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Nordic Council of Ministers
Ved Stranden 18
DK-1061 Copenhagen K
Phone (+45) 3396 0200

www.norden.org

Content

Preface

This report constitutes part of the documentation of the larger project *Eco-design and Future Product Policy – Further research on Energy-related Products*. The overall purpose of the research project is to investigate the inclusion of environmental aspects such as natural resources and raw materials in the Eco-design Directive. The Nordic Council of Environmental Ministers (NCM) finances the project, and it is guided by the sustainable consumption and production working group of NCM. The project was initiated by the working group including: Professor Arne Remmen, Aalborg University, Ph.D. fellow Rikke Dorothea Huulgaard, Aalborg University, associate prof. Henrik Riisgaard, Aalborg University, associate prof. Carl Dalhammar, IIIEE, Lund University, and associate prof. Andrius Plepys, IIIEE, Lund University.

The project is subdivided into the following three parts: (1) From energy efficiency during use to resource efficiency, (2) the role of the Ecodesign Directive within a broader policy package for improved resource efficiency, (3) resource efficiency in Eco-labels and an Implementing measure for one project group. This report is part of the documentation of part two but also relates to part one.

The purpose of the study has been to investigate how the synergies and coherence between nine European and Nordic policy instruments can be improved in order to minimize the environmental impacts from all life cycle stages of washing machines and drive innovation. The interaction and improvement potential was examined through a case study of household washing machines available on the Danish market in 2011.

The lead authors would like to thanks those who participated in interviews during the project. A special thank is given to Rikke Næraa from Danish Ministry of Climate, Energy and Building for qualified review and valuable comments.

Author team

- Project manager: Arne Remmen
- Lead Authors: Anja Marie Bundgaard and Kristina Overgaard Zacho
- Quality assurance: Henrik Riisgaard and Rikke Dorothea Huulgaard

Sigurbjorg Saemundsdottir
Chair of Nordic SCP working group,
Ministry for the Environment,
Reykjavik, Iceland

Summary

Through a case study of household washing machines on the Danish market in 2011, it is investigated how nine European and Nordic policy instruments interact to reduce the environmental impact from household washing machines and moreover how they encourage eco-innovation in industry. The objective of the study is to investigate how the synergies and coherence between the instruments can be improved in order to minimize the environmental impacts from all life cycle stages of household washing machines and to drive eco-innovation. The initial choice of using household washing machines as the case study was based on the deviations found between the requirement in the Ecolabels and the Ecodesign Directive. However, this report represents a single case study and does not attemp to generalize on the function of other products than household washing machines.

The policy instruments are: the Eco-design Directive, the EU energy label, the WEEE Directive, the RoHS Directive, the REACH Regulation, the EU Ecolabel, the Nordic Swan, Green Public Procurements (GPP), and Voluntary Environmental Agreements (VA).

The intended synergies between the policy instruments

The Eco-design Directive is a strong policy instrument, which sets requirements to the industry to improve the environmental performance of energy-related products by incorporating environmental considerations in the design, considering each life cycle stage. The Eco-design Directive does together with RoHS set requirements, which the industry has to comply with and they ensures that all products live up to certain environmental minimum standards. Other mandatory policy instruments are the EU Energy label, WEEE, and REACH. Additional voluntary policy instruments (the Nordic Swan, EU Ecolabel, Green Public Procurement and Voluntary Agreements) set up environmental criteria to inspire producers towards eco-innovation. Thus there is an intended synergy between the mandatory and the voluntary instruments, where the mandatory instruments set minimum requirements to the performance of products and the voluntary instruments aim to drive the market demand for more envi-

ronmentally friendly products. However, in the case of household washing machines this intended synergy is not found.

Focus on use stage – neglecting the life cycle perspective

Despite the intended life cycle perspective of the Eco-design Directive, the Implementing Measures for household washing machines only cover the use stage with requirements for energy efficiency and water consumption. The other life cycle stages, which include the use of resources and hazardous substances, production, transport, reuse and waste, are left for other instruments such as WEEE and RoHS to regulate. However, WEEE has not succeeded to incorporate considerations on material use and waste in the design stage, and thus there is currently unutilized potential in the Eco-design Directive to set requirements to resource efficiency and end-of-life management. The current call for resource efficiency makes it even more relevant for the Eco-design Directive to incorporate requirements regarding resource – and material use as well as waste management (EC, 2010c) (Udenrigsministeriet, 2012).

Among the voluntary instruments, the ecolabels have the most comprehensive life cycle perspective, but the criteria have been outdated for years and have thus not been an inspiration to the industry.

Policy instruments and drivers of eco-innovation in the case of washing machines

Since 1997, a continuous improvement of energy and water efficiency of household washing machines has taken place on the Danish market. This environmental improvement has primarily been driven by the EU Energy Label, which has succeeded in increasing the consumer demands for energy and water efficient machines. This has given the producers incentive to produce A-rated machines, and the majority of the market has consisted of A-rated machines. In 2010, an updated version of the Energy Label introduced new energy classes with A+++ as the most efficient in order to improve the energy efficiency further.

The Ecolabelling criteria in the Nordic Swan and the EU Ecolabel are outdated and the latest revisions are from 2004 and 2001 respectively.[1] Thus the eco-labels have not managed to inspire industry to develop greener household washing machines. Actually some of the worst performing washing machines on the market regarding energy and water consumption are labelled with the Nordic Swan. This is mainly due to the higher concern on allergy risks in the Nordic countries, where concerns on water use are less important.

Delays in the development of Ecolabel criteria are problematic because the Ecolabels, based on a life cycle perspective, have the potential to improve the environmental performance of other parameters than energy and water consumption. The innovation dynamics of energy using products give challenges to the setting of ecolabelling criteria, and therefore it has to be considered how to set long-term criteria that can encourage development of new technologies.

Final conclusions on the effect of the Eco-design Directive on household washing machines can yet not be made, because the Implementing Measures for household washing machines became effective in December 2011. However, an analysis of the market shows that all household washing machines on the Danish market in 2011 live up to the new requirements. The next tier of the Implementing Measures, stepping into force in 2013, are quite ambitious and will remove almost 30% of the bottom of the current market in terms of requirements for water consumption and 73% of the market in terms of energy consumption.

Improved coordination between the instruments

Comprehensive and time-consuming background studies are made for each policy instrument, when setting or updating new requirements or criteria for a product group. Common background studies and a mutual knowledge platform for all instruments could reduce time and resources spent. Even more importantly, this could create opportunities to further coordinate the instruments during the initial stages of policy development, so the intended synergies are strengthened further.

[1] A new criteria set for household washing machines are currently being developed for both the EU Ecolabel and the Nordic swan.

1. Objectives

The overall objective of this report is to investigate how nine policy instruments affect the development and environmental performance of household washing machines. Through a case study of household washing machines on the Danish market in 2011, it will be examined how the policy instruments work and interact and how the synergies and coherence can be further improved. More specifically the possibilities of a common knowledge platform between the different instruments and how a further coordination between the instruments can be developed will be investigated.

The following policy instruments are investigated:

- The Eco-design Directive
- The EU energy label Directive
- The WEEE Directive
- The RoHS Directive
- The REACH Regulation
- The EU Ecolabel Regulation
- The Nordic Swan
- Green Public Procurements (GPP)
- Voluntary Environmental Agreements (VA)

The strength of the Eco-design Directive is the focus on the integration of environmental considerations in the design stage. The directive sets minimum energy performance requirements for products, and creates a driver for innovation in industry by tightening the demands over the years. However, this potential is in the Implementing Measures restricted to energy efficiency improvements in the use stage, while other environmental aspects in relation to other life cycle stages are not included. Thus the Eco-design Directive does not – in the Implementing Measures – encompass the life cycle perspective

within the original scope of the Directive.[2] Currently, there is a call within the Commission (DG Environment) for inclusion of environmental aspects related to natural resources and raw material use (EC, 2011b) e.g. in the Eco-design Directive. The Directive is one of the few existing policy instruments at the EU level that can address these issues in an effective way. Hence it is relevant to investigate how the Eco-design Directive's role should be in relation to current policies regarding use of resources i.e. WEEE, RoHS and REACH.

Energy labelling, The Eco-design Directive, the WEEE Directive and the RoHS Directive apply to all products within the relevant product group, whereas the ecolabelling and the Green Public Procurement (GPP) are drivers for front-runner enterprises to get a competitive advantage on the market. In the report it will also be investigated how the relation between the minimum mandatory requirements and the voluntary criteria should be developed in order to stimulate product innovation in enterprises. This is conducted at a general level but also in relation to the case study of household washing machines.

The research will be conducted with the purpose to inform the policy makers of future policies.

[2] A screening for the most significant environmental impacts in a life cycle perspective have been conducted, but as the Eco-design Directive regards energy-related products, the energy consumption in the use stage is often assessed to be the most significant. For many products other parameters connected to the use stage are also assessed important, e.g. water consumption of household washing machines.

2. Methodology

2.1 The case study of washing machines

The methodological approaches used in this study include a single-case study of household washing machines, literature reviews and interviews in relation to the instruments.

The case was chosen because we found a mismatch between the law requirements and the level of ambition of the supposedly most eco-friendly products – the ecolabelled products. In the initial analysis we found that the requirements in the IM for household washing machines were stricter than the criteria in the EU Ecolabel and the Nordic Swan, and from an ideal policy perspective the reverse would be expected. Thus in terms of the interaction between the ecolabels and the Eco-design Directive we found that the case study of household washing machines represents a case, which deviate from what we would expect. Therefore the case of household washing machines is considered an extreme or deviant case cf. Bent Flyvbjerg's definition of case types. Flyvbjerg defines the purpose of the extreme or deviant case as

> "to obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense" (Flyvbjerg, 2001: 79).

Thus the case was not chosen because it was a representative case. It was chosen because it might shed light on some of the problems in the interaction between the nine different schemes and to make the issues within this field clear. However, it should be clarified that it is only in terms of the interaction between the Ecolabels and the Eco-design Directive that the household washing machines represents an extreme or deviant case. In other aspects it might be found that the washing machines are actually a representative case.

2.2 Interviews

As our field of study is fast moving, and some of the instruments we wish to examine have just recently been adopted, an important method for knowledge generation has been the qualitative research interview. In total we have interviewed four persons; two working with or having knowledge on the Eco-design Directive and/or the Energy Label; and two having knowledge on the Ecolabels. The interviewees can all be considered as experts within their field. Interviews with the following interviewees were conducted:

- Kasper Dirckinck-Holmfeld, Former SCP responsible at the Danish Environmental Protection Agency
- Gert Sønderskov Hansen, the Danish Environmental Protection Agency and responsible for the Eco-design Directive
- Charlotte Vincentz Fischer, from Ecolabelling Denmark and responsible for amongst other things ecolabelling of household washing machines
- Lisbeth Engel Hansen, head of criteria development at Ecolabelling Denmark

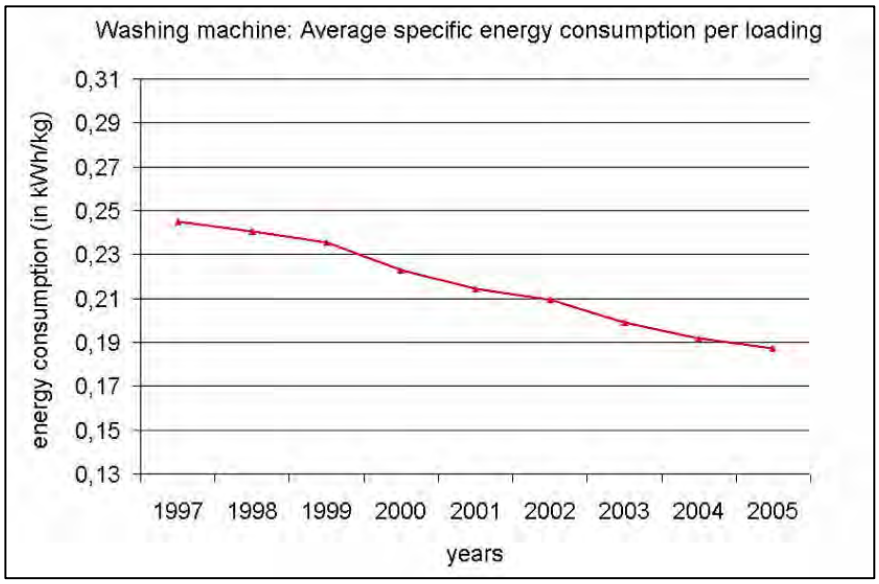
3. Case study of household washing machines

This chapter presents a study of the product category *household washing machines* in relation to the requirements in the nine instruments: the Eco-design Directive, the EU Energy labels, the WEEE directive, the RoHS directive, REACH, the EU Ecolabel, the Nordic Swan, GPP and Voluntary Agreements. This is followed by a study of the household washing machine models available on the Danish market compared to the requirements set forward in the instruments regarding water and energy consumption. The definition of a household washing machine used in this study is:

> "Household washing machine' means an automatic washing machine, which cleans and rinses textiles using water which also has a spin extraction function and which is designed to be used principally for non-professional purposes" (EC, 2010: 22).

