Impact of Ecodesign and Energy/Tyre Labelling on R&D and technological innovation

Final report

European Commission

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Impact of Ecodesign and Energy/Tyre Labelling on R&D and technological innovation

Final report

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Abbreviations

A/C:	Air conditioning
CECED:	Trade association for white goods sector
CSTB:	Complex set top boxes (CSTBs)
ED:	Ecodesign directive
EHI:	The European Heating Industry sector organisation
ELD:	Energy Labelling directive
ELC:	European Lamp Companies Federation
EPBD:	Energy performance of buildings directive
EPS:	External power supplies (EPS) and battery chargers.
EuP:	Energy using product
ErP:	Energy related product
ICT:	Information and Communication Technology
IPC:	International Patent Classification
GPP:	Green public procurement
LLCC:	Least Lifecycle cost – an approach to assessing policy costs
MEERP:	Methodology for the Ecodesign of Energy-related Products
MEPS:	Minimum energy performance standards
OEM:	Original Equipment Manufacturer
OJEC:	Official Journal of the European Commission
REHVA:	An HVAC trade association
SSTB:	Simple set top boxes (SSTBs)
VA:	Voluntary agreement
WEEE:	Waste Electrical and Electronic Equipment directive

Executive Summary

In 2005, the European Commission issued the Ecodesign directive, with the aim of reducing the environmental impact of Energy-using Products during their life-cycle. The directive was extended in 2009, to also cover Energy-related Products. The Ecodesign and Labelling directives have the potential to not only deliver energy savings but also to positively impact the innovation activities and competitiveness of the manufacturers of the regulated products. With regard to the upcoming revision of the directives in 2014, it is therefore of great importance to identify and optimize the factors that influence the innovation friendliness of the regulations. Such factors include the level of ambition of the regulation, industry participation in setting standards, the technical capabilities of regulators as well as the stability, speed and predictability of the regulatory process.

So far, experience with the Ecodesign and Labelling regulations has shown that for some industry sectors, the reaction to, and involvement in, the legislative process was very positive; while, by contrast, other sectors have acted in a rather defensive way. Whereas for some sectors, even in the early phases of the regulation process, the directives seem to have stimulated innovation, in other sectors no such effect has been observed.

Our study aimed to provide empirical evidence of the impact of the Ecodesign and Energy/Tyre Labelling implementing regulations on R&D and technological innovation by combining analysis of primary data gathered through company case studies with the analysis of secondary data, such as patent statistics and R&D funding. Furthermore, a typology of manufacturers was designed in order to characterise the companies' responses to the legislative process. Based on the findings, policy recommendations on how to enhance the innovation impact of the implementing regulations were derived.

Findings from the literature: Existing research on the topic was reviewed and summarised to obtain a clear picture of the current understanding of the innovation impact of the Ecodesign and Labelling legislation. The literature review allows the following conclusions to be drawn: The innovation impact of environmental policy has been discussed widely and the factors that contribute to the "innovation friendliness" of policy instruments are rather well understood. In theory the Ecodesign and Labelling directives fulfil a number of the criteria for innovation friendliness and thus have the potential to positively influence innovation. However, empirical evidence of the innovation impact of the directives has been considered only marginally and no systematic analysis has been reported so far. Our study helps to fill this gap by analysing both primary and secondary data for a range of products.

Secondary data analysis: We analysed the correlations between the regulatory process and the innovation activities of the companies affected by the regulation by using secondary data reflecting the innovation behaviour of companies for several product groups. The innovation impact was analysed in two ways:

1) The approved requests for R&D funding from the European Investment Bank between the years 2001 and 2012 were analysed in order to identify projects concerned with energy efficiency measures in products that are affected by the regulation. Our analysis observes funding requests that coincide

with the regulatory measures, especially in the white goods and tyre sector, however, the limited number of funding requests does not allow for statistical analysis.
2) We further analysed patent data as an indicator of technological innovation for improving the energy efficiency of products affected by the regulation. As energy efficiency is generally not reflected in the available patent classification system, search strategies were developed for a series of products. The data from the patent analysis show that the Ecodesign directive has typically not had a significant effect on the patenting activities of the affected companies. The findings of the patent analysis suggest that the companies already had the necessary technologies to meet the requirements, but were lacking incentives to bring them to market at a given time. The role of Ecodesign and Labelling (at least in the short term) is rather to promote the acceleration of the market diffusion of high-efficiency technologies.

Primary data analysis: As a central element of this study, we performed case study interviews with companies directly affected by the legislation and experts from industry associations, member states and research institutions. In the company case studies, we collected and analysed primary data from manufacturers for a series of different products including white goods, electric motors, electronic appliances, heating supply, air conditioning and ventilation appliances, lighting products and tyres. The case study results show that the innovation impact differs for the various sectors. In sectors where the Ecodesign requirements and Labelling class levels were set in a rather ambitious way, the companies conducted a significant restructuring of production processes and product lines. The directives have supported market transformation towards more efficient technologies, mainly by facilitating the wider market introduction of existing high-efficiency technologies. Both for Ecodesign and Energy Labelling, most of the companies interviewed stated that the legislations have an influence on their innovation behaviour. The innovation impact is stronger in the deployment, commercialisation and diffusion of innovative energy efficiency technologies and is rather limited in the earlier R&D stages.

For both Ecodesign and Labelling, a rather direct relationship between the ambition of the requirements and the innovation impact was observed. The ambition of the requirements is reflected in the share of products that are removed from the market when the regulation is adopted and differs rather strongly between the different products. For products where the implementing regulations define ambitious requirements in relation to the market, the innovation impact is strong.
We further observed that the market and sales structures play an important role regarding the potential of Ecodesign and Energy Labelling to address the barriers to the deployment and diffusion of innovations. For the consumer market, information-related barriers to the adoption of energy efficiency innovation are predominant and are adequately addressed by the Labelling legislation for the high-efficiency end and by Ecodesign for the low-cost segment. In the business-to-business market for components it is essential to set ambitious Ecodesign requirements, as products are typically not sold to end users and are used as components in larger systems (e.g. electric motors and pumps, air conditioning, tyres). The line of purchase is therefore broken in a sense that buyers are typically not interested in energy efficiency as they will not benefit from energy savings themselves, such that Labelling plays a lesser role.

Typology of manufacturers: A typology of manufacturers was defined in order to provide a basis for analysing the role of different actors and maximising the positive impact of the Ecodesign and

Labelling legislation on innovation. The available literature on typologies of manufacturers with respect to their reaction towards environmental regulations was reviewed. It was found that existing typologies are not well matched to the specific research questions of this study, tending to miss one of the crucial elements of firms, innovation and engagement and response to the legislative process.

We were able to propose a typology of firms, classifying their likely interactions in the legislative process based on two key criteria, their relative eco-innovativeness and the perceived impact of the proposed regulation on their firm. Only a weak positive link was found between the two criteria. The four types that were defined were constructive supporter (high eco-innovation, positive perceived impact), challenger (high eco-innovation, negative perceived impact), ambivalent (low eco-innovation, positive perceived impact) and obstructive (low eco-innovation, negative perceived impact). This only classified the firms actually active in the process, a fifth category, passive, was briefly defined for the great majority of firms that do not engage in the process, at least not directly.

In general firms and sectors almost universally accepted the need for action on product energy use. Firms primarily engaged in the process through sector organisations and industry engagement was on the whole positive but pragmatic, with a focus on the practical implications, non-discrimination and ambition levels of the regulatory requirements.

Policy recommendations: The results of our study allowed for deriving recommendations on how to enhance the positive impact of the Commission's legislation on innovation and R&D, as well as the Commission's information and communication strategy and the Commission's knowledge about upcoming innovations and technologies in the legislative process. In particular, the following recommendations were highlighted:

Increasing stringency of regulatory requirements: With some changes in the process, more stringent requirements could be defined. Stakeholder feedback suggested the following potential approaches to increase stringency based upon their insights from specific sectors:

- A shift in focus from Least life cycle cost (LLCC) to equivalent cost assessment: Least life cycle cost assessments carried out in the preparatory study can limit the degree of ambition/innovation drive that can be achieved. Input related to the electronics and white goods sectors supported the use of "equivalent cost assessments" or taking into account learning curves (as e.g. used in approaches of the United States Department of Energy and recommended by several European experts).
- A focus on engaging innovative manufacturers: Include a stage in the Methodology for the Ecodesign of Energy-related Products (MEERP) to investigate innovation (best not available technology) via one-to-one interviews with component manufacturers and less vocal, more innovative manufacturers to develop a better understanding of what can be achieved.
- More robust requirements by proportionate preparatory studies: During working plan development assess necessary budgetary spend per product area taking into account complexities (some have been underfunded in the past e.g. refrigeration).

Market surveillance and control: A long-term innovation impact can only be achieved if the enforcement of the legislation is secured. The need for increased market surveillance to achieve long-

term support for innovation was highlighted by most interviewees and stronger enforcement is supported by the industry representatives as well as independent experts.

Recasting of the Labelling classes: Stakeholders highlighted that the incentives to innovate are limited when the top of the classes are reached too early (A+++). Recast labels with A set at best not yet available (BNAT) level would resolve this. This was supported by case study results e.g. in the white goods and lighting areas, and is already under development by the various parties involved.

Sector specific innovation dynamics: It has been observed by a number of interviewees that in order to increase the innovation impact of the legislations, it would be useful to take into account the sector specific innovation systems in more detail. The ability of the regulation to induce innovation depends on its alignment with the innovation cycles in a sector. A prime example of this is in the electronics sector, where innovation is very fast and it is challenging for the legislative processes to keep up with the dynamics.

Consumer response to Labelling: The extent to which Labelling influences consumers' decisions varies between different products, sales structures and between different member states. In some sectors, the introduction of a label/regulation has resulted in the visibility of their products increasing, which provided a means of differentiating between products that did not previously exist e.g. for tyres. Some companies commented that more active promotion of legislative activity in product areas could inform customers about the positive aspects of regulation and Labelling, and lead to increased incentives to innovate. For example, mobile applications could be used to facilitate product comparison on the basis of Labelling attributes to facilitate user understanding of lifecycle costs.

Complementary measures: The most important complimentary option highlighted was that of Green Public Procurement. In both the electronics and lighting sectors procurement was highlighted as a customer driven means of motivating innovation. It can also provide a means of strengthening the impact of endorsement labels – for example, procurement of office equipment complying with ENERGY STAR requirements has been an obligation for central government and EU institutions requirement since 2008, as specified in Regulation (EC) No 106/2008. However, a barrier can be the lack of appropriate mechanisms to identify the best performing products – for example, there are issues with the recent drive in Europe to purchase even better than ENERGY STAR as there are not sufficient initiatives identifying the very best performing class of products to use as a reference.

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1 Introduction

Eco-innovations are generally expected to play a crucial role in the transition towards a sustainable economy. In order to simultaneously achieve the objectives of sustainability, energy security and competitiveness of the European economy, innovation both on the demand and supply side is required (Foxon, Köhler, & Oughton, 2008). In recent years, innovation has gained increasing importance both within European energy policy (Schiellerup & Atanasiu, 2011) and in the academic debate.

The Ecodesign and Energy Labelling directives are key policy instruments to increase energy efficiency in Europe. The Ecodesign directive was issued in 2005 for energy using products and was extended in 2009, to also cover Energy Related Products. To date, there are more than 40 implementing measures for Ecodesign and Labelling, and a number of further products are currently being addressed in the preparatory stages.

While the primary policy goal of the Ecodesign and Labelling directives is "reducing the environmental impact of products, including the energy consumption throughout their entire life cycle"[1], the European product policy instruments have received increased interest also from an innovation policy perspective (Schiellerup & Atanasiu, 2011), (Blind, 2012), (Edler, 2013). The objective of this study is to empirically analyse the factors that positively influence the innovation friendliness of the Ecodesign and Energy/Tyre Labelling directives as key European policy measures to increase energy efficiency.

So far, experience with the regulation has shown that for some industry sectors, the reaction to and involvement in the legislative process was very positive; while, by contrast, other sectors have acted in a more defensive way. For some sectors, even in the early phases of the regulation process, the directive seems to have stimulated innovation, whereas in other sectors no such effect has been observed (see e.g. ECEEE, 2013). Understanding why the different actors behave in such different ways requires the understanding of many interrelated technical, economic, legal and environmental aspects. This, in turn, is of fundamental importance for the successful implementation of the legislation, ensuring a positive impact on innovation and constructive cooperation between the Commission and the manufacturers, resulting in more energy efficient products that save consumers money and reduce environmental impacts.

The aim of this study is to provide the Commission with information for the upcoming revision of the Ecodesign implementing measures in 2014 in order to maximize the innovation impact and the positive involvement of companies in the legislative processes. The results are expected to contribute

[1] http://ec.europa.eu/energy/efficiency/Ecodesign/eco_design_en.htm

to enhancing the positive impact of regulation on R&D, as well as the communication and knowledge transfer between the Commission and manufacturers.

In order to capture a wide range of innovation activities and to identify a causal link between the legislation and innovation, a case study approach was combined with an analysis of patent data related to energy efficiency. Additionally, a typology of manufacturers was developed in order to analyse the involvement of manufacturers in the legislative processes.

In the secondary data analysis, the impact of the policy measures on the early stages of the innovation process was studied based on patents related to energy efficiency for a selection of products regulated under these directives. The correlations between the policy measures and the patenting activities were explored by analysing the evolution of the patenting behaviour before, during and after the implementation of the policy measures. The trends of patenting activities in these product groups were assessed relative to general patenting and economic trends. Sector specific developments driven by the directives were taken into account by studying the relative growth in the number of energy efficiency-related patents within the total number of patents for a given product.

For the case studies, a multiple case study approach (Yin, 2002) was used to collect primary data. This approach allows the in-depth insights to be gained into the causal links between the regulations and the innovation activities of the manufacturers. In order to achieve a thorough understanding of the mechanisms that positively and negatively influence the innovation impact, the case studies were conducted in seven different sectors, namely lighting, heat supply, electric motors and pumps, tyres, electronics and air conditioning. The company representatives included R&D management positions, product managers and leaders of the policy departments.

The combined findings of the case studies and the secondary analysis were used to derive policy recommendations to improve the innovation impact of the legislation. Furthermore, recommendations concerning the Commission's information and communication strategy and the Commission's knowledge about upcoming innovations and technologies in the legislative process were derived.

Figure 1 outlines the various tasks that were performed in the study. The findings are described in detail in the following chapters. Chapter 2 summarizes the literature that was reviewed within the study. Chapter 3 presents the results of our secondary data analysis. Chapter 4 presents the methodology and sector results of the case study analysis. Chapter 5 summarizes the main results from our case study research. Chapter 6 highlights some of the most important policy recommendations to increase the innovation impact of the Ecodesign and Energy Labelling legislation that were derived from the project.

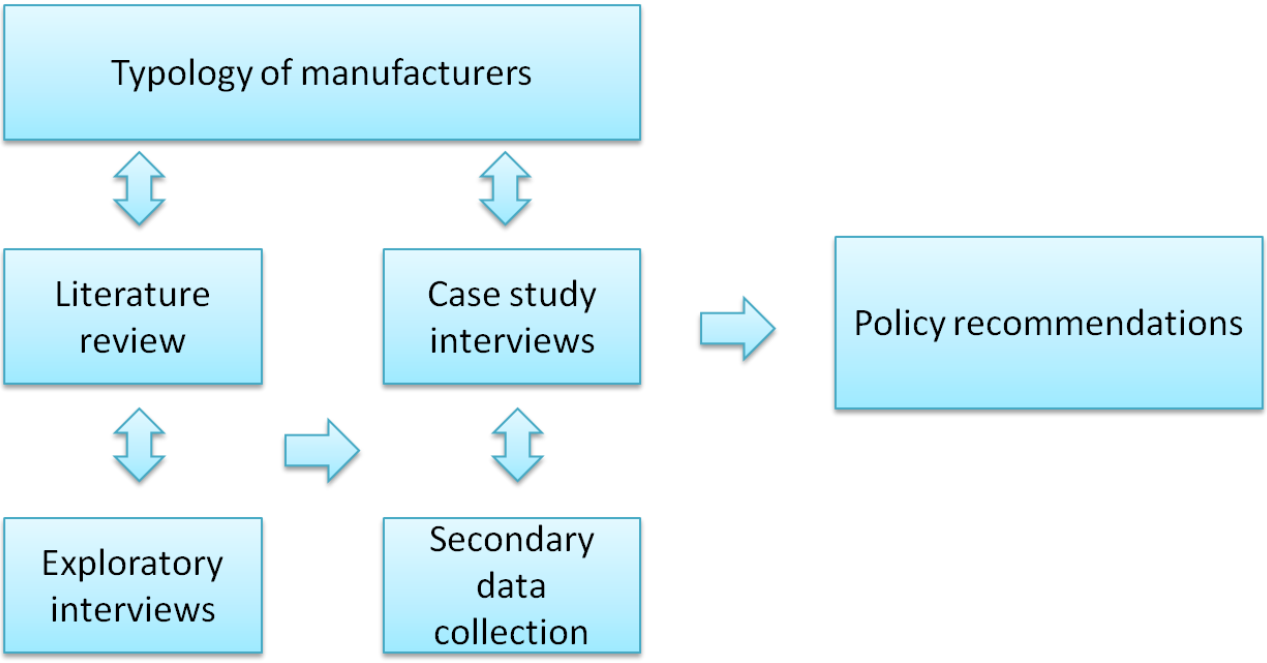


Figure 1: Schematic overview of the main tasks performed in the study

2 Literature Review

As a first step, we reviewed the most relevant contributions in the literature that provide the basis for our study. This chapter summarises the findings of our literature review and analyses the applicability of the findings to our research questions. The first section reviews the **definitions and classifications** of innovation that are used in the study. The second section consists of a literature review on the theoretical background of the **innovation impact of environmental policy**, discussing the main criteria for innovation-friendly environmental policy. The third section considers indicators and methods to collect **empirical evidence** of the innovation impact of environmental policy. The fourth section discusses literature on empirical evidence of the **innovation impact of the Ecodesign and Labelling directives**. Finally, the main findings concerning **manufacturer involvement in the regulatory processes** are outlined.

2.1 Innovation: Definition and drivers

The term "innovation" is frequently used both in common language as well as in the scientific community. However, as different people typically apply the term to rather different concepts, it is essential to define the scope of the term innovation that is used in our research.

2.1.1 Definition and classification

One of the most commonly used definition of innovation is given in the Oslo Manual (OECD, 2005): "An innovation is the implementation of a new or significantly improved product, or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."

The use of the term "implementation" reflects the distinction between innovation and invention, which was pointed out among others by Schumpeter in 1939 by stating that an invention "is without importance to economic analysis" (Schumpeter, 1939). Furthermore, the term innovation is to be distinguished from the diffusion of available technologies.

The definition of innovation provided in the Oslo Manual implies a characterisation of innovations with respect to the target of the innovation:

Product innovation: a new or significantly improved product with respect to its characteristics or intended uses. In the context of the Ecodesign and Labelling directives, an example for a product innovation would be the development of a new or significantly improved technological approach to increase a product's energy efficiency.
Process innovation: implementation of a new or significantly improved production or delivery method. In the context of the Ecodesign and Labelling directives, process innovations play a role

where production lines for already available energy efficient products are significantly improved, e.g. to allow for a more cost-effective production, thus facilitating the market entry of the product.
Marketing innovation: implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. In the context of our study, marketing innovations may include providing mobile applications to calculate the energy cost of products or the promotion of products based on their energy efficiency class.
Organisational innovation: implementation of a new organisational method in the firm's business practices, workplace organisation or external relations. In our study, organisational innovations play a lesser role as the main focus lies on technological innovations.

Furthermore, the Oslo manual distinguishes innovations by the degree of novelty associated with them. **Incremental innovations** represent minor improvements or simple adjustments in current technologies, whereas **radical innovations** imply paradigmatic changes leading to completely new technologies. A more refined classification of innovations with respect to their novelty was designed in (Henderson & Clark, 1990). However, for the purposes of this study the classification of radical vs. incremental innovation is considered sufficient.

2.1.2 Drivers of Innovation

Within the past decades, a great variety of models have been developed to describe the innovation process. Recent innovation models apply rather complex structures in order to capture the numerous interrelated factors that influence and drive innovation. In order to understand the possible impact of policy measures on innovation, it is instructive to review the early linear models of innovation developed since the 1960s (Godin & Lane, 2013).

The early **technology-push model** of innovation postulates that technological innovations are triggered by basic science, then go through a stage of applied science and development and are finally commercialised (see Figure 2 upper part). Examples for technology push factors that can influence the innovation behaviour include the emergence of new technologies to be exploited, new collaborations with research institutions, or new funding opportunities.

In the **demand-pull model** market forces are the main driver to initiate technological innovation, followed by the development and manufacturing stage and finally going on the market (see Figure 2 lower part). Demand-pull factors that influence the innovation behaviour of companies include, for example, opportunities to enter new markets, new demands from clients or the increased pressure from competitors.

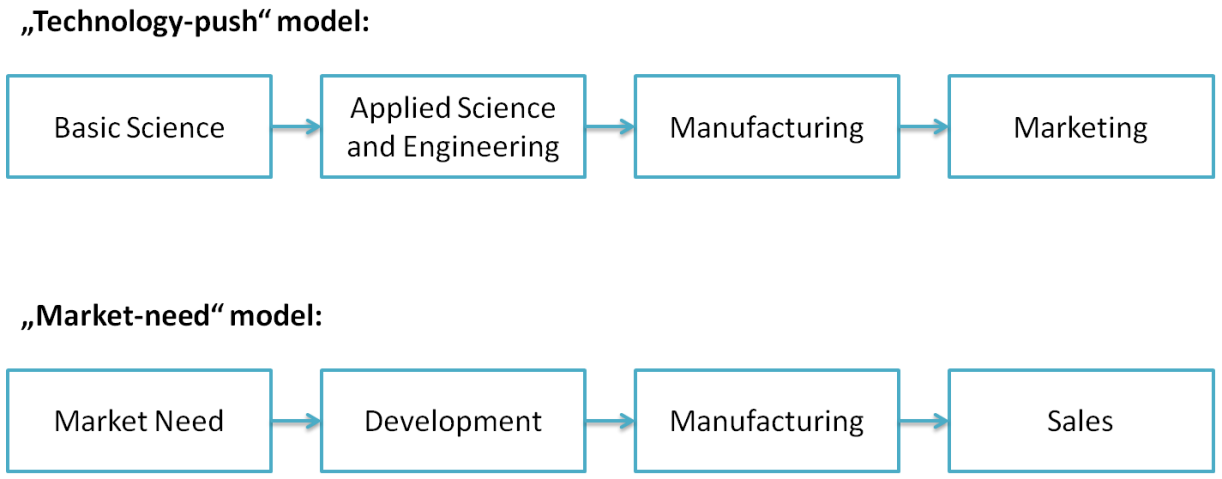


Figure 2: Early models of innovation. Figure adapted from (Godin & Lane, 2013).

The innovation behaviour of firms is typically influenced by a variety of factors including both technology-push and market-pull aspects. The results of the 2009 innobarometer survey show that the firms were more likely to cite demand-pull factors as positive influences on innovation than technology-push factors (Miles, 2010).

2.2 Innovation impact of environmental policy

The question of whether, and under what conditions, environmental policy may spur innovation has been a controversial discussion since the seminal work of Porter & Van der Linde (1995). The so-called Porter hypothesis states that well-designed environmental regulation may have a positive impact on innovation and business performance. The link between environmental regulation, innovation and business performance that is described by the Porter hypothesis is schematically displayed in Figure 3. The connection between environmental regulation and innovation (left-hand-side connecting arrow in Figure 3) is referred to as the "weak" version of the Porter hypothesis (Jaffe & Palmer, 1997). This weak version does not make a statement on whether the innovation is good or bad for firms. The right-hand side connecting arrows in Figure 3 display the link of innovation and environmental performance as well as business performance. The arrow on the lower right-hand side reflects the "strong" version of the Porter hypothesis, stating that environmental regulation may lead to an increase in firm competitiveness.

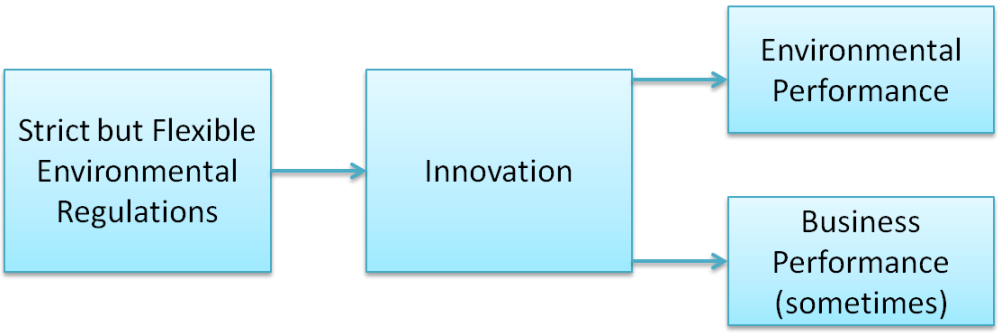


Figure 3: Schematic representation of the Porter Hypothesis. Figure adapted from Ambec, Cohen, Elgie, & Lanoie, 2011.

Since the article by Porter & Van der Linde, 1995, possible factors determining an innovation-friendly approach to environmental policy have been discussed widely. The work of Porter & Van der Linde, 1995 lists a set of principles of regulatory design that promote innovation and competitiveness, including the following:

- *Enact strict rather than lax regulation:* Companies can handle lax regulation incrementally, often with end-of-pipe or secondary treatment solutions. Regulation, therefore, needs to be stringent enough to promote real innovation.
- *Employ phase-in periods.* Ample but well-defined phase-in periods tied to industry-capital-investment cycles will allow companies to develop innovative resource-saving technologies rather than force them to implement expensive solutions hastily, merely patching over problems.
- *Make the regulatory process more stable and predictable.* The regulatory process is as important as the standards. If standards and phase-in periods are set and accepted early enough and if regulators commit to keeping standards in place for, say, five years, industry can lock in and tackle root-cause solutions instead of hedging against the next twist or turn in government philosophy.
- *Require industry participation in setting standards from the beginning.* Industry should help in designing phase-in periods, the content of regulations, and the most effective regulatory process. A predetermined set of information requests and interactions with industry representatives should be a mandatory part of the regulatory process.
- *Develop strong technical capabilities among regulators.* Regulators must understand an industry's economics and what drives its competitiveness.
- *Minimise the time and resources consumed in the regulatory process itself.* Time delays in granting permits are usually costly for companies. Self-regulation with periodic inspections would be more efficient than requiring formal approvals.

The work of Jänicke, 2008 specifies additional criteria for the innovation-friendliness of regulation and policy instruments that include that they should be open and flexible and support innovation as a process and take account of the different phases of innovation and its diffusion.

Several studies reinforce that the stringency of regulations (e.g. aiming at achieving challenging environmental objectives) is one of the most important factors that influence the innovation impact (Leitner, Wehrmeyer, & France, 2010), (Ashford & Hall, 2011) (Frondel, Horbach, & Renning, 2004).

As stringent regulations require a change in order to comply with the regulation, they are often referred to as inducing "compliance" innovations. The degree of stringency furthermore influences the type of innovation that is induced: Stringent and disruptive regulations tend to promote more radical innovation, whereas the moving target approach of gradually increasing stringency over time is more likely to result in incremental innovation (Blind, 2012).

A study on the impact of regulation on innovation in the United States (Stewart, 2010) identifies three main dimensions that influence the innovation impact of new regulations:

- Flexibility: describing the number of implementation paths firms have available for compliance.
- Information: measuring whether a regulation promotes more or less complete information in the market.
- Stringency: measuring the degree to which a regulation requires compliance innovation and imposes a compliance burden on a firm, industry or market.

The study points out that each of these three dimensions largely influences the innovation impact of a regulation, where "greater flexibility and more complete information generally aid innovation; with stringency, there is a trade-off between the compliance burden and the type of innovation desired, as more radical innovation will generally come at a higher cost."

There are conflicting arguments regarding the influence of company size on the innovation impact (Leitner, Wehrmeyer, & France, 2010). On one hand, larger companies have a larger capital base to fund innovation research than smaller companies. On the other hand smaller companies tend to have a larger flexibility and adaptability and may be more innovative than larger firms. Both viewpoints were supported in the interviews undertaken in this study.

2.3 Empirical evidence of innovation impact

There is a rather extensive body of literature investigating empirical evidence of the innovation impact of environmental policy. From a methodological point of view, the studies either use purely qualitative approaches (e.g. case studies), purely quantitative approaches (e.g. surveys, patent data or R&D data), or a combination of both. Table 1 provides an overview over the main innovation indicators used in the literature.

Table 1: Overview over the main innovation indicators used in the literature

Innovation indicator	Advantages	Disadvantages
Surveys and Interviews	Allow collection of detailed information (OECD, 2011) Allow for macro and micro scale studies (OECD, 2011) Primary source of information (OECD, 2011)	Can be very costly (OECD, 2011) Lack of standardisation hinders cross-country analyses (OECD, 2011)
R&D expenditure (number of scientific personnel)	Allows for macro and micro scale studies (OECD, 2011) Primary source of information (OECD, 2011)	Focus on the input of the inventive process (Ambec, et al., 2011) Not all innovations are R&D based (OECD, 2005) Incomplete statistics and general lack of data at macro level (governmental) and micro level (private companies) (OECD, 2011)
Pollution Abatement Control Expenditure (PACE)	Primary source of information (OECD, 2011) Proxy for environmental regulatory stringency (Popp, 2010) Strong relationship with environmental innovation (Popp, 2010)	Focus only on end-of-pipe environmental technologies (Ambec, et al., 2011) Aggregate proxy that might not be suitable to represent regulation stringency particularly in cross country studies (regulation heterogeneity) Difficulty of identifying expenditures on environmental compliance compared to what they would have been in the absence of environmental regulations (Ambec, et al., 2011)
Patents	Focus on the output of the inventive process (Ambec, et al., 2011) Provide a wealth of information on the nature of the invention and the applicant (Ambec, et al., 2011) Data is readily available (Ambec, et al., 2011) Data is discrete (statistical analysis) (Ambec, et al., 2011). Data can be disaggregated to specific technological areas (Ambec, et al., 2011) There are very few examples of economically significant inventions	Some innovations are not patented, and some are covered by multiple patents (OECD, 2005) Many patents have little technological or economic value, and others have very high value (OECD, 2011) Cannot detect industrial secrecy. Secondary source of information (OECD, 2011)

Innovation indicator	Advantages	Disadvantages
	which have not been patented (Dernis, et al., 2001)	
Scientific Publications	Useful for analysing the diffusion of knowledge among inventors (and between countries), based on co-publications and citation (OECD, 2011) It is an "output" indicator of innovation (OECD, 2011)	It is only an indirect indicator of a market output (OECD, 2011). Publication in a peer-reviewed journal reflects a scientific advance, but not necessarily one that has commercial applications (OECD, 2011).

The OECD Manual on Impacts of Environmental Policy Instruments on Technological Change (OECD, 2007) surveys the empirical literature, assessing whether there is evidence of an effect on the rate and direction of technological change associated with different environmental policy instruments. The papers that are reviewed clearly observe changes in invention, innovation and diffusion of technologies, although the direct causal link with environmental policy is not always clear in specific cases. The overall conclusion seems justified that environmental policy in general has an impact on at least the direction of technological change. This conclusion holds, regardless of the type of instrument applied, *i.e.* whether command-and-control or market-based instruments are used. Based on the literature review, the author further concludes that proper design of instruments is extremely important. It is observed that patent counts typically provide a good indicator for the direction of technological change.

The connection between environmental policy-induced eco-innovation and firm performance is further examined by Rennings & Rammer, 2010. Using data on firms from the German innovation survey (the "Mannheim Innovation Panel"), the article investigates if environmental policy-triggered innovations have similar success for firms as market driven innovations. The authors find that that both product and process innovations driven by environmental regulation generate similar success, in terms of sales of new products and cost savings, as other innovations do. Furthermore, they find that the majority of innovations induced by environmental regulation were product innovations (82 percent of all firms with innovations driven by environmental regulation) while 31 percent introduced process innovations.

Another report (DG Enterprise/Innovation, 2004) studied the relationships between regulation and the emergence of new markets by analysing the various impacts of different regulations on innovation. It states that in general, environmental regulations may have a positive impact on innovation by creating incentives for new processes creating less environmental damage and for the development of new products, while at the same time it may have a negative impact on innovation by restricting innovative activities and hampering the competitiveness and therefore their innovative capacity. The general overview and the case studies performed in the environmental sector underline that various aspects proved to be very influential in deciding on the innovative effects of environmental regulation: the existence and performance of general economic regulation, the institutional processes which determine the interaction between R&D institutions, suppliers of

technology and users to create knowledge spillovers, or the existence of long-term policy goals such as water quality or the doubling of renewable electricity supply. Furthermore, the report states that, since innovation is a complex process, the promotion of innovation by regulatory policies requires a comprehensive approach, co-ordinating or even integrating the regulatory policies of all the regulatory bodies, e.g. it is not sufficient to set a favourable framework for research, it is also necessary to stabilise the demand for new products and services.

Johnstone, Hascic, and Popp (2008) examined the effect of environmental policies on technological innovation in the field of renewable energies in 25 countries for a period of 26 years using patent counts. The study finds that "public policy plays a significant role in determining patent applications" and that "different types of policy instruments are effective for different renewable energy sources" (Johnstone, Hascic, & Popp, 2008).

Nicolli, Johnstone, & Söderholm (2012) studied the innovation impact of national and EU recycling policy conducting an econometric analysis on patent data. The study found that the policy measures have a significant positive impact on innovation in the plastic waste sector (Nicolli, Johnstone, & Söderholm, 2012).

Noailly, Batrakova, & Lukach (2008) undertook a case study in the Netherlands reviewing nine technological areas involving energy efficiency in buildings over a time period of 27 years, where technological innovation was assessed using patent data. Their major findings indicate that regulation produces "a positive impact on the incentives for firms to innovate" (Noailly, Batrakova, & Lukach, 2008). The authors also acknowledge restrictions on their study because this includes only one country and several policies were introduced almost simultaneously preventing a disaggregated analysis.

2.4 Innovation impact of the Ecodesign and Labelling directives

The literature review allows some conclusions to be drawn on the expected innovation impact of the Ecodesign and Labelling directives. First of all, analysing the three dimensions (stringency, information, flexibility) that may have an influence on the innovation impact of the directives, the following observations can be made.

- The mechanism to induce innovation of the policy instruments is rather different for Ecodesign and Energy Labelling;
- For Ecodesign, the stringency of the regulation is a key factor for inducing innovation;
- For Labelling, the increase of market information is a key factor for the innovation impact.

