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Design requirement on recyclability under the Ecodesign Directive

*- a possible synergy between waste and
product policies on electric and electronic equipment?*

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Summary

The newly released 'New Circular Economy Package' puts emphasis on resource efficiency through increased recycling, as well as ecodesign of products to accomplish it. The waste stream of electrical and electronic equipment (WEEE) is increasing and since these types of products contain valuable material the material contained in them should be recycled. The 'Synergy Approach' employed in this thesis presents a way of strengthening the enforcement of the WEEE Directive through the creation of synergies with other policies, especially the Ecodesign Directive. In order to increase the recycling rates, resource efficient pre-processing treatment alternatives need to be made more economically competitive compared to alternatives reaping a lower recycling yield to a corresponding lower cost. Moreover, mechanical treatment options must also become more applicable, raising the productivity of the pre-processing and making the operations more profitable. Hence, the product policies on EEE should be aiming at enabling these two waste treatment approaches in order to create synergy and, through that, support increased recycling of WEEE.

The RoHS Directive is regulating ten hazardous substances in EEE, which is facilitating the recycling. While the Ecodesign Directive ought to be able to set product requirements aiming at facilitating the recycling, through for example the choice of materials and the ease of dismantling, this has not been done with regards to the absolute majority of the regulated product categories. The main hindrances for setting these types of requirements consist in the fulfilment of the provisions in the Ecodesign Directive on significant environmental impact, potential for significant environmental benefit (due to uncertainties regarding how the waste treatment will look like) and measurability, as well as the possibility of 'double-regulation' with the WEEE Directive and the RoHS Directive. For the Ecodesign Directive to be able to set further recyclability requirements changes on a number of levels are required, especially in the process of developing the product-specific ecodesign requirements. Increasing EU policy focus on resource efficiency, the upcoming standardization process and the possibility of obtaining a clear definition of 'double-regulation' from the Commission are some of the identified enablers past these hindrances. However, the uncertain waste treatment remains an issue receiving limited attention in the analysed judicial doctrine. Therefore, some strategies on how this uncertainty can be dealt with has been proposed, both within the context of the Ecodesign Directive as well as outside. The most efficient approach to create synergy, and to overcome the hindrance in the form of uncertain environmental benefit from the design requirement, seems to consist in regulation of the design features in the Ecodesign Directive, together with correlating regulation of the waste treatments in the WEEE Directive.

1. Introduction

1.1 Circular economy, electric and electronic equipment and waste

1.1.1 The interest behind resource efficiency

Ever since the Industrial Revolution, industries and markets have been accustomed to a linear model of resource use because it was cheaper to discard than to reuse or recycle. This way of managing resources has led to a continuous increase of resource extraction from the earth, resulting in accumulations of anthropogenic materials in the atmosphere, and increased amounts of waste as well as emission flows into the environment. Two main problems have arisen from this development: a decrease of natural resources available to use, and an increase of wastes and pollutants harmful to human health and the environment. The worldwide use of natural resources is accelerating due to a growing population, along with the increasing prosperity in developing countries, putting increasing demands on the world's resources. Annual material extraction has, in fact, increased eightfold during the twentieth century.¹

Not only is the environment in danger, the increasing global competition for resources constitutes a threat to the industries located in the European Union (EU), and to the EU at large, since the dependence upon the import of raw material is likely to make the EU fall victim to increasing prices, to market volatility, and to the tumultuous political situations in the countries supplying these resources.²

1.1.2 EU as a circular economy

The EU has responded to these trends by recognizing the need for a shift in the use of natural resources. The Commission states that resources shall not be seen as abundant, available and cheap to dispose of, and that the life of a product is not linear. They have instead expressed the intention of 'closing the loop' of production and reducing the constantly growing amount of waste. In such an economy, called a 'Circular economy', waste is regarded as a resource which, through recycling, allows urban resources to preserve natural resources, lowers the dependence on imports of raw materials, and lowers impacts on the environment. What is today regarded as waste should either be reused, refurbished or recycled in a continuous circle.^{3 4}

¹ Green Alliance, 'Resource resilient UK - a report from the Circular Economy Task Force' [2013] Green Alliance 978-1-905869-90-93, p. 7f; UNEP, 'Decoupling Natural Resource Use and Environmental Impacts from Economic Growth, a Report of the Working Group on Decoupling to the International Resource Panel' [2011] p.10f

² Commission, 'Circular Economy Strategy' (Initiative) April 2015 pp. 2
Available at:

http://ec.europa.eu/smartregulation/impact/planned_ia/docs/2015_env_065_env+_032_circular_economy_en.pdf 2015-10-22

³ Commission, 'Roadmap to a Resource Efficient Europe' (Communication) COM(2011)571

⁴ Commission, 'Towards a circular economy: A zero waste programme for Europe' (Communication) COM(2014)398 final

Increased resource efficiency is an important EU objective. In 2011 the Commission published the flagship, 'A Resource efficient Europe'⁵ under the Europe Strategy 2020,⁶ as well as the 'Roadmap to resource efficiency'.⁷ In 2014, the Commission published a communication on circular economy and a zero waste programme.⁸ Resource efficiency is also an important part of the 7th Environment Action Plan⁹ setting the objectives for EU's environmental policy until 2020. On the 2 December 2015, the Commission adopted a new, ambitious circular economy package. First Vice-President Frans Timmermans, responsible for sustainable development, states that:

Our planet and our economy cannot survive if we continue with the 'take, make, use and throw away' approach. We need to retain precious resources and fully exploit all the economic value within them. The circular economy is about reducing waste and protecting the environment, but it is also about a profound transformation of the way our entire economy works.¹⁰

1.1.3 Life cycle thinking

A Circular Economy requires a new way of looking at the life of a product: not as a straight line with a beginning and an end, but as a cycle. The stages of a product's life consists of extraction of raw material, material and product design, manufacturing, distribution, consumption, repair, remanufacturing and reuse, waste management, and recycling, as illustrated below in figure 1. All these stages are interlinked, and improvements need to be made in terms of resource efficiency and energy efficiency at all stages.¹¹ In the Communication on 'A Resource-efficient Europe' the Commission state the 'need to consider the whole life- cycle of the way we use resources'.¹² Dalhammar remarks that this statement is an example of how life cycle thinking resembles a guiding EU policy principle.¹³

⁵ Commission, 'A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy' (Communication) COM 2011(21)

⁶ Commission, 'EUROPE 2020 A strategy for smart, sustainable and inclusive growth' (Communication) COM(2010) 2020)

⁷ COM(2011) 571 (not 3)

⁸ COM(2014)398 final (not 4)

⁹ Decision No 1386/2013/EU on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' [2013] OJ 354

¹⁰ Commission, 'Closing the loop: Commission adopts ambitious new Circular Economy Package to boost competitiveness, create jobs and generate sustainable growth' (Press release) 2 December 2015 http://europa.eu/rapid/press-release_IP-15-6203_en.htm 2015-12-20

¹¹ Commission (n 2) Initiative: *Circular Economy Strategy*, p. 3

¹² COM 2011(21) (n 5) p. 4

¹³ Dalhammar C, 'The Application of 'Life Cycle Thinking' in European Environmental Law: Theory and Practice' [2015] Volume 12 Journal for european environmental & planning law 97-127, p. 99



Figure 1: The Product lifecycle¹⁴

The last phase of a product's life is referred to as 'End-of-life' (EoL) and the options constitute in re-use, recycling, recovery or disposal. The waste treatment the product received in this stage determines if the material contained in the product will be re-used or recycled, which means the material will enter the circle again as so called 'secondary raw material', 'close the loop' and lower the need to extract new resources from the earth.¹⁵

1.1.4 The policy role of recycling and design

The EU Waste Framework Directive¹⁶, EU's general legislation regarding waste streams, underlines the need to identify prevention measures with regards to waste, including 'the formulation of a product eco-design policy addressing both the generation of waste and the presence of hazardous substances in waste, with a view of promoting technologies focusing on durable, re-usable and recyclable products'.¹⁷ It is estimated that over 80% of all product-related environmental impacts are determined during the design phase of a product.¹⁸ This realization has led to the development of 'Ecodesign', referring to a product design process which takes into consideration the collective environmental impact from the product during its entire lifecycle, including the End-of-life, and which makes efforts to minimize this collective impact through the design of the product.^{19 20}

The Commission states that 'the complex and interlocking approach needed to build a resource-efficient Europe can only be achieved with a policy mix that optimises synergies and

¹⁴ <http://it.ecodyger.com/2014/lca/> 2015-10-31

¹⁵ P Chancerel, C EM Meskers, C Hagelúken, V S Rotter 'Assessment of Precious Metal Flows During Preprocessing of Waste of Electronic and Electric Equipment' [2009] Volume 13 No 5 Journal of Industrial Ecology 791-810, p. 794

¹⁶ Directive 2008/98/EC on waste and repealing certain Directives [2008] (OJ L 312/3) (The Waste Framework Directive)

¹⁷ Article 9(a) The Waste Framework Directive (n 16)

¹⁸ <http://www.eceee.org/ecodesign> 2015-10-25

¹⁹ Article 2(23) Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products (recast) [2009] (OJ L 285/10) (The Ecodesign Directive)

²⁰ C Luttrupp, J Lagerstedt, 'EcoDesign and the Ten Golden Rules: generic advice for merging environmental aspects into product development' [2006] vol 14 no 15-16 Journal of Cleaner Production

addresses trade-offs between different areas and policies'.²¹ Increasing recycling rates is listed as a way of reducing the pressure on demand for primary raw materials, assist in the reuse of valuable materials, which would otherwise be wasted, as well as reducing energy consumption and greenhouse gas emissions. Improving the design of products is also mentioned since it can decrease the demand for energy and raw materials, as well as make products more durable and recyclable.²²

1.1.5 Electric and electronic equipment (EEE)

Waste from electrical and electronic equipment (WEEE) in the EU is currently increasing at an annual rate of 3-5 %, making it one of the fastest growing waste streams in the EU,^{23 24} estimated to have exceeded 12 million ton by 2020.²⁵ The increase of the waste stream can be attributed to an increasing development of new designs, functions and technology during last two decades, along with a drop in prices of consumer EEE, which have led to a rapid obsolescence of many EEE products.^{26 27} The fast pace of product development has made WEEE one of the waste streams with the highest material complexity; WEEE can contain more than 1000 different substances and materials, many of which are hazardous, with others having a considerable market value.^{28 29 30} The Commission states that 'To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential.'³¹

1.1.6 The Waste Electric and Electronic Equipment Directive

The Waste Electric and Electronic Equipment Directive (the WEEE directive)³² is put in place to ensure an effective waste treatment and to achieve recycling rates through, for example, collection schemes and waste treatment requirements. The Impact Assessment on the WEEE Directive in 2008 states that 'Both at the time of the WEEE Directive's conception and for the

²¹ COM(2011)21 (n 5) p. 4

²² COM(2011)21 (n 5) p. 4

²³ <http://ec.europa.eu/eurostat/web/waste/key-waste-streams/weee> 2015-10-02

²⁴ Commission, 'Commission Staff Working paper accompanying the Proposal for a Directive of the European Parliament and of the Council on waste electric and electronic equipment (WEEE)(recast)' (Proposal) COM(2008)810 final, p. 17

²⁵ http://ec.europa.eu/environment/waste/weee/index_en.htm 2015-10-02

²⁶ P Tanskanen, 'Management and recycling of electronic waste' [2013] Acta Materialia 61 1001–1011, pp. 1001

²⁷ V Pérez-Belis, M D Bovea, A Gómez, 'Waste electric and electronic toys: Management practices and characterisation' [2013] 77 Resources, Conservation and Recycling 1–12, p. 1

²⁸ R Widmera, H Oswald-Krapf, D Sinha-Khetriwalb, M Schnellmann, H Bo, 'Global perspectives on e-waste' [2005] vol. 25 Environmental Impact Assessment Review, 436-458, p. 444

²⁹ P Vanegas, J R Peeters, W Dewulf, D Cattrysse, C R Douflou, 'Improving Resource Efficiency through Recycling Modelling: A Case Study for LCD TVs' [2015] 12th Global Conference on Sustainable Manufacturing, Procedia CIRP 26 601 – 606, p. 601

³⁰ E Sundin, E Kristofer, H Mien Lee, 'Design for automatic end-of-life processes' [2012] Assembly Autom 2012;32(4) 389–398, p. 392

³¹ http://ec.europa.eu/environment/waste/weee/index_en.htm 2015-10-02

³² Directive 2012/19/EU on waste electrical and electronic equipment (WEEE) (recast) [2012] OJ L 197/38 (The WEEE Directive)

future, there are two central problems with WEEE: A) disposal of WEEE to landfill and B) suboptimal recycling and recovery of WEEE by techniques that release or generate harmful substances. Both ends result in a loss of significant valuable recyclable resources, as well as damage the environment and health, in the EU and in developing countries.³³

Even though recyclers bear a great deal of the responsibility for the transition of the EU economy to an ‘e-recycling society’, the recyclers are merely reacting to the supply of used goods available to them, and there is not much they can control. Unsustainable design choices and the externalization of waste management costs at the EoL of the product create and reinforce a rift between how things are made and how they come apart. In order to increase the recycling of WEEE, one must look beyond the end-of-life phase and see how products are made in the first place.³⁴ This approach constitutes a part of the Ecodesign approach outlined above, and has led to an increasing attention of how the design of EEE can facilitate recycling and reuse of the material contained in the product, in order to close ‘the material loop’.³⁵

In an effort to internalize the waste treatment cost in the design phase, and to create synergy between the waste treatment and the product design, the WEEE directive holds the producer of the EEE responsible for the EoL-phase of the product’s life through the so called ‘Extended Producer Responsibility’ (EPR).³⁶ The EPR to date has not provided the incentives for EoL considerations in the design of EEE as intended by the policy maker.^{37 38} Attention has instead turned to the product policies to make products more recyclable. As expressed by Dalhammar ‘If current EPR rules provide limited incentives for such market developments, new policies are needed.’³⁹ Without policy, there not adequate incentives for manufacturers to apply design considerations to the EoL phase.⁴⁰ Legislative pressure has been found to be a better incentive to design for the purpose of recycling and reuse than potential cost reductions have, which is the main idea behind the EPR,⁴¹ even though voluntary instruments

³³ COM(2008) 810 final (not 24) p. 5

³⁴ G Pickren, ‘Making connections between global production networks for used goods and the realm of production: a case study on e-waste governance’ [2015] Vol 15 no 4 Global Networks 403-423, p. 405

³⁵ see section 1.1.4

³⁶ Recital 6 and Article 12 and 13 the WEEE Directive (n 32)

³⁷ C Van Rossem, C Dalhammar, F Toulouse, ‘Designing Greener Electronic Products: Building Synergies between EU Product Policy Instruments or Simply Passing the Buck?’ [2009] Report: European Environmental Bureau (EEB), p. 6

³⁸ A Kunz, A Atasu, et al. ‘Extended Producer Responsibility: Stakeholder Concerns and Future Developments’ [2014] Report: INSEAD Social Innovation Centre.

³⁹ C Dalhammar ‘Industry attitudes towards ecodesign standards for improved resource efficiency’ forthcoming

⁴⁰ C Dalhammar, ‘Product and life-cycle issues in European environmental law: A review of recent developments’ [2007] Yearbook of European Environmental Law Vol. 7. Oxford Univ. Press

⁴¹ WM Cheung, R Marsh, P W Griffin, L B Newnes, A R Mileham, J D Lanham, 2015. *Towards cleaner production: a roadmap for predicting product end-of-life costs at early design concept* [2015] vol 87 Journal of Cleaner Production 431-441, p. 435

(certifications and labelings) has been somewhat successful at giving rise to EoL considerations in terms of the product design.⁴²

1.1.7 The product policies for EEE

The Regulation on Hazardous Substances in EEE (The RoHS Directive) is limiting the use of certain hazardous substances in EEE, and is said to serve as a counterpart to the WEEE directive, since the limitation of hazardous substances facilitates the waste treatment.⁴³

The Ecodesign directive regulates the design of EEE, and is aiming at improving the environmental life cycle performance of products through the design. The aim is to ban the most energy and resource demanding products on the EU market.⁴⁴ So far however, the design requirements have almost exclusively been energy efficiency related, despite the fact that the directive can be used to set product requirements on recyclability.^{45 46} Van Rossem et al refers to this as a ‘false marketing.’⁴⁷ They conclude that ‘One question obviously needs to be answered: *What is the actual role of [the Ecodesign directive] and associated methodology?*’.⁴⁸ It seems this question may soon receive an answer. In ‘The Roadmap for resource efficiency’ the Commission states that the Ecodesign Directive should ‘include more resource relevant criteria’.⁴⁹ In the new Circular Economy Package, the Ecodesign directive is given an important role with regards to the promotion of reparability, durability and recyclability of products, in addition to energy efficiency.⁵⁰

1.1.8 Synergy between the waste policy and the product policies: The Virtuous circle

While the waste policy sets the framework for the proper treatment of waste, the Product Policies focus on requirements with which products should comply when being commercialised. The connection between the WEEE directive and the Ecodesign Directive is expressed in both directives.⁵¹ An increased synergy between the waste policy for WEEE and the product policies for EEE are desired in order to, among other goals, increase the

⁴² F Ardente, M Calero Pastor, F Mathieux, L Talens Peiró, ‘Analysis of end-of-life treatments of commercial refrigerating appliances: Bridging product and waste policies’ [2015] vol 101 Resources, Conservation and Recycling 42–52

⁴³ http://ec.europa.eu/environment/waste/rohs_eee/index_en.htm 2015-11-11

⁴⁴ Recitals 5, 8, 9 and 15 The Ecodesign Directive (n 19);

<http://www.energimyndigheten.se/energieffektivisering/lag-och-ratt/ekodesign1/> 2015-09-17

⁴⁵ A M Bundgaard, A Remmen, Z K Overgaard, ‘Ecodesign Directive version 2.0: From energy efficiency to resource efficiency’ [2015], Report, Miljøstyrelsen [Danish Environmental Protection Agency]

⁴⁶ D Jepsen, L. Spengler & L. Augsberg of Ökopol, ‘Delivering resource-efficient products. How Ecodesign can drive a circular economy in Europe’ [2015]. Report, European Environmental Bureau.

⁴⁷ van Rossem et al (n 37) p. 8

⁴⁸ van Rossem et al (n 37) p. 9

⁴⁹ COM(2011) 571 final (n 3) p. 5

⁵⁰ Commission, ‘Closing the loop - An EU action plan for the Circular Economy’ (Communication) (COM(2015) 614/2) p. 3f

⁵¹ Recital 11 and Article 4 the WEEE Directive (n 32); Recital 36 and Annex I the Ecodesign Directive (n 19)

recyclability of WEEE⁵², as expressed by the Commission.⁵³ Ardente et al refer to this approach as 'the Virtuous circle', illustrated in image 2 below, and argues for the need of better alignment between product characteristics (defined in the context of the Ecodesign Directive) and recycling treatments (defined in the context of the WEEE Directive) and the recycling techniques available. Van Rossem et al⁵⁴ also highlight the gains from synergy between the RoHS Directive, the Ecodesign Directive and the WEEE Directive. 'These three directives should, in the best case, be complementary; they should be used in synergy in order to promote life cycle thinking in a clear and consistent manner.'⁵⁵

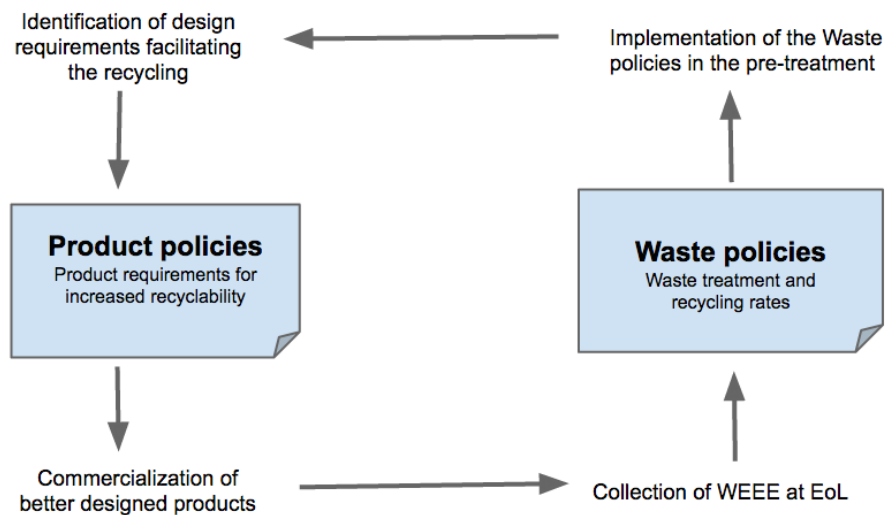


Image 2. 'The Virtuous circle' illustrating the synergy between the Product policies and the Waste policies. Inspiration: Ardente et al 2015

Ardente et al suggest that the identified 'criticalities', which constitute product features which are not fully adapted to the recycling process, should form the basis for the setting of product requirement under the Ecodesign Directive.^{56 57} This is referred to as the 'Synergy approach' from here on. However, the creation of such a synergy raises many questions: What does it mean that an EEE is recyclable? Could such requirements be set under the Ecodesign Directive? What are the hindrances for an increased synergy between the Ecodesign Directive and the WEEE directive as well as the RoHS Directive? How can such a synergy be formed, despite the hindrances?

1.2. Objectives

The main purpose of this thesis is to analyze the capacity of the Ecodesign Directive to function as a tool for the transition of the European Economy to a resource efficient, circular

⁵² Ardente et al 2015 (n 42); Bundgaard et al (n 45) p. 31; Jepsen et al (46) p. 43

⁵³ see section 1.1.4

⁵⁴ van Rossem et al (n 37) p. 5

⁵⁵ van Rossem et al (n 37) p. 5

⁵⁶ Ardente et al (n 42) p. 43

⁵⁷ Ardente et al (n 42) suggest to use both mandatory requirements and voluntary instruments to achieve this synergy. The later is, however, not within the scope of this thesis. See section 1.5

economy with regards to WEEE. At present, the Ecodesign directive, almost exclusively regulates the energy consumption and impact on energy consumption of EEE, despite the extending and deepening plans of turning the EU into a circular economy, and the reference of the Ecodesign Directive in those plans.⁵⁸

The aim of this thesis is to analyse the possibilities for increased synergy between the Ecodesign Directive and the WEEE directive, initiated by Ardente et al⁵⁹, by analysing the hindrances of setting product requirements, aiming at redressing the product criticalities hampering the recycling, under the Ecodesign directive and possible ways of overcoming these hindrances. The aim is to identify enablers, strategies and possible ways forward, to allow for a synergy to be created and for the Ecodesign Directive to be able to function as a tool in realizing the EU ambition of a circular economy regarding WEEE.

This thesis will only cover the WEEE directive, the Ecodesign directive (including the implementing measures and voluntary agreements) as well as the most relevant parts of the RoHS directive. Only the part of the regulations and directives with consequence for the recyclability of EEE will be included.

1.3 Research questions

1. How can EEE be made more recyclable?
 - a. What kind of waste treatment are stipulated in the WEEE Directive regarding the pre-processing and recycling?
 - b. What does the application of the Synergy Approach show regarding how products can be made more recyclable in their design?
2. To what extent are these design aspects regulated in the product policies for EEE (the Ecodesign Directive or the RoHS Directive)?
3. What are the hindrances for setting product requirements on recyclability under the Ecodesign Directive?
 - a. What are the provisions on ecodesign requirements in the Ecodesign Directive? How does the process of setting ecodesign requirement look like?
 - b. Which of these provisions constitute the main hindrances for setting recyclability requirements? What types of obstacles exist in the process?
4. What are the enablers and measures with the potential to alleviate the hindrances and allow for synergies to be created between the Ecodesign Directive, the WEEE Directive and the RoHS directives?
 - a. What are the enablers and measures which might alleviate the identified hindrances?
 - b. What are some of the strategies for diminishing the uncertain environmental benefit and enable the creation of synergies?

⁵⁸ COM(2015) 614/2) (n 50) p. 3f

⁵⁹ Ardente et al (n 42)

1.4 Demarcation of subject area

Only EU-level legislation will be analysed. Implementation problems on a member state level will not be discussed, in order to make the thesis manageable in scope and time. Court practises will not be within the scope of this thesis either, partly because of time-related issues, but also because these questions are seldom resolved through trials.

Focus will be on the pre-processing, while the recycling (the conversion of waste to secondary raw materials) will be shortly described. The collection system will not be discussed, since it is not affected by the design of the product and is therefore less relevant for the synergy. The implications for 'historic WEEE' will not be included in the analysis.⁶⁰

Some recycled materials will not reach a high enough quality to be suited for the same use as before, and some material recycling might not be practical from an environmental point of view, due to the energy consumption needed to transform them from waste to secondary raw material.⁶¹ This particular material recycling will not be discussed, since it applies to only some materials and the focus of this thesis is intended to be general. Nor will the 'concentration dilemma' in material purification be discussed due to the specificity of this issue.⁶² Recycling in developing countries will not be discussed either, since all EU member states are industrialized, and the objective of becoming a circular economy applies to EU.

The suitability of using the Ecodesign Directive for the setting of resource efficiency requirement compared to other legislations or voluntary instrument will not be touched on. See Dalhammar et al⁶³ for a discussion on that subject. The arguably questionable effectiveness of voluntary agreements⁶⁴ will not be discussed either, since the scope of the thesis is on the Ecodesign Directive as a whole. Potential alterations of the Extended Producer Responsibility and the synergies that might create will not be elaborated on since the focus is on the product policies.

1.5 Definition of concepts

Synergy between the WEEE directive and the Ecodesign Directive: in the context of this paper, this term refers to the level of complementary elements in the directives. One way of creating synergy, which is the focus of this thesis, is to set product requirements with the

⁶⁰ see H Kalimo, R Lifset, R. C van Rossem, L van Wassenhove, A Atasu, K Mayers, 'Greening the Economy through Design Incentives: Allocating Extended Producer Responsibility' [2012] *Energy and Environmental Law Review* December 274-305

⁶¹ COM(2008)810 final (n 24) p. 96f

⁶² C Hagelüken, 'Improving metal returns and eco-efficiency in electronics recycling – a holistic approach for interface optimisation between pre-processing and integrated metals smelting and refining' [2006] In *Proceedings of the IEEE International Symposium on Electronics & the Environment*, 8–11 May, San Francisco 218– 223. p. 220

⁶³ C Dalhammar, E Machacek, A Bungaard, Z Overgaard, K Zacho, A Remmen, 'Addressing resource efficiency through the Ecodesign Directive. A review of opportunities and barriers' [2014]. ISBN 978-92-893-2720-6

⁶⁴ Bundgaard et al (n 45) p. 19

potential of facilitating the waste treatment, preferably eliminating or remedying the product criticalities. The goal is to reach the recycling targets in Annex V the WEEE Directive.

Criticalities: product design features not adapted to the waste treatment.

Ecodesign: a product design and development process where consideration is taken to the collective life-cycle impact of the product and efforts are made, in the design, to minimize that impact.

Recyclability: the capacity of an EEE to become recycled. A material is assumed to be 'recyclable' when technologies are available and the treatment is economically viable.⁶⁵

Design for recyclability: Like ecodesign, but only with consideration for the recycling treatment.

BOM: A Bill of Materials (BOM) lists the contents of the product. BOM is identified in scientific literature as an important source of information for life cycle assessments to measure the product's recyclability and recoverability in the design stage, as well as to identify priority resources and hazardous substances in the product.⁶⁶

Resources: include raw materials such as fuels, minerals and metals but also food, soil, water, air, biomass and ecosystems.⁶⁷

Resource efficiency: Resource efficiency is the benefit obtained from the use of natural resources. Benefits can be represented by economic goods, services provided, social gains, etc. The use of natural resources can be accounted for as the volumes of resources consumed (materials, water, energy) or used (land, air, ecosystems), or the impacts derived from the use of resources.⁶⁸

Material: Material is the substance of which a thing is made or composed. This term comprises raw materials (for example minerals and biomass) as well as materials processed by humans, by physical or chemical processes.⁶⁹

Material efficiency: Material efficiency is the ratio between material input per benefit derived.⁷⁰

Prevention: measures taken before a substance, material or product has become waste, that reduce the quantity of waste, the adverse impact from the waste or the prevalence of harmful substances.⁷¹

Recovery: 'Recovery' is the umbrella-term for 'preparation for re-use', 'recycling' and 'other recovery'.⁷² It can be that by any operation, the principal result is that waste serves a useful

⁶⁵ F Ardente & F Mathieux, 'Integration of resource efficiency and waste management criteria in European product policies – Second phase Report n. 2 Application of the project's methods to three product groups' [2014] European Commission, JRC, Institute for Environment and Sustainability, Unit Sustainability Assessment p. 45

⁶⁶ C Dalhammar, Dalhammar, C. 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

⁶⁷ COM(2011)21 (n 5) p. 2

⁶⁸ BIO Intelligence Services, 'Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products. Part 1: Material Efficiency for Ecodesign Report' [2013] prepared for the European Commission DG Enterprise and Industry, (BIOis) p. 14

⁶⁹ BIOis (n 68) p. 10

⁷⁰ BIOis (n 68) p. 10

⁷¹ Article 3(12) the Waste Framework Directive (n 16)

⁷² Commission (DG Environment), *Guidance on the interpretation of key provisions of Directive 2008/98/EC*. June 2012. [2012] p. 30-31

http://ec.europa.eu/environment/waste/framework/pdf/guidance_doc.pdf 2015-10-25

purpose by replacing other materials, which would otherwise have been used to fulfil a particular function. Annex II in Directive 2008/98/EC sets out a non-exhaustive list of recovery operations: fuel generation, recycling/reclamation of metals and metal compounds, and recycling/reclamation of other inorganic materials are some examples.

Recycling: includes any physical, chemical or biological treatment leading to a material that does no longer meet the waste-criteria.⁷³ It refers to any recovery operation by which waste materials are reprocessed into products, materials or substances both for the original and other purposes.⁷⁴

Other recovery: constitute operations of reprocessing of the waste into materials that are to be used as fuels or for backfilling operations.⁷⁵

Disposal: any operation that is not recovery, for example: landfilling and incineration.⁷⁶

Treatment: recovery or disposal operations, including preparation prior to recovery or disposal.⁷⁷

Pre-processing: Processing of waste, which still results in a waste, and subsequently, undergoes other waste recovery steps would not be considered recycling, but pre-processing prior to further recovery, such as for example dismantling, shredding, sorting, crushing and separating.⁷⁸

Hazardous waste: waste which displays one or more of the hazardous properties listed in Annex III the Waste Framework Directive 2008/98/EC, such as toxic.