Since the first washing machines were put on the market in the 1950's, there has been an increase in the household ownership rate to above 90%. The market is now driven by substitution of old machines rather than first-time procurements, leading to a slight drop in sales (ISIS, 2007b). The performance of washing machines has improved over the years, and both water and energy consumption has decreased since the 1990's (see figure 1) (ISIS, 2007a).

Figure 1. Development in the average specific energy consumption per loading, from 1997 to 2005 (ISIS, 2007a: 168)



The purpose of a washing machine is to clean textiles mostly by using water, energy and detergents, and afterwards the textiles need to be dried. Besides, the impact from the washing machines there are also environmental impacts from the detergents and from the drying process. There is an interdependency between the different parameters and processes of washing: the amount of detergents affects the need for water to rinse the clothes properly and reduce risks of allergy; the amount of water affects the energy needed to heat the water; wash duration, spinning speed and drying also affects the need for energy; the need for drying efficiency is connected to local climate and/or availability of tumble drier.

Additionally, consumer behavior is relevant to consider, because the increase in energy efficiency of washing machines experienced since the 1990's may be out-weighted by changes in consumer behavior. A study shows that an average Danish family washes more frequently than previously. This means that the clothes are less dirty and the machines are often not full during the wash. Further, there are problems with dosing the detergents properly. (elforsk, 2005) To gain the maximum energy savings from domestic washing these consumer behavior patterns needs to be taken into account, both through information to consumers, but should also be considered in requirements and criteria in the policy instruments.

3.1 The Instruments and their requirements to household washing machines

3.1.1 The Implementing Measures of the Eco-design Directive

Household washing machines were covered during the transitional period 2005–2008 in the first working plan (EC, 2008a). After the product group was included in the Working Plans, the background study for household washing machines, the EuP Preparatory Study (PS), was conducted and completed in December 2007. Subsequently the first Consultation Forum with the drawing up of the first working document was held in December 2008. In March 2010, an additional Consultation Forum was held before the Implementing Measures (IM) was adopted by the Regulatory Committee in May 2010 and finally became effective in December 2010 (eceee, no date). Thus the development of the IM for household washing machines lasted five years.

The requirements in the IM are divided into generic and specific requirements. The main environmental aspects considered as significant are energy and water consumption in the use stage, and therefore these parameters are the key ones to be addressed in the IM. The specific requirement concerns the energy and water use in the use stage and the washing efficiency. The requirements are applicable from December 1st 2011, and are further tightened from 1st December 2013. The requirements for energy consumption (the Minimum Efficiency Performance Standards, MEPS) are given in terms of an energy efficiency index EEI. The EEI is calculated as the weighted annual energy consumption of the household washing machine in question divided by the standard annual energy consumption of a household washing machine. The weighted annual energy consumption is based on a weighted average of the energy consumption of three different washing programmes (a standard 60 °C cotton programme at partial and full load and a standard 40 °C cotton programme at partial load) and the energy use for stand-by modes. The generic and specific requirements can be found in table 3–8 (EC, 2010).

In the IM the best available technology on the market at the time of the adoption of the IM is defined in terms of water and energy consumption, washing efficiency and airborne acoustical noise emissions during a standard 60 °C cotton program. The BAT levels are intended for benchmarking purposes. In appendix 1, the BATs are listed in relation to rated capacity (EC, 2010).

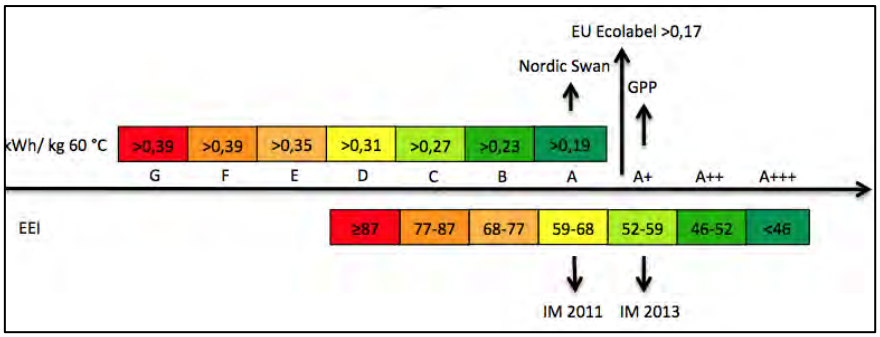
3.1.2 The EU Energy Label

The Energy Label was originally developed for household appliances and the Energy Label for household washing machines dates back to 1996. Apart from energy efficiency, the Energy Label sets requirements for the effectiveness of washing and spin-drying performance. These two requirements are as the energy efficiency divided into the classes A–G. Furthermore, the Energy Labelling scheme requires information on: the maximum spin speed, the total cotton capacity in kg; water consumption in litres; noise in washing and spinning cycles in dBa. The requirements for energy were until 2010 derived from the calculation of kWh/kg of washing. All the information was based on a 60 °C cotton wash with full load. However, the Directive was recast in September 2010 and this new delegated act emphasizes a significant potential for further reductions of energy consumption of household washing machines (EU, 2010b). An important change is the way in which the energy requirements are calculated. From now on the energy efficiency index from the IM in the Eco-design Directive is used to define the requirements in the EU energy label. Thus, instead of energy consumption for a standard 60 °C cotton wash with full load a weighted average of the annual energy consumption is now used to calculate the requirements.[3] This gives a more accurate picture of the actual annual energy consumption (EU, 2010b). However, this would also increase the price for testing and thereby market surviellance considerably.

In figure 2, the new and old classification of household washing machines in terms of energy can be found. The table illustrates how the value 0.19 kWh/kg was formerly the most ambitious one (green A), and how this value according to the energy labeling scale valid from 2011 would be ranked as the 4th best (the worst) – equivalent to the MEPS which came into force in 2011. From 2013 the MEPS will be in the A+ energy class, keeping the household washing machines not fulfilling the A+ energy requirements off the European market. The figure also indicates the criteria in the ecolabels and the GPP.

[3] For further explanation se section 3.1.1 The Implementing Measures of the Eco-design Directive.

Figure 2. Energy Efficiency Classes of the EU energy label (topmost) compared to the new Energy Efficiency Index values from 2010 (lowermost) (EU, 2009b) (Europe's Energy Portal, No date)



3.1.3 WEEE

The WEEE directive does not set specific requirements for household washing machines but instead divides the different electrical and electronic equipment into 10 different categories. In each category, recovery rate, rates for reuse and recycling as well as an overall collection target is set. Household washing machines belong to category 1 and the recovery rate and component, material and substance reuse and recycling rate can be found in table 1 (EU, 2003b). In December 2011, a new revision of the WEEE Directive was presented. In the new recast the European Commission has agreed on a mandatory collection target of 65% of the average weight of electrical and electronic equipment placed on the market during the last three years,4 and this goal is to be reached by all Member States in 2019. Thereby the collection target should reflect the Member State's consumption of electrical and electronic equipment (EC, 2011c). The Danish collection rate already exceeds 65% (DPA, 2012) of the marketed equipment, but the European average collection rate is only approximately 30% (EC, 2011c).

Table 1. Recovery and Reuse and recycling rate for large household appliances (EU, 2003b)

Average European Collection target (/person/year)	4 kg
Recovery rate by an average weight/appliance	80%
Reuse and recycling rate by an average weight/appliance	75%

[4] Or alternatively 85% of all weee generated.

In Denmark the Danish Producer Responsibility (DPA) is responsible for the administration of the requirements in WEEE. Producers and importers, who market electrical and electronic equipment in Denmark, shall be registered in the DPA-system. The producers and importers can choose to handle the obligations by individual producer responsibility or they can choose to join a producer's scheme and let them handle the waste – called the collective schemes. When a producer or importer chooses to handle their obligation individually the procedure is different depending on if the equipment is for private use or for professional use. In terms of household washing machines it is mostly for private use and the producers or importer are therefore covered by the same scheme as the collective schemes, namely the allocation scheme. The allocation scheme assigns each producer or importer a specific geographic collection site. Then the producer, importer or collective scheme is responsible for the collection and treatment of the electronic and electric waste handed in by the citizens at the assigned site. The sites are assigned to the producers according to their market share of the product categories. Thus when the producers or importers take individual producer responsibility in terms of equipment for private use, they are not responsible for their own products but for a random mixture of product handed in at the specific site. In terms of equipment for private use DPA recommends the producers to join the collective schemes (DPA, 2011). As a consequence 88 producers or importers of large household appliances has chosen to join the collective schemes in Denmark and only four has chosen to take individual producer responsibility in 2010 (DPA, 2010).

3.1.4 RoHS

The RoHS Directive requires that the use of the following substances in electrical and electronic equipment is replaced: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (brominated flame retardants), polybrominated diphenyl ethers (brominated flame retardants). The six substances are particularly problematic in the production and waste stage, but in some cases the substances can evaporate in the use stage and thereby cause problems (EU, 2003a). No specific requirements for household washing machines are set in the RoHS Directive, as the directive sets general requirements for all electronic and electrical equipment. It is the responsibility of the producer to ensure that imported parts do not contain substances covered by RoHS (EU, 2003a).

3.1.5 REACH

An important aspect of REACH is that the manufacturers have the responsibility of reporting the use of chemicals and documenting the safety of the use of the chemicals. This puts many new obligations on the industry, and there can be challenges regarding the import of parts for the production from countries outside the EU. No specific requirements apart from the general ones are applicable for washing machine producers (EC, 2006).

3.1.6 Voluntary Agreements

In the case of household washing machines there have been two Voluntary Agreements (VA) between EU and the CECED (the European Committee of Manufacturers of Domestic Equipment) with the aim of reducing energy consumption of household washing machines. The first one was negotiated in 1996, and here the CECED committed to reduce the energy consumption of household washing machines by 20% in the period 1994–2000. By 1999, the average specific energy consumption had fallen from 0.30 kWh/kg (class D) to 0.228 kWh/kg (class B). This is a reduction of 24%, and by the end of the agreement the energy efficiency classes G, F and E had been phased out. Because of the success of the first VA, CECED agreed to enter into a new VA running from 2002–2008. Here the "hard target" was to stop producing and importing household washing machines with energy efficiency class D. The "fleet target" was to achieve a European production of washing machines with an average energy consumption of 0.20 kWh/kg (between class B and A). Additionally, there was a number of "soft targets" regarding e.g. consumer information and collaboration with detergent producers on the promotion of energy saving detergents (IEA, 2010).

3.1.7 Ecolabels – The Nordic Swan and the EU Ecolabel

Household washing machines were among the first products to which criteria for the EU Ecolabel were developed in 1992. In 1999, a revision of the criteria was carried out, and the criteria from 1999 were extended a couple of times and remained valid until 2009 (EC, 2003). Since, 2009 no valid criteria for the EU Ecolabel have existed, and new criteria are currently under revision. The fact that no criteria exist means that no household washing machines are or can be awarded with the EU Ecolabel currently (Miljømærkning Danmark, no date b).

The criteria set for the Nordic Swan was first adopted in 1994. They were revised in 1996, 2001, 2004 and a revision of the criteria is currently

under development. The revision in 2001 implied a harmonization with the EU Ecolabel meaning that the two schemes became comparable. In 2004 tightening of the criteria for water consumption, the spin-drying efficiency, the wash performance and noise were adopted. The 2004 criteria have been continuously prolonged, and are the criteria set valid until the new criteria set is approved (Miljømærkning Danmark, 2012).

In the current revision process of the criteria for household washing machines, the criteria sets for household washing machines, spin dyers, refrigerators, freezers and dishwashers are combined to make the process more efficient (Fischer, 2011a). The new criteria set will therefore contain a list of criteria covering all five products and product specific criteria on especially the performance of the product. In the new revision of the criteria set, the criteria are harmonized with the Eco-design Directive and the EU Energy Label. Hence, the Energy Efficiency Index will be used to set criteria for energy, and it is very likely that the new energy criteria for washing machines will be A+++. Furthermore, the criteria set will allow for an additional rinsing program using more water and energy than allowed for a A+++ household washing machine. This should ensure that all detergents can be rinsed out of the cloth and thereby allergies and other can be avoided (Christensen, 2013). Currently only one household washing machine models certified with the Nordic Swan is available at the Danish market and the household washing machine is from the Swedish brand Asko Vølund. However, in total 22 household washing machine models are labelled with the Nordic Swan (Ecolabelling Sweden, 2012).

The criteria for both the EU Ecolabel and the Nordic Swan are as described under revision and new criteria set will soon be adopted. However as non of these new criteria have been adopted at the present time, the criteria from 1999 have been used for the EU Ecolabel and the criteria set from 2004 have been used for the Nordic Swan. In the table 3–8, the criteria are presented. Both of the ecolabelling schemes have harmonized the criteria with the old requirements from the Energy Label, and where it is relevant this is written in a parenthesis.

3.1.8 Green Public Procurement of household washing machines

Household washing machines is not a product group highly represented in public procurements, because the large scale needs of public institutions often call for industrial washing machines with large capacities or using laundry services. This is probably the reason why the Commission has not

set criteria for household washing machines. However, some use of household washing machines in small public institutions is common, and Danish recommendations for the procurements of household washing machines and white goods in general exist. In the following the recommendation from the three organisations; the Nordic Council of Minister (2009), the Danish Energy Saving Trust (Center for Energibesparelser) and SKI (National Procurement Ltd.) will be presented. These are selected because they are considered the most important in a Danish context.