Concerning the factors that determine the innovation friendliness of regulations,

Table 2 displays our first analysis of the Ecodesign and Labelling directives with respect to the criteria specified in (Porter & Van der Linde, 1995).

Table 2: Analysis of design principles of the Ecodesign/Labelling directive with respect to innovation friendliness

Design principles	Ecodesign/Labelling directive
1. Focus on outcomes, not technologies.	Product oriented with specific outcomes.
2. Enact strict rather than lax regulation.	Subject to assessment for each product. However, the objective of Ecodesign is to remove the worst products from the market.
3. Regulate as close to the end user as practical, while encouraging upstream solutions.	Energy performance (design stage or upstream) throughout the product lifetime (end user period).
4. Employ phase-in periods.	The regulation is developed in phases and also deployed in stages over time (however if each phase is not sufficiently stringent then at most incremental innovation will be induced rather than radical).
5. Use market incentives.	The Labelling directive contributes to product differentiation in the market that can be utilised by the companies.
6. Harmonise or converge regulations in associated fields.	It supersedes previous related regulations to conform to an EU-wide up-to-date regulation.
7. Develop regulations in sync with other countries or slightly ahead of them.	Subject to assessment, partly fulfilled.
8. Make the regulatory process more stable and predictable.	In principle, the implementing directive is developed along with the manufacturers providing an informed and transparent process and room for participation.
9. Require industry participation in setting standards from the beginning.	Industry is involved in the regulatory processes
10 Develop strong technical capabilities among regulators.	Information transfer between consultants and Commission crucial. Frequent turnover of Commission staff responsible for a technical area may slow the process.
11. Minimise the time and resources consumed in the regulatory process itself.	Variable because of the nature and diverse complexity of EuPs/ErPs and due to the participation of numerous stakeholders for each product.

Concerning previous literature, the innovation impact of the Labelling directive has been considered in the DG Environment study of 2009. It includes case studies in several sectors that are affected by the Labelling directive and draws a series of conclusions relevant for this study:

- The study finds evidence of where demand pull instruments can be designed to help bring forward unexplored eco-innovations which are searching for a market, or to bring forward a product that offers a large potential for eco-efficiency.
- The study observed that a combination of market pull instruments and regulations is an effective way to increase the innovation impact.

- Education plays an important role for the innovation impact of market pull instruments, as informed consumers are more likely to make eco-rational decisions.

The evaluation of the Ecodesign directive (CSES 2012) mentions its impact on innovation, however, the main focus of the study is rather on the effectiveness of the directive with respect to its central goals of energy saving. The innovation impact of Ecodesign and Labelling was subject of an ECEEE seminar held in Brussels in March 2013. The presentations of the workshop reflect the fact that in some sectors, the Ecodesign and Labelling directives have had a positive impact on innovation, whereas in other sectors opportunities were missed. The presentations have been considered to direct our study and some of the presenters have been interviewed within the scope of this study.

2.5 Firm typologies

In order to analyse the engagement of manufacturers in the legislative processes of the Ecodesign and Labelling regulation, we reviewed literature contributions on typologies of manufacturer involvement based on typical behaviour of manufacturers and industry associations during previous EU legislative processes, such as industries/manufacturers trying to be leaders in energy efficiency actively supporting the legislative process, or industries/manufacturers working against any legislation and trying to slow down or even stop the legislative process, and correlate the actions of each type with the legislative process, for example at which point of the process did which type of industries/manufacturers start investments in new technologies anticipating the legislation, or at which stage did which type of industries/manufacturers request significant changes.

We conducted a literature review of potentially relevant typologies, from which a draft typology was created and questions to test its validity were developed (see Appendix II). These questions were asked to firms, industry associations and other stakeholders as part of our product group case studies. Our analysis of these results produced a refined final typology (See Section 5.2).

Based on the range of literature reviewed (see Appendix II) we can make the following key observations:

- The impact of a regulation is important in determining the type of firm response – firms self-interest is a powerful driver of the strength and type of its response…
- …but regulations are not the only motivator for many firms – other internal (i.e. financial, company philosophy, leadership, CSR, process efficiency) or external (market-pull, company vision) factors are also important drivers of innovation and response.
- The opportunity to actually influence the regulation is an important factor in the type of response and engagement. The opportunity to influence is a product of the legislative system, with a multiple institutional form in the EU.
- Some firms, regardless of innovativeness, are likely to take a less constructive position towards the regulation as they are naturally reluctant to change, perhaps even opposing the regulation on grounds beyond simple financial self-interest, i.e. ideological opposition to regulation in general.
- Firms at the leading edge tend to go beyond regulations anyway, with their company vision or mission driving their actions.

- Firms' innovation strategies and activities are varied, with typologies pointing to a generally proactive and riskier strategy against a more passive strategy.
- Direct engagement with the legislative process is expensive, therefore typically only a few of the biggest firms will participate, alongside associations.
- A change process has different stages, with resistance being a natural stage, typically before change, acceptance and adaptation.
- Individuals deal with change in different ways, a framework of active vs. passive, constructive vs. destructive, could provide insight into how and why firms may also act.

3 Secondary data analysis

This chapter presents the findings of our analysis of secondary data reflecting the innovation behaviour of companies that are affected by the Ecodesign and Labelling regulation. Typically, such innovation indicators are classified in *input* and *output* indicators. Input indicators, such as R&D spending or the number of personnel working in R&D, measure the input to innovation. On the contrary, output indicators, such as patent data, measure the output of innovation activities. All innovation indicators have their advantages and drawbacks, and the reliability of the results is typically enhanced when several indicators are combined. Within the scope of this study, the R&D funding from the European investment bank for activities in energy efficiency and patents related to energy efficiency were analysed.

3.1 R&D funding for activities in energy efficiency from the European Investment bank

The European Investment Bank provides a database of R&D projects that have been financed since the year 2001. It contains a short description of the project that specifies the product or sector that is addressed by the measure, as well as the main goals. In our study, the database was screened in order to identify projects related to improving the energy efficiency of products affected by the Ecodesign and/or Labelling regulation.

Out of the 766 projects financed between 2001 and 2012, eight projects were identified to be related to the improvement of energy efficiency in products affected by the Ecodesign and Labelling directives (see Table 3).

Table 3: Projects funded by the European Investment Bank related to energy efficiency of products regulated by Ecodesign and/or Labelling (2001 – 2012).

Year	Company	Sector	Funding (Mio €)
2004	BSH	White goods	300
2008	Not specified	White goods	220
2009	Vaillant GmbH	Heating	120
2009	Pirelli	Tyres	200
2011	Powertrain	Electric motors	30
2011	BSH	White goods	300
2012	Arcelik	White goods	100
2012	Pirelli	Tyres	150

The total number of funded projects is not sufficient to perform a statistical analysis of the relation between the legislative processes and the funding requests. However, Figure 4 displays a graphical analysis of the funding requests and the implementing measures of the Ecodesign/Labelling legislation in the respective product groups.

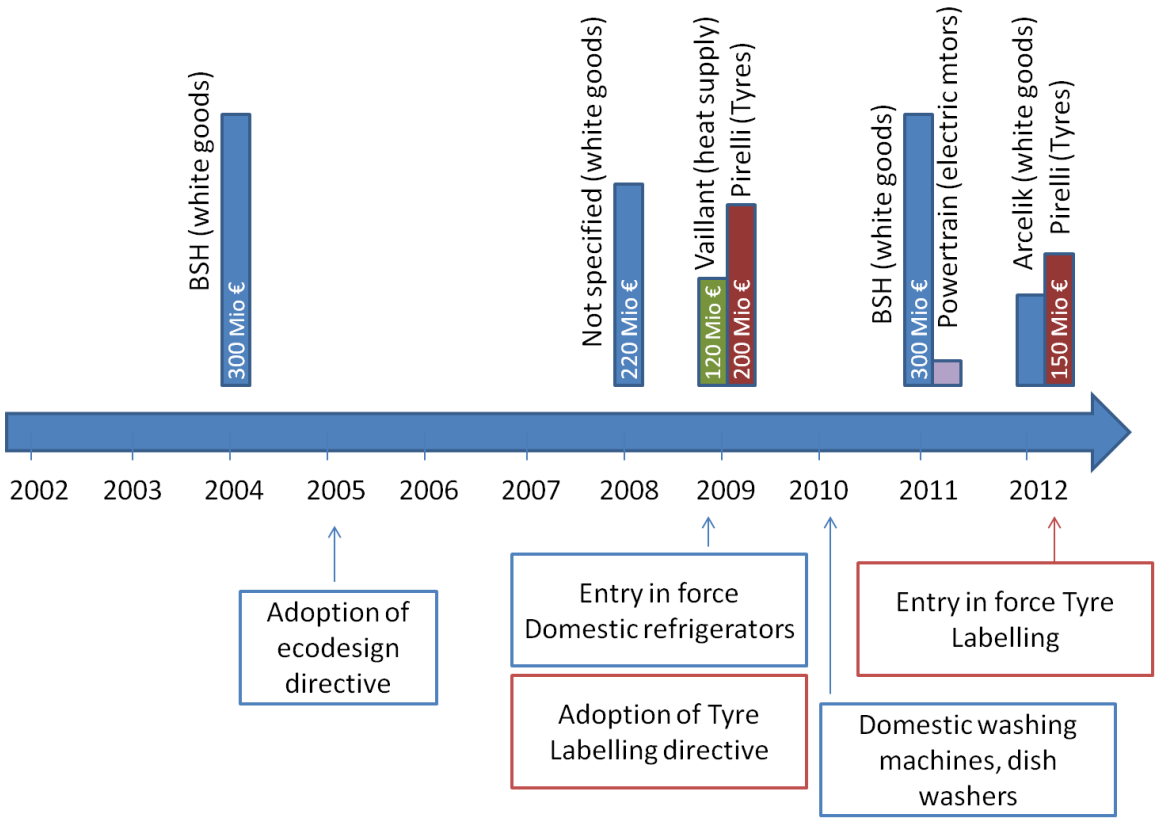


Figure 4: R&D funding from the European Investment bank and Ecodesign/Labelling legislation

The analysis of the R&D funding data from the European Investment Bank allows the following observations to be made:

- For white goods, several companies requested funding during the time of the implementing measures being investigated, defined and coming into force. The Ecodesign legislation possibly contributed to this development, however the limited number of data points does not allow for a statistic analysis. For tyres, one company (Pirelli) requested funding both in 2009, when the tyre Labelling directive was adopted and in 2012, when the legislation came into force. Unfortunately the company was not available for a case study interview, such that a causal relationship with the legislation could not be established.
- For both heating supply and electric motors, only one request was issued in the observed time frame.
- In general, even though for some sectors there were requests during the time frame relevant to the regulatory processes, due to the limited amount of total requests no clear conclusions can be drawn from the analysis.

3.2 Patent statistics

Patents have been used widely to analyse the innovation impact of environmental regulation. Whereas for renewable energies, the connection between policy measures and patenting activities has been identified in several studies, for energy efficiency, the policy impact on patenting activities has received much less interest so far. This may partly be explained by the fact that energy efficiency is not included in the patent classification and tagging system, such that it is much more challenging to identify patents related to energy efficiency than for renewable energies.

This chapter presents the results of our study on the impact of Ecodesign/Labelling on the patenting activities for a selection of products under regulation. As the aim is to investigate the patenting trends before and after the regulatory measures, we select only products for which the regulation has been in force for at least four years.

3.2.1 Methodological approach

Identifying the impact of Ecodesign/Labelling on the patenting activities of the manufacturers requires exploring patent statistics related to energy efficiency during the time span in which the regulation was implemented. However, the patenting activity is influenced by a number of factors other than regulation. Examples include global economic events, global patenting trends, sector-specific events, etc.

Our evaluation of the impact of the Ecodesign/Labelling directive on innovation takes into account the following factors:

1. **General patenting activity:** In general, the global patenting activity has increased considerably during the last decade. It is essential to take into account this general trend, in order to avoid overestimating the influence of the policy measures.
2. **Product specific patenting activity:** For each product, a number of events and circumstances may lead to a change in the patenting activity from one year to another. Examples for such events include radical technological advances, large changes in the market structure or company landscape or shifts in consumer behaviour.
3. **General economic evolution:** The evolution of the economy is typically reflected rather strongly in the patenting activity. Years of economic crisis result in downward kinks in the patent count statistics. The data that is collected for the patents related to energy efficiency therefore has to be reassessed taking these trends into account.
4. **Policy impact:** The policy impact is the variable of most interest to this study. The effect of the Ecodesign directive is assessed by defining the time at which the directive can have an influence on the patenting activities. For the products that are studied here, the implementing directives came into force around the year 2009. However, this is not necessarily the relevant date to consider when assessing the influence of the directive. On the one hand, the manufacturers start their innovation activities well in advance of the date the directive comes into force - product cycles are typically around five years and products have to be adjusted in advance. On the other hand, there is a time lag between the initiation of innovation activities and the actual publication of a patent. For this study, the "positive" time lag reflecting the

time between the invention and the patent is assumed to be around three years, whereas the "negative" time lag reflecting the initiation of innovation activities before the directive comes into force is assumed to be around five years depending on the product.

Factors 1-3 in the above list are treated in an aggregated way by using the total number of patents for a given product as a reference against which the energy efficiency-related patents are normalised. This approach has the advantage of simplifying the analysis, as one single variable accounts for all trending behaviour. The methodology for identifying patents related to energy efficiency is described in Appendix I: Patent search methodology.

3.2.2 Visual analysis

To visualise the relationship between the Ecodesign directive and innovation, the increase of the relative number of patents with respect to the base year 1990 is displayed in Figure 5 for five products. From the visualization, it becomes clear that for most products, no significant changes have occurred in the years around the regulatory processes. This relationship is analysed in more detail in the following section.

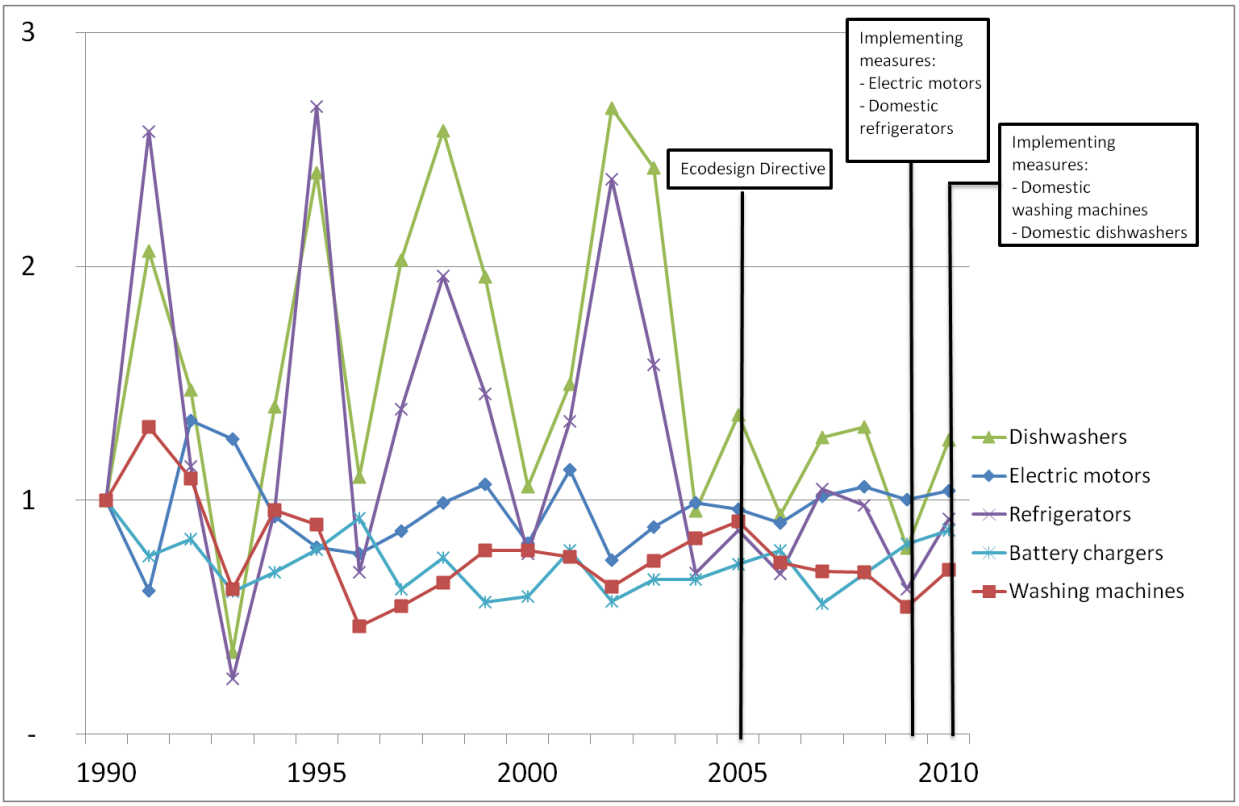


Figure 5: Relative increase of patents related to energy efficiency with respect to base year 1990. The majority of products do not show a significant growth in the years around Ecodesign regulation.

3.2.3 Quantitative analysis

A quantitative indicator was defined for the impact of the Ecodesign/Labelling regulation on the patenting activity by comparing the following two parameters:

1. **Energy efficiency gain:** The difference in the percentage of patents related to energy efficiency for a given product before and after the regulation: If the regulation has an impact, the percentage of energy-efficiency-related patents should increase. In order to take into account both the fact that companies start to innovate around 3-5 years before the regulation comes into force and the fact that patents are claimed around 1-5 years after the innovation activity was initiated, the value to measure patents with regulation is calculated by taking the mean of a three-year time span prior to regulation coming into place. For the value before regulation, the three years previous to the formerly named period are considered.
2. **Standard deviation:** Typically the number of patents fluctuates from one year to the other. The difference between the relative amount of patents before and after regulation is therefore compared to the standard deviation of the patent statistics in the time span that is considered.

Table 4 displays the energy efficiency gain and the standard deviation for the five products displayed in Figure 5. The last row in Table 4 shows that no significant impact is observed for four products, and a low negative impact is observed for the remaining product.

Table 4: Quantitative analysis of the impact of the Ecodesign and Labelling on patent statistics.

	electric motors	dish washers	fridges	battery chargers	washing machines
energy efficiency gain	1,2%	-1,9%	-0,4%	0,7%	-2,4%
standard deviation	1,3%	5,0%	3,3%	2,9%	1,8%
impact factor	no	no	no	no	low negative

3.3 Conclusions

The results of the secondary data analysis suggest that to date the Ecodesign and Labelling directives did not have a significant impact on the patenting activity of the sectors addressed. This implies that, so far, the Ecodesign directive has not had a strong impact on technological inventions (early stage innovations). As will be shown in the following chapters, this is supported by our case study results from the majority of product sectors.

To some extent, it is surprising that a directive that has the potential to be "innovation friendly" (see analysis in Chapter 2) does not have an impact on the patenting activities. However, it is important to keep in mind, that innovation and invention are not equal. As patents are basically an indicator of inventions, the patent analysis does not address the impact of the Ecodesign directive on such innovation activities that are not related to inventions (e.g. implementation of new production lines, bringing into market of existing technologies, etc.). These aspects are covered in the case study analysis (see Chapter 4 and 5).

Furthermore, a key point regarding the innovation-friendliness of environmental regulation (Ambec, Cohen, Elgie, & Lanoie, 2011) is that ambitious levels need to be set for the industry. In case of the Ecodesign directive, especially for white goods, this was not necessarily the case - the main goal of the directive was to remove the worst (i.e. least efficient) products from the market. In this sense, the minimum efficiency standards cannot be considered to be overly ambitious with respect to inventions (separate to innovations).

It would be interesting to observe how the impact of the Ecodesign and Labelling directives on the patent activity for the regulated products evolves in the longer term. At the current stage, the measures are still rather recent and, in some cases, the first set of requirements was set at a rather low level. As the stringency successively increases, the long-term effect may be different from the results obtained in this first stage.

In summary, the secondary data analysis found that the Ecodesign directive does not have a significant impact on the patenting activities of the manufacturers of the products under regulation. This result implies that, for the technologies that were investigated, energy efficient technologies already exist, however, without regulation there is only a limited market for them. As will be discussed in the case study analysis (see Chapter 4 and 5), Ecodesign and Labelling do have an impact on the production lines and processes, suggesting that the directives can be useful tools to enable or accelerate the diffusion of high-efficiency technologies that would otherwise not have entered the market at a given point in time.

4 Case study analysis

This chapter presents the results of our case studies, in which a total of more than 30 interviews were conducted with companies, associations, industry experts, NGOs and member state experts. The main research questions and the methodology will be outlined in Section 4.1. The subsequent sections present the results of the case studies at sector level. A cross-sectoral analysis is performed in Chapter 5.

4.1 Purpose and methods

The case studies focused on three main research questions (Figure 6): The central task of this project was to evaluate the impact of Ecodesign and Energy/Tyre Labelling on R&D and Innovation. Subordinate research tasks were to define a typology of manufacturers and to derive recommendations on how to improve the innovation impact of the directives.

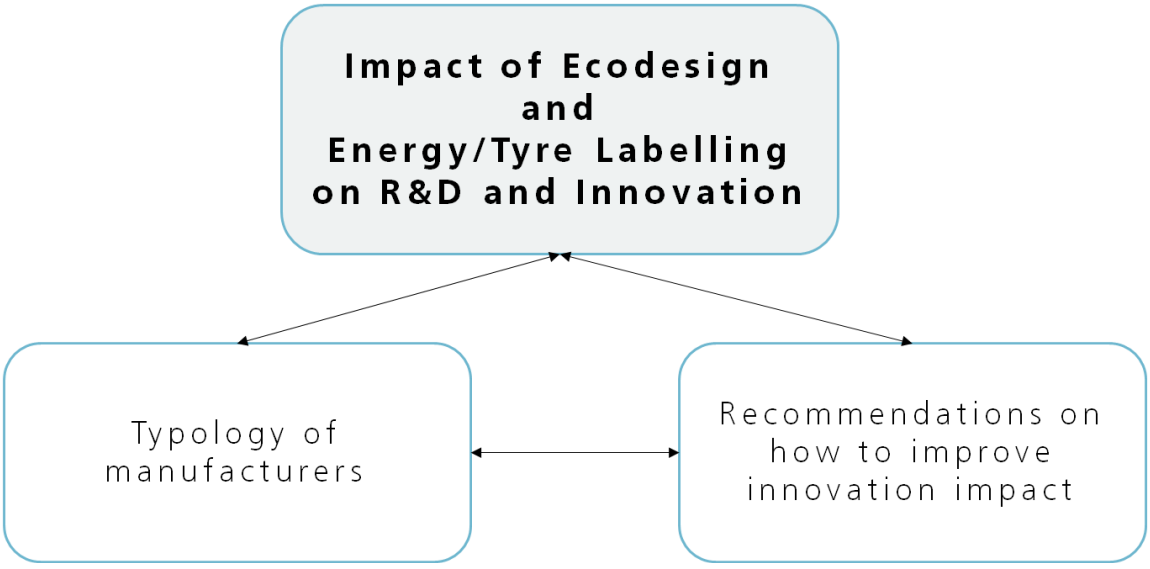


Figure 6: Schematic view of the main research question

In order to address these questions, it was essential to study manufacturers of a wide range of products that are affected by the regulation. For the purpose of this study, the following seven product clusters were considered:

1. Tyres
2. Electric motors and pumps
3. White goods
4. Electronics
5. Lighting
6. Air conditioning
7. Heat supply (boilers)

The sector specific results were then analysed and generalized in a cross case analysis (see Figure 7).

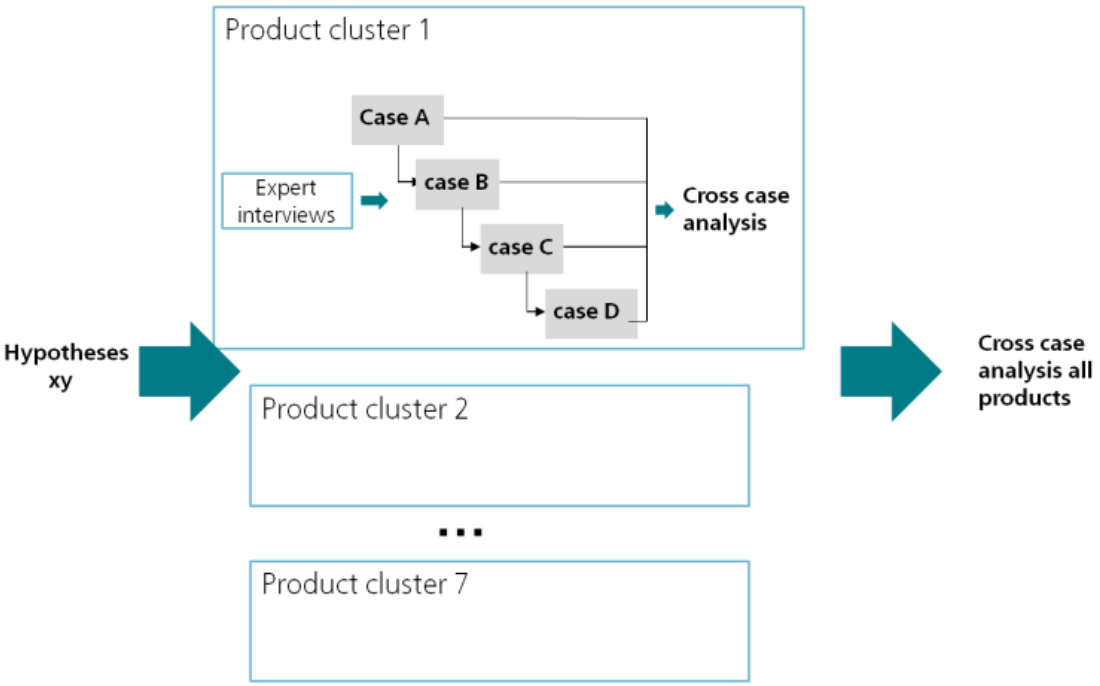


Figure 7: Schematic view of the multi-case-study approach.

The case studies were based on a semi-structured interview questionnaire. The questionnaire was structured in five blocks covering the following aspects:

1. Function and role of innovation in the company.
2. Engagement in energy efficiency/environmental innovation.
3. Role of Ecodesign and Labelling for innovation activities.
4. Company's engagement in the regulatory process.
5. Recommendations to improve the legislative process.

Additionally, a questionnaire that addressed the characteristics of SMEs was developed and complemented the general questionnaire whenever SMEs are interviewed.

The selection of firms for the case studies reflects our main research questions. In particular, the following points were taken into account:

- Stringency of regulation: The Ecodesign standards do not show an equal level of ambition for all products. In our case selection we selected manufacturers of products regulated under rather ambitious standards as well as for products where the regulation is less challenging for the companies.
- Company size: As we expect that the innovation impact of the legislation depends rather strongly on the size of the company, we studied both large companies and SMEs.
- Level of innovation activity: We expected that the level of innovation activity of a company would play an important role in its reaction and involvement in the legislative processes.

The level of innovation activity of the companies that were selected was estimated using data on their R&D spending, information from the company web pages and possibly patent data.
Involvement in the legislative process: Whenever possible, the Ecodesign documents were scanned in order to characterise the company's level of involvement in the legislative process.

4.2 Case study results: Tyres

4.2.1 Products

This case study focused on the tyre Labelling legislation and comprised passenger car tyres, light commercial vehicle tyres and heavy commercial vehicle tyres.

The energy efficiency of tyres is directly related to their rolling resistance, where tyres with a low rolling resistance lead to reduced fuel consumption. However, the rolling resistance is also directly related to safety aspects such as the wet grip, which is therefore also included in the tyre label. Furthermore, the external noise performance is displayed on the label.

Currently, the main technological developments to achieve a low rolling resistance while maintaining safety aspects are related to advanced material compositions. The case study therefore focuses not only on tyre manufacturers but also on manufacturers of chemical compounds as well as plant manufacturers.

4.2.2 Market structure

The tyre market is divided into two main segments: The original equipment market (OEM; automotive industry), which accounts for about 25% of the tyre production, and the replacement market, which constitutes the main share of about 75%.

European tyre production, estimated to be 4.6 million tonnes in 2012, represents 21% of world tyre production (ETRMA 2012). In 2012, 252 million passenger car & light commercial vehicle tyres were sold. These correspond to almost 90% of the total tyre market both by volume and value. By contrast, 9.6 million units of medium and heavy commercial vehicle tyres were sold (ETRMA 2012 and Eurostat).
In comparison to the OEMs, the replacement market offers much higher margins and is therefore extremely competitive (Frent 2010).

4.2.3 Labelling in the Sector

The tyre Labelling legislation came into effect on 1st November 2012[2]. It applies to passenger car tyres, light commercial vehicle tyres and heavy commercial vehicle tyres, produced from 1st July 2012 (Date of Production Code "2712")[3].

The label shows information regarding three criteria: fuel consumption, wet grip and noise (see figure 2), which are shortly described below.

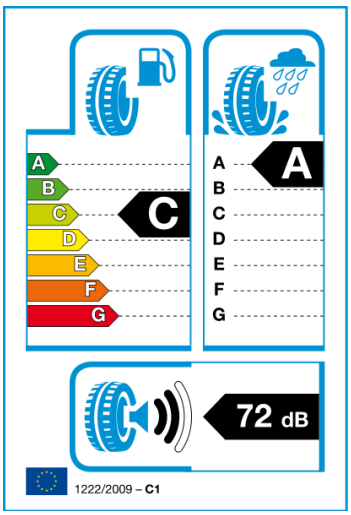


Figure 8: Tyre Label with the three criteria fuel consumption, wet grip and external noise

- **Fuel consumption:** is related to the rolling resistance and is the main factor in measuring the energy efficiency of a tyre. A recent field experiment showed that switching from D to B labelled tyres reduced the fuel consumption by around 8.5% (Lanxess 2013).
- **Wet grip:** is one of the most important safety characteristics of a tyre. Tyres with very good wet grip have a shorter braking distance in wet conditions. The basis for the wet grip criterion is the absolute stopping distance when driving 80 km/h.
- **External noise:** The external noise is quoted as an absolute value in decibel (dB) and is symbolized in a 3-wave pictogram. One wave indicates the best performance, which means that the noise level of the tyre is at least 3 dB (=double the noise level) below the

[2] REGULATION (EC) No 1222/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2009 on the Labelling of tyres with respect to fuel efficiency and other essential parameters.

[3] excluded from the scope are the following categories: Retreaded tyres, Professional Off Road tyres, Racing tyres, Studded tyres, Temporary use spare tyres, Tyres designed to be fitted on vehicles registered for the first time before 1 October 1990, Tyres whose speed rating is less than 80 km/h and Tyres whose nominal rim diameter does not exceed 254 mm or is 635 mm or more.

future legal limit. Three black waves depict the weakest performance and represent a noise level that is greater than the future limit but complies with today's noise regulation.

4.2.4 Case selection

As innovation towards more energy efficient tyres is strongly related to the materials that are used, our case study includes companies along the tyre manufacturing chain. Furthermore, we conducted interviews with a trade association as well as an environmental organisation.

4.2.5 Innovation impact

Most of the companies that were interviewed stated that the introduction of the label resulted in a positive impact on their innovation activities. Even though developments towards high-efficiency tyres were initiated in order to meet the needs of the automotive industry before the Labelling legislation, the companies stated that Labelling had provided a strong additional impulse.

Several interviewees welcomed the fact that Labelling provided a tool for differentiating their products, which eventually made it easier to achieve a return on their investments in innovation. This was especially true as tyres were described to be a low-interest product, where companies have limited opportunities for product placement (several interviewees pointed out the fact that most people do not know the brand of their own tyres).

The legislation had an impact on innovation for tyre manufacturers, rubber manufacturers as well as for plant manufacturers. Innovation in improving the rolling resistance and wet grip are strongly driven by the rubber compounds. Furthermore, the new compounds require the development and adaption of machinery. The impact on the rubber manufacturers seems to have been at least as strong as for the tyre manufacturers.
The tyre manufacturers stated that their main activities included an extensive restructuring of the production lines.

The manufacturers stated that the innovation activities started around four years before the legislation came into place. The first AA-labelled tyre was presented five months before the legislation came into force - however, at that point a ready-to-market production was not yet possible.

4.2.6 Involvement in the legislative process

Most of the companies that were interviewed stated that they were involved in the legislative processes, both through the association as well as individually. One interviewee stated that the decision-making within the association was rather difficult due to the strong competition and the rather different interests of the individual companies.

The attitude towards Labelling was rather different between the companies even although all of them stated that "in principle" they felt that it had a positive impact on their firm. Some companies were highly enthusiastic about Labelling and participated very actively in the regulatory processes and in

the promotion of the legislation. Other companies focused more on the shortcomings during the interview.

The main motivation for the companies' involvement in the regulatory processes was the maximisation of positive outcomes for the company. Companies that considered themselves as innovators and that already had a strong focus on energy efficiency before the legislation, showed a strong positive involvement.

4.2.7 Recommendations

The positive impact of Labelling on the innovation activities of manufacturers could be enhanced by actively promoting the legislation once it is issued. Several interviewees stated that there was little positive press about the legislation, and that they would have appreciated a more active role of the Commission in promoting it.

For the tyre sector, where no standard measuring schemes for energy efficiency and wet grip had been in place before the Labelling legislation, one interviewee stated that the process could have been improved by first defining the testing procedure. The tyre companies felt it was confusing not to be able to know in which Labelling class their products would be placed.

4.2.8 Summary and Conclusions

The tyre Labelling legislation has had an impact on innovation across the production chain including manufacturers of rubber, tyres and production plants. The innovations that were induced were mainly at process level and can be considered improvements of existing products rather than radical innovations. The involvement in the legislative processes was generally positive, however it was evident that the main motivation for engagement was the maximisation of the firms' positive outcome.

4.3 Case study results: Electric motors, pumps and circulators

4.3.1 Products

This sector study deals with the innovation impact of the Ecodesign directive in the area of electrically driven motors and pumps. From the user perspective, energy efficiency is very relevant for both types of products, as long-term energy savings may easily outweigh the additional investments for more energy-efficient products in these applications.
Pumps and circulators were first addressed within the Ecodesign preparatory studies carried out under Lot 11. Circulators are a special type of pump - inline pumps typically used for re-circulation heating or cooling media in closed circuits. The preparatory study on circulators addressed small circulators mainly used in domestic applications as well as large standalone circulators used in commercial and residential buildings. The preparatory study on water pumps addressed water pumps

used in commercial buildings, in agriculture, in the food industry and for drinking water. Additional preparatory studies on pumps are currently ongoing within Lots 28 and 29. The preparatory study in Lot 28 specifically addresses wastewater pumps. The study carried out under Lot 29 deals with clean water pumps larger than those considered in Lot 11.