Manufacturer and producer: are used synonymously and refers to an economic actor managing product development of EEE.

⁷³ Commission (n 72) p. 32

⁷⁴ Recital 28 and Article 3(17) The Waste Framework Directive (n 16)

⁷⁵ Commission (n 72) p. 33

⁷⁶ Annex I The waste Framework Directive (n 16) sets out a non-exhaustive list of disposal operations

⁷⁷ Article 3(14) the Waste Framework Directive (n 16)

⁷⁸ Commission (n. 72) p. 33

2. Method

Due to the diverse nature of the four research questions the method employed for each question will be discussed under separate sections.

2.1 Overall approach

2.1.1 The relevance of the question

The goal to aspire to work for a 'Sustainable Development' is expressed as an EU principle in Article 3 of the Treaty of the European Union. According to Article 11 in the Treaty on the Functioning of the EU, requirements on environmental protection must be integrated into the definition and implementation of EU policies and activities, taking the promotion of a sustainable development into particular consideration. The EU ambitions to establish a Circular Economy constitute a part of the efforts to promote sustainable development. However, the ambition has only taken the form of some soft law (communications) and the plans have not yet been taken further. Yet, it is a clear indication of the direction the EU policy is going to take in the near future. Additionally, as argued by Westerlund, in order to judicially 'operationalize' environmental aims, such as the goal of sustainable development and the recycling targets, one must look to the environmental conditions and accordingly establish the requirements of the environmental law.⁷⁹ In the case of this thesis, the waste and product policies regarding EEE must be regarded as tools for operationalizing the ambition of circular economy (and subsequently, a sustainable development consisting of increased recycling). Hence, the merits of the Ecodesign Directive, the WEEE Directive and the RoHS Directive should be evaluated according to their potential to fulfill that role. As the empirical perspective is highly relevant, this thesis is taking the starting point from an empirical perspective through the application of 'the Synergy Approach'.⁸⁰ The analyses in the continuing chapters are, however, based on theory. The results from interviews⁸¹ are used throughout the thesis in order to provide an additional element of authenticity, and to create a discussion that isn't purely theoretical.

Despite the growing focus on 'life-cycle impact,' this thesis will focus on the recyclability of EEE. The choice is a practical one, provided the scope of the thesis. Additionally, the ability to recycle seems to be the long-term key to resource efficiency and the creation of a 'closed loop'. Resource efficiency by way of recycling will be the main focus, but as recycling is encompassed by the common umbrella term of 'resource efficiency,' this term will be used when the distinction of what is specifically relevant for recycling cannot be determined.

⁷⁹ S Westerlund, *Miljörettsliga grundfrågor 2.0* (2nd edition lustus Förlag 2003) p. 98f

⁸⁰ see section 2.2.2

⁸¹ see section 2.1.4

2.1.2 General approach

The literature study on 'Design for Recycling' of EEE show a focus on the recycling of a certain product category or a certain material type. This paper intends to avoid such a narrow scope and maintain a general approach. The challenge with this approach, however, consists of the variety of different waste treatments, their particular challenges and the various design options to facilitate the waste treatment and how these vary, depending on material and the WEEE in question. Details pertaining to specific types of EEE, substances and materials will be kept to a minimum and only brought up as illustrative examples.

2.1.3 Interviews

Three semi-structured interviews⁸² were conducted for this thesis. The purpose was to get a basic understanding of the topic at hand, to pose the questions derived from my research and to gain insight into the latest developments on the issue of recycling and designing EEE. I began with an interview of Johan Felix, material expert at the Foundation Chalmers Industriteknik (CIT).⁸³ He then referred me to Martin Alehem, Nordic Production manager at Stena Technoworld AB⁸⁴, and Annachiara Torciano, Sustainability Manager at Samsung Electronics Nordic.⁸⁵ All the interviews were recorded and all but the irrelevant parts were later transcribed by hand. I find that this selection of subjects for my interviews offers a wide-reaching scope of perspectives, including the scientific perspective, the pre-processor perspective, and the manufacturer's perspective. All interviews contributed immensely to my basic understanding, and some sections of these discussions have been included in the thesis, with a specific focus on the interview with Alehem. However, it is worth keeping in mind that the interviews convey only the expressed views and experiences of the particular interviewee. The purpose of including the findings from these interviews is, as discussed in section 2.1.1, to make the analysis more practically applicable. The persons interviewed for this study do not necessarily endorse the analysis or conclusions of this paper.

2.1.4 Parts and sub-conclusions

The thesis is divided in four parts, with one section dedicated to each question. Questions one, two and three will be answered in sub-conclusions. Seeing as question four constitutes the main question, the answer to this prompt will be revealed in a mid-sub-conclusion, as well as in the final conclusion. The sub-conclusions are both a summary and an analysis, giving the reader an overview of what to expect in the upcoming chapters.

⁸² This interview technique consist of prepared questions, but with an openness to relevant 'sidetracks'

⁸³ Interview with Johan Felix, Project Manager at the Foundation Chalmers Industriteknik (CIT), 20 October 2015, see Annex I

⁸⁴ Interview with Martin Alehem, Production manager at Stena Metaltech AB, 27 October 2015 see Annex II

⁸⁵ Interview with Annachiara Torciano, Sustainability Manager at Samsung Electronics Nordic, 17 November 2015 see Annex III

2.1.5 Introductions to chapters and sections

Due to the complicated nature of the subject, as well as the length of this thesis, I have chosen to include short introductions to each chapter stating the purpose and contents of the chapter or section. This might seem repetitive and increase the length of the thesis, but the ambition is to facilitate the reading and engage the focus of the reader.

2.1.6 Choice of sources

Throughout the literature studies, the aim is to include the latest possible research, regarding both the recycling process and the Ecodesign Directive and recyclability requirement. My rationale for this is to present a current image of the problems behind setting recyclability requirements under the Ecodesign Directive. Research later than 2012 has been referred to in papers and reports published in 2015, which has ensured me of their persisting relevance.

2.2 Part one - Research question one

2.2.1 Background and Chapter 4: The WEEE Directive

The purpose of the background is to give the basic understanding for the ambitions for EEE expressed in the newly released Action plan for the Circular Economy Package along with the concerns and goals regarding WEEE in the EU, as expressed in the proposal for the recast of the WEEE directive.⁸⁶ An introductory explanation of 'dismantling' and 'recycling' is also included in order to provide the reader with a basic understanding for further reading.

In order to get the picture of the relevant legislation regarding the waste treatment of WEEE, the relevant conditions on the WEEE Directive on material, component and substance separation, as well as overall recycling, is presented. It is also coupled with explanatory comments from the interview with Alehem⁸⁷, and from the WEEE recast proposal, in order to promote an understanding of the implications of the legislation. The relevant recitals from the WEEE Directive are also referred to in an attempt to indicate the objectives behind the Directive.

2.2.2 Chapter 5: The Synergy Approach

'The Synergy Approach' constitutes both the theoretical framework, as well as the scientific method, by which I analyze the requirements on the product policies and define the desirable synergy guiding the *de lege ferenda* discussion in part four. The Approach was selected due to its relevance for answering the question as to how EEE can be made more recyclable, as well as how an effective systematic legislation on EEE could be achieved with regards to recycling, according to the chosen empirical perspective.⁸⁸ The four steps described are my interpretations of the method, as outlined in the work by Ardente et al.^{89 90} After my interview

⁸⁶ COM(2008)810 (n 24) final

⁸⁷ Alehem (n 84)

⁸⁸ see section 2.1.1

⁸⁹ Ardente et al (n 42)

with Alehem⁹¹, I put increasing emphasis on the factors behind the pre-processing (step 2). To complement the Approach, I included the 'components targeted for separation' from the earlier work of Ardente and Mathieux⁹² in order to describe the pre-processing.

The description of the pre-processing and the techniques employed is collected from various scientific articles found by using search words such as 'design for disassembly' together with 'EEE' and 'recycling' on the search engine *Summon*. The balance between general conditions, and conditions influenced by product or material, has been rather difficult. The initial interview with Alehem⁹³ established a fundamental comprehension of the matter, which then allowed for a deeper understanding of the contents in the scientific articles. The interview with Alehem also constitutes the basis for the identification of general product criticalities⁹⁴, supported and expanded by findings in the literature study. This list is only to be regarded as an overall illustration of what hampers the pre-processing, as the criticalities are product-specific and depend on the contents and design of the product in question.

When describing the design process briefly, the purpose is to formulate an understanding of this process, and illustrate why recyclability might be difficult to consider. To do so, findings from the paper of Marwede et al and their interviews with manufacturers are included. The ecodesign aspect is presented through the inclusion of a paper written by Professor Conrad Luttropp⁹⁵, a renowned expert in ecodesign.

In an attempt to identify suitable correlating design typologies with the general criticalities, the typologies found in a literature study conducted by Ardente and Mathieux^{96 97} are used and compiled into a table. As this compilation is performed by myself, lacking any qualifications regarding product design and recycling, the table can be regarded as nothing more than an illustration of the fourth, and last, step of the Synergy approach. The purpose is also to determine which type of product requirements to look for in the product policies in the following chapter.

⁹⁰ F. Ardente, F Mathieux & M Recchioni, 'Recycling of electronic displays: Analysis of pre-processing and potential ecodesign improvements' vol 92 Resources, Conservation and Recycling [2014]158–171

⁹¹ Alehem (n 84)

⁹² F Ardente, F Mathieux, 'Integration of resource efficiency and waste management criteria in European product policies – Second phase: Report n. 3: Refined methods and Guidance documents for the calculation of indices concerning Reusability/ Recyclability/ Recoverability, Recycled content, Use of Priority Resources, Use of Hazardous substances, Durability' [2012] European Commission, JRC, Institute for Environment and Sustainability, Unit Sustainability Assessment. pp. 25

⁹³ Alehem (n 84)

⁹⁴ Product features not fully adapted to the recycling process.

⁹⁵ Luttropp & Lagerstedt (n 20)

⁹⁶ Ardente & Mathieux (n 65)

⁹⁷ Ardente & Mathieux (n 92)

2.3 Part two - Research question two

2.3.1 Chapter 6: Recyclability requirements in the product policies

Addressing this question, which pertains to how the recyclability of products is treated within the current product policy, requires posing a basic judicial inquiry based on a linguistic analysis of the legislation acts themselves, complemented by relevant recitals and descriptions from relevant Swedish authorities to capture the objectives behind the legislations. The analysis can therefore be said to be both linguistic and teleological.⁹⁸

The analysis of the presence of any requirements facilitating recycling under the Ecodesign Directive was performed through the use of the list, provided by the Commission, of all the 26 regulations (with amendments) and voluntary agreements under the Ecodesign Directive.^{99 100} All the regulations, including the listed amendments, were searched using the words ‘dismantling’, ‘disassembly’, ‘separation’, ‘fasteners’, ‘connection’, ‘material’, ‘recycling’, ‘recyclable’ and ‘substance’. This assortment of words were derived from the findings in section 5.5, but also from the formulation and nature of the recycling criterion formulated in the voluntary agreement from EuroVAprint for imaging equipment.¹⁰¹

2.4 Part three - Research question three

In regards to how to answer the third question about the hindrances on setting recyclability requirements, a *de lege lata* analysis of both the provisions in the Directive as well as judicial doctrine is deemed the most relevant method.

2.4.1 Chapter 7: The Ecodesign directive, provisions on product requirements and the process

In order to answer the question of whether the Ecodesign directive can be used to create further synergies between the product policies and the waste policy for EEE, a deeper linguistic analysis of the provisions in the Ecodesign Directive was required. The analysis of the provisions on the ecodesign requirements was based solely on the relevant sections of Article 15 in the Ecodesign Directive. Since the analysis in chapter 6 showed that recyclability requirements could, and are, being set under the Ecodesign Directive I found it necessary to broaden the analysis and include a description of the actual process of setting the requirements to see if any obstacles could be detected there.

⁹⁸ L Heuman, M Leijonhufvud, P Seipel, U Bernitz, H H Vogel, *Finna rätt : juristens källmaterial och arbetsmetoder* (13th Edition Norstedts Juridik AB 2014) p. 74

⁹⁹ https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf 2015-11-04

¹⁰⁰ https://ec.europa.eu/energy/sites/ener/files/documents/List_Eco-design-Voluntary%20Agreements.pdf 2015-11-04

¹⁰¹ EuroVAprint, ‘Industry Voluntary Agreement to Improve the environmental Industry Performance of Imaging Equipment placed on the European Market’ VA v.5.2 April 2015

2.4.2 Chapter 8: Identified hindrances for the setting of recyclability requirement and the creation of synergy

The criterion and the outlined process of setting ecodesign requirements in Chapter 7 constitute the 'filter' through which the literature study was seen when trying to identify hindrances to the setting of recyclability requirements in the judicial doctrine. The objective here is to evaluate the challenges with regards to fulfilling the provision in Article 15 of the Ecodesign Directive and the process of setting the ecodesign requirements.

The basis for the literature study is the article of Dalhammar¹⁰² from 2015, outlining the problems with adopting resource efficiency requirements under the Ecodesign Directive. It contains references to the latest reports on the issue. I also got access to not-yet-published papers in my quest to get the very latest updates of the research on ecodesign requirements on recyclability.¹⁰³ When selecting the judicial doctrine, the aim is to cover as many aspects as possible. Therefore, the two groups of reports on a potential expansion of the Methodology guiding the preparatory studies are included. The Methodology used for the preparatory studies was also pointed out as a hindrance, especially by Bundgaard et al¹⁰⁴ and Jepsen et al, which is why it is relevant to examine the reasoning in these reports.

Four of the sources can hardly be considered judicial doctrine: Two position papers from EU manufacturer representative organizations, as well as excerpts from the interviews with Torciano, Alehem and Felix. The position papers are analyzed for potential hindrances, in order to ensure that the manufacturer perspective is represented. The perspectives expressed in these position papers are in response to the Commission submitted working document for the new regulation on displays,¹⁰⁵ containing several recyclability requirements (e. g. information, ease of disassembly of key components and marking of plastics).¹⁰⁶ The interview with Torciano is also helpful in providing the manufacturer perspective. These three sources are included in the analysis since Bundgaard et al¹⁰⁷ identified the role of the industry as a barrier during the process of setting ecodesign requirement, as well as to get a realistic idea of the resistance towards recyclability requirements, and not just the issues acknowledged by scholars. Excerpts from the interview with Alehem are also added,

¹⁰² C Dalhammar, *The Application of 'Life Cycle Thinking' in European Environmental Law: Theory and Practice* (n 13)

¹⁰³ see section 2.1.6

¹⁰⁴ Bundgaard et al (n 45)

¹⁰⁵ Commission, 'Commission Working Document implementing Directive 2009/125/EC of the European Parliament and of the Council with regards to ecodesign requirements for electronic displays and repealing Regulation 642/2009 with regards to ecodesign requirements for televisions and supplementing Directive 2010/30/EC of the European Parliament and of the Council with regards to energy labelling of electronics displays and repealing delegated Regulation 1062/2010 with regards to energy labelling of televisions'. Available at: <http://www.eceee.org/ecodesign/products/television>

¹⁰⁶ The Working Document contains requirements such as disassemblability on printed circuit boards assembly (larger than 10 cm²); thin-film-transistor liquid-crystal display (larger than 100 cm²); PMMA board and mercury containing backlighting lamps along with marking of the type of plastic and a detailed 'End-of-Life report' on information on recycling and disassembly. The report should also contain a video of the dismantling of the components mentioned above (Point 6.5 Annex II and Annex III Working Document n 104).

¹⁰⁷ Bundgaard et al (n 45) p. 45

constituting the fourth non-judicial doctrinal source of information, for the purpose of having the pre-processor perspective represented.

Following these objectives and using this material, I managed to identify the three provisions in Article 15 of the Ecodesign Directive that recyclability requirements had most issues fulfilling. The literature study showed a focus on the difficulties in determining environmental impact and environmental benefit (potential for improvement) in Article 15(2) as well as issues with regards to the requirement on measurability in Article 15(6) in the Ecodesign Directive. The provisions on ecodesign requirements in Article 15(5), mandating that the requirement shall not lead to 'significant negative impact' on, for example, industry competitiveness, innovation and functionality, are only briefly mentioned. In order to refine the scope of the thesis, I decided to focus on the three most discussed provisions, and the hindrance they created for the implementation of recyclability requirements, and to treat the provisions in Article 15(5) only very briefly. This creates a limitation within my method, as it does not provide a full picture of the problems nor the solutions to setting recyclability requirements. However, this approach was deemed necessary, due to time constrictions and scope. The question of double-regulation was raised, mainly from the manufacturer perspective, and since the main question of the thesis is on synergy, this impediment seemed highly relevant and was therefore included as a hindrance, despite that it does not constitute a provision in the Ecodesign Directive. Information requirements will be analysed in particular since they constitute the most widely applied ecodesign requirements and were also found to be the most controversial, due to alleged 'double regulation' and questionable environmental benefit. The purpose of discussing the requirement is also to provide a concrete example to the reader.

An alternative method to establishing possible hindrances would have been to analyse the latest preparatory studies. However, my lacking knowledge about the technical aspects of the product design made the analysis of judicial doctrine more relevant.

2.5 Part four - Research question four

The fourth question concerns the enablers and possible ways to deal with the identified obstacles. The initial chapter of this section will present both concrete measures, such as the addition of further impact categories in the Methodology and standardization, as well as general development with the potential of diminishing the significance of the hindrances, such as an increasing political focus on resource efficiency. Identified difficulties with the implementation will also be addressed. In the second chapter of this part, my suggested approaches for an increased synergy will be outlined and presented as examples of strategies in the implementation allowing for recyclability requirements to be set under the Ecodesign Directive, and for synergies to be created.

The question entails elements of both *de lege lata*, due to the attempt to adapt the product requirements to the provisions in the Ecodesign Directive, but it is mainly a *de lege ferenda* discussion due to the changes proposed regarding the implementation of the directive. In

order to distinguish the more distinct *de lege lata* analysis in Chapter 3 from this more varied discussion, the hindrances and enablers are presented in different chapters, even though they are identified in the same literature study, and are connected due to the fact that the hindrances constitute the starting-point.

2.5.1 Chapter 9: Enablers and measures for alleviating the hindrances

The chapter is structured in the same way as chapter 8 and the enablers presented in this chapter were identified based on their relevance for overcoming the hindrances. The identified enablers are the result of the same literature study as the one used to identify the hindrances. The aim is not to give a full account of all the enablers with the possibility to affect the four identified hindrances, but to identify the most relevant ones. This chapter ends with a 'Sub-conclusion' containing an analysis of the enablers in order to determine the possibilities of overcoming the hindrances, and to explore what is missing in the debate. The missing links will constitute the subject of further analysis in chapter 10.

2.5.2 Chapter 10: Strategies to mitigate the uncertain environmental benefit

The analysis showed that the hindrance in the form of an uncertain environmental benefit is the one least discussed in the EU law doctrine. This analysis will therefore focus on possible ways to deal with this uncertainty and how to achieve a synergy between the Ecodesign Directive, The WEEE Directive and the RoHS, despite the uncertain EoL scenario. The section consists, initially, of a short discussion about my ideas about different approaches to identifying relevant design requirements, despite the uncertainties in the EoL scenario. Subsequently, my suggestions of further synergy measures, outside the Ecodesign Directive, are shortly analysed and compared to the ambitions expressed in the new Circular Economy Package as well as relevant sections from chapter 8 and 9.

3. The Background

3.1 Waste and product design policies in the new Circular Economy Package

3.1.1 The Action plan for a circular economy

The proposed actions in the new Circular Economy Package, presented on the 2 December 2015, are aimed at supporting the circular economy in each step of the value chain: from production to consumption, repair and remanufacturing, waste management, and secondary raw materials that are fed back into the economy.¹⁰⁸ The Action plan for a Circular Economy was accompanied by legislative proposal concerning both the WEEE directive and the Ecodesign directive. These proposals will be shortly described in this section.

3.1.2 Waste policies

The legislative proposal for waste, including an amendment of the WEEE directive, proposes long-term targets to reduce disposal to landfills and increase the preparation for reuse and recycling. The intention is that these targets shall compel member states to encourage investments in waste treatment and the adoption of best-practice levels within the EU.¹⁰⁹ The Commission is also proposing minimum conditions on transparency and cost-efficiency in the waste treatment. Non-toxic material cycles, along with better tracking of certain chemicals in products, will facilitate the recycling process and improve the transformation of waste into secondary raw materials and should be promoted. In this regard, the Commission brings up the interaction between legislation on waste, products and chemicals and states that their reciprocation must be assessed in the context of a circular economy, or, '.. In order to decide the right course of action at EU level to address the presence of substances of concern, limit unnecessary burden for recyclers and facilitate the traceability and risk management of chemicals in the recycling process.' Unnecessary barriers must be overcome while the high level of protection of human health is maintained.¹¹⁰

3.1.3 Design policies

The proposal includes a 'comprehensive commitment to ecodesign' and the Commission states that:

Better design can make products more durable or easier to repair, upgrade or remanufacture. It can help recyclers to disassemble products in order to recover valuable materials and components. Overall, it can help to save precious resources. However, current market signals appear insufficient to make this happen, in particular because the interests of producers, users and recyclers are not aligned. It is therefore essential to provide incentives for improved product design, while

¹⁰⁸ COM(2015)614/2 (n 50) p. 2

¹⁰⁹ COM(2015) 614/2 (n 50) p. 2

¹¹⁰ COM(2015)614/2 (n 50) p. 9, 12

preserving the single market and competition, and enabling innovation (...)
Electrical and electronic products are particularly significant in this context. Their reparability can be important to consumers, and they can contain valuable materials that should be made easier to recycle (e.g. rare earth elements in electronic devices). In order to promote a better design of these products, the Commission will emphasise circular economy aspects in future product design requirements under the Ecodesign Directive...¹¹¹

The Commission says that, to this date, the ecodesign requirement has mainly consisted of energy efficiency requirements, but in the future, targets such as reparability, durability, recyclability or identification of certain materials or substances will be systematically evaluated. This is to be done on a product by product basis by taking account of the specialities and particular challenges of the product in question, such as innovation cycles, in new working plans and reviews and in close cooperation with important stakeholders. The initial step is said to consist of mandatory product design and marking requirements to make dismantling, reuse and recycling of electronic displays, for example flat computer screens and television screens, safer and easier to perform.¹¹²

Finally, the Commission states that it intends to examine options and actions for a more coherent policy framework¹¹³ and how these policies and their coherency contribute to the circular economy. Plastic and critical raw materials are pointed out as two of the ‘priority areas’.¹¹⁴

3.2 The role of WEEE for resource efficiency

3.2.1 Definitions of EEE and WEEE

According to the WEEE, Directive *EEE* is defined as ‘equipment which is dependent on electric currents or elec-tromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current’.¹¹⁵ *WEEE* is defined as ‘electrical or electronic equipment which is waste within the meaning of Article 3(1) of Directive 2008/98/EC¹¹⁶, including all components, sub-assemblies and consumables which are part of the product at the time of discarding’.¹¹⁷

¹¹¹ COM(2015)614/2 (n 50) pp. 3

¹¹² COM(2015)614/2 (n 50) p. 4

¹¹³ The commission is referring to Ecodesign, Energy Labelling, Ecolabel, Green Public Procurement, and other relevant product legislation in footnote 4.

¹¹⁴ COM(2015)614/2 (n 50) pp. 5

¹¹⁵ Article 3(1)(a) (n 32) The WEEE Directive

¹¹⁶ ‘Waste’ refers to any substance or object which the holder discards or intends or is required to discard.

¹¹⁷ Article 3(1)(e) the WEEE Directive (n 32)

3.2.2 The characteristics of WEEE

WEEE is constituted by a complex mixture of materials and components; Materials which are important for economic reasons (for example Critical Raw Materials (CRM)), for reasons of high consumption (for example aluminium), or rarity (for example rare earths), among others.¹¹⁸ It also contains hazardous substances damaging to the environment and human health, if not treated properly. The composition of different categories of WEEE differs greatly: an electronic toy has a very different composition compared to a television. The three main materials in WEEE are metals, glass and plastics. Ferrous metals account for approximately 50%, non-ferrous metals for 5% and plastics for about 20-25%. Other materials and substances in the WEEE are, for example: oil and cooling agents from fridges, freezers and air conditioners, concrete from washing machines and wood from TV's.¹¹⁹

The Commission states that the WEEE arising now are products which have been put on the market in the preceding years. The lifetime of EEEs¹²⁰ depend on the product type but the average time of, for example, a mobile phone is estimated to be around 2 years, while the average lifetime of a refrigerator is approximately 15 years. The composition of the future WEEE will change, which can be seen in the difference between the current WEEE and the EEE put on the market.¹²¹

3.2.3 Environmental and human health reasons to recycle WEEE

The potential environmental impacts of WEEE vary depending on the type and are comprised of emissions of toxic substances, as well as inefficient use of materials and energy. As mentioned above, the Commission estimates that 50% of WEEE by weight consists of ferrous metals, largely made up of steel. Collecting and recycling this material typically results in savings of 74% energy, 86% air pollution and 76% water pollution, compared to primary steel production.¹²² Recycling of WEEE can potentially lower the emission of Greenhouse gases, and is considered a key factor in creating a closed resource loop.¹²³ Therefore, to place WEEE in landfills without extracting the valuable and hazardous materials and substances is not only potentially directly damaging for the environment and human health, but also causes an indirect burden for the environment, since virgin material needs to be extracted and refined to take its place in the material circle.^{124 125}

¹¹⁸ BIOis (n 68) p. 27f

¹¹⁹ COM(2008)810 final (n 24) p. 17,28ff

¹²⁰ The time between the selling of the product until it reaches the waste streams

¹²¹ COM(2008)810 final (n 24) p. 28

¹²² COM(2008)810 final (n 24) p. 46

¹²³ F Cucchiella, I D'Adamo, S C L Koh, P Rosa 'Recycling of WEEEs: An economic assessment of present and future e-waste streams' [2015] Volume 51 Renewable and Sustainable Energy Reviews 263–272, p. 264

¹²⁴ COM (2008)810 final (n 24) p. 46

¹²⁵ The decreasing quality of some materials constitute a part of the demarcation for this thesis, see section 1.4.

3.2.4 Economical reasons to recycle WEEE

The unsorted WEEE fractions, which end up in landfills and incinerators, comprise a cost for society¹²⁶ since, due to the loss of critical and valuable materials contained in the EEE, their disposal is a giant waste of resources¹²⁷ EEE is a primary consumer of both precious¹²⁸ and some critical raw material,¹²⁹ and the high economic value of these metals on the world market, as well as the limited available reserves of precious metals, serve as incentives to improve these recycling rates, together with the fact that they do not lose their properties during recycling. It is therefore imperative that a circular flow is established in order to recover these metals and other valuable elements.¹³⁰

3.3 Recycling and dismantling

3.3.1 Recyclability¹³¹

The recyclability of a product and its components depends on two factors. First, the material need to be separable from the other materials in the product or component ('dismantlability' or 'separability'). Materials with high environmental impacts as well as high recyclability may not be recycled if they cannot be separated from other incompatible materials in recycling processes. Secondly, the technique available must have capacity to recycle the material and substances ('recyclability'). The latter is dependant on the inherent properties of the material, whereas the separability depends on the methods used when assembling the product as well as the available recycling techniques.¹³²

3.3.2 Dismantling and disassembling

'Disassembly' is referring to the systematic approach that makes it possible to separate a component, part and subassembly and the goal is to achieve homogenous materials.¹³³ 'Disassembly' takes place when the product is disassembled and reversed to how it once was assembled. 'Dismantling', on the other hand, refers to the same process, but also includes elements of sheer forcing in order to make the components come apart, and is not dependent on how the product was assembled. Dismantling is therefore a wider concept.¹³⁴ Figure 3 below illustrate the disassembly of a kettle.

¹²⁶ COM(2008)810 final (n 24) p. 47

¹²⁷ http://ec.europa.eu/environment/waste/weee/index_en.htm 2015-10-02; Cucchiella et al (n 123)

¹²⁸ For example gold, palladium, platinum and silver and so on.

¹²⁹ For example, platinum, tantalum, gallium, magnesium, cobalt, indium, rare earths

¹³⁰ Ardente & Mathieux (n 65) p. 42; Chancerel et al 2009 (n 15); COM(2015)614/2 (n 50) pp. 3, 15f

¹³¹ Only characteristics dependant in the product or the waste treatment itself. In section 5.3 further factors are taken into account.

¹³² Bundgaard et al (n 45) p. 49; Ardente & Mathieux (n 90) p. 45; BIOis (n 68) p. 38

¹³³ J Chen, 'A general study of design for disassembly for electronic products' [2010], Computer-Aided Industrial Design & Conceptual Design (CAIDCD), IEEE 11th International Conference on (Volume:1) pp. 544

¹³⁴ Felix (n 83)

Example of a kettle

This example of a sketch of a kettle shows how the different part look like and how they are attached to one and other.

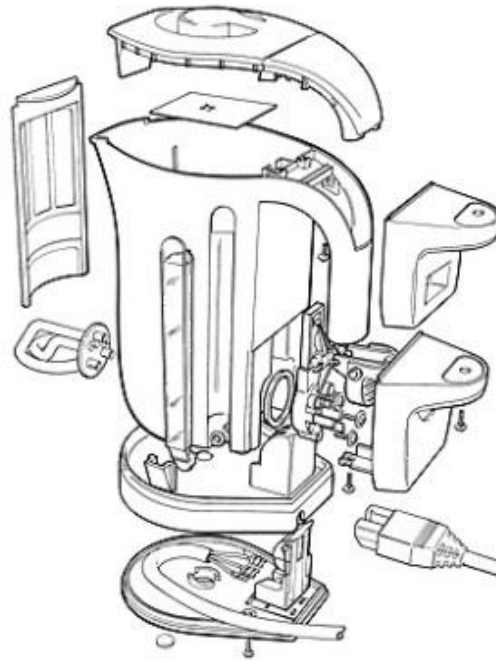


Figure 3. The design of the disassembling of a kettle¹³⁵

Disassembly of used products is needed in order to make recycling economically and environmentally viable; Without disassembly of certain components recycling would not be possible.¹³⁶

3.3.3 The pre-processing

As illustrated by the sketch of the kettle in figure 3, the components consist of different types of materials: in the case of the kettle, mostly different kinds of plastic and metals but, as outlined in section 3.1, WEEE can contain a much wider variety of components and materials that need to be dismantled and separated in order for the materials to be recycled. This process is referred to as ‘pre-processing’, and is performed prior to the recycling of the materials and substances.¹³⁷

¹³⁵ <https://woolyhairedideas.wordpress.com/2014/03/04/design-for-disassembly/> 2015-10-13

¹³⁶ Alehem (n 84)

¹³⁷ Commission (n 72) p. 33; Alehem (n 84)

PART 1

In this part of the thesis, the question regarding how EEE can be made more recyclable will be analyzed. In order to do so, the waste treatment legislation (The WEEE Directive) as well as the Synergy Approach will be examined.