Nordic Council of Ministers (2009) identifies the key environmental impacts as energy consumption and noise. The criteria take point of departure in the old Energy Label, and it is recommended that the household washing machines shall fulfil the criteria for EU energy class A, washing efficiency class A and spinning efficiency class B. Additionally the tender shall comply with the requirements of WEEE. For comprehensive criteria it is suggested to set the energy consumption to ≤0.17 kWh/kg and spin efficiency class A (see table 5 with comparison of criteria) (NCM, 2009)(Miljøministeriet, no date). These GPP criteria are from 2009, which is why the Nordic Cooperation of GPP has not used the new Energy Label requirements of the latest 2010 revision.

Other recommendations are provided by SKI, who informs public procurers about environmental considerations when purchasing white goods in general. They recommend specific attention be paid to energy and water consumption of household washing machines, but they do not make specific requirements to these aspects. SKI instead refers to the Danish Centre for Energy Conservation's guide on procurement from 2011, and here specific recommendations on the purchase of household washing machines can be found. They recommend A+ labelled machines regarding energy consumption, but they further specify the recommendations regarding water consumption (see table 2). The recommendations for energy consumption are more ambitious than the requirements in the IM from 2013, which they also ought to be given the fact that the IM are minimum requirements.

As mentioned, the Commission have not presented GPP criteria for household washing machines, but generally the Commission advices public procedures to take point of departure in the existing EU ecolabel criteria and the Energy label when procuring green (EC, 2008b). The Danish EPA also recommends taking point of departure in the ecolabel criteria for a given product when procuring green (gronindkobsportal.dk, no date).

Table 2. Recommendation for GPP by the Danish centre for energy savings Go'Energi (Go'Energi 2011)

Load capacity (kg)	Water consumption/wash (l)
3–5	39
6–7	44
8	56

3.2 Comparison between the Instruments' requirements

Both the MEPS and the Ecolabels (and to some degree the GPP) take point of departure in a life cycle perspective. The tables 3–8 contain the requirements to household washing machines from the Eco-design IM, the WEEE Directive, the RoHS Directive, the Nordic Swan, the EU Ecolabel, the GPP respectively, the Energy Label and the Voluntary Agreements 2002–2008 listed according to which life cycle phase they address.

The smilies in the tables illustrate our evaluation of which instrument puts forward the most ambitious requirements or criteria. The happy smilie represents the most ambitious, the sad smilie the least ambitious, the neutral smilie is the one in the middle, and where it is blank no requirements or criteria are set. The Energy label is blank as it only set information requirements. It should be emphasized that the smilies only illustrate how ambitious the requirements are compared to each other. It is not an evaluation of the level of ambition of the requirements and the criteria in general.

3.2.1 Materials

Resources

None of the instruments address the issue of resource extraction and material composition. However, in its outset the WEEE Directive strives to affect the design stage by introducing producer responsibility and thereby giving the producers an incentive to design for end-of-life. If fully incorporated, this could affect the producer's choice of materials. However, there are a number of obstacles for full implementation of the individual financial responsibility; the Nordic countries had along with a few other European countries[5] developed effective waste collection

[5] Denmark, Norway, Sweden, Belgium and the Netherlands (and Switzerland).

schemes before the WEEE Directive was adopted. These schemes were and still are primarily based on the collective schemes (ISIS, 2007a). The success of the collective schemes regards the recovery rates, which already exceed the requested 80%. In these schemes the producers pay an annual membership fee and a fixed fee depending on how much the producer sells. Furthermore, the producer is assigned a random mixture of electrical and electronic waste, because all the waste is collected at collection sites. Thereby, the producers do not get a financial benefit from designing products, which include design considerations on repair, possible upgrading, material compositions related to reuse, disassembly and recycling. The producers can benefit financially for reducing the weight of the products and thereby get a small incentive to reduce the amount of resources used. Yet, the part of the fee related to weight is small (0.01 DKK/kg) (DPA, 2011). Moreover, large household appliances – and thereby household washing machines – are an exception from this economic benefit, because it for this product group is legal to raise the final price of the product corresponding to the size of the fees (DPA, 2011). Thus the incentive to design for end-of-life is removed.

The EU Ecolabel sets requirements for the producers to take back the household washing machine free of charge. This is a seldom example of individual producer's responsibility and might in its outset prepare the grounds for a design for end-of-life. The criteria is from before the WEEE Directive was adopted and it is unknown how this criteria works in practice. Given the need for improved resource efficiency, there are strong indications that the instruments should further address the use of resources.

Chemicals and hazardous substances

The main legislative instrument approaching this stage is the RoHS as it forbids the use of six substances in electronic and electric appliances, with some exceptions. On a longer-term basis REACH can provide a basis for prohibiting certain harmful substances. Both ecolabelling schemes ban some chemical substances categorized by REACH, and they are both more ambitious than RoHS. The reason why the EU Ecolabel is assessed to be more ambitious is because it excludes more categories of chemicals than the Nordic Swan. There is a noticeable difference in the chemicals they each prohibit; the Nordic Swan only prohibits chemicals that are harmful to human health whereas the EU Ecolabel also prohibits chemicals harmful to the water environment and organisms living in water. This indicates differences in the Nordic and the European perceptions of which environmental issues are the most relevant to address. As only the voluntary instruments address

the use of chemicals not covered by RoHS, it is even more essential that the GPP criteria also include considerations on chemicals.

Table 3. Overview of the requirements and criteria regarding materials, resources and chemical substances in each of the 8 instruments. The smilies only indicates how ambitious the requirements are in comparison to each other

Requirements	Materials	
	Resources	Chemical Substances
Voluntary agreements 2002–2008		
GPP[6]		
EU Ecolabel (1999)		12 flame retardants are specified not to be used in plastic parts >25 g Flame retardants in the categories R45, R46, R50, R52, R53, R60, R61 (REACH) must not be used in plastic parts >25 g Plastic parts >25 g must be provided with permanent markings specifying the material 
The Nordic Swan (2004)		In plastic material no adding of the substances of RoHS and their compounds (except cables) Flame retardants in the categories R45, R46, R60, R61 (REACH) must not be used in plastic parts >25 g Plastic parts >25 g must be provided with permanent markings specifying the material 
RoHS (2003)		Restricts the use of Pb Hg Cd Cr6+ PBB PBDE 
WEEE (2003)		
Eco-design		
Energy label 2010		

[6] As described there exist a number of recommendations for GPP criteria, and in this report it is chosen to present the ones most commonly referred to in guidelines on GPP i.e. the recommendations from the Nordic Council of Ministers (NCM, 2009) and the Danish Saving Energy Trust (GO' Energi, 2011). Another option could be to use the Ecolabelling criteria for GPP, and in that case the GPP criteria would off course be equal to the Ecolabelling criteria.

3.2.2 Production

The Nordic Swan addresses the production stage and here the criteria concerns health and safety issues and the working environment. It is noticeable that neither of the policy instruments set requirements for the environmental impacts from the production, since the production is assessed in the EuP Preparatory Study to be the second most environmentally harmful life cycle stage for some environmental parameters (ISIS, 2007b). Since the production stage is the second most relevant stage this ought to be addressed if the policy instruments are to live up to their life cycle approach.

For GPP there are possibilities to include considerations on the production stage in the technical specifications on the basis of some of the aspects of EMAS or ISO 14001, but it is not legal to specifically make requirements to have an environmental management system. Suppliers can, however, use their certification as easy documentation for complying with the technical specification regarding environmental management.

Table 4. Overview of the requirements and criteria regarding production, packing and transport in each of the 8 instruments. The smilies only indicates how ambitious the requirements are in comparison to each other

Requirements	Production	Packing	Transport
Voluntary agreements 2002–2008			
GPP	There are possibilities to require certain qualifications included in environmental management systems (general for GPP) 		
EU Ecolabel (1999)			
The Nordic Swan (2004)	The manufacturer must follow the legislation in force in each country of manufacture regarding recycling systems for products and packaging, safety, the working environment, occupational safety and conditions/concessions specific to production facilities 	Follow legislation on recycling of packaging 	
RoHS (2003)			
WEEE (2003)			
Eco-design (2010)			
Energy label (2010)			

3.2.3 Distribution and transport

This life cycle stage is not addressed by any of the instruments. As with the lack of requirements for the production this is noteworthy because transportation can have great environmental impact especially regarding emissions to the air. There might be possibilities to encourage more environmentally friendly means of transportation though, especially through the voluntary instruments like the ecolabels. A study on transportation has recently been conducted with the purpose of making some general guidelines on the inclusion of transportation in criteria for the Nordic Swan (Fischer, 2011a).

3.2.4 The use-stage

The use stage is generally the most addressed stage in all the policy instruments, but it is also the stage having most environmental impacts according to the LCA in the EuP Preparatory Study. In relation to the requirements for water and energy consumption, the MEPS and one of the GPP guidelines put forward the strictest requirements followed by the EU Ecolabel, and the Nordic Swan has the softest requirements. The Voluntary Agreements primarily set requirements for the energy consumption including both hard targets phasing out the worst products and more soft targets promoting more energy efficient technologies. Thus the Voluntary Agreements has been marked with neutral smilie.

The MEPS additionally has a requirement for a 20 °C programme and a clearly identifiable program selection or display. In section 3.3 the requirements for energy and water consumption are further elaborated. However the requirements in the use stage include other parameters than energy and water consumption. All the instruments with a life cycle perspective (Eco-design/IM, the ecolabels and GPP) include requirements for the washing performance. These instruments also include consumer information, which are assessed to be very similar e.g. information of dosing detergents. Hence no differentiation between the six schemes has been applied to the table. In relation to health issues in the use stage, the Nordic Swan set forward most requirements, including requirements for rinsing performance and noise, whereas the EU Ecolabel only set requirements for noise and the IM does not set up any apart from washing efficiency, which is not specifically related to health issues. It can be questioned why there are no requirements to noise in the IM, since one of the principles of the Eco-design Directive is that environmental performance must not be on the expense of quality. Noise is from a consumer perspective an important aspect of the quality of the machine, hence it should be ensured

that noise levels are retained low. However, noise is included in the indentification of best available technology in the IM.

Table 5. Overview of the requirements and criteria to the use stage, regarding energy and water consumption in each of the 8 instruments. The smilies only indicates how ambitious the requirements are in comparison to each other

Requirements	Use	
	Energy consumption	**Water consumption**
Voluntary agreements 2002–2008	"Hard" target Stop producing and importing WM with energy efficiency class D "Fleet" target Contribute to an average energy consumption for a household WM on 0.20 kWh/kg in 2008 "Soft" targets Support a new quality mark that promotes WM at a level of 0.17 kWh/kg Support rebate schemes that introduces more efficient WM Co-operate with the detergent industry to save energy Push for the development of new standards that includes the change in consumer behaviour 	
GPP	A or 0.17 kWh/kg (NCM) A, A+ (GO'Energi) 	39 l/cycle (3–5 kg machines), 44 l (6–7 kg), 56 l (8 kg) (GO`Energi) 
EU Ecolabel (1999)	For the standard 60 °C cotton programme: ≤0.17 kWh/kg (between A and A+) 	≤12 l/kg of washed load 
The Nordic Swan (2004)	For the standard 60 °C cotton programme: 0.19 kWh/kg (A) The mean value of four different operating modes: 0.23 kWh/kg 	<16 l/kg of washed load 
RoHS (2003)		
WEEE (2003)		
Eco-design (2010)	Energy Efficiency Index (EEI) EEI <68 in 2011 (A) EEI <59 in 2013 (A+) 	From 2011: W_t </=5 · c + 35 From 2013: W_t </=5 · $c_{1/2}$+ 35 
Energy label (2010)	A^{+++} EEI < 46 A^{++} 46 ≤ EEI 52 A^{+} 52 ≤ EEI 59 A 59 ≤ EEI 68 B 68 ≤ EEI 77 C 77 ≤ EEI 87 D EEI ≥ 87	

Table 6. Overview of the requirements and criteria to the use stage, regarding design for use and noise. The smilies only indicates how ambitious the requirements are in comparison to each other

Requirements	Design for use	Noise
Voluntary agreements 2002–2008		
GPP	Availability of 20 °C programme Consideration of capacity needs Technologies such as connection to hot water tab, or water heated by renewable energy (GO´Energi) 	
EU Ecolabel (1999)		$<L_{Wad}$ 56 dB (A) during washing $<L_{WAd}$ 76 dB (A) during spinning 
The Nordic Swan (2004)		$<L_{Wad}$ 56 dB (A) during washing $<L_{WAd}$ 76 dB (A) during spinning 
RoHS 2003		
WEEE		
Eco-design (2010)	20 °C programme must be available From December 2012 the washing programmes for standard cotton 60 °C and 40 °C shall be clearly identifiable on the program selection or display 	
Energy label (2010)		Information hereon must be provided on the label

Table 7. Overview of the requirements and criteria to the use stage, regarding consumer information in each of the 8 instruments. The smilies only indicates how ambitious the requirements are in comparison to each other

	Use
Requirements	**Consumer information**
Voluntary agreements 2002–2008	"Soft" targets Inform about the advantages of high spin speed when tumble-drying is preferred Give information on the energy efficient use of the WM 
GPP	
EU Ecolabel (1999)	Descriptions of correct use with regard to environmental impact and recommendations for the optimum use of energy, water and detergent when using the machine 
The Nordic Swan (2004)	Instructions that include descriptions of correct use with regard to environmental impact and recommendations for the optimum use of energy, water and detergent when using the WM The WM must be clearly marked so that suitable settings can be selected for different materials and washing instructions All programmes must be clearly marked on the WM 
RoHS 2003	
WEEE	
Eco-design (2010)	The manufacturer shall provide information to the consumer on how to use the WM including recommendations on the use of programmes and detergents at various temperatures. Also the fact that the actual water temperature is not always as the one indicated, must be made clear to the consumer 
Energy label (2010)	Information should be provided on: Maximum spin speed Total cotton capacity(kg) Weighted annual energy consumption Weighted annual water consumption Noise in washing and spinning cycles (dBA)

3.2.5 End-of-life

The main instrument approaching the end-of-life stage is the WEEE Directive by setting requirements for collection, recovery, recycling and reuse of electrical and electronic appliances. RoHS does not set direct requirements for the end-of-life, but the requirements of RoHS have an effect because of the restriction of the use of the six substances, which would have been especially harmful in the waste stage. There are no requirements for reuse or recycling in the MEPS. The Nordic Swan and the EU Ecolabel have quite similar criteria for the end-of-life stage, but a difference is that the EU Ecolabel sets requirements for the take-back

free of charge by the manufacturer. Both schemes lean on to the standards set by the WEEE directive in 2003, which is 75% recycling or reuse of components, materials and substances (EU, 2003b). This is most likely due to the lack of up-dates of the ecolabelling criteria.