Electric motors were first addressed within Lot 11. The corresponding preparatory study focused on single speed three-phase motors with a medium power range between 0.75 and 375 kW.
A subsequent study within Lot 30 discusses motors with a rated power between 0.12 and 1000 kW. Thus, by including smaller and larger motors, this study has a wider scope than Lot 11. In general, electric motors are part of many other products analysed within the Ecodesign process, including pumps, fans or compressors.

The motor/pumps sector encompasses a large variety of different products and technologies. In general, at least two general trends towards higher energy efficiency can be observed. First of all, there is a trend for both motors and pumps towards better system integration. Whereas previously energy efficiency improvements in motors and pumps have been focused on improvements in the motors/pumps as such or various components, in recent years, a more pronounced trend towards a consideration of these components as part of larger systems can be observed. This brings new challenges for producers and implementers of such components as not only the motor or pumps itself has to be considered, but the entire system the component is used in. Secondly, energy efficiency of motors is currently discussed along the motor efficiency classes laid down in IEC 60034-30. IE1 denotes the lowest and IE3 the highest efficiency class. In the current standardisation process, extensions of these classes to include higher efficiency levels (IE4 and IE5) are currently being discussed. Not all motor technologies currently used may achieve these higher motor efficiency classes. Thus, increases in energy efficiency may necessitate changes to existing technological platforms, e.g. the materials employed.

4.3.2 Market structure

The market for electric motors and pumps consists of several large international companies holding the majority of market share as well as several smaller manufacturers. Some companies specifically manufacture pumps and/or motors or special types of them. Other companies possess a larger product portfolio where motors and pumps are one product among many others. Depending on the size of the companies and their products, manufacturers of electric motors often serve an international market, while the pumps market appears to have a slightly stronger focus on more regional, i.e. national, markets.

With regard to the market and sales structure it is important to note that motors and pumps are often provided to the end-user via an intermediary, e.g. a large distributor or OEM. In contrast to other product groups discussed within this study (e. g. refrigerators, dishwashers), most motors and pumps are not simple plug-in devices sold to consumers. They are most typically part of larger systems and therefore are usually sold in a business-to-business environment.

4.3.3 Ecodesign/Labelling in the Sector

An overview of the relevant Ecodesign/Labelling regulations for this sector is provided in Table 5. For electric motors, it is worth noting that a voluntary agreement for efficient low-voltage three-phase motors was introduced by CEMEP (European Committee of Manufacturers of Electrical Machines and Power Electronics) in 1998. This agreement was renewed in 2006 and in place until 2009.

At that time the International Electrotechnical Commission (IEC) published the IEC standard 60034-30 defining the worldwide harmonized IE efficiency classes. According to CEMEP statistics, many standard motors were replaced by more efficient motors during the time of the agreements.

However, only about 17% of motor sales in 2009 achieved the efficiency class IE 2 (or higher). For circulator pumps, Europump (the European Pump Industry association) set up a voluntary Labelling scheme in 2005, which has now been replaced by the Ecodesign requirements.

Table 5: Ecodesign studies and regulations for the considered product groups (source: EuP Network 2013).

Product	Ecodesign study	Regulation
Water pumps	Lot 11	Commission Regulation No 547/2012
Circulators	Lot 11	Commission Regulation No 641/2009 Amendment No 622/2012
Wastewater pumps	Lot 28	-
Large water pumps	Lot 29	-
Electric motors	Lot 11	Commission Regulation No 640/2009 Corrigendum
Other electric motors	Lot 30	-

4.3.4 Case selection

Within this sector, manufacturers of pumps and motors were interviewed. Two of the companies are mainly focused on either pumps or motors with Europe as their key market whereas one company is a large technology company active world-wide.

4.3.5 Innovation impact

The innovation impact of Ecodesign was considered in comparison to the previously established voluntary Labelling for pumps as well as the voluntary agreement for motors, which had been active before the Ecodesign implementing measures came into force. According to our interviewees, Ecodesign has a strong impact on the pump market and has induced process innovation and a radical restructuring of the production lines. However, its impact on more radical product innovations is limited as it rather serves to ban low-efficiency products from the market. The voluntary Labelling scheme that was in place before Ecodesign came into force served to stimulate competition to introduce more efficient products. In their view, a well-defined Labelling scheme comprises an efficiency index that is technology independent, takes various usage scenarios into account and is

sufficiently ambitious, such that, e.g. efficiency level "A" is not possible with best available technology and requires innovative products.
For motors, Ecodesign was considered important as the voluntary agreement that was in place previously had achieved the expected impact.
One interviewee highlighted the importance of not only European but global standardisation and regulation as drivers for innovation activities in the company. In addition, the new requirements in key branches and key applications drive innovations.

4.3.6 Involvement in the legislative process

The different companies were very active in the whole Ecodesign process. This was mainly through their respective association.

The pump industry in general and the companies interviewed in particular were very active and supportive in the Ecodesign process. Early on, their association supported well-defined standards in energy efficiency and helped formulating the efficiency index and prospective goals or minimum energy performance standards.

4.3.7 Recommendations

One interviewee highlighted that even though no EU Energy Labelling scheme had been introduced for their products, Energy Labelling schemes in other regions of the world brought administrative burdens and a variety of country specific requirements. Complexity therefore rose considerably for companies operating in the international market. One recommendation this company made was to try to reduce specific Labelling procedures in individual companies and to setup world-wide uniform standards. All interviewees highlighted that the EU should improve the market surveillance. They pointed out that producers from outside the EU claim to achieve current efficiency standards but that nobody verifies whether the minimum requirements are actually met.

The current Ecodesign requirements are generally positively received, especially for making customers aware of the life-cycle impact of motors and pumps. However, companies pointed out that energy efficient solutions not only depended on the components but also on the entire system. For example, they questioned whether the introduction of IE3 motors in conjunction with frequency converters is always the most energy efficient solution. Here, efficiency indices that take a system perspective have to be developed. Furthermore, the motor company pointed out that next to energy efficiency, resource efficiency should also be considered when further increasing existing minimum performance standards. According to the company, additional increases in energy efficiency may be only achieved by using especially scarce materials.

Thus, the following recommendations could be extracted from the case study analysis:

- Industry, best represented by its associations, has expertise in the field and should be integrated very early into the legislative process, but one has to make sure, that the associations are not dominated by large enterprises or individual companies.

- For motors and pumps, the system aspect is very relevant to the energy use. The development of a system approach to Ecodesign, which has already been started, mainly by the Europump, should be accelerated.
- High-quality experts with both technology and market knowledge need to accompany the process in order to complement the industry position and to support decision making.
- Market surveillance should not be neglected.
- The specific efficiency requirements should be ambitious to stimulate innovation and competition.

4.3.8 Summary and Conclusions

To summarise, the motor and pump case studies indicate that Ecodesign has had an impact on the innovation activities of manufacturers, however, it is not considered to have a strong impact on product innovation. It should be noted that not only the type of measure but also the implementation determines any potential impact on innovation.

4.4 Case study results: White goods

4.4.1 Products

This case study focused on white goods, particularly on cooling appliances. However, given the fact that most companies are active across different products within the white goods group, most of the companies interviewed discussed white goods as a whole, including cold and wet appliances.

The white goods is a relatively calm, low innovation market. The innovation that does occur normally comes in terms of additional features (e.g. digital controls, materials).

- Clothes Washers and Dryers
  The clothes washers and dryers market has not seen a great deal of radical innovation in recent times. Initially, dryer manufacturers did not respond to the label with radical improvement in the efficiency of their products, with most machines being ranked in the B and C classes. Reaching the A class required a fundamental change in technology, and this class remained empty for many years. However, many years after Class A was created, this was achieved with the use of heat pumps.
  The product trends that have been apparent in recent years include a move towards larger load capacities. Evidence suggests that this trend partly started because the Energy Label depended on the energy consumption per kg. The new Labelling classes relate to yearly energy consumption according to mixed loads and no longer to kWh/kg[4].

[4] Changing washing machines and driers: let's have a look at the laundry room (ECEEE, 2011)

- Dishwashers
  For over 10 years all of the dishwashers available have been labelled A or higher. This has led to the opinion that the label has not driven innovation because it was not stringent enough. Many current models already comply with the new A+++ rating (although it is not possible to directly compare the new A+++ with the old A because of the differences in the calculation method).

- Cold appliances: Refrigerators & Freezers
  There has been much discussion of (slim) vacuum panel doors (which have been in development since 2003); however these are not yet used. In cold appliances, improved energy efficiency can be achieved by using very good (better than A+++) insulation, design and compressors but this does not imply a technological leap. According to a recent study[5], there is further opportunity for technological improvement in the efficiency of household refrigerators, particularly by incorporating vacuum insulation panels and variable speed compressors. The study also mentions the need to revise the Energy Label as nearly the entire 2012 market in the EU is class A or higher[6].
  In February 2004, Arcelik won an award in the 'Energy Plus' Competition organised by the EU Energy Commission with 'the world's least energy consumption refrigerator model'. This fridge was almost as energy efficient as the A+++ fridges now and it was designed and in the market 10 years ago. This proved that companies already had the technology developed in their labs; the label transformed these products from lab to commercial products but there was no technological leap.

4.4.2 Market structure

Partly due to the low innovation and differentiation, and also due to high levels of competition and low margins, there has been considerable consolidation and outsourcing in the market over the last decade or two. The white goods industry in Europe is dominated by a limited number of players.

The demand pattern for white goods differs from other product groups. Demand is not fast moving, as product life cycles tend to be longer. As a consequence, leading manufacturers have different production locations across Europe, generally specialised in one product group and meeting the needs of the whole European market from one location. Most factories are located in Italy, Poland, Germany, Spain, Hungary and Turkey; and imports into Europe are decreasing[7].
Some of the key companies in the sector are listed in the table below along with their brands, country of origin, size and level of globalisation.

[5] Estimating potential additional energy savings from upcoming revisions to existing regulations under the Eco design and Energy Labelling directives (CLASP, February 2013).
[6] The current classification is from A+ to A+++ since 2012; in July 2014 the Ecodesign and Energy Labelling regulations for household refrigerating appliances will be reviewed.
[7] White goods distribution in the spotlight (Capgemini Consulting, February 2012).

COMPANY	BRANDS	COUNTRY	SIZE (N EMPLOYEES)	GEOGRAPHIC MARKET[8]				
				EUROPE	NORTH AMERICA	LATIN AMERICA	ASIA PACIFIC	AFRICA MIDDLE EAST
Electrolux	Electrolux, AEG, Frigidaire, Chef, Molteni, Zanussi, Kelvinator (& other national brands)	Sweden	55 000[9]	+++	+++	++	+++	++
Whirlpool	Whirlpool, Maytag, Jenn-Air, Amana, Bauknecht, KitchenAid, Brastemp, Consul	USA	68 000[10]	+++	+++	+++	+++	+
BSH	Bosch, Siemens, Gaggenau, Neff, Coldex, Balay, Pitsos, Profilo	Germany	Over 46 000[11]	+++	+++	+++	+++	+
Indesit	Hotpoint, Indesit, Scholtes	Italy	16 000[12]	+++	-	+	++	-
Arcelik	Arçelik, Beko, Blomberg, Elektrabregenz, Arctic, Leisure, Flavel, Defy and Altus	Turkey	23 000[13]	+++	-	-	+	++
Gorenje[14]	Atag, Asko, Gorenje, Pelgrim, Korting, Upo, Mora, Etna	Slovenia	10 895[15]	+++	+	-	+	-
Miele	Miele	Germany	Over 16 000[16]	+++	+++	+	+++	+
Haier Group	Haier, Casarte, Leader	China	Over 70 000[17]	+++	+++	-	+++	+++
Samsung	Samsung Electronics	South Korea	88 000[18]	+++	+++	+	+++	+
LG	LG	South Korea	87 000[19]	+	+	+	+++	+

[8] Key: +++ = predominant presence in the region; ++ = Important presence; + marginal presence; - no presence
[9] http://group.electrolux.com/en/organizational-overview-2644/
[10] http://www.whirlpoolcorp.com/about/history.aspx
[11] http://www.bsh-group.com/index.php?page=100325
[12] http://www.indesitcompany.com/inst/it/vision/vision.jsp
[13] http://www.arcelikas.com/page/10/About
[14] http://www.gorenjegroup.com/en/filelib/investor_relations/roadshows_2012/presentation_of_the_gorenje_group_ljubljana_24_april_2012.pdf
[15] http://www.gorenjegroup.com/en/about_gorenje_group
[16] http://www.miele.com/international/enint/company/facts_and_figures_13540.htm
[17] http://www.haier.net/en/about_haier/haier_global/china/
[18] http://www.forbes.com/companies/samsung-electronics/
[19] http://www.lg.com/global/about-lg/corporate-information/at-a-glance/overview

4.4.3 Ecodesign/Labelling in the Sector

A number of papers[20] consider that the EU Energy Label system for domestic electrical appliances has been a success since its introduction in early 1990s[21]. However, the introduction of this Labelling system has meant that in the last years almost all of the products on the market fell into the 'A' class as manufacturers have sought to improve their products. This situation led to the upgrading of the Energy Labelling system with additional top ratings going 'beyond A' and Ecodesign setting more stringent requirements and phasing out those appliances with low ratings. The table below provides an overview of the existing regulation within the white goods product group as well as other information such as when it entered into force, when it applies, when it will be reviewed, etc.

[20] DG TREN (2007) - CONSULTATION DOCUMENT on the revision of the Energy Labelling directive 92/75/EEC of 22 September 1992 on the indication by Labelling and standard product information of the consumption of energy and other resources by household appliances.
CECED position paper PP 01-02 (January 2002) - Market Transformation Initiative - Domestic Appliance Strategy
SEVEn (June, 2008) Energy Labelling for domestic appliances in Central and Eastern Europe – overview of enforcement and promotion activities. CECED (2005) Energy-efficiency: A shortcut Tokyo to targets - The vision of European home appliance manufacturers
[21] Council Directive 92/75/EEC of 22 September 1992 on the indication by Labelling and standard product information of the consumption of energy and other resources by household appliances.

	Ecodesign	Energy Labelling
Household dishwashers	(EU) No 1016/2010 into force 1st Dec 2010 (applies 1 Dec. 2011): • Ban on energy class B in Dec 2011 (Except for appliances with less than 9 place settings or width less than 45cm) and energy class A in 2013 (Except for appliances with less than 9 place settings or width less than 45cm). Class A will be banned for all machines in 2016. • Revision after four years.	(EU) No 1059/2010 into force 20 Dec. 2010 (first introduced in 1992): • Scale up to A+++.
Household refrigerating appliances	(EC) No 643/2009 into force 12 August 2009: • From July 2010, only class A products are allowed to enter the EU market, and from July 2012, only class A+ and better; • Revision after five years.	(EC) No 1060/2010 into force 20 Dec. 2010 (first introduced in 1992): • Scale up to A+++.
Household tumble driers	(EU) No 932/2012 into force Oct. 2012 (applies from 1 Nov. 2013): • Prohibition of current energy class D in Nov. 2013 • Prohibition of energy class C for condenser dryers in 2015. Also, their condensation efficiency class should be C and better.	(EU) No 392/2012 into force May 2012 (applies May and Sep 2013): • One label per type of appliance: air-vented, gas fired or condenser tumble drier, but with the same energy classification; • Energy efficiency classes for household tumble driers range from D to A+++; • Condensing efficiency classes for condenser household driers range from G to A.
Household washing machines	(EU) No 1015/2010 into force 1 December 2010: • Generic requirements from June 2012; • Ban on energy class B in Dec. 2011 and energy class A in 2013.	(EU) No 1061/2010 into force 20 Dec. 2010 (first introduced in 1992): • Scale up to A+++.

4.4.4 Overview Case selection

For the case studies, we were able to conduct interviews with two companies, two industry associations and a civil society organisation, which represents European citizens.

The companies are active in the EU (either selling and/or manufacturing their products). The companies interviewed were either directly involved in the Ecodesign/Energy Labelling process or were indirectly involved through their industry association (CECED). All companies considered and interviewed were players in the large domestic appliance market, covering not only cooling appliances but all other white goods, including washing machines, clothes dryers, dish washers and stoves.

4.4.5 Innovation impact

One of our expert interviewees mentioned that both Ecodesign and Energy Labelling led to major improvements. They were considered different and complementary; with the combination providing the most advantage:

- Ecodesign – process innovation;
- Labelling – product innovation.

However, it was also mentioned that companies would innovate anyway, since there are inherent drivers for innovation such as competitiveness. It was suggested that high cost brands look at aspects such as longer lifetime and good brand image, while innovation in lower cost products is always about reducing cost.

Ecodesign
Ecodesign has (almost) no direct effect on those companies who focus on the high-end products. It has an impact on the market overall, which moves to meet the requirements. However, it was also mentioned that often this does not happen due to the lack of control and market surveillance. A direct effect on companies on the high end of the market is that they face expenditure on meeting market surveillance requirements even though other companies do not comply, and authorities often do not care, which they feel leads to unfair competition.

Ecodesign can have a big impact on innovation, when there is a need to change something, e.g. refrigerants in cooling appliances.

Energy Labelling
The Labelling directive provides incentives for particular products to differentiate themselves from competitors in the market by being in the higher class, therefore supporting product innovation.

The label affects companies because for white goods consumers, after looking at the price, look at the Energy Label. This drives innovation because companies want to differentiate themselves with more efficient products and avoid being in the lower (red) end of the label. In this sense, the Energy Label was felt to be better than the US endorsement label because it provides more information. A

positive impact from the label is that it creates a common ground for competition and it helps to communicate to consumers about energy performance.

Certain companies (in the high-end of the market) already have no challenge placing most of their portfolio in A++ or A+++ classes. However, they have as an internal challenge to go beyond (e.g. A+++ -30% or -40%). However, Energy Labelling does have some direct impact for these companies because it is an important decision factor for the customer. However, this is limited to those aspects mentioned in the label. Those consulted felt that a stronger link between real life and the label is needed.

It was also mentioned that product development is very much focused on the label. The Energy Label drives innovation, where companies focus on making the programme showed in the label as energy efficient as possible, which might compromise other aspects such as the length of the cycle. High end companies focused on offering the best appliances might not have the best class because they do not compromise other aspects.

Difficulties in the fulfilment of the requirements

High end companies had no difficulties in fulfilling the standards and requirements. However, in some cases these standards forced them to include or consider aspects that they didn't consider as the best-fit for the consumer. E.g. the definition of standard washing needs to be taken to all appliances, and therefore they are forced to put 'standard cotton programme' in the panel, which is an extra cost and does not (in their opinion) actually help meet the consumer's needs.

It was also mentioned that even although it is always an effort to comply with upcoming standards, the challenge is to plan it properly having clarity and the knowledge of upcoming standards well-in advance.

One of our expert interviewees pointed out that it is never difficult to fulfil the Ecodesign standards. It is never a technical feasibility issue because the technical solutions, though not always economically mature, are available. The main argument not to implement the standards is the economic consequence, given that companies consider the return on investment (RoI), and the risk of no RoI makes them wary of undertaking the investment. This economic issue is the obstacle that needs to be overcome.

Time scale

Companies mentioned the need to anticipate future developments. They track the development of e.g. the minimum performance requirements with the intention of being ahead of the requirements and can plan for up to five years regarding development (because their development processes are long). They usually have reports on upcoming trends (usually regulation is based on these). The companies usually already prepare their product portfolio even before the regulation is in place.

It was mentioned that for smaller companies there is not enough time to implement regulations. For bigger companies, who are more involved in the process, it is easier to have foresight and start changes before they are legally required.

4.4.6 Involvement in the legislative process

It was clear that some companies were leaders in energy efficiency (and their products were at the high-end of the market), whereas other companies had brands across the market spectrum. The latter were not actively blocking the policy process but were also not strongly pushing to take them further. These companies are concerned with following the market, e.g. if it's improving they have to do the same by cutting the tail (worst performing products) and improving the high performance products.

The size of the company was also mentioned as an important factor. Innovation seems to be easier for bigger companies. In addition, bigger companies tend to be involved in the policy process and are therefore aware of what is coming up; whereas smaller companies generally don't have the capacity to do this. Smaller companies have to spend a large part of their budgets in adapting their processes to meet requirements, which leads them to wait until they are sure regarding the new regulations in place. They have less ability to check draft regulations so they are more reactive than proactive.

It was also mentioned that a drawback was when the technical content (and therefore related investments) are in place but there is a delay in approval due to the political process. In this case, even though investments are being made and products are being improved, the products cannot get in the market with the proper visibility.

4.4.7 Recommendations

All companies agreed that there is a need for the existing regulations, though some of them (particularly those on the higher end of the market) did not see Ecodesign as much of a challenge. However, they did have suggestions on how regulations could be improved. Some of the recommendations for improving the legislative process provided by the interviewees (companies and experts) are provided below:

- **The legislative process has to be transparent to all.** This includes those companies who cannot be involved directly (e.g. due to smaller size and fewer resources).
- **There should be equal possibilities to influence the process** for the different stakeholders. Current policy process gives little opportunities for the stakeholders to have an influence on the outcomes.
- **There should be enough time for providing input** (e.g. some consultations started before the summer break and gave only 4-6 weeks to provide input).
- Legislation should be comprehensive and in line with other EU level objectives. The sector also is affected e.g. by the WEEE directive and other regulations.

In addition, the interviewees (companies and experts) provided the following overall recommendations:

- **Market control/surveillance** could be improved. Some companies (front-runners) have established internal verification procedures to fill the gap. However, these should be driven by Member States. E.g. at the moment some Nordic MSs are more active, while other MSs are not active at all.
- **Additional incentives for energy efficient products** and technologies should be provided to consumers to cover direct costs. The costs of R&D, at least at the initial stage, are translated to consumers, given that it's difficult to reach economies of scale.
- **Harmonisation of standards at a global level.** Even though the EU has developed standards for e.g. the measurement of energy consumption, this is not the case worldwide. This is currently a challenge for global companies, which have to tune to specific standards. Furthermore, global standards would push innovation on developing countries (though this introduction needs to be done in an appropriate way, such that companies have enough time to implement these measures), and would help transform the market as these countries would stop receiving the least efficient products which cannot be sold anywhere else.

In addition, the interviewees (companies and experts) provided the following overall recommendations in order to stimulate eco-innovation most effectively:

- Scope.
    - **Broaden scope.** It was suggested to broaden the scope of existing regulation (both Ecodesign and Energy Label) in order to include 'real life' thinking and to tailor the standards to 'real life' situations. There might be a need to avoid thinking that everyone falls under the same paradigm and uses the products in the same way. (E.g. in Italy the use of dryers is far less common, and a class D tumble dryer might cause less impact due to the low use it receives; however this is not taken into account because the 'paradigm' is 160 cycles annual use for an EU citizen). It was also suggested that durability and material efficiency of products should be included, given that these are fields where major improvements can be made.
    - **Energy Label scope.** It was also mentioned that it would be interesting to combine the different criteria in the label in a good and understandable way for consumers. However, the same interviewee mentioned that the aim is not to include a lot of extra requirements in the Energy Label (as it gets too complicated for consumers to understand), and that the focus should remain on energy.
- **There is a need to create more consistency between the different instruments.** E.g. Voluntary Agreements are used in the wrong way. They are used as substitute for minimum requirements. However, they should be complementary to existing regulation, going beyond the minimum regulation. This would lead to a more dynamic market transformation; however, at the moment, synergy cannot happen because one instrument is replacing the other.
- Review Energy Labelling and Ecodesign as a major opportunity to improve success.
    - **Improve the scale.** E.g. even though the label shows all classes, some are not allowed in the market any more due to Ecodesign requirements (E.g. for refrigerators

only A+ products are in the market). This has serious implications for consumers, who are not always aware of this and might still believe that an A appliance is very energy efficient. At the moment, the classes are not very effective in promoting improvement in appliances. A suggestion to change this was to make a label that goes to zero. An alternative would be to identify a path that allows companies to promote their products when they are better than what the label shows as most efficient, which would give room to companies to try and get the best to outperform competitors.

  - **Make labels easier for consumers** (e.g. to enable them to calculate the operating savings against the higher purchase price for the appliance).
  - **Extend the timeline.** It would help to have a longer time horizon (e.g. 2030). This is in line with having a label that goes to zero and having medium term steps in Ecodesign as well as aspirational targets. In this way the label would represent these aspirational targets and help orient investments in R&D.
  - **Use Least Life Cycle Cost (LLCC).** It was mentioned that the LLCC[22] approach to evaluating costs in the preparatory studies neglects the learning curve and the potential of being more ambitious regarding energy consumption. This should be questioned and a more innovative approach to set the long term requirements should be proposed. It should be able to set an ambitious level to draw the market towards this (e.g. use market monitoring to see if what was set is realistic). At the moment the EC is perceived as overly cautious, it was suggested that they should reverse the trend and be more ambitious.
- Learn from other experience:
  - US approach – good documentation on standards
  - For tumble dryers – Swiss regulation after 2015 is very ambitious, but the EU is very far behind this. In a few years heat-pumps might be used more regularly and then regulation would not affect the market which would mean time was lost during the whole process because classes were not ambitious enough. (E.g. TVs, where in 2008/2009 LED technology was not considered mature enough and was therefore not taken into account when developing the regulatory requirements. By the time regulation came into force, the peak of sales was over)
  - Incentives at national level. E.g. in Spain the government spent money on promoting most energy efficient products. This could be done directly in monetary terms or through taxes, both at the consumer or company level.

[22] The reference for setting the maximum ambition of requirements. It refers to the most economic option at a point in time for a consumer between what he will pay for the appliance and for using the appliance.

4.4.8 Summary and Conclusions

From the companies interviewed, we can conclude that the Energy Label has a higher impact on innovation than Ecodesign because it offers a clearer opportunity to differentiate products and can be used as a marketing tool. Ecodesign does change the market, but once companies reach the minimum requirements there is no incentive to carry on.

4.5 Case study results: Electronics

4.5.1 Products

The products addressed were all the electronics products covered by Ecodesign legislation and Labelling, including:

- Simple Set Top Boxes;
- Televisions and Displays;
- External Power Supplies;
- Computers and servers;
- Products included in the standby regulation and network standby amendment.

4.5.2 Market structure

Electronics manufacturers span a wide range of products and componentry, from consumer products such as computers and TVs to commercial products such as servers. There are manufacturers dedicated to a single product, as well as large OEMs whose ranges cover many products. Markets are generally global. Some smaller specialist manufacturers cater to home markets – although they are usually more assembly than manufacture based – for example desktop computer assemblers. The majority of manufacturing occurs in China. Large manufacturers of products currently addressed by Ecodesign regulations (not voluntary agreements) with head offices in Europe include Alba/Bush, Digital Stream, Goodmans, Grundig, Loewe, Logik, Nokia, Pace, Philips/TP Vision, and Sagem. Many OEMs based in the US and the Far East (Japan, Taiwan and South Korea) also have additional offices within Europe.

Technology development in the electronics area is rapid, with a range of natural drivers for product and process innovation. The sector is undergoing a shift toward higher definition and 3D visual services, touch and voice controls, and cloud and mobile based data delivery[23]. There is likely to be considerable future convergence of individual electronics products toward smart phones and tablets - for example they may absorb the digital camera and portable game console markets in the same way

[23] Top 10 IDC Predictions 2013: Competing on the 3rd Platform, Frank Gens Nov 2012.

that they have already absorbed the portable MP3 player market. It is also likely that more companies will enter this market to make the most of the growth opportunity. With continued increases in data demand and energy prices, it is likely that the number of data centre players will reduce. In light of fierce competition, a similar trend may be observed in the telecoms sector. In the area of televisions, margins are likely to shrink further and sales may slow as the market becomes focused on replacement.

4.5.3 Ecodesign/Labelling in the Sector

Table 6 provides a summary of implementation and ambition of Ecodesign legislation. The only electronics product to be addressed by Labelling requirements to date is the television (displays are to be added to this in the revision of the television measure in 2014).

The first wave of legislation was put in place from 2008/2009 onward, and as a result revisions of requirements have recently been under discussion for a number of areas, including simple set top boxes, external power supplies, standby and televisions. Where the proposed requirements are relatively simple, and do not require a full preparatory study and impact assessment, a fast-track approach is being considered – the first area is being piloted in the external power supply revision. The most recent new requirement to be brought in is that for computers and servers, which was agreed in mid-2013 as a result of protracted discussions with industry, member states and NGOs. The process of re-defining television requirements, and bringing displays under the scope of regulation has also been a lengthy one.

Table 6: Legislative requirements for electronics products

PRODUCT	ECODESIGN	LABELLING
	Legislation since	Legislation since
PCs and servers	26/06/2013	
Imaging equipment	Voluntary agreement (2011/2012)	
Televisions	22/07/2009 Revision as displays.	28/09/2010 Currently under review
Displays	CF : 08/10/2012 RC : 21/03/2013	Pending
Standby and off-mode losses of EuPs	17/12/2008	
Networked Standby	RC 21/03/2013 (as revision to above)	
Simple set top boxes (SSTBs)	04/02/2009 Revision CF 10/04/2013	
Complex set top boxes (CSTBs)	Voluntary agreement (2011)	
External power supplies (EPS) and	06/04/2009 (no battery chargers)	

PRODUCT	ECODESIGN	LABELLING
battery chargers.	Revision in progress	
Sound and imaging	Game console voluntary agreement proposed Aug 2012	
Enterprise servers	Preparatory study 2013	

Historical engagement on Ecodesign in the electronics area has shown many instances where both companies directly, and trade associations lobbied for more product exemptions, less stringent allowances, allowances for additional functionality and longer timescales (clearly where it believed these were necessary, so that the process did not proceed faster than their ability to adapt). Such interaction has occurred both via formal meetings and consultations, but also via ad hoc contact directly with the desk officers at the Commission. Often valuable evidence is provided to the process by companies, who play a key role in ensuring the robustness of requirements. However, in some cases evidence provided by companies has suggested higher costs than proven by other sources, has been weighted toward older less efficient models, and/or has been provided late in the process – demanding a re-evaluation of assessments that can considerably extend the process of defining requirements. Some past statements that ambitious levels of efficiency could not be achieved have been proven inaccurate with the process of time, but this could also be due to a lack of foresight within companies on the efficiency gains that innovation was capable of achieving. In general, the electronics industry is highly competitive and this dynamic is likely to create a barrier to the sharing of information on innovative developments.

Often a key request from electronics companies in the Ecodesign process is for international harmonisation on requirements, as this can reduce design, testing and compliance costs for companies operating in global markets. However, in some cases, the way in which companies engage with the various players in standards processes can create a barrier to development of harmonised approaches, by the placing of confidentiality stipulations on data provided to the standards process (possibly due to commercial concerns). This was, for example, encountered in the exploration of potential for globally harmonised game console standards in 2012/2013, with confidentiality requirements making it difficult for the information provided by industry to be shared and discussed in an open way between regions.

4.5.4 Industry engagement in case studies

Originally, the goal was to address a comparable cross section in the computer area. The intention was to compare two large, innovative companies who were actively involved in ErP against two of the more innovative SMEs in the area, who may not be so involved in ErP processes. However, responses obtained from the initial contacting of companies were poor. Some companies failed to respond, whilst others politely declined to be involved. As a result the net of prospective companies was widened – first to cover all types of computer companies, and then to cover all types of electronics products impacted by Ecodesign regulations. A European electronics trade organisation

was enlisted to help distribute the interview request to the widest number of companies. However, feedback from various sources suggested that the lack of interest in involvement might be because:

1. Companies were being inundated with requests from consultants carrying out studies on behalf of the Commission, and were unlikely to respond unless there was a specific impact/risk upon their business as a result of not responding (could be due to risk-driven approach to engagement).
2. The question being asked was a difficult one to respond to, and it might be challenging to present a response in the positive light in which CSR departments of companies prefer (could be due to negative perceived impact).
3. The scope of the question was restricted to Ecodesign and Energy Labelling – some manufacturers may have been willing to engage in discussions if voluntary agreements, eco labels and other mechanisms were included in the focus (could be due to ideological objections to regulatory approaches).

This leads to the speculation that many electronics companies could be of the challenger typology. Electronics is a very innovative area, where large companies are actively involved in the process at both individual and trade association levels, but there may be negative perceived impact of Ecodesign regulations that drive companies to be more critical of, or defensive toward, Commission proposals.

In total, 26 contacts in around 17 organisations were contacted directly for interviews (not counting European trade association members to whom a request was circulated – around 57 companies). Due to the lack of willingness of individual companies to be involved, it was decided to carry out a more-general interview with an electronics trade organisation.

4.5.5 Innovation impact

Labelling and Ecodesign regulations are considered to have different influences on the market and on innovation. The two can work together, so that whilst regulation improves the energy efficiency performance of the bottom high-volume end of the market, compulsory Energy Labelling has the potential to drive energy efficiency innovations at the low-volume top-end of the market. However, neither is considered, by the trade association interviewed, the ideal means of driving energy efficient innovation in the electronics sector.

Ecodesign

The view of the trade organisation was that Ecodesign regulations have not in a direct way induced innovation in the electronics sector. Nonetheless, the addressing of a product group by Ecodesign helped to keep energy efficiency in a general sense on the list of priority innovation drivers (even as early as when a product group is listed in the working plan). This is not just because of the Ecodesign activity in Europe but also because of parallel processes underway in the countries such as the US, Korea and Japan. The following points were highlighted:

- **Ecodesign processes are at odds with innovative fast moving industries:** Product development cycles in the electronics sector are much faster than many other sectors, with very different drivers, making it harder for regulatory processes to keep pace with developments.
- **Other approaches influence innovation more effectively:** Innovation is better addressed by endorsement mechanisms and industry driven voluntary Labelling initiatives.
- **Innovation will happen anyway:** There are strong natural drivers for innovation in the electronics sector regardless of activities in Ecodesign and Labelling. Drivers for innovation in the electronics sector include a drive for cost improvements leading to improved manufacturing processes. E.g. From 1969 to 1999 there was a huge improvement in the efficiency of TVs without a major technology shift and without any form of legislation. Power demand of an average 19 inch TV reduced from 500 W to 60W.
- **Ecodesign can restrict innovation:** Ecodesign can risk limiting innovation at top-end of market, by:
    - **Not allowing for gradual efficiency improvements in new technologies:** All-encompassing requirements (non-technology specific) are sometimes put in place, which restrict the ability for new technologies to be introduced to the market. It is difficult for a slow-moving legislative mechanism to keep up to date on technology developments.
    - **Not taking into account commercial considerations sufficiently:** Non-commercial individuals decide the requirements - the consultants involved in the Ecodesign process may not have the most realistic view of the market, and may come up with requirements that are not easily measurable and would be more appropriately addressed via other approaches.
- **Ecodesign can create unfair market dynamics:** Regulations run the risk of removing weaker and smaller companies from the market. E.g. making plasma TV technology, which provides improved picture quality in very large screens, efficient enough to comply with the tier 2 requirements of the revised regulation required considerable investment that smaller companies could not afford, and so some left the market.