4. The WEEE directive

In this chapter the waste treatment regulation on material, component and substance separation, as well as overall recycling, will be described, and the responsibilities of recyclers and manufacturers outlined.

4.1 *The general waste treatment*

Among the key objectives of the WEEE Directive are the aims to reduce the ‘wasteful consumption of natural resources’ and ‘the disposal of waste and [contributing] to the efficient use of resources and the retrieval of valuable secondary raw materials,’ as well as to avoid ‘the loss of valuable resources’.¹³⁸ The loss of valuable materials and the risk of exposing the environment to the hazardous substances in the WEEE can be significantly reduced by sound management of WEEE. According to the Commission, the elements of sound WEEE management include: the separation of WEEE from other waste to allow for targeted and technically adequate treatment, applying treatment standards that minimize the release of harmful substances, and recovering as much as feasible of the materials and energy from the waste.¹³⁹

4.1.1 Separate collection

The separate collection of WEEE is a precondition for specific treatment and recycling of WEEE, which is why member states are to ensure that collection systems for WEEE are set up, and that WEEE are separately collected at a high level.¹⁴⁰ This allows for the specialization mentioned above.

4.1.2 The recovery targets

Article 11(1) the WEEE directive refers to the recovery targets¹⁴¹ set by the Commission in Annex V. The recycling targets are set together with the targets for reuse. For example, WEEE from product category one, 'large Households appliances', shall be recycled or reused to 80%.¹⁴²

¹³⁸ Recital 3 and 6 the WEEE Directive (n 32)

¹³⁹ COM(2008)810 final (n 24) p. 17

¹⁴⁰ Recital 17 and Article 5 the WEEE Directive (n 32)

¹⁴¹ The 'recovery and recycling rates' (%) of WEEE measure the 'Treatment efficiency'. This is the ratio between the 'recovered' / and 'recycled and re-used' amounts versus the total amount of WEEE 'treated' (and not versus the total amount of WEEE 'generated' or EEE 'put on the market' (n 23).

¹⁴² Annex I the WEEE Directive are listing the product categories while the recycling targets are found in Annex V. See table 1 Annex IV to this thesis for a compilation of these two Annexes.

4.2 The responsibility of recyclers

4.2.1 The Best available technique

The best available treatment, recovery and recycling techniques should be applied, provided that they ensure human health and a high level of environmental protection in the treatment process.¹⁴³ The member states shall ensure that producers, or third parties acting on their behalf, set up systems to provide for the recovery of WEEE, and are using the best available techniques. This means that any establishment or undertaking carrying out collection or treatment operations to store and treat WEEE shall do so in compliance with the technical requirements, such as being equipped with scales to measure the weight of the treated waste, as well as impermeable surfaces and waterproof covering in appropriate areas.¹⁴⁴ None of the requirements are of direct relevance to the separation of materials discussed in section 3.2.

4.2.2 Proper treatment

Article 8(2) states that proper treatment consists of the preparation for reuse, recovery or recycling operations and shall, as a minimum, consist in the removal of fluids and the so called 'selective treatment', which comprise of the removal of the substances and components listed in Annex VII, see table 1 below. The definition of 'removed' reads that 'hazardous substances, mixtures and components are contained in an identifiable stream or are an identifiable part of a stream within the treatment process. A substance, mixture or component is identifiable if it can be monitored to verify environmentally safe treatment'.¹⁴⁵

Specific components	Components containing a certain substances
<ul style="list-style-type: none"> ● polychlorinated biphenyls (PCB) containing capacitors ● batteries, ● printed circuit boards <ul style="list-style-type: none"> ○ in mobile phones generally ○ other devices if the surface of the printed circuit board is greater than 10 square centimetres ● cathode ray tubes ● toner cartridges, liquid and paste, as well as colour toner ● gas discharge lamps, ● liquid crystal displays (together with their casing where appropriate) of a surface greater than 100 square centimetres and all those back-lighted with gas discharge lamps, ● external electric cables ● electrolyte capacitors containing substances 	<ul style="list-style-type: none"> ● mercury containing components, such as switches or backlighting lamps, ● plastic containing brominated flame retardants, ● asbestos waste and components which contain asbestos, ● chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC) or hydrofluorocarbons (HFC), hydrocarbons (HC), ● components containing refractory ceramic fibres ● components containing radioactive substances (the exception of components that are below the exemption thresholds set in Article 3 of and Annex I to Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the

¹⁴³ Recital 17 the WEEE Directive (n 32)

¹⁴⁴ Article 8(3) and Annex VIII The WEEE Directive (n 32)

¹⁴⁵ Article 3(1)(l) the WEEE Directive (n 32)

of concern (height > 25 mm, diameter > 25 mm or proportionately similar volume).	protection of the health of workers and the general public against the dangers arising from ionizing radiation).
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Table 1. Components subject to 'Selective treatment'¹⁴⁶

The list in Annex VII contains valuable components (such as circuit boards, which also contain hazardous substances) as well as hazardous substances (for example, the mercury in backlighting lamps).¹⁴⁷ These components and materials, as well as the requirement to remove all fluids, can be regarded as the statutory minimum level of dismantling and material separation that has to take place during the pre-processing prior to recycling.

4.3 The responsibility of producers

4.3.1 Financing

Producers are financially responsible for the collection, treatment, recovery and environmentally sound disposal of WEEE from private households, as well as from users outside of private households.¹⁴⁸ This is referred to as the Extended Producer responsibility mentioned in the introduction.¹⁴⁹

4.3.2 Information for waste treatment facilities

Producers are obliged to, upon request, provide information free of charge with relevance to the EoL treatment for each new type of EEE within one year after the EEE was placed on the market. 'This information shall identify, as far as it is needed by centres which prepare for re-use and treatment and recycling facilities in order to comply with the provisions of this directive, the different EEE components and materials, as well as the location of dangerous substances and mixtures in EEE.'¹⁵⁰

¹⁴⁶ Annex VII the WEEE Directive (n 32)

¹⁴⁷ Alehem (n 84)

¹⁴⁸ Article 12 and 13 the WEEE Directive (n 32)

¹⁴⁹ See section 1.1.5

¹⁵⁰ Article 15(1) the WEEE Directive (n 32)

5. The Synergy approach

5.1 How to apply the Synergy approach

In this section the Synergy approach and the steps required for the implementation of this approach will be outlined, along with examples from a case study of the pre-processing of Commercial Refrigeration Appliances (CRA) and on the disassembly of LCD-TV's, performed in the context of the Synergy Approach.^{151 152} In the following sections to this chapter, the four steps will be analysed further.

5.1.1 Importance of Synergy

Ardente et al highlights how research has showed that changes in the WEEE directive and enlargement on its scope have had impact on various levels, such as creating burdens for local authorities, and producers as well as recyclers, given rise to additional costs for consumers, and has had unexpected effects on developing countries, giving rise to increased traffic due to waste transports. The enforcement of waste policy can be strengthened by the creation of synergies with other policies, especially the Ecodesign Directive, with whom a synergy would have a beneficial effect.¹⁵³ A synergistically development of product and waste policies can ensure that product and process requirements defined in these legislation are consistent with each other, which maximizes the environmental and economic performances both for manufacturers and recyclers.¹⁵⁴

In recital 11 and Article 4 in the WEEE directive it is said that ecodesign requirements, set under the Ecodesign Directive, with the potential to facilitate re-use, dismantling and recovery of WEEE, should be applied. In recital 35 to the Ecodesign Directive, the WEEE directive is listed as one of the 'complementary' legislations and dismantling and recycling is listed possible as objectives design parameters in Annex I of the Ecodesign Directive.

5.1.2 The outcomes from the Synergy Approach

Ardente et al found that their analysis of the waste treatment on CRA resulted in useful knowledge and evidences both for the WEEE and for the Ecodesign Directive: for the WEEE Directive, the analysis brought relevant understanding of the waste treatment of the specific waste product and for the Ecodesign Directive, product criticalities and corresponding design improvement opportunities were identified. They found that this analysis identifies common interest to both policies, especially with regards to how the design of products can be altered to improve its recyclability.¹⁵⁵

¹⁵¹ Ardente et al (n 42)

¹⁵² Ardente et al (n 90)

¹⁵³ Ardente et al (42) p. 43; Jepsen et al (n 46); Ardente et al (n 90) ; Bundgaard et al (n 45)

¹⁵⁴ Ardente et al (42) p. 51

¹⁵⁵ Ardente et al (n 42) p. 49

5.1.3 The four steps of the Synergy Approach

- **Modelling of the EoL scenario**

In order to properly design the product for recycling, a deep understanding of the recovery treatment is needed. This can be achieved through the compilation of secondary data and modelling of the process steps, which require data availability, or through information collection at the recycling plants.¹⁵⁶ The later approach was introduced by Ardente et al with the purpose of identifying design measures for facilitated disassembly of displays at the EoL.¹⁵⁷

- **The determining factors behind the pre-processing**

The driving factors behind the recycling is important to take into consideration when estimating the recyclability of WEEE and identifying the criticalities. Generally, the priorities of the pre-processors are to treat the WEEE as economically as possible, abide the environmental requirements of the WEEE Directive and extract the valuable components.¹⁵⁸

- **Identification of criticalities**

'Product criticalities' are identified as product features which are not fully adapted to the recycling process. The data collected during the modelling of the EoL scenario is used to detect the difficulties encountered by the recyclers during the treatment of the specific product in question, and to analyse the aspects of the product that hinder the treatment. For example, Ardente et al concluded that CRA not properly designed could hamper the compliance with minimum targets and requirements, and refers to the recycling and recovery rates in Annex V in the WEEE Directive, as well as the obligation outlined in Annex VII to treat certain components. An analysis of the pre-processing of CRAs showed that a number of 'criticalities', such as the variety of design and the structure of the different CRA models, can cause problems at the recycling plants, because recyclers possess limited knowledge of the product composition and cannot easily locate and extract certain components.¹⁵⁹

- **Identification of potential product improvements**

Ardente et al propose that the identified criticalities shall lead the way for the identification of appropriate design considerations, which will lead to more recyclable products. For example, Ardente et al found in their case study of CRAs that design measures enabling the identification, access and extraction of the following electric and electronic components would facilitate the recycling process: printed circuit boards, electrolyte capacitors, LCD, mercury containing switches or backlighting lamps, gas discharged lamps and batteries, components listed in Annex VII of the WEEE Directive. The substitution of certain substances and material, such as insulation foams and insulation blowing agents, would be preferable from a recycling point of view. However, they also point out the unknown effects of the unidentified substituter, and the risk of 'informal recycling' if valuable components are

¹⁵⁶ Ardente et al (n 42) p. 45

¹⁵⁷ Ardente et al (n 90)

¹⁵⁸ Ardente et al (n 90) p.160

¹⁵⁹ Ardente et al (n 42) pp. 43

easily removed, as well as the safety issues that might arise for users if certain parts are easily dismantled. Information about the prevalence and labelling of certain components, materials and substances were also considered a facilitating measure.¹⁶⁰

5.2 The pre-processing¹⁶¹ - Identification of the EoL scenario

5.2.1 The overall process

Once the WEEE has been collected, it is taken to a pre-processing facility for pre-processing. In the beginning of this process, all WEEE is considered 'hazardous waste,' and the purpose of the pre-processing is to convert the WEEE to 'salable waste'.¹⁶² Depending on the type of WEEE, the EoL treatment for WEEE varies.¹⁶³

In order to be salable, the material fractions such as iron, copper and some plastics, must reach a certain required purity level, depending on the type of material. The impurities can consist of hazardous substances, but also of other types of material, and are caused by non-separability. The latter is called 'contamination' of the material, while the presence of a hazardous substance constitutes 'pollution'. A non-salable material fraction, due to contamination, pollution or the lack of demand for such a recyclate, will be disposed of. The salable fractions are sold to recyclers and taken to smelters to be turned into 'secondary raw material',¹⁶⁴ a process belonging to the phase 'raw material production' at the beginning of the product life-cycle.^{165 166}

The dismantling of the WEEE and the separation of the different materials can be carried out manually, automatically, or by using a semiautomatic process, which entails a combination of manual and automatic techniques.¹⁶⁷ These three different EoL scenarios for LCD-TVs are illustrated below in figure 4.

¹⁶⁰ Ardente et al (n 42)

¹⁶¹ Ardente et al (n 42) defines the Pre-processing as manual dismantling. However, the definition used in this thesis is the one employed by the Commission: the definition of the entire waste treatment process until recycling takes place and the waste ceases to be waste. See section 1.5

¹⁶² Alehem (n 84)

¹⁶³ see <http://www.erp-ewaste.co.uk/wp-content/uploads/2012/03/WEEE-Recycling-Processes-WEB.pdf> 2015-10-01

¹⁶⁴ Alehem (n 84)

¹⁶⁵ Chancerel et al (n 15) p. 794

¹⁶⁶ see Figure 1

¹⁶⁷ Ardente et al (n 90) p. 162; Chancerel et al (n 15) p. 794

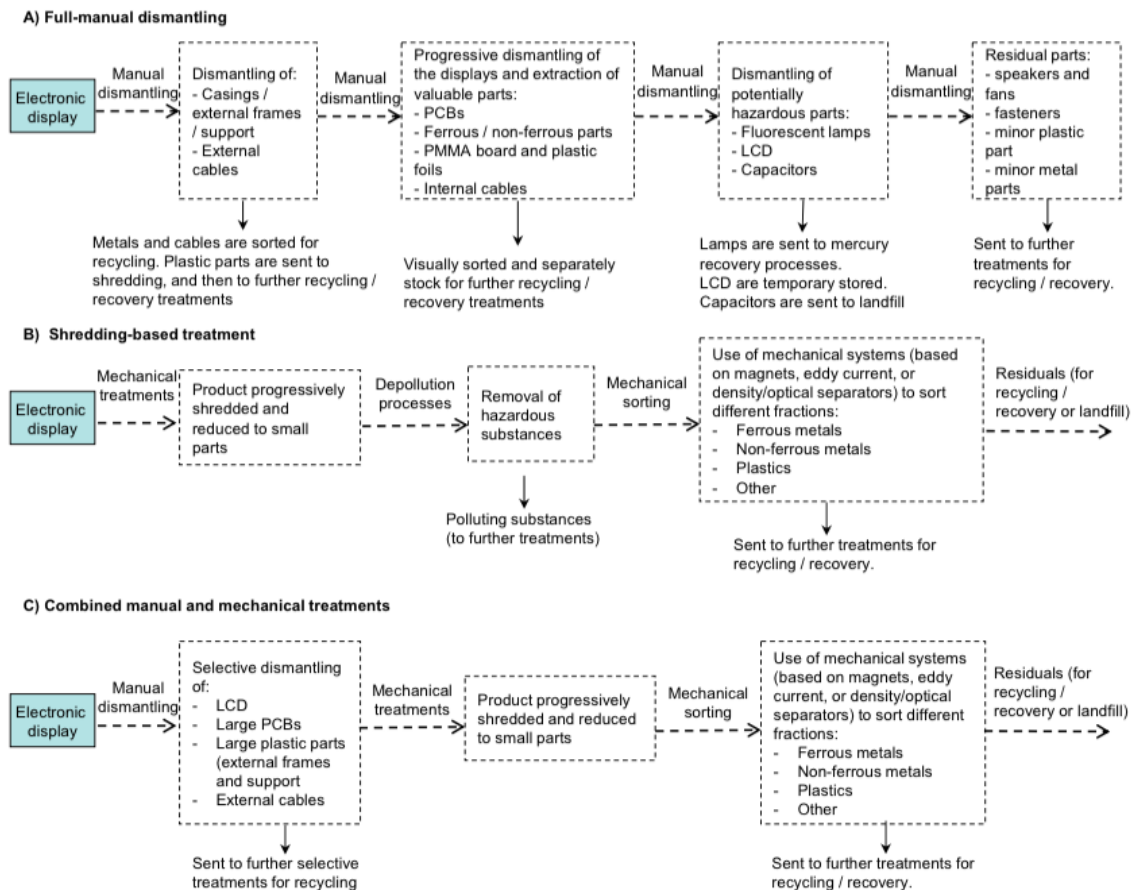


Figure 4: Three possible EoL scenarios for an LCD-TV.¹⁶⁸

5.2.2 Targets for separation

The parts of the WEEE targeted for separation, for different reasons, can be subdivided in the following groups: parts for selective treatments, parts for selective recycling, parts difficult to process, and other parts.¹⁶⁹

Selective treatment includes the removal of the components and substances listed in Annex VII (The WEEE Directive). During the manual dismantling the visible targeted components containing hazardous and problematic substances, such as batteries, motors and large metal sheets, together with easily dismantled printed circuit boards and mercury lamps, are removed. The rest of the components subject to selective treatment are usually removed through pre-shredding, followed by manual sorting, shredding and mechanical sorting¹⁷⁰ as the 'other components targeted for removal', see below. Important here is to recall the definition of the obligation to 'remove' the components and substances from the rest of the WEEE, as outlined in Annex VII in the WEEE directive: they need to be removed either at the initial manual stage or after the mechanical treatment through the sorting operations, *if* the technique enable separation at that later stage. It must be possible to follow the components

¹⁶⁸ Ardente et al (n 90) p. 162

¹⁶⁹ Ardente & Mathieux (n 92) p. 25f

¹⁷⁰ Ardente et al (n 42) p. 45f; see Alehem (n 84)

and substances in a separate flow and predict their end-point. If this cannot be done, the product will have to be further dismantled manually, which is costly. Increasing sorting technique development enables the use of less manual dismantling and manual sorting. One example of this is circuit boards: the easily accessible circuit boards are removed manually while the others are collected after the first shredding. To do this, the pre-processors at Stena are using an optical machine programmed to recognize circuit boards, which will have them removed from the rest of the waste stream through a blowing mechanism. Before this optical sorting was made available, the majority of all the circuit boards had to be removed manually before shredding.¹⁷¹

Parts for *selective recycling* are those embodying one or more recyclable materials economically worth being manually dismantled and separately recycled. The parts generally fulfil the following conditions: the size of the part and nature of the material makes it profitable to dismantle and it exists a specific EoL channel for these material, achieving higher recycling rates compared to material separation further along in the treatment belt.¹⁷²

Parts difficult to process are those that have to be preventively extracted due to the hazard they present to either the pre-processing equipment or the personnel. Counterweights (in concrete or cast-iron), glass, wood and cotton mats are example of materials that might disrupt the mechanical treatment¹⁷³ while some lithium-ion batteries pose a work environment issue since they might explode if treated mechanically.¹⁷⁴

Removal of other part (for material separation) includes the remaining parts in the waste flow that are processed by one or more shredders in line, with a decreasing cutting size, and separated afterwards by various systems. The main valuable materials that are finally obtained include ferrous metals (sorted by magnetic separation), non-ferrous metals (copper, aluminium and zinc, which are sorted by Eddy current separators), and some plastics (sorted by density separators).¹⁷⁵ Residues from the shredding have their energy recovered or are landfilled. The residues are comprised of plastic and metal, which did not get intercepted by the sorting techniques targeting them.¹⁷⁶ For example, this will be the case for a metal bolt or screw having been used to attach plastic: if plastic residues are still present on it, the piece of metal will be considered contaminated and cannot be recycled.¹⁷⁷

Selective treatment and parts for *selective recycling*, as well as parts *difficult to process*, will be manually dismantled depending on the material value contained in the product (the profit from the recycling) and the technical capacity (to process or to extract). If the component or substance cannot be removed in an economically viable or safe manner, it will not continue to the next mechanical step and will instead get disposed of. Some particularly demanding

¹⁷¹ Alehem (n 84)

¹⁷² Ardente & Mathieux (n 92) p. 25

¹⁷³ Alehem (n 84); Ardente & Mathieux (n 65) p. 94

¹⁷⁴ Felix (n 83)

¹⁷⁵ Ardente et al (n 42) p. 46

¹⁷⁶ Ardente & Mathieux (n 65) p. 91ff; Ardente & Mathieux (92) p. 26

¹⁷⁷ Alehem (n 84)

products or components might be sent to specialized facilities, given that there is an economical viability in doing so.¹⁷⁸ An inadequate treatment leads to material losses.¹⁷⁹

5.3 Determining factors behind the pre-processing

5.3.1 Price competition

Through the EPR in the WEEE directive, the manufacturer is responsible for the collection and treatment of the WEEE, according to their current market share. The pre-processing itself is performed by profit-driven corporations, after competitive bidding has taken place.

Depending on the material value contained in the WEEE, the pre-processing companies either pay or get paid for the collected WEEE. The more treatment the WEEE require, the higher the price the pre-processing company is going to charge the Producer Organization managing the collection and delivery of the WEEE for accepting the waste.¹⁸⁰

The cost of the pre-processing is dependent on the features of the WEEE and the available treatment techniques for performing the dismantling and material separation. The revenue from the pre-processing is determined by the material value contained in the WEEE, which depends on market prices for recyclates¹⁸¹. The recyclates are subject to the prices on the competing market for virgin materials, as well as on the market for recyclates¹⁸². Therefore, the higher material value contained in the WEEE, the more important are the incentives for the pre-processor to invest in the pre-processing. The lesser the cost of the pre-processing, the higher the chances of making a profit from the recycling.^{183 184}

5.3.2 The choice between manual and mechanical dismantling

Pre-processors are faced with complex material matrixes joined, screwed, press- fitted, soldered, tempered, alloyed or glued together. On one hand they have to liberate the materials from each other, and on the other hand, the separated material fractions need to be as clean as possible.¹⁸⁵ To do this, and to achieve a high productivity, pre-processors in industrialized countries are mainly using mechanical treatment, followed by high-tech identification and automated sorting technologies.^{186 187} The lack of manually performed operations are due to

¹⁷⁸ see figure 4, see Alehem (n 84)

¹⁷⁹ Hagelüken (n 62)

¹⁸⁰ Alehem (n 84)

¹⁸¹ Secondary raw material

¹⁸² Naturally, the very existence of a market for the recyclate determines the recycling of the material in question. Alehem (n 84) took the example of the rare earth neodym: when the recyclate market was limited they recycled less neodym. Now that the demand is growing, which has caused the recycling rates to increase.

¹⁸³ Provided there is a market for the recyclate.

¹⁸⁴ see Alehem (n 84)

¹⁸⁵ M Marwede, P Chancerel, M Ueberschaar, V R Rotter, N F Nissen & K-D Lang. 'Building the bridge between innovative recycling technologies and recycling- friendly product design – The example of technology metals' Forthcoming

¹⁸⁶ J R Peeters, P Vanegas, J R Duflou, T Mizuno, S Fukushige & Y Umeda,

high labour costs raising the cost of recycling, along with the narrow markets for recyclates, limiting the revenue for recycling companies.¹⁸⁸

The mechanical recycling techniques achieve high recovery rates for certain materials, such as iron and aluminium, but underperforms regarding others, like various rare and precious metals, critical and rare earths, and specific plastics, such as plastics containing Flame Retardants.^{189 190 191} A comparison of recycling treatments of televisions (TVs) showed that less than 10% of precious metals are recovered with the use of mechanical treatments, while the manual dismantling of waste products allows for the recovery of more than 90% of such metals.¹⁹² Many WEEE fractions consist of, in various ways, closely interwoven materials which makes mechanical shredding unable to liberate each material from all its interconnections. Hence, the technical limitations of mechanical size reduction, as well as automated sorting processes, processes characterized by imperfect material liberation and separation, lead to material losses.¹⁹³ Although shredding-based scenarios seem to be more economically viable than manual-based scenarios, they achieve lower recovery rates.¹⁹⁴ Ardente et al highlights how these material losses in a shredding-based scenario fail to fully address key policy objectives in the WEEE directive.^{195 196}

The preference for mechanical treatment, and the potential material loss accompanying that choice, is aggravated by the increasing complexity in the design of EEE which is becoming more complex, heterogeneous and sleeker, and are also containing more proprietary joints.¹⁹⁷ The variety of product designs also makes automatic disassembly difficult to apply.^{198 199}

'Effects of boundary conditions on the end-of-life treatment of LCD TVs' [2013] vol. 62 CIRP Annals - Manufacturing Technology 35 -38, p. 36ff

¹⁸⁷ Marwede et al (n 185)

¹⁸⁸ Peeters et al 2013 (n 186) p. 35; Vanegas et al (n 29) p. 601

¹⁸⁹ Vanegas et al (n 29) pp. 601; Chancerel et al (n 15) pp. 802

¹⁹⁰ J R Peeters, P Vanegas, L Tange, J Van Houwelingen & J R Duflou, 'Closed loop recycling of plastics containing Flame Retardants. Resources' [2014] Conservation and Recycling 84 35–43

¹⁹¹ P Chancerel, V S Rotter, M Ueberschaar, M Marwede, N F Nissen & K-D Lang, 'Data availability and the need for research to localize, quantify and recycle critical metals in information technology, telecommunication and consumer equipment' [2013] vol 31 Waste management and research 3-16

¹⁹² Peeters et al. (n 186) p. 33

¹⁹³ A. Manhart, 'International Cooperation for Metal Recycling From Waste Electrical and Electronic Equipment' [2011] vol 15 Journal of Industrial Ecology 13-30, p. 17ff

¹⁹⁴ F Mathieux, M Recchioni & F Ardente, 'Measuring the time for extracting components in end-of-life products: needs for a standardized method and aspects to be considered' [2014] Proceedings of the 21st CIRP conference on life cycle engineering: Procedia CIRP 15 245–250, p. 246

¹⁹⁵ Ardente et al (n 90) p. 161

¹⁹⁶ See Chapter 4

¹⁹⁷ Vanegas et al (n 29) 2015 p. 602; Sundin et al (n 30) p. 392

¹⁹⁸ BIO Intelligence Services (BIOis), *Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products*. Part 2a: Enhancing MEerP for Ecodesign. Report prepared for the European Commission DG Enterprise and Industry. 5 December 2013. p. 9

¹⁹⁹ Vanegas et al (n 29) p. 602

5.3.3 Manual treatment

The adoption of manual disassembly for the EoL treatment is necessary to, for example, increase the recovery of Precious Metals (PMs), critical and rare earth elements and plastics.²⁰⁰ LCD-TVs constitute an interesting illustration of manual dismantling. LCD-TVs contain mercury lamps for lighting of the screen ('selective treatment') and these lamps must be removed before the TV can continue to the next treatment stage (mechanical treatment) in order to avoid contamination of the waste stream. The removal of these lamps require manual dismantling of the entire TV, including the LCD-module ('the screen package'), a project which is both time consuming and entails a risk of mercury exposure for the operator. In the case of LCD-screens, there is no widely applied mechanical dismantling process available and, since the material value does not make manual treatment profitable, the LCD-module is sent to destruction or landfills.²⁰¹ Ardente et al found that manual disassembly granted a higher recycling yield while mechanical treatment constituted a more economically viable option due to the high wage expenses associated with the manual dismantling. In order for the manual dismantling to be economically competitive, the increase in profit from the heightened recycling yield, compared to the yield from mechanical treatment (depending on market prices for the recycle), must exceed the cost increase for implementing manual dismantling (the time required for the dismantling multiplied by the wage rate). For waste treatment to be economically viable, as well as resource-efficient, the dismantling time must be reduced enough make the treatment option competitive. Therefore, to support the adoption of manual dismantling by pre-processors, future displays will have to be designed to be easily dismantled.²⁰²

An ideal recovery scenario for TV-sets in the future could be to systematically and easily (meaning at low cost) manually extract a set of key components (for example, display screen, printed circuit boards and large plastic housing) in the initial steps and then to send the remaining fractions to mechanical treatment (shredding and sorting). Such a solution has the potential of being both economically viable and increase the recycling of valuable resources.²⁰³

5.3.4 Economically viable and resource efficient pre-processing

Ardente et al demonstrated the importance of facilitated manual dismantling and how it is a precondition for the economical viability of the treatment alternative. The pre-processing in general need to become more cost-effective, productive and, through these changes, more economically viable, as well as resource efficient. This can be achieved through two approaches: through increased innovation on efficient recycling techniques and modelling of

²⁰⁰ J R Peeters, P Vanegas, W Van den Bossche, T Devoldere, T Dewulf & J R Duflou 'Elastomer-based fastener development to facilitate rapid disassembly for consumer products' [2015] vol 94 Journal of Cleaner Production 94 177-186 p. 185

²⁰¹ Felix (n 83); Ardente & Mathieux (n 65) p. 140

²⁰² Ardente et al (n 90) pp. 167; Felix (n 83)

²⁰³ Mathieux et al (n 194) 2014 p. 246

the volumes of waste,²⁰⁴ as well as innovative product development allowing for the WEEE to be more recyclable once they reach the waste stream.²⁰⁵

The next step in the Synergy Approach is to determine which product features constitute the criticalities, hence creating obstacles for an economically viable and resource efficient pre-processing.

5.4 Identification of criticalities in the waste stream

The criticalities will differ depending on the product category. However, general complicating aspects of the waste stream will be listed according to an interview with the Nordic Production manager at Stena Technoworld AB, Martin Alehem.²⁰⁶ His experience of waste treatment will also be complemented by findings from literature studies on the recycling of WEEE.