The criteria set in the ecolabelling schemes do not distinguish themselves from legislation, and hence it must be questioned what the purpose is of having criteria that are equal to the legislation. Further, initiatives to prolong the durability of the product might be possible by designing the washing machines in a way that not only secures the availability of spare parts but also makes the machines easy and cheap to repair.

Table 8. Overview of the requirements and criteria to the end-of-life, regarding life time extension, reuse, recycling and dismantling in each of the 8 instruments. The smilies only indicates how ambitious the requirements are in comparison to each other

Require-ments	End-of-life		
	Lifetime extension	**Reuse and recycling**	**Dismantling**
Voluntary agreements 2002–2008			
GPP		Follow the requirements in WEEE (NCM) 	
EU Ecolabel (1999)	2 years without faults Availability of spare parts for 12 years 	The producer should take back the machine free of charge 	Easy disas-sembly 
The Nordic Swan (2004)	2 years without faults Availability of spare parts for 10 years 	At least 75% by weight of the compo-nents, materials and substances can be reused or recycled in accordance with the WEEE directive 	Easy disassem-bly 
RoHS (2003)			
WEEE (2003)		Recovery rate by an average weight/appliance on 80% and a component, material and substance reuse and recycling rate by an average weight/appliance on 75% Producer financial responsible 	
Eco-design (2010)			
Energy label (2010)			

3.3 A comparative study of household washing machines on the Danish market in 2011

The intention of this part of the study is to examine how ambitious the environmental requirements are in the Ecolabels, the GPP and in the IM of the Eco-design Directive (applicable from December 2011 and December 2013) in relation to the household washing machines on the Danish market in 2011. In relation to the requirement from GPP the recommendations provided by the Danish Energy Saving Trust was used, as they set the strictest requirements. This is done, by comparing the washing machine models available on the Danish market with the requirements set forward in the Ecolabels, the GPP and the Eco-design IM. The parameters used to make the comparison are energy and water consumption in the use stage. The reason for this is that energy and water consumption is quantifiable and directly comparable (as opposed to e.g. requirements for consumer information).

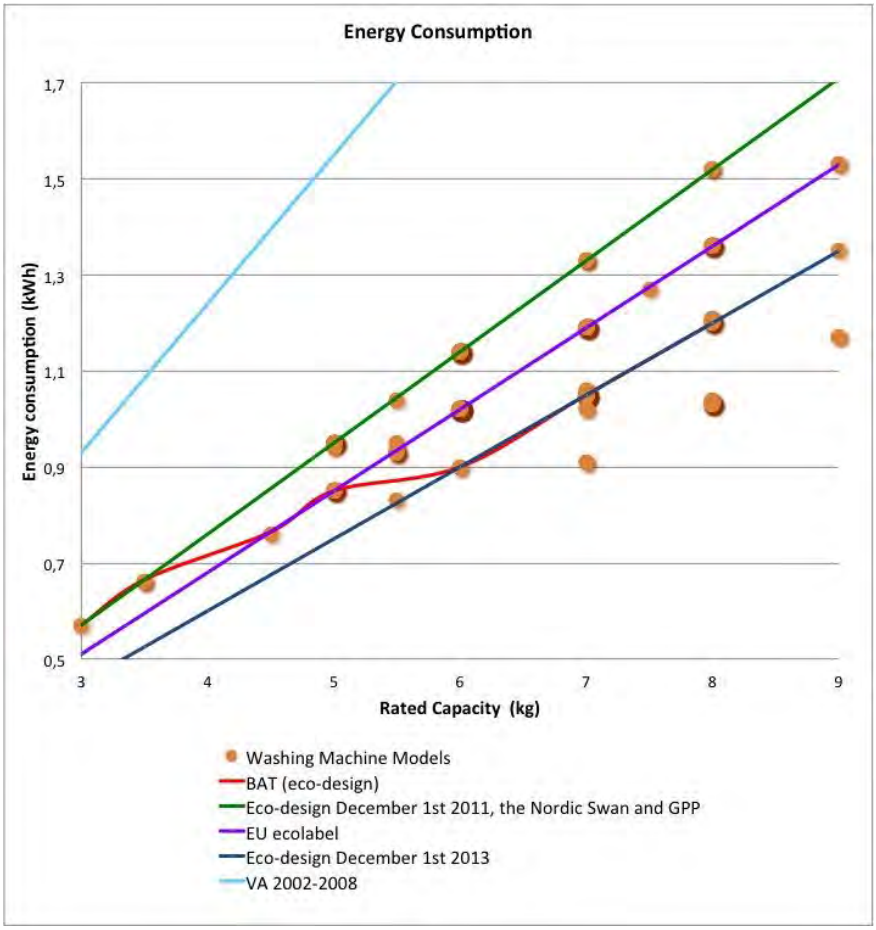
The study includes in total 327 household washing machine models.[7] Two of the 327 household washing machines are labelled with the Nordic Swan, and these are from the Swedish brand Asko-Vølund. The study includes 27 different producers, five of these being Nordic. The study includes a broad cross-section of the producers on the European market. The household washing machine models' rated capacity is between 3 kg and 11 kg.

3.3.1 Energy consumption

The requirements from the ecolabelling schemes, the requirements from the Eco-design Directive and the energy consumption for the household washing machines available on the market are illustrated in figure 3 according to the rated capacity, for further explanation of the requirements and the conversion of the requirements see appendix 2.

[7] Information on the performance of the household washing machines on the Danish market is acquired from the homepage www.hvidevarepriser.dk (GO'Energi, 2011b). It includes all the washing machine models, with a Danish importer May 2011.

Figure 3. Energy Consumption



The study of the energy consumption of the washing machines on the Danish market in 2011 showed that:

- 100% of the household washing machines models on the Danish market comply with the criteria for energy in the Nordic Swan (A) and the MEPS from 2011(A)
- 80% of the household washing machine models comply with the criteria for energy in the EU Ecolabel (a bit better than A)

- 34% of the household washing machines models comply with the energy level from BAT[8] from Eco-design IM
- 27% of the household washing machine models on the Danish market comply with the requirements in the MEPS coming into force in 2013[9] (A+) and with the GPP recommendations (A^+)

The MEPS from 2011 does not remove the worst performing models from the Danish market, actually they do not remove any household washing machine models at all. There is no indication that the Danish market performs better than the rest of the European market – on the contrary the energy efficiency of machines in EU generally tends to be better than in Denmark (IEA, 2010). Hence the requirements in the Eco-design IM are not ambitious at all. Nevertheless the figures indicate that the MEPS valid from December 2013 are quite ambitious.[10] The purpose of the Eco-design Directive, which is to cut out the worst performing products from the market, does seem to be fulfilled since a large share of the household washing machine models will be removed from the market, when the second step of the MEPS come into force in 2013.

As mentioned all the household washing machine models complied with the energy criteria in the Nordic Swan and 80% comply with the criteria in the EU Ecolabel, so in terms of energy the Nordic Swan and the EU Ecolabel far from represent the 10% best performing household washing machine models on the Danish market. The recommendations in GPP for energy consumption are "A" or "A+" according to the Energy label. As mentioned "A" corresponds to the MEPS from 2011 and "A+" corresponds to the MEPS from 2013. Thus the recommendations in GPP equal the law minimum requirement from 2011 and 2013. This cannot be considered as sufficiently ambitious, additionally in the light of all machines being A-rated. If the GPP criteria are to be ambitious "A++" should be required. All models comply with the "hard" targets in the Voluntary Agreement 2002–2008 as all household washing machine models with energy efficiency class D have been phased out of the Danish market. However the Voluntary Agreement 2002–2008 also included

[8] It might seem a bit odd that the energy level from BAT are lower than the MEPS valid from December 2013, however this is because the BAT level represents the best available technology at the time where the PS was conducted (2005). This also highlights that the benchmarking in the Eco-design is not sufficiently good.
[9] It is important to keep in mind that the requirements from 2013 are only an estimate.
[10] This is in accordance with the evaluation of the Eco-design Directive; the purpose of step 1 is primarily to give the producers time to adjust to the system, whereas step 2 tightens the environmental performance requirements.

a fleet target of the industry to achieve a European production weighted average of 0.20 kWh/kg (between energy classes B and A) in 2008. This indicates that there could have been possibilities for establishing a new VA, since the MEPS 2011 are only slightly stricter than the fleet targets of the VA three years earlier. This has however not been assessed further in the present study.

As the comparative study shows the MEPS are stricter than the criteria in the Ecolabelling schemes. A consequence of the new MEPS valid from 2013 is that only Energy labelled "A+", "A++" and "A+++" will be allowed access to the internal EU market. This also implies that the products fulfilling only the Nordic Swan on its current basis will be excluded from the European market. The EU Ecolabel criterion for energy consumption is 0.17 kWh/kg, which lies between "A" and "A+" rating of the Energy label. Hence, it does not comply with the MEPS in the Ecodesign which come into force from 2013. Both ecolabel schemes are outdated and do really have a challenge of updating the criteria now.

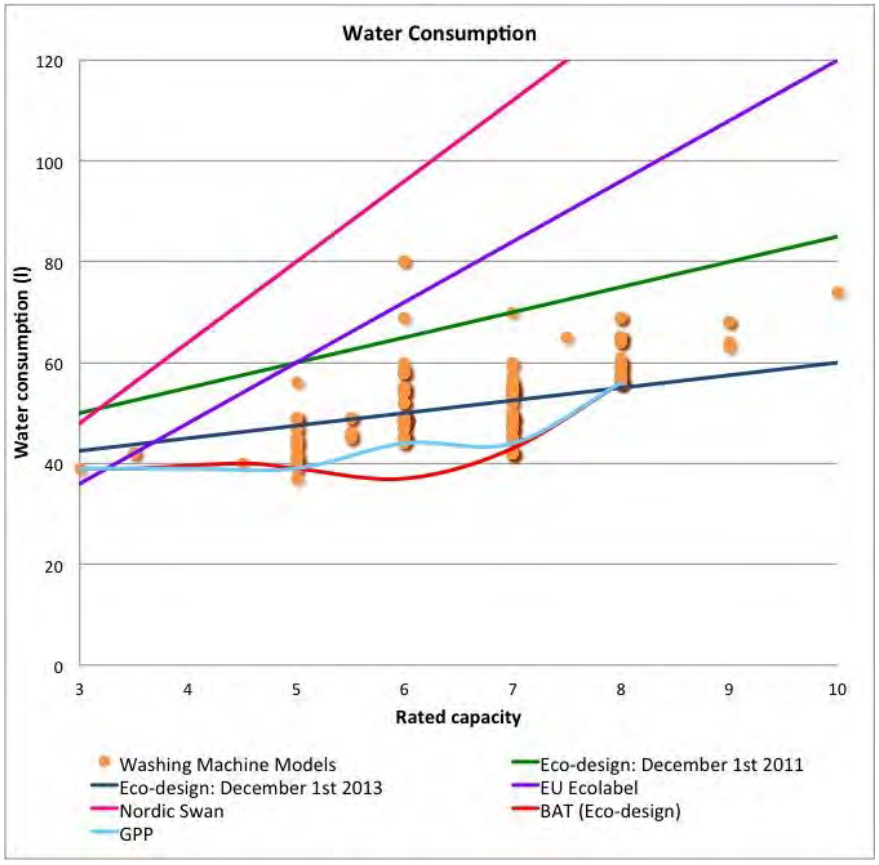
Currently, the requirements for water and energy in the implementing measures for washing machines apply a linear relationship between energy and water consumption and the capacity of the washing machines. Hence, the larger capacity of the household washing machine the larger energy and water consumption is allowed. If however applying a logarithmic scale there would be set stricter requirements to machines with a larger capacity. For other product groups (e.g. domestic lighting) a logarithmic relationship has already been applied in order to set stricter requirements for larger appliances, as these by often consume more energy. An argument for applying a logarithmic relationship in the requirements to washing machines in the Energy Label could also be to give consumers an incentive to purchase smaller machines. Users often do not fill the machine (ISIS, 2007), and hence smaller machines would in many cases be sufficient to meet the needs of the users. A logarithmic scale would have the effect that high capacity washing machines would be awarded with lower energy efficiency class than smaller machined. This can potentially discourage consumers to buy bigger machines thus preventing a possible rebound effect of the energy efficiency improvements.