In contrast to the findings of other case studies, process innovations were not considered by the trade association to occur as a result of Ecodesign requirements, but as a result of a drive for cost efficiency.

Energy Labelling

The view of the trade organisation was that Labelling may induce innovation in the electronics sector to a small degree by acting as a market differentiator. However, for the more luxury products like consumer electronics, energy efficiency is seldom a key influence on consumer buying decisions. Products are subject to emotional purchase decisions – for TVs for example, priorities will more likely be size, price, brand, styling etc. On the introduction and initial promotion of the label to a product area, there may be enthusiasm to reach the 'A' category, and some image-conscious companies may even work to ensure all their products are at least A rated. Yet, this influence may dwindle over time, due to a lack of sustained customer influence.

It was suggested that there were alternative mechanisms could be more effective in helping the top-end of the market to innovate toward greater efficiency than a compulsory Energy Label:

- **National subsidy schemes:** These can have more influence on bringing energy efficient innovations to market than Labelling as they influence the customer via the higher-priority purchase criteria of price. As energy efficient features of TVs would not influence product sales, the UK CERT[24] scheme instead promoted efficient products to market by providing a monetary subsidy per product. Through subsidies, the CERT scheme led the shift from shipping TVs in ultra-bright shop mode (in case of display in a shop environment) to shipping with an intelligent option that enabled a "shop mode" or "home mode" to be selected, with home mode selected as default.
- **Voluntary Labelling (TM license labels like ENERGY STAR):** A voluntary Labelling scheme with active industry involvement can be more agile in the face of the rapid development of technology. For example the ENERGY STAR label aims to cover the top performing 25% of the market. It has proven successful in providing a strong driver toward energy efficiency in the US for TVs and ICT products, although it only applies in Europe for ICT.
- **Voluntary agreements:** Formal Commission approved VAs can prove to be more stringent than regulation especially as market surveillance is so strict. One trade association did not consider these truly voluntary due to the high level of regulator involvement in prescribing the process for definition, monitoring and revision. VAs can provide a means of addressing the wider system in a way that regulation cannot – for example there are opportunities for service providers as well as product manufacturers to become involved. However, the market needs to be quite concentrated in terms of number of manufacturers for a VA to be feasible, and as not all manufacturers need to sign up, it can result in an uneven influence on the market leading some manufacturers to prefer regulation.

The trade organisation stated that labels have the potential to fail where they include requirements that are overly ambitious and lacking in commercial understanding. They provided the example of the Ecoflower label for TVs: in their opinion, due to the involvement of non-commercial consultants requirements that could not be delivered by the majority of manufacturers were set (isolation switch and spare parts available for 7 years). This caused veryfew tosign up and the label had no real influence.

[24] CERT is the Carbon Emission Reduction Target (formerly the Energy Efficiency Commitment). It is a target imposed on the gas and electricity transporters and suppliers. The EEC 1 (2002 - 2005), EEC 2 (2005 - 2008), and CERT (2008 to 2011, then 2012) programmes required that all electricity and gas suppliers with over a certain number of domestic customers had to achieve a combined energy saving by the end of each specification period, by assisting their customers to take energy-efficiency measures in their homes: suppliers had to achieve a minimum proportion of their energy savings in households on income-related benefits and tax credits. Approaches taken by suppliers included subsidies on energy efficient products to facilitate innovations in energy efficiency coming to market. From 2013 CERT is superseded by the Energy Company Obligation (ECO).

4.5.6 Involvement in the legislative processes

As mentioned earlier, the lack of willing of electronics companies to be involved in these case studies implies that they may fit with the challenger typology suggested of this study – whilst being innovative, companies may have a negative perceived impact of Ecodesign regulations that drives them to be more critical of, or defensive toward, Commission proposals.

The industry stakeholders in the regulatory process are usually represented by trade associations. The national trade organisation interviewed aimed to educate their members to the same level of understanding and then find a common point of view to represent. They would subsequently follow up using their connections with the EU trade associations and via direct contact with their national Government.

Stages of involvement
Whilst the national trade association interviewed would like to have been involved at the earliest stages, they felt that they often had not had that opportunity because of their lack of resources/funds to send representatives to Brussels. They were conscious that they were often involved too late, once the regulations had already been defined and were at the draft stage. Sometimes members of the national trade organisation would attend with the EU trade organisation but this was not a frequent occurrence as most of the national trade association activity is UK focused, and national views are normally passed on informally through the companies that have members involved in both groups.

The European electronics trade organisation is usually found to be involved in the Ecodesign process from the point that a product is being considered for inclusion on the work-plan (for example, recent discussions which resulted in a delay in addressing mobile phones to allow for market innovations) to the very end of the process. In the past they have even be involved in the creation of guidance. If they are concerned about developments at any stage, they usually engage directly with the Commission and/or member states – for example, they have recently engaged directly on the development of the computer measure, television revision, and external power supply revision.

View on process
The national trade organisation did not feel that they had sufficient influence in the process, and our observation is that they could perhaps have benefitted from a closer working relationship with the European trade organisation. They often found themselves frustrated by the difficulties in achieving regulation that accounted adequately for technology developments, although they accepted that due to the slower nature of the regulatory process accounting for fast moving technologies was not an easy thing to do.

They also often found that they were not convinced about the data used for the analyses that provided the foundation for the requirements, but felt it was difficult to make their voice heard at this later stage at which they engaged in the process, plus they did not always have the resources to gather the relevant data at the point when it was requested. They also had issues regarding the level of trust in data sharing with their own members. They suggested that consultants should be obliged

to widen their data collection processes as in some cases consultants had worked with independent testing house "best guesses" for current and future efficiency instead of sufficiently engaging industry. It was stated that the requirements of one of the regulations was based on an opinion given to an expert by only one manufacturer, which negatively impacted other manufacturers less engaged in the process. They also considered that the suggested use of non-disclosure agreements might be a way to guarantee a degree of confidentiality or anonymity and facilitate data gathering processes. The national trade organisation also felt it would be more effective for industry to provide assistance when the evidence was being gathered rather than trying to challenge evidence that had already been gathered some time before. They relied on the EU trade organisation and their resources at this stage.

4.5.7 Recommendations

The national trade organisation interviewed considered the following recommendations to have potential:

- **Endorsement approaches to influence innovation – subsidies and voluntary labels**: This was strongly supported by the national trade organisation, which had direct experience of such initiatives and felt they could be much more effective in terms of inciting innovation than the traditional Energy Label.
- **Voluntary agreements**: Trade organisations were keen on these as an alternative to legislation wherever they were possible, whilst recognising that they are not suitable to all products.
- **Greater commercial awareness in leadership of Ecodesign work**: Independent consultants can put forward requirements that are difficult to achieve at a commercial level. The trade organisation felt that a greater commercial understanding would enable a more effective Ecodesign process (although our view is that objectivity and a focus on an appropriate level of ambition would also be required of consultants).

The national trade organisation considered the following recommendations not worth pursuing:

- **Industry focus groups**: It was considered that competition in the electronics area was too fierce to facilitate such an initiative.
- **Innovation competitions**: These could be pursued as long as they had the appropriate global coverage, but there is already a quite substantial coverage of awards and innovation promotion evens in the sector, so it's unlikely further work in this area would result in sizeable additional innovation influence.
- **Top Ten approaches for electronics**: In the electronics sector, consumer decisions are not made based on energy efficiency as discussed previously, so such initiatives were considered not to have an influence on either consumers or manufacturers, who did not favour such approaches for competitive reasons.

The experience from the case studies leads us to the following observations

- For product areas such as electronics with rapid technology development and high innovation, it is more likely that companies engage in a defensive way (as they may perceive the risk of Ecodesign limiting future innovation);
- For the electronics area, Ecodesign regulations provide a driver for innovation only in the very general sense of energy efficiency being kept on the list of design considerations;
- Labelling can act as a direct driver to innovation for the electronics area, but endorsement and voluntary agreement approaches may drive innovation more effectively;
- Where innovation is required to meet Ecodesign regulations (e.g. for some specific technologies), small companies are unlikely to be able to make the necessary investments, and are more likely to be those who leave the market;

4.5.8 Summary and Conclusions

Ecodesign regulation is more likely to be viewed in the electronics sector as a threat to innovation than as a driver.

For the already innovative electronics sector it appears that Ecodesign regulations do not influence innovation except in the following two situations:

1. When a specific technology needs to innovate to reduce energy consumption in order to meet requirements or be removed from market (plasma TV example).
2. In a general sense by keeping energy efficiency on the list of design considerations.

Energy Labelling can influence innovation for companies that wish to present themselves as high end, high quality electronics providers. However, as energy efficiency is not a priority for electronics consumers, other mechanisms such as endorsement subsidies may have greater influence on innovation.

4.6 Case study results: Lighting

4.6.1 Product scope

This case study addresses the impact of Ecodesign and Energy Labelling on R&D and innovation in the lighting sector. The relevant product groups and regulations can be summarised:

- **Tertiary lighting** – lamps and luminaires for professional or special applications such as street lighting, sports lighting, office lighting, shop lighting, emergency lighting, etc.
- **Non-directional household lamps** and **domestic lighting** – lamps for domestic application, including standard filament (incandescent), fluorescent, high-intensity discharge and LED lamps, and luminaires.

Our case study spanned both professional and domestic lamps but with a focus on domestic lamps. We spoke with firms that produce both types of lamps.

Lamps have been undergoing a rapid transformation in the last 10-20 years, at least partly driven by Ecodesign and Energy Labelling measures in the EU. This period has seen a strong move away from the traditional incandescent lamps toward much more energy efficient alternatives. At first the switch was primarily to Compact Fluorescent Lamps (CFLs) and other more efficient alternatives such as Halogen lamps. More recently, Light Emitting Diode Lamps (LEDs), which are even more efficient than CFLs, have become increasingly common. Alongside this there is also a move in the sector away from simple lamp production, toward a greater focus on lighting systems, fixtures and controls. These switches have been transformational for the product and sector.

4.6.2 Market structure

The global lighting market has been valued at around €70 billion per year and is expected to grow to around €100 billion per year in 2020[25]. Until recently the global market was dominated by an effective oligopoly of 3 firms, Philips, Osram and General Electric, which accounted for more than 60% of the market. These firms were able to dominate a market in which their knowledge and experience in traditional lamp manufacture made competition from new players difficult. SMEs were present in the sector, but typically in specialist niches and applications, rather than general household lamps.

The transformational switch to LED lamps and more integrated solutions is leading to significant change in the market and has opened up opportunities for other market players, as the manufacturing process for LEDs is based on semi-conductors and is less complex. New players with semi-conductor chip expertise, including major conglomerates such as Samsung and LG, are now also securing a foothold in the market. The fastest market growth for lighting is in Asia, and in China there is a strategic focus on developing an LED manufacturing industry.

The technology switch in the sector is also having an important impact on company business models as the average lifetime of lamps is increasing, from a typical 1,000 hours for an incandescent lamp, to 10,000 hours for CFL lamps and 25,000 hours for LED lamps. This has important implications for firms whose traditional business model was based on selling replacement lamps, and although higher prices for CFLs and LEDs somewhat compensate for lost replacement income, the technological transformation has also been the trigger for the move in the market towards more integrated lighting solutions, controls and systems.

4.6.3 Ecodesign and Energy Labelling in the Sector

Ecodesign

[25] McKinsey (2012) Lighting the way: perspectives on the global lighting market, 2nd edition

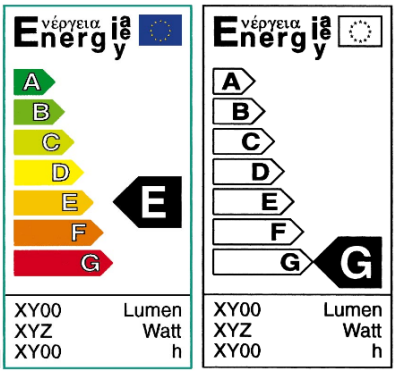
Tertiary lighting was first regulated for energy efficiency from September 2000 (2000/55/EC). The mandatory efficiency requirements that were introduced were separate from Ecodesign which was only introduced in 2005. An Ecodesign implementing regulation for tertiary lighting was introduced in April 2009 (EC/245/2009), and further amended in April 2010 (EC/347/2010), superseding and repealing the pre-Ecodesign regulation. The 2009 implementing regulation set 3 stages for performance requirements for lamps and luminaires, applicable after 1 year (2010), 3 years (2012) and 8 years (2017). The requirements addressed lighting efficacy (lumen/watt efficiency) and other output and environmental aspects.

Non-directional household lamps and domestic lighting were first regulated by an Ecodesign implementing measure in April 2009 (EC/244/2009) which introduced minimum performance requirements for lighting efficacy (lumen/watt efficiency) and other output and environmental aspects, including mercury content. The requirements were set over 6 stages of increasing efficiency applicable from 2009, 2010, 2011, 2012, 2013, 2016. Amendments to the regulation were adopted in 2012 (EC/1194/2012), which introduced new requirements for Compact Fluorescent Lamps (CFLs) and Light Emitting Diode Lamps (LEDs) applicable from Sep 2013 and increasing in 2014, 2016.

The Ecodesign requirements for household lamps introduced in 2009 were quite controversial with consumers as incandescent lamps, which were still widely used, were progressively banned from the market. This phase-out will now focus on halogen lamps. The requirements for tertiary lighting are also leading to phase-outs of the most energy inefficient lighting technologies.

Energy Labelling

Energy Labelling for lamps was first introduced in February 1998 (98/11/EC), introducing a standard Energy Label for most lamps sold in the EU. The Ecodesign regulations in 2009 (see above) also introduced information requirements for lighting packaging, which required display of a number of key performance indicators and information on the packaging, in addition to the Energy Labels.
The Energy Label for lamps was updated by a delegated act (EC/874/2012) adopted in October 2012, with a redesigned Energy Label, which added the A++ and A+ categories and removed the F and G categories. The new labels came into force in September 2013. Both the old and new labels are displayed in **Error! Reference source not found.** below.

Old 

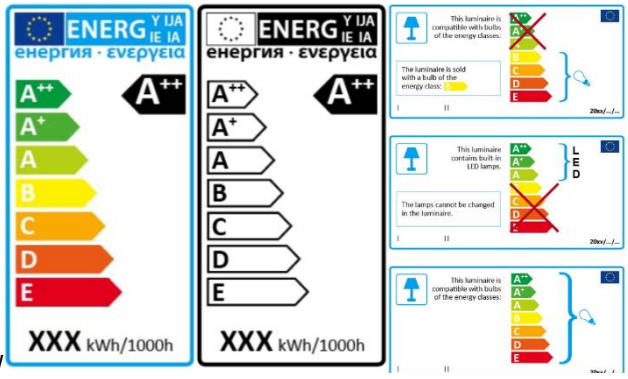
New 

Figure 9 Energy Labels for household lamps introduced in 1998 under 98/11/EC (left), new Energy Labels for lighting and luminaires introduced as a delegated regulation in July 2012 under 2010/30/EU

The consultations held by the Commission over the Energy Label revision for lamps saw debate over the addition of the A++ classes, rather than rescaling, i.e. making the old A class into the new D class. Due to the on-going transition from incandescent to energy saving lamps it was decided to review the labels again in 2015. Nevertheless, from 2012, the lowest energy class allowed under the regulation on non-directional lamps has been C, leaving classes D and E empty, except in the special case of halogen lamps until 2016.

The following table, prepared by LightingEurope, the industry association for the sector, summarises the lamps in the different categories.

Table 7 Summary of lamps across the lamp classes, from LightingEurope guidance document, ver. 2, Aug 2013

Energy efficiency class	Non-directional lamps	Directional lamps
A++ (most efficient)	Class currently empty, apart from some low-pressure sodium lamps used in street lighting. Soon to include best LEDs (including modules)	Class currently empty, soon to include best LEDs (including modules)
A+	Best LED lamps and modules, best linear fluorescent, compact fluorescent and high intensity discharge (HID) lamps	Best LED lamps and modules
A	Average LEDs and modules, average compact fluorescent lamps and less efficient linear fluorescents and less efficient HIDs	Average LEDs and modules, average to good compact fluorescents and HIDs
B	Less efficient compact fluorescent lamps and LEDs, best halogen lamps (extra low voltage capsules)	Less efficient compact fluorescent lamps and LEDs, best halogen lamps (extra low voltage capsules)
C	Less efficient conventional extra low-voltage halogen lamps	Less efficient conventional extra low-voltage halogen lamps
D	Best (xenon-filled) mains-voltage halogen lamps Conventional halogen lamps and best incandescent	Best (xenon-filled) mains-voltage halogen lamps Conventional halogen lamps and best incandescent
E (least efficient)	Typical incandescent range	Incandescent lamps and less efficient mains-voltage halogen lamps

Global legislative context

Regulatory action on energy efficiency of lamps has also grown globally in the last 5-10 years, with Ecodesign equivalent legislation focused on improved lamp energy efficiency (including phase-outs of

incandescent and now halogen lamps) implemented in around 30 countries including the US, Japan, China, Russia and Brazil. Analysis of the strictness of requirements by the IEA 4E group in 2011[26] showed that the EU standards use the same method as Australia and Canada, but that even when different methods are used, as in the US and Korea, the minimum energy performance standards, as measured by lumen/watt are broadly similar across the major countries.

Labelling of lamps has also spread around the globe, with different Energy Labelling schemes for lamps present in more than 30 countries including Australia, Canada, China, India, Japan and the US.

4.6.4 Overview Case selection

We selected lighting as a case study due to:

- its importance - lighting accounts for around 20% of global energy consumption;
- the significant influence of regulation – i.e. incandescent phase-out; and
- the rapid rate of technological change and innovation.

To perform this case study we carried out in-depth interviews with representatives from firms within the lighting sector, the main EU sector association and an Environmental NGO that was also involved in the legislative process.

4.6.5 Innovation impact

Innovation focus, process and resources

Innovation in the lighting sector is strongly product-based and is both incremental and radical. Incremental in the case of innovating to improve the energy efficiency of more mature lamp technologies, i.e. CFLs and halogen lamps, and radical, in innovation in new LED and other technologies. All firms acknowledged that the switch to LEDs has been a radical change for the sector and LEDs have now become the main focus of their innovation activities. One company reported a 60:40 split in their focus, in favour of R&D on LEDs. The remaining 40% focusing on technologies most appropriate for their business, i.e. halogen or compact fluorescent technologies, and more integrated system level work. The focus of innovation on LEDs is not only to improve energy efficiency but also to improve lighting quality and functional performance; additional functionalities are of particular importance to the firms working in tertiary lighting due to client demands for them.

The innovation process within firms was varied but in each case structured along broadly similar lines. It typically involved a level of product-market analysis, with input from relevant product managers and sales teams. On this basis a product innovation plan or roadmap was developed, which took into account innovation needs, feasibility, timing, costs and projected outputs. This plan was

[26] 4E (2011) Benchmarking Report: Impact of Phase-Out Regulations on Lighting Markets

then presented to management at board level to make the final decision on whether to proceed. In at least one of the biggest firms this decision was taken on the explicit basis of the expected return on investment.

The firms that we interviewed typically spent around 5-10% of their turnover on R&D and innovation, although the smallest of the 4 firms took a more ad-hoc approach, making investment decisions on a per project basis rather than aiming for R&D spend of a specific percentage of turnover. Typical lead-times from innovation plan to expected outputs were 2-3 years. One firm commented that LED technology is currently advancing at such a speed that the technology is making small leaps forward every 6 months, which makes it difficult to keep pace.

Motivations for innovation

The motivations for innovation were broadly consistent across all firms and focused on the following four points:

1. **Competitive position** – was understood by firms to be closely linked to having products with good energy performance and therefore maintaining market position was an important motivation for innovation.
2. **Consumer demand** – closely linked to the point above, but flagged as important for domestic customers that are now demanding 'green' technologies. Although it was noted that consumers do not have a strict efficiency/cost focus, i.e. they think in more general 'green' terms, but not in terms of payback times vs. purchase cost, with the green benefit more vaguely defined than the specific, and typically more expensive, purchase cost. For B2B sales, demand has already shifted in many cases to talk of 'total cost of ownership' which is motivating innovation in efficiency in lamps and also wider lighting systems and controls, i.e. not just 'selling bulbs'.
3. **Regulation** – firms reported that they were motivated as a minimum to always meet the legal thresholds of regulations. Additionally that regulation, particularly the incandescent phase-out, has been an important driver of their innovation activities (see below). Other potential policy drivers of innovation were flagged as the RoHS and REACH regulations,, as were national level requirements, i.e. for lighting controls in Denmark and UK.
4. **Intrinsic** – two of the firms stated that energy saving and environmental performance are part of their company mission and values, and that this was a motivation for their innovation. The other firms also, but less explicitly, referenced wider energy saving for society as an innovation goal.

One firm also made a more explicit link to profitability and revenues, simply that innovation is a necessary means to generate a profit and is therefore treated as any other investment, in that it should generate sufficient returns to justify it.

Impact of Ecodesign

The level of the Ecodesign regulation was perceived by the firms to have an impact on the market and their product range, especially incandescent lamps, but that the significance of this impact was low for three of the four firms - 'not a big deal' - as every firm already had alternative lamp

technologies. In this sense the regulation was viewed as an opportunity, with, for example, one company stating that they saw it as generally positive for them, and that the regulation initially drove higher sales of some of their CFL products. The one firm which was an exception perceived the regulation more as a threat. It was clear that due to their focus on halogen lamps they had a much larger share of their product range subject to the phase out, and that the regulation necessitated further investment and R&D. The environmental NGO we interviewed highlighted halogen lamps as a special case where Ecodesign requirements were quite challenging. Overall, LightingEurope reported similar differences in opinion within the wider sector but that these were 'nothing that could not be overcome'.

Despite the relatively low significance and level of Ecodesign it was flagged by LightingEurope as having a huge impact on the sector. By simply taking incandescents off the market this had the most visible impact of any of the Ecodesign measures. The controversy in the media and among consumers to the phase-out is further evidence of the significant impact on the market.

The actual impact on innovation is debated, all respondents saw Ecodesign having some impact on innovation. For some it was a significant transformational impact for the market, which was clearly the case from simply looking at the shop shelves, but for others, particularly the firms in the industry, it was one of a number of wider drivers, as they were already all investing in LED innovation and the product features (efficiency, lifetime) that the regulation addressed. One firm observed that Ecodesign had affected their supply chain and product portfolio, and therefore that it encouraged them to take a longer-term view of innovation and investment. Another firm commented that Ecodesign struggled to keep up with the pace of change in the sector, particular the switch away from lamps to lighting systems, and that all their products already complied with the requirements. For the firm that was most threatened by Ecodesign the impact has been to signal a re-focus of their strategy, to withdraw from general lighting, due to the size of new R&D investments required and the strength of existing players, and to focus on special lighting and developing LEDs in the higher (A+, A++) classes.

Overall, firms felt that Ecodesign had a greater impact on their innovation activities than Energy Labelling, although it was highlighted by one firm that more needs to be done on enforcement and market surveillance as it is still possible to buy banned incandescent lamps in many Member States.

Impact of Energy Labelling

While Energy Labelling was thought to be a lesser driver than Ecodesign, firms were largely positive in the purpose of the labels, to improve consumer information and understanding. The switch away from watts to lumen as the standard unit for lamps was supported as correct but with some concerns over whether consumers would fully understand the switch.

One firm highlighted that they viewed Energy Labels as an opportunity for them to sell the premium products on which they focus their innovation - this was despite the labels causing them 'a lot of work'.

Another firm found the labels 'a mess' by trying to convey too much information on the box, this created significant packaging and design difficulties which are made worse when packaging needs to be adapted for niche products with only a few units produced, and significantly less than the minimum production runs for packaging. Also that in special and niche lighting that other functionalities, rather than energy efficiency, were often more important for customers and for B2B customers that they were already well informed so labels didn't add much.

Overall, the direct impact of Labelling on innovation appeared to be limited, with no firms stating that they specifically targeted innovation to gain higher energy classes for their products. It can be argued that labels played a supporting role to Ecodesign, helping to drive innovation towards halogen and CFL bulbs.

As Energy Labels are in the process of changing with a new label being introduced from September 2013, firms highlighted that it will be necessary to wait and evaluate the impact of the new label. There was a small concern raised that the switch to LEDs will render a large number of the energy classes on the lamp labels redundant (empty), i.e. that the worst LEDs now still rank B or A, and with technological improvements they can become A+, A++. Therefore the top classes could become full relatively quickly. There is an interesting point to note here in terms of the interaction of companies in the Labelling process – who on the one hand lobby for less ambitious requirements so that there is a limited financial impact on their company, and on the other hand complain if the higher classes become saturated and the label ceases to be effective.

4.6.6 Involvement in the legislative process

Starting point on regulation

As a starting point we asked firms for their views on the need for Ecodesign and Energy Labelling regulations. All but one stakeholder was positive regarding the need for the regulations, although some were more pragmatic in their positivity, viewing the regulation simply being what was there and supporting it, rather than re-examining the need for it in the first place. In general the benefit to society of lower energy use (and money savings) the regulations delivered was viewed positively. The one dissenting voice was from an individual from the most threatened firm who was not in favour of the product bans forced by Ecodesign and thought an information based strategy such as Energy Labelling was more appropriate.

Also at this stage, further concerns were raised over the effectiveness of regulation when rules were not enforced or followed, particularly for Ecodesign, which reduced the return on investments in innovation and which could impact their future willingness to invest. A step further from this, in the case where regulation lagged the market there were concerns that this lag resulted in some sub-standard products 'poisoning the well'. This was thought to have occurred in the case of cheap LED imports from outside the EU, where consumers bought these cheaper, unregulated products, a number of which subsequently performed poorly, and that this then has tainted consumer perception of the new technology, hindering innovation adoption and making it harder for all firms.

Involvement in the regulatory process

For the lighting industry the sector works together through the industry association, LightingEurope, and previously through the European Light Companies Federation (ELC), to engage with the process at all stages, except the Vote by Regulatory Committee (see **Error! Reference source not found.**). ll four of the firms we interviewed are members of LightingEurope and one of the interviewees was a member of the ELC board during the previous regulatory process. Interestingly the two biggest firms we spoke to referred us directly to LightingEurope when asked regarding their role in the regulatory process, refusing to elaborate further on an individual basis, therefore it is difficult to say anything specific on their direct involvement in the regulatory process.

The ELC was closely involved in the original regulatory process, particularly from the Ecodesign working plan onwards, although involvement at the working plan stage was not high as 'it was clear that lighting would be targeted'. The ELC made a number of submissions and comments on the EU proposals, including comments in March 2008[27] on the preparatory study that highlighted the impossibility to switch production in time to produce new bulbs in necessary volumes, and the corresponding social, economic and political impacts of such changes. They proposed an alternative and slower timetable for phase-out, 5 stages over 9 years, as opposed to original proposal of 3 stages over 5 years. In the end a compromise was reached that saw 6 stages over 7 years and a number of product exemptions.

A review of the feedback to the consultation process by the ELC showed that it generally agreed with the thrust of proposals from the EC but sought to lower the requirements and spread them further over time. Post adoption of measures the ELC / LightingEurope have played an important role in communicating the changes to the sector, including the production of guidelines on the requirements for dealing with labels.

In general stakeholders felt that the process was balanced and included sufficient views. LightingEurope highlighted the unique vulnerability of industry, among all of the consultees, to the outcomes, which makes the process highly important for them. They also highlighted their concerns over the quality of the technical analysis and data that was used at different stages of the process. They reflected that they thought a better understanding was emerging between the Commission and the sector over time.

Of the two smaller firms we spoke to, one commented they had sufficient influence in the process, courtesy of having a member of staff on the board and relevant working groups. Nevertheless, they also reflected on the differences in capacity, resources and influence between themselves and the bigger firms, i.e. one person working full time on the issue compared to many at the bigger firms. This issue was echoed by the other smaller firm, which was unable to participate in the process for

[27] Summaries of the process and links to the relevant documents can be found at http://www.eceee.org/Ecodesign/products

these, and other internal, reasons. The main goal of these firms was to stay informed of what was going on.

When asked about the goals of their involvement in the process, the focus for LightingEurope was on securing regulatory outcomes that are workable for the industry and addressing key issues of concern such as market surveillance and enforcement. None of the interviewees perceived specific changes in their role or commitment during the process.

In terms of outcomes the firms were broadly positive. One firm reflected that the outcomes were mostly beneficial to them given their product positioning, though they also cautioned that the process took a long time and did not go far enough.

4.6.7 Recommendations

The main recommendations for process improvements came from the environmental NGO involved in the process who identified the need for faster, more streamlined processes and that consideration should be given to clearly merging the Ecodesign and Labelling processes, providing guidance and information on key recurring aspects i.e. complementarity, integration with WEEE, and harmonising consultation feedback. They also recommended better coordination with policies such as Ecolabel and GPP to promote and incentivise sustainable consumption and production. They identified that it was crucial to keep the Energy Label classes up-to-date and relevant, and advised a system of automatic, or scheduled, review and revision of labels and similarly for the Ecodesign MEPS.

Finally, they also identified the issue of data provision as a clear weakness in the process with few incentives for industry to provide current, comprehensive data, which then leads to poor data and preparatory studies and outcomes being sub-optimal. They recommended that manufacturers be obliged to provide the information, potentially through a centralised product database with mandated data provision timetables and conditions. If necessary information could be requested on an aggregate basis to reduce confidentiality and competitiveness concerns.

Firms supported wider policy linkages for Ecodesign and Energy Labelling, particularly in ensuring complementary standards on products, i.e. lighting controls, or moving to a lighting system basis for regulation in the future.

The feedback from firms and stakeholders on improvements and complementary policy approaches found limited support for innovation competitions. There were concerns that this would simply favour the biggest firms who were able to invest to win and also that the winning products were not guaranteed to reach the market, i.e. for refrigerators a winning product was 'kept on the shelf' for several years.

Stakeholders, particularly firms, agreed that signposting of long-term goals would be helpful to them in their long term planning and innovation. This was identified as particularly important in the context of products with a long lifetime such as LEDs as to simply test their lifetime takes years. While longer

term guidance on goals was useful it was also noted that this should be flexible and be able to adapt to the speed of technological change, so that it could adjust its ambition in the event of faster or slower development than expected. The environmental NGO noted that long-term goals should also not be afraid to challenge industry and to treat with healthy scepticism any claims of technical and physical limits to further improvement, as these simply have not been reached in any product group.

4.6.8 Summary and Conclusions

In summary the lighting sector is a large sector, with a global market worth of more than €70 billion annually, and billions of lamps sold to consumers and is responsible for nearly 20% of global energy use. Ecodesign, or its pre-cursors (2000), and Energy Labelling (1998) regulations for the sector have been in place for a relatively long period of time. This time has coincided with a radical change in the sector with a move away from traditional incandescent lamps to energy efficient lamps. This is a global trend, in both regulation and technology.

Innovation in the sector is closely focused on energy efficiency, measured as lumen/watt, as this is a key characteristic that firms use to compete and differentiate their products, and that consumers now factor into their purchase decisions. Firms in the lighting sector tend to go about innovation in a similar way and have a similar focus on the new LED technologies, rather than their existing or traditional lighting technology products. For the firms we spoke to their technological innovation on energy efficiency is driven by four key factors:

1. Competitive position
2. Consumer demand
3. Regulation
4. Intrinsic company commitment to energy efficiency

In the lighting sector, Ecodesign and Energy Labelling are the primary regulatory drivers, with Ecodesign being thought the more powerful of the two. The power of the regulation is mixed - firms were mostly comfortable with the levels of the regulation, some even thought it was not ambitious enough, and all already had products that met the criteria. At the same time it is one of the few product groups to be so transformed by the changes, with a whole product type (incandescent lamps) being effectively banned. The regulation has therefore been a contributor, though firms don't attribute it as a major contributor, to the radical transformation of the sector in recent years.

The lighting sector has taken a unified approach to the regulatory process in the EU, and took care to present one voice on these issues, therefore it is difficult to elaborate or distinguish different approaches. The sector was seen to engage in a critical but constructive manner with the regulatory process, searching for exemptions and changes to phasing and technical levels where it believed these were necessary, so that the process did not proceed faster than their ability to adapt, but being generally supportive of the overall goals. Individually, their support or opposition for the regulation was related to the extent to which their product range was affected and additional costs incurred. Perhaps the biggest concerns of the sector regarding the regulation are related to its effectiveness and compliance in the following two areas.

(1) **Enforcement of regulation was too weak** – that incandescent lamps can still be bought in the EU because of lax enforcement. This reduces firms' potential returns on their innovation investment and makes innovation less attractive.
(2) **Slow adaptation and enforcement of regulation** – where the regulation has not fully kept pace with the market changes, particularly for LED technologies, resulting in poor quality products reaching the market and 'poisoning the well' for their own innovation efforts for the same product.

4.7 Case study results: Air Conditioning

4.7.1 Products

Air Conditioning (A/C) products are used to adjust and regulate the internal temperature, humidity and air quality of buildings. There are a very wide variety of types of equipment and applications. The range from the smallest packaged units, which are designed to heat and/or cool individual rooms, to carefully designed bespoke systems which are responsible for the heating, cooling and ventilation of the largest buildings on earth. The main environmental impacts of A/C systems include:

- The electricity used to power the fans that bring in and extract air;
- The energy used to alter the state of the air (heating, cooling, (de)humidifying). The air is typically heated by passing over hot coils. The heat in these coils can come from many sources. The same is true for the energy used for cooling the air. The efficiency of these heating and/or cooling systems is of major importance to the environmental impact of A/C systems;
- On larger systems some of the heat in the air extracted from within buildings is recovered to heat the fresh air being brought in. The efficiency of this heat recovery is important for the environmental impact;
- The refrigerant chemicals used in the systems which cool air can be harmful if / when released to the atmosphere;
- Noise, from fans and motors.

As energy prices have increased and environmental concern has grown, the pressure to become efficient has increased, particularly on large whole building A/C systems. Small packaged units, in contrast, are often fitted into existing buildings - for example, to help cool offices where the ambient temperature has become too high, partly due to increased heat gain from IT equipment.

The fundamental function of A/C systems offers limited potential for efficiency improvements. However, A/C systems use a range of components where there are energy efficient options available, this includes motors, fans, cooling systems and heating systems. The amount of energy needed to pull/push air through an A/C system is affected by its design, with some applications having higher energy demands than others - for example, the intense air filtering needed for some scientific and medical applications.

