolabelled for at least 4 years from the time that production ceases.			
Data deletion To allow reuse of the device it shall be designed so as to enable the user to completely and securely delete all personal data without the help of pay software. This can be accomplished by either physically removing the memory card or the use of free manufacturer-provided software. As an alternative to removing the data, it shall also be possible to encode the personal data on the data medium by means of software provided, thus allowing a secure deletion of the key. In addition, the device shall include a software function that resets the device to its factory settings. The product documents shall include detailed instructions on how to securely delete data and how to reset the device to its factory settings. Note: It shall not be possible to restore the personal data by means of commercially available recovery software tools that			X
Capacity expansion Computers to be Blue Angel ecolabelled must be so designed as to ensure easy accessibility to the replaceable components and expansion interfaces (e.g. IC sockets plug-in connectors). For this purpose, it must be possible to open housing parts, chassis and battery covers easily and without expert knowledge. The computers must provide the following expansion options: ▪ Replacement or expansion of Random Access Memory (RAM) (if any), ▪ Replacement or expansion of the mass storage (if any).	X		
EU Green Public Procurement (EU GPP)	**Laptops**	**TVs** (N/A)	**Smartphones** (N/A)
Warranty and service agreements (TS4) The tenderer shall provide a minimum two-year warranty effective from delivery of the product. This warranty shall cover repair or replacement and include a service agreement with options for pick-up and return or on-site repairs. The warranty shall guarantee that the products are in conformity with the contract specifications at no additional cost. This shall cover battery defects.	X		
Repairability and replacement of components and parts (TS5) *Continued availability of spare parts (TS5(a))* The tenderer shall guarantee the availability of spare parts, including as a minimum those identified in criterion TS5(b), for at least three years from the date of purchase. *Design for repairability (TS5(b))* The following parts, if applicable, shall be easily accessible and replaceable by the use of universally available tools (i.e. screwdriver, spatula, plier or tweezers): Computers (i) HDD/SSD, (ii) Memory, (iii)Rechargeable battery	X		

Displays (i) Screen assembly and LCD backlight (ii) Power and control circuit boards (iii) Stands (excluding those integrated with the enclosure) Tablets and two-in-one notebooks shall be exempt for computer parts (i) and (ii). *Ease of replacement for rechargeable batteries (TS5(c))* Rechargeable batteries shall not be glued or soldered into portable products. It shall be possible for a professional user or repair service provider to replace the rechargeable battery. Instructions on how the rechargeable battery packs are to be removed shall be provided in the user instructions or via the manufacturer's webpage.			
Cost competitiveness of spare parts (AC2) The tenderer shall provide a price list for, as a minimum, the following component parts: *[the parts list to be provided here, with the TS5(b) list to be provided as a minimum]* For the component parts listed above indicative labour costs for replacements carried out by the tenderer's authorised service providers shall be provided. Points shall be awarded according to the most cost-competitive offers. *Additional component parts, if considered important to the price comparison, should be added to the list provided.*	X		
Longer warranties and services agreements (AC3) Additional points shall be awarded to each additional year of warranty and service agreement offered that is more than the minimum technical specification. This shall be awarded A maximum of x points *[to be specified]* may be awarded. • +4 years or more: x points • +3 years: 0.75x points • +2 years: 0.5x points • +1 year: 0.25x points	X		
Tablet and all-in-one notebook memory and storage (AC4) Points shall be awarded for products that incorporate the following features: (i) RAM memory – Soldered RAM with a minimum capacity of 4GB, or; – The potential to replace and upgrade the RAM (socketed design). (ii) Mass storage – The potential to expand the storage by using slots supporting mass storage media, or; – Additional mass storage incorporated into the keyboard (for all-in-one notebooks).	Only for all-in-one notebook/ laptops		