As a final remark, the measurement and calculation methods for energy consumption used by the different instruments should be harmonized to improve the synergies between the instruments. The new measurement of the MEPS and the Energy Label is better than the old one, which is used by the Nordic Swan, because it includes both 60 °C and 40 °C programmes and standby, thus providing a truer picture of the actual energy consumption than measurements solely using the 60 °C programme.

3.3.2 Water consumption

The requirements from the ecolabelling schemes, the GPP, the MEPS from the Eco-design Directive and the water consumption for the washing machines available on the market are illustrated in figure 4 according to the rated capacity, for further explanation of the requirements see appendix 2.

Figure 4. Water consumption



The study of the water consumption of the washing machine models on the Danish market in 2011 showed that:

- 100% of the household washing machines on the Danish market comply with the criteria in the Nordic Swan.
- 99% of the household washing machines on the Danish market comply with the criteria in EU Ecolabel.
- 99% of the household washing machines comply with the MEPS applicable from December 2011.

- 73% of the household washing machines comply with the MEPS applicable from December 2013.
- 27% of the household washing machines comply with the recommendation made for GPP by in the Danish centre for Energy Conservation, *Go'Energi.*
- 27% of the household washing machines comply with the water level in BAT from Eco-design IM.

As the graphs in the figure indicate the household washing machine models' actual water consumption is considerably lower than most of the criteria and requirements, with perhaps the exception of the GPP recommendations and the MEPS applicable from 2013. That such a high number of household washing machines already complies with the criteria set forward in the different voluntary schemes and legal requirements indicate that both the criteria and requirements are not ambitious. It could be questioned if the requirements will result in any reduction in water consumption before December 2013. However the recommendation for GPP made by the Danish Energy Saving Trust seems to be ambitious as only 27% of the household washing machine models comply with this level of water consumption. 27% of the machines perform better than BAT. BAT ought to describe the best available technology, and these results illuminates that the BAT-levels from 2005 used in the Eco-design IM are too old. The requirement in the MEPS applicable from 2013 seems to be quite ambitious as they remove almost 30% of the worst performing washing machine models in terms of water consumption.

The study also showed that, as for energy consumption, the MEPS are stricter in comparison to the Ecolabels. The Swan allows 16 l/kg and the EU Ecolabel allows up to 12 l/kg, and neither of these will be able to comply with the requirements in the MEPS from December 2011 for all rated capacities. During the revision of the EU Ecolabel it was agreed to revise the criteria to be in line with the MEPS (Fischer, 2011b), which seems odd considering ecolabels ought to indicate best in class.

The reason for the allowed high water consumption in the Nordic Swan can be related to health considerations. In the Nordic Swan both environmental, health and quality issues is emphasised. In the old criteria set it has been assessed that to retain the quality of the wash (i.e. rinse all detergents out of it and thereby leave the clean clothes with a minimal allergy risk) a high amount of water is needed (Fischer and Hansen, 2011). This consideration is also connected to the differences in rinsing performance requirements. The main difference between the EU

Ecolabel and the Nordic Swan is the requirement to rinsing performance (ISIS, 2007a: 62). Natural geographical differences may play a role in the differences for water consumption criteria; the dry winters in the North may worsen allergic reaction to residues in the cloth, leaving the need for thorough rinsing higher than in the Southern parts of Europe. Moreover the Nordic region do not face the same gravity of water scarcity as the southern parts of Europe, and this may affect the perceived importance of reducing water consumption. According to Fischer (2011), the revision of the criteria will include discussion of the water consumption and the test methods, and as a minimum it will have to live up to the Eco-design Directive. One of the strengths of the Nordic Swan is exactly their holistic approach and Fischer (2011) therefore emphasizes that in the new revision they will have to find a balance between environment and health considerations. She states that there may be ways to solve the problem of rinsing performance and water consumption e.g. by securing the right dose of detergents, and also challenge the producers to think in innovative solutions (Fischer, 2011a).

The water consumption has despite the unambitious ecolabelling criteria decreased since the 1990's. The water consumption is linked to the energy consumption in the way that, the more water used, the more water needs to be heated, and then more energy is needed. So in order for the producers to develop more energy efficient household washing machines they have had to reduce the amount of water consumed during a cycle. Furthermore, information about the water consumption is also applied to the Energy Label, and as for the energy consumption the consumer has a financial interest in buying a machine with low water consumption. However, the consumers also have an interest regarding health issues (allergy), which may actually be what has been driving the sales of the Nordic Swan labelled machines. These machines have higher water consumption due to the assumption that this gives higher rinsing performance.

3.3.3 Sales of washing machines in Denmark according to energy class

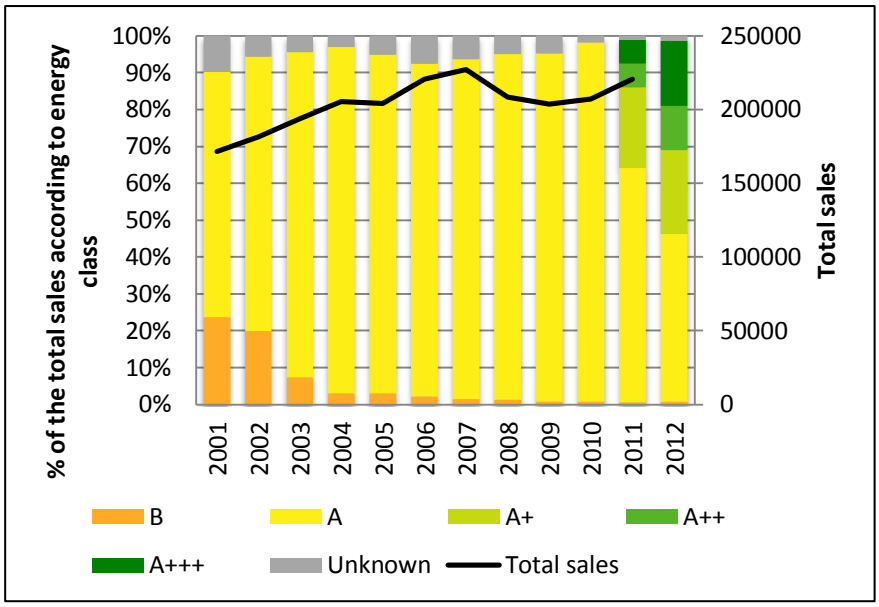
In the previous section the household washing machine models available on the Danish market have been compared to the requirements in the different instruments. In this section the actual sales numbers of household washing machines on the Danish market will be accounted for according to their energy class. Figure 5 shows the actual sales numbers of household washing machines in Denmark and the percentage distribution of the sales according to energy class, from 2001 to May 2012. It

clearly shows that the sales of household washing machines with energy class B has gone down since 2001, from 23.6% of the total sales in 2001 to 0.8% of the total sales in 2011. Thus the sales of energy class B household washing machines is almost out phased of the Danish market, however a small but somewhat constant number of household washing machines with energy class B is still sold each month. It is conflicting with the study of the household washing machine models available on the Danish market in 2011 (section 3.3), according to this study all models for sale on the Danish market were energy class A. Thus, as the amount of energy class B sold in 2010 was so small it is not considered to change the main conclusions of the study.

The sales of household washing machines with energy class A have gone up from 67% of the total sales in 2001, to 98% of the total sales in 2010. The sales of household washing machines with energy class B have gone down in the same period from 24% in 2001 to below 1% in 2010, hence are now almost phased out of the market. The sales of household washing machines with energy class A has gone down in 2011 and 2012 compared to 2010, mostly because of the adoption of the new energy classes A^{+++}, A^{++} and A^{+} December 2010. The sales of the new energy classes have increased steadily during 2011 and 2012. A+ energy labelled household washing machines constituted 22% of the total sales in 2011, and in 2012 (until November) it increased to 24% of the total sales. A++ energy labelled household washing machines constituted 6% of the total sales in 2011, and in 2012 (until November) it increased to 12% of the total sales. A+++ energy labelled household washing machines constituted 6% of the total sales in 2011, and it increased to 18% in 2012 (until November) of the total sales. However, it should be mentioned that some of the product, now labelled with energy label A^{+++}, A^{++} and A^{+}, might have been on the market before 2011, but labelled with energy class A. This indicates that it has been easy for the industry to produce A rated washing machines, and this stresses that the Energy Label should have been revised earlier in order to have the intended effect of pulling the industry by consumer demands.

Furthermore, the VAs running from 2002 to 2008 had the hard target of removing all HWM with energy efficiency class D, and a fleet target of achieving a European energy efficiency average between B and A. According to the Danish sales figures the VAs were thus very unambitious, if not to say irrelevant, since these targets were already achieved before the agreement was engaged. According to the IEA (2010), however, the two VAs contributed significantly to the phasing out of HWM performing worse than energy efficiency class B at the European market.

Figure 5. The total sales of washing machines in Denmark 2001 to 2011 (the black line) and the percentage distribution of the total sales according to energy class (bar chart) from 2001 to November 2012(FEHA, 2012)



3.4 Best Available Technologies (BAT)

Common to all the instruments is that the requirements and criteria are rather specific and not targeted towards the identified changes in consumer behaviours and needs. In none of the instruments, the development of new technologies is emphasised, though the EuP Preparatory Study identifies a long list of different technological options and future technological development to improve the washing machines. These technological options includes different measures for optimising the motor, unbalance control, analogue water sensor, temperature control sensor, rinsing phase optimisation, high temperature (77 °C) intake, boiling water or steam cycle, weight sensors, sophisticated electronic control, increased time control, LCD with actual load display, increased spin speed, internet connectivity, voice controlled appliance, mixed appliance and alternative washing systems (ISIC, 2007c, 493).

A look at the individual washing machine brands on the market also point to the fact that the industry is interested in developing innovative solutions. AEG has identified additional technologies like the use of smart grid, automatic dosing of detergents, and there is even a washing machine developed, which uses as little as a cup of water per wash cycle

(AEA, 2009). Thus there are many examples of these innovative solutions, but they are never connected to the MEPS or the criteria of the ecolabels. Both instruments could set more generic requirements to the use of new technologies that take point of departure in some of the identified challenges regarding consumer behaviour.

The tendency to not wash with full load and to overdose the detergents could be accommodated with a load sensor and an automatic dosage system. This would reduce energy and water consumption as well as chemicals released to the environment, due to the interdependence between these parameters. The tendency could also be met through the encouragement of the production of washing machines with lower load capacities to meet the needs of modern families. For the Nordic Swan to retain their focus on allergy risk reduction, technologies like steam could be applied for killing dust mites without increasing the need for further water or energy use. Many of the technologies are relatively simple and could most likely be implemented in household washing machines today.

3.5 Sub-conclusion

The life cycle perspective is the overall aim of the Eco-design Directive, but when analysing the IM for household washing machines it becomes apparent that the instrument primarily addresses the use stage i.e. energy and water efficiency improvements. This is problematic in the light of the need for resource efficiency improvements. WEEE and RoHS set requirements regarding this issue but not in a way that support eco-design. The voluntary instruments cover the life cycle impacts from household washing machines better than the legislative instruments, but because of the delays in revision of criteria the ecolabels are very un-ambitious.

As mentioned previously, the purpose of the ecolabels is to label the 10–20% best environmentally performing products on the market. However, this study of household washing machine models available on the Danish market has shown that this is far from the case, when it comes to water and energy consumption. Actually the models labelled with the Nordic Swan are from December 2011 excluded from the internal EU market because of the very high water consumptions.

Of the 327 household washing machine models included in the study the two models labelled with the Nordic Swan actually had the second and third highest water consumption. There are two explanations to the problem with the unambitious ecolabelling criteria; firstly the prolonging of the ecolabelling criteria instead of real updates; secondly the Nor-

dic Swan gives high priority to health issues and hence finds it important that the detergents are removed from the clothes, which increases water consumption. There are differences in perception of which environmental issues are the most important in the Nordic countries compared to the rest of EU. The Nordic Swan generally has a stronger focus on human health and well-being. This is seen in criteria regarding working environment, the choice of chemicals prohibited and in the focus on rinsing performance. Water consumption is most likely not as high on the Nordic agenda as in EU due to different levels of water availability. Higher water consumption does by the way also mean higher energy consumption in a life cycle perspective, since energy is used for pumping the clean water and the wastewater.

Different institutions and organisations offer different recommendations for GPP and some are more ambitious than others. However, these recommendations do not reflect the life cycle perspective and do not seem to be well structured. The fact that the recommendations from the Nordic Council of Ministers were outdated already a year after being published points towards inefficiencies in the current way of guiding public authorities on GPP. In general, the ecolabels and the GPP have not affected the market for household washing machines significantly in terms of water and energy consumption, and the improvements made within this field can more likely be ascribed to the mandatory instrument namely the Energy Label and to the Voluntary Agreements.