Energy use in buildings results from the interaction of the design, materials and services (heating, cooling, lighting, water supply etc.). It is possible, and increasingly common, to design buildings which rely entirely on natural ventilation and do not need A/C. However there are certain building functions and scenarios where it is vital. A very important aspect of energy efficiency in A/C is its control, i.e. how well its output is matched to the real load. The control of A/C systems also relates to the need to consider buildings as systems, so in order to maximise the energy efficiency of the building as a whole the efficiency and interaction of all the components needs to be considered. For example if the heating of a building is implemented via a separate system from the comfort cooling it will be important to ensure that both systems are not used at once, or if a building has a high efficiency boiler but low quality thermal insulation this would be a poor system.

The construction sector has traditionally been relatively conservative, with changes in design standards and practice often being more driven by legislation, including national building standards, and international legislation such as the Energy Performance of Buildings directive (EPBD), than by consumer demand.

4.7.2 Market structure

Our review of the market revealed a diverse mix of companies though there has been substantial consolidation of companies over recent years. The supply side of the market includes large global companies who cover the full range of products – from the smallest to the largest systems. There are also some global companies who are not active in all sectors or in all locations. The sector includes European based companies who export globally, with these companies typically focused on market niches. The supply side of the market also contains smaller companies who assemble components made by others. Some examples of these companies are provided in the following table.

Table 8: Analysis of global market for air conditioners

COMPANY	Parent (if relevant)	HQ	Size (No. employees)	Innovativeness	Product focus
Group 1a: Global – Japanese based					
Daikin		Japan	Large	High[28]	Wide range of products
Mitsubishi		Japan	Large	Medium not highlighted	Mainly small packaged units [29]
LG		S Korea	Large		LG linked to Siemens on A/C[30]

[28] See corporate goals at: http://www.daikin.com/investor/report.html
[29] http://www.mitsubishielectric.com/products/airconditioning/index.html#air05

COMPANY	Parent (if relevant)	HQ	Size (No. employees)	Innovativeness	Product focus
Group 1b: Global - USA based					
Carrier	Part of United Technologies Corporation (US)	USA	Very large 61,000[31]	Medium –	wide range, US focussed
Trane	Part of Ingersoll Rand	USA	>29,000[32]	Medium	
Johnson Controls		USA[33]	Large	medium	Large chillers (York) plus HVAC
Group 2a: EU based – globally active					
Ciat		France	2,100	5% of turnover to R+D[34]	
System air		Sweden	3,300	Med - high[35]	
Trox		Germany	3,650	Med - high[36]	
Group 2b: EU based – smaller companies or niche market					
Stulz		Germany[37]			Focussed on data centre cooling
Vortice		Italian/UK[38]			Mainly small scale – ventilation fans
Proklima		Croatia	Small (probably SME)[39]		

4.7.3 Ecodesign/Labelling in the Sector

There are a number of Ecodesign and Energy Labelling lots relevant to air conditioning.

[30] http://www.lg.com/uk/corporate-information/overview/strategic-alliances
[31] See company information at http://www.carrier.com/carrier/en/worldwide/about/
[32] http://www.trane.com/people.aspx
[33] http://www.johnsoncontrols.co.uk/content/gb/en/products/building_efficiency/product_information/Integrated-HVAC-Systems.html
[34] http://www.grupociat.es/rubrique/index/eng-CIAT-group-company-profile/475
[35] http://www.systemair.com/en-GB/UK/About-us/ - links to universities, R+D centres
[36] See http://www.troxtechnik.com/en/company/about_trox/index.html
[37] http://uk.stulz.com/about-us/stulz-headquarters/
[38] http://www.vortice.ltd.uk/about-us.html
[39] http://www.proklima.hr/en/onama/povijest/

Table 9: Ecodesign and energy labelling lots relevant to air conditioning

Lot	Title (and start date)	Scope	Implementation Date
11	Ventilation fans Preparatory study 2008	Fans of power range 125 W to 500 kW	Final regulation entered into force 26 April 2011. The two tiers of minimum energy efficiency requirements effective from 1 January 2013 and 1 January 2015.
10 (merged with ENTR lot 6)	Residential ventilation and kitchen hoods	Energy Labelling requirements cover residential ventilation units (with the same exceptions as for the proposed Ecodesign requirements) and are proposed two be introduced in two stages.	Draft Ecodesign and Labelling requirements in October 2013. Voting Regulatory Committee held December 2013.
10 (DG En) Ecodesign	Room air conditioning appliances, local air coolers and comfort fans. Preparatory study in 2009	Applies to air-to-air-conditioning appliances up to 12 kW cooling and/or heating design load. The 12 kW level is the generally agreed limit between small (mainly domestic) and bigger (mainly commercial) air-conditioning appliances.	Two tiers of introduction; 2013 and 2014.
Lot 10 (DG En) Labelling	Room air conditioning appliances, local air coolers and comfort fans.	•A-G Energy Labels with a new design. •Energy rating of the cooling and heating functions. •Indication of the annual or hourly energy consumption. •Indication of sound levels. •Separate Energy Labels for split, double duct and single duct products.	In force from 2011 Gradual introduction of additional classes (A+ to A+++) from 2013.

4.7.4 Overview Case selection

We spoke to A/C companies, attempting to get a mix of large and small companies, and EC and non EC based companies covering a range of products that come under the Ecodesign and Labelling regulations. In addition, two experts were interviewed. One of the experts works for a trade association and has strong industry and Ecodesign and Energy Labelling knowledge. The other expert works for a building research association, he has more general expertise on construction industry and where A/C fits in.

4.7.5 Innovation impact

All of the companies looked on Ecodesign requirements as largely positive. It was viewed as having increased the speed of what most of them termed as on-going product development, rather than requiring the design of radical new product lines. This relates to the use of relatively standard components and the fact that it is possible to upgrade these to achieve the performance standards required.

All of them felt the regulations would have more impact on the packagers of other people's components, and also on the component manufacturers.

The general approach of Ecodesign was supported. The comments included –

"Ecodesign has an open approach to technology; it doesn't have a 'winning and losing' technology path but sets targets and lets companies decide how to comply – with cost safety, environmental impacts considered."

One of the large companies reported that their product development is also strongly influenced by which market they want to focus on - for example, the life sciences (labs) market has very different needs to offices or data centres – so their products need to be adapted to fit market requirements. The same company also reported that they have found with many of the apparently new approaches, that fundamentally they are not new and that when looking to use them in practice there are problems of (e.g.) scale, cost, reliability that limit practical use. There have not been any major product innovations in the recent past. Their customers are relatively conservative and show no interest in radical change.

All of the companies felt that Ecodesign results in improved product standards and that if the requirements are kept realistic virtually all of the A/C OEMs will support them. They also felt that the transition time (to higher standards) needs to be kept reasonable, because if it is done too quickly it could regulate too high a proportion of products out of the market.

4.7.6 Involvement in the legislative process

Of the two large (non EC head quartered) companies, one was slightly more proactive than the other in terms of seeking engagement via trade associations and directly. However, this may have been biased by the interviewee - the government affairs person was spoken to in the seemingly more proactive company. The less actively engaged company cited lack of resources for the lower engagement – although they would have (and had) engaged directly when deemed important.

The large EC headquartered company had sought active direct engagement in one process, where they felt their interests were threatened. They did this themselves (with national energy agency support) rather than via an EC wide trade association, partly because other EC A/C companies had differing opinions.

The experts and larger companies thought smaller companies would be less likely to engage in the process due to lack of resources.

4.7.7 Recommendations

There were concerns expressed by two of the companies regarding what they perceived as the presence of bias in favour of specific technologies/approaches by the consultants leading the preparatory studies and IAs. The companies also had concerns regarding the consultant's lack of current and relevant sector knowledge. For example, they reported that the consultants had not used all of the technical names for components that are commonly used in the industry. The consultant's lack of knowledge of the impacts on competition of an overly stringent a target level (that would exclude too many products) was also mentioned as a concern in terms of the credibility of the process with companies.

Some of the companies interviewed, and one of the stakeholders commented on the lack of firmness in the future timetable for defining and implementing standards. It was suggested that an early and firm timetable would be of help in research and innovation planning within the companies.

It can be difficult for product guidelines to properly cover the climatic variations within the EC. It is hard to avoid a N, S or W bias. If more effort was made at the start of the procedure to reflect the full width of climatic variations (and various construction techniques) this would help.

An external stakeholder with long experience of the A/C Ecodesign process said that it is a challenge to get the right information to the right companies at the right times. The regulatory process is long and appears to have long breaks (in terms of opportunity to comment). There is a need for constant monitoring to know when the time to put comments in is.

Enforcing/testing the Ecodesign regulations can be risky for a national authority. If a product fails they risk being pursued for damages/or legally challenged by the product manufacturer, e.g. was the test done correctly, how was the test product picked etc. Many of the problems with building EE are caused by poor design, installation or commissioning, Ecodesign can't really help with these.

4.7.8 Summary and Conclusions

A/C products are generally selected and specified by professionals in the construction industry. This is a relatively traditional and slow-moving sector where regulatory drivers (national building standards which are linked to the EPBD) are key to the energy efficiency progress. While Ecodesign and Labelling of A/C products does have some impact on increasing the speed of product development in the sector it appears likely that the overall energy efficiency of the sector is not considerably affected by it.

The A/C companies felt that there are more 'rational' purchase decisions made in business-to-business markets – e.g. sale of A/C equipment to industrial users, than in business to public markets. The reason and evidence they gave for this was that industrial buyers prioritise efficiency and reliability in a product and will pay a premium for this if this premium is recouped/generates a return.

It is apparent that companies affected by Ecodesign or the Energy Labelling directive will tend to engage with the regulatory process in a relatively self-interested way. They will engage directly when their interests slightly differ from the majority of companies (and hence trade association positions) but will not engage if their interests match the most likely proposal and/or the most common responses.

From stakeholder opinions it appears that SMEs are unlikely to engage in the regulatory process largely due to a lack of capacity to keep up with the debate and to know when to contribute. In contrast larger companies have the capacity to follow policy development, keep ahead of it and influence it.

The nature of the product market is of key importance. In traditional and relatively slow moving markets (like construction) innovation is harder to 'force'.

For companies who focus on quality, Ecodesign will require less innovation (and compliance effort). It is important to recognise the importance of 'competing' legislation and regulation within a product sector. When these policies align with each other they enhance, when they contradict it causes confusion.

4.8 Case study results: Heat supply

4.8.1 Products

This case study addresses the impact of Ecodesign and Energy Labelling on R&D and innovation in the heat supply sector. The relevant products groups that are regulated under Ecodesign and/or Energy Labelling are:

- **Space and Combination Heaters** – Space and combination heaters with a rated energy of 400 kW or less.
- **Water Heaters** - Water heaters with a rated heat output of 400 kW or less and hot water storage tanks with a storage volume ≤ 2 000 litres.

Both product groups exclude heaters specifically designed for biomass fuels or solid fuels. For this case study companies that produce both types of heaters were interviewed

Space or water heaters used in Europe show large design differences between Member States. Heating products can vary in terms of the type of energy carrier used, as well as their energy

efficiency. Which space or water heater is used is often dependent on national characteristics such as:

- **Local energy infrastructure** e.g. in the Netherlands gas boilers are often used because of the good Dutch gas infrastructure.
- **Local climate** e.g. Southern European houses require less heating throughout the year than Northern European houses, resulting in a less attractive business case for high efficiency space heaters.
- **Local focus on heater energy efficiency** e.g. in the Netherlands the *"gaskeur"* label has informed consumers of high efficiency heaters since 1994 facilitating the shift toward high market penetration of condensing boilers.

Condensing boilers are currently the most efficient non-renewable heating products on the market. Fossil fuel heaters still have the largest share on the European market. Heat pumps and solar heaters are a small but growing niche market, and it is now typical for boiler suppliers to also include heat pumps and solar collectors in their product portfolios. Companies position themselves in these new emerging market markets by acquiring small manufacturers specialised in heat pumps and solar collectors.

4.8.2 Market structure

The total market for boilers, water heaters, and radiators in the target area can be estimated at more than €10 billion per year. About 7.3 million domestic boilers, 12.7 million water heaters, and 50 million radiators are manufactured and sold annually (under floor heating not included). The five major suppliers for commercial and domestic boilers and other heating equipment are, in descending order: BBT Thermotechnik (Germany), Vaillant (Germany), Viessmann (Germany), Baxi (United Kingdom), and MTS (Merloni TermoSanitari, Italy). Based on 2005 data, these companies are responsible for 60% of the European market for heating equipment (Euroheat, 2006[40])

A relatively large number of companies are active on the European market. The European Heating Industry sector association (EHI) has 38 company members and 15 association members at Member State level. Companies typically focus on a few countries, rather than on the European market as a whole.

4.8.3 Ecodesign/Labelling in the Sector

In September 2013 the Ecodesign regulations on boilers and combi-boilers (EC/813/2013) and water heaters (EC/814/2013) were published in the Official Journal (OJEC). Ecodesign performance requirements become effective from 2015 onwards (tier 1) followed by a second set of requirements

[40] http://www.euroheat.org/files/filer/ecoheatcool/documents/Ecoheatcool_WP1_Web.pdf

in 2017 (tier 2). Labelling requirements for boilers and combi-boilers (EC/811/2013) and water heaters (EC/812/2013) were published in February 2013 and will become effective in 2015. From 2019 an additional energy efficiency class will be added to the label, and the three lowest energy efficiency levels will be moved. The single Energy Label will enable consumers to compare different technologies when choosing a heater for their homes. Systems will be labelled by the manufacturer or by the installer.

(Combi-)Boilers and water heaters were one of the first products groups for which the regulatory process of Ecodesign was started, with the preparatory study undertaken in 2006. The study was finalised in 2007, after which it took approximately 6 years to adopt the final Ecodesign and Labelling regulation.

The process was the longest of all product groups currently regulated under Ecodesign or Energy Labelling. Discussions on standards and thresholds, and a process that could have been more structured contributed to the protracted process. Better structuring would have involved improved sub-categorisation, to separate out more difficult products so that they did not slow the whole process.

The label for boilers is shown in Figure 10. It shows information on the energy efficiency, noise and capacity of the boiler. For other products in the scope of the Labelling for boilers and combi-boilers (e.g. heat pumps) additional information such as external noise levels is included.

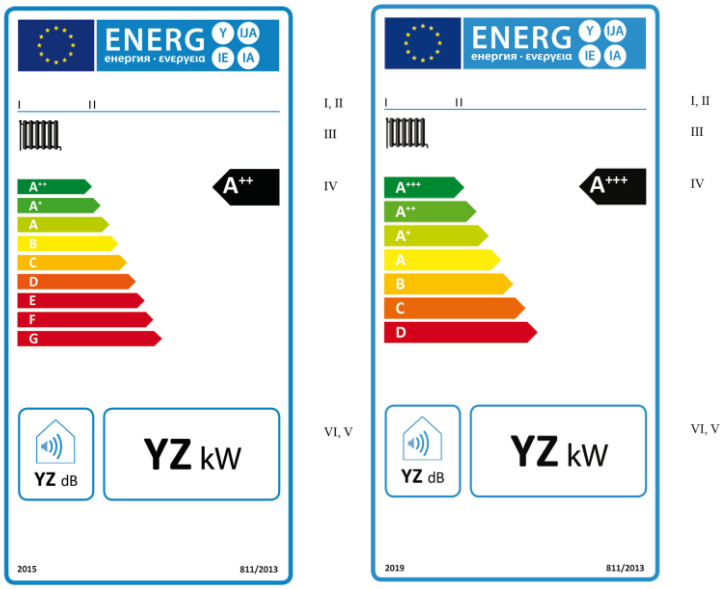


Figure 10: Energy Label for boiler space heaters in seasonal space heating - left = 2015 label, right = 2019 label

The label for water heaters is shown in Figure 11 and shows energy efficiency, noise, annual consumption and capacity of the water heater. It also includes an optional pictogram at the bottom of the label that indicates if a water heater is only able to work during off-peak hours.

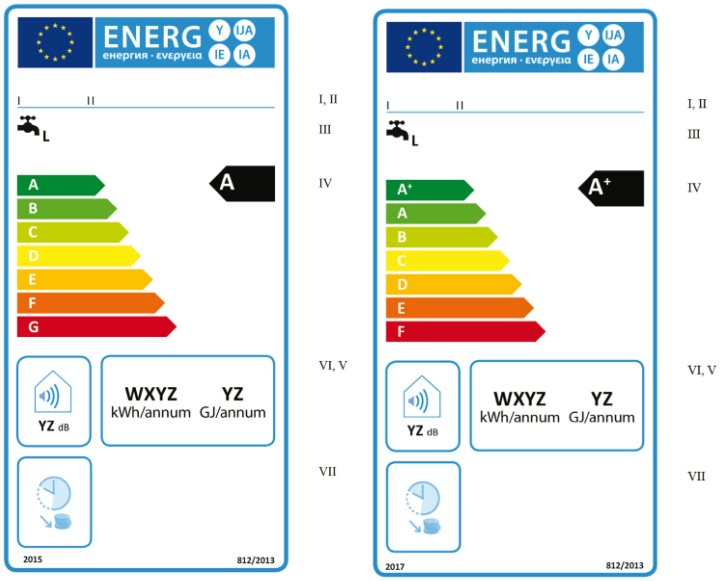


Figure 11: Energy Label for conventional water heaters - left = 2015 label, right = 2019 label

In a global legislative context minimum energy performance standards (MEPS) and comparative labels have been implemented in several economies outside of the EU. Amongst others, Australia, California, Canada, China, Japan and the United States have implemented MEPS or comparative Energy Labels for boilers and water heaters.

4.8.4 Overview Case selection

Heating products were selected as a case study due to:

- Their importance – Heating accounts for a major share of the European energy consumption
  - In 2007 space heating accounted for 13,225 PJ of heating fuel use or 53% of the total European heat demand.
  - In 2007 water heating accounted for 2,150 PJ of heating fuel use or 9% of the total European heat demand.
- The extended regulatory process
  - Preparatory study was started in 2006 and finished in 2007
  - Regulation was published in 2013
  - Regulation will become effective in 2015
- Linkage with other important European energy efficiency regulations such as the European Energy Performance of Buildings directive (EC/31/2010).

Our case study includes interviews with companies in the heat supply sector as well as an environmental NGO with a technical focus that plays an active role in the Ecodesign and Energy Labelling rulemaking process – including for the heat supply sector. Unfortunately it was not possible to interview EHI, the European Heating Industry sector organisation, for this case study.

4.8.5 Innovation impact

Innovation process, focus and resources

Innovation in the heating products sector is both incremental and radical. Incremental innovation can be seen where products that are already available are improved to reach higher efficiencies. Two manufacturers noted that the best conventional heating products on the market, condensing boilers, are nearing their maximum potential for burner efficiency. This means that in the future radical innovations, that use other technologies such as heat pumps and renewables, are needed to reach even higher energy efficiency levels.

All companies expect radically innovative technologies to play an important role in the EU in the coming years. Heat pumps and solar heating systems are already available on the market, but represent only a small share of the total sales. One manufacturer mentioned that 95% of sales are conventional boilers, and that heat pumps and solar heaters are a small but growing niche market. At the same time as still being a niche market, one manufacturers mentioned that only 40% of their current R&D budget goes into the (conventional) products that now represent around 70% of the market (for them). The other 60% of the R&D budget is spent on technologies that will become increasingly important in the years to come such as solar and heat pumps.

The innovation and R&D process in all companies is structured in roughly the same way. Innovative ideas can arise from the engineering department of the company (technology push), or from demand from the market. Demand from the market can sometimes be shaped by comparative labels or by subsidies and other incentives from national governments.

The first step of technological push innovation is to perform a technical feasibility study. If an idea is feasible a business case is developed in which the input from the (local) sales department is taken into account. Based on the business case the higher management makes the decision to invest in a new product or new technology. The process in the case of a market demand innovation is similar to technology push innovation, but the innovative idea is, in this case, a reaction to an external, rather than an internal, process. One company mentioned that, although market demand is a key driver for the direction of innovation, for instance an additional focus on energy efficiency, it is usually not the market that expresses the need for a specific technology or product. One manufacturer mentioned that the Dutch *"Gaskeur"* label, an industry label identifying high efficiency products, plays a key role in the innovation strategy of the company, which is also based in the Netherlands.

The companies spent in total around 3-5% of their turnover on R&D and innovation. One company indicated that the largest share of the innovation budget goes to product development (75%) rather than to research and pre-development (20%). One of the larger companies indicated that dedicated budgets are reserved for research and pre-development. Another firm indicated that much R&D and innovation is also done by the component producers, and that by working together with them innovative solutions to improve the quality of the product can be found.

Motivations for innovation

The motivation to innovate was broadly consistent in all companies, with some difference between the larger and smaller companies. All four companies that were consulted innovated for the following reasons:

- **Competitive position and product positioning** – innovation is needed to shape the company's products and make them stand out against the products of competitors.
- **Regulation** – National and European regulations can demand that a product is adapted.
- **Green image** – innovation in energy efficiency is needed for the green image of the brand.

The two larger companies we interviewed both indicated the intention to have products available in all market segments as a driver for R&D and innovation.

Impact of Ecodesign on innovation

The impact of Ecodesign on innovation was perceived differently across the companies that were interviewed:

- For one firm the Ecodesign requirements will not impact their business or innovation as their products all have a higher performance than the Ecodesign requirements.
- Another firm indicated that the Ecodesign requirements will have some impact on their business and that 0.5% to 1% of their turnover is spent on upgrading the current product portfolio to match the Ecodesign requirements.
- Two firms both indicated that the Ecodesign requirements will have a large impact on their business.
    - Around 2/3 of the product portfolio of one company will need to be adapted because of the new Ecodesign requirements.
    - For the other, although the drive for sustainable energy efficient products is in line with their company vision, it does have a significant impact on their product portfolio. Their non-condensing boilers have a significant market share in the EU and they expect that non-condensing boilers will, as a result of the Ecodesign regulation, be phased out of the European market.

We can conclude that the Ecodesign regulation for heating products has an impact on innovation in companies. Some companies have to adapt their products through incremental technological innovations and making new combinations of technologies to match the Ecodesign requirements. It is not expected that the Ecodesign requirements will lead to additional sales of radically new technologies such as heat pumps or solar heaters, as these technologies tend to be much more expensive than the less efficient technologies they replace.

All companies indicate that the Ecodesign regulation is likely to have a bigger impact on companies focusing on Southern and Eastern European markets, rather than on companies focusing on the North-Western and Central European Market. In the latter there is already a large market for high efficiency products, whereas in Southern and Eastern European market there is less demand.

Impact of Energy Labelling on innovation

For most companies (3/4) Labelling has some impact on incremental innovation in the company. The companies indicated that they look into the possibility of improving their products in such a way that a higher Labelling class is reached. One firm indicated that the impacts on innovation will be largest in the markets where no local or national label was already in place as these markets typically have a lower market penetration of high efficiency products. Others indicated that they have put additional focus on the noise performance of their products, as this parameter will be displayed on the label. Of these, one firm indicated that their products should score well on all parameters displayed on the label and not only the energy efficiency rating.
All companies were also critical of the Energy Label:

- All four companies indicated that it is very difficult to go up an efficiency class, as the efficiency ranges are too wide. This reduces the label's ability distinguish the best performing product from the other products. One firm noted that their condensing boilers will always be in A+ class, and that it would require a great deal of effort to rise up or go down an efficiency class. Putting additional effort in improving the energy efficiency of a condensing boiler will, in most cases, not be reflected by a change in class on the Energy Label;
- Another firm does not believe that the label provides a good tool to make a comparison between the different heating products on the European market. They indicated that the business case for a consumer is dependent on the local conditions, such as the local climate and energy infrastructure. A product that is not the most energy efficient, but is low in costs, can have a good business case in regions were heating is not often required. The label fails to reflect this in a good way.
- The same firm also voiced the concerns on how the enforcement of the Energy Label would be implemented. The concern came from the role of installers who, in the company's view, could present the label however they wanted to.
- One firm indicated that training their employees to work with the label required a burdensome investment of time. Furthermore they felt that the label only focused on efficiency and price, thereby not taking into account the important aspect of product quality.

Energy Labelling was considered by 3/4 companies to have a bigger impact on innovation and R&D than Ecodesign. One company did not think Ecodesign or Energy Labelling has an impact on innovation.

4.8.6 Involvement in the legislative process

All four companies indicated there is a need for regulation to improve the environmental performance of heating products. All companies agreed that some form of Labelling is needed to inform consumers of the performance of the product they buy. One firm mentioned that the market in itself will not be able to deal with societal problems and that therefore regulation is needed. Another firm indicated that regulations are also a tool that can be used to stimulate innovation and the competitiveness of the European industry, although they also expressed contradictory views of poor regulatory design and enforcement, clearly thinking there is room for improvement.

Involvement in the regulatory process

All the companies that were interviewed are members of EHI, the European heating industry sector organisation. EHI was involved in all stages of the regulatory process. Unfortunately EHI was only able to refer to their members for input, and we were unable to interview EHI themselves.

The two larger companies we interviewed both had a direct involvement in the process, whereas the two smaller companies chose to be involved via EHI. The bigger firms both provided data for the preparatory study and were directly involved in the discussions in the consultation forum. One of the smaller firms indicated that it was not possible to be actively involved in the process as they are a small company and being actively involved would require too many resources. At the same time they did try to stay informed of the process by keeping track of the documentation.

In general the stakeholders felt that the process was at some times unstructured, therefore some remarks were made on how this could be improved.

- One firm commented that the process could have been more structured at the start of the process and that there was not enough guidance. However, as heating products were one of the first product groups to be regulated they considered it to be part of the regulation's learning curve.
- The same firm also commented that the process could have been shorter if in the beginning more focus was placed on the testing standards, rather than on the regulation itself. If it is not yet clear how the products will be tested it is difficult to have constructive discussions on the minimum performance standards or Labelling requirements. Furthermore the methodology should use existing test standards as much as possible rather than trying to develop a separate standard for the regulation.
- Another firm noted that the process was difficult to follow from the side-lines and that the structuring could have been improved e.g. by better version management of the documentation. Furthermore they mentioned it would have been helpful to see the calculation models that were used to determine product performance.

Three of the four firms indicated that they felt they had enough influence on the process, either through direct involvement or through EHI. One of the bigger firms commented that influencing the process did take a considerable amount of resources and that it was difficult to keep the people involved motivated, as the process took such a long time. One of the smaller firms did not feel they had an influence in the process, as they did not have the resources to be directly involved.

All companies indicated a similar motivation for their involvement in the regulatory process. Primarily companies were involved to be informed about a regulation that will impact their business. Secondly, companies were involved to ensure to steer the process to a workable regulation that offered a "good comparison between the different heating technologies on the European market".

Three of the firms provided data for the preparatory study and were directly involved in the discussions in the consultation forum. One of these firms noted that they would also have liked to be more involved in the analysis of the data they provided. This would have, in their opinion, improved the outcomes of the preparatory study.

4.8.7 Recommendations

The main recommendation to increase the impact of Ecodesign and Energy Labelling on innovation in the heating products sector are:

- **Policy integration:** All companies agree an increase in the integration with other important European policy programs would increase the effect of Energy Labelling, primarily with the Energy Performance of Buildings directive (EPBD) (EC/31/2010). The EPBD is considered by all companies to be an important program to increase the efficiency of buildings in the European Union. By coupling it to the Energy Labelling directive, complexity is reduced and the impact is increased. A better coupling with Renewable Energy directive was also proposed by one firm.
- **Industry involvement:** One firm suggested to more actively involve industry in the technical parts of the process, especially early on, to improve the quality of the technical analysis and reduce the need for technical discussions later on in the process.
- **Compliance:** Another firm indicated that third party certification is needed for heating products on the European market. They also suggested that market surveillance should also be done by third parties.

According to two of the firms, signposting long term requirements would aid the market in developing a long term stagey for their products. While the two other firms agreed that it might help, but also question the accurateness of long term predictions.

The feedback from firms and stakeholders on improvements and complementary policy approaches found limited support for innovation competitions.

4.8.8 Summary and Conclusions

Innovation aims in the sector amongst others, include energy efficiency. A relatively large percentage of R&D is going to innovative (renewable) technologies such as heat pumps and solar water heaters, yet these technologies are currently only a niche market. It is expected that non-condensing boilers will be phased out of the market which leads to a lower innovation focus on those technologies that will be phased out. Innovation is influenced by three main factors:

- Competitive position and product positioning
- Regulation
- Green image

In the short term Ecodesign will spur companies to improve their low-end products to the levels acceptable under the Ecodesign requirements by incremental innovation to products that are already widely available. In the long run, Energy Labelling is expected to act as a driver for innovative (renewable) technologies requiring innovation of the more radical type. Although firms indicate that both the directives have some influence on innovation, none consider the regulation to be a leading driver for innovation in the sector.

All companies constructively engaged in the regulatory process. The intensity of the engagement is related to the size of the company, as only the larger companies were able to continuously participate in the process. The smaller companies participated through their membership of EHI, the sector organisation, and by keeping track of the documentation of the process.

5 Cross case analysis

The main goal of our case study research was to provide empirical evidence and to investigate the factors that influence the innovation impact of the Ecodesign and Labelling legislation across the different product groups that are affected. Furthermore, we aimed at designing a typology of manufacturer engagement in the process.

5.1 Potential of the legislation to induce/support innovation

Among the companies that were interviewed, the majority stated that both Ecodesign and Labelling have an influence on their innovation behaviour (see Figure 12). Out of the 17 companies that were affected by Ecodesign, 12 stated that the regulation has an impact on their innovation activities. Out of the 14 companies that were affected by Labelling, 12 stated that the legislation had an impact, whereas only 2 stated that this was not the case.

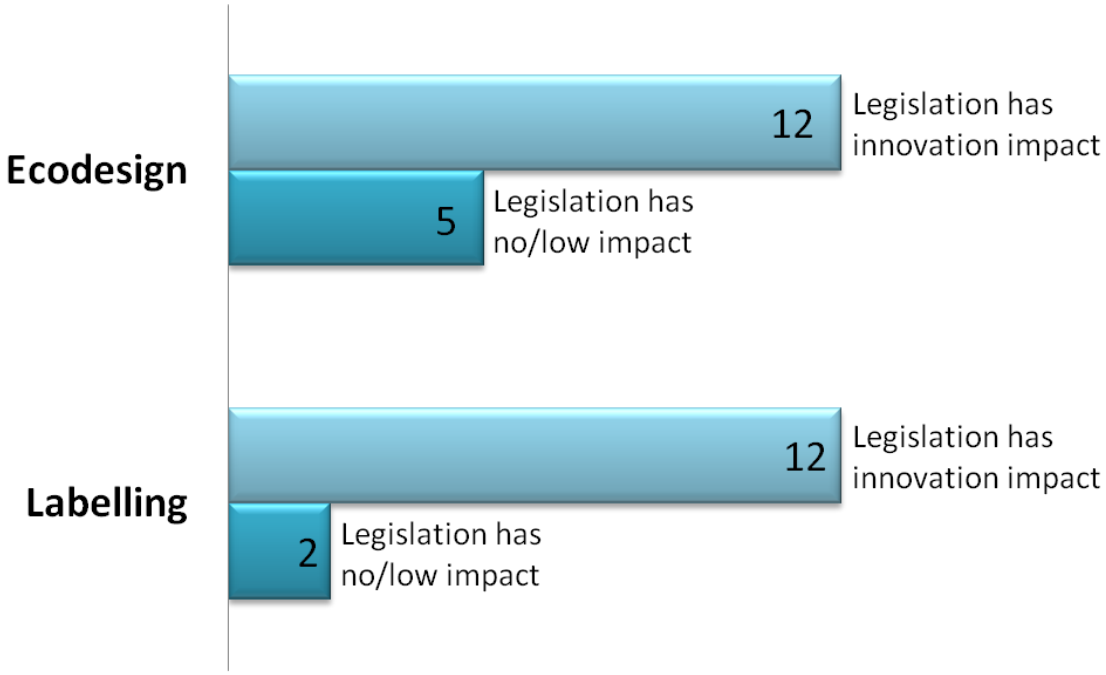


Figure 12: Relation between companies that affirmed that Ecodesign and Labelling had an impact on innovation and companies that did not.

It is important to keep in mind that the distribution of companies displayed in Figure 12 depends on our case selection and would probably look different for a different case study sample. The aim of the case selection was not to create a statistically relevant sample, but to get an in-depth understanding of the mechanism and the factors that influence the innovation impact of the directives.

Furthermore, it is important to keep in mind that the understanding of "innovation" differed considerably between the various interviewees, ranging from a rather narrow focus on basic R&D to a very broad view including any activities that the companies did in response to the legislation. In our study, we have chosen a rather broad view and discuss the various innovation activities that were induced. As will be discussed, most of the European product policy-induced innovation activities are not related to R&D and are relatively incremental adjustments that are not necessarily carried out by the innovation departments.

The innovation impact of Ecodesign and Labelling was found to differ in a number of ways, which will be discussed in the following sections:

- The potential and limitations to support innovation.
- The type of innovation activities that are induced.
- Barriers to the deployment of innovation that are addressed by the directives.

Potential and limitations - Ecodesign

For products where the Ecodesign implementing regulations define what the manufacturers in the sector consider as ambitious standards, the innovation impact is strong, as confirmed by the case studies for circulators and lighting. Products that do not comply cannot be sold, and therefore the adaption of the product portfolio to the regulation is the first priority for companies.

The ambition of the minimum energy performance standards is often considered in relation to the share of products that are removed from the market when the regulation is adopted. However this differs considerably between the different products. For example, for circulators, 90% of the market at the time of adoption did not meet the requirements. By contrast, for televisions the majority of market was above the requirements when the regulation came into force. This difference may be due to market agility, rather than just stringency of requirements. The TV market is highly innovative with fast moving R&D processes that enable it to adapt quickly to proposed legislation prior to its entry into force, whilst the circulators market will move more slowly.

Minimum requirements call for innovation if the products do not comply. Ecodesign has the power to lead to innovation because it regulates the mass market, and is therefore a strong instrument to support innovation and optimisation of the design/manufacturing process. It drastically affects the production process and related innovation and accelerates the learning curves in mass product production processes.

For products where the Ecodesign standards are set in a less ambitious way, the innovation impact is limited. In such cases, the main impact that was reported by the companies was a slight bringing forward of products already under development, rather than the development of new products. Furthermore, all the companies that stated that the legislation did not have a significant impact on their innovation activities reported that only very few or none of their products did not comply with the regulation.

Within each sector, the stringency of the standards can be perceived differently by different companies. Whereas producers of high-end products stated that all of their products already fulfilled the standards at the time of adoption, other manufacturers stated that they had to make significant adjustments to their products in order to comply. In sectors where the energy-efficiency gap between high-end and low-end products is large, it is more difficult to design a regulation that is sufficiently stringent to induce innovation among the high-efficiency companies, while at the same time taking into account the needs of low-end producers. In the following discussion, we use the term "relative stringency" to refer to the company-specific perception of the ambition of the standards.

Figure 13 shows that there is a direct relation between the innovation impact and the relative stringency of the regulation.