5.4.1 General criticalities

- **Non-recyclable materials**

Some materials and substances cannot be recycled (due to the lack of a method to recycle it or the lack of a market for that recycle) or the technique to enable their separation is non-existent, which is the case, for example, of brominated flame retardants in plastic.²⁰⁷ There are several combinations of substances that cannot be separated by means of the available recycling processes, which do, however, significantly affect the quality of the secondary material, and therefore, its potential to contribute to resource conservation. This is true for copper and iron that cannot be separated after melting.²⁰⁸ Another example of currently non-recyclable material combination is plastic fillers, which is a plastic diluted with other substances in order to change the density and flexibility of the plastic. In the sorting, conducted by a density test, this type of plastic will behave like brominated plastic and be sent to incineration. Glass, for example, is another example of a material that is difficult to recycle due to the low material value and the problem it causes in the mechanical treatment. In order for recycling to be profitable, it needs to be removed in large fractions, something the fragile nature of glass will seldom allow for. The trend of increasing use of glass in EEE, despite no increase in functionality, is therefore a problem for the recyclability of products.²⁰⁹

- **The manual disassembly time**

The removal of batteries for example ('selective treatment') constitutes one of the most time consuming parts of the manual dismantling process. Products containing batteries are easy to identify through looking at the type of product, and the batteries are, for the most part, not

²⁰⁴ Vanegas et al (n 29) p. 606; Ardente & Mathieux (n 65) p. 69

²⁰⁵ Ardente et al (n 42); Ardente et al (n 90); Pérez-Belis et al (n 27); Chancerel et al (n 15); Luttrupp & Johansson (n 20); Sundin et al (n 30)

²⁰⁶ Alehem (n 84)

²⁰⁷ Ardente & Mathieux (n 65) p. 173

²⁰⁸ Jepsen et al (n 46) p. 52

²⁰⁹ Alehem (n 84)

very difficult to remove today.²¹⁰ However, the dismantlability of batteries are expected to become more complicated in the future, due to the trend of increased complexity of the EEE design.²¹¹ On the other hand, the development of environmentally friendly batteries, such as some lithium-ion batteries, which can be shredded, indicates a beneficial development for pre-processing with regards to batteries.²¹² Peeters et al performed a disassembly test with LCD-TVs and found that the localization of fasteners accounts for two thirds of the manual disassembly time. The diverse design also requires a plethora of different tools and equipment, sometimes very specific ones, in order to dismantle the WEEEs.²¹³ The disassembly of valuable recyclable parts (for example printed circuit boards) of TVs is often hampered by the large number and complexity of fastening systems, sometimes comprised of up to ten different screws, which require long times for disassembly due to having to continuously change the tools.²¹⁴

- **Many small material fractions on one product**

The prevalence of the large amount of different materials in the EEE design poses a problem at the pre-processing. Alehem gave an example of cell phones: 10-15 years ago they contained 14 basic elements. Today, that number has increased to 70 in one single cell phone. He concludes that even if it was possible to extract all the materials inside the cell phone there would not be buyers for all these materials, so many of them will not be recycled.²¹⁵

- **Complex and varied design**

Many operational pre-processing recycling plants are designed empirically, which means that the operations are based on experience with past system performances.²¹⁶ The product development is increasing in pace, which means that recyclers are often faced with technology changes in the products. Such an example is the change from cold cathode fluorescent lamps (CCFL) to light-emitting diodes (LED) backlighting in the backlighting on liquid crystal displays (LCDs), and, at the same time, recyclers still need to treat older devices, such as CRT screens. That means that recyclers need to have the capability to treat different generations of product technologies at the same time. The uncertainties on the sizes of return flows of these products make it even more complicated to scale and cost-optimize processes,²¹⁷ especially regarding automatic treatment. The CRT-TV is an example of how the product design diversity constitutes a problem for the development of automatic dismantling, and instead, it has to be done manually.²¹⁸

Predictability and high volumes allows the recycling companies to invest in treatment procedures that are adapted and therefore effective for the product in question. This allows for

²¹⁰ Alehem (n 84)

²¹¹ Felix (n 83)

²¹² Alehem (n 84)

²¹³ Peeters et al (n 200) p. 179

²¹⁴ Alehem (n 84); Ardente & Mathieux (n 65) p. 163

²¹⁵ Alehem (n 84)

²¹⁶ Vanegas et al (n 29) p. 606

²¹⁷ Marwede et al (n 185)

²¹⁸ Alehem (n 84)

a high level of material separation. The variety of different products and the multitude of different materials and different pieces they each contain makes the dismantling problematic, since it takes time and sometimes the dismantling requires skilful workers. Regarding material choices, Alehem explains that the multitude of new materials incorporated in the design of EEE does not make some research on recycling worthwhile. Plastic fillers are such an example, where a multitude of new versions of the material is being developed.²¹⁹

- **Hazardous substances**

As described in section 5.2, certain substances cannot be allowed to remain in the WEEE when it enters the manual treatment out of risk of contamination, which is why it needs to be removed. The four most prevalent hazardous substances in WEEE is PCB, mercury, lead and cadmium. Another hazardous substance is brominated flame retardants (BFR) in plastic.²²⁰ When there is no efficient way of removing the hazardous materials through disassembly, the entire product must be sent as 'hazardous material' which results in a loss of resources since non-hazardous material (the other materials) have to be treated as hazardous.²²¹

- **Unknown contents**

While the prevalence of a battery in a WEEE is fairly easy to identify, judging from the type of WEEE, the presence of hazardous substances is much harder to predict, making the treatment less productive.²²² For example, an operator at a pre-treatment facility cannot tell the difference between a LCD-screen with a LED-lighting (containing no mercury) and the one with fluorescent light in the screen (containing mercury).²²³

5.4.2 Summary of the criticalities

The criticalities consist of aspects of the product's design making the extraction of the components targeted for separation difficult, either through the lack of knowledge of their presence in the product or the ability to extract them either manually (different fasteners and the long dismantling time required) or mechanically (diverse design and the presence of hazardous substances). Other problems identified exist in the non-recyclable materials and the small quantities of valuable materials in one product, making treatment unprofitable.

5.5 Identification of design improvements

The Commission states that the waste treatment measures can be complemented by design measures aimed at avoiding, to the greatest possible extent, the use of certain substances, hazardous substances in particular, as well as measures to reduce possible exposure of workers and consumers and to favour the efficient dismantling and sorting of waste.^{224 225}

²¹⁹ Alehem (n 84)

²²⁰ Alehem (n 84)

²²¹ Sundin et al (n 30) p. 392

²²² Alehem (n 84)

²²³ Felix (n 83)

²²⁴ COM (2008)810 final (n 24) p. 17

²²⁵ Alehem (n 84)

5.5.1 The design process

In the product developing process and designing of a product the manufacturers and designers follow a wide range of goals.²²⁶ The balance between environmental ‘cost’ and functional ‘income’ is essential for a sustainable product development, and the basic problem is how to maximize or optimize functionality and other benefits with the resources at hand.

Environmental issues must be balanced against the other requirements for the product and the possible ways of making the product more recyclable have to be related to all the elements in the design core, and cannot be the dominant factor, since environmental demand is not the only priority. Instead, functionality and economic factors normally hold the highest business priority.²²⁷ Recyclability constitutes one of the lower priorities in the hierarchy of eco-design goals, and is preceded by reduction of mass, reduction of energy use, avoidance of hazardous materials, and the use of sustainable materials in the design.²²⁸ Product designers are no experts at recycling, therefore they need clear and simple statements on which design solution can facilitate the recycling of the materials in the product. Clear and simple design recommendations can often not be given due to manifold boundary conditions such as technical requirements, recycling limits, costs and user demand and behaviour.²²⁹

5.5.2 Design measure with the potential to increase recyclability

Some basic design measure, with the potential of remedying the six criticalities identified in section 5.4, have been identified in the work of Ardente and Mathieux²³⁰ and are outlined in table 2.²³¹ The seven general criticalities can be found in the left column table, while the correlating Typology and Sub-typology are listed in the following two columns. For example, all criticalities can potentially be improved through a design requirement on a threshold of recyclability, suggestively a general indicator (see the second row in table 2). The criticality of 'unknown contents' can be remedied by declaring and establishing thresholds on hazardous substances, as well as marking and information about contents (see row 5-7 in table 2).

Criticality	Typology	Sub-typology
<i>All (potentially)</i>	<i>Declaration of recyclability</i> (RRR rates or RRR benefits rates)	- General indices - Indices restricted to some specific material (e.g. RRR rates or Recycled content restricted to plastics, CRM, etc.)
<i>All (potentially)</i>	<i>Threshold of recyclability</i> (RRR rates or RRR benefits rates)	- General indicator - Indicators restricted to some specific material (e.g. RRR rates or Recycled content restricted to plastics, CRM, etc.)
<i>- Different types of materials</i>	<i>Design for recycling</i>	- Use of compatible materials (or

²²⁶ Marwede et al (n 185)

²²⁷ Luttrupp and Lagerstedt (n 20) s. 1397

²²⁸ Marwede et al (n 185)

²²⁹ Marwede et al (n 185)

²³⁰ Ardente and Mathieux (n 65) p. 67

²³¹ See section 2.2.2 for a description of the method of how this table was put together.

- <i>Non-recyclable materials</i> - <i>Hazardous substances</i>		forbid the jointly use of materials that are not compatible for recycling) - Use of materials more recyclable - Reduce number of contaminants (labels, glue, solders, etc.)
- <i>The manual disassembly time</i> - <i>Varied and complex design</i>	<i>Design for disassemblability / dismantlability</i>	- Time based index (e.g. dismantling of a component) - Mass / Time based index - Reduction / simplification of fastening (e.g. reduction of number and typologies) - identification of 'key' components and facilitate their dismantling ²³²
- <i>Unknown contents</i> - <i>Hazardous substances</i>	<i>Declaration of substances</i>	- BOM of product or parts (at different level of detail) - Relevant substances (e.g. CRM to be recycled) - Pollutants (e.g. flame retardants), which interfere with EoL treatments
- <i>Unknown contents</i> - <i>Hazardous substances</i>	<i>Threshold of substances</i>	- Relevant substances (e.g. CRM to be recycled) - Pollutants (e.g. flame retardants), which interfere with EoL treatments
- <i>Unknown contents</i> - <i>Hazardous substances</i>	<i>Marking / labelling / tracing</i>	- Easy identification of recyclable materials /parts - Identification of pollutants - Use of innovative technologies for the automatic sorting systems (tracing substances, magnetic powders, etc.)
- <i>The manual disassembly time</i> - <i>Hazardous substances</i> - <i>Complex and varied design</i>	<i>Information</i>	

Table 2 Design aspects and parameters on recyclability²³³

5.5.3 Design measures for increased synergy

Some design measures are of a more general nature and would increase the recyclability regardless of the product category, such as the removal of hazardous substances making the treatment safer and more cost efficient.^{234 235} Another such general example is the reduction of substances lacking a technical and economically viable recycling treatment.²³⁶

²³² Ardente et al (n 42)

²³³ Column two and three are collected from Ardente & Mathieux (n 65) p. 67

²³⁴ Alehem (n 77)

²³⁵ Dalhammar, C. 'Rethinking the Ecodesign Policy Mix in Europe' Forthcoming

²³⁶ Alehem (n 77)

Regardless, the proposed Synergy Approach by Ardente et al²³⁷ includes more product specific design measures developed based on the criticalities observed in the individual waste treatment of the product group in question. Hence, the general sub-typologies²³⁸ can then be made more specific in order to make the product more recyclable. For example, a product containing printed circuit boards²³⁹ should be designed in order to allow for a facilitated dismantling of this specific component. The same with the glass or wood components.²⁴⁰

5.6 Sub-conclusion: Recyclable EEE

'Recyclable EEE' must be understood as a product design which enables an increase in recycling rates. The Synergy Approach promotes a direct link to the recycling process (instead of general assumptions about the treatment) in order to increase the recyclability performance of products through the design and achieve the recycling rates in Annex V in the WEEE Directive. Through the application of the Synergy Approach, an analysis consisting of four steps has been conducted in order to determine: how the EoL scenario might look like, which factors influence the extent of the pre-processing, which general criticalities hampers the pre-processing and which design parameters can correspond to these criticalities. The components stipulated in Annex VII of the WEEE Directive for removal turned out to be but one out of four groups of components targeted for separation in order to recycle the product contents.

Since the pre-processing is exposed to competition, the efforts invested in the treatment must be inferior to the material value in the product. Generally, the more cost-efficient a resource efficient recycling treatment alternative is made, the higher the recycling rates achieved. The analysis showed that the dismantling and identification of the targeted components are crucial for a well-functioning pre-processing. The facilitation of this dismantling through the product design involves two options: enabling mechanical dismantling (for example by removing hazardous substances), or facilitate manual dismantling through decrease in dismantling time (for example by the choice of screws). Since manual treatment is more costly than mechanical treatment, but the application of the former results in higher recycling yields, the cost-effectiveness of manual treatment should be supported through the design. As illustrated by Ardente et al²⁴¹, this can be done through design measures enabling a dismantling time, and correlating cost for wages, providing a sufficient profit margin. The next aspect of importance for the design turned out to be the choice of materials and the combinations of such since certain combinations will not allow for recycling.

Ardente et al find that the Ecodesign Directive represents a useful policy instrument for setting some minimum requirements of the products, in order to exclude products with

²³⁷ Ardente et al (n 42)

²³⁸ see column three in table 2

²³⁹ Printed Circuit Boards constitute a components for 'selective treatment', see section 5.2.2

²⁴⁰ Glass and wood constitute 'Parts difficult to process' see section 5.2.2

²⁴¹ Ardente et al (n 90)

insufficient recyclability performances from the market.²⁴² A number of general product criticalities were identified in section 5.1 according to the idea of increased synergy between the waste treatment and the product design, and the following design aspects has been deemed relevant for recyclability of EEE²⁴³:

- Material choices, combinations and mixes
- Ease of disassembly/dismantling, which includes fasteners and connections, especially with regards to targeted components
- Use of hazardous substances
- Identification of content and information about the above mentioned choices

However, it is important to keep in mind that the components targeted for separation, the recycling techniques, as well as the criticalities, are likely to change some during the lifetime of the product, the so called “delayed effect” of product policies.²⁴⁴ These uncertainties and their implications for setting recyclability requirements under the Ecodesign Directive will be further discussed in section 8.2 and 9.2.1.

In the following chapter the prevalence of these types of design requirements in the Ecodesign Directive and the RoHS Directive will be examined.

²⁴² Ardente et al (n 42) p. 43

²⁴³ See table 2 for further details.

²⁴⁴ see Felix (n 83)

PART 2

In this part, a juridical inquiry will be conducted in order to determine the inclusion of recyclability requirements in the current product policies for EEE.

6. Recyclability requirements in the product policies

6.1 *The Restriction of Hazardous Substances (RoHS) Directive*

The phase-out of hazardous substances from the design EEE constitute one aspect of facilitating the dismantling of the WEEE, since it allows for more mechanical treatment.²⁴⁵ The directive on Restriction of Hazardous Substances RoHS²⁴⁶ deals with the restrictions of hazardous chemicals in electrical and electronic equipment in order to protect human health and the environment and facilitate the waste treatment.²⁴⁷

6.1.1 The scope of the directive

Products released on the market before the 1 July 2006 are not subject to the restrictions, as well as spare parts to these products.²⁴⁸ Other exemptions are listed in Article 2(4) the RoHS directive and consist of, for example, large-scale stationary industrial tools and space equipment.²⁴⁹ Besides these exemptions, the recast of the RoHS Directive in 2008 included all EEE in the scope of the WEEE Directive. However, the inclusion of the new product categories²⁵⁰ will be subject to compliance in transitions until 23 July, 2019, when the last category will be included in the scope.²⁵¹

6.1.2 Restricted Hazardous Substances

Initially the directive included only six substances. The restricted substances were, however, updated in 2015 and now consists of ten substances listed in Annex II of the RoHS Directive, see table 3.

²⁴⁵ C Dalhammar, *Rethinking the Ecodesign Policy Mix in Europe* (n 235)

²⁴⁶ Directive 2011/65/EU (The RoHS Directive)

²⁴⁷ Recital 7 and 8 and Article 1 the RoHS Directive

²⁴⁸ Article 4(4) the RoHS Directive (n 246)

²⁴⁹ Article 2(4) the RoHS Directive (n 246)

²⁵⁰ EEE categories 8, 9 and 11, see Annex I the RoHS Directive (n 246)

²⁵¹ The RoHS directive Article 2(2) and 4(4) (n 246);

<http://www.energimyndigheten.se/energieffektivisering/lag-och-ratt/ekodesign1/> 2015-09-17

The restricted hazardous substances and the maximum concentration values tolerated by weight in homogeneous materials²⁵²

- Lead (0,1 %)
- Mercury (0,1 %)
- Cadmium (0,01 %)
- Hexavalent chromium (0,1 %)
- Polybrominated biphenyls (PBB) (0,1 %)
- Polybrominated diphenyl ethers (PBDE) (0,1 %)
- Bis(2-ethylhexyl) phthalate (DEHP) (0,1 %)
- Butyl benzyl phthalate (BBP) (0,1 %)
- Dibutyl phthalate (DBP) (0,1 %)
- Diisobutyl phthalate (DIBP) (0,1 %)

Table 3. The list of hazardous substances regulated under the RoHS Directive²⁵³

6.1.3 Exemptions from the substitutions requirements

Annex III lists a number of hazardous substances that are exempt, and introduces other limits than in Annex II. Annex IV exempts certain substances used specific to medical devices and monitoring and control instruments, such as equipment utilising or detecting ionising radiation.

Exemptions from the substitution requirement in Article 4(1) should only be permitted if substitution is not possible from a scientific and technical point of view, taking specific account of the situation of SMEs, or if the negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the environmental, health and consumer safety benefits of the substitution or the reliability of substitutes is not ensured.²⁵⁴

6.1.4 Summary: The RoHS directive and recyclability

The very objective of the RoHS directive, to phase out the use of hazardous chemicals through thresholds, improves the recyclability of EEE. The conditions set up in the RoHS directive offers a certain degree of predictability, due to the fact that the product category will provide an indication about the contents of hazardous substances permitted,²⁵⁵ which might be considered to partially redeem the product criticality of 'unknown product contents'.²⁵⁶ However, the scope of the exemptions is too wide, and the 'delayed effect' of new substitutions requirements, due to the lifetime of products, also limits the effects on the recyclability of the WEEE.²⁵⁷

²⁵² Homogeneous material refers to material which can not be dismantled mechanically, through for example crushing, cutting or grinding, and by that separated to different materials. These materials can for example be different plastic, metals, alloys, glass and coatings (n 251)

²⁵³ Directive 2015/863 amending Annex II to Directive 2011/65/EU of the European Parliament and of the Council as regards the list of restricted substances [2015] OJ L 137/10

²⁵⁴ Preamble 18 in The RoHS Directive (n 246)

²⁵⁵ Alehem (n 84)

²⁵⁶ see section 5.5.2

²⁵⁷ Alehem (n 84)

6.2 The Ecodesign directive and recyclability

6.2.1 The directive

The overall objective with the Ecodesign directive is to improve the environmental performance of products by integrating the environmental aspect as early as possible in the life cycle, preferably at the design-phase, and minimize the environmental life cycle impact.²⁵⁸ Even ‘embedded’ environmental impacts can be considered and the aim is to ban the most energy and resource demanding products on the EU market.²⁵⁹ The long-term ambition of the directive is that all products’ collective environmental impact shall be regulated in the Ecodesign Directive.²⁶⁰

6.2.2 The scope of the directive

The Ecodesign directive was introduced in 2005, and included only energy using products. In 2009 an extended version of the directive was accepted, and since then, energy related products, such as windows and water-using appliances, have also been subject to the directive. These products do not require energy for their function in a direct way, but affect the total energy consumption.²⁶¹

6.2.3 Implementation measures

The Ecodesign directive is a frame directive, which means that it constitutes the legal basis for the setting of requirements in the form of implementations measures. The directive sets the criterion the implementation measures need to fulfil in Article 15, while the actual requirements, in the form of specific and generic requirements, are found in product specific regulations (implementing measures) or self-regulation such as voluntary agreements. Generic product requirements refer to any ecodesign requirement based on the entire product, without setting limit values, such as requirement to provide information relevant to the recycling process. Specific ecodesign requirements are quantified and measurable ecodesign requirements, such as energy consumption.²⁶² As regulations, the implementation measures have immediate effect in the member states once adopted by the Commission.²⁶³ All products need to fulfil these requirements in order to obtain the CE-marking and be granted entrance into the EU market. The burden of proof is on the manufacturer or the importer.²⁶⁴

²⁵⁸ Recitals 5, 8, 9 and 15 The Ecodesign Directive (n 19)

²⁵⁹ M Calero Pastor, F Mathieux & D Brissaud, ‘Influence of Environmental European Product Policies on Product Design - Current Status and Future Developments’ [2014] 24th CIRP Design Conference Procedia CIRP 21, 415 – 420, p. 416

²⁶⁰ COM(2011)571 final (n 3) p. 5

²⁶¹ <http://www.energimyndigheten.se/energieffektivisering/lag-och-ratt/ekodesign1/> 2015-09-17

²⁶² Article 2(25) and 2(26) the Ecodesign Directive (n 19)

²⁶³ <http://www.energimyndigheten.se/energieffektivisering/lag-och-ratt/ekodesign1/> 2015-09-17

²⁶⁴ Bundgaard et al (n 45) p. 19

6.2.4 Self-regulation

As an alternative to regulation, industries can choose to collaborate and develop self-regulations, known as 'voluntary agreements' (VA). These require the industry to unify around a set of requirements, which needs to be approved by the Commission as a good alternative to (mandatory) implementation measures.²⁶⁵ The reason for this alternative to mandatory legislation is that 'priority should be given to alternative courses of action such as self-regulation by the industry, where such action is likely to deliver the policy objectives faster or in a less costly manner than mandatory requirements'.²⁶⁶ For a voluntary agreement to be valid, a market coverage of at least 70 % is required, meaning that 70 % of the producers on that market have to sign the agreement. In addition, at least 90 % of the products placed on the market have to fulfil the criterion in the agreement.²⁶⁷

6.2.5 Recyclability requirements under the Ecodesign Directive

Up until now, the requirements in the implementing measures and voluntary agreements under the Ecodesign Directive has primarily targeted energy consumption in the user phase, even though it is possible to apply environmental requirements to the entire lifecycle of the product. Requirements with regards to product durability and resource savings have started to emerge under the Ecodesign Directive.²⁶⁸

A review of the current Implementing measure and VA, conducted in October 2015, showed that the total amount of regulated or voluntarily restricted product categories amount to 26 (23 of them regulated through implementing measures while 3 are subject to recognized voluntary agreements).²⁶⁹ Of the 26 implementing measures and VA, 14 stipulated that the producer has to provide information on disassembly and/or the prevalence of a specific hazardous substance (lead and mercury) and 3 implementation measures listed design options for increased recyclability as subjects of the next revision (not listed as a design criteria but indicate a growing focus). Regarding computers and computer servers, requirements on dismantlability is explicitly stated as subject of the upcoming revision, along with information requirements on critical raw material in the product.^{270 271} No requirements affecting the design of the product could, however, be detected.

Of the three voluntary agreements, two established requirements relating to recyclability: the VA on imaging equipment and the one on game consoles.²⁷² The VA on imaging equipment from 2015 sets recyclability requirements in commitment 5.2-5.4 with regards to 'Design for recycling', 'Polymer composition' and 'Cartridges,' containing several different recyclability

²⁶⁵ Bundgaard et al (n 45) pp. 21

²⁶⁶ Preamble 18 the Ecodesign Directive (n 19)

²⁶⁷ Bundgaards et al (n 45) p. 19

²⁶⁸ Bundgaards et al (n 45) p. 13; Jepsen et al (n 46) p. 39

²⁶⁹ Commission (n 99); Commission (n 100)

²⁷⁰ Article 9 Regulation No 617/2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for computers and computer servers [2013] OJ L 175/13

²⁷¹ See table 2 and 3 in Annex IV

²⁷² see table 3 Annex IV

requirements: marking indicating the type of plastic, manually separable plastic parts, applicability of commonly available tools and fasteners for dismantling, avoidance of non-separable connections, non-destructive disassembly and limitation of the variety of polymer in the product, limitation to the use of, and even prohibition of some, coatings. Requirements are also set to ensure that the product do not prevent the reuse and recycling of cartridges.²⁷³ The VA on Game consoles contains the criteria that the game consoles shall be possible to dismantle in a non-destructive manner, and that the marking identifies the type of plastic.²⁷⁴ The analysis can be found in Annex IV of this thesis.

6.3 Sub conclusion: Recyclability requirements in the current product policy

The analysis shows that the RoHS Directive and the Ecodesign Directive contain requirements facilitating the pre-processing, but that they occur in a limited degree. The recyclability requirements found in *the RoHS directive* constitute thresholds of the use of the ten hazardous substances listed in Annex I of the RoHS Directive. These requirements are somewhat narrow in the way they are facilitating the pre-processing, due to the limited amount of substances regulated, the many exceptions, and the ‘delayed effect’.

The review of the product requirement set under *the Ecodesign Directive* showed the possibility of setting product requirements on recyclability under the Ecodesign Directive. However, a very limited number of recyclability requirements were found in the current Implementing measures and VA, mostly generic information requirements on disassembly and recycling, as well as revision plans on increased recyclability, indicating a potential increase in recyclability requirements. The only concrete design requirements can be found in two of the voluntary agreements, and consist of criteria on limitation of material combinations and ease of disassembly/dismantling, similar to the design parameters identified in Chapter 5.

²⁷³ Commitment 5.2-5.4 EuroVApriint 2015 (n 101) see table 4 Annex IV

²⁷⁴ Sony Computer Entertainment Inc. Microsoft Corporation Nintendo Co., Ltd. ‘Energy Efficiency of Games Consoles. Self-Regulatory Initiative to further improve the energy efficiency of Games Consoles Version 1.0 – 22 April 2015’ Commitment 3.3. Available at: <https://ec.europa.eu/energy/sites/ener/files/documents/Games%20Consoles%20Self-Regulatory%20Initiative%20V1%20-%20Final.pdf> 2015-12-21

PART 3

In Part 2, it became clear that recyclability requirements have been set under the Ecodesign Directive. The question this raises is why more of these product requirements have not been set, a question which will be partly answered in this chapter, where the hindrances for setting recyclability requirements will be analysed. To understand the hindrances, the provisions in the Ecodesign Directive itself on ecodesign requirements must initially be outlined alongside the process of setting ecodesign requirements. Subsequently, the obstacles for setting recyclability requirements under the Ecodesign Directive will be identified through analysis of judicial doctrine.

7. The Ecodesign directive, provisions on product requirements and the process

7.1 The provisions on product requirements under the Ecodesign Directive

7.1.1 The Product category and environmental impact

In order to become subject to implementation measures or a voluntary agreement, the product group initially needs to enter the Working plan, which serves as an indicative list of the categories under consideration.²⁷⁵ The criteria for a category to be covered by an implementing measure of a self-regulation are listed in Article 15(2): the product category has to have a significant environmental impact, representing a significant volume of sales and trade (indicatively more than 200,000 units per year) and present significant potential of improvement in terms of its environmental impact without entailing excessive costs.²⁷⁶ The EoL stage constitutes one of the stages of a product's life cycle where significant environmental impact needs to be identified, such as emissions, pollution, generation of waste material and the possibilities of recycling.²⁷⁷

7.1.2 The Ecodesign parameters

The methods for setting requirements are found in Article 15(6), which is referring to Annex I with regards to generic requirements, while Annex II is outlining the aspect to be considered in the formulation of specific requirements.²⁷⁸ The ecodesign parameters which must be used, if appropriate, and also be supplemented by other parameters when deemed necessary, in order to evaluate the potential for improving the environmental aspects, such as:^{279 280}

²⁷⁵ Article 16 the Ecodesign Directive (n 19)

²⁷⁶ Article 15 the Ecodesign Directive (n 19)

²⁷⁷ Part 1 Point 1.1(f) and Point 1.2 Annex I of the Ecodesign Directive (n 19)

²⁷⁸ Quantifiable requirements, see section 6.2.3

²⁷⁹ Part 1 point 1.3 Annex 1 the Ecodesign Directive (n 19)

²⁸⁰ The listed parameters are an excerpt based on relevance for the EoL

- '(f) ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, complexity of tools necessary for disassembly, use of component and material coding standards for the identification of components and materials suitable for reuse and recycling (including marking of plastic parts in accordance with ISO standards), use of easily recyclable materials, easy access to valuable and other recyclable components and materials; easy access to components and materials containing hazardous substances;'
- '(h) avoidance of technical solutions detrimental to reuse and recycling of components and whole appliances;'
- '(j) amounts of waste generated and amounts of hazardous waste generated;'

The implementing measure might also include requirements regarding 'information for treatment facilities concerning disassembly, recycling, or disposal at end-of-life.',²⁸¹ if applicable. The information should be given on the product itself when possible and applicable.²⁸² Specific ecodesign requirements shall be introduced for selected environmental aspects which have been deemed to have a significant environmental impact.²⁸³ The Commission shall identify the relevant parameters for the product category in question, and specify the levels appropriate.²⁸⁴

Article 15(5) states that the implementing measure shall not have:

- a significant negative impact on the *functionality* of the product
- a significant negative impact on *health, safety and the environment*
- a significant negative impact on *consumer*, in particular as regards the affordability and the life cycle cost of the product
- a significant negative impact on *industry competitiveness*
- in principle, the imposition of *proprietary technology* manufacturers
- the imposition of an *excessive administrative burden* on manufacturers.

A technical, environmental and economic analysis shall select a number of representative models on the market of the product in question and then identify the technical options for improving the environmental performance of the product, ensuring the economic viability of the options and avoid any significant loss of performance or of usefulness for consumers. Based on this analysis, concrete measures must be taken in order to minimize the product's environmental impact.²⁸⁵

The product requirements also have to be enforceable,²⁸⁶ meaning it has to be possible to verify compliance through market surveillance.