The RAM memory sub-criteria are not suitable for devices designed to run their main applications from the cloud. This criterion should not be used to compare bids that offer differing solutions i.e. integrated or cloud storage.			
Rechargeable battery life and endurance (AC5) Points shall be awarded for improved endurance greater than 300 cycles (with 80% capacity retention) respectively. A maximum of x points [to be specified] may be awarded. • 1000 cycles or more: x points • 800 cycles or more: 0.75x points • 500 cycles or more: 0.5x points • Up to 499 cycles: 0.25x points *The minimum battery life in hours shall be set according to the Contracting Authority's requirements.*	X		
Notebook computer drives (AC7) Points shall be awarded where the primary data storage drive used in notebooks is tested and verified to meet at least one of the following requirements: i. The HDD drive shall withstand a half sine wave shock of 400 G (operating) and 900 G (non-operating) for 2 milliseconds without damage to data or operation of the drive. ii. The HDD drive head should retract from the disc surface in less than or equal to 300 milliseconds upon detection of the notebook having been dropped from desk height (76cm) and regardless of its orientation. *iii.* A solid state storage drive technology such as SSD or eMMC is used.	X		
Notebook durability testing (AC8) Points shall be awarded for products that have passed durability tests carried out according to IEC 60068, US MIL810G or equivalent. A maximum of x points [to be specified] may be awarded: • Accidental drop (x/4 points) • Resistance to shock (x/4 points) • Resistance to vibration (x/4 points) • Screen resilience (x/8 points) • Temperature stress (x/8 points) Functional performance requirements and test specifications are provided in Annex I of the criteria document. In-house tests with a stricter specification shall be accepted without the need to retest. *The tests applicable shall be specified in the ITT in order to reflect the conditions of use defined for the product.*	X		

Table A4. Criteria to be fulfilled by laptops, TVs and smartphones to achieve The Nordic Swan Ecolabel, TCO Certified or The Blue Angel. Criteria for laptops within EU GPP are also listed (only comprehensive criteria). N/A is used when the ecolabel does not cover the product group.

Nordic Swan Ecolabel	**Laptops**	**TVs**	**Smartphones**
The manufacturer must ensure that disassembly of the unit is possible and compile disassembly instructions demonstrating that: ▪ connections are easy to locate and access and easily separable with generally available tools. ▪ connections are, where possible, standardized.	X	X	N/A
Plastic parts heavier than 25 g must be composed of one polymer or compatible polymers.	X	-	N/A
Plastic parts shall be of one polymer or be of compatible polymers for re-cycling and have the relevant ISO11469 marking if >25g in mass. Exception is made for extruded plastic materials and for light emitters in flat screens.	-	X	N/A
Plastic parts heavier than 25 g may contain metallic inlays provided that these can easily be separated without the use of special tools.	X	-	N/A
Metal inlays that cannot be separated shall not be used.	X	-	N/A
If labels are required they shall be easily removable or integrated. This does not apply to safety labels according to CENELEC safety standard EN 60850 §1.7.2.	X	-	N/A
Plastic parts heavier than 25 g must not be painted or metallized. Exempted from this requirement are: · Notebook computers. · Fog paint with maximum 1% by weight paint per plastic part. · Coatings made from the base polymer.	X	-	N/A
Plastic parts > 25 g must carry permanent labelling specifying the material in accordance with the latest versions of ISO 11469 and ISO 1043, sections 1 to 4. This requirement does not apply to extruded plastics or light conductors in flat displays. Plastic parts covering a flat surface of less than 200 mm2 are also exempted from this requirement.	X	-	N/A
Fixtures within the products shall allow for this disassembly, e.g. screws, snap-fixes, especially of parts containing hazardous substances.	X	X	N/A
TCO Certified	**Laptops**	**TVs**	**Smartphones**
Plastic parts weighing more than 25 grams shall be material coded in accordance with ISO11469 and ISO 1043-1, -2, -3, -4. Exempted are printed wiring board laminates.	X	N/A	-
Plastic parts weighing more than 5 grams shall be material coded in accordance with ISO 11469	-	N/A	X