4. The Eco-design Directive's role in a broader policy package

In this chapter the role of the Eco-design Directive in relation to the legislative and voluntary instruments will be discussed on basis of the results found in the case study.

4.1 The Eco-design Directive's life cycle perspective

The strength of the Eco-design Directive is that it can provide a way to integrate environmental considerations already in the product design stage. The Eco-design Directive has in its outset a life cycle approach to the improvement of the environmental performance of products. However the case study of household washing machines has shown that the IM primarily address the use stage. Hence energy and water consumption in the use stage are the issues mainly addressed, and issues such as resource efficiency in the design stage in the choice of materials, resources used for production and transportation, and the disposal of materials in the end-of-life stage are not addressed. The emphasis on the use stage i.e. energy consumption is a general tendency in the IM of the Eco-design Directive for all electrical and electronic equipment (Dirckinck-Holmfeld, 2011; Huulgaard & Remmen, 2012). The narrow focus is problematic because the Directive then fails to utilize its potential to incorporate life cycle considerations. The IM sets no requirements to include life cycle thinking in the design stage, so the manufacturers are not encouraged to learn more about the concept of eco-design and life cycle thinking. Hence resource efficiency is not addressed regarding other resources than energy and water, because these are the two aspects with specific requirements.

The focus on the use stage may be a result of the LCA method applied in the EuP Preparatory Study, as it has a tendency to emphasize the use stage due to assumptions on the durability of the product (15 years). The longer the use stage is assumed to be, the more important will the environmental

impacts from the use stage become in a LCA. Whether the duration of the use stage of a washing machine is set to 5, 10 or 15 years will have consequences on the significance of the life cycle stages in the assessment.

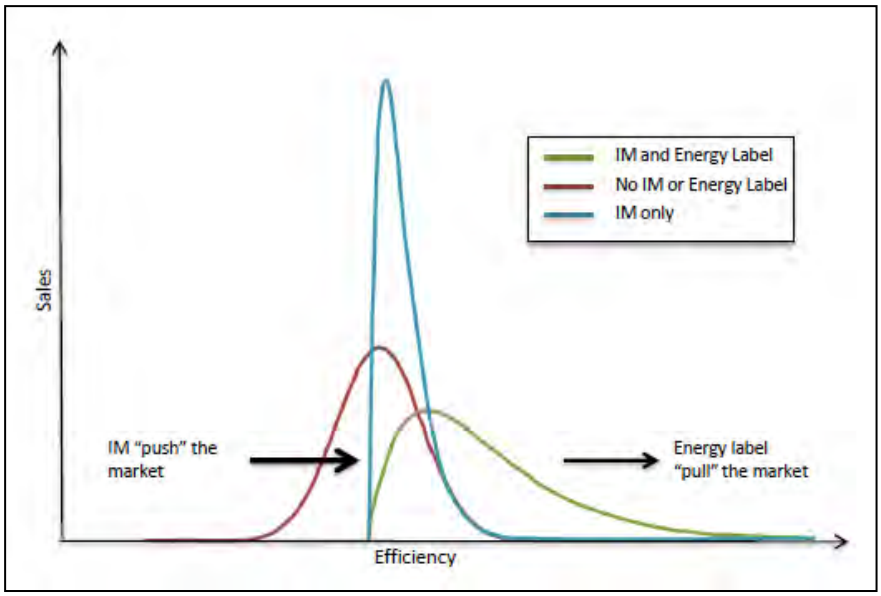
In a previous study by Mälkki *et al.* (2010) a similar tendency is found. The study assessed how energy and other environmental aspects were included in the product specific EuP Preparatory Study studies for four product groups: solid fuel small combustion instillation, laundry driers, vacuum cleaners and complex set-top boxes. The study concluded that in the EuP Preparatory Study for the four product categories the use phase dominated many impacts, because of the characteristics of the products' use patterns. However, it also concluded that the overall aim of the Eco-design Directive would not be realized if reducing energy and improving energy efficiency were the only targets included.

Other reasons for the focus on the use stage could be to reap the benefits of the low-hanging fruits. It is relatively easy to measure energy use and thus also possible to set requirements for energy consumption. Another determining reason for the focus mainly being on the use stage can be linked to that the Eco-design Directive has mainly been under the responsibility of DG energy and DG industry (EC, 2010b). This has been a contributing factor to place the responsibility of the implementation of the Eco-design Directive in Denmark within the jurisdiction of Danish Ministry of Energy (Dirckinck-Holmfeld, 2011). DG Energy as responsible is understandable as the scope of the Eco-design Directive originally was energy-using product – now expanded to energy-related product. Since the interests of these administrative entities mainly regard energy, then energy might be represented more strongly than other environmental issues. Another important factor for the emphasis on the use stage could be a confidence in the WEEE and RoHS Directives to be responsible of addressing environmental problems from other life cycle stages. This will be discussed further below.

4.2 The instruments and their synergies

The nine policy instruments are to supplement each other and the mechanisms they rely on to support sustainable consumption and production are different. Together the instruments encompass both the normative governmental approach to remove the worst performing products from the market, and the voluntary approach which uses the consumer demands to pull the manufacturers towards greener products.

Figure 6. The intended synergy between the Eco-design Directive and the Energy Label. The Energy Label has a pulling effect and the Eco-design Directive has a pushing effect on the industry (based on eceee, 2011)



However, through the case study of household washing machines we found that this interaction does not work in practice as intended.

The IM in the Eco-design Directive are to remove the worst performing products on the EU internal market and thereby push the manufacturers in a more environmentally sound direction. This mechanism was confirmed by the case study of household washing machines; the requirements applicable from 2013 will actually remove the worst performing products. However, the IM do not present any requirements beyond 2013. Within the near future the IM will have to be revised, and as described the process of developing IM has been rather time consuming. Hence, stepwise tightening of demands in IM over a longer period would reduce the need for frequent up-dates, and also provide the industry with incentives to invest in eco-innovations to meet future demands. This concept could apply to specific energy and water minimum standards but also to more generic requirements addressing material and resource aspects.

In the following section it will be examined on the basis of the case study, if the separate instruments function as intended as well as the connection to the Eco-design Directive.

4.2.1 Mandatory instruments

EU Energy Label

EU Energy Label has had a positive impact on the energy efficiency of washing machines. The EU Energy Label has contributed to the reduction of the energy use of household washing machines through mechanisms building on market forces. Consumers have had a direct incentive to demand energy and water efficient machines, because of the savings this gives on their household budgets. In comparison to this, the consumer gets no clear economic advantage from buying an eco-labelled product. This demand has provided an incentive for the industry to develop more efficient machines. However, the market figures (figure 5) show that the market already in 2001 primarily consisted of A-labelled machines until 2010, where the new energy efficiency classes A+, A++ and A+++ were introduced. Moreover, the average energy consumption of the washing machines on the market was already in 2004 higher than class A (IEA, 2010). Since the EU Energy Label had not been revised by then, it can be questioned how much impact it have had on pulling the industry towards producing machines with higher efficiencies than energy class A.

The prospect of the future energy classes can have had a pulling effect, and so can the prospect of future minimum standards of the Eco-design Directive. However, in 2011, i.e. one year after the application of the revision of the EU Energy Label, some machines already exceeded the performance of A+++ by 9%. This indicates that the Energy Label, despite its recent update, does not use its potential to pull the industry much further (Topten, 2011).

However, is it needed to ban products from the market via a legislative instrument, if the Energy Label has already succeeded in phasing out almost all household washing machines below A rating? One reason for introducing the Eco-design Directive could be the initial idea to include life cycle considerations in the design stage i.e. expanding the energy efficiency focus of the Energy Label to a broader environmental scope. The evidence could be the life cycle approach mentioned in the Directive, but as confirmed by the case study the life cycle focus is not implemented in practice. Nevertheless, the Eco-design Directive will remove the bottom of the market by setting MEPS equal to A+ in 2013. This will significantly increase the average energy efficiency of washing machines on the market. By 2013 the Energy Label will only utilize the top 3 energy classes (A+, A++ and A+++), and hence it can be questioned what role the EU Energy Label will play in the future policy package.

RoHS Directive and REACH Regulation

The RoHS directive sets requirements to the substitution of hazardous substances. This may have effect on the IM, that the use of hazardous substances is not fully assessed in the EuP Preparatory Study for household washing machines. The study includes a section on RoHS, and this may result in a reliance on the RoHS directive to take care of the issue of hazardous substances. RoHS have been successful, but the industry may be further encouraged by the Eco-design directive to include further considerations regarding the use of and substitution of hazardous substances and chemicals. However, the case study provides no clear indication on this subject.

The ecolabels set criteria on the basis of the categories in REACH. In the future there may be possibilities to utilize this further. As ecolabels are intended to represent the best performing products, it is important that they differentiate themselves from RoHS, and set stricter criteria than the legislative instruments.

WEEE Directive

By setting requirements for the recovery, reuse and recycling of electrical and electronic waste the WEEE Directive mainly focuses on the waste stage. However, the directive also strives to affect the production and design stage by the principle of *extended producer responsibility*. This is done by making the producers or importers financially responsible for collection, treatment, recovery and environmentally sound disposal of electronic and electrical waste. However, by introducing the collective schemes and by dividing the waste according to geographical location as in Denmark, the incentives is largely removed from the producers to design their products in a manner which takes the waste stage into consideration, as they themselves do not benefit from an easy waste handling. The collective schemes may create a small incentive for the producers to design products with low weight, which might benefit the use of resources. However, it will not encourage design including considerations on repair, possible upgrading, reuse, disassembly and recycling. Nevertheless, a prerequisite for reuse and recycling is collection and recovery of electrical and electronic waste, and in this regard the collective schemes in the Nordic countries are effective. A study shows that the Danish consumers prefer to deliver their e-waste at collection sites rather than to the producer. The extended producer responsibility would only have the intended positive effect if the waste is returned to the initial producer in opposition to the current random mixture of electrical and electronic waste the individual producer is responsible for (cf.

page 23). This would require a major and difficult change in consumer habits and national structures.

There exist a historical link between the WEEE Directive, the RoHS Directive and the Eco-design Directives, as these three directives originally were intended as one joint directive. For this reason, several overlaps exist between the directives, and there might exist an understanding that the WEEE Directive covers the waste stage and thus leaves no need to put up requirements for this stage in the Eco-design Directive. As mentioned ealier, the intention of *extended producer responsibility* in the WEEE Directive (to spur considerations regarding waste in the design and production stage) has not been properly implemented in all Member States due to different structures and habits. Therefore, the Eco-design Directive has to include a life cycle perspective and ensure that all stages are considered in the design and innovation of new products.

4.2.2 The voluntary instruments

The intention of the voluntary instruments is to encourage eco-innovation through creating incentives for the consumers to buy eco-friendly products on the market, and thereby influencing the competitive strategies among industries. Ecolabels are supposed to represent the environmentally best products on the market, thereby giving producers an incentive to live up to the criteria and apply for the label. The case study has shown that the ecolabels far from represent the best performing household washing machines, and that GPP criteria from both EC and The Nordic Council of Ministers are so vaguely defined that they can hardly encourage eco-innovations. Before elaborating this, a discussion of the Voluntary Agreements and their effect will be presented.

Voluntary Agreements

The CECED made two Voluntary Agreements with EU, which had the target of phasing out of machines performing worse than energy efficiency class D by 2003, and a ”fleet” target of the sales weighted average efficiency of 0.2 kWh/kg by 2008 (IEA, 2010). Danish market figures (figure 5) shows that by 2003 more than 80% of the machines were A-rated, and no machines under class B was on the market. Hence, the target of phasing out class D machines was not ambitious. This not only accounts for the Danish market, but other European markets (Defra, 2008). Moreover, the average efficiency of washing machines in 2008 was 0.18 kWh/kg, leaving the fleet target rather unambitious too.

Ecolabels

The case study of household washing machines has shown that from a narrow environmental perspective (only including water and energy in the use stage) the Nordic Swan-labelled washing machines are the worst performing ones with their excessive use of water and electricity. From a health perspective however they perform well, but not significantly better than other machines. The MEPS from 2013 are stricter than the criteria in the Ecolabels. This is primarily due to the time lag between the renewal and update of the instruments; actually the ecolabelling criteria for household washing machines have not been updated for many years, whereas the IM for household washing machines are new and set upcoming standards in 2013. Since the ecolabelling criteria have not been updated recently, they cannot be given credit for the efficiency improvements during the last decade (the Nordic Swan most recently updated in 2004 and the EU Ecolabel most recently updated in 2001). Consequently they have not had the intended effect.

The comparative study indicates that the two Ecolabels also have a narrow focus on the use stage, even though they include parameters in more life cycle stages than the Eco-design Directive's IM, such as more restriction on chemical substances. However, many life cycle stages are not addressed sufficiently and there is room for improvement. Actually a full life cycle perspective in the Ecolabels might be what could differentiate the Ecolabels from the legislative instruments, and thereby strengthen the role of Ecolabels. In practice this could include criteria regarding transportation. Ecolabelling Denmark is investigating the potential to affect transportation through the ecolabelling scheme. Also the criteria for the end-of-life stage could be tightened, e.g. with criteria for the use of recycled materials and contents. However, it does not seem to be a likely development in relation to the EU Ecolabel. On the contrary, EU will most likely narrow the focus to just include the "most significant impacts of the products" instead of a more comprehensive life cycle approach (EU, 2009a).

