TOWARDS GREEN GROWTH- THE INFLUENCE OF EUROPEAN PRODUCT POLICY ON INNOVATION

Sibylle Braungardt, Diego Contreras and Susanne Discher
Fraunhofer Institute for Systems and Innovation Research ISI

ABSTRACT

Green growth requires the redirection of innovation activities towards eco-innovations, which ideally are beneficial for the environment, for consumers and for manufacturers. Environmental policy therefore plays an increasing role not only with respect to its environmental benefits but also regarding its innovation impact. Our study investigates the innovation impact of the Ecodesign and Labelling directives as key European policy measures to increase energy efficiency. We combine a quantitative analysis of patent data with a qualitative case study approach to investigate the impact of the legislations on a broad range of innovation activities. Our study covers a wide range of products that are affected by the regulation, thus providing the possibility to study the factors that positively influence the innovation impact. We find that the legislations have supported market transformation towards higher energy efficiency, however, their impact on research and development of new technologies has been limited so far. We find that the stringency of the regulation plays a crucial role for the innovation impact and conclude that the implementation of ambitious requirements provides incentives to innovate for companies, cost-savings for consumers and significant energy savings that are beneficial for the environment.

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 are 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.

In order to develop a coherent and effective governance framework to sustain the transition towards a green and competitive economy, it is essential that the design and analysis of policy measures take into account the multiple benefits related to environmental as well as socio-economic aspects. In order to achieve this goal, it is essential to develop a framework to measure and monitor the impact of policy measures going beyond their environmental benefits.

The objective of our study is to empirically analyse the factors that positively influence the innovation friendliness of the Ecodesign and Energy Labelling directives as key European policy measures to increase energy efficiency. The Ecodesign directive provides a framework to set minimum efficiency requirements, where products that do not comply are banned from the European market. The Labelling directive requires manufacturers to provide information about the products' energy efficiency through the European Energy Label, displaying the energy efficiency class on a predefined scale. In total, implementing measures for more than 40 products have been adopted so far.

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 European product policies provide a rich playground to investigate the influence of policy on innovation taking into account a number of complex interrelated factors. Firstly, the different regulated products vary strongly in their market structures. Secondly, the national innovation systems of the different European countries differ significantly. Thirdly, the implementing measures for different products show a varying level of ambition. Fourthly, there are strong differences in the innovation dynamics of the various products affected by the regulations. Lastly, the legislative processes and stakeholder interaction differ between the implementing measures.

The paper is organised as follows. Section 2 outlines the methodological approach of our study. Our main results are presented in Section 3. Section 4 presents a summary of the work and our conclusions.

2. METHODOLOGICAL APPROACH

Our study empirically analyses the innovation impact of the Ecodesign and Labelling directive by combining a quantitative approach based on patent statistics with a qualitative approach using case study analysis. The combined analysis allows for investigating a broad range of innovation activities. The conceptualization of the term innovation in our work is based on the Oslo manual (OECD, 2005) and we differentiate between research, development (testing new technologies in small-scale pilot projects), demonstration (first larger-scale implementations) and adoption (investment in state-of-the-art technologies).

Among the various factors that have been found to influence the innovation impact of environmental legislation (Ambec, 2011; Porter & Van der Linde, 1995; Popp, 2010), the stringency of the legislation has been shown to play a crucial role (see e.g. Frondel, Horbach, & Rennings, 2007). In our approach, the stringency of an Ecodesign implementing measure is defined by the market share of appliances that do not fulfill the requirements at the time of adoption. The stringency of Labelling legislations is defined through the share of appliances in the highest populated class. Both for Ecodesign and Labelling, the stringency varies significantly between the implementing measures for different products.

Within each sector, the stringency of the levels of Ecodesign and Labelling classes is perceived rather differently by different companies. Whereas producers of high-end products stated that all of their products already fulfilled the requirements at the time of adoption, other manufacturers stated that they had to make significant adjustments. In sectors where the 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 in the high-efficiency end, while at the same time taking into account the needs of low-end producers. In the following, we use the term "relative stringency" to refer to the company-specific perception of the ambition of the requirements.

2.1 PATENT ANALYSIS

In the secondary data analysis, the impact of the policy measures on the research stage of the innovation process is studied based on patents related to energy efficiency for a selection of products regulated under these directives. The patent data are extracted from the PATSTAT database, where the products to be studied are specified using the International Patent Classification (IPC). The products are selected based on the time of adoption of the implementing measures and include electric motors, refrigerators, battery chargers (all since

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

2009), dishwashers, washing machines (since 2010). More recent measures could not be studied due to a lack of data avalability.

In order to identify patents related to the energy efficiency of the products, we define search criteria based on the technological specifications of each product. The search strategy is iteratively tested by analysing the percentage of false positives (patents that appear in the results but are not related to energy efficiency) and true negatives (patents that are related to energy efficiency but do not appear) until achieving a validity of at least 80% for both criteria.

The influence of the policy measures on the patenting activities of manufacturers is investigated by comparing the evolution of patents related to energy efficiency prior to regulation, as well as after its adoption. *Trending behaviour* in patenting activities in these product groups are assessed relative to general patenting and economic trends. Sector specific developments driven by the directives are 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. *Time lags* between research activities and the publication of a patent are considered to be slightly minor to the time difference between the announcement of a regulation and its adoption. We therefore assume that patents that were filed up to three years before the regulation may have been regulation-driven, whereas this is not the case for patents filed prior to this time.

Based on the considerations outlined above, the impact of the Ecodesign and Energy Labelling directives on the patenting activity is investigated by comparing the following two parameters, where the patenting activities are considered to be influenced by regulation if the energy efficiency gain exceeds the standard deviation.

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 is calculated by taking the mean of a three-year time span. For the value with regulations, the three years up to the regulation is considered. For the value before regulation, the previous three years are considered.

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.

2.2 Case study research

For the case studies, we use a multiple case study approach (Yin, 2002) to collect primary data. This approach allows for gaining in-depth insights into the causal links between the regulations and the innovation activities of the manufacturers. Our case study analysis is based on 45 semi structured interviews conducted between August and December 2013 with representatives from 25 different companies as well as experts from trade organizations, non-governmental organizations and member state institutions. In order to achieve a thorough understanding of the mechanisms that positively and negatively influence the innovation impact, we conducted our case studies 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 selection of firms included in our case study research mainly focuses on producers of the products that are regulated. However, for products where relevant innovation activities occur at earlier stages of the product value chain, component suppliers have been included in the sample. The aim of our case selection was not to generate a statistical representative sample but include a broad range of companies taking into account the diversity and heterogeneity of firm-level innovation responses. To increase the validity of our results, whenever possible we included firms with similar characteristics as well as firms with contrasting characteristics in order to allow for literal and theoretical replication (Yin, 2002).

The results of the case studies were evaluated at company level, at sector level and in a cross-sectoral analysis to identify the most important factors that lead to the implementation of an innovation friendly regulation. A special focus is given to the stringency of the requirements, the different market and sales structures and the different innovation cycles for the various products that were analysed.

1. MAIN RESULTS

This section presents the results of our study on the impact of the Ecodesign and Labelling directives on innovation, covering the quantitative approach (Section 3.1) and the qualitative approach (Section 3.2).

3.1 PATENT ANALYSIS

As outlined in Section 2.1, our patent analysis focuses on the increase of the share of patents related to energy efficiency with respect to the total number of patents for each product. Figure 1 visualizes the increase of the relative number of patents related to energy efficiency with respect to the base year 1990 for seven products. From the visualization it becomes clear that for most products, no significant changes have occurred in the years around the regulatory processes.