²⁸¹ Part 2 (d) Annex I the Ecodesign Directive (n 19)

²⁸² Part 2 Annex I the Ecodesign Directive (n 19)

²⁸³ Article 15(6) the Ecodesign Directive (n 19)

²⁸⁴ The parameters can be found in Part 1 point 1.3 Annex I The Ecodesign Directive (n 19). The ones relevant for recyclability are listed above

²⁸⁵ Point 1 Annex II of the Ecodesign directive (n 19)

²⁸⁶ Article 15(6) the Ecodesign Directive (n 19)

7.2 The process of setting Ecodesign requirements

7.2.1 The process

The analysis, which has been described above, is initially made in a preparatory study conducted by external consultants, in close dialogue with a variety of stakeholders, such as manufacturers, industrial associations, NGOs and consumer associations. They are actively involved in the technical and economic discussion of the feasibility of product requirements, in order to ensure that the requirements are in line with their interests. The objective of these discussions is to cut out only the least environmental performing products from the market.²⁸⁷ In the Commission, DG Energy and DG Enterprise and Industry have the main responsibility for the implementing measures and voluntary agreements.²⁸⁸

The preparatory study results in a Working Paper, which contains a set of recommendations. The working paper is sent to the Consultation Forum for discussions, organised by the commission, to which stakeholders are invited. This process is finalized through the creation of an impact assessment and a draft of the implementing measure. This draft is then sent to The Ecodesign Regulatory Committee, consisting of representatives from the Member States as well as observers from associated countries, whom has to approve the draft through a majority of votes. If the draft passes through that process it is sent to the EU Parliament for inspection and then the last step consists in its adoption and publishing.²⁸⁹

7.2.2 The Methodology study for Ecodesign of Energy-related Products

The developed methodology for how to conduct the assessment, if and to what extent a product category is to be subject to implementing measures, called 'the preparatory study', is referred to as 'The Methodology study for Ecodesign of Energy-related Products' (The MEErP).²⁹⁰ The MEErP stipulates that the environmental impact is calculated through an initial life cycle inventory, and then through a life cycle analysis where the inputs (resources) and output (emissions) quantified in the life cycle inventory are translated into environmental impacts (for example, Global Warming Potential and Waste). Each input and output can potentially produce impacts on several impact categories. To facilitate the process the MEErP contains an EcoReport, a simplified MS Excel life cycle assessment (LCA) tool which is used to 'translate' data on product characteristics into the environmental impact indicators during different phases of its life-cycle (for example the EoL phase). The required inputs for the EcoReport are a Bill of Material (BOM)²⁹¹, and data on energy consumption, as well as economic data. The output from the tool consists of the impact indicators and Life-Cycle Cost (LCC).²⁹²

²⁸⁷ Calero Pastor et al (n 259) p. 418

²⁸⁸ <http://www.eceee.org/ecodesign> 2015-10-25; Bundgaard et al (n 45) p. 12

²⁸⁹ <http://www.eceee.org/ecodesign> 2015-10-25; Bundgaards et al (n 45) pp. 20

²⁹⁰ R Kemna, N. Azaïs et al, 'Methodology for Ecodesign of Energy-related Products Final report' [2011]

²⁹¹ List of contents, see section 1.5

²⁹² Kemna et al (n 290)

The outcome of the EcoReport tool will steer consultants conducting the preparatory studies towards proposing specific and generic ecodesign requirements in line with the EcoReport result, which in turn influences the work conducted by the Commission, the Consultation Forum and the Regulatory Committee in developing implementing measures.²⁹³ The MEErP is therefore highly important for determining the choice of ecodesign requirements.

7.2.3 Studies on expansions of the MEErP

Two studies have been performed, through the initiative of the Commission, on the possibilities of including more resource efficient requirements under the Ecodesign Directive. The first set of studies was performed by the Joint Research Center on resource efficiency requirements.²⁹⁴ The second set of studies, performed by the BIO Intelligence Services²⁹⁵ ²⁹⁶investigated the possibilities of revising the MEErP and adding more parameters on material efficiency, which includes recyclability, to the EcoReport Tool.²⁹⁷

The latest study, the BIO Intelligence Service study, resulted in the addition of a 'material-efficiency module' to the MEErP²⁹⁸, consisting of a recyclability benefit rate as a new feature in the EcoReport Tool, leaving the possibility to assess the potential benefit from recyclable bulk and technical plastic parts in the product. The limitation to these materials is due to data constraints.²⁹⁹ The other analysed parameter on Critical raw materials (CRM) was already a part of the MEErP even before the study, but had never been applied in a preparatory study. The parameter is based on economical considerations for scarce material, not environmental considerations.³⁰⁰

²⁹³ van Rossem (n 37) p. 24

²⁹⁴ Ardente & Mathieux (n 65); Ardente & Mathieux (n 90)

²⁹⁵ BIOis (68); Biois (198)

²⁹⁶ BIO Intelligence Services 'Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products. Part 2b: Test Report TV and Washing Machine' [2013] Report prepared for the European Commission DG Enterprise and Industry.

²⁹⁷ http://www.eceee.org/ecodesign/Horizontal-matters/Resource_efficiency 2015-11-18.

²⁹⁸ Only the parameters related to recyclability are mentioned in this section.

²⁹⁹ Bundgaard et al (n 45) p. 23; BIOis (n 68) p. 110

³⁰⁰ BIOis (n 198) p. 25

8. Identified hindrances for the setting of recyclability requirement and the synergy

Four barriers will be analysed in this Chapter: The environmental impact, the potential for environmental benefit, measurability and the possible case of 'double-regulation'.³⁰¹

8.1 Environmental impact

In this section, the problems posed by the provision in Article 15(2)(a) saying that the product shall have a 'significant environmental impact', will be analysed with regards to recyclability requirements.

8.1.1 The MEErP

When estimating the environmental impact due to recyclability of materials, or their non-recyclability, the impacts from the disposal of the material or substance, the extraction of virgin material as well as the impacts from the secondary production (compared to the impacts from primary production) are of interest.³⁰²

Bundgaard et al concluded that there is a lack of EcoReport tools for evaluating resource efficiency impact along with a MEErP methodology, leaving insufficient room for resource efficiency consideration in the preparatory study.³⁰³ For example, environmentally important impact indicators measuring land use and biodiversity are missing from the Methodology.³⁰⁴ Bundgaard et al find the additioned Material Efficiency Module insufficient in ensuring a wider focus on resource efficiency in the MEErP and the EcoReport Tool.³⁰⁵ The MEErP also contains some false assumptions when calculating the environmental impact in the LCA. One example of such is the link between natural resources and EoL management, as estimated by the EcoReport Tool, which is not accurately calculated due to the chosen default scenarios for recycling rates; increased consideration for the overall collection rates in the MEErP and EcoReport tool might show a more important environmental impact than what is currently the case.³⁰⁶ Another example is the assumed lifespan of products (a time on the high end according to van Rossem et al), which makes the energy consumption appear more important than in the case of a more realistic, shorter lifetime in comparison to other environmental impacts during the product's lifecycle.³⁰⁷

³⁰¹ see section 2.4.2 for a description of how the hindrances were identified

³⁰² BIOis (n 68) p. 34

³⁰³ The lack of EcoReport Tools and the insufficient MEErP methodology when it comes to resource efficiency was not a finding of the case study conducted by Bundgaard et al (2015) but a conclusion they reached earlier in their report. The inclusion of these two factors is therefore made by the author in this paper.

³⁰⁴ Jepsen et al (n 46) 2015 p. 45

³⁰⁵ Bundgaard et al (n 45) p. 24

³⁰⁶ van Rossem et al (n 37) p. 6,9

³⁰⁷ van Rossem et al (n 37) p. 9

8.1.2 Data availability

Both of the studies on a potential expansion of the MEErP³⁰⁸ concluded that there is a lack of data availability on the environmental impact from certain materials, as well as controversy among scientists regarding some environmental impact categories.³⁰⁹ The insufficient data on different aspects of the environmental impact, for example, the impacts from recycling, limit the applicability of recyclability parameters as product requirement. This was the case with the parameter 'Recycling rate' and the depending parameter 'Recyclability benefit rate' in the findings of the JRC-report.³¹⁰

The identification of 'hot spots' in a product group (such as certain materials or component with an identified environmental impact) requires more or less detailed information on product contents.³¹¹ The lack of such information might prevent the identifications of the product category's environmental impact in the process of setting Ecodesign requirements.³¹²

8.1.3 Life cycle assessment

A barrier to the setting of recyclability requirements for EEE is the fact that EEE generally gives rise to the highest environmental impacts during the use phase in the form of energy consumption. In comparison, the impacts taking place at the EoL seem less interesting to regulate.³¹³ The inability of the MEErP to take resource efficiency into proper consideration is of course a contributing reason for this impression.³¹⁴ The policy focus in the Working Plans has been on product groups with a high-energy consumption, which is another explanation for the majority of energy requirements in the implementing measures.³¹⁵

The calculation of the environmental impact from recycling also suffers from the lack of a commonly agreed upon method on how reuse/recycling/recovery should be properly modelled into the LCA and life-cycle based tools, how product systems should be structured and to which product system the impacts should be allocated.³¹⁶

8.1.4 Trade-offs with other design goals

When assessing the lifecycle impact from a product at the design phase, the incidences of trade-offs between several resource efficiency goals constitute an issue: for example, between form, robustness and recyclability. The design of a battery offers an illustrative example: the choice of a battery without outer casing reduces the thickness of the device, making it more

³⁰⁸ see section 8.2.2

³⁰⁹ BIOis (n 68) p.34; Ardente & Mathieux (n 65) p. 34ff

³¹⁰ Ardente & Mathieux (92) pp. 41, 81f

³¹¹ Ardente and Mathieux (n 65) p. 73

³¹² see Ardente & Mathieux (n 65) p. 96,111 where they had to use declarations from recyclers to set up a BOM for a washing machine for a case study

³¹³ Jepsen et al (n 46) p. 45; BIOis (n 68) p. 110

³¹⁴ See section 8.1.1

³¹⁵ D Maxwell, K Schischke, O White, L McAndrew, L Stobbe & W Sheate, 'Review of EuP Preparatory Study Evidence: Does it support development of non-energy related implementing measures?' [2011] Executive Summary. DEFRA.

³¹⁶ Ardente & Mathieux (n 92) p. 33

resource efficient. However, the battery then has to be glued into the casing, a design feature that hampers the recycling. So on one hand, the manufacturer can promote resource efficiency (as well as meeting the market demand for slimmer products) and on the other, recyclability.³¹⁷ EEE designed for automatic dismantling might be less durable.³¹⁸ Torciano concluded that it is therefore better to talk about 'Design for sustainability' instead of 'Design for recyclability'.³¹⁹

8.1.5 The focus on energy issues

Overall, van Rossem et al found that the Methodology 'steers' the process of setting ecodesign requirements towards the user phase and energy issues.³²⁰ This impression is shared by Bundgaard et al, who also identified the 'institutionalization of the Ecodesign Directive' as a hindrance for setting resource efficiency requirements; Bundgaard et al found that DG Energy and DG Enterprise has too much of a focus on energy requirements, a focus shared by the Member States when voting.³²¹

Dalhammar points out that Article 15 in the Ecodesign Directive appears to have been formulated with energy issues in mind, and takes the example of establishing the 'significance' of a ban on substances in a product, from the aspect of health and environment; These types of effects are often difficult to determine, assign a monetary value, and establish how it may increase the recyclability of the product. He finds that the provisions are easier to apply to calculations on energy consumption.³²²

8.2 Environmental benefit

The provision on 'significant potential of improvement' with regards to the environmental impact in Article 15(2)(c) in the Ecodesign Directive are of course dependant on the calculations of environmental impact discussed above. However, additional hindrances exist for the fulfilment of this criterion in the form of uncertainty factors: the diversity in the number of possible EoL scenarios, the questionable usefulness of information regarding recycling, the future material design, and fluctuating material prices. These aspects were touched on in chapter 5 and will be elaborated further in this section.

8.2.1 The changing EoL scenario

There is a lack of certitude that the EoL scenario is such as to accommodate the design measures taken by the manufacturer. Firstly, the pre-processing and recycling processes do not necessarily look alike at every plant across the EU³²³, and different processing techniques

³¹⁷ Marwede et al (n 185); Torciano (n 85)

³¹⁸ Felix (n 83)

³¹⁹ Torciano (n 78)

³²⁰ van Rossem et al (n 37) p. 23

³²¹ Bundgaard et al (n 45) pp.12, 44

³²² Dalhammar C, 'The Application of 'Life Cycle Thinking' in European Environmental Law: Theory and Practice' (n 13) p. 113

³²³ Ardente et al (n 42) p. 49; see image 4

exist which might result in another waste treatment than what the product was originally designed to accommodate. Secondly, the product's lifetime³²⁴ is usually between seven to ten years (depending on the product) and during that time, the recycling technique will have improved, and may face other challenges than the ones faced today. For example, a parameter aiming at facilitating manual disassembly of a key component will not provide for any potential for improvement of the environmental impact if the product is treated mechanically instead of manually, which is an increasing trend.^{325 326}

8.2.2 Information relevant for the recycling process

The information requirements targeting the recyclers of the end-of-life products, including information on the correct disassembly, the structure of the design and the prevalence of hazardous substances or key components, are connected to the above mentioned uncertainty about the EoL scenario, but are also relevant in today's waste treatment.

Information relevant for the waste treatment is, at least partially, already made available by manufacturers to recyclers through the requirement in Article 15 the WEEE directive. However, this requirement is somewhat debated. From the recycler perspective, the information requirement in the WEEE directive is not detailed and some observers claim that manufacturers are rather reluctant to provide this type of information,³²⁷ while manufacturers are of the opinion that they are already providing information. They also question the usefulness of this information and claim that recyclers rarely request this type of information, despite its availability.^{328 329} Even recyclers question the usefulness of information requirements to make information available on websites or instruction manuals, due to the lack of time to process it.³³⁰ Therefore, manufacturers generally object to an increase of information obligations due to the administrative burden it imposes, without a corresponding environmental benefit.^{331 332}

From the manufacturers point of view, the provision of detailed product information, such as a BOM, constitute an administrative burden.³³³ Detailed information about the product content, such as the provision of a BOM, and design structure might present a challenge due

³²⁴ The time between the selling and disposal of the product

³²⁵ Ardente & Mathieux (n 65) p. 124; see also Felix (n 83)

³²⁶ Felix (n 83); see Alehem (n 84)

³²⁷ Alehem (n 84)

³²⁸ Torciano (n 85)

³²⁹ The European Committee of Domestic Equipment Manufacturers (CECED), *CECED comments on the resource efficiency requirements proposed in the ecodesign requirements for electronic displays*. Position Paper. 23-01-2015 p. 2

Available at <http://www.ceced.eu/site-ceced/news/2015/01/CECED-comments-on-Televisions-and-Electronic-Displays-Regulations-.html> 2015-11-22

³³⁰ Alehem (n 84)

³³¹ DigitalEurope, *Position on draft display regulation*, Brussels, 5 December 2014 p. 8

Available at:

http://www.digitaleurope.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=865&PortalId=0&TabId=353 2015-11-22;

³³² CECECED (n 329) p. 3; Torciano (n 85)

³³³ Torciano (n 85)

to the complexity of the supply chain of EEE as well as the issues which might arise in relation to the company's property rights and trade secrets.³³⁴

8.2.3 Changing product design

The future product design is unknown, as well as the new types of materials developed, which might present other challenges to the waste treatment than the ones currently dealt with by pre-processors.³³⁵

8.2.4 Fluctuating material prices (primary and secondary material)

Section 5.3 described how the profit from the pre-processing, and the effort worth investing in performing the dismantling and treatment of a WEEE, depends on the value of the material contained in the product, determined by market prices on primary and secondary material. These prices are fluctuating, and of course have precautions on choice of pre-processing treatment of WEEE over time.³³⁶

8.2.5 Implications for recyclability requirements

The above listed aspects make a realistic waste treatment difficult to assess, and therefore complicates the estimation of what improvement potential the design measure possesses with regards to the environmental impact of the product. For example, the parameter on 'time of disassembly', was eliminated in the Bio Intelligence Service Study, due to an estimated mere 'medium' level of relevance (the potential to achieve the objective, being to decrease the environmental impact from the product).³³⁷ Bundgaard et al also questioned the improvement potential with regards to disassembly requirements³³⁸ and from the pre-processor perspective scepticism is expressed towards the use of parameters such as 'disassembly time' due to the changing technology applied.³³⁹

The criteria of 'improvement potential' in Article 15(2) in the Ecodesign Directive create not only a problem for disassembly requirements, but also for other recyclability parameters, such as recyclability rates, marking of the product and information requirements, since their improvement potential (environmental benefit) lies in their potential to facilitate the recycling process and, through that, result in increased recycling;³⁴⁰ The design consideration might not lead to a higher recyclability due to the amount of manual work required, the lack of valuable material in the product, and the variety of product designs, which makes automatic disassembly difficult to apply and perhaps means that no disassembly takes place at all.³⁴¹

³³⁴ Bundgaard et al (n 45) p. 52

³³⁵ Ardente et al (n 42) pp. 50; Torciano (n 85); see Felix (n 83)

³³⁶ see Felix (n 83); see CECED (n 329) p. 4

³³⁷ BIOis (n 68) p. 84

³³⁸ Bundgaard et al (n 45) p. 50

³³⁹ Alehem (n 84)

³⁴⁰ Bundgaard et al (n 45) p. 49, 53; CECED (n 329) p. 4

³⁴¹ BIOis (n 198) p. 9

8.3 Measurability and verification of compliance

8.3.1 Measurability and verifiability

The BIO IS-study concluded that several parameters on material efficiency found in the literature suffers from a lack of directly quantifiability (measurability) and verifiability.³⁴²

Verifiability constitutes a problem, particularly environmental impacts resulting from processes far back in the production chain, without leaving traces in the product. They can only be assigned to products by requiring a documentation of the relevant processes.³⁴³

Regarding the type of verification, Jepsen et al claims it is unclear whether ecodesign requirements that cannot be verified by visually examining the product constitute a realistic option under 'real life conditions of market surveillance'.³⁴⁴

8.3.2 Competition and market surveillance

Market surveillance makes for a key challenge in regards to the setting of resource efficiency requirements due to the insufficient verifiability.³⁴⁵ There seemed to be a general consensus amongst manufacturers that general design requirements are too vague to be used for binding laws; It would be difficult for manufacturers to prove compliance and there is a risk that market surveillance authorities interpret the rules differently.³⁴⁶ There is also a concern amongst manufacturers about the currently insufficient market surveillance, and questions about how the situation will be affected by the introduction of even more and diverse product requirements.³⁴⁷ Compliance monitoring typically requires that standardization bodies develop standards that can be used to prove compliance.³⁴⁸ DIGITALEUROPE, representing the digital technology industry in Europe, opposes the use of recycling and end-of-life requirements as market access requirements which are not based on international measurement standards 'Without such standards, effective, fair, transparent verifiability and enforcement is impossible'.³⁴⁹

McAlister et al summarizes the situation as follows:

Manufacturers cite lack of standards as a barrier to the inclusion of material efficiency requirements in ecodesign regulations and to the integration of this factor as a design objective in their projects; Policy makers encounter difficulties specifying consistent requirements in product policies; and Market

³⁴² BIOis (n 68) p. 110

³⁴³ Jepsen et al (n 46) p. 39

³⁴⁴ Jepsen et al (n 46) p. 40

³⁴⁵ Dalhammar *Industry attitudes towards ecodesign standards for improved resource efficiency* (n 39); Bundgaard et al (n 45) 2015 p. 44; Torciano (n 85)

³⁴⁶ Dalhammar, *Industry attitudes towards ecodesign standards for improved resource efficiency* (n 39)

³⁴⁷ Torciano 2015 (n 85)

³⁴⁸ Dalhammar, *Industry attitudes towards ecodesign standards for improved resource efficiency* (n 39)

³⁴⁹ DIGITALEUROPE (n 331) p. 7

Surveillance Authorities highlight concerns about the ability to verify the conformity of products put on the market.³⁵⁰

Hence, the development of solid, product-specific standards are crucial for verifying compliance and is said to constitute a prerequisite for the use of the Ecodesign Directive as an instrument for setting recyclability requirements.³⁵¹

8.4 'Double-regulation'

8.4.1 The meaning of 'Double-regulation' and the consequences

The question of 'double regulation' is commonly brought up by the industry as an argument against ecodesign requirements on recyclability. They claim that since the WEEE directive regulates waste collection and treatment of WEEE, the need for ecodesign requirements is doubted.³⁵² There is no clear definition of 'double-regulation' in EU law, but Dalhammar and Kiss give the example of the regulation on recycling in both the Ecodesign Directive and the WEEE directive as an example of what might be considered 'double-regulation'. Industries find double-regulation problematic due to the induced costs and reduced industry flexibility. The loss of flexibility occurs, especially if policies regulate several parts of the product, instead of the entire product performance at a systemic level. The later regulatory approach is preferred, since the former might lead to suboptimal outcomes and hinder an optimal design.^{353 354} For example, the setting of a maximum disassembly time might be counterproductive and actually prevent manufacturers from making the EEE more resource efficient.³⁵⁵

The concern is also that double-regulation shall present obstacles to innovation, something there for which there is little support, with regards to the current product policy. However, Dalhammar points out that the current product policies are 'rather straightforward' as they set minimum requirements on energy performance and aim at phasing out chemicals.³⁵⁶ Therefore, the introduction of new types of standards might present an obstacle to innovation.³⁵⁷

³⁵⁰ C McAlister, F Mathieux, F Ardenne & P Tecchio, 'Horizontal standards: the missing link to ensure minimum performance of products from a material efficiency perspective?' forthcoming

³⁵¹ Marwede et al (n 185); McAlister et al (n 350)

³⁵² Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

³⁵³ C Dalhammar & B Kiss, 'Regulating complex products: The policy mix for product and building energy efficiency', forthcoming

³⁵⁴ CECED (n 329) p 2

³⁵⁵ Felix (n 83)

³⁵⁶ Dalhammar, 'Rethinking the Ecodesign Policy Mix in Europe' (n 235)

³⁵⁷ Dalhammar & Kiss (n 353)

8.4.2 Information requirements

As discussed under section 8.2.2, Article 15 in the WEEE Directive obligates the manufacturer to provide information relevant to the recycling process. Information requirements, such as an EoL Report, could constitute a 'double-regulation' due to the obligation in Article 15 the WEEE Directive.³⁵⁸

8.4.3 Threshold on hazardous substances

In Bundgaard et al's analysis of the transferability of criterion in voluntary instruments to implementing measures under the Ecodesign Directive, they notice how some of the criterion remove the exemptions on mercury found in the RoHS Directive and thus strengthen the requirement in the RoHS Directive. They found both general requirements (concerning the entire product) as well as requirements for specific materials and components, such as plastic, batteries and backlights. Chemical regulations in both the RoHS Directive, the REACH Regulation and the Ecodesign Directive might constitute a problem, and Bundgaard et al seems to find an expansion of the RoHS Directive the most attractive solution.³⁵⁹ CECED also brings up this overlap and the risk for inconsistencies in this regard.³⁶⁰

8.4.4 Dismantling requirements

Dalhammar seems to have detected the opinion amongst manufacturers that dismantling requirements under the Ecodesign Directive would constitute a double regulation with the WEEE directive.³⁶¹

8.5 Sub-conclusion: The main hindrances

The barriers to setting recyclability requirements under the Ecodesign Directive seem to exist on all levels. Both Article 15 in the Ecodesign Directive and the MEErP are found less adapted for setting recyclability requirements, despite the objectives of the Ecodesign Directive to regulate resource use and the entire lifecycle of the product. Van Rossem et al's reference to this as 'false marketing'³⁶², mentioned in the introduction, is understandable. The study performed by BIO Intelligence concluded that the number of indicators on material efficiency in the literature are many, but so are the barriers for their introduction in the MEErP: high requirement of data collection together with an insufficient data availability as well as a lack of directly quantifiability and verifiability make them unsuited for inclusion in the MEErP.³⁶³ These difficulties constitute hindrances for expanding the MEErP, giving the EoL phase an unrealistically small role in the LCA.

³⁵⁸ CECED (n 329) pp. 1; see also DigitalEurope (n 331) pp. 2

³⁵⁹ Bundgaard et al (n 45) p. 51f

³⁶⁰ CECED (n 329) p. 1

³⁶¹ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

³⁶² van Rossem et al (n 37) p. 8

³⁶³ BIOis (n 68) p. 110

The uncertainties of the EoL scenario are due to many aspects and seem to raise questions about the validity of adopting recyclability requirements in the first place. CECED, a Brussels based association representing household appliance manufacturers in Europe, states that 'The decisive factors [of the recycling process] is economic and depends on time, but also labour cost and the benefit gained with dismantling instead of shredding. This latter depends then on recycled material quality and market prices. This aspect cannot be measured during the design phase'.³⁶⁴ As mentioned in the sub-conclusion to Chapter 5, due to the “delayed effect”, caused by the lifetimes of EEE³⁶⁵, the waste treatment are likely to have changed some. Price fluctuation on the markets for raw and secondary material, and the developments of recycle markets, parts targeted for 'selective recycling' and 'other parts' will follow the market developments since pre-processors will extract valuable materials. New materials might become appealing for purposes of extraction and recycling, and the components targeted for separation today might become less economically viable to treat. The developing pre-processing technology will increase the capacity to treat what is today considered ‘parts difficult to process’. The same might also be true due to some of the inability to recycle certain material combinations. In both cases, the design measure taken to facilitate the recycling would have been done in vain, since it might have been profitable to extract the material even without the facilitating design measure or the recycling of the material might not even take place despite the design measure aimed at simplifying recycling.³⁶⁶ The environmental improvement is therefore uncertain.

Measurability, as well as the practical feasibility of compliance verification for market surveillance, is a major issue for recyclability requirements, since standards are lacking and some recyclability parameters require testing to verify compliance. How market surveillance authorities will be able to deal with such an increase in the workload seemed to be another reason for scepticism towards some recyclability requirements. The more demanding the testing for verification is, the more complicated the market surveillance becomes.

Overall, the main hindrances for setting product requirement on recyclability under the Ecodesign Directive has been found to consists of:

- the lack of data and methodology for calculating environmental impacts and benefit
- the uncertainties in the EoL scenario
- the lack of measurable and verifiable standards
- the risks of double-regulations

Given the fundamental nature of the hindrances identified, one can wonder how the Ecodesign Directive will be able to fulfil its role regarding recycling of EEE set out in the new Circular Economy Package.³⁶⁷ However, as states by Torciano: product requirements on energy

³⁶⁴ CECED (n 329) p. 3

³⁶⁵ The average lifetime of a refrigerator is 15 years, while the same time for a mobile phone is two years, see section 3.2.2

³⁶⁶ see Felix (n 83)

³⁶⁷ COM(2015) 614/2 (n 50) p. 5

efficiency have been applied, and developed, for 20 years now. Requirements on resource efficiency in general are still in their development phase.³⁶⁸

³⁶⁸ Torciano (n 85)

PART 4

In this section, enablers for an increased synergy by using the Ecodesign Directive, along with possible measures to deal with the hindrances identified under chapter 8, will be outlined and analysed. The first chapter will present the enablers and measures identified in the doctrine, while the second chapter of this part will discuss, in the judicial doctrine, the least treated hindrance: the uncertainties of the EoL scenario and how strategies for overcoming this hindrance might look like.

9. Enablers and measures for increased synergy

9.1 Environmental impact

9.1.1 Increasing focus on resource efficiency

Bundgaard et al identified the political climate of increasing focus on resource efficiency, which is demonstrated in Chapter 1, as an enabler to setting resource efficiency requirements under the Ecodesign Directive. To confirm this, Dalhammar found in his interviews with manufacturers that standards benefitting recycling probably have gained some support from manufacturers due to the policy discussions on the EU level and the promotion through the EU strategies on how to achieve a Circular Economy.³⁶⁹ Bundgaard et al emphasizes the connection to the goals behind the EU Circular Economy and the basic shift in perception that the introduction of this type of economy will require, from both producers and consumers, by saying that ‘producers do not have the same incentive to make resource efficient products, as they had to make energy efficient product. This will be the case, when resource efficiency is understood as material efficiency, recycling and closing material loops.’³⁷⁰

Bundgaard et al believes that, as energy efficiency increases among the product categories regulated by the Ecodesign Directive, other types of impacts, such as increased resource efficiency will be regarded as relatively more important.³⁷¹ This opinion is shared by Dalhammar et al, who also bring up the decreasing lifetime of some products in particular, and how this trend will increase the importance of material use.³⁷² Dalhammar suggests that short-term trade-offs could be deemed acceptable when innovation can be expected to solve trade offs between resource efficiency goals in the design within a reasonable timeframe.³⁷³

³⁶⁹ Dalhammar, ‘Industry attitudes towards ecodesign standards for improved resource efficiency’ (n 39)

³⁷⁰ Bundgaards et al (n 45) p. 45

³⁷¹ Bundgaard et al (n 45) p. 44

³⁷² Dalhammar et al (n 63) p. 13

³⁷³ Dalhammar C, *The Application of ‘Life Cycle Thinking’ in European Environmental Law: Theory and Practice* (n 13) p.104

9.1.2 Changes to the MEErP and the EcoReport Tool

Dalhammar points to the studies conducted by JRC and the BIO Intelligence Service³⁷⁴ as evidence for methodology development conducted for the purpose of allowing new environmental issues to be included in the preparatory studies. He concludes that 'We can therefore expect more types of environmental aspects to be included in ecodesign requirements in the future.'³⁷⁵ Jepsen et al finds that the MEErP, in its current form, is 'in principle' suitable to identify non energy-related aspects, as well as to assess the effects of different ecodesign options. However, they find that in order to address resource efficiency more comprehensively, 'the environmentally important' impact categories consisting of land use and biodiversity loss should be included. Adding these categories would not require any major changes to the setup of the MEErP and the EcoReport Tool; it would only entail the elaboration of a suitable methodology and new data requirements for the calculation of the life cycle impact.³⁷⁶

Overall, to accomplish a wider focus on resource efficiency, the EcoReport Tool must include more resource efficiency parameters, and the MEErP methodology have to be constructed in a way that ensures focus on resource efficiency in the preparatory studies, when relevant for the product category under examination.³⁷⁷ Jepsen et al finds that the adoption of a more pragmatic approach is needed in the short-term in order to address the pressing issue of resource depletion. They suggest the adoption of core impact categories according to which relative improvement can be measured or, alternatively, the focus on certain materials.³⁷⁸ In order to achieve a wider focus in the MEErP, Jepsen et al sees an evident need for more detailed resource conservation targets regarding certain material types or specific environmental impact. They find that without such targets: '... it is no wonder why energy efficiency and greenhouse gas emissions – those aspects which have been quantified – dominate the Ecodesign agenda so far.'³⁷⁹

It is worth noting that no targets have yet been set for resource use or resource efficiency at a European level.³⁸⁰ However, in the communication 'Towards a circular economy: a zero-waste programme for Europe'³⁸¹ the European Commission proposed the adoption of a resource-productivity target.³⁸²

³⁷⁴ see section 8.2.2

³⁷⁵ Dalhammar, 'The Application of 'Life Cycle Thinking' in European Environmental Law: Theory and Practice' (n 13), p. 113f

³⁷⁶ Jepsen et al (n 46) p. 45

³⁷⁷ Bundgaard et al (n 45) p. 24

³⁷⁸ Jepsen et al (n 46) p. 45f

³⁷⁹ Jepsen et al (n 46) p. 45

³⁸⁰ <http://www.eea.europa.eu/downloads/d6efece23c848f7b4d386be825ebc03/1437389121/resource-efficiency.pdf> 2015-11-30

³⁸¹ COM/2014/398 final (n 4) p. 13

³⁸² 'Resource productivity' is defined as the ratio between gross domestic product (GDP) and domestic material consumption (DMC). DMC measures the total amount of materials directly used by an economy, and is defined as the annual quantity of raw materials extracted from the domestic territory, plus all physical imports minus all physical exports (in tonnes per capita) (n 375)

9.1.3 'Un-institutionalization'

In order to remedy the 'institutionalization' of the process of setting Ecodesign requirement for a specific product group, Bundgaard et al believes the shift of focus would be required from the ones responsible for the process (DG Energy and DG Industry and Enterprise) as well as further inclusion of DG Environment in the process of designing the requirements. The later would be advantageous, since the organisation possesses the competence necessary, as well as the broader view on environmental aspects.³⁸³

9.2 Environmental benefit

9.2.1 The relevance of design for recyclability

The criticism against the relevance of design requirement for recyclability, due to the changing factors determining the waste treatment, are valid, as was determined in the sub-conclusion to Chapter 5. Dalhammar found in manufacturer interviews that shredding was being promoted by manufacturers to increase the productivity in the pre-processing³⁸⁴ but as explained in section 5.3, non-discriminatory shredding leads to material losses. Overall, manufacturers seem to think that it would be more efficient to provide incentives for the recycling industry, which is not considered to be very innovative, than to regulate product design.³⁸⁵ However, Dalhammar surmises that the introduction of new types of product requirements, such as a maximum disassembly time, has the potential of affecting recyclers' investments in new technology and methods. Therefore, he finds it a bit dangerous if manufacturers are of the opinion that most waste will be shredded in the future, and subsequently, find standards on recyclability to be unnecessary.³⁸⁶ It is also worth remembering from Chapter 5 that the wide variety of product designs prevents the development of automated treatment, and since the design keeps changing, the investment in such treatment is not economically viable. Alehem brings up the fact that, despite the constant development of recycling techniques applied, pre-processors and recyclers will not be able to keep up with the pace of manufacturers' product development.³⁸⁷

9.2.2 Future pre-processing challenges

Bundgaard et al found that that since manual disassembly is still performed when economically feasible, or when regulation requires (for example the WEEE Directive), disassembly requirements might still serve as a relevant ecodesign requirement. They found this argument especially true when considering valuable components or components containing hazardous substances. As pointed out in chapter 5, the development of automatic

³⁸³ Bundgaard et al (n 45) p. 44

³⁸⁴ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

³⁸⁵ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39); see also CECED (n 329) p. 4

³⁸⁶ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

³⁸⁷ Alehem (n 84)

dismantling (performed by robots) is made impossible with regards to some products, due to the large variety in the design.³⁸⁸ Furthermore, there are challenges in the pre-processing that pre-processors know are not going to be solved within ten years, for example, the mechanical treatment of hazardous 'liquid' substances.³⁸⁹ In that case, manual dismantling is necessary, as well as its facilitation, in order to increase the economical and the environmental benefits from the recycling.