The ecolabels are supposed to pull the market and then the industry towards eco-innovation. In this case, the criteria set only consist of specific and easily attainable requirements, and from the industry's viewpoint this might not lead to creative ideas that can drive technological innovations. For the ecolabels to distinguish themselves from the legislative policy instruments, they should encourage further development of greener technologies and support the introduction of the BAT already introduced on the market. By setting more generic criteria to new technologies it may also become easier and less time consuming to develop and update the criteria, thereby reducing the risk of becoming outdated

too quickly. Household washing machines are assessed to be a product group evolving at medium speed (eceee, 2010), and to what extent ecolabels can affect the environmental performance of other electronic products evolving faster may also depend on the emphasis on either specific or generic criteria.

The initial choice of household washing machines as case study was based on the deviations found between the requirements in the Ecolabels and the Eco-design Directive. These deviations were confirmed through the case study, and the ecolabels do not in the case of household washing machines point towards the best performing products on the market. This is critical, because in order to have an effect the ecolabels need to be widely known and respected among the consumers. The information to the consumer will influence the consumer behavior and hereafter affects the industry. Hence, the ecolabels rely on the consumer trust.

This report presents one case and do not attempt to generalize on the function of ecolabels of other products than household washing machines. However, the consumers might make such generalisations. If the information spreads that an ecolabelled product is not among the most environmental friendly products on the market, the consumers can quickly lose their trust in the ecolabels. The consumers might even generalize that if one ecolabelled product is not trustworthy, neither of them are.

Green Public Procurement

The EU commission has produced product-specific environmental criteria for green public procurement of 19 product groups, and more are under development (EC 2012). Green public procurement is a voluntary instrument, hence the member states can determine if and to what extend they want to implement it. However, household washing machines are not included in this list.

A general European and Nordic recommendation for the GPP is to follow the ecolabelling criteria. One can use the ecolabels to develop technical specification to define the qualities of the household washing machine during tender and ecolabelling can be used as an approach to control if the products comply with the criteria in the tender (Europa-Kommissionen, 2005). However, one cannot require that the tenderer is registered according to certain ecolabels. In the case of household washing machines this would not have brought about the procurement of the environmentally best household washing machines, but ecolabels are the most easily accessible source for criteria on other aspects than energy and water consumption. However, in the case of household washing machines the ecolabels do not provide sufficient criteria from a life cycle perspective and they are outdated. Thus if the ecolabelling criteria gen-

erally are updated and represent the top of the market as intended, they could provide a useful tool for GPP. It is also rather likely that the public procurement of household washing machines does not exceed the threshold values for public tenders, which is DKK 500,000 (udbudsportalen, 2012). Thus there will be more freedom to single out the most environmentally friendly household washing machines without sending it to tender. In that case, it could simplify the process to purchase an ecolabelled product. Therefore, considerations on GPP should to a larger extent be included in the criteria development process of the ecolabels. This should imply focus on the technical specifications needed for invitation to tender as well as information on life cycle costs (LCC). LCC include both the price of the household washing machine as well as the expenses to energy and water consumption, maintenance and reparation etc., i.e. the total costs, which the owner will have during the time of ownership. The total cost of ownership is mostly lower if a green model is chosen despite a higher purchase price (ECOS, 2010).

Public authorities could potentially account for a large share of green procurements, hence the GPP and the Ecolabels could mutually reinforce each other by a stronger coordination. The process for GPP could be made easier if the technical specifications and life cycle costs were already included in the ecolabels, and ecolabelled products could substantially increase their consumer segment, which would give further incentive to producers to fulfil the criteria. Moreover, the extra function of the ecolabels could imply more resources allocated to the ecolabelling boards, making it easier for them to maintain continuous revision of criteria that can keep up with the general market development.

4.3 Resource efficiency and the Eco-design Directive

The WEEE directive has aimed to give incentives to design for end-of-life through extended producer responsibility. However, the producers' responsibility does not seem to be the optimal solution because of too many obstacles to a full implementation (national systems, consumer habits, imported electrical and electronic equipment, which would not be returned to the producer among other). Therefore, one option is that the WEEE Directive should primarily concern effective recovery and recycling of electrical and electronic equipment. The Eco-design Directive on the other hand has the scope to spur the industry to design for resource efficiency.

In its outset the Eco-design Directive has a life cycle perspective, and this scope should also be reflected in the IM, which currently has

too narrow a focus on energy consumption in the use stage. Inspiration can be found in the OECD indicators for products (OECD, 2011) (Ardente *et al.*, 2011a; 2011b; 2011c):

- Recycled/reused content
- Recyclability
- Renewable materials content
- Non-renewable material intensity
- Restricted substances content
- Energy consumption intensity
- Greenhouse gas emissions intensity

Currently only one of these indicators is reflected in the IM for washing machines and that is the energy and water consumption during use, which is set as a specific requirement. The OECD indicators could be applied to spot other areas for improvement, and the Eco-design Directive could oblige the industry to provide information on key concerns as generic requirements. First of all, this could imply design for durability (prolonging the use stage) to reduce the amount of washing machines replaced each year. Secondly, design for easy dismantling and recyclability (end-of-life), so that the reuse of spare parts and recycling of material becomes as easy as possible. Thirdly, the producers must have an incentive to use recycled materials, and this could either be given by setting specific requirements in the Eco-design Directive to the use of a certain amount of recycled materials, or by making it economically attractive for the producers to use secondary raw material in the production.

This calls for a development of the market for secondary raw materials. The expected future rise in prices on virgin raw materials may make the market for secondary raw materials viable (EC, 2011b). A potential obstacle to setting requirements to the use of recycled materials is the fact that this could cause the presence of hazardous substances in the new products, which one are not aware of and which cannot be documented. Requirement for recycled material could alternatively be made as an information requirement and only for certain materials.

4.4 Strengthening the synergies and coherence

4.4.1 Information platform

An important weakness is the lack of interaction and sharing of knowledge between the policy instruments. There is only minor coordination during the criteria setting processes, in the implementation of the criteria and in the control functions. The different instruments have in some cases used the background studies and the requirements from the other instruments, but they have not actively tried to affect each other, and accordingly the synergy between them is weak. The most comprehensive background study is the one conducted in relation to the Eco-design Directive and the EU Energy Label. These background studies are time consuming, including among other research on the European market of the product and sometimes a full scale LCA. The accuracy and precision of the background studies are important for the setting of suitable requirements and criteria. Therefore, the PS averagely takes 1.5 years to conduct (ECOS *et al.*, 2011) and on average the IM takes 4 years to develop (CSES, 2011). Time is an important factor especially in relation to EEE, because the development of the products happens at a fast rate.

A way to make the process more efficient and less time consuming could be a higher degree of coordination between the background studies and the consultations. The PS is already systematically used for the IM of the Eco-design Directive and for the Energy Label. Thus, the PS has these two policies as main targets. The result is a tendency to focus on energy efficiency already in the background studies. Keeping a life cycle perspective in the PS, as in the scope of the Eco-design Directive, could facilitate a coordinated background study, where consideration regarding e.g. resource and disposal are comprehensively included. Thereby opening up for a larger coordination of the background studies at the Eco-design Directive, RoHS, WEEE, Ecolabels and GPP. Further coordination of the consultation forums could also be strengthened, so that officers from WEEE and RoHS and the ecolabelling schemes participate in the Eco-design consultation forum.

Thus to solve the problems related to resource and time consumption there is a need for a less extensive process for setting the criteria and requirements in the different instruments as well as more resources allocated to the process (CSES, 2011). Thus an obvious potential is increased knowledge sharing and coordination between the instruments. A platform for this could be the Institute for Prospective Technological Studies (IPTS), which is one of the scientific institutes of the EU's Joint

Research Centre. The IPTS conducts research on sustainable development and Integrated Product Policies.

4.4.2 Coordination of control functions and test methods

The control functions are not coordinated between the Eco-design Directive, the Energy Label, the ecolabels, GPP, the WEEE or the RoHS Directive – as mentioned above. In relation to the Eco-design Directive, Energy Label and the Ecolabelling schemes there is a need to control the products on the market e.g. by making random checks. The need for this originates both in the need to control that the producers live up to what they claim to do, and in order to check whether the criteria and the requirements are corresponding to the market. For the ecolabels (and the other instruments) the control and testing is important in order to maintain the legitimacy among consumers, since trust is the determining mechanism for the effectiveness of the labels. In addition it might be possible to save resources by coordinating the control functions, as e.g. testing of compliances can be expensive. An example is the different measures used to compare the energy consumption. The Eco-design Directive and the EU Energy Label uses the EEI, but the ecolabels and GPP still use the energy consumption of a standard 60 °C cotton programme.[11] Standardising the measures used in the different instruments will not only simplify the control functions but also ease the process for the producers.

In a Danish context an obstacle in the coordination of the control functions can be the fact that the instruments are managed by different organisations. The Eco-design Directive and the Energy Label is managed by the Danish Energy Agency. The Ecolabels are managed by Ecolabelling Denmark, and the individual municipalities manage GPP. RoHS is managed by Danish Environmental Protection Agency and the Danish Producers Responsibility DPA manages WEEE.

[11] There is evidence that the EU Ecolabel will apply the EEI in the upcoming revision of the criteria for household washing machines (Fischer, 2011b).

4.5 Recommendations

Based on the case study of household washing machines a list of recommendations can be outlined. The IM of the Eco-design directive should not just cover the use stage but should encompass a broader life cycle perspective.

IM could include:

- Information requirements for the use of materials, e.g. percentage reused/recycled materials.
- Requirements to the rate of reusable/recyclable components and materials.
- Requirements to durability extension of products e.g. by making the products easy to repair.
- Apply a logarithmic relationship between energy and water consumption and the capacity of the household washing machine.

Ecolabels should also encompass a broader life cycle perspective:

- Set criteria for eco-friendly transportation.
- Take point of departure in BAT to a higher degree. Like smart grid related (use during non-peak hours), load sensor, automatic dosing of detergents, quick and cold water washes as default (the more frequent washes means less dirty clothes and cold water detergents do exist).
- More frequent updates or incorporation of criteria, which are being tightened during the period.
- Stricter criteria for the production stage and waste stage.
- Must have much stricter criteria than the legislative instruments.

WEEE Directive could strengthen:

- improved recycling and development of market for secondary raw materiales
- economic benefits for the producers to design for end-of-life

Improved synergies between the instruments:

- Common information platform with background studies.
- Common way of calculating and measuring. Common use of the EEI.
- Coordination of the process of setting requirements in the Eco-design IM and ecolabelling criteria, so that the intended synergies are reflected in them in practice.
- Coordination of Eco-design IM with WEEE and RoHS.
- Inclusion of GPP criteria in the ecolabelling criteria setting process: inclusion of life cycle costs, formulation of technical specifications for tenders based on ecolabelling criteria.
- Coordination of control functions.

5. Conclusion

The mandatory and the voluntary instruments are intended to support each other. The mandatory instruments such as the Eco-design Directive and RoHS should remove the environmentally worst performing products and materials from the market, while the voluntary instruments should encourage the marketing and sale of the best performing products and encourage eco-innovations. The different policy instruments could function as building blocks, building on top of each other to achieve the common goal: to improve the environmental performance of products.

However, this intended synergy was not found in the case study of household washing machines. The case study showed that in terms of energy and water consumption the ecolabelled household washing machine models were the worst performing on the market. Thus the ecolabels have not been a driver for the eco-innovation of household washing machines in terms of energy and water efficiency. However, the initial choice of using household washing machines for the case study was a result of deviations found between the requirement in the Ecolabels and the Eco-design Directive suggesting that the intended synergies would not be found. Furthermore, this study represents a single case study and does not attempt to generalise regarding other product groups. The first Voluntary Agreements between the industry (CECED) and EU may have affected the market towards more energy and water efficient machines, but the second Voluntary Agreement was far too unambitious to have any effect on the market. What seems to have driven the improvements of energy efficiency of household washing machines is the EU Energy Label. This instrument ensured high penetration of A-class machines during the first decade of the 2000's. The EU Energy Label should however have been revised earlier than 2010 to retain its driving effect on the industry.

Actually, the MEPS applicable from 2013 for energy and water consumption are quite ambitious and by 2013 the MEPS will remove the worst performing models on the market equal to 30% of today's household washing machines. However, the MEPS only address energy and water consumption in the use stage. Thus the broader life cycle perspective is not reflected in the requirements. As a consequence the Eco-design Directive does not cover resource efficiency beside energy and water use. Given the limited amount of materials available combined with the in-

creased global use of materials and amounts of waste this issue could be addressed by the Eco-design Directive. The Eco-design IM does not set requirements to hazardous substances and chemicals in household washing machines specifically, but relies on RoHS to address this. Thus RoHS is the only legislative instrument, which sets requirements to hazardous substances. REACH provides a useful tool for the ecolabels and potentially the Eco-design Directive to single out hazardous substances to future requirement. The WEEE directive has not sufficiently succeeded to incorporate considerations on waste in the design stage, because individual producer responsibility has not been fully implemented. Thus, the Eco-design Directive has a potential to encourage producers to do so e.g. by setting requirements to the materials and end-of-life stages.