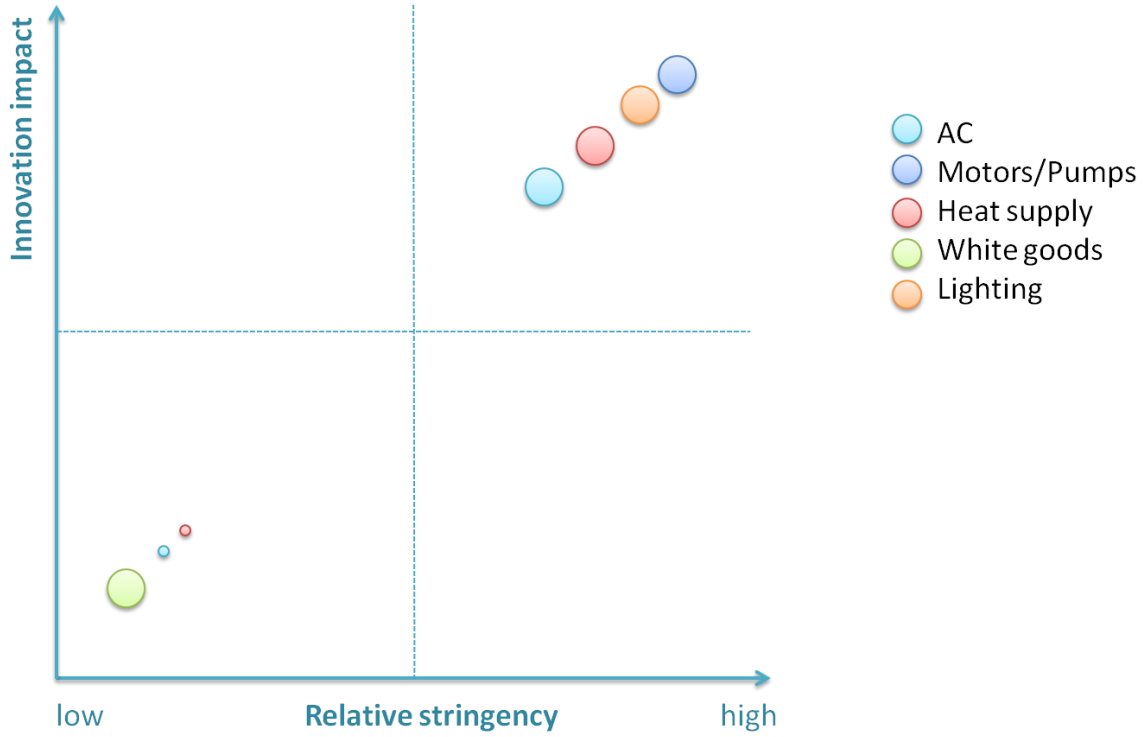


Figure 13: The innovation impact of Ecodesign is directly related to the relative stringency of the standards. The size of the circles reflects the number of companies with similar statements on stringency and innovation impact.

Apart from the ambition of the standards, the enforcement of the legislation plays an important role in the innovation impact. Some of the interviewees pointed out that the innovation impact can be limited as products that are banned by Ecodesign are still widely found on the European market (e.g. lighting).

Potential and limitations - Labelling

For Labelling, the innovation impact is found to be rather strong for high-end producers, who would like to see at least some of their products in the highest Labelling class. For low-end manufacturers the innovation impact tends to be weaker, however, most companies react to the label at least by making minor adjustments to their products or by adjusting the product portfolio. Labelling provides

the manufacturers with an opportunity to differentiate their products, and the consumers with the possibility of including energy efficiency as a factor in their decision making process. Manufacturers that differentiate their products mainly on a purchase-price basis will tend to appeal to consumers who (without clear information on running/lifetime costs) consider energy efficiency a lower purchasing priority. These manufacturers are therefore less likely to show strong responses to the Labelling legislation. In some sectors such as electronics, products tend to be feature-rich, and chosen on that basis, with energy efficiency very low down the list of purchase considerations, reducing the potential influence of a label. However, it has been found that some consumers associate the label with quality rather than energy efficiency, and therefore may still be influenced by it to some degree.

It has also been observed that SMEs have lower capacity for additional innovation activities and are therefore less likely to respond to Labelling. On the other hand, SMEs can be more agile than larger companies and react more flexibly to new legislative conditions. SMEs with a focus on high-efficiency products perceive Labelling as an opportunity to compete with bigger brands. In addition, our case studies observed an innovation impact on small and medium component manufacturers that are indirectly affected by the legislations through the requirements of the big manufacturers.

As was the case for Ecodesign, if the ambition of the Labelling classes is low the innovation impact is limited. For Labelling, the ambition is reflected in the market share of products that are in the highest Labelling class. Evidently, if most products are in the highest class the policy measure becomes meaningless and no innovation impact is observed. An example of this occurring could be seen in the white goods market before the introduction of the new classes. Likewise, and as for Ecodesign, Labelling is not a very flexible policy tool and has an inherent inertia. Single measures take time to be prepared, revised and be implemented (especially for Labelling with a sticker being fixed on products in shops) – which may influence innovation, its pace and ambition.

By contrast to Ecodesign, the relationship between the stringency and the innovation impact is not as straightforward (Figure 14). Unlike Ecodesign, where the producers cannot sell products that do not comply, for Labelling the companies may chose not to upgrade their products in order to reach the higher Labelling classes.

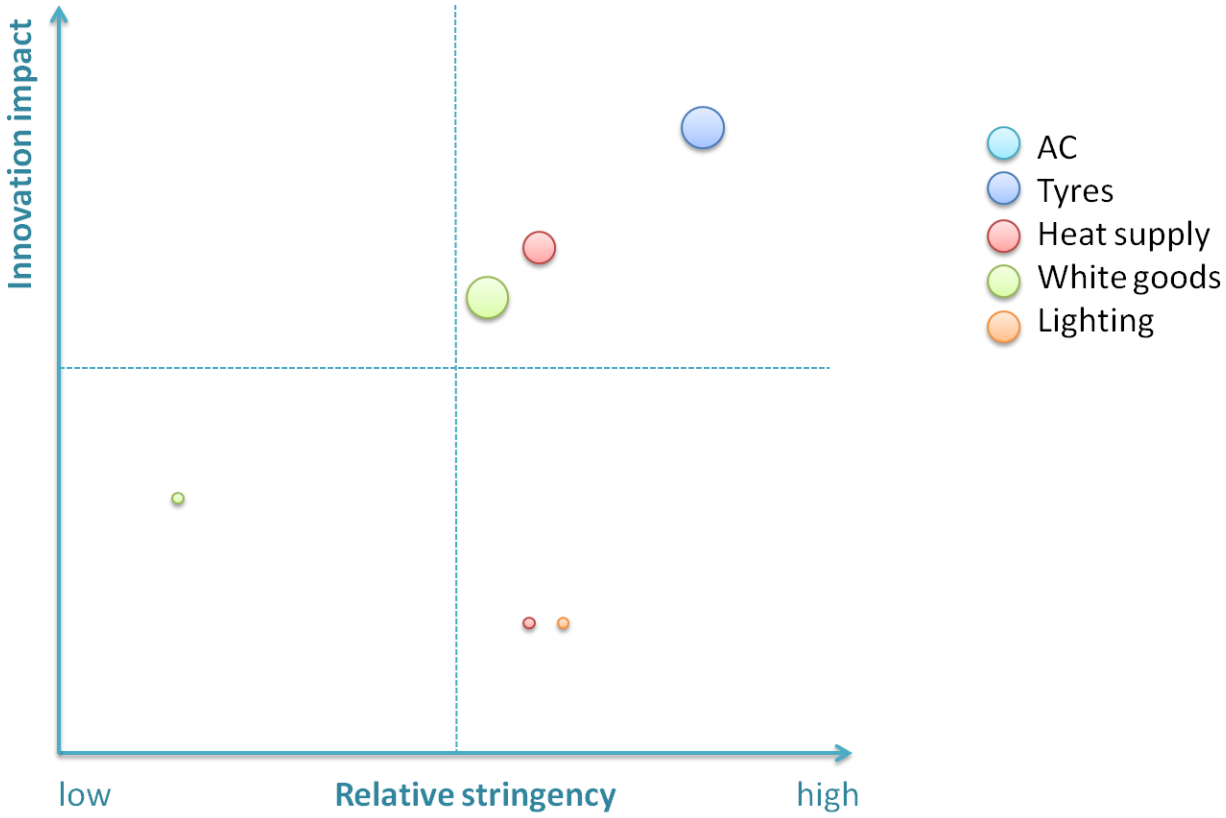


Figure 14: The innovation impact of Labelling is related to the energy efficiency thresholds of the upper classes of the label. However, for some companies the innovation impact is low despite the high relative stringency. The size of the circles reflects the number of companies with similar statements on stringency and innovation impact.

Labelling has a potential to induce innovation in two ways: First, manufacturers respond to the label by increasing the energy efficiency of their products. Later, consumers respond to the legislation – subsequent to promotion efforts. This could be observed for the example of tyre Labelling, which came into force in the end of 2012 and where a rather strong response by manufacturers was observed in the case studies - however, a number of interviewees expressed their concern about the weak response by customers to date. It was further observed that retailers do not tend to inform customers about the label and that market control is largely not implemented.

The consumer response to Labelling differs rather considerably between member states. In member states with a low penetration of high-efficiency devices, where purchase price is the main consumer consideration (and running costs a lesser consideration potentially because of low usage), companies are less likely to innovate. Examples for this are heat supply and air conditioning, where the market characteristics are different in Southern Europe, compared to North-Western Europe (mainly climate related). For heat supply, companies with a focus on the south of Europe have less incentive to innovation in high-efficiency products due to the lower consumer interest in more efficient products

as less energy savings can be made. However, in most of the sectors that were studied, for companies operating at European or global levels such impacts were small.

Innovation activities

The innovation activities that are influenced by Ecodesign and Labelling differ. For Ecodesign, the aim of the policy-induced innovation activities is to replace the non-compliant products in the product portfolio (and by extension on the market) with products that comply. The majority of innovation activities that were described are rather incremental changes to the production process and / or the choice of components. Ecodesign tends to have a stronger influence on process innovation, as the product portfolios of the companies change in such a way that the share of high-efficient products increases. Consequently, these products have to be produced on a larger scale for mass consumption and thus the production processes are reworked.

For Labelling, the aim of the policy-induced innovation activities is to improve the energy efficiency of the products in such a way that they enter a higher efficiency class. Labelling therefore tends to have an influence on product innovation, consisting mainly of incremental changes in the product design in order to reach the lower bound of the next Labelling class.

For both Ecodesign and Labelling, the innovation activities that were highlighted in the case studies as influenced by the legislation are mainly found in the later stages of the innovation process (see Figure 15). It is possible that in a longer term the innovation impact spreads to the earlier stages. Especially in the early stages of the Labelling legislation (e.g. tyres), the label drives the innovation activities towards the criteria that are included in the label. Similar observations were made for Ecodesign with ambitious standards (e.g. pumps), where the innovation activities were strongly influenced before the regulation came into force.

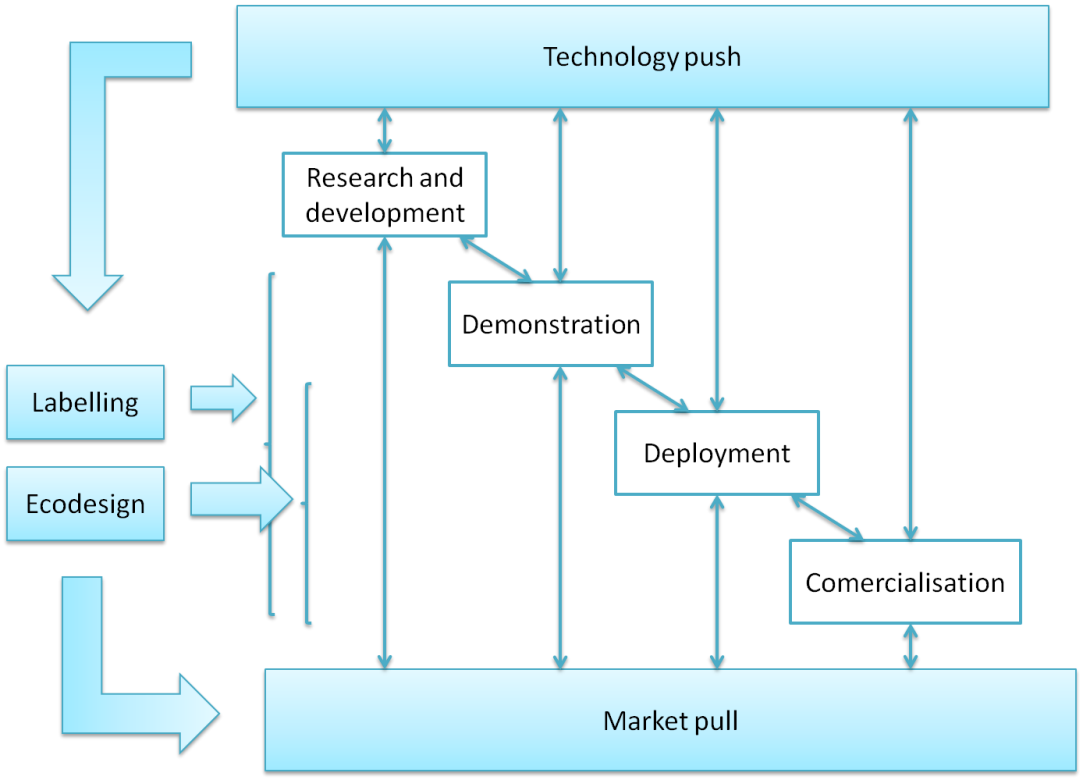


Figure 15: The Ecodesign and Labelling legislation mainly has an impact on the later stages of the innovation process. The early stages rather provide an input to the standard setting.

Potential to address barriers to the deployment of innovations

A number of interviewees stated that Ecodesign and Labelling have reduced barriers to the deployment of innovations. Comparing the different sectors, we observe that the market/sales structure plays a role regarding the level of impact that the regulation has on innovation. The barriers were highlighted in the case studies to be addressed by the legislation are discussed in detail in Table 10.

Table 10: Barriers to the deployment of innovations that are addressed by Ecodesign and Labelling

Market	Barriers/Characteristics	Role of Ecodesign	Role of Labelling
Consumer market	Consumers typically do not conduct a life-cycle-cost analysis before purchasing a product. The importance of the investment price therefore tends to be overestimated compared to the life-cycle energy savings.	Ecodesign is a strong measure to address the barrier, as products with low investment costs but high life-cycle costs are banned. However, Ecodesign does not influence consumers' choices beyond the minimum standards.	Labelling can draw the consumers' attention to life-cycle aspects and shift consumers' choices towards more efficient products. On the low efficiency end, this approach is weaker than Ecodesign, as a proportion of consumers

Market	Barriers/Characteristics	Role of Ecodesign	Role of Labelling
			will still choose the low-investment option, but Labelling has the potential to address the high-efficiency end.
B2B-components	For sectors where products are not sold to end users and are used as components in larger systems (e.g. electric motors and pumps, air conditioning, tyres), the line of purchase is broken in a sense that buyers are typically not interested in energy efficiency as they will not benefit from energy savings themselves. An exception to this is larger systems that are themselves regulated, e.g. tyres/emission standards or AC/EPBD.	Ecodesign addresses this barrier at least in the low end, as low efficiency products are removed from the market.	Labelling typically plays a minor role for such products and would not have a significant impact, as the lack of information is much less of an issue, because business buyers will research this for themselves.
B2B plug-in – products that significantly influence energy use	For products that are sold to companies for their direct use and that significantly influence the energy use of the company (e.g. tyres for fleet companies, AC for industrial users, servers for data centres), the buyers are usually rather well informed and rational about energy savings and take them into account in their decisions.	The impact of Ecodesign is not as strong as for the consumer and B2B-components markets, as the buying decisions are already strongly influenced by the energy efficiency of the products.	Labelling typically plays a minor role for these products, although it can assist in GPP.
B2B plug-in – products that do not significantly influence	For products whose energy use is small compared to the total energy use of the company (e.g. commercial refrigeration), the	Ecodesign is a strong measure to address the barrier, as products with low investment costs but high life-cycle costs are	Labelling can draw the attention of the purchasing unit to life-cycle aspects, however, split incentives can still

Market	Barriers/Characteristics	Role of Ecodesign	Role of Labelling
energy use	importance of the investment price tends to be overestimated. This is especially where the purchasing unit is typically not responsible for energy savings (split incentives).	banned. However, Ecodesign does not influence purchasers' choices beyond the minimum standards.	hamper the diffusion of high-efficiency products.

Innovation cycles

The ability of the regulation to induce innovation depends on its alignment with the innovation cycles in a sector. It was observed by a number of interviewees that if innovation was to be a main aim of the directives, it would be useful to take into account the innovation processes of the respective products in more detail. A prime example of this is in the electronics sector, where innovation is very fast and it is a great challenge for the legislative processes to keep up with the dynamics. Where requirements are specified in the short term that do not align with development cycles, this can incur considerable costs for manufacturers. Also, for lighting it was highlighted that earlier indications of future requirements are important as new lighting products have increasingly long lifetimes, and just carrying out lifetime measurements can enlarge the innovation cycle and delay a product reaching the market.

Summary

Ecodesign and Labelling have the potential to positively influence the innovation activities of the manufacturers that are affected. On the one hand Labelling supports the market pull for high-efficiency products and therefore indirectly influences innovation in this direction depending upon how much differentiation the label offers, and if purchasers consider energy efficiency in their buying decisions. On the other hand, the relationship between Labelling and market pull is rather complex and Labelling also influences innovation before it is clear if the consumers will respond to it. Ecodesign removes the worst performing products from the market. If the levels are set in such a way that a large share of the market is removed, Ecodesign can be a strong driver for innovation activities.

The innovation activities that are induced by Ecodesign and Labelling are found in the later stages of the innovation process and are typically incremental. The policy measures are not likely to have an impact on the technological development of radical innovations, however, they do have the potential to support the accelerated market uptake of such technologies.

5.2 Results on firm typology

This section presents our analysis of the case study interviews and the final firm typology.

5.2.1 Key findings

Engagement in the regulatory process

In the first step in our typology we sought to filter firms that were either active or passive in the regulatory process. We found that of the 27 firms and sector organisations we interviewed for the case studies the ratio of active:passive was 22:5, demonstrating that the majority were active in the regulatory process. 3 of the 5 passive firms were scored as perceiving a negative impact of the regulation on their firm, while only 5 of 22 of active firms scored the same, appearing to show that in general, but not always, active participation gives firms a more positive perception of the regulation impacts. However, it is important to note that this was not a statistically robust sample, so cannot be considered a reflection of the market as a whole. It is likely that passive and obstructive firms would not engage in a case study, so our results may be somewhat biased towards companies that view the process positively.

Firms were passive in the process due to a lack of resources or capacity dedicated to the process. For smaller firms it was simply not feasible to closely follow or engage with the process. These firms typically relied on their trade association for information and representation, and would in most cases simply react to the outcomes of the process rather than trying to influence them.

The reasons for firms and sector organisations to become actively involved are primarily to stay informed and to influence the process where they feel they need to. Their goals can, in general, be summarised as:

- Supporting workable regulations, which properly take into account:
  - Technology and market differences across the whole EU;
  - Consistency and coherence with existing requirements, standards and international processes;
  - Practical needs and market characteristics, i.e. surveillance, enforcement, speed of innovation.
- Protecting (and/or enhancing) their market position, by focusing on:
  - Ensuring the information and assumptions used by the Commission are appropriate;
  - Ensuring technology neutrality and fair competition;
  - Avoiding product bans;
  - Opportunities to increase possibilities for product differentiation, including through more ambitious requirements;
  - Acting to protect individual interests when these diverge from the association or industry position.

Firms and sector organisations were active across many stages of the regulatory process, but particularly at the preparatory study (3) and consultation forum (4) stages (see **Error! Reference ource not found.**). Many did not have the resources to engage before the preparatory study and none reported any influence on the regulatory committee vote (5), although this is not to say that firms or sector groups do not try to influence at this and other stages, but we found no direct evidence of this. There was little evidence that firms significantly changed their positions or approach

across the stages, it seemed more the case that their position was relatively stable, but that the intensity of their engagement would vary according with the requirements 'on the table' at the time and how these would impact on their goals (see above). Awareness could also be a factor in position changes, with some firms or sectors simply being slower to understand the impacts of the regulation, and then reacting when they do.

Figure 16: Stages of the Ecodesign and Energy Labelling regulatory process

Rating firms and associations

Based on the interviews we carried out and the background research into the sector and specific firms, our experts were asked to score each firm/association on the two axes we defined – relative Eco-innovativeness of the firm and perceived impact on the firm of the proposed regulation (see Appendix III for a fuller elaboration). The results (see **Error! Reference source not found.**) show hat the largest group of firms falls in the upper right quadrant, the second largest group, in the lower right, While only a handful of firms were judged as being of relatively low eco-innovativeness and falling on the left hand side of the quadrant. This type of rating bias represents a challenge in implementing such ratings, as all firms innovate to some degree, therefore rating their relative position in the product or sector is difficult. We tested re-basing and/or standardising the eco-innovation scores, but this had little impact on the scatter distribution.

A regression analysis found only a very weak (R^2=6%) positive relation between the variables. We therefore cannot say with any confidence that there is a strong relation between the eco-innovativeness of a firm/sector and the perceived impact of a regulation on it.

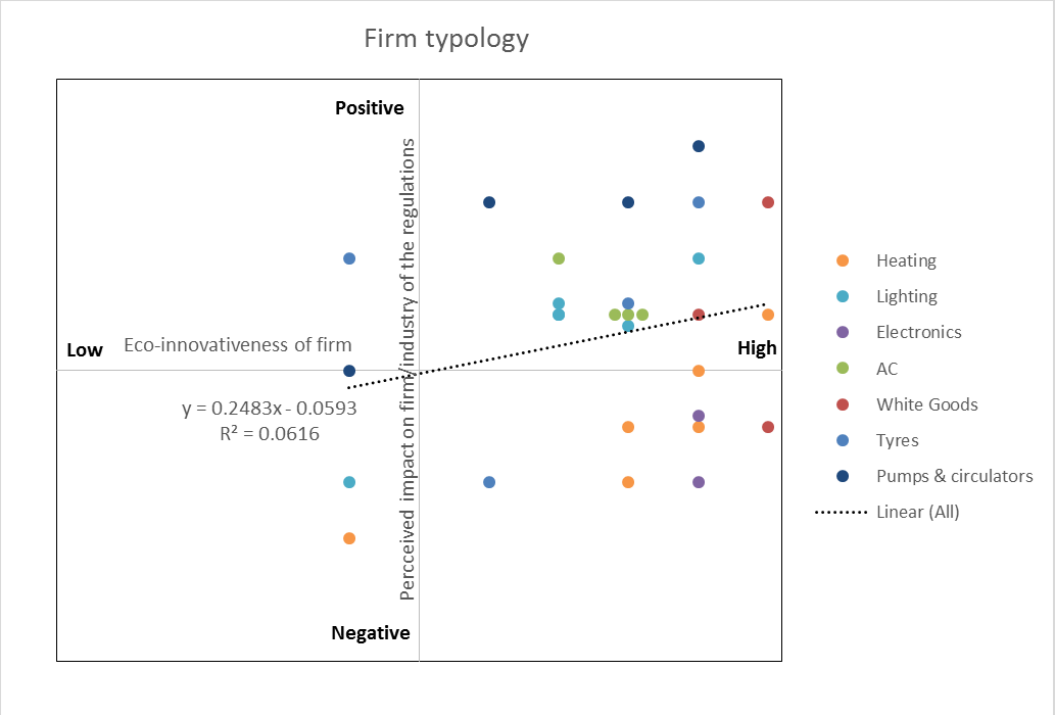


Figure 17: Firm ratings on the axes – as scored by research team experts

Relevance and strength of the axes: Eco-innovativeness

Eco-innovativeness is something that almost all firms claimed to pursue, and could provide some evidence of. Given the difficulty in knowing the quality of the innovation it was very difficult to distinguish firms with the least eco-innovative approaches, hence the scoring results of our analysis.

Nevertheless, as was discussed in Chapter 4 and 5, it was clear that the regulations have an impact on firms' innovation behaviour, stimulating eco-innovation. This demonstrates a link between the regulation and eco-innovation, which would be expected to come back in a firm's involvement in the process, either positively or negatively. This may also be grouped by sector, for example with heating, electronics and air conditioning having relatively tightly clustered rankings.

Eco-innovation strength was most closely linked to the goals related to market position, and typically in a more positive sense, of firms seeing the regulatory process as a way that their eco-innovations can be used to better differentiate their products, potentially through more ambitious requirements.

Eco-innovation weakness tended to be tied to more passive interactions, perceptions of negative impact and greater criticism of the process and its outcomes.

In general it is possible to make a case, though not a strong case, for a firms relative eco-innovativeness to affect its position and engagement in the regulatory process, with the strongest conclusion being that less eco-innovative firms are more likely to be passive or negative in the

process. This is not to say that the most eco-innovative firms will always interact, or interact positively in the process.

Relevance and strength of the axes: Perceived impact of the regulation
The perceived impact of the regulatory measure upon firms was evident as the key determinant of their position. It was clear that the intensity and focus of firms engagement was directed towards areas which they anticipated would have the biggest impact upon them. This corresponded closely to the goals described above, in supporting workable regulations and protecting (and enhancing) their market position, and covered examples of both positive and negative responses to the process. The comments below clearly illustrate the way impact underlies a firms / sector organisations way of engaging, with the associations being noted as needing to accommodate the impact for the whole sector, particularly the smaller, and/or less innovative firms.

Based on these responses we conclude that the perceived impact on a firm or the wider sector is a key determinant of how these organisations interact with the regulatory process and therefore that this is a highly relevant criteria/axis by which to distinguish firms.

5.2.2 Final typology and types

Based on this analysis we propose the following typology can be a useful framework, with a few important caveats.

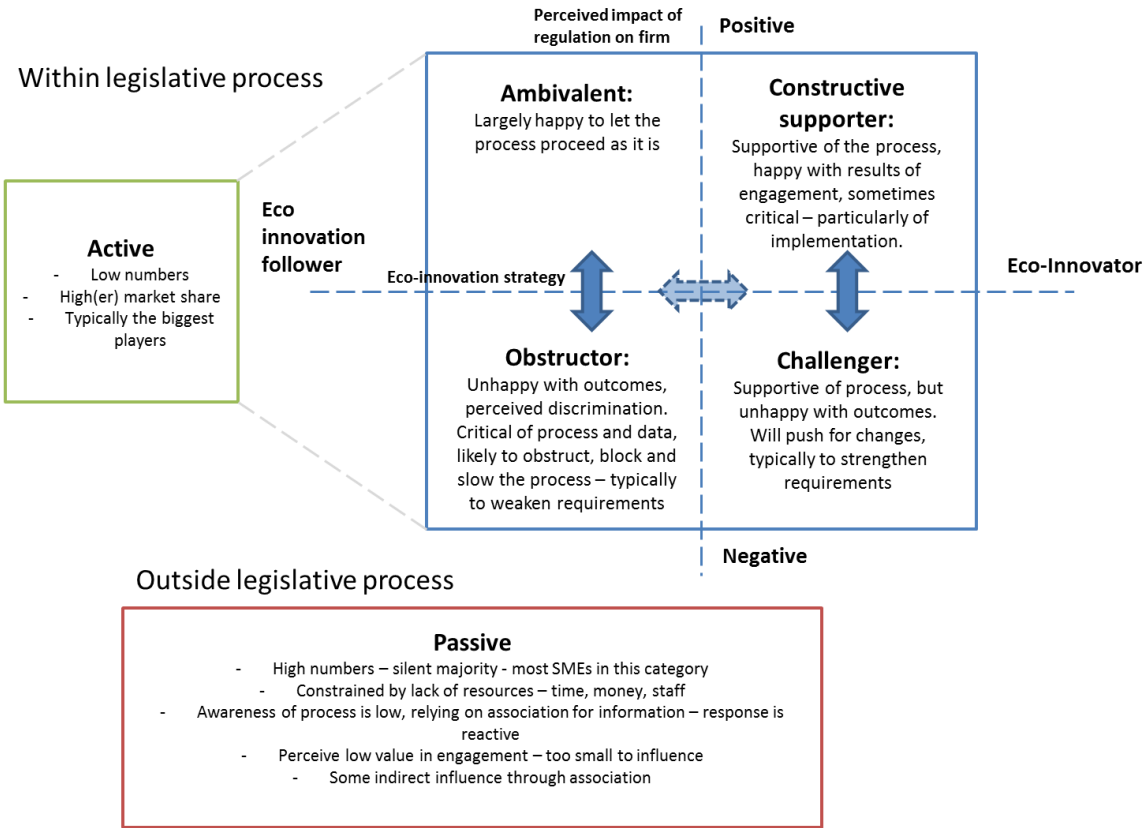


Figure 18: Typology of firms engagement in the regulatory process for Ecodesign and Energy Labelling

- **Constructive supporters -** high eco-innovation – positive perceived impact
  The largest number of firms and associations were scored in this group and could be found across almost all product groups, possibly a result of self-selection bias in case studies, i.e. the most constructive firms also the most willing to engage with the research. These firms were characterised by general satisfaction with the outcomes of the regulatory process. They tended to feel their viewpoints were heard and that they had sufficient influence in the process. They typically participated in the consultation forums and provided data and engaged with the technical consultants on the preparatory study.
  A few firms in this group mentioned that they would have preferred stronger requirements, but this was not a typical view, and even when brought up, the same firms commented on the difficulty of getting industry as a whole to agree to stricter requirements. This occurred in product groups with requirements judged as having medium-low ambition.
  This group was conscious of the investments that they had made in eco-innovation and were particularly keen to see market surveillance and enforcement of the regulation, although these points were also mentioned by most of the other groups too.
  These firms were also critical of particular elements of the process, their engagement was not always positive, for example when they disagreed with the technical information being used,

but their reaction to this was typically constructive, rather than obstructive, for example supporting the Commission and consultants with improved data and market insights.

- **Challengers -** high eco-innovation – negative perceived impact
  Seven firms or associations were classed in this group. These firms were characterised by wider scepticism of the process. In some cases they had more limited resources to commit to engaging with the process. Although they did try to play an active role it was limited to the issues which were most important to them.
  These firms felt the requirements would result in a negative impact upon their firm or the wider sector, they were more critical of the proposals coming from the Commission than the constructive group, and they were also less likely to feel that their opinions were taken into account.
  While judged as relatively eco-innovative these firms adopted a more defensive position towards the regulation, this was a combination of different factors across firms, from a large product range with some products at risk, to a lack of trust in Commission experts and proposed requirements and more general scepticism or desire for independence through alternatives such as industry agreements. Their response in the process was difficult to elaborate but seemed focused on ensuring the technical requirements were improved – or at least that the resulting impact on their firms improved – which could encompass both raising or lowering of the ambition of requirements.

- **Ambivalent -** low eco-innovation – positive perceived impact
  The two firms in this category could be characterised as more loosely engaged in the regulatory processes and to feel relatively comfortable with the outcomes. While judged relatively weak on eco-innovation, the ambition of the requirements did not appear to restrict their products at a pace that they couldn't adapt to.
  Firms in this category can be assumed to be relatively inactive in the process, but generally co-operative and constructive when called upon. It is possible that they could withhold information that suggests that they can relatively easily comply with higher standards. If actions are taken towards stricter regulatory requirements, which result in negative impacts, then these firms would be likely to become more obstructive.
  We scored only two firms in this category, which could suggest that it is uncommon for firms that are relatively weak on eco-innovation to expend the resources to actively engage in the process when they perceive the impacts of the regulation to be positive. Equally it could be a result of the self-selection bias of the firms we interviewed, with firms in this category ambivalent about involvement in the research.

- **Obstructors -** low eco-innovation – negative perceived impact
  Only one firm was actively characterised in this group, reflecting the difficulty in drawing out more negative sentiment and feedback from firms and also possibly that the firms who were willing to engage with us with were relatively eco-innovative and positive about the process. The feedback suggested that firms within such a grouping would not be against the regulation as a whole but the particular formulation as it stood. They would most typically feel the

requirements as too strict and that this disproportionately affected their firm, perceived as a form of discrimination against their particular product or technology.
We understand that this group can be a barrier to a successful regulatory process, with their engagement focusing on addressing the discrimination they perceive. Their response being likely to take various forms, in the first case, they would seek to secure a joint position from their sector association which supported less ambitious requirements, representing the 'lowest common denominator' industry position some stakeholders referred to. When this approach was less successful, they may also obstruct the process itself, by proposing amendments (product level exceptions and exemptions), blocking decisions, withholding data, applying lobbying and political pressure. This group will most likely switch to ambivalent the regulation is weakened to the point their returns become neutral or positive.

- **Passive -** all eco-innovation levels – all impacts
  Firms that are passive can be of any eco-innovation type and the regulation could have any possible impact upon them. It is very difficult to classify their engagement with the process as there is none or very little. Passive firms may play some role in the process via influencing the views of their sector organisations and associations, but this is an aggregated and diluted reflection of their wishes.
  The passive group is likely to comprise the great majority of the firms in any product group, particularly the SMEs, but also including larger firms, with it not being unusual for firms we classed as ambivalent or constructive supporters to step out of the process when they are happy with the outcomes.
  We anticipate that if passive firms become active they are most likely to become active as obstructors or challengers. This is a reflection of the natural human risk aversion, that we value losses more than gains, i.e. that a regulation that is expected to have a negative impact is more likely to motivate a firm to engage in the regulatory process than a regulation with a positive impact.

As noted above while the active firms can often represent a significant share of the market, they are rarely more than a tiny minority of all firms in the sector, and one that can be regarded as relatively more eco-innovative than the average.

Of the firms and associations active in the process our findings are that the majority (i.e. >50%) of active firms could be classified as constructive supporters, at least at the conclusion of the process. Very few firms were classified as ambivalent or obstructors, i.e. (<10%), with challengers the second largest group as a whole. It is possible that the breakdown between the types is more even and fluid during the process, with more obstructors and challengers especially, but there was no real evidence for firms changing their position (type) during the process.