and ISO 1043-1, -2, -3, -4. Exempted are printed wiring board laminates.			
The Blue Angel	**Laptops**	**TVs**	**Smartphones**
The devices must be so designed as to allow easy disassembly for recycling purposes to make sure that housing parts, chassis, batteries (if any), display units (if any) and printed circuit boards can be separated as fractions from materials of other functional units and, if possible, recycled by the type of material. They shall be so designed as to allow manual disassembly by a waste disposal company by the use of universal tools 14 and it shall be possible for a single person to disassemble the device.	X	N/A	-
Batteries/accumulators (if any) must be easy to remove without the use of any tools or with the use of universal tools.	X	N/A	-
Electrical/electronic components must be easy to remove from the housing.	X	N/A	-
The following applies to plastic parts with a mass greater than 25 grams as well as to key caps, provided that their total mass is greater than 25 grams: A maximum of 4 types of plastic may be used for these parts. The plastic housings may consist of two separable polymers or polymer blends at the most.	X	N/A	-
Plastic parts with a mass greater than 25 grams each and an even surface area of more than 200 sq.mm. must be permanently marked in accordance with ISO 11469 with due regard to ISO 1043, Parts 1 to 4. Transparent plastic parts the function of which requires transparency (e.g. visible plastic films in displays) shall be exempt from marking according to ISO 11469.	X	N/A	-
It shall not be permitted to apply metallic coatings to plastic housing parts. Exception: plastic housing parts of notebook computers may have a metallic coating provided that such coating is technically required. However, galvanic coatings of plastic housing parts shall not be permitted.	X	N/A	-
(Post-consumer) recyclate material may be used in housing parts and chassis. It may be used on a percentage basis.	X	N/A	-
90% of the mass of plastics and of the metals of housing parts and chassis must be recyclable by material (this does not mean the recovery of thermal energy by incineration).	X	N/A	-
The rechargeable batteries shall be easy to remove for recycling purposes to allow their recycling by material type separate from the rest of the device.	-	N/A	X
An efficient removal of the rechargeable batteries for recycling purposes shall be possible by using standard tools (guidance value: in no more than 5 seconds). The housing of the device may be damaged during this process but the leaking of battery chemicals must be prevented.	-	N/A	X
EU Green Public Procurement (EU GPP)	**Laptops**	**TVs**	**Smartphones**
Parts shall not contain moulded-in or glued-on metal inserts unless they can be removed with commonly available tools. Disassembly instructions shall show how to remove them.	X	N/A	N/A
The presence of paints and coatings shall not significantly impact upon the resilience of plastic recyclate produced from these components upon recycling and when tested according to ISO 180 12 or equivalent.	X	N/A	N/A
External plastic casings, enclosures and bezels with a weight greater than 25 grams for portable all-in-one notebooks and a surface area greater than 50 cm^2 shall be marked in accordance with ISO 11469 and ISO 1043, sections 1 and 4.	X	N/A	N/A

Points shall be awarded for the time efficient manual dismantling and extraction of printed Circuit Boards relating to computing functions >10 cm², rechargeable batteries, HDD and optical drives (excluding SSD) from products. Extraction of the relevant components shall be possible using universally available tools. The maximum time required to extract them shall not exceed 600 seconds.	X	N/A	N/A

Appendix 4: Questionnaire for interviews

1. What percentage of the consumer price does the producer responsibility fee generally represent (for TVs, smartphones, laptops, refrigerators and washing machines)?

2. What percentage of the total price of manufacturing does the producer responsibility fee generally represent (for TVs, smartphones, laptops, refrigerators and washing machines?

3. Do you generally believe that a differentiated producer responsibility fee could lead to different design of TVs/smartphones/laptops/refrigerators/washing machines based on the above conditions? Why/why not?

4. In France the differentiated producer responsibility fees are based on bonus-malus. For certain product categories the differentiation means reward whereas for others it means penalty. An example of a reward is for washing machines where a minimum one out of two conditions must be lived up to in order to achieve a reduction of fee of 20% (from 7.5 to 6 Euro).

There is also a possibility to work with malus systems. Refrigerators and freezers are in the French system subject to three conditions. All three conditions must be lived up to in order to avoid an additional 20% fee. For a refrigerator of between 40 -80 kg this means an increase in fee of 2.67 Euro per refrigerator (from 13.33 Euro to 16 Euro). A similar example is for smartphones where two conditions need to be fulfilled in order to avoid an additional 100% fee. The ordinary fee is in this case 0.02 Euro, which leads to an increase to 0.04 Euro per smartphone. 100% means in this case a relatively small difference compared to the ordinary fee.

4.1 Can such sizes of differentiations lead to changed design in your view?
4.2 If not, what do you think the size of the differentiation would need to be in order to change the product design?

For example the manufacturer has to pay an additional:
- 1 Euro per product put on the market?
- 5 Euro per product put on the market?
- 10 Euro per product put on the market?
- If you do not think that any of the above mentioned figures would lead to a difference in product design, what size of additional fee is required in your view?

4.3 Is it necessary to have various sizes of differentiation based on product groups?

5. In the case of much higher producer responsibility fees than today, how would manufacturers cover the extra expenses?

6. Which other policy instruments or other drivers would lead to a product design that facilitates recycling and the life time of products in your view?

7. Does your company have experiences from systems where differentiated fees are used, for example the French system?

8. Is there any information you would like to add?