Despite the changing EoL scenario, Alehem suggests that policy makers shall look at the current challenges faced today: 1.) locating the hazardous substances 2.) plastic with fillers 3.) the use of metal bolts in plastic products and vice versa.³⁹⁰ The design measures necessary to resolve these problems do not have to have an important impact on the product design, but would have a great impact on the recyclability of the products. The choice of materials and their combinations will still be an issue in the future, and due to the large amount of different materials developed by manufacturers, and incorporated in the product design, research on recycling methods for each and everyone of these materials are not economically viable. Since the development of new materials and mixes can be expected to increase in time, this issue will remain highly relevant in the future.³⁹¹

9.2.3 Methods for estimating the future EoL scenarios

Ardente and Mathieux found that the definition of representative EoL scenarios represents a key step in the methods for developing ecodesign parameters on recyclability. It requires a detailed analysis of current EoL treatments at the EU level, based on information from recyclers and manufacturers. There are two aspects to the definition of a representative EoL scenario: Firstly, the 'dynamic' analysis of potential future scenarios, which is especially important when there is evidence for changes to the EoL scenarios in the near future due to, for example, economic reasons and/or technological evolution. Secondly, the other aspect becomes relevant when different scenarios are deemed feasible, and in that case, Ardente and Mathieux recommend the application of a defined and 'multiple-weighted' scenario, where the different alternatives are taken into account and are weighted according to mass flows of waste. By doing this, the 'multiplicity' nature of the EoL scenarios are calculated. This calculation is made per components targeted for separation and the suggested formula contains a variable where the manufacturer is supposed to perform recycler consultation.³⁹² McAlister et al also seems to suggest a calculation approach in order to account for the impact of different design measures on the recyclability, among other goals, in the context of developing standards,³⁹³ which will be discussed below.

³⁸⁸ Bundgaard et al (n 45) p. 50

³⁸⁹ Alehem (n 84)

³⁹⁰ This design entails an important risk of contamination (see section 5.2.2 'Removal of other parts')

³⁹¹ Alehem (n 84)

³⁹² Ardente & Mathieux (n 92) pp. 25f, 27, 81

³⁹³ McAlister et al (n 350)

The development of methods for estimating the EoL scenario and, with that, the environmental benefit from the design requirement, are ongoing and depend greatly on data availability.³⁹⁴

9.2.4 Information and marking requirements

The product information needs to be easily accessible for the recyclers in order to be useful in the pre-processing, which means it must be embedded in the product and not merely made available on websites and/or user manuals.³⁹⁵ Bundgaard et al recommend that before indicating the ecodesign requirements by making visual markings on plastic, it is important to investigate whether the waste from the product group in question is manually sorted, along with the prospects regarding future technology development. They recommend alternative marking applicable to automatic sorting.³⁹⁶ In this context, both Torciano and Alehem mention the use of digital means, such as an ID-chip, which can be read off automatically from the WEEE along the recycling belt.³⁹⁷ However, the risk of creating a waste treatment system relying on this information is that the chip might get damaged if the product is repaired and/or altered, which makes the information either incorrect or inaccessible. The risks of an increased demand for information disclosure lie in resistance from the industry due to trade secrets and intellectual property rights.³⁹⁸ However, Dalhammar found that the industry attitude towards requirements on a BOM was mixed in terms of this issue, and that it most certainly depends on the sector. The application of a chip would probably work better on some product groups than others.³⁹⁹

Generic information requirements serve the purpose of paving the way for the development of specific requirements, as they help to make the necessary information for such a development available.⁴⁰⁰

9.3 Measurability and verifiability

9.3.1 Standardization

The European Standardization Organisations (ESOs) CEN and CENELEC ('CEN-CENELEC Ecodesign Coordination Group') are involved, under mandate from the Commission, in the development of 'harmonised' product-specific standards set out in the implementing measures under the Ecodesign Directive.^{401 402} Due to the clear need for standardised measurement

³⁹⁴ see Ardente & Mathieux (n 65) p. 157; Ardente et al (n 42)

³⁹⁵ Bundgaard et al (n 45) p. 28; Alehem (n 84)

³⁹⁶ Bundgaard et al (n 45) p. 53

³⁹⁷ Alehem (n 84); Torciano (n 85)

³⁹⁸ Bundgaard et al (n 45) p. 52

³⁹⁹ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

⁴⁰⁰ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39); Bundgaard et al (n 45) p. 29, 31

⁴⁰¹ <http://www.cencenelec.eu/standards/Sectors/SustainableEnergy/Ecodesign/Pages/default.aspx>
2015-12-21

methods for material efficiency, the European Commission has been engaged in the process of preparing a standardisation request to issue to ESOs, requesting horizontal (generic and therefore non-harmonised) standards to be developed to support ecodesign requirements on material efficiency aspects. In a draft of such a request, the Commission states that one of the reasons not more resource efficiency requirements have been set under the Ecodesign Directive is due to the lack of adequate metrics. The development of standards would facilitate the discussion on more such requirements.⁴⁰³ ⁴⁰⁴ Work towards standardised approaches on disassembly is in its early stages, but Mathieux et al has provided early indications that such tests can achieve consistent, comparable results.⁴⁰⁵

9.3.2 The 'Chicken-and-egg' scenario

McAlister et al highlights the situation of 'the chicken-and-egg scenario' since policymakers need to define the standards before the requirements have been drafted, or vice-versa. Not only is there a lack of standards on recyclability, but also a lack of common understanding about the portfolio of requirements on resource efficiency in general, as well as how these can be addressed in a consistent way across different product groups. The development of product-specific standards and regulations requires a framework of consistent methodologies, data and reporting formats. They conclude that:

'In order for standards to be useful, they need to be built upon solid evidence. Much research is still required in the resource efficiency area, especially in terms of product testing and the development of databases and calculations on which to base material efficiency indices. Increased research in this area could actively contribute to the preparation of over-arching and product-specific harmonised standards, so that the societal aspiration of improving products from a material efficiency perspective becomes reality.'⁴⁰⁶

9.3.3 Transferability of criteria in voluntary instruments

Both Dalhammar et al and Bundgaard et al find that the existence of resource efficiency criteria in voluntary instruments provides evidence for the feasibility of such criteria. Bundgaard et al therefore encourages the development of such criteria in order to create evidence for this feasibility.⁴⁰⁷

⁴⁰² in accordance with the procedure laid down in Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations (1), for the purpose of establishing a European requirement, compliance with which is not compulsory.

⁴⁰³ Commission, 'A Notification under Article 12 of Regulation (EU) No 1025/2012- Draft standardisation request as regards new European standards and European standardisation deliverables on material efficiency aspects for energy-related products' (draft). pp. 2 Available at: http://ec.europa.eu/growth/single-market/european-standards/notification-system/index_en.htm 2015-12-20

⁴⁰⁴ McAlister et al (n 350)

⁴⁰⁵ Mathieux et al (n 194)

⁴⁰⁶ McAlister et al (n 350)

⁴⁰⁷ Bundgaard et al (n 45) p. 41; Dalhammar et al 2014 (n 63) p. 14

9.4 Increased synergy instead of 'double regulation'

9.4.1 Double regulation or not?

Dalhammar and Kiss find the arguments on alleged 'double regulation' interesting, since the requirements have been proposed in the context of the Ecodesign Directive partly because the WEEE directive has not managed to give rise to incentives for design considerations for the EoL phase. Therefore, they mean, there is a need to set mandatory standards in order to promote cost-efficient recycling. 'Thus, whether the proposed rules constitute 'double regulation', or should rather be seen as a 'complement' to existing regulations, providing additional incentives, depends on the view taken'.⁴⁰⁸ Furthermore, Dalhammar sees the need for the Commission to provide a clear definition of 'double regulation' in the context of product regulations.⁴⁰⁹

9.4.2 Complementing regulation

Alehem suggests that product requirements can be set to complement the exemptions in the RoHS Directive⁴¹⁰ by making the components subject to exemption subject also to disassembly requirements. The removal of mercury lamps sometimes requires the loosening of as many as six different screw heads and reducing the number of permitted number of different screw heads has the potential of facilitating the manual dismantling process.⁴¹¹ This approach can be compared to the criteria Bundgaard et al found in voluntary instruments that removed the exemptions in RoHS, and therefore regulated the same substance as the RoHS Directive.⁴¹²

9.4.3 Counteract 'Passing the buck'

On the subject of creating synergy between the RoHS Directive, the Ecodesign Directive and the WEEE directive, van Rossen et al noticed a tendency to 'pass the buck', meaning that rather than dealing with an issue within the context of one Directive, it may appear more convenient to state that the issue should be dealt with through an alternative directive. The danger with this approach, as perceived by van Rossem et al is that sub-optimal and fragmented policies are designed.⁴¹³ Dalhammar⁴¹⁴ find that consultants performing the preparatory study should investigate how well other instruments perform for the product group in question in order to see if there is a need for complementing horizontal legislation under the Ecodesign Directive. van Rossem et al find it reasonable that the Ecodesign Directive can address relevant toxicity issues for each of the product groups covered by the directive. According to their analysis, this could lead to 'a more serious discussion as to what

⁴⁰⁸ Dalhammar & Kiss (n 353)

⁴⁰⁹ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

⁴¹⁰ Annex III and IV the RoHS Directive (n 246)

⁴¹¹ Alehem (n 84)

⁴¹² See section 8.5.3

⁴¹³ van Rossem et al (n 37) p. 5

⁴¹⁴ Dalhammar, 'The Application of 'Life Cycle Thinking' in European Environmental Law: Theory and Practice' (n 13) p. 112

will be genuinely implemented through RoHS/REACH, and where gaps need to be filled.⁴¹⁵ They suggest that changes shall be made in the MEErP in order to allow for a more appropriate assessment of chemical substances and toxicity.⁴¹⁶

9.5 Sub-conclusion: The enablers and measures

It is obvious that the proposed solutions come with new problems and hindrances, such as the development of standards and the 'chicken-and-egg' scenario, which is suffering from the lack of data. McAlister et al are highlighting the need for the development of databases in order to develop solid standards to be used for setting material efficiency requirements, such as recyclability requirements and the development of methodologies for determining which material to target. Hence, the solution to the 'measurability problem' is suffering from the same problem as experienced by the authors of the JRC-report, as well as the BIO IS-reports, when trying to develop methodologies and parameters on resource and material efficiency.⁴¹⁷ The increased EU policy focuses on resource efficiency and the newly released Circular Economy Package, emphasizing the role of the both product design and recycling, will hopefully manifest in the allocation of resources for the development of such data bases and the development of methodologies to either replace or expand the current MEErP.

The setting of resource efficiency targets seems to constitute an important policy move in regards to promoting the development of a methodology allowing for more recyclability requirements. The Commission has expressed the intention of establishing such targets and newly published Action plan for the New Circular Economy⁴¹⁸ has already formulated 'priority areas' of which plastic and critical raw material⁴¹⁹ are included. Regarding plastic, the idea is to formulate an action plan, to among other things 'help to increase plastics recycling, including ecodesign'.⁴²⁰ In this regard some kind of regulation on plastic fillers should be considered to increase the recyclability of plastics. As far as critical raw materials are concerned, the Commission acknowledges that critical raw materials are often used in electronic devices, and that the currently low rate of recycling of these materials leads to the loss of 'significant economic opportunities'. Consequently, the Commission states that 'For all these reasons, increasing the recovery of critical raw materials is one of the challenges that must be addressed in the move to a more circular economy.' The formulation of concrete targets regarding these two material categories could very well signify a way of initiating the development of methodologies to set material efficiency requirements in the form of recyclability requirements.

Another issue with the MEErP lays in the LCA, and the LCC, which also require changes in order for recycling to be able to 'compete' with other life-cycle impacts from the product. If recycling is to increase through the use of ecodesign measures, as is one of the goals in the

⁴¹⁵ van Rossem et al (n 37) p. 7

⁴¹⁶ van Rossem (n 37) 2009 p. 9

⁴¹⁷ see section 7.2.2

⁴¹⁸ see section 3.1

⁴¹⁹ Critical raw materials are, for example rare earth elements and other precious metals.

⁴²⁰ Com(2015)614/2 (n 50) pp. 13

Action Plan for the New Circular Economy⁴²¹, the EoL impact must not only be measurable, but recyclability must also be noticed amongst other ecodesign goals, such as durability and energy efficiency, in a manner giving proper attention to recycling. The 'pragmatic' approach suggested by Jepsen et al on core environmental impacts could provide that 'multi-focus', and still leave room for a weighted analysis of design goals when they are in conflict.

The possibilities of double-regulation are important for the creation of synergy between the Ecodesign Directive and the WEEE Directive, as well as the RoHS Directive. The setting of information requirements raises this question of overlap: is the information requirement an overlap of the obligation in the WEEE directive, or is it more specific and therefore not an overlap? Does the overlap alone constitute double regulation? Regarding the alleged double regulation with the WEEE Directive on disassembly requirement, it is difficult to see how such an argument could be supported. As to disassembly requirements and double regulation with the RoHS Directive, there is a distinct difference between the suggestions made by Alehem, that ecodesign requirements on disassembly could be set regarding exemptions in the RoHS, and the criterion found by Bundgaard et al in voluntary instrument, which eliminates the exemptions granted in the RoHS Directive. In adopting the later requirements, the Ecodesign Directive could indeed be entering the domains of the RoHS Directive, while in the suggestion made by Alehem, the complementing approach is clearer, since the actual substance is not regulated. Nevertheless, with regards to restricting the actual substance, regulated under the RoHS directive, in the Ecodesign Directive, the strength of the Ecodesign Directive lies in the product-specific requirements; While the exemptions in Annex III of the RoHS Directive are based on non-product specific use, the product-specific use can be further analyzed under the Ecodesign Directive, and perhaps even be restricted for certain products. Overall, ecodesign requirements on disassembly ought to be deemed acceptable as a complement to the exemptions in RoHS regulation when considered a criticality, depending on the functionality and safety of the user. Such design requirements have potential to create synergy between the three directives, and to facilitate the pre-processing, thereby increasing the recyclability of WEEE. I find it hard to believe that it would constitute double regulation nor lead to suboptimal outcomes, but that would have to be further analyzed and perhaps even require a definition of 'double regulation' from the Commission.

The development of standards appears to constitute an important step for increasing the feasibility of recyclability requirements, but the development of such standards is not without difficulties. Regarding verification, it seems as though a pragmatic approach is needed in order to make market surveillance practically viable. Certain recyclability parameters found in the literature will probably impose too great a burden for any real verification to take place, which will create room for noncompliance.

The questionable relevance of design for increased recyclability of EEE creates an issue. With regards to, for example, dismantling requirements, the dismantling time may be the only variable determining the waste treatment that can be affected by the design of the EEE (the

⁴²¹ see section 3.1

labour cost due to the dismantling time),⁴²² but it is still an important factor. Additionally, the implementation of other product requirements, such as the absence of chemicals, might enable the development of other recycling techniques. The advantage of the 'delayed effect' is that recyclers can plan their treatments, but the wide variety of product designs limit the economically viability of the investments. Provided with some limitations of the product design through ecodesign requirements recyclers, investments in new recycling treatments might be considered more viable. Hence, the potential benefits from design adjustment for recyclability cannot be rejected.

When discussing the standardization process and developing a framework for such a development, McAlister et al does not seem to mention the uncertainties regarding the EoL scenario outlined in section 8.2, and how the standardization process shall handle these factors. They are just referring to the use of 'alternative indicators' for resource efficiency as a way of recognizing the barriers to approaches, such as the one on dismantling criteria. In fact, the subject of uncertainties connected to the EoL scenario is only vaguely mentioned in the judicial doctrine used for chapter 8 and 9. This impression might be due to a weakness in the method employed for this thesis, in the form of the choice to focus on the latest publications, which might have lead me to 'miss out' on established approaches regarding this issue for the setting of recyclability requirements. Nevertheless, the development of approaches and strategies on how to deal with these uncertainties appears to be missing in the doctrinal discussion, which seems to mainly consist of calculations of possible EoL scenarios. In an attempt to cover this gap, some possible strategies will therefore be proposed in the following Chapter 10.

⁴²² see CECED (n 329) p. 3

10. Strategies to diminish the uncertain environmental benefit

In this chapter, some strategies for dealing with the uncertainty factors in the EoL scenario will be discussed, initially through the Ecodesign directive and then, subsequently, through the use of means other than the Ecodesign Directive, in order to build a synergy between the Ecodesign Directive and the WEEE Directive as well as the RoHS Directive.

10.1 Valid means of achieving synergy through the Ecodesign Directive

10.1.1 Product categories targeted

Due to the varying lengths in lifetime for different product groups, the ones with shorter lifetimes could potentially be considered more eligible for recyclability requirements. As identified by the Commission: the average lifetime of a cell phone is two years while the same time for a refrigerator is 15 years⁴²³, meaning that the estimation of the EoL scenario will be far less challenging with regards to the cell phone than a refrigerator. A product with a short lifetime, due to user behaviour and rapid obsolescence, also means that durability measures might be considered superfluous, from a resource efficiency perspective, which might give priority to a more recyclable design. These decisions would of course have to be substantiated by reliable data on average lifetime of the product categories. Despite this, it is highly questionable if this strategy would make the design measure fulfil the criteria of 'significant improvement of environmental impact' since the lifetime is only a statistical estimation. Further certitude is required.

10.1.2 'Long-term' criticalities

As explained by Alehem in section 9.2.1, there are challenges in the waste treatment which are going to remain, and even become exacerbated in time, such as the multitude of different plastic-fillers and the treatment of 'liquid' hazardous substances. With regards to the latter, complementing legislation to the RoHS would be regarded as a valid alternative, since these substances will have to be treated manually; Manual disassembly requirements on components containing such substance therefore ought to be relevant for an unforeseeable future. An important aspect of such requirements, especially regarding hazardous substances, is the safety issue for users.

Research to map these 'long-term' criticalities would be one way of bringing more certitude to the estimation of the environmental benefit. The problem of the flexibility, and predictability, of the regulations under the Ecodesign Directive in time is a challenge regarding this approach, as well as the assessment of when a criticality can be expected to cease to be a criticality.

⁴²³ see section 3.1.2

10.1.3 Flexible product requirements

Another strategy to deal with the uncertain EoL scenario could be to focus on flexible design requirements. One such an example is the ID-chip discussed in section 9.2.3. It seems to present a both flexible and convenient source of information on the product content, adaptable to the changing treatment techniques and component's targets of separation due to market prices or waste regulation, since the pre-processor can collect which information he or she wants from the chip. However, the risk is the dependence on these chips and the consequences that would arise if they were to provide inaccurate information. Another potential downside with this requirement is that, in order for the chip to actually be as adaptable as possible, all materials in the products must be listed, at least theoretically, to ensure usefulness and full adaptiveness to the EoL scenario at the end of the product's life. In that respect, the reluctance from the manufacturer to give 'full disclosure' of the contents of their products, for reasons of trade secrets and intellectual property rights, constitutes a hindrance. Furthermore, the potential for environmental benefit is, with all probability, not certain enough to justify the requirements of an exhaustive BOM, due to the immense administrative burden it would impose on the manufacturer.⁴²⁴ More research is needed regarding what type of information would be needed, as well as other types of flexible requirements, which would entail economical and environmental benefit, preferable with consideration for the average lifetime of the product group in question.

10.2 Further synergy outside of the Ecodesign Directive

10.2.1 Increased regulation of the waste treatment

The 'two-folded' ways of increasing the recycling rates, in the form of developing recycling techniques and the product design requirements for increased recyclability, was discussed in section 5.3, as well as in 9.2.1. It seems as though the uncertainties are coming from both directions; the waste treatment at the product's future EoL treatment cannot be established with certitude, and the wide variety of product designs makes investment in their treatment uneconomically viable.

The importance of the effectiveness of the waste treatment itself and the techniques applied can of course not be denied. Marwede et al found that some manufacturers are of the impression that most of the fees from the EPR covers costs for transport and logistics and leaves insufficient room for investments in the improvement of the recycling processes. The financing of the waste treatment, the EPR, is structured so that, depending on the type of financing of the recycling scheme, the main interest is usually to keep recycling costs low, which leads to the choice of the cheapest available treatment option instead of the best available recycling technology for the waste treatment.⁴²⁵ The ambition expressed in the Action Plan for the New Circular Economy is to encourage investments in the waste treatment, and the adoption of best-practice levels within the EU, and to propose minimum

⁴²⁴ see section 8.2.2

⁴²⁵ Marwede et al (n 185)

conditions on transparency and cost-efficiency in the waste treatment.⁴²⁶ This minimum level has the potential to decrease the incertitude in the EoL scenario, allowing for more recycling requirements to be set under the Ecodesign Directive, since the design could be adapted to some kind of 'minimum level' of recycling.

The question is, 'how could the requirements on the pre-processing facilities be set?' The 'Best Available technique' listed in Annex VIII of the WEEE Directive⁴²⁷ could be expanded to include certain processing equipment, forming a 'minimum level' to which the design could be adapted to. This option would be non-product specific, and perhaps less effective when creating predictability with regards to the waste flow and increased recyclability. Another alternative would be to expand the definition of “proper treatment” in Article 8(2) the WEEE Directive.⁴²⁸ Options under the WEEE Directive, or complementing legislation, should be examined for possibilities of setting product-specific treatment requirements in order to create clearer predictability regarding the EoL scenario. Another option could be to use other types of legislation, such as the Industrial Emission Directive⁴²⁹, depending on the targeted type of waste minimization. This approach might hamper the innovation of recycling technology as well as increase the cost of the waste treatment; Alehem indicated that increased costs of recycling could lead to a decrease in collection rates. He also pointed out that in order to create the conditions for an effective recycling, there are going to be a few manually performed measures. But if, for example, strict requirements are made to dictate that a product should be dismantled manually, this is going to disfavour the recyclers who want to increase the mechanical treatment of the WEEE in order to increase the recycled material. Such legislation could lead to the development of a lengthened chain of specialized pre-processing operations, increasing the cost of recycling.⁴³⁰ Notwithstanding, all pre-processors and recyclers would be subject to the same regulations, which mean they would compete on equal terms.

This suggestion requires further research for identifying the benefits and drawbacks on recycling rates, as well as the appropriate way of regulating the waste treatment of WEEE. It should also be complemented by increased research on recycling opportunities, aiming at increasing economically and environmentally performance of the pre-processing.

10.2.2 Collaborations between manufacturers and pre-processors

As pointed out by Marwede et al: the missing dialogue between manufacturers and recyclers constitutes a problem in making EEE more recyclable. Recycler and manufacturers address different markets, use different equipment and comply with different regulations, which is why interlinkages and common meetings rarely take place. This is more relevant in the context of EPR, but affects the groundwork for the setting of minimum requirements in the

⁴²⁶ COM(2015) 614/2 (n 50) p. 2

⁴²⁷ see section 4.2.1

⁴²⁸ see section 4.2.2

⁴²⁹ DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (Recast)

⁴³⁰ Alehem (n 84)

form of, for example, research and voluntary instruments, which have both been identified as enablers in Chapter 9.

One way of increasing the communication between manufacturers and recyclers, and increasing the likelihood of achieving a more certain potential for environmental improvement, are the standardization forums discussed in section 9.3.2. The degree of stakeholder consultation applied in the process, as well as the presence of a third party (CEN-CENELEC) in this communication exchange, have potential of contributing to an increased synergy through the formulation of effective and relevant standards.

Pilot projects on potential future recycling opportunities, initiated by governments or/and through independent collaborations between manufacturers and recyclers, provide for one avenue of progress.⁴³¹ Marwede et al found that 'open innovation' projects with producers and recyclers, aimed at transferring high-tech technologies from manufacturing to the lower tech recycling world, would create a way of bridging the gap between the world of product design and the world of recycling.⁴³²

⁴³¹ Dalhammar 'Industry attitudes towards ecodesign standards for improved resource efficiency' (n 39)

⁴³² Marwede et al (n 185)

11. Conclusion

The newly released 'New Circular Economy Package' puts emphasis on increased recycling, as well as ecodesign to accomplish it. The establishing of a resource efficient, circular economy would benefit greatly from synergies between policies in order to, among other objectives, increase the recycling rates. Through this approach environmental and economic performances, both for manufacturers and recyclers, can be maximized. The Synergy Approach presents a way of strengthening the enforcement of the WEEE Directive through the creation of synergies with other policies, especially through mandatory requirement under Ecodesign Directive. As stated by the Commission in the Action Plan, the interest of recyclers and manufacturers are not aligned and the current market signals are not making the design of EEE more recyclable. Hence, mandatory product requirements on recyclability are warranted.

To determine which design measure that might be relevant for increasing the recyclability of EEE, the Approach entails a study of the pre-processing. An analysis of the pre-processing shows that specific components are targeted for separation, either due to Annex VII in the WEEE Directive and/or because they are valuable, disrupt the pre-processing or entails a contamination risk of the waste flow. The manner in which these components are extracted varies depending on the product category and which pre-processing facility it ends up in. In order to increase the recycling rates, resource efficient pre-processing treatment alternatives, such as manual disassembly, need to be made more economically competitive compared with alternatives that reap a lower recycling yield to a corresponding lower cost. Additionally, mechanical treatment options must also become more applicable, raising the productivity of the pre-processing and making the operations more profitable. Hence, these two aspects are what the product policy for EEE should be aiming at enabling in order to create synergy and, through that, support the recycling process. A wide range of design features can be either stipulated or forbidden in the product policies, depending on the specific product in question.

The RoHS is currently regulating ten hazardous substances through substitution requirements and is facilitating the pre-treatment. The Ecodesign Directive presents the possibility of setting a wider range of different ecodesign requirements to ensure resource efficiency in the EoL phase, such as requirements on the material, the disassemblability and marking. However, the analysis in part 3 showed that the provisions on ecodesign requirements, and the difficulties for recyclability parameters to fulfil these provisions, as well as the 'structural' problems with the process and the actors involved in the setting the product-specific ecodesign requirements, is hindering the inclusion of more recyclability requirements under the Ecodesign Directive. The main hindrances in Article 15 in the Ecodesign Directive seem to consist of the fulfilment of the provisions on environmental impact, environmental benefit and measurability, as well as the possibility of 'double-regulation' with requirements in the WEEE Directive and the RoHS Directive.

The main question of this thesis consisted of analysing possible ways of overcoming the identified hindrances to enable further regulation of the recyclability of EEE under the Ecodesign Directive and a strengthened synergy. The potential solutions and enablers,

outlined in Chapter 9, illustrate how changes need to be made in a wide range of different areas to allow for a greater focus on recyclability in the process of setting ecodesign requirements. On an EU policy level, the important enablers consist of: the formulation of concrete resource efficiency targets in the EU policy, alterations to the MEErP and the LCA, increased data collection on environmental impacts and material consumption, and the further inclusion of DG Environment in the process of developing the requirements. It also seems as though a definition of double regulation from the Commission would have an important impact on the kind of synergies and complementary elements that can be created between the three directives, as well as the possibilities to eliminate the observed tendency to 'pass the buck'. Without such a definition the situation is unclear.

On a practical level, the measurability of the recyclability requirements constitutes a hindrance for the performance of efficient market surveillance. Some requirements will probably be considered unsuitable due to the demanding verification process, while some might justify an increased resource allocation to the market surveillance authorities. The development of effective and verifiable requirements signifies a challenge for CEN-CENCELEC and the standardization process.