5.2.3 Conclusions, challenges and limitations

Conclusions

In carrying out the work to elaborate a typology of firms engagement in the regulatory processes for Ecodesign and Energy Labelling we were able to arrive at the following conclusions:

- **Firms and sectors almost universally accept the need for action** – there is widespread agreement on the need to take action, either to regulate or self-regulate energy use and better inform consumers, therefore there is little evidence of obstructive behaviour being driven by ideological positions against regulation. The strongest contrast to this view was in the Electronics sector, which, while agreeing with the need for action, preferred to be given more time and space to achieve eco-innovation on its own via self-regulation rather than mandatory regulations.
- **Firms primarily engaged in the process through sector organisations** – while some of the biggest firms also participated individually, and others when the sector could not agree a joint position, the standard approach was for the sector organisations to lead in the process. This is consistent with the findings on lobbying behaviour presented in appendix II, which identified the cost and resource barriers to most firms in engaging in such work. It also points to a need to better understand how consensus and positions are reached in sector organisations, perhaps reducing the importance of a firm-level typology. There is some anecdotal evidence that sector organisations have to accommodate the lowest common denominator position in the sector, leading to lower ambition outcomes.
- Industry engagement was positive in most sectors but pragmatic and focused on:
    - ***Practical implications:*** that the final regulations would be workable in practice, with specific product and market characteristics taken into account, enforcement and testing properly considered and fairness to producers and users.
    - ***Non-discrimination:*** that the level of requirements, or specific nature of them, did not unfairly discriminate against their company or product range in comparison to others, i.e. by favouring a particular technology or fuel. This is a natural stance, to protect their self-interest and to maintain their competitive position.
    - ***Regulations that were not too ambitious – allowing reasonable time for adjustment:*** there is a natural self-interest for firms in not wishing for the Ecodesign minimum requirements to be set too high when their product range includes a large share of products that could be affected. Firms were also keen to ensure that they would still have top rated products and therefore would not necessarily support open space / growth room in the highest Labelling classes, although these would maintain innovation incentives over a longer period. They generally pushed for requirements that allowed for manageable adjustments, not too fast, with a minimum of push, but a reasonable pull.
- **Very little evidence of firms 'pushing' for more ambitious requirements** – although one or two firms mentioned that requirements could have been more ambitious, there was little or no evidence that they took action within the process to make this happen.
- **Evidence of more negative engagement was sparse** – some firms alluded to occasions where they would engage in a more negative way, to slow the process or change a requirement, but these examples were not well elaborated – the sample of companies who agreed to be interviewed did not seem to cover such companies extensively. (also see below)

- **Firms' experience of the process and its outcomes was largely positive** – most firms interviewed felt they had sufficient and fair influence in the process and that the outcomes were reasonable, this is consistent with the perceived impact scores presented above. Although at the same time…
- **Firms identified some shortcomings in the process** – with a focus on the quality of the preparatory studies, technical experts and data used in the assessments, but also encompassing speed and communication issues.

Challenges

At the same time our work faced a number of challenges, which places some limitations into what can be read into our findings, including:

- **Firms were unable or unwilling to take credit for influencing the process – particularly negatively** – it is clear that although the process is multi-stakeholder and balance must be found, industry does have a significant influence on the regulatory outcomes, particularly as they are typically the owners or gatekeepers of the technical data necessary to develop a regulation. We suspect industry was more influential than our interviews and research was able to reveal, particularly in a negative sense, as a threat to a firms position will always encourage a robust response – and it is perfectly understandable why firms would not share this information, or indeed to even view their actions in this way.
- **Detailed analysis of specific product processes was not possible** – while consultation forum and other documentation was reviewed for the case studies it was not possible to dive into very in-depth analysis of how the process for each product group developed - the reasons for the changes, delays and developments that occurred.
- **Difficulty to distinguish eco-innovation lagging firms** - and/or those that engage negatively – it is possible that our interview sample was simply biased towards eco-innovative and/or positively engaging firms, therefore the representation we make is only of their views. Yet, as discussed above, it is difficult to distinguish the relative eco-innovation strength of a firm, we believe this introduces some positive bias into our assessments of eco-innovativeness.

Insights and limitations in using the typology

Taking this all into account some final insights into what the typology should be used for, and limitations of its use include:

- **The initial regulatory proposal will partially determine firms' type** – there is no intrinsic type of firm, but it can be possible to estimate, on the basis of understanding the relative eco-innovativeness of firms (but also see next point), in which half of the quadrant firms are likely to place.
- **Eco-innovation is very difficult to judge –** placing a firm on the eco-innovation axis is a difficult judgement, making the types somewhat subjective.
- **It is also useful to think in terms of relative sector eco-innovativeness –** while the typology analysis has provided useful insight as a whole, the differences in relative eco-innovativeness in a sector are likely to also have a bearing on where firms might place within the typology.

- **Types may change vertically in short term, horizontally in longer term** - within the framework we propose, we see that firms probably do change type to some extent, with the intensity of their involvement changing quite quickly in the short term based on any perceived change in the impact upon their firm or sector, representing a vertical movement in the typology. Horizontal movement is understood to be longer term and a result of a re-focusing on eco-innovation.
- **Most firms will not drive for stricter requirements –** unless the requirements start from very low ambition. Even from the most eco-innovative firms that theoretically have most to gain from stricter requirements are unlikely to push for them. We understand that they either see that their market strength is already supported by the label and other factors, i.e. brand loyalty, reputation for quality; and does not need further support through regulation.
- **The typology is only relevant to a handful of firms –** in each product group only a handful of firms have the capacity and inclination to be actively involved in the regulatory process. Associations are often the most influential industry representative in the regulatory process.
- **The typology was unable to gather clear evidence of negative engagement** – it is clear that some negative engagement in the process by industry must occur, i.e. process obstruction, lobbying, providing incomplete or out-of-date data and other actions, but we were unable to find any evidence of this – likely due to the types of companies who were willing to engage in our case studies, and a reluctance to admit to such types of interaction by those who did engage.

6 Policy recommendations

The key goal of this project was to derive policy recommendations to improve the innovation impact of the Ecodesign and Labelling regulations. Recommendations concerning the following three considerations were requested:

1. Options to improve the impact of the Commission´s policies on innovation and R&D in European industry
2. Improvements to information flows from the Commission to industry to best inform business investments
3. Improvements to innovation information flows from industry in terms of quality of data, timing of data provision etc.

6.1 Options to improve the impact of the Commission´s legislation on innovation and R&D in European industry

This study has highlighted various opportunities to improve the impact of the Ecodesign and Labelling legislation on innovation. In the following sections we consider how the Ecodesign directive could better drive innovation, how the Labelling directives could better drive innovation, and alternative policy mechanisms that could also provide a means of driving innovation.

6.1.1 Driving innovation via Ecodesign regulations

When the Ecodesign directive was created, the main objective was to increase energy efficiency by removing the worst performing products from the market. However, our case studies have also shown that Ecodesign has the potential to induce non-radical/process innovations in most sectors (although in some cases it was also highlighted as potentially having a negative impact on innovation). If positively influencing innovation is considered a priority for Ecodesign, then it would be useful to provide clarity on i) the level of priority innovation has within the directive compared to other aspects such as energy efficiency and ii) the definition of 'a positive influence on innovation', taking into account:

- **At what stage of the innovation process the directive should have an impact:** Our case studies showed that Ecodesign had potential to significantly transform the market towards more efficient products by accelerating the market diffusion of high efficiency products that were either not on the market or niche products. However, the impact on new technological inventions is limited.
- **Whether the focus is on only energy efficiency innovation, or also on wider product innovation:** Our case studies indicate that for a number of products, manufacturers feel that the technologically reasonable limits of energy efficiency have been reached. In such cases it

is essential to go beyond the improvement of energy efficiency of components and to extent the regulation to other aspects such as a system approach or to resource efficiency.

The positive influence of Ecodesign regulations on innovation could be improved upon via a number of approaches:

Improved market surveillance

Market surveillance was one of the biggest priorities for the European industry interviewed. There were recognised disincentives for member states to carry out market surveillance in terms of cost and the risk of legal challenge for manufacturers, but in a number of sectors (motors and pumps, white goods, lighting, air conditioning, tyres and heat supply) improved market surveillance would be supported by industry. It was suggested that the lack of market surveillance activity reduced the motivation for companies to innovate in order to comply, especially as it was evident that non-compliant products were still visible in the market place. It was also suggested that the current approach created a market distortion whereby only those countries in Europe that were very active in market surveillance had a high level of compliance and the gains in terms of energy efficiency at the lower end of the market may not actually exist. A recommendation to resolve this issue would be to place a greater obligation on member states to survey the market, whilst supporting them in legal terms to be able to follow up on any non-compliance. Alternatively, market surveillance could be commissioned by third parties.

Improved timing

Porter & Van der Linde, 1995 supported phase-in periods tied to investment cycles to keep costs down and result in effective solutions, and a stable predictable process so industry had clear medium term goals. Both experts and industry representatives interviewed suggested that the process of defining Ecodesign requirements would have been more effective in inducing innovation if there had been fewer delays. Frequently, by the time the requirements were drawn up, the preparatory study was out of date, and by the time the regulation came into place, the requirements had missed the opportunity to drive innovation. Findings in a number of sectors suggested that a streamlined process would be more effective. This could be improved upon by the following:

- Clear outline in the directive of how revisions (standard and fast track) should be managed;
- Mandates for standardisation launched as soon as the working plan is ready;
- IA completed at the same time as regulation development;
- Reduced gap between preparatory study and regulation design;
- Sufficient time for consultation input, whilst at the same time strict limits on the length of the consultation phase, after which no further data is considered
- Adapting planned regulatory timings to accounting for complexity of products;
- Technical capability of the regulator (Porter & Van der Linde) – a consistent EC desk officer (long term contract) from inception to enforcement as staff changeover slows the process.
- More funding for technical support;
- Improved sharing of information between EC departments.

Signposting of future requirements

An indication of the potential direction and levels of future requirements beyond the immediate tiers would give manufacturers longer term targets to strive toward that might require greater innovation. In the majority of sectors addressed (white goods, electronics, lighting, air conditioning and heating), manufacturers supported such an approach as long as there was the flexibility for a re-assessment of the levels in relation to current market status nearer to the time of implementation. This was especially the case in the lighting sector for long lifetime products such as LEDs.

Definition of more ambitious requirements

As supported by a range of studies including Porter & Van der Linde, 1995, the definition of more stringent regulatory requirements could improve the impact of Ecodesign regulations on innovation by requiring changes that were not just incremental and ensuring that requirements were not outdated too quickly. This was also supported by respondents in the motors and pumps sector. This could be achieved via a number of refinements to the preparatory study methodology (MEERP):

- **A shift in focus from LLCC to equivalent cost assessment**: Lowest life cycle cost (LLCC) assessments can limit the degree of ambition/innovation drive that can be achieved. Research related to the electronics and white goods sectors supported the use of "equivalent cost assessments" (as used in US legislative processes) to justify more ambitious requirements. These would take into account learning curves to achieve the same life cycle cost as the existing product. This was also supported (for long term requirements) by respondents in the white goods sector.
- **A focus on engaging innovative manufacturers:** The investigation of best not yet available technology (BNAT) could require one-to-one interviews with component manufacturers and less vocal more innovative manufacturers to develop a better understanding of what can be achieved.
- **More robust requirements by proportionate preparatory studies:** During working plan development assess necessary budgetary spend per product area taking into account complexities (some have been underfunded in the past, e.g. refrigeration).

Harmonised/coordinated approach with other legislation

Working to ensure that there are no conflicting legislative requirements was something that manufacturers in the white goods, lighting, AC, and heat supply sectors believed was important to the effectiveness of the Ecodesign process. This was also supported by a previous DG Enterprise report on innovation in 2004. This could include:

- Ecodesign and Labelling combined within a single process
- Aligned EU regulations – WEEE, ecolabel, EPBD, GPP etc
- Harmonisation on a global level between country requirements

A systems approach

It was highlighted that when developing efficiency metrics in some areas (i.e. data centres, motors and pumps, air conditioning and heating) it was important to take into account the wider system in

which the product was installed. This would ensure that the most efficient approach overall was advocated. A system approach is currently developed for pumps.

Addressing resource efficiency

Whilst there are reducing opportunities in some areas to improve on energy efficiency, there is still an opportunity in many groups to address resource efficiency. This would require clear guidance by the Commission regarding methodologies and process (some work currently being done by DG ENV). Such an approach was supported by a respondent in the white goods sector who felt that durability and material efficiency could become important considerations in the future. If resource considerations are not taken into account they also present a risk – if energy efficiency is pushed too far, negative resource efficiency impacts may occur, as suggested by a respondent in the motors and pumps sector.

Regulatory incentives

Innovative features that may result in overall improved energy efficiency could be given an additional energy allowance to encourage them being brought to market. Such features could be for example presence sensors to enter low power modes when the user is not present, provision of energy use information to the user, or provision of feedback on use to service providers.

Reduction of potential negative impacts

It was highlighted, particularly in the electronics sector, that there can be negative impacts on innovation due to Ecodesign regulation – for example, smaller companies being forced out the market because they are unable to afford the necessary innovation investment to remain, or difficulties bringing new innovations to market as they can initially be lower efficiency before mass-market refinements. This can result in strong resistance from industry to ambition and/or timing of proposals. Such issues could be tackled by the following:

- **Manufacture focus in MEERP:** Incorporating research into manufacturing processes as an integral stage in the preparatory study (MEERP) process.
- **Parallel manufacturer engagement throughout:** Engaging manufacturers via a separate work stream from the moment the product appears on the work plan, on an ongoing basis rather than at trigger points in the preparatory and regulatory process (this was also supported in the motors and pumps and heating areas).
- **Signposting of future requirements:** This was strongly supported by manufacturers as it can give them sufficient time to adapt.
- **Flexibility in requirements:** Avoiding prescription of solutions in regulation so that different innovation paths can be encouraged.
- **Short-term allowances for future technologies:** Some regulations have "catch all" requirements to bring future technologies under scope, but this can prevent some innovative and potentially energy efficient (long term) technologies from being brought to market. Short term allowances could facilitate their introduction the market and then phase out.
- **Avoidance of inappropriate non-energy requirements on products:** Requirements aiming to reduce wider lifecycle impacts need to be carefully considered as they have a restrictive impact

or knock on effect – e.g. recycled material content restrictions may not allow for future material innovations in the overall plastics environment.

6.1.2 Driving innovation via Labelling regulations

The following potential opportunities to improve on the innovation impact of Labelling were identified:

- **Promotion of the directive/label:** In some sectors, the introduction of a label/regulation resulted in increased visibility of a sector's products, providing a means of differentiating between products that did not previously exist, e.g. for tyres. Some companies commented that more active promotion of activity in product areas could inform customers about the positive aspects of regulation and Labelling, and lead to increased incentives to innovate.
- **Mobile applications to enable comparison between labelled products:** A mobile product comparison application could be created to facilitate user understanding of lifecycle costs, and to drive lower energy consuming classes of products to be purchased rather than just the best performing in the chosen class.
- **Recasting of labels based on ambitious A to G scale:** Stakeholders highlighted that the incentives to innovate are limited when the top of the classes are reached too early (A+++). Recast labels with A set at (Best not yet available) BNAT level would resolve this. This was supported by case study results in the motors and pumps, white goods, and lighting areas.

6.1.3 Alternative options to drive innovation

Whilst in general, regulation improves the energy efficiency performance of the bottom high-volume end of the market, and compulsory Energy Labelling has the potential to drive energy efficiency innovations at the low-volume top-end of the market, it was suggested by industry in some sectors that other options may prove a more effective means of incentivising innovation:

- **Green Public Procurement** – In the electronics and lighting sectors procurement was highlighted as a customer driven means of motivating innovation.
    - **Innovation incentives:** Other innovation related incentives could include the linking of innovation funding to transparency of eco-information and Ecodesign priorities, and schemes to educate departments dealing with innovation funding on environmental priorities. The facilitation of innovation focus groups/think tanks to disseminate insights on new innovations was not considered feasible in the electronics sector due to competition issues, but innovation competitions (whereby innovative products are awarded and promoted) were considered to have the potential to provide some degree of additional incentive in electronics, although these were not supported in the lighting and heating sectors.
    - **National subsidy schemes:** These can have more influence on bringing energy efficient innovations to market than Labelling as they influence the customer via the higher-priority purchase criteria of price. These were favoured by the white goods and electronics sectors.

- **Voluntary Labelling (TM license labels like ENERGY STAR):** A voluntary Labelling scheme with active industry involvement can be more agile in the face of the rapid development of technology. For example the ENERGY STAR label aims to cover the top performing 25% of the market. It has proven successful in providing a strong driver toward energy efficiency in the US for TVs and ICT products, although it only applies in Europe for ICT.
- **Voluntary agreements:** Formal Commission approved VAs can provide a means of addressing the wider system in a way that regulation cannot – for example there are opportunities for service providers as well as product manufacturers to become involved. However, the market needs to be quite concentrated in terms of number of manufacturers for a VA to be feasible, and as not all manufacturers need to sign up, it can result in an uneven influence on the market leading some manufacturers to prefer regulation. It was suggested in the white goods area that VAs could be implemented in addition to regulation, to act in a way similar to EU Codes of Conduct by providing additional innovation drivers and recognition for progress made at the higher end of the market.

- **Voluntary industry initiatives** – these were considered to drive innovation in the electronics sector.

6.2 Improvements to information flows from the Commission to industry to best inform business investments

The current information flows between the Commission and industry when developing Ecodesign legislation, is summarised in the figure below:

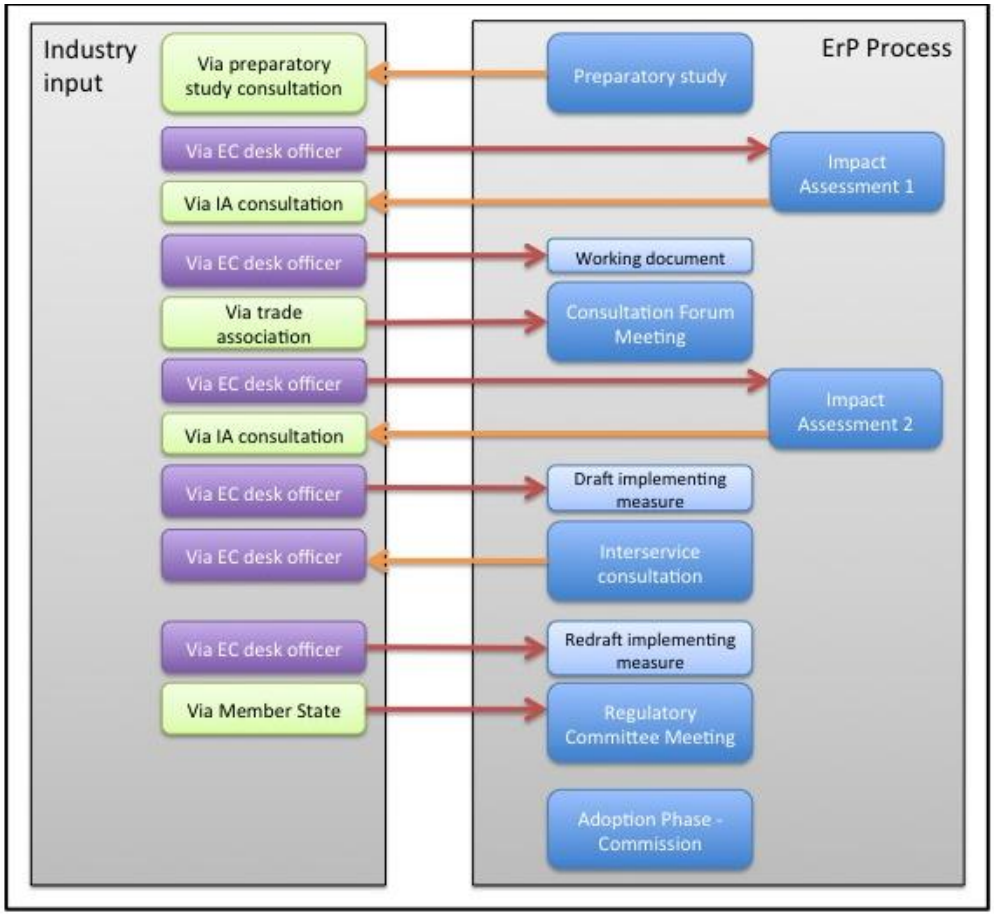


Figure 19: Industry information flows in current ErP process

Note: The arrows show the general originator of the information flow. Green shows formal input processes, purple shows informal processes. The figure above is based upon examples from the ICT/consumer electronics area and applies mainly to OEM input. In addition to the information flows listed above, there may be informal side meetings between various parties, such as Non-Governmental Organisations (NGOs) and manufacturers.

A key goal of this project is to identify improvement options for the Commission's information and communication strategy, in order to keep industry (especially small and medium sized businesses – SMEs) informed about on-going legislative processes and allow for planning of research and development investments. Possible improvement options for information provision include signposting of future requirements, as mentioned in the previous section, as well as the following:

Increased process transparency

Improvements to the transparency of the Ecodesign process were supported in a number of sectors (white goods, electronics, lighting, air conditioning and heat supply). These could comprise a more transparent evidence based standards process where there is a formal data call, deadline (allowing adequate time for industry input), and change management process for late data, as well as

transparency of calculation models. Clear communication could be provided to manufacturers upfront on data confidentiality - regarding how their data will be interpreted and used in the ErP process, as well as the levels of confidentiality that can be expected. All correspondence could be made available for public scrutiny (to make clear that the input of all stakeholders is considered equally) via a frequently updated website, which could also provide detailed information on the status of each product group, host copies of preparatory studies etc. (sometimes contractor sites expire). Automatic email updates to interested stakeholders could reduce the need for constant monitoring to know when to submit comments, as highlighted in the lighting sector. A better defined process with clearer guidance to stakeholders was particularly supported for lighting, heating and electronics.

Engagement with manufacturers from earliest stages

Porter & Van der Linde, 1995 supported this as a means of improving the innovation impact of policy. Manufacturers are usually represented by trade organisations in formal meetings due to limitations on attendance numbers, but this results in a discussion focused on the views of the most vocal and potentially least innovative. Respondents in the motors and pumps sector suggested that as well as early engagement with trade associations, there was a need to ensure equitable representation in the associations involved in process. The involvement of trade associations in the Ecodesign process was highlighted in many of the case studies undertaken in this project, but was not the focus of our typological work. We therefore suggest that an additional study to examine more closely the interaction of trade associations in the Ecodesign process could be undertaken.

In addition, in order to ensure the voice of the manufacturer who can achieve increased efficiency is heard, the following recommendations could be considered to engage at a one-to-one level with manufacturers:

- **Workstream for manufacturer engagement -** From point of a product appearing on the work plan, on an ongoing basis rather than at trigger points in the preparatory and regulatory process. Could discourage lobbying and misinformation also.
- **Additional MEERP stage to investigate innovation -** Via one-to-one interviews with component manufacturers and less vocal more innovative manufacturers.

Improved SME involvement

SMEs were not usually found to be actively engaged in the Ecodesign process - they would often be included on member state stakeholder mailing lists but little more. A respondent in the lighting sector suggested that this was largely due to a lack of capacity to keep up with the debate and to know when to contribute, whilst one from the heat supply sector suggested that it was due to a lack of available resources.

Regarding the influence of company size on innovation, in line with the insights of the literature review (Leitner, Wehrmeyer, & France, 2010), it was found that there were conflicting views of SME interactions. SMEs could be ahead larger companies in terms of innovation because they had a greater flexibility, but on the other hand some SMEs would tend to follow, and may struggle in dealing with Ecodesign requirements that demanded innovation on short timescales (highlighted for

white goods and electronics) because i) they had less warning of requirements due to being less involved in the process ii) they delayed on taking action because wanted to be sure of developments before investing in a change ii) any investment represented a bigger proportion of their turnover. In such cases SMEs may even be forced to leave the market.

Where they were particularly innovative in the electronics area (usually driven by competition), SMEs tended to grow in size outside the SME bracket quite quickly. A high SME presence could make data collection and the introduction of ambitious standards.

The necessity to engage with SMEs was not entirely supported by all respondents interviewed for this study, for the following reasons:

- **Filter down from large companies and universities:** SMEs will often follow these parties in terms of Ecodesign and innovation;
- **Low Member State priority:** SME engagement low priority for some member states;
- **Lack of collective responsibility/coherence:** SMEs are not collectively responsible for a major product genre, though they can contribute the components to a product genre;
- **Higher flexibility:** In some sectors, SMEs can be more flexible than large manufacturers with respect to product changes;
- **Limited engagement resources:** SMEs often don't have the available resources to actively engage: no time for keeping up to date/attendance/follow up, no travel expenses etc.

Greater involvement of, and improved information to, SMEs within the Ecodesign process could be achieved through a mini SME preparatory study to identify SME stakeholders. As soon as the working plan was ready, the Commission could examine the SME involvement in the sector and scope out SME contacts (via a mini preparatory study or similar). Depending upon the degree of SME involvement, they could either:

- Identify at least one EU SME in the area;
- Identify a trade organisation with SME membership;
- Develop a comprehensive database of contacts for SMEs.

SME details can be obtained through individual member state governments, especially environmental departments, NGOs, and through looking at the individual schemes – for example, identifying efficiency manufacturers from the ENERGY STAR database. The Commission could then inform and consult SMEs on potential developments, Ecodesign goals and how their feedback will be taken into account – via either:

- Direct mailings and specialist SME meetings
- Comprehensive information via a regularly updated webpage tailored to SME needs (ideally with update notifications to a stakeholder list, and a contact page for SMEs to provide feedback) – this type of transparent information provision was particularly supported for the white goods area;
- SME representation at meetings forming part of the regulatory process;
- SME impact assessment as part of the ErP impact assessment process.

6.3 Improvements to innovation information flows from industry in terms of quality of data, timing of data provision etc.

In order to define the technical specifications leading to the standards, the Commission needs input from the industry (as they know about the technologies, market situation, customer needs, etc.), as well as the independent view of consultants to review industry data and draft the proposals. Taking into account the timelines for introduction of legislation, and the (often) tiered approach to introducing requirements, it is particularly important that there are clear insights on the performance of current products, as well as where technology is potentially headed in future years.

The companies that engage in the process do so because they expect their engagement to be economically better than not engaging. This can be the case for several reasons:

- The company is good at energy efficiency and sees a direct competitive advantage of energy efficiency regulation;
- The company is innovative and good at energy efficiency but sees a risk that their early stage product innovations (which could result in improved energy efficiency in the long-term, but have reduced energy efficiency in the early market stage) may be prevented from entering the market if they do not engage;
- The company is innovative an good at energy efficiency, but sees a risk of unplanned design and manufacture costs being incurred if their planned innovation curve is brought forward too soon by requirements;
- The company is bad at energy efficiency and wants to block to prevent incurring costs due to design and manufacture changes;
- The company is an innovator and appreciates the opportunity to compete at a higher level.

In view of the various reasons that can motivate companies to interact, it can be challenging for the Commission to judge the quality and comprehensiveness of manufacturer provided information. Issues can include:

- **Lack of data:** Manufacturers are not forthcoming with data, or claim it is not available;
- **Inaccurate data:** Manufacturers provide data, but it is found retrospectively to be outdated or inaccurate – often suggesting lower levels of efficiency that those that can actually be achieved;
- **Only assumptions provided**: Manufacturers provide a model, model outputs, or assumptions rather than real data, reducing reliability and usability;
- **Selective data:** Manufacturers provide a subset of data, which often skews any analysis in their preferred direction;
- **Delayed data:** Data is withheld in earlier stages of the process and provided close or after deadlines later in the process, potentially in order to open up old discussions and delay the legislative process in general;
- **"Confidential data":** that can't be peer reviewed; This can occur due to commercial, cost or legal concerns. In order to improve information provision and the evidence base used to define requirements, several recommendations could apply.

These issues could be overcome by the following recommendations:

- **Introduction of a horizontal data provision directive:** It was suggested by respondents in the lighting and electronics sectors that a horizontal directive could be created that requires all product information already asked for in established and new legislation to be submitted to a Commission body for inclusion in a central database. And alternative would be a voluntary database for product information, but this would require a clear incentive for manufacturers to contribute.
- **Formalised expert evaluation of data submissions:** The Commission could formalise the role of expert analysis of submitted data and work toward a more transparent process.
- **Formalised and funded testing component to data collection:** The Commission could make available an EC Testing budget as part of a call off contract, to enable resolution of doubts regarding energy impacts of specific functionalities via primary data. They could also work more closely with NGOs to make the most of their testing capabilities.
- **Sufficient funding to enable the use of well qualified consultants:** It was observed that the choice of the consultants to carry out Ecodesign preparatory studies and draft regulations could have been improved upon in some sectors, including motors and pumps, electronics, and air conditioning. It was highlighted as important to select a consultant with sufficient expertise in the technology, markets and commercial considerations of the product under study, but observed that current funding can be insufficient to involve consultants with the necessary level of expertise. This could be taken into account in the development of tendering criteria

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Appendix I: Patent search methodology

The methodological approach for the patent identification and extraction used in this study consists of various steps (see also Figure 20):

Step 1: Identification of technological properties: For each of the products that are studied, the technological properties related to energy efficiency are identified using various sources including the Ecodesign preparatory study, scientific publications and expert opinions.
Step 2: Identification of IPC classes: The IPC classes that correspond to the respective technological properties are identified through a bottom up search. The verification of the identified classes is performed using Espacenet, the patent search facility provided by the European Patent Office.
Step 3: Definition of key words: Key words that are required to appear in the abstract of the patent are defined in order to make sure that a significant proportion of the identified patents focus on improved energy efficiency. As in the previous step, the verification is performed using Espacenet.
Step 4: Data retrieval: The patent data are retrieved using PATSTAT for a relevant time span before and after the implementation of the legislation. The retrieved data is then again validated by randomly selecting a number of patents that were identified and checked for their relevance concerning energy efficiency.
Step 5: Data quality revision
A relevance test was developed and implemented to provide a measure of the effectiveness of the search strategy by minimising the amount of false positive and true negative patents.

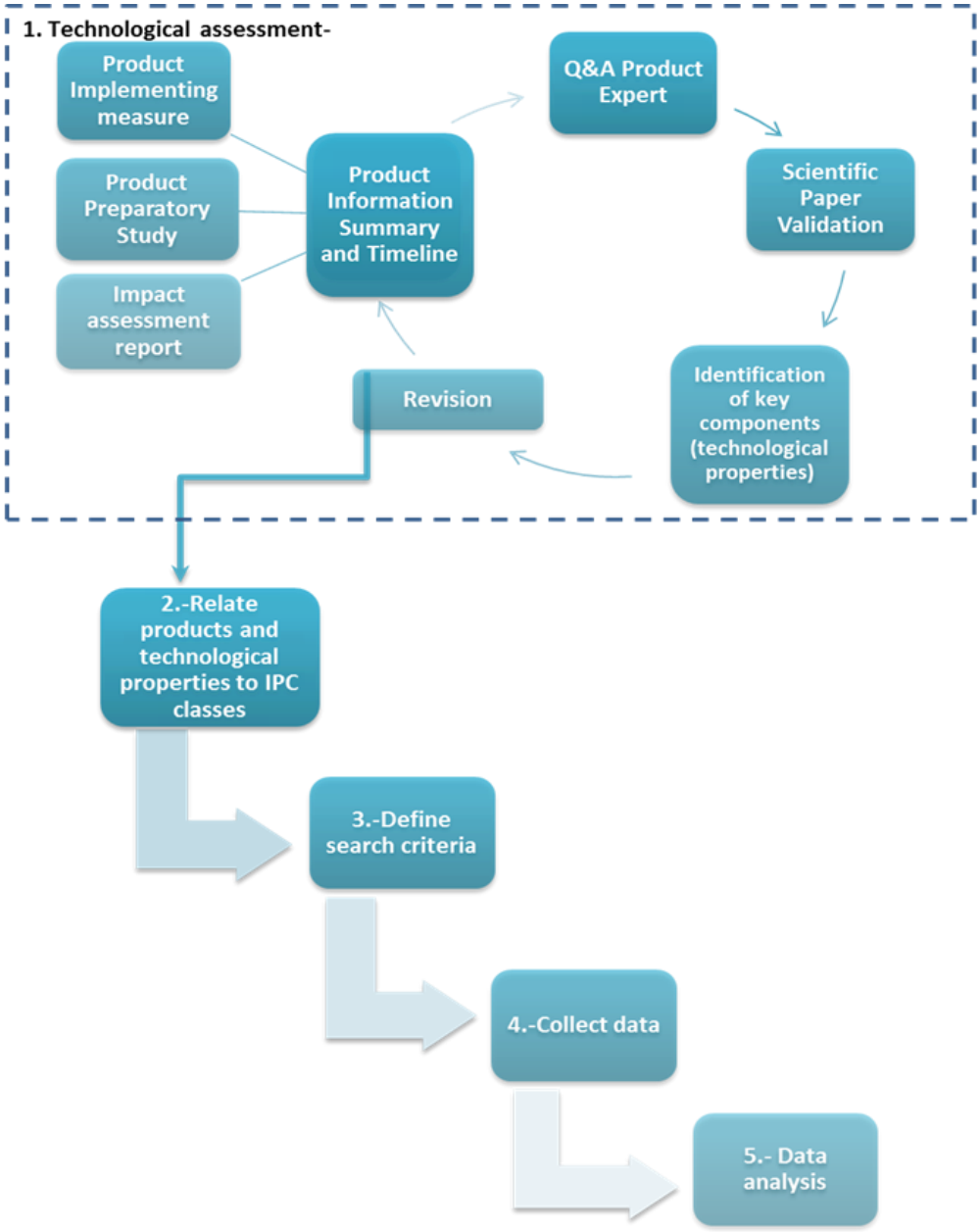


Figure 20: Schematic view of the secondary data methodology

Appendix II: Literature review of firm typology

Existing typologies

A variety of industry and individual behavioural typologies exist, the search for relevant typologies was focused in the following areas:

- Environmental legislation compliance;
- Innovation activities, adoption, diffusion;
- Lobbying; and
- Behavioural sciences.

The following sections present our findings in each of these areas.

Environmental compliance typologies

Environmental compliance is relevant to how the Ecodesign and Energy Labelling legislation deal with energy and other environmental parameters. Understanding how firms respond to, and comply with environmental legislation in general can give insight into how they engage with the earlier legislative creation process.