The criteria in both the EU Ecolabel and the Nordic Swan are far too unambitious for household washing machines, perhaps with the exception of requirements for chemical substances. Moreover, the Nordic swan criteria are valid until 2014, and thus seems to disregard the fact that the MEPS from 2013 are stricter than the energy criteria of the Nordic swan. The energy criteria of the Nordic swan simply will not comply with the law from December 2013. Therefore, the criteria must be tightened in all life cycle stages in the upcoming revisions, if the ecolabels are to represent the top of the market. Two main reasons for these out-dated criteria are delays and postponement of the revision. Otherwise, the legitimacy and the consumer's trust in the ecolabels are at risk. Moreover, the ecolabels could focus more on BAT and inspire producers towards greener technologies and eco-innovation. This could include technologies regarding connection to smart grid, which would provide means for washing outside peak hours; cold water washes; and automatic load sensors securing the proper amount of water, energy and detergents needed.

The lately increased coordination of GPP with the other policy instruments is not yet seen in the criteria for household washing machines. The GPP criteria for household washing machines were not particularly ambitious with the exception of the criteria regarding energy consumption from the Danish Centre for Energy Conservation. A stronger coordination between ecolabels and GPP, where environmental criteria are developed in the same process for GPP and EU ecolabels, will make the GPP more effective and easier to evaluate. Public purchasers are also given information and tools for estimating the total life cycle costs, which will mean that not just price but also aspects like energy consumption, length of life-time, and the quality and amount of waste are seen as the total cost of purchase. However, this specific product group "household washing machines" is not yet in the working plan for EU GPP criteria.

To improve the process of setting criteria and requirements to product groups within all the instruments, a higher degree of knowledge sharing is recommended. The criteria setting process is long for all the instruments, and if the background material were developed for all instruments together, and participation of stakeholders and officers representing each tool in the consultations, it could not only reduce time and resources spent but also facilitate a better coordination between the instruments. Additionally, measurement and test methods for energy and also other parameters could be standardized and coordinated better.

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Dansk sammenfatning

På baggrund af et casestudie af vaskemaskiner på det danske marked i 2011 undersøges det, hvordan ni europæiske og nordiske produktpolitikker samvirker for at reducere miljøpåvirkningerne fra vaskemaskiner, samt hvordan de tilskynder industrien til at udvikle og designe miljøvenlige vaskemaskiner. Formålet med studiet er at undersøge, hvordan samspillet og synergien mellem politikkerne kan forbedres, så det sikres at miljøpåvirkninger fra alle livscyklusfaserne af produktet indtænkes og minimeres i designfasen.

De ni politikker er: Eco-design direktivet, EU's energimærkningsdirektiv, WEEE direktivet, RoHS direktivet, REACH forordningen, EU Ecolabel forordningen, Det nordiske Svanemærke, Grønne Offentlige indkøb, og Frivillige aftaler.

Hensigten med politikkerne og deres synergi

Udgangspunktet for undersøgelsen er Eco-design direktivet, som stiller krav til industrien om at inddrage miljøhensyn i designet af deres produkter for at minimere miljøpåvirkningerne fra hele produktets livscyklus. Eco-design og RoHS direktivet stiller ufravigelige minimumskrav til industrien, der skal sikre at alle produkter lever op til en specifik miljømæssig standard, og at de mest forurenende produkter forbydes på det indre marked i EU. Andre obligatoriske direktiver er EU's energimærkning, WEEE og REACH, som stiller krav til henholdsvis mærkning og håndtering af produkter ud fra energi-, affalds- og kemikaliehensyn. For at tilskynde udviklingen af miljøvenlige produkter yderligere har også de frivillige ordninger (Svanen, EU Ecolabel, GPP og VA) opstillet miljømæssige kriterier for vaskemaskiner, som industrien kan tilstræbe at leve op til og dermed opnå en konkurrencemæssig fordel på markedet.

Lovkravene og de frivillige ordninger skal således fungere i samspil med hinanden, ved at lovkravene fjerner de mest forurenende produkter, mens de frivillige ordninger tilskynder til udvikling af mere miljørigtige produkter. Denne synergi kan imidlertid ikke helt genfindes på markedet for vaskemaskiner.

Fokus på brugsfasen – det glemte livscykluserspektiv

Selv om Eco-design direktivet har udgangspunkt i livscykluserspektivet, så stiller gennemførselsforanstaltningerne for vaskemaskiner kun krav til forbedret energieffektivitet og reduceret vandforbrug, og dækker dermed kun brugsfasen. De andre livscyklusfaser som ressource- og materialeforbrug, produktion, transport, genanvendelse og affald, forventes reguleret af andre politikker, herunder WEEE og RoHS. WEEE er implementeret på en måde, der ikke medfører forbedret design for genanvendelse og genindvending af materialer. Der er altså grund til at overveje hvordan Eco-design direktivet kan stille krav til ressourceeffektivitet og affaldshåndtering, samt de livscyklusfaser der ikke er dækket af andre politikker. Særligt gør det øgede behov for effektiv ressourceudnyttelse det relevant for Eco-design direktivet at styrke fokus på ressource- og materialeforbrug og herigennem på minimering af affald til deponi og forbrænding.

Blandt de frivillige miljøordninger har miljømærkerne et bredt livscykluserspektiv. Men da kriteriesættene har været forældede i årevis, har miljømærkerne ikke formået at inspirere industrien til miljørigtigt design.

Hvad har drevet miljø-innovationen af vaskemaskiner?

Siden 1997 er energi- og vandforbruget i vaskemaskinerne på det danske marked løbende blevet reduceret. Denne miljømæssige forbedring er primært blevet drevet af to politikker. I 1996 og i 2002 indgik industrien frivillige aftaler (VA) med EU om at forbedre effektiviteten af energi- og vandforbruget. Dernæst har EU's energimærkningsordning medvirket til øget efterspørgsel på energieffektive vaskemaskiner blandt forbrugerne, og dette har givet producenterne et vigtigt incitament til at producere bedre maskiner. Siden 2002 har størstedelen af de solgte vaskemaskiner været A-mærkede. I 2010 udkom en opdateret version af energimærket for vaskemaskiner, og her er blevet tilføjet yderligere energiklasser med A+++ som den mest energieffektive.

Kriterierne for vaskemaskiner i miljømærkningsordningerne Svanen og EU Ecolabel er forældede, og de seneste revisioner af kriteriesæt stammer fra henholdsvis 2004 og 2001, som siden er blevet forlænget. Disse ordninger har således ikke inspireret industrien til at udvikle mere miljørigtige vaskemaskiner. Faktisk er de ret få svanemærkede vaskemaskiner på markedet blandt de mest energi- og vandforbrugende maskiner. Derudover har

kun *en* ud af 27 producenter tilstræbt at udvikle en vaskemaskine i henhold til miljømærkningsordningens kriterier. Den manglende opdatering af miljømærkekriterierne er særligt problematisk, fordi miljømærkerne netop sætter kriterier ud fra en livscyklustankegang og dermed har potentiale til at forbedre andre miljøparametre end energi- og vandforbruget. Derudover vanskeliggør den hurtige udvikling af produkter fastsættelsen af miljøkriterier for længere perioder, og derfor anbefales det, at miljømærkerne i højere grad tager udgangspunkt i nye teknologier frem for faste parametre, når kriteriesættene udvikles.

På nuværende tidspunkt kan der ikke drages konklusioner om Ecodesign direktivets indvirkning på markedet for vaskemaskiner, fordi de første gennemførelsesforanstaltninger først trådte i kraft i december 2011. Dog viser analysen, at alle vaskemaskiner på markedet i efteråret 2011 lever op til kravene. De næste gennemførselsforanstaltninger gyldige fra 2013 er derimod ambitiøse og vil fjerne de 30 % dårligst præsterende maskiner fra markedet, og dermed leve op til hensigten med direktivet.

Forbedret koordination mellem politikkerne

Der ligger omfattende og tidskrævende baggrundsstudier bag hver af de enkelte politikinstrumenters krav til hver produktgruppe. Fælles baggrundsstudier og vidensplatform for alle instrumenterne kunne reducere tids- og ressourceforbruget, men vigtigere endnu kunne det give mulighed for yderligere koordination mellem politikkerne så den tiltænkte synergi bliver bedre understøttet.

Appendices

Appendix 1 – Best Available Technology (BAT)

Rated capacity (kg)	Energy consumption (kWh/cycle)	Water consumption (l/cycle)	Washing efficiency index I_w	Airborne acoustical noise
3.0	0.57	39	1.03>/=I_w>1.00	-
3.5	0.66	39	1.03	-
4.5	0.76	40	1.03	(1,000 rpm): 55/70 dB(A) re 1 pW
5.0	0.850	39	1.03	(1,200 rpm): 53/73 dB(A) re 1pW
6.0	0.90	37	1.03	-
7.0	1.05	43	1.03	(1,000 rpm): 57/73 dB(A) re 1pW (1,400 rpm): 59/76 dB(A) re 1pW (1,200 rpm): 48/62 dB(A) re 1pW (built-in washing machines)
8.0	1.200	56	1.03	(1,400 rpm): 54/71 dB(A) re 1 pW (1,600 rpm): 54/74 dB(A) re 1 pW

Appendix 2 – Energy and water consumption

Energy consumption

The Ecolabels put forward the requirements for energy consumption in terms of energy use for standard 60 °C programme. In the Nordic Swan the energy consumption should be below or equal to 0.19 kWh/kg cloth washed, and in the EU Ecolabel the energy consumption should be below or equal to 0.17 kWh/kg cloth washed. As mentioned in section 4.2.2 the Eco-design Directive puts forward requirements to the energy consumption in terms of an EEI. This makes it more complicated to compare the requirements in the Eco-design Directive with the requirements in the Ecolabelling schemes and the performance of the household washing machines available on the Danish market, as these are given in terms of the energy use for a standard 60 °C programme. To enable a comparison it is necessary to rewrite the EEI to the energy use of a standard 60 °C programme. The reason why we chose a 60 °C programme and not the

EEI is first of all because we do not have the information needed i.e. energy consumption for a standard 40 °C programme partially loaded or the energy consumption for a standard 60 °C programme partially loaded for the washing machine models available in the Danish market.

The conversion is done by comparing the new requirements from the Energy Label, which are given in terms of EEI, with the old requirements from the Energy Label, which are given in terms of the energy use of a standard 60 °C programme. It appears from table 5 that A corresponds to an EEI of 59–68. Thus, the requirements applicable from December 2011 correspond to an A in the Energy Labelling scheme. According to the old scheme an A corresponds to and energy consumption below 0.19 kWh/kg laundry washed. Thus, it is estimated that the requirements for December 2011 corresponds to energy consumption below 0.19 kWh/kg laundry washed. However is gets a bit more difficult when it comes to the requirements applicable from December 2013. According to table 5 the requirements for December 2013 corresponds to an A+ in the Energy-labelling scheme. However, A+ did not exist in the old requirements, so it is not possible directly to find the energy use for a standard 60 °C programme in this way. In the old Energy labelling scheme the energy use decreases with 0.04 kWh/kg laundry washed between the categories ranging from G to A. It is assumed that this is also the case between A and A+, therefore the energy use in the requirements from 2013 of a standard 60 °C programme is estimated to 0.15 kWh/kg cloth washed. The preconditions require that the scale in the Energy labelling has not been changed in the new and the old requirements. However it is assessed that it is very unlikely that the scale has been changed considerably, as it would undermine the scheme. Nevertheless, it should be emphasized that the two methods for calculating the energy consumption are quite different and the results we have reached are only estimates and only for the purpose of comparison.

The requirements for energy consumption for a standard 60 °C programme

The Nordic Swan	0.19 kWh/kg
The EU Eco-label	0.17 kWh/kg
The Eco-design Directive, December 2011	0.19 kWh/kg (estimate)
The Eco-design Directive, December 2013	0.15 kWh/kg (estimate)
BAT	Appendix x

Water consumption

The Ecolabels put forward the requirements for water consumption in terms of water use for a standard 60 °C programme. In the Nordic Swan the water consumption should be below or equal to 16 l/kg washed cloth and in the EU Ecolabel the water consumption should be below or equal to 12 l/kg cloth washed. The requirement from the Eco-design Directive is put forward in terms of two equations, see table 5. The requirement for water use valid from December 2011 is calculated depending on the rated capacity, and the requirement valid from December 2013 is calculated depending on the rate capacity multiplied with 0.5.

Nordic Council of Ministers

Ved Stranden 18
DK-1061 Copenhagen K
www.norden.org

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Product policies on the environmental performance of washing machines

Product policies on the environmental performance of washing machines is a study that investigates how nine policy instruments regulate the environmental performance of household washing machines.

Through a case study of washing machine models on the Danish market in 2011, it is examined how the policy instruments work and how the synergies and coherence can be improved. The level of ambitions behind the different policy instruments is assessed. The study includes the following policy instruments: the Ecodesign Directive, the EU energy label, the WEEE Directive, the RoHS Directive, the REACH Regulation, the EU Ecolabel, the Nordic Swan, Green Public Procurements (GPP), and Voluntary Environmental Agreements (VA).

A synergy between the mandatory and the voluntary policy instruments are supposed to exist, where the mandatory instruments set minimum standards to the performance of products, while the voluntary instruments should drive the business initiatives and the market demand for more environmentally friendly products.

The study was financed by the Nordic Council of Environmental Ministers (NCM) and guided by the working group on Sustainable Consumption and Production.

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