Another practical problem with recyclability requirements, identified in the first part of this thesis, is the definition of 'recyclable' EEE, due to the changing factors affecting the pre-processing. Increased recyclability is not necessarily the outcome when designing EEE with consideration for the current criticalities in the pre-processing. Not even requirement meant to facilitate manual treatment, or to allow for more automatic treatment, does necessarily entail a 'significant improvement of the environmental impact'⁴³³ due to the uncertainties in the EoL scenario. The strategies for dealing with these uncertainties in the context of setting recyclability requirements under the Ecodesign Directive are less developed and consist mainly of ways of calculating possible EoL scenarios in order to determine the relevance of the requirement.

In the pursuit of contributing to the construction of an increased synergy, and for the Ecodesign to fulfil its role set forth in the plans for the Circular Economy, I have outlined some possible strategies for dealing with these uncertainties. The proposed strategies are attempting to both deal with the incertitude, through the development of flexible recycling requirements, as well as reducing the uncertainties, through the choice of product categories with shorter lifetimes and a focus on remedying 'long-term' criticalities. However, these suggestions only have the potential to create a slightly higher certitude and more research is needed to determine how requirements can be set in order to facilitate the recycling process, despite the changing EoL. Another strategy proposed is to look beyond the Ecodesign Directive in the pursuit of creating more certitude, and include the WEEE Directive in the creation of synergy through increased regulation of the waste treatment. The risks of doing so are many, especially cost increases and limitations on the innovation of the recycling techniques, which is why such a regulation has to be supported by research. Collaboration

⁴³³ Article 15(2) the Ecodesign Directive (n 19)

between manufacturer and recyclers, to ensure the economical competitiveness of the pre-processing, is important 'ground-work' for this development, as well as the development of voluntary instruments.

The advantages of the 'two-folded' interpretation of the Synergy Approach, consisting of regulations for increased recycling in both design and waste treatment regulation, is in line with the plans in the New Circular Economy Package; the ambitions is to increase the quality of the waste treatment and create more 'coherent policy framework'.⁴³⁴ A synergistic development of the two pieces of legislation could decrease the uncertainties with regards to the EoL scenario in the setting of recyclability requirements under the Ecodesign Directive, hence, contributing to increased recycling. More research on how the waste treatment should be regulated, and how the Directives can complement one another is required, with special consideration for the 'delayed effect' caused by the product's lifetime.

The challenge in designing strategies to tackle the uncertain and changing EoL scenario with regards to product design requirements, without hindering innovation on either recycling techniques or product development, constitutes one of the challenges when establishing a circular economy. Despite all the hindrances, the alternatives seem to consist of either awaiting further certitude while more WEEE gets disposed of, increasing the certitude by regulation the waste treatment further, and/or accepting a certain level of uncertainty with regards to the environmental benefit of recycling requirements. Given the resource depletion and the EU ambition of facing this challenge by creating a Circular economy with 'closed material loops,' passivity does not seem to fit.

The results of research projects and the development of databases on environmental impact and material consumption, as well as suitable methodologies to take these factors into consideration, are crucial for the capacity of the Ecodesign Directive to 'emphasize Circular Economy aspects in future product design requirements',⁴³⁵ hence fulfilling its role set out in the plans for an EU Circular Economy.

The setting of resource efficiency requirements at large under the Ecodesign Directive is in its initial development phase, and this thesis has pointed out some of the important 'knots' in this process. As expressed by the Commission, and suggested by Bundgaard et al: the circular economy is about a profound transformation of the way the entire economy works and the perception of what 'resource efficiency' implies.⁴³⁶ Profound changes might be required, so also for the product and waste policy on EEE in order to ensure a sustainable use of resources.

⁴³⁴ Com(2015)614/2 (n 50) pp. 5, see section 3.1.3

⁴³⁵ Com(2015)614/2 (n 50) pp. 3, see section 3.1.3

⁴³⁶ http://europa.eu/rapid/press-release_IP-15-6203_en.htm 2015-12-20

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ANNEX I

Interview of Johan Felix, PhD in Polymer technology and Project leader at The Foundation Chalmers Industriteknik (CIT), Gothenburg, Sweden.

The interview was conducted on the 22 October 2015 over the phone and lasted for approximately 50 minutes. The interview was recorded.

Johan Felix was the project leader for HÅPLA, 2012 (Sustainable Recycling of Flat Panel Displays). See <http://extra.ivf.se/hapla/> for more information.

Questions and answers

1. Is there any difference between “disassembly” and “dismantling”?

Johan says that, in his opinion, “disassemble” refers to a non-destructive process of dismantling where the product can be disassembled the same way, or similar, to how it was assembled in the first place. “Dismantling” on the other hand is a wider term and could also include destructive ways of getting the product apart, like for example using shredding, crushing or smashing. The advantage of “disassembly” is that the components remain intact and can be reused.

2. What is the meaning of the word “component”? Can it constitute of different materials?

Johan explains that a component consists of different materials. A component is “a distinct part of a product”, for example a bumper on a car. A component can be divided into sub-components, lamps, cables, clips and so on.

3. “Selective treatment” in the WEEE directive (Annex VII) requires manual treatment, because it’s not possible to remove cables, batteries and PCB by using automatic techniques, right?

Johan answers that that kind of a treatment is not automatized today.

4. What happens to the WEEE that cannot be subject to selective treatment, like for example the battery or cables cannot be removed? Does the product get sent to incineration?

John was unsure of how much contamination it takes for the product to be considered to be too contaminated for recycling.

Johan was not sure about what happens if cables are not removed but regarding the batteries he pointed out that it depends on what kind of battery it is. Recyclers have to remove the battery, if they can. Some batteries have to be removed, regardless of the ease of disassembly, if they contain mercury, which is hazardous. This also applies to nickel-cadmium batteries (rechargeable batteries in, for example, electrical toothbrushes). It is not desirable, from an environmental perspective, to have these substances to spread in the material stream.

Johan explained that the WEEE that is being collected is taken to pre-treatment facilities, where the majority of the work on the products is performed manually. There, cables are being removed, not because of the risk of contamination but because they contain valuable copper. Lithium batteries have to be removed for occupational health reasons: they can cause fire or explode if treated in the wrong way. It may happen that alkaline batteries, like triple A batteries, can be crushed together with the rest of the product. However, all batteries are to be removed in the pre-treatment.

In these pre-treatment facilities the people are struggling with the removal of batteries, a process that John estimates will become more and more expensive. The removal of batteries is not an easy process for some products. Some screens (exceeding 100 square centimetres) have to be removed since they might have background light contain mercury (fluorescent lamps), which is common for older products with screens. These screens are treated separately. Thick television sets (CRTs) are handled separately and dismantled pretty thoroughly since they might contain up to 3 kilos of lead in the cathode ray tube glass.

What is left after the manual removal of either hazardous or valuable components is mostly shredded - which constitute one part of the pre-treatment. Some substances are undesired in the shredder - like contaminants, glass containing mercury, batteries or mercury-containing fluorescent light tubes and so on. Therefore they are removed manually. If this removal cannot be done the product is sent to, for example, a facility that can separate mercury from the rest of the material stream. There are facilities in Sweden that can shred mercury-containing lighting products and then isolate the mercury, which is then brought to safe disposal.

5. But then I am confused, the recovery rates of material from WEEE are not very high, implying that a lot is sent to incineration or landfills.

After the shredding and separation of material (magnetic metals, non-ferrous metals, circuit boards and so on) takes place. Circuit boards are economically and ecologically the most valuable components, which is why they are top priority. What is left is mostly plastic, paper or other material, which is usually taken to incineration since waste containing more than 10 % organic material cannot be put in landfills according to Swedish law. Some facilities can recycle plastics, like Stena. Glass is put in landfills, it is not profitable to recycle.

6. When HÅPLA was initiated the recycling situation for LCD-equipment was described as not too positive; the majority of the equipment was incinerated due to the content of hazardous substances.

The majority of the LCD-equipment is constituted by the LCD-screen, which could not be recycled. The “aluminium package” (the LCD module) containing the screen can be separated, along with the circuit board, the speakers, cables and the plastic envelop. The LCD module can be opened and there you will find “the glass package” (LCD panel), thin plastic parts, and lighting components (either LED or mercury-containing light tubes) all in all it does not contain any noteworthy value, which did not encourage recyclers to keep dismantling the LCD-module any further, instead it was sent to incineration. The module

contains mercury that might put the personal at the recycling facility at risk of exposure if they were to demolish the module manually. In Sweden the modules were sent to SAKAB (now Ekokem) which is licensed to destroy this kind of components by incineration. There was no method how to proceed with the waste treatment of the LCD-module at the initiation of the project HÅPLA, which is why the entire module was sent to incineration due to the mercury content. The HÅPLA project created a machine where the LCD product could be dismantled automatically. It is currently used at Nordic Recycling in Sweden.

7. That is the priority, to make it possible to use automatic dismantling, right?

The initial pre-treatment is often more profitable if done manually: the removal of major circuit boards (preferable intact) and the removal of the frame. The dismantling of the rest (the LCD module) is not profitable enough to disassemble any further. They contain few circuit boards and little material of value.

8. What can “design for disassembly” do in order to facilitate the recycling process? Since the trend consists in the use of more and more automatic disassembly, isn’t the risk that the design efforts do not facilitate the recycling process, which make the efforts pointless?

The main argument is that when the product ends up in the waste stream it might be ten years since they were produced. The residence time of products (not just the user phase or the functional lifetime but the time from their production and until they reach the waste streams to get recycled) can be long. How can the future recycling methods be predicted? How can we adapt product to a recycling system we don’t know what it will look like? How can we carry out guesswork and say “this is how it must look like”?

9. What are your experience of producers’ unwillingness and resistance towards requirements about design for disassembly? I have read about producers’ fear of products getting “hacked” or “repurposed” and that DfD go against the trend on increasing complicity of product design.

Johan disagrees with the term “Design for disassembly” and prefer, depending on the product, to rather focus on “design for upgradability” or “design for repair”. He thinks that it is a more useful way of approaching design requirements. But he says he finds the arguments about “hacking”, repurposing and an increased trend of complexity of EEE design weak. Johan says that the strongest objection to design consideration about disassembly is that the requirements might be counterproductive: if you put these requirements in the Ecodesign directive saying that “this is the maximum time allowed to take the product apart” it might not result in the most recyclable product at the time the product reaches the waste stream. It might be better to make the product more suitable for shredding in clearly definable material fractions. He gave an example from an EU project concerning LED-lamps: the first generation of LED-lamps contained a lot of aluminium in order to cool the LED-diodes efficiently. Aluminium has a high economic value, which means that recyclers are prepared to invest time in the dismantling of the product in order to separate it from other materials, collect the aluminium and they also get other materials at the same time “into the bargain”. This meant that the aluminium incentivised recyclers to achieve a high recycling rate overall, not just with regards to the aluminium in the lamps. Sure, the use of aluminium means that more material value is

being tied up to the product but the new LED-lamps contain more and more plastic, which means less and less value of the material in the LED-lamp. This resulted in decreasing incentives for recyclers to put time into dismantle the LED-lamps, instead it's being shredded and a larger part of the lamp ends up in incineration facilities instead of being recycled. The expected recycling rate therefore went down after the removal of aluminium in the design - the value of the material had decreased. Hence, if the product contain valuable material, or dismantling is required by law, recyclers are prepared to invest time in the dismantling process in order to collect the materials. Less value means less time invested in dismantling, which leads to decreasing recycling rate since less material is recycled. Another example confirming this is the case of gold: of all the gold extracted worldwide from the earth approximately only 7 % has been dissipated (is beyond human control, in landfills or at the bottom of the oceans). The high value of gold creates incentives to put efforts into retract it. EEE is actually one of the reasons why gold is dissipating: it is diluted and spread out in the EEE, which makes it harder to retrieve than for example for concentrated gold in jewellery, which does not get thrown away, unlike WEEE.

So, from the perspective of Design for Disassembly: even though an EEE is made to be easily disassembled it might lack valuable material, and therefore the recycler lacks incentives to make use of the advantageous product design and unbolt the product. The design measure then becomes pointless.

10. So, meaningful design measure would be more along the lines of fulfilling the requirements of WEEE? For example the easy removal of the battery?

Johan agrees that that would be a much more meaningful design measure to design product to meet the requirements for proper treatment in the WEEE directive. Measures required at the EoL, as well as other measures that have to be done, should be made easy to perform through design efforts.

Markings on the product, saying for example “does not contain mercury” or cadmium or lead would be helpful. With regards to LCD-screens (the lightning of the screen may contain mercury) such a distinction would be very helpful for the recyclers. An operator at a pre-treatment facility can't tell the difference between a LCD-screen with a LED-lightning (no mercury) and the once with fluorescent light in the screen (which contains mercury). These two should not be treated on the same line.

Johan also points out that the marking of bigger plastic components, stating what kind of a plastic it is, would be useful. This applies, according to standards, to plastic components weighing more than 25 gram since recyclers are more prone to recycle the plastic if it is clear that it does not contain, for example, brominated flame retardants. If they suspect the plastic contains bromine, all Swedish recycler will send the plastic to incineration. Some bromine is allowed in EU and some is not, and determining the type of bromine compound is difficult.

11. What are the arguments against the marking of EEE in this way? That the aesthetic design is affected?

No, the main argument against marking is that no one is looking at the markings anyway. But Johan is in favour of marking anyway and claims it is no hassle to implement a system of marking.

12. So design requirements in the Ecodesign directive, which might be meaningful, would constitute of requirements matching the once in WEEE about proper treatment. Would requirements that are aiming to make the recycling cheaper also be meaningful? For example, that EEE containing metals are designed so that the metal is easily separated and extracted from the product?

What has been discussed in the ecodesign report about televisions is the accessibility of circuit boards, because they have the greatest negative environmental impact and the highest value of the components in a television. The separation and collection of circuit boards are the main motive behind the manual pre-treatment today, at least for flat screen TV:s. So the accessibility of circuit boards has been a hot topic, but some claim that if the circuit boards are too easy to disassemble there is a risk is that the circuit boards are removed before the television is disposed of, some kind of “informal” recycling.

13. Okey, so what else do you think could be meaningful requirements for the Ecodesign directive about disassemblability?

Markings, like TCO Development has created. It is a voluntary scheme but there are a lot of producers who are getting certified through them. They can put edge requirements on the producer. Johan thinks that this system constitutes a driving force with the potential to inspire buyers of EEE to only buy products with the TCO marks. For example, the Swedish Public sector can demand to only purchase TCO-marked screens.

14. One last thing: the form of Design for disassembly requirements, what do you think about specific requirements, for example that it should only take two types of tools to disassemble an EEE or to prohibit the use of certain glues? Because you are against a maximum time of disassembly, right?

Johan says that the time requirement might be counterproductive, as mentioned above. He thinks that one type of “bitz” (screw) should be enough for one product. And designers should not use more screws than needed.

15. So what do you think about policies that stipulate the goal, but let the market players decide the way to get there, like in the IPPC-directive, in order to stimulate innovation?

Johan confirms that those kinds of policies are preferred from the perspective of the market players: “Set the targets and let us deal with how to get there”. Policies about the way to reach the target blocks efforts to innovation and makes markets players feel trapped since the means of thinking “outside the box” are closed to them.

16. But aren't requirements like “only one type of screw” kind of regulating the way rather than the goal?

Johan agrees that might be the case, but points to the fact that the option is to set up a maximum disassembly time and the problems that come with that. What is a reasonable

disassembly time? What happens if the design changes or the material value increases, then a longer disassembly time might not constitute an issue from the perspective of the recyclers. Johan concludes that it is preferable to keep a more or less unhindered way to the goal, but what the goal should be is harder to determine. He thinks that recycling rates is a rather blunt tool, he prefers specific recycling rates, for example aiming at the recycling of metal.

17. The recycling rates in the WEEE directive are not achieved anyway so...

Johan says that the question is what kind of sanctions that evokes. The Distributed Producer Responsibility takes away the design incentives for producers. The discussion about differentiated producer responsibility has the capacity to create that, but the problem of products “residence time” remains. It may take many years before the EEE reaches the waste streams and by then the recycling methods and the technique used might have changed. Design features, which might have been expensive to handle at the recycling stage five years ago, are not costly today. But the talk about Differentiated producer responsibility is still a discussed topic because the cost the Extended Producer Responsibility in WEEE directive incurs is nothing for the producers today, there is no incentive to adapt the design in order to make them easier to handle at their EoL. But then the question is: what characterize a product easy to handle in the waste stream? There are no clear answers to that question.

ANNEX II

Interview with Martin Alehem, Nordic Production Manager at Stena Technoworld AB, Sweden

27 October 2015 between 15:30 - 16:30

1. How are WEEE-recycling companies financed? From the Extended Producer Responsibility (EPR) or from the profit of the actual recycling?

That depends on the prices on metal and competitive bidding. During some periods Stena can get paid for accepting certain goods, while in others (for example until not so long ago when the metal prices were high) we were actually paying for almost all types of materials that were being delivered to us. Today there are still some products we are getting paid to handle, like for example LCD-screens, which contains a lot of hazardous waste, are costly to recycle and does not contain enough metal value to make the recycling process profitable. So, the balance between financing from the EPR and financing from selling the material streams from the recycling is determined by the prices of metall.

2. So when the metal prices are high, the extended producer responsibility ceases to have effect and they get paid for the WEEE they deliver to you?

The Extended Producer Responsibility is always there, but the metal prices determines the value of what Stena can extract from the WEEE, which determines if the producers are paying for the recycling or if they will get paid.

Producers are responsible for making sure that at least 65 % of the products they are putting out on the market are being recycled. In order to do that they are also responsible for the collection of the WEEE. In Sweden, the producer organization 'Elkretsen' is responsible for organizing and executing the actual collection of WEEE and also to pay for the actual recycling. If Stena is efficient enough and the material value contained in the products delivered by Elkretsen, then Elkretsen will charge Stena for the WEEE delivered. The difference is regulated through monthly price adjustments, which apply to all of Stena's operations throughout Europe.

3. What consequences does this system have on the incentives created through the Extended Producer Responsibility?

Elkretsen is spreading the cost and profit from the recycling on their members in a way that does not create any incentives for individual producer to make efforts to facilitate the recycling of their products.

During the time of high metal prices Stena was having a dialogue with a number of producers who were interested to know how they could make their products more recyclable.

4. The pre-treatment: How is that performed at Stena's facilities?

I recommend that you search for 'Stena' on youtube where you will find a video illustrating the recycling process at Stena. At Stena's eleven pre-treatment facilities, located throughout Europe, where the WEEE initially are gone through manually in order to remove any contamination of the material streams, consisting in environmentally hazardous substances, which are removed in what we are calling 'The first Step' (First treatment). Material and substances not suitable or desired in the mechanical treatment (The Second treatment) are also removed at this step, for example wood.

5. 'Selective treatment' in Annex VII of the WEEE directive stipulates the removal of the listed components and substances. Are these included in the pre-treatment?

Those components and substances are removed in the initial pre-treatment if they cannot be monitored and followed in an identified waste flow. For example, some circuit boards are removed manually but not all of them are accessible and that does not constitute a problem because after the WEEE has gone through the first shredding process and continue from there, there is an optical machine, programmed to recognize circuit boards, which will have them remove from the rest of the waste stream through a blowing mechanism. The same applies to cables. So either we are removing the components and materials initially in the manual treatment or they are allowed to follow the rest of the waste stream into the automatic treatment, if we can predict where they will end up. So the extent of the manual treatment is depending on the level of technique available in the automatic processes. Before the introduction of this optic machine we removed a lot more circuit boards than we are doing today. Now we are only removing easily removable circuit boards of high value, the rest of them are separated mechanically.

All hazardous, wetting agents ('Blöta farliga ämnen'), for example mercury, can spread if mechanically treated, which is why it's being removed manually at the first treatment site to prevent their entrance into the next phase: mechanical treatment.

6. Is this process of manual treatment referred to as 'decontamination' or 'dismantling'?

Stena uses the name 'depollution' for decontamination process and it takes place in the context of the manual treatment of the WEEE. It means that all hazardous substances and materials in Annex VII are being removed. But since Annex VII also stipulates the removal of circuit boards and external cables (which are not hazardous but valuable) the correct answer would be that Annex VII set up 'dismantling measures', some of which constitute 'decontamination' or 'depollution' measures.

7. So the dismantling is performed for two reasons: 1. To take out valuable components or materials and 2.) to remove impurities, such as hazardous substances and unwanted material?

Yes, that is correct.

8. How important is the initial dismantling for the rest of the recycling process and the products recyclability?

If dismantling did not take place and all products would be sent to the second treatment recycled (mechanical treatment) then the material streams would not be salable, since they could not be turned into secondary raw material due to contamination of, for example, mercury, PCB and cadmium. So in order to conduct a legally acceptable waste treatment, manual dismantling constitutes a necessity and is extremely important. The iron, copper and so on would not be salable.

9. What happens to the WEEE where unwanted substances and materials cannot be removed in the first treatment (manual treatment)? Like batteries or external cables found in Annex VII?

If we, for example, receive a product containing beryllium, which is hazardous and can sometimes be difficult to remove, then that entire product is sent to destruction. There are few products that cannot at least partially be dismantled. The WEEE that are causing problems for us are very specific products, such as WEEE coming from the pharmaceutical industry, the military or aerospace. We do not receive a great deal of these types of products, which is making it difficult to plan the treatment of them. On the other hand, we are still receiving a large amount of CRT-TVs (Cathode Ray Tube) with CRT-glass containing lead and they all have to be dismantled manually otherwise the material flow will be contaminated with lead.

10. What about recycling facilities in other European countries that are not as well-equipped as Stena's facilities?

All the Nordic countries have always been good at recycling but the other countries are catching up pretty quickly. Both Germany and Italy have come very far, for example. But we have a lot of Eastern block-countries who are lacking the mechanical treatment. To their advantage they have lower wages than the rest of Europe, which potentially would allow them to conduct manually performed recycling that is still economically viable. The problem in some countries is the lack of an efficient and functioning control mechanism surveying the quality of the recycled material. It is possible in the recycling industry to cheat and dilute for example the mercury in the iron by adding more iron in order to decrease the level of mercury, called 'the dilution effect', making the iron salable. This keeps hazardous substances in the materials, and is not permitted by the WEEE directive, which is why it is important that the authorities keep an eye on the recyclers of WEEE.

11. Stena is selling waste, not secondary raw material?

No, Stena receives 'hazardous waste' and after the recycling process the material is sold as 'waste' which is then transformed by the buyer to secondary raw material. Stena is only selling aluminium as a 'product' since Stena has its own smelters for aluminium, but the rest of the materials extracted from the recycling process are sold as 'waste'.

12. What kind of material or substances can contaminate the waste flow?

Hazardous substances, such as PCB, mercury, lead and cadmium. These are the four most prevalent hazardous substances in WEEE. Another hazardous substance is brominated flame

retardants (BFR), which is spread out in some plastic components. When the plastic is shredded a density test is performed, which allows us to extract the plastic containing BFR. Some brom is allowed in the EU and some are not, and to test the kind of brom is too expensive and difficult, which is why all brominated plastic is sent for destruction.

13. Which design features (design and content) or requirements in the design directive are difficult to handle in the pre-treatment?

If I look ahead I regard the use of plastic as the main concern due to the trend of using different flame retardants as well as the use of 'fillers' in the plastic (the plastic is diluted with other types of materials and substances in order to change the density of the plastic and make it more flexible). We will not be able to recycle this type of plastic since in the density test we are performing to separate brominated plastic from recycled plastic, the plastic with fillers will behave as the brominated plastic and will therefore be sent to incineration as 'hazardous material'. Therefore plastic, and the increasing trend of using plastic fillers, constitute a great challenge for the recycling industry in the future.

Glass is also difficult to recycle since it needs to be removed in larger fractions. Mechanical removal often causes the glass to break, which will make it become mixed up with other materials. And the price of glass for melting is not high enough for the process to be worth it. It results in a 'zero price' that increases the cost of the recycling.

So substances, for which we are lacking a technical and economically viable recycling treatment, should be used in the product design with restraint.

14. Is there any requirement in Annex VII that are causing difficulties? Johan Felix at CIT mentioned the removal of batteries, as an example. Is there any consideration to these kind of requirements you would like to see reflected in the design of EEE?

Batteries are one of the components we are putting the most time on removing. In the majority of the cases the existence of a battery in a product is easily recognized, judging from the type of product. The location of the battery inside the product is often easily identified as well and they are attached in a way that makes the removal possible. So it's often not very hard to remove them. The prevalence of, for example, mercury is more difficult to handle since the substance is hard to detect. The use of environmentally friendly batteries is increasing, makes the product suited for second treatment without the manual removal of the battery. Lithium-ion batteries today does not contain any hazardous substances so in order to extract the cobalt, which constitute the valuable part of those types of batteries, together with aluminium, the batteries has to be shredded.

In general, the use of plastic bolts and screws when attaching plastic and metal bolts and screws when attaching metals would increase the amount of recycled material. When, for example, metal bolts are used to connect plastic parts and the products gets shredded and when the bolt is separated from the waste stream by the use of magnets or other kind of technique the bolt often has plastic fractions still attached to it, which makes it unsuited for metal recycling. This is a subject we have discussed with certain producers of EEE. For

example Electrolux has developed a 'Green serie' where they have tried to accommodate many of our requests. But those products are what I would like to call 'nisch products' so I would say that they listen to us and they can sell some of the products as more 'green' but the bigger mass of products are unaffected by these requests.

15. How much assistance does the RoHS directive provide in making the contents of the waste stream predictable and manageable for you?

The products we are receiving today are between seven to ten years old. So the changes of permitted substance limits or the banning of substances tell us that in about seven to ten years we will see a decrease in the use of that substance in the WEEE. The exemptions to the RoHS, and the admission to use a higher amount of hazardous substances, requirements means that those products cannot be recycled as well as products containing a smaller amount of these substances. The prevalence of these substances entail such a high recycling cost that it does not become worth it. However, I believe that most of the type of product subject to the exemptions, which are medical equipment and other types of specialized equipment, does not reach our facilities. Instead they are taking other routes, avoid the WEEE system and does not get recycled. So I would say that the exemptions does not really affect recycler of WEEE, but for the EEE which are subject to the exemptions and do reach the WEEE stream the exemption will mean that the product will be recycled to a lower extent.

All in all, I would say that the RoHS directive helps us to plan our processes in the future, but the exemptions are too many. An example how the RoHS directive is helping us is when we are planning the treatment of for example flat screens, we are consulting the RoHS directive to see of mercury is allowed in flat screens.

16. What about fluorescent light and the fact that they are subject to exemption?

That is a product where the recycling is well-functioning. They are collected separately and recycled at a pretty high rate.

17. What is your opinion about the incentives that exists today for producer to take account of their products ability get dismantled and recycled?

The WEEE directive stipulated that producer must provide the recycler with information about product contents and in other ways facilitate the recycling process. That does not work at all today. Producers are interested in making new products and making them as cost-efficient as possible. If they consider the recyclability of the product, it is in the last minute. Of course it varies from company to company, but generally this is the routine. They are reluctant to share information about content and disassemblability, since it's considered a trade secret.

19. How useful is information about content and disassemblability from the producer for your day-to-day waste treatment? Do you have time to look up this information?

No we don't. There is just no time. I was down in Brussel and spoke to EU representatives about this and we actually don't have any use for this information since we don't have the time. On the other hand, if we are looking at the End-of-life vehicle directive for example, the

recycler of cars have started to look into techniques for how to remove the airbag but that's because they can sell the component for reuse if they can remove it without damaging it. In that case information about disassembly is very useful for the recycler.

In Europe there is an interest to get access to the design sketches of EEE, for example washing machines. But that interest is not coming from recyclers, it's coming from people in the re-use business. They extract functional components and sell them as spare parts. But since producers are making a lot of money from selling newly made spare parts (the 'aftermarket'), they are reluctant to enable this re-use business by providing the design sketches.

20. What about marking of the products (a mark on the product) indicating the contents of hazardous substances or how the product is dismantled?

Yes, marking indicating the prevalence of hazardous substances would be helpful since the first treatment is made manually and then the recycling personnel could easily see the marking and take action accordingly. But in that case every product must receive this marking for the system to be helpful for us. But then you have the risk of the marking falling off during the product life. Then you have the problem of delayed effect: products put on the market today will reach us in seven to ten years. At that time recyclers might think that another substance is more important to be able to recognize in a product. Therefore I think that the only really interesting solution is so called RSID-chip. The chips can be read off from a distance and can be programmed to contain information about the product content and its design. It would be like connecting the instruction manual of the product this chip. So when the products, provided with this chip, would pass the scan at the recycling facility the information would be available at an instant. This information marking (with a chip) or clear marking on the product (non-removable) are, in my opinion, the two most useful and effective ways of providing recyclers with information which could increase the recyclability of the product. But there are risks with both ways of marking the products. The physical marking can disappear. The risk with the use of chips is that the recycler rely too much on this information, so the products that have been altered through repair or other operations changing its content and design or if the chip is unreadable it will cause problems. The issue with instating such a system is that the producers are reluctant to release too much information. If the chips get hacked then trade secrets might be revealed to competitors. This makes it hard to require too much information from the producers. Few organisations are pushing for the introduction of this system: The Swedish Environmental Agency, along with some English organisations but producers are reluctant. Say for example that the authorities would require Apple to put a chip on their iPhone containing information about all the substances in the iPhones. They would not be willing to do it. I think producers are working hard to not allow for this system to be set up. I think Apple would rather see that they have to list, on the inside of the shell of the iPhone, the substances that are considered hazardous at the time of the making of the product.

21. My research has so far indicated that there are two groups of design requirements with potential to facilitate the recycling process: 1.) design requirements aligned with the waste

treatment requirements (the WEEE directive) and, 2.) design requirements which makes valuable components and materials more easily accessible, which increases the profitability from the recycling process. Would you agree?

I think it sounds good. I don't believe in the type of requirements regulating a maximum disassembly time, the technique applied is likely to change which would allow for a mechanical dismantling. On the other side, it would be interesting if producers would take the product design and then look at the separation techniques available to us today at the recycling facilities and calculate whether it is possible to achieve the stipulated recycling rates. The prohibition of material which are difficult or not possible to recycle in certain products would also be interesting, like for example glass. That is a material which is used more and more frequently in products, despite that the glass does not serve any functional purpose. Plast fillers in another example of a substance that will be sent to incineration and decrease the recycling rates. What I would like to see in the future product design is the elimination of these kinds of material. Along with the bolts and screws in the same material as I mentioned earlier. So it's not only about facilitating the recycling because some materials just cannot be recycled, and some materials do not have any buyers. Like for example rare earth metals: even if we could extract all of them from the products (which we cannot) we can only find buyers to a few of them. For example neodym, which can be found in a lot of products, has enjoyed a limited interest among buyers. That has meant a low amount of recycling of this metal, but the latest development consisting of an increase in the numbers of buyers. This has increased the amount of recycled neodym.