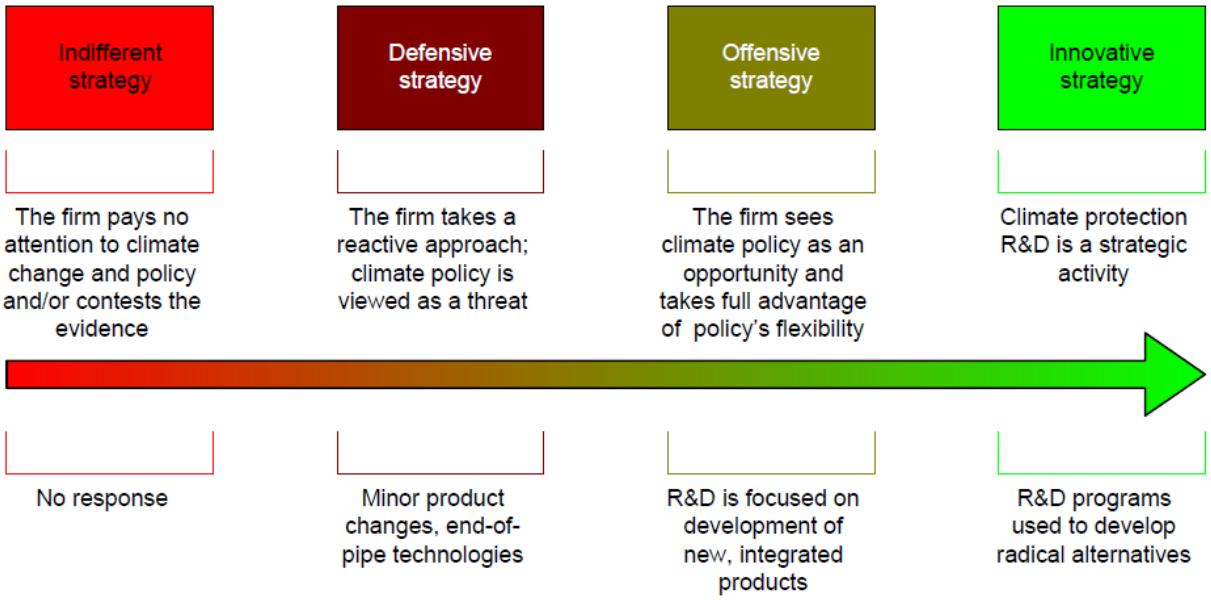
Roome (1992) developed a typology of corporate postures regarding the natural environment, which defined five types of compliance behaviour:

1. **Non-compliance:** least advanced natural environment postures – applying no natural environmental measures of any kind and not even conforming to regulatory requirements;
2. **Compliance:** comprising firms whose postures are determined by prevailing regulation;
3. **Compliance-plus:** covering firms that not only abide by the law but also have approaches based on their own natural environmental management systems;
4. **Commercial and natural environmental excellence:** firms that systematically apply preventive methods based on principles of total quality management in their natural environmental and overall managerial practices; and
5. **Leading edge:** firms whose postures point the way for future development by others, including legislators.

We can extrapolate how compliance behaviour by firms also affects how they engage with the legislative process and how they respond in terms of innovation to different extents. It is not clear if, for example, noncompliance also translates to negative engagement with the legislative process, or simple non-engagement. Similarly a firm at the leading edge in its own operations and compliance may not necessarily engage with the legislative process, or have it affect their existing innovation behaviour.

There has been a range of recent work on environmental compliance relating to the EU ETS. A paper by Rogge (2006) analysed corporate climate innovation strategies within the ETS. It built upon previous work by Steger and Kemp et al, to develop a typology of firms' climate innovation strategies. Four types of strategy were defined (see Figure 21), from the indifferent, to defensive, offensive and innovative, with varying levels of pro-activity and depth of the firms' response to the regulation.

Figure 21 Four categories of climate strategies



Source: Rogge (2006), adapted from Kemp, Smith and Becher (2000)

This can be relevant to the innovation response of firms to the Ecodesign and Energy Labelling regulations, defining both a positive or negative response. But this approach does not directly define how this will impact a firm's engagement with the legislative process. Assumptions could be made regarding proactivity in innovation also translating into proactivity in regulatory engagement, although this may not necessarily be the case.

More theoretical work by Pinkse and Kolk (2009) analysed firms' responses in a carbon market environment. The two key factors they ascribed to determining a firm's response within the carbon market were the expectation (or reality) of the regulatory constraint and the opportunities for the firm from the regulation. Within this framework four types of firms were determined, as shown in Table 11.

Table 11 Scenarios for strategic responses to regulatory constraints

		Opportunity recognition	
		Low	High
Expected regulatory constraint	High	**Conformist:** accepts a regulation as it is, sees high constraints but weak opportunity to change, or gain from changes, in the regulation.	**Entrepreneur:** firm expects to be constrained by the regulation, it also sees, and takes, the opportunity to influence the regulation to improve it, at least from its own perspective.
	Low	**Evader:** firm perceives only weak constraint, but also with only weak opportunities to influence or gain.	**Arbitrageur:** firm perceives only weak constraint from regulation, but also see an opportunity for strategic or financial gain from it.

Source: Pinkse and Kolk (2009)

This framework doesn't focus on a firm's actual environmental compliance and instead focuses on how it perceives and responds to the regulation. It works within a framework of the self-interest (opportunity) of the firm having a strong influence on how actively it responds. The impact on self-interest is also a clear factor of how the firm perceives or experiences the constraint imposed by the regulation. The opportunity in this case is seen as both the financial/market opportunity to the firm, but also their opportunity to influence the regulation. These issues could be considered quite distinct in the context of a typology of firm engagement with the regulatory process, for example a firm may see high constraint from the regulation and low market opportunity, but therefore be more active in the regulatory process to reduce the constraint or increase the financial opportunity, rather than just conforming as this typology suggests. Similar potential contradictions exist for the other groups. This framework also does not directly relate the innovation element of the response, although this could be argued to be implicit within the opportunity, i.e. more innovative firms are more likely to perceive high opportunities, although an innovative firm expecting a low constraint, may see a low opportunity and therefore be more frustrated by the outcome, than evasive as the typology suggests.

A study in Germany by Heyder et al (2010) on firms' responses to regulations on traceability in agri-businesses which found three main motivations for innovation and compliance within firms:

- Internally driven: effectiveness concerns processes;
- Externally driven motivation: is requested by consumers;
- Externally driven motivation: is requested by regulation.

From these motivations they defined five types of companies, based on their response to the regulations.

1. **Certified companies:** implemented tracking systems that were certified and audited by third parties. Certification is seen by firms as a step to compliance but of little wider value to the business. These firms were typically small, but producing for retailer-owned brands. Their implemented systems were rather low-tech.
2. **Disregardful firms:** would prefer not to have the regulatory obligation in the first place and apply only limited resources into compliance, sometimes failing to comply with requirements. These firms can be of any size and typically implemented low-tech systems if any.
3. **Lawful investors:** were motivated by legal and stakeholder requirements. These firms were typically small and without a retail-owned brand relationship. Their implemented systems were relatively advanced.
4. **Image-oriented firms:** motivated strongly by stakeholder requirements these firms implement systems, often certified systems, to meet stakeholder and regulatory needs. They not only comply with regulations but also ascribe benefits in implementing the required systems. These firms are typically larger and tied to retail-brands.
5. **Versatile companies:** have a range of motivations for compliance and consider it very important. These firms vary in size and have the most advanced and successful systems for implementation.

This gives insight into the differing motivations that compete to drive firms in their compliance actions. It can also give insight into what drives firms in their behaviour, for example if these are mainly internal or external factors, and what this means. Whilst it helps to frame how firms engage with the legislative process at earlier stages, there is little insight, for example, into if lawful investors aim to steer the regulation or if disregardful firms actually mobilise against or obstruct the legislative process.

Related to compliance typologies is work on company corporate social responsibility (CSR) and external engagement. A study by the Helsinki School of Economics (Kourula and Halme, 2008) defined three types of firms in their CSR strategy for engagement with NGOs:

Table 12: Three types of corporate social responsibility approaches

Type	Relationship to core business	Target of responsibility	Expected benefits
Philanthropist	Outside core business	Additional activities	Image improvement
Integrative	Close to core business	Environmental and social performance of existing business	Improvements in eco-efficiency and social aspects of core business, image improvement
Innovative	Enlarging core business	New product or service development	Alleviation of social or environmental problem, eco-efficiency and social aspects of business, image improvement

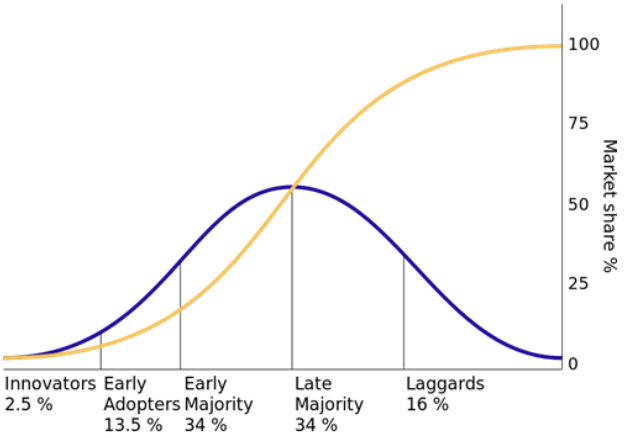
This can offer insight into the way firms will approach regulation and innovation, based on their overall CSR perspective and strategy. It points to the societal, environmental and other benefits aimed for by Ecodesign and Energy Labelling as being drivers only for firms that take an innovative approach to CSR, that see the benefits in new market or business model development. The typology doesn't offer any insight into the way firms engage with legislative processes, for example if innovative firms do try to drive legislation to match their aims, or if they see the legislation as something separate and irrelevant to their CSR mission.

Innovation typologies

Innovation has been an important economic focus for many decades, with roots as far back as the 1940's and Joseph Schumpeter's popularisation of the concept of creative destruction and subsequent work on how this translates into firms' actions and activities at micro-level and the economic impacts at macro-level.

Among the first areas in which innovation typologies were developed is innovation diffusion and adoption. This was to better understand the way in which innovation happens and spreads, the reasons for this, and the characteristics of those who adopt innovations at different stages. This first work was developed by Rogers (1962) who proposed a process of the individual uptake of innovation over time, i.e. that as a new idea or concept is launched it will not be implemented by all relevant individuals at the same time. Rogers concluded that individuals can be grouped according to their swiftness in the uptake of innovations or innovative technologies, with repetitive characteristics for different innovations, in the following groups (see Table 13):

Table 13: Innovation adoption and diffusion typology

Type	Description	
Innovators	Innovators are the first to adopt new innovations and innovative technologies. Innovators are willing to take risks and usually have a strong financial position.	
Early adopters	Early adopters are typically opinion leaders within the other adopter categories and realise that their early adoption of innovation or innovative technologies will allow them to keep their leading position.	
Early majority	The early majority are the largest share of individuals that follow the leadership of the early adopters and innovators. They are willing to take more risk than the late majority.	
Late majority	The late majority are a large share of all individuals that are more cautious and wait longer to adopt or innovate. The late majority is risk averse.	The percentages provide an estimate of the proportion of a population that fall in each category
Laggards	Laggards are very conservative, reluctant to change and show little to no opinion leadership. Laggards are the last group, to adopt innovation and innovative techniques.	

While this work has been taken on and heavily developed in the area of innovation adoption and diffusion, with the categories such as innovators, early adopters and laggards becoming popularised, this typology is assessed to have only limited applicability to the development of a typology of manufacturer behaviour in the legislative process. One of the reasons is that the typology's focus is on individuals rather than firms, and although the typology has been applied to firms, it remains focused on their uptake of new technology rather than their innovation activity itself or their engagement with the legislative process. Regarding the extent to which innovation adoption can be assumed to be closely related to innovation activity, this typology could point to the proportion of firms that exist in each category.

Porter (1980) developed a strategy of differentiation and innovation leadership vs. innovation followership, which concluded that companies should differentiate in their products based on:

1. Product quality;
2. Product innovation;
3. Services;
4. Design and properties; and/or
5. Brand.

The theory contends that this differentiation should prevent companies from getting "stuck in the middle" where they do not have unique features and where their profitability suffers. Within this, companies should also choose between innovation leadership (where firms aim to be the first on the market) and innovation followership (where companies aim at being late on the market, learning from the experiences of the leadership companies to quickly catch-up without the initial innovation expenditures and risks). This effectively builds upon the work of Rogers, taking on a similar concept of leaders/innovators and followers but applied to firms. This is relevant to some of the market specific characteristics and reasons that underlie a firms' behaviour in innovation and/or engagement with legislative processes.

An alternative typology has been developed by Pavitt et al (1997), which can be summarised as 'technology push and demand pull'. This is a theory based on innovations being developed and implemented in an interactive process between "technology push" and "demand pull". Technology push is the process in which R&D activities give rise to new innovative technologies, which offer new opportunities for companies to develop new innovative products. Demand pull is the process in which there is a demand on the market for a certain innovative solution or product which is then answered by a company developing a new product. The typology of firms and their reaction to these push and pull factors defines four firm types:

- **Supplier-Dominated:** includes firms from mostly traditional manufacturing such as textiles and agriculture, which rely on sources of innovation external to the firm (demand pull).
- **Scale-Intensive:** characterised by mainly large firms producing basic materials and consumer durables, e.g. automotive sector. Sources of innovation may be both internal and external to the firm with a medium-level of appropriability.
- **Specialised Suppliers:** smaller, more specialised firms producing technology to be sold into other firms, e.g. specialised machinery production and high-tech instruments. There is a high level of appropriability due to the tacit nature of the knowledge.
- **Science-based:** high-tech firms, which rely on R&D from both in-house sources and university research, including industries such as pharmaceuticals and electronics. Firms in this sector develop new products or processes and have a high degree of appropriability from patents, secrecy, and tacit know-how (technology push).

This typology profiles a firm's innovation activities and drivers, and is relevant to Ecodesign and Energy Labelling, with the former providing some level of technology push, by banning the least efficient technologies, and Labelling providing a pull through providing an incentive for firms to

achieve higher Labelling classes. But again it provides little insight into how a firm engages with the legislative process.

Another innovation typology (Cavell, 2011), groups firms by their innovation attitude, and the extent to which firms simply address latent demand or seek to drive demand themselves by re-shaping their marketplace. He determines five types of company:

- **Latent demand**
  - *The Rock:* takes its initial innovation, the latent demand it has addressed, and 'milks it for all it's worth' without ever innovating again. This can be profitable and low risk, but is often only a short term strategy as changing market demand can shrink income.
  - *The Pivoter:* doesn't like the short life span of Rocks and invested in innovation when they saw the initial latent demand starting to diminish. They try to follow demand and have the advantages of their existing market position but this can also be a drag on innovation, tying them to their initial concept.
  - *The Portfolio:* focuses on more than one area of latent demand, seeking to find a range of new ideas and managing them all within one firm. Advantages from synergies in their unified management structure, production and processes, and overall diversification, can make this idea successful, e.g. 3M, but bigger firms can also struggle to spot new demand and adapt to it effectively and efficiently, e.g. Yahoo, AOL.
- Reshaping the market
  - *The Smart Kids:* are like portfolios except they also shape the marketplace, the best example of this is Apple. Their new products and services aim to change the way people look at the world and help to shape it.
  - *The Visionary:* is a company constructed around a vision for reshaping the marketplace. Any and all attempts to address latent demand revolve around enabling and monetising the central vision. Google is a good example of this, with its vision of an open internet with Google at its back bone, effectively charging a small tax on users.

This typology provides some insight into the different drivers of innovation that firms carry out, It could also be profiled within a technology push - market pull paradigm. It could be relevant to Ecodesign and Energy Labelling engagement by helping profile how firms react, based on their overall innovation and long-term strategy.

Lobbying typologies

Lobbying is an important way in which political processes can be influenced. Some firms therefore devote considerable resources to lobbying, either directly or through sector and trade associations. By providing supporting information, alternative arguments, new narratives and sometimes other

incentives, firms and other organisations can move policies to a more favourable course. This is obviously relevant to how firms engage with the policy process for the Ecodesign and Energy Labelling regulation where firms and other organisations engage directly and indirectly to influence the outcomes.

Much of the research on lobbying behaviour has been carried out in North America. Work on lobbying by Shock (2004) looked at the behaviour of interest groups, rather than firms, within the environmental policy process in Canada and the US. Among the main findings was the impact that the policy-making system has upon the type of lobbying behaviour that is employed. It identified four types of policy systems and associated behaviours:

1. Legislative Lobbying (low fragmentation, low discretion);
2. Bargaining (low fragmentation, high discretion);
3. Multiple Institutional Lobbying (high fragmentation, low discretion); and
4. Intergovernmental Lobbying (high fragmentation, high discretion).

The two axes of this classification are fragmentation and discretion. Fragmentation refers to the extent to which decision / policy making power is centralised or dispersed, and discretion the extent to which the regulation and final implementation of a policy can be influenced by other decision makers, e.g. high discretion being a national decision, implemented sub-nationally, with the sub-national body having considerable influence and control on how it is implemented. The study found interest group behaviour in Canada to be best explained by the "bargaining" classification because of the relatively low level of fragmentation in the Canadian political system and because of the high level of discretion that provincial governments have over environmental policymaking and implementation. In the United States, the situation is characterised by high fragmentation, given the power of state governments, but with the outcome felt to vary by government type, Democrat administrations offering less discretion than Republican administrations.

The EU Ecodesign and Energy Labelling processes could be characterised within these system types, possibly as multiple institutional lobbying, a situation of high fragmentation could be said to exist as the decision making power is dispersed across the Commission, Council and Parliament, with influence from national governments, and low discretion with the implementing legislation required to be transposed in full across Member States. The resulting situation, with firms, interest groups, associations, national governments and other agencies all attempting to influence the process, corresponds with a multiple institutional system type. While this offers some insight into the system it doesn't offer much insight into why firms engage in the process, or how it relates to innovation. It also points to some of the structural process issues that exist and how lobbying is relevant at various stages, i.e. the initial proposals from the commission, the response of member states to the proposals, the consultation forums and the national implementation;

A study by Kerr et al (2011) looked at the dynamics of firm lobbying within the United States in relation to immigration policies. They found a few key characteristics of lobbying behaviour, including:

- Only a few big firms lobby;

- Lobbying is highly persistent over time, a firm that lobbies is very likely to continue to lobby in future;
- Lobbying intensity is closely related to the self-interest of the firm;
- Firm's lobbying expenditure is much higher than other politically targeted expenditures;
- Entry costs to the policy process are high; and
- Being able to predict the actors brings predictability to the process - positions and outcomes can be anticipated in advance.

This is interesting for a behavioural typology for firms in the Ecodesign and Energy Labelling process, suggesting that there is already a good understanding of positions by the players in the process, and that the number of influential players is low and consist primarily of big firms or associations. This could undermine the value of developing a typology of behaviour if it is only relevant for a handful of big firms. It also highlights questions for the case studies towards small and medium enterprises regarding their involvement in the process and perception of entry costs. In addition, it raises the issue of self-interest also highlighted in the environmental compliance section by Pinkse and Kolk.

Work by Rival (2012) examined firms' lobbying strategies in the UK and France to compare and contrast them. The study concluded that different strategies existed in France and the UK, but with some overlap, suggesting that while some lobbying approaches were universal others were determined by the system (country) specific political environment and economic structures. This corresponds with the work of Shock that examined the system influence on firm lobbying behaviour.

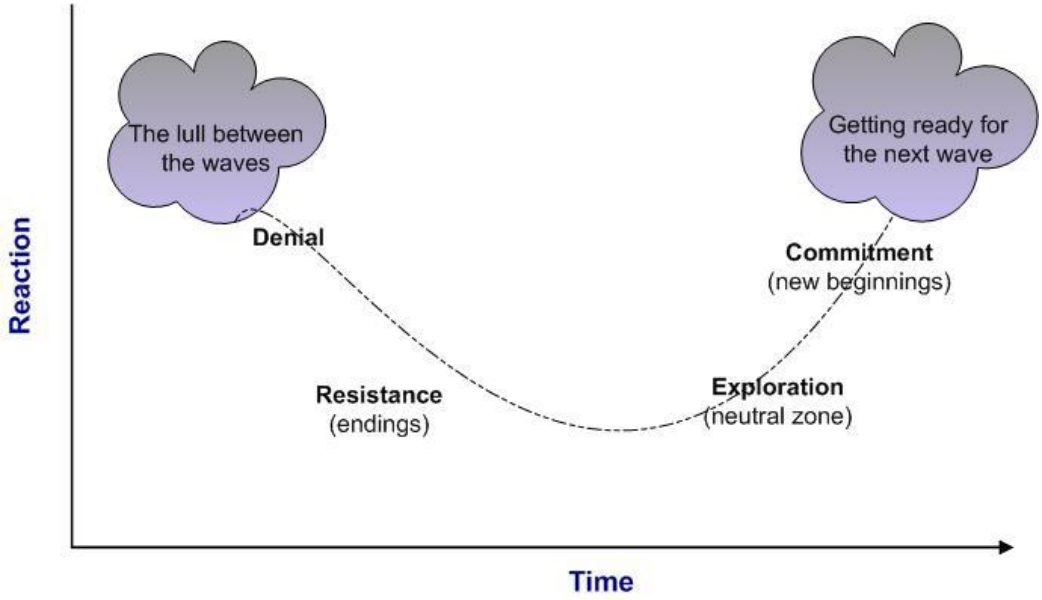
Behavioural typologies

Developments in behavioural theory are being applied to individual and organisational decision making. This can be relevant to the way in which firms engage with the Ecodesign and Energy Labelling legislative process and their innovation decisions.

The introduction of new legislation starts a process of change. Work by the University of Victoria (2012) has developed a transition model for understanding how people perceive and respond to change. It defines four stages from the start of the change of the process, see also Figure 21:

- Not yet in transition (Denial): Before people realise how change will affect them. People need help understanding the change and how it might affect them.
- Endings (Resistance): People begin to fear how the change might affect them. People need help dealing with losses, concerns, issues and fears.
- Neutral Zone (Exploration): People trying to understand and adjust to the change. People need help getting organised and exploring options.
- New Beginnings (Commitment): People adjusting and finding ways to make change work. People need help adjusting and making the change work.

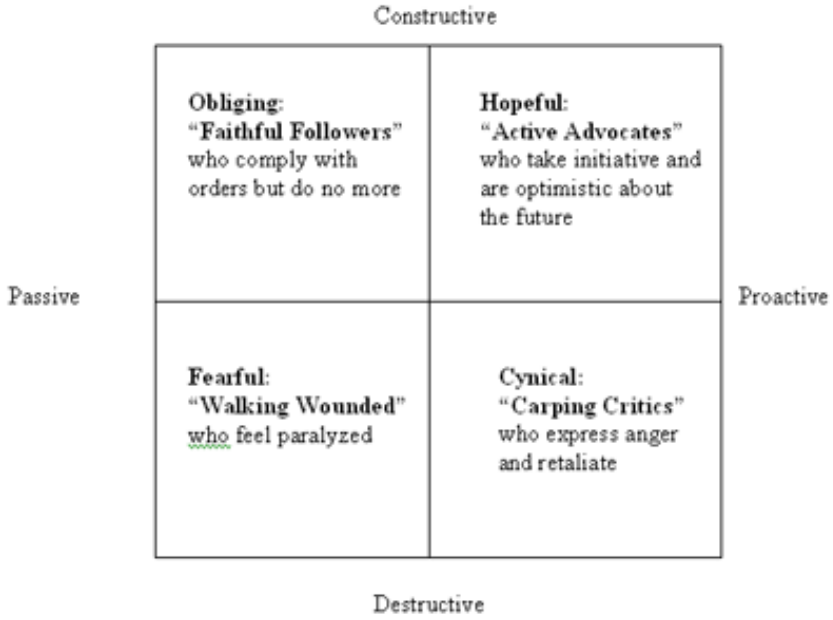
Figure 22: The transition model for change



While this model is tailored to the change process for individuals in times of stress, there could also be parallels to how firms engage with the change process for legislation. The transition from resistance to exploration and commitment can be of particular interest to a typology and of how firms interact at different stages of the legislative process and why.

Work by Spreitzer (2013) focused on behaviour in times of stress, particularly in the context of hope/survival proposes two axes to typical behavioural responses, constructive-destructive and passive-proactive, with these axes being largely self-explanatory. Figure 23 summarises the four resulting response types. In this context hope and fear are the contrasting emotions that steer where people end up. Over time people can also move from one category to another.

Figure 23: Typology of response to change in trying times



The categories and the descriptions offer insight into how a firm may engage in the legislative process - certainly the level of activity and type of engagement, constructive-destructive, appear a logical match with this. Yet this typology framework is not designed with organisations in mind and has no direct link to innovation. Further links could be made to the typology of firms proposed by Pinkse and Kolk, which identifies similar characteristics in the respective quadrants, although the axes are different.

Other work has produced a typology of negotiation styles, which can inform on how firms respond within the legislative process, the characteristics this represents, and the potential motivations behind a particular position. Five types are defined:

- **Accommodating:** Individuals who enjoy solving the other party's problems and preserving personal relationships. Accommodators are sensitive to the emotional states, body language, and verbal signals of the other parties. They can, however, feel taken advantage of in situations when the other party places little emphasis on the relationship.
- **Avoiding:** Individuals who do not like to negotiate and don't do it unless warranted. When negotiating, avoiders tend to defer and dodge the confrontational aspects of negotiating; however, they may be perceived as tactful and diplomatic.
- **Collaborating:** Individuals who enjoy negotiations that involve solving tough problems in creative ways. Collaborators are good at using negotiations to understand the concerns and interests of the other parties. They can, however, create problems by transforming simple situations into more complex ones.
- **Competing:** Individuals who enjoy negotiations because they present an opportunity to win something. Competitive negotiators have strong instincts for all aspects of negotiating and are often strategic. Because their style can dominate the bargaining process, competitive negotiators often neglect the importance of relationships.

- **Compromising:** Individuals who are eager to close the deal by doing what is fair and equal for all parties involved in the negotiation. Compromisers can be useful when there is limited time to complete the deal; however, compromisers often unnecessarily rush the negotiation process and make concessions too quickly.

This typology may offer insight into how a firm engages with the legislative process in the negotiations and consultations.

A draft typology of manufacturers

Analysis and definition of typology scope

Based on the key points identified above we concluded that our typology should explicitly:

- Have a link to the relevant innovation behaviour of the firm – as we wanted to understand the extent to which the regulation drives a firm's innovation and engagement response and/or that a firm's innovation behaviour drives their engagement and influence on the regulation.
- Focus on the firms (and industry associations) that are actively engaged in the regulatory process – which while only a relatively small group, these represent the firms that will most influence the process and that have active behaviour to categorise and analyse.
  - Firms that were passive in the process were analysed to understand why they are passive, what effect this has on the regulations and market, how they feel about this and what it would take to get them involved.
- Take account of the economic impact upon the firm – while it was clear that other factors and motivations can, and do, play an important role in how firms respond to and engage with the regulations, the size of the economic opportunity/threat and impact upon the firm itself was arguably the most important determinant of their behaviour. The impact being a factor of both the firms' internal characteristics and adaptability, and also the specific nature of the regulation and the constraints and opportunities it imposes.

It was also identified as important that any typology should take account of:

- The firms' underlying product-market strategy and company philosophy, including their main motivations for innovation and engagement;
- The underlying market and consumer characteristics; and
- How and why behaviour becomes active/passive, constructive/destructive at different stages.

Our draft typology

We selected a quadrant-based approach for our draft typology, with two-axes representing the characteristics that set firms apart. This approach mirrors a number of the examples presented in section 4.1 (see Pinkse & Kolk, Shock, Spreitzer) and is a commonly-used, easily represented and

understandable way to present findings. It also provides a manageable level of complexity for the analysis, focusing on two key variables. Therefore the choice of the two axes was important.

For the first axis, the purpose of this part of the study was to identify how and why firms engage with the Ecodesign and Energy Labelling regulatory processes, particularly to identify when and why they become obstructive. Taking the literature review and key findings into account it was clear that the perceived impact of the regulation upon a firm was likely to be a key determinant of its attitude and engagement in the process, therefore it is crucial to account for whether the regulation is perceived as having a positive or negative impact on the firm or sector. The perceived impact of the regulation on the firm (positive-negative) was therefore selected as our first axis.

For the second axis, the other key thrust of the study was to understand the relationship between innovation and engagement in the regulatory process, i.e. investigating both how a firm's strength or weakness on innovation may influence its position in the regulatory process, and how the outcomes of the regulatory process may influence a firm's innovation behaviour. Therefore the eco-innovativeness of a firm was selected for the second axis, represented through their eco-innovative strategy (follower-innovator).

These choices also enabled us to build upon the existing typologies, adding something new, while taking on board their findings. Our first axis, on perceived impact of regulation, represents the impact of the external factors on the firm, and is quite similar to the opportunity recognition axis used in Pinkse & Kolk for firms' response to carbon market regulation. It includes an accounting for the ambition of the regulation, process structure, market structure and compliance issues which were also identified and are important to the impact upon a firm and its potential response. The second axis represents more the internal drivers of the firm, an amalgam of its overall attitude to innovation, its market position, company philosophy and management quality, all of which could play an important impact on how a company engages with, and responds to, the regulatory process.

We discuss these axes further below.

Perceived impact of regulation

This axis represents the perceived (or real) total impact of the regulatory measure, as it is currently formulated, on a firm. This is assumed to be the key determinant of company position within the legislative process – as a combined filter of all their motivations and drivers. It is based on the assumption that firms have a strong sense of self-interest and self-awareness, i.e. that they understand quite clearly what the regulatory changes will mean for them financially, within their market and in relation to their wider company goals. We anticipated that the consideration of financial impacts would be dominant within this, but that the other factors can also play a role, i.e. firms considering the long-term impacts on their strategic market position or on other goals, i.e. a firm with a strong commitment and image on CSR may take care on being seen to be supporting a regulation with low environmental ambitions and requirements, anticipating that this could pose a risk of negative reputational impacts among consumers and other important stakeholders.

Ideological opposition to regulation aside, the perceived impact of the regulation on a firm is clearly a result of the regulation that is proposed, and how this impacts the markets and opportunities for a firm. A less or more ambitious regulation will each have winners and losers, with the underlying assumption that a regulation with low ambition in environmental requirements will be more likely to result in positive impacts for less innovative firms and a more ambitious regulation to result in negative impacts, and vice-versa for the more innovative firms.

We anticipated that companies could quite rapidly change their position on this axis as the ambition of the regulation progresses and changes throughout the legislative process.

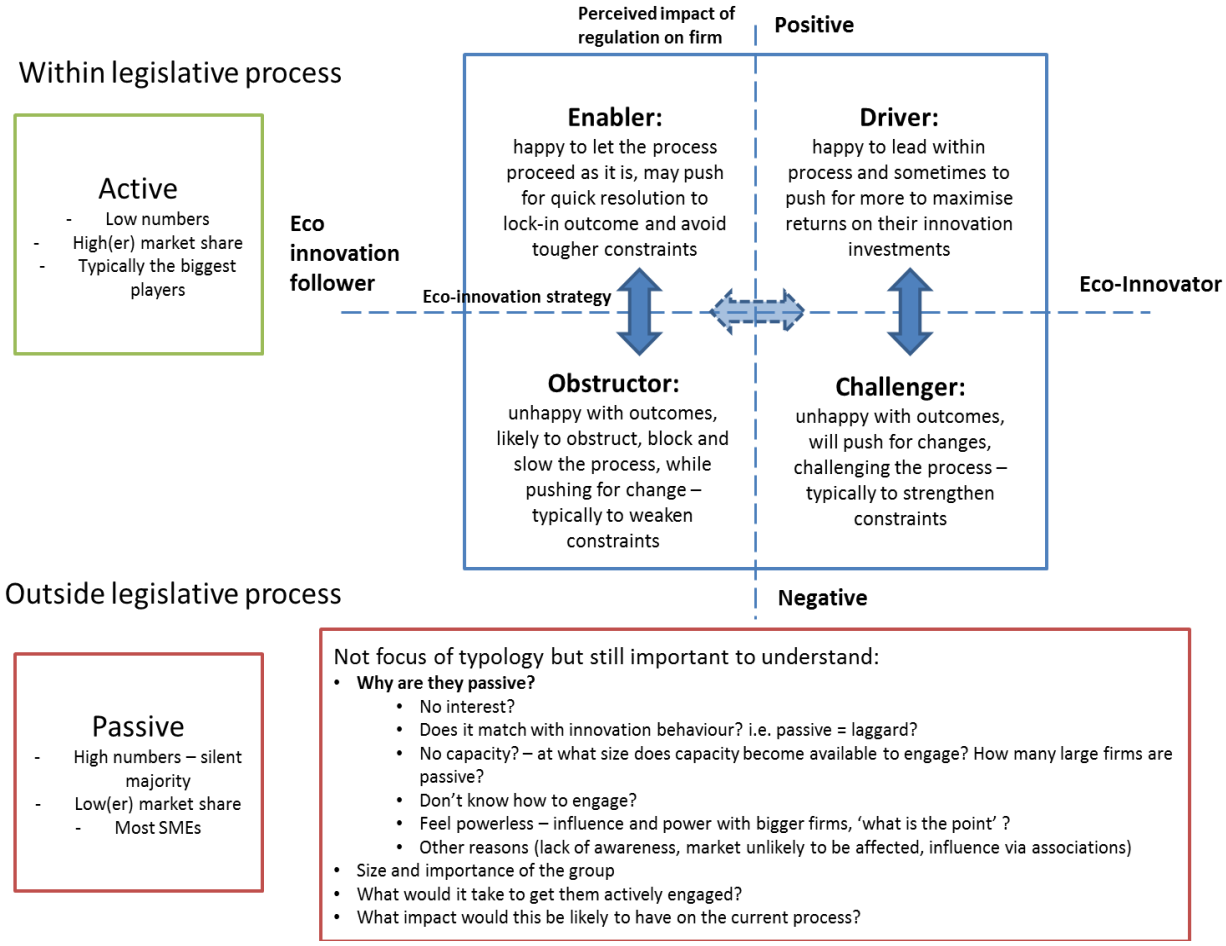
Eco-innovation strategy and activities

This axis ranks firms on their eco-innovativeness. It provides a direct link to their innovation activities and is specific to the areas of innovation (i.e. eco-) that are relevant to the Ecodesign and Energy Labelling directives. Firms rank on the scale according to the extent that they are regarded as an eco-innovation follower or leader – similar to the typologies discussed in section 4.1.2. The ranking is relative to the other firms in their sector/product group. Moving along this scale is understood to be something that takes time, i.e. to change from a follower to an innovator a firm will need to change its innovation strategy and investments and that this will take time to pay-off in terms of improving their relative innovation position.

The draft typology

We present in Figure 24 our draft typology of firms' innovation and legislative engagement behaviour. This defines 5 types of firm, based on a first distinction between whether a firm is active or passive in the legislative process. We make this first distinction as the literature suggests that the majority of firms will not be actively engaged in the regulatory process, and as the focus of the typology is on classifying the active firms we use this as a first filter. Firms identified as passive, were still of interest, as it remained useful also to understand why this is the case and what it would take for them to become active. Among the active firms our quadrant defines four different types of firms based on their relative eco-innovation strategy and performance, and the perceived impact of the regulation on the firm.

Figure 24: Our draft typology of firms innovation and legislative engagement behaviour



These four draft types were elaborated in more detail and questions designed to test for the existence of the characteristics and actions proposed for them. The specific questions can be found in the questionnaire in Appendix I, with blocks 3 and 4 of the questionnaire being most relevant.

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