22. When looking strictly at the pre-treatment and the dismantling process, would you say that the two groups of requirements I mentioned would apply?

When looking strictly at the dismantling process, then requirements such as the limitation to only one type of screw would be helpful. Marking about where in the product the hazardous substances and the substances in Annex VII are located would also facilitate the treatment.

23. Would you like to see an increased synergy between the design of products and the requirements in the WEEE directive?

Absolutely. There are products on the market today that cannot be recycled. The prevalence of hazardous substances in products put on the markets are steadily decreasing. As the situation is today we are facing two challenges: 1.) the proper collection of the WEEE and 2.) reaching the recycling rates set in the directive. For example a washing machine: according to the WEEE directive the material recycling and energy recovery should reach 85 %. Today there is an important part of the WEEE that does not end up at a recycling facility. If the recycling process is being made more expensive I am afraid that more of the WEEE is not going to end up outside the recycling systems.

24. What about an increased synergy with regards to the pre-treatment? What is causing trouble today?

The substances we cannot remove manually causes problems. LCD-screens in one example: it takes many steps before the material is extractable. Material, which cannot be recycled, needs

to be removed so making them easy to remove would increase the recyclability of the products. But I find it hard to think that producers will accept too many limitations, that is not legal obligations of course. Not making so many exemptions in RoHS is one idea, or to list material which are allowed in certain products. The use of plastic fillers for example. In order to increase the recycling rates it would be very useful if recycle plastic could be marked. But then the producers will say that 'That issue will have been solved by the recyclers by the time the product reaches the waste stream'. And that holds true, but only if the volumes of these products are big enough. Then we can plan and adjust the separation techniques. But since the fillers keep changing it is pointless to conduct any research about how to improve the treatment of plastic treatment. In our experience the content and amount of fillers changes rapidly, resulting in hundreds of thousands of different plastic fillers and we do not have the means to set up waste treatment processes for that many varieties.

23. What do you think about design measures which makes it easier to remove valuable components or material, and that such a design feature might make the product subject to so called 'informal recyclers' who would remove the valuable parts and then send the remains to the official waste collection?

That is the risk. The risk is also that such design requirements would hamper the product development and that the products become more expensive. However, I find it hard to believe that a facilitated removal of valuable components would decrease the recycling of the products. Take circuit boards for example: Worldwide there are only six smelters in the world for circuit boards and they want to do business with big suppliers.

24. What are your thoughts on the arguments against applying 'design for disassembly'-measures saying that the efforts are pointless since we don't know what the recycling techniques will be capable of performing once the product reaches the waste stream? That any consideration to the future disassembly in the recycling process would be guessing game?

I think we should look at the challenges we are facing today: 1.) locate the hazardous substances 2.) plastic with fillers 3.) use plastic bolts and screws for plastic products. These measures do not have an important impact on the producers but it would do a great deal in order to increase the recyclability of the products. But the biggest question remains: the choice of material in the products. They must be able to be extracted and purified and there has to be a buyer to the waste. Take a cell phone: 10-15 years ago they contained 14 different substances and materials. Today that number has increased to 70 basic elements in a cell phone. We cannot find buyers to all 70 substances, so many of them will not be recycled. So even if we can extract a material containing a large amount of copper, but it also contains chrome then we will not find a buyer that will pay for such a combination. Instead we sell the fraction and get paid only for the copper.

25. Can you understand the motivation issue that producers might suffer from if they think that all the recycling issues experienced today will have been solved once the product hits the waste stream and therefore any design efforts today are meaningless?

I think that the producers are aware of the fact that we will have improved our facilities and the techniques applied but we will never be able to keep up with the pace of their product development. They know that there are substances that will not be recyclable, even in a few years.

26. When it comes to dismantling: CECED are for example saying that it's pointless for product designers to adapt the product design to a certain type of disassembly or dismantling since the recycler might use a totally different disassembly process than the one the product is designed for. What do you think of that?

I think they are correct in that statement. In order to create the conditions for an effective recycling there is going to be a few manually performed measures. If strict requirements are set that a product should be possible to dismantle manually then that is going to disfavour the recyclers who want to increase the mechanical treatment of the WEEE in order to increase the recycled material. We would also get many small recyclers performing different part of the dismantling process, which would lengthen the chain of operators involved.

We will never be able to recycle hazardous 'wet' substances mechanically, so marking and easy removal in the product design would facilitate the recycling process, even recycling ten years from now. Mercury in LCD-screens, for example, can be recycled mechanically but there are extremely few facilities with this technique and it's extremely expensive. So the majority of recyclers use manual removal in the treatment of LCD-screens. LCD-screens enjoy an exemption with regards to the level of mercury in the RoHS directive. The process of loosening all the screws in order to remove the mercury lamps takes a long time and the number of different screw head might be as many as six different once. So an interesting aspect to regulate would be to combine the exemption from the mercury limit in these lamps with the obligation to only use one type of screw and enable a fairly quick dismantling. That would facilitate our work. To stipulate products not containing hazardous substances to only contain one type of screw head would be very helpful but I think that would be difficult for the producers to implement in their design.

27. It must be 'better to be safe than sorry' when talking about increasing the recyclability of products today - meaning that its must be better to take action with regards to the design with the potential to increase product's recyclability rather than assuming that the technique will solve the problems in the future?

True, from a recycling perspective. But from the perspective of the producers the benefit from the requirements must exceed the costs, otherwise the market economy will push the legislation aside. The environmental benefit from the measure must be clear to the producers. So the measures with the highest environmental benefits should be required.

The WEEE directive, which in my opinion is a good directive, it's required that the member states shall collect 65 % of the products release on the market but there are extremely few countries who manage to fulfil this obligation. At the same time EU is increasing the recycling rates, indicating that they have not performed a follow-up on the former rates. So instead of requiring that all products should be recycled to for example 85 % EU should make

sure the collection rates are reached. It's the same with requirements about substances or material that we know are difficult to recycle and causes problem in the recycling process. They should be the focus of attention, not the entire recycling.

28. What are your thoughts on the different types of design requirements: maximum disassembly time, marking, same types of screw heads and so on?

The producers are saying that such requirements are very difficult to implement. But in my opinion, to standardize products more: the types of screws used and prohibiting plastic bolt with metal, which constitute fundamental design changes and require a dialogue between producers and recyclers. Like the dialogue that has taken place between Stena and Electrolux. We all know that there are aspects of the product which is hard to deal with at the recycling stage, which can be changed by the producer by small means, leading in an increased recyclability: for example don't mix too many different kinds of materials and material which can be treated mechanically should be made easy to remove. Or like RoHS: some substances are not allowed. Top controlling from EU should be used to ensure that some design measures and material use becomes forbidden.

29. Recyclers want predictability with regards to the contents and the design of the waste stream?

Predictability and high volumes - that allows us to invest in treatment procedures that are adapted and therefore effective for the product in question and we can separate materials and substances.

30. What do you think about products designed for mechanical dismantling?

Mechanical treatment solutions can be developed for all products but the diversity of products does not allow us to do that. That requires high volumes. An example is mechanical dismantling of CRT-TVs that has been subject to a lot of research at Stena. But the conclusion is that it is not possible to have a robot dismantle all the CRT-TV's due to the variety of different models. The products can also be damaged and dirty, which would prevent the mechanical treatment. So the answer has always been that it's more profitable to remove the screen manually, even in high cost countries as Switzerland and Norway. But if only one model of CRT-TVs existed we would have had a mechanical process.

ANNEX III

Interview with Annachiara Torciano, Sustainability Manager at Samsung Electronics Nordic

November 17 between 1:00 PM and 2:00 PM.

The interview was performed over the phone by Sahra Svensson.

Annachiara Torciano's background

Annachiara has been working with Ecodesign requirements and Energy Labelling, both from the perspective of manufacturer implementation at Electrolux as well as the process of setting ecodesign requirements. During her time at Electrolux Annachiara was stationed in Brussels and Sweden. At Electrolux she collaborated with product designers. She has also been working with Public Affairs on trade, agriculture and competition in Brussels as a consultant for five years. Currently, she is working at Samsung Nordic as Sustainability Manager.

Q1: What are your general thoughts on design requirements for material disassembly and recyclability?

Annachiara points out the importance of keeping the history of the implementation of ecodesign in mind because it is, and has been, a lot of focus on energy efficiency. It all started in the 90's with Energy Labelling of refrigerators, dishwashers and so on. Today the EU has 20 years of experience of developing efficient methods and legislation with regards to energy efficiency in products. The system with the Energy Labelling has become effective due to the fact that companies are competing for energy performance and the labelling is communicating the progress in this area to the customers through the labels. This has enabled an extensive change on the market for energy-using products. In order to remove the worst performing products the Ecodesign directive was introduced "on top of" the energy labelling scheme. Since the energy efficiency could be subject to controls and verification it was a relatively easy legislation to follow and to uphold. The minimum requirements could be increased to a more ambitious level over time. The extension of the scope of the ecodesign requirements has led to an inclusion of products outside the scope of the Energy Labelling Directive, which is complicating market surveillance.

Until not so long ago the market surveillance were not very actively performed (not even with regards to the energy efficiency requirements) and that constitutes a problem, even though the situation is improving. Surveillance is very important when establishing a legislative system and should be taking place at a higher rate than what is currently the case. With regards to white goods, energy requirements has been in place for 20 years but it's not until recently that market surveillance is actually being performed. With regards to energy efficiency it is possible to perform tests and compare those to the energy declaration, thereby establishing compliance. The problem with design requirements regarding recyclability is the difficulties to measure the requirement and, through that, perform market surveillance. Measurement

methods can be developed but how can compliance be measured in a uniform way when the surveillance is taking place? On the other hand, if a product group is subject to a high number of ecodesign parameters, will the authorities be able to perform compliance tests on all of these requirements? Today the requirements consists in mostly energy efficiency requirements and some other ecodesign requirements and the surveillance is deficient. How will the surveillance system be affected by an increase in number and types of ecodesign parameters? This is very important because if there is legislation there has to be compliance monitoring performed by the authorities in order to preserve competition between the manufacturers. Insufficient market surveillance will create unfair competition, as there will be no controls that the requirements are actually fulfilled. Annachiara says that from her experience, and from what she has heard from the industry associations, the verifiability of the requirements and market surveillance constitutes one of the most important issues.

Q2: What are your thoughts on the counter arguments regarding ecodesign requirements for recyclability? For example that the profitability from recycling depends on the recycling process and the market prices of material, and that the design of the product cannot affect any of those parameters?

It might be true, it might not be. Like Johan Felix at CIT is saying: You could build a product made out of gold, that would constitute a very recyclable product design but that will not happen due to the high material costs.

When thinking about product design and sustainability and recyclability the focus is on functionality: What is it the product is supposed to be able to perform? What are the features of the product? The functionality is number one priority in the design process. The environmental parameters are then prioritized in the following order: energy efficiency, chemical contents and material choice/efficiency. Design for recyclability is not among the first environmental parameters in the design process. And there is a reason for this: energy and chemical performance are more regulated. There is of course an important link between the phase-out of chemicals and recyclability, so at some extent the recyclability owns priority.

Product design and recyclability is also in potential conflict with the environmental impact from other life-cycle phases, which it is better to think of “Design for sustainability”. The reduction of the weight of the product, for example, which constitute an improvement with regards to material efficiency but might make the recycling more difficult.

Q3: What do you think of the other arguments against the introduction of product design requirements on recyclability and material dismantling? That it would enable “repurposing” and “hacking”, that is goes against the design trend of increasingly more complex and slim products and that disclosure of design and contents might jeopardise intellectual property rights and trade secrets?

Annachiara says that the one argument she recognizes from the debate is the one about an increasing complexity of products and the desire to make them smaller and slimmer. This is connected to the priority of interest in the design process. Customers want slim and light products. The product features are increasing while the size is reducing, which leaves the

designer with relatively limited options on how to attach components and materials to one another, where gluing constitute an interesting option. Annachiara brings up the case of a specific phone model with a design enabling the customers to remove and replace the battery in the phone themselves. The upgraded models are slimmer, and are featured by a bent screen, which altogether forced the designer to take away the features that allowed the battery to be easily removed and use glue to connect the part covering the battery. This decision was taken due to the lack of other viable design options. The battery can still be removed and instructions on how to do it are readily available but Samsung no longer recommend customers to do it themselves.

With regards to the potential disclosure of sensitive information: the WEEE directive is already requiring information about disassembly and information relevant to recycling. Samsung has this type of information available but no one is asking for it. There has to be a better way to analyse this type of information than what is being done today. Maybe in the future the information can be transformed in a way that will actually be of assistance to the recycler, by using digital means and more electronic technique along the recycling belt.

The level of sensitivity in the information enclosed in for example a material declaration and BOM (Bill of Materials) depend on the component and the product. But to impose such an administrative burden on the manufacturers, without knowing the effects on recyclability nor how to monitor compliance in a efficient way, is a problem. As a legal requirement it has to be supported through a cost-benefit analysis for society at large and accommodate follow-up on compliance.

Q4: What are the incentives for manufacturers to take the recycling into consideration in the design process? Is it solely based on demand and increasing “goodwill”?

The phase-out of chemicals and reducing risk later in time is in the interest of manufacturers. Also, the consumer warranty that makes manufacturers responsible for repairing of problems related to quality is between two to five years, which creates economic incentives to facilitate repair in the design of the product. This is related to recycling and reuse.

Q5: Do you have any experience of the design of Imaging Equipment subject to the “Design for recycling” requirement in the Voluntary Agreement? What is it about this product group that made it subject to the most detailed recycling requirements of all regulations and VA under the Ecodesign directive?

Annachiara has no direct experience with this VA. However, Samsung abide to those criteria in their design for printers. Printers are made up of a great deal of plastic, which made these requirements relevant for this particular product group. Marking of plastic is already taking place though. But the question remains on how the compliance of these requirements will be monitored. At the moment she is not aware of market surveillance for these requirements. She is not aware that the product declarations are subject to control from the authorities.

In principle, the industry does not use a lot of voluntary agreements in other context than the Ecodesign Directive due to the lack of monitoring.

When looking at the requirements they are not difficult to implement when it comes to for example printers: they are composed of big plastic components.

Q6: What are your thoughts on the suggested requirements on displays regarding Technical documentation and “End of life requirements”?

Technical documentation is already made available through the WEEE directive, and Samsung’s information for recyclers pretty much meet these requirements for displays and no recycler has ever requested access to these documents. The Industry is against the requirements on a video showing the disassembly of the display due to the administrative burden and cost of developing a video for each product model. Another issue is the requirements “easy to disassemble”; since there is no more precise definition, manufacturers are going to interpret the requirement in different ways and this lack of clearness will also create difficulties in the monitoring. If a design criteria shall become a mandatory requirement it has to be possible to verify compliance, otherwise it should be used as a voluntary standard were the manufacturers can interpret the requirement, implement it accordingly and argue for their position. Legislation requires uniform standards and controls.

With regards to marking of the plastic it is already implemented through voluntary standards. The logos on mercury are acceptable, as long as they facilitate the recycling process. Samsung has already phased-out the use of mercury in their displays. The logo regarding brominated flame retardant is included in the marking of plastic and a separate logo stating the same information is not necessary, as stated by Digital Europe (footnote).

The applicability of recycling rates as an Ecodesign requirement is dependant on the development of standards on how to calculate the recycling rates. CENELEC are waiting for guidelines from the Commission on how to develop such standards and, through that, establish the goals for the product group.

Q7: What are your thoughts on the argument that there is a lack of data when setting design requirements on resource efficiency? Is it preferable then to do nothing?

What the Industry is saying is that there is a Waste Framework and, the most important directive on WEEE: the WEEE directive, where it is possible to work on improvements of the waste treatment in order to increase the recycling rates. The waste treatment conditions in the WEEE directive can become stricter, the information about the waste streams can increase, the recycling rates can become more ambitious and there is a lot that can be done. The critics consist in protest in using the Ecodesign directive in the pursuit of increasing the recycling rates and that the data available does not support this approach. We don't know about the environmental benefit, we don't know whether the requirements will facilitate recycling once they reach the waste stream, we don't know about the future recycling technology nor how the products will look like in the future or what kind of material they will contain. Nor can the requirements be measured or monitored. All these uncertainties, together with the fact that many of the requirements for recyclability are costly to implement, makes the Industries opposed to dealing with recyclability through mandatory product requirements.

Q8: What about the design requirements for recyclability in voluntary standards and schemes, such as Eco Label, EPEAT, Nordic Ecolabel and so on?

These requirements do not present a challenge to implement.

Q9: What do you think about the creation of synergies between the Ecodesign Directive and the WEEE Directive by setting design requirements on disassembly related to the components and substances listed for “selective treatment” in the WEEE directive? Such as facilitated removal of circuit boards and batteries?

The problem with this requirement “easy to disassemble” is that there is no definition of “easy”, therefore there is no method of measuring compliance and no means of monitoring. If the requirements are made more specific, for example “The dismantling of circuit boards shall be possible to perform in maximum 2 minutes by professionally trained recycling personnel using a certain tool” then you have a standard but we are not there yet. And even if you could develop the perfect standard with the perfect limits you still have to apply a cost-benefit analysis. You also need to calculate how these design requirements affect other design parameters. If these aspects are not considered the requirement is going to be treated as a wish, not a mandatory requirement. The application of mandatory requirements requires the answer to many counter questions.

ANNEX IV

Annex I and V the WEEE Directive

Product Category (Annex I WEEE Directive)	2015 - 2018 (Annex V WEEE Directive)	2018 - (Annex V WEEE Directive)
1. Large household appliances	— 85 % shall be recovered, and — 80 % shall be prepared for re-use and recycled;	85 % shall be recovered, and — 80 % shall be prepared for re-use and recycled
2. Small household appliances	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;	— 80 % shall be recovered, and — 70 % shall be prepared for re-use and recycled;
3. IT and telecommunications equipment	— 80 % shall be recovered, and — 70 % shall be prepared for re-use and recycled;	— 80 % shall be recycled. — 70 % shall be prepared for re-use and recycled;
4. Consumer equipment and photovoltaic panels	— 80 % shall be recovered, and — 70 % shall be prepared for re-use and recycled;	— 85 % shall be recovered, and — 80 % shall be prepared for re-use and recycled
5. Lighting equipment	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;
5.a. Gas discharge lamps	— 80 % shall be recycled	— 80 % shall be recycled
6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;
7. Toys, leisure and sports equipment	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;
8. Medical devices (with the exception of all implanted and infected products)	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;
9. Monitoring and control instruments	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;	— 75 % shall be recovered, and — 55 % shall be prepared for re-use and recycled;

10. Automatic dispensers	— 85 % shall be recovered, and — 80 % shall be prepared for re-use and recycled;	— 85 % shall be recovered, and — 80 % shall be prepared for re-use and recycled;
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Table 1. The Recovery targets by product category

Product category	Information requirements	Design requirements	Revision: Design options for increased recyclability
Air conditioners and comfort fans ⁴³⁷	-	-	-
Circulators ^{438 439}	Recital 10 and Article 2(3) Annex I Regulation (EC) No 641/2009) (Amendment) Article (2(1)(c) Annex 1 Regulation (EU) No 622/2012).		Article 7 Regulation (EC) No 641/2009) Article 7 Regulation (EU) No 622/2012
Computers ⁴⁴⁰	Annex II 7.1.1(y) Information about mercury content (for products with an integrated display containing mercury)	-	Article 9 Regulation (EU) No 617/2013 (“dismantlability” mentioned)
Domestic cooking	Article 2(b) Annex 1 Regulation	-	-

⁴³⁷ Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans Text with EEA relevance

⁴³⁸ Commission Regulation (EC) No 641/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products (Text with EEA relevance)

⁴³⁹ Commission Regulation (EU) No 622/2012 of 11 July 2012 amending Regulation (EC) No 641/2009 with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products Text with EEA relevance

⁴⁴⁰ Commission Regulation (EU) No 617/2013 of 26 June 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for computers and computer servers Text with EEA relevance

appliances ⁴⁴¹	(EU) No 66/2014).		
Electric motors ^{442 443}	Recital 16 and 2(d)(11) Annex 1 Regulation (EC) No 640/2009)	-	Article 7 Regulation (EC) No 640/2009
External power supplies ⁴⁴⁴	-	-	-
Household dishwashers ⁴⁴⁵	-	-	-
Household tumble driers ⁴⁴⁶	-	-	-
Household washing machines ⁴⁴⁷	-	-	-
Industrial fans ⁴⁴⁸	Recital 19 and Article 3(2)(12) Regulation (EU) No 327/2011	-	-
Lighting products in the domestic and tertiary sectors - fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires	3.2 (A)(E) Regulation (EC) No 245/2009 Recital 10 and Annex III 3.1.2(n), 3.1.3(m) Regulation No 1194/2012 - Information about mercury content	-	-

⁴⁴¹ Commission Regulation (EU) No 66/2014 of 14 January 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for domestic ovens, hobs and range hoods Text with EEA relevance

⁴⁴² Commission Regulation (EC) No 640/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors (Text with EEA relevance)

⁴⁴³ Commission Regulation (EU) No 4/2014 of 6 January 2014 amending Regulation (EC) No 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors Text with EEA relevance

⁴⁴⁴ Commission Regulation (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies (Text with EEA relevance)

⁴⁴⁵ Commission Regulation (EU) No 1016/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household dishwashers Text with EEA relevance

⁴⁴⁶ Commission Regulation (EU) No 932/2012 of 3 October 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household tumble driers Text with EEA relevance

⁴⁴⁷ 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 Text with EEA relevance

⁴⁴⁸ Commission Regulation (EU) No 327/2011 of 30 March 2011 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for fans driven by motors with an electric input power between 125 W and 500 kW Text with EEA relevance

able to operate such lamps ^{449 450} - directional lamps, light emitting diode lamps and related equipment ⁴⁵¹ ⁴⁵² - non-directional household lamps ^{453 454}	Recital and Annex II 3.1(k) No 244/2009 - Information about mercury content		
Local space heaters - Local space heaters ⁴⁵⁵ - Solid fuel local space heaters ⁴⁵⁶	Recital 21 and Article 3(a)(i)(5) Regulation (EU) 2015/1188 Recital 22 and Article 3(a)(i)(3) Regulation (EU) 2015/1185	-	-
Heaters and water heaters - space heaters and combination heaters ⁴⁵⁷ - water heaters and hot water storage tanks ⁴⁵⁸	Recital 20 and Article 5(a) Annex II Regulation (EU) No 813/2013 Recital 18 and Article 1.6 (f) and Article 2.2(d) Annex II Regulation (EU) No 814/2013	-	-

⁴⁴⁹ Commission Regulation (EC) No 245/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council (Text with EEA relevance)

⁴⁵⁰ Commission Regulation (EU) No 347/2010 of 21 April 2010 amending Commission Regulation (EC) No 245/2009 as regards the ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps (Text with EEA relevance)

⁴⁵¹ Commission Regulation (EU) No 1194/2012 of 12 December 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment Text with EEA relevance

⁴⁵² Commission Regulation (EU) 2015/1428 of 25 August 2015 amending Commission Regulation (EC) No 244/2009 with regard to ecodesign requirements for non-directional household lamps and Commission Regulation (EC) No 245/2009 with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps and repealing Directive 2000/55/EC of the European Parliament and of the Council and Commission Regulation (EU) No 1194/2012 with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment (Text with EEA relevance)

⁴⁵³ Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps (Text with EEA relevance)

⁴⁵⁴ Commission Regulation (EC) No 859/2009 of 18 September 2009 amending Regulation (EC) No 244/2009 as regards the ecodesign requirements on ultraviolet radiation of non-directional household lamps (Text with EEA relevance)

⁴⁵⁵ Commission Regulation (EU) 2015/1188 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for local space heaters (Text with EEA relevance)

⁴⁵⁶ Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters (Text with EEA relevance)

⁴⁵⁷ Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters Text with EEA relevance

Power transformers ⁴⁵⁹	-	-	-
Professional refrigerated storage cabinets ⁴⁶⁰	Article 2(b)(3) Annex II, Article 2(b)(3) Annex V, Article 2(b)(3) Annex VII Regulation (EU) 2015/1095	-	-
Refrigerators and freezers ⁴⁶¹	-	-	-
Simple set-top boxes ⁴⁶²	-	-	-
Solid fuel boilers ⁴⁶³	Recital 15 and Article 2(b) Annex II	-	-
Standby and off mode electric power consumption of household and office equipment and network standby ^{464 465}	Annex I 5.1.(e) and 2 Regulation No 642/2009 - information about presence of lead and mercury	-	-
Televisions ⁴⁶⁶		-	-
Vacuum cleaners ⁴⁶⁷	Article 2(b) Annex I Regulation (EU) No 666/2013		

⁴⁵⁸ Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks Text with EEA relevance

⁴⁵⁹ Commission Regulation (EU) No 548/2014 of 21 May 2014 on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers

⁴⁶⁰ Commission Regulation (EU) 2015/1095 of 5 May 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for professional refrigerated storage cabinets, blast cabinets, condensing units and process chillers (Text with EEA relevance)

⁴⁶¹ Commission Regulation (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances (Text with EEA relevance)

⁴⁶² Commission Regulation (EC) No 107/2009 of 4 February 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for simple set-top boxes (Text with EEA relevance)

⁴⁶³ Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers (Text with EEA relevance)

⁴⁶⁴ Commission Regulation (EC) No 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment (Text with EEA relevance)

⁴⁶⁵ Commission Regulation (EU) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions Text with EEA relevance

⁴⁶⁶ Commission Regulation (EC) No 642/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for televisions (Text with EEA relevance)

⁴⁶⁷ Commission Regulation (EU) No 666/2013 of 8 July 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for vacuum cleaners Text with EEA relevance

Ventilation units ⁴⁶⁸	Article 3 Annex IV and Article 3 Annex V Regulation (EU) No 1253/2014 (“detailed instructions” about tools for manual disassembly for permanent magnet motors, and of electronics parts (printed wiring boards/printed circuit boards and displays > 10 g or > 10 cm ²), batteries and larger plastic parts (> 100 g) for the purpose of efficient materials recycling, except for models of which less than 5 units per year are produced.)	-	-
Water pumps ⁴⁶⁹	Recital 16 and Article 2(10) Annex II Regulation (EU) No 547/2012		

Table 2 Implementing measures containing recyclability requirements under the Ecodesign Directive

Product category	Information requirement	Design requirements	Revision: Design options for increased recyclability
Complex Set Top Boxes ⁴⁷⁰	-	-	-
Imaging equipment ⁴⁷¹	-	(see table 3 and 4 below)	-
Game consoles ⁴⁷²		<p>“Non-destructive disassembly” shall be possible⁴⁷³</p> <p>Material composition in plastic parts marked, with the exception of:</p> <ul style="list-style-type: none"> - part with less than 1cm² level surface available for marking - marking damaging functions - external transparent parts - Marking is not technically possible 	-

⁴⁶⁸ Commission Regulation (EU) No 1253/2014 of 7 July 2014 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for ventilation units Text with EEA relevance

⁴⁶⁹ Commission Regulation (EU) No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps Text with EEA relevance

⁴⁷⁰ CSTB VA (2013) “Voluntary Industry Agreement to improve the energy consumption of Complex Set Top Boxes within the EU” Version 3.1 19 June 2013

⁴⁷¹ EuroVAprint 2015

⁴⁷² VA “Energy Efficiency of Game Consoles” (2015)

<https://ec.europa.eu/energy/sites/ener/files/documents/Games%20Consoles%20Self-Regulatory%20Initiative%20V1%20-%20Final.pdf> 2015-10-05

⁴⁷³ 3.3. Non-Energy Efficient commitment VA “Energy Efficiency of Game Consoles” (2015)

		due to the specific production method of the plastics used in the part e.g. extrusion moulding ⁴⁷⁴	
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Table 3 Voluntary agreements and requirements containing recyclability requirements

From The Voluntary Agreement on Imaging Equipment (EuroVAPrint 2015)

5.2 Design for recycling

- Plastic parts >100 g shall be manually separable into recyclable plastic streams with commonly available tools
- Product shall utilize commonly used fasteners for joining components, subassemblies, chassis and enclosures.
- Non-separable connections (e.g. glued, welded) between different materials shall be avoided unless they are technically or legally required.
- Product plastics shall be marked by material type (ISO 11469 referring ISO 1043, resin identification code, SPI, DIN, or country specific).
 - Marking requirement does not apply to plastic parts weighing less than 25 g or with surface area less than 50 cm²; tape; plastic protective and stretch wraps and labels; or plastic pieces when due to shape marking is not possible.
 - Exempted are plastic parts contained in reused complex modules.
 - An exemption from the criteria in sections 5.1 and 5.2 will be acceptable for models that are sold in small numbers (less than 5,000 units per year), on the ground that the cost of implementing the criteria is disproportionate to the sales of the product.
 - Exceptions should be reported to the Independent Inspector.

5.3 Polymer composition

In order to limit the variety of materials used:

- plastic casing parts with a mass greater than 100 grams have to consist of one single polymer or a polymer blend.
- All plastic casing parts may only consist of up to four separable polymers or polymer blends.
- Large-sized casing parts must be designed in a way that the contained plastics can be used for the production of high-quality durable products by applying available recycling techniques.
- The use of coatings for special parts is to be reduced to a minimum, unless it can be demonstrated that it does not alter recyclability.
- Galvanic coatings on plastic parts are not permissible.

5.4 Cartridges

- Any cartridge produced by or recommended by the OEM for use in the product shall not be designed to prevent its reuse and recycling.

⁴⁷⁴ 3.3. Non-Energy Efficient commitment VA “Energy Efficiency of Game Consoles” (2015)

Excerpt from the voluntary agreement on game consoles (Sony, Microsoft & Nintendo 2015)

Commitment 3.3 “Non-Energy Efficiency Commitment”

- ...recycling... of each games console shall be possible by non-destructive disassembly
- Console plastics parts >25g will be marked indicating their material composition (using ISO conforming marks), with the following exceptions:
 - The part has <1cm² level surface available for marking
 - The performance or function of a part is compromised e.g. buttons with tactile surface, plastic lenses, or display screens.
 - External transparent parts
 - Marking is not technically possible due to the specific production method of the plastics used in the part e.g. extrusion moulding.

Table 4 Excerpt regarding dismantlability from the voluntary agreements with regards to Imaging equipment, restructured by the author of this paper (Commitments 5.2-5.4 EuroVApriint 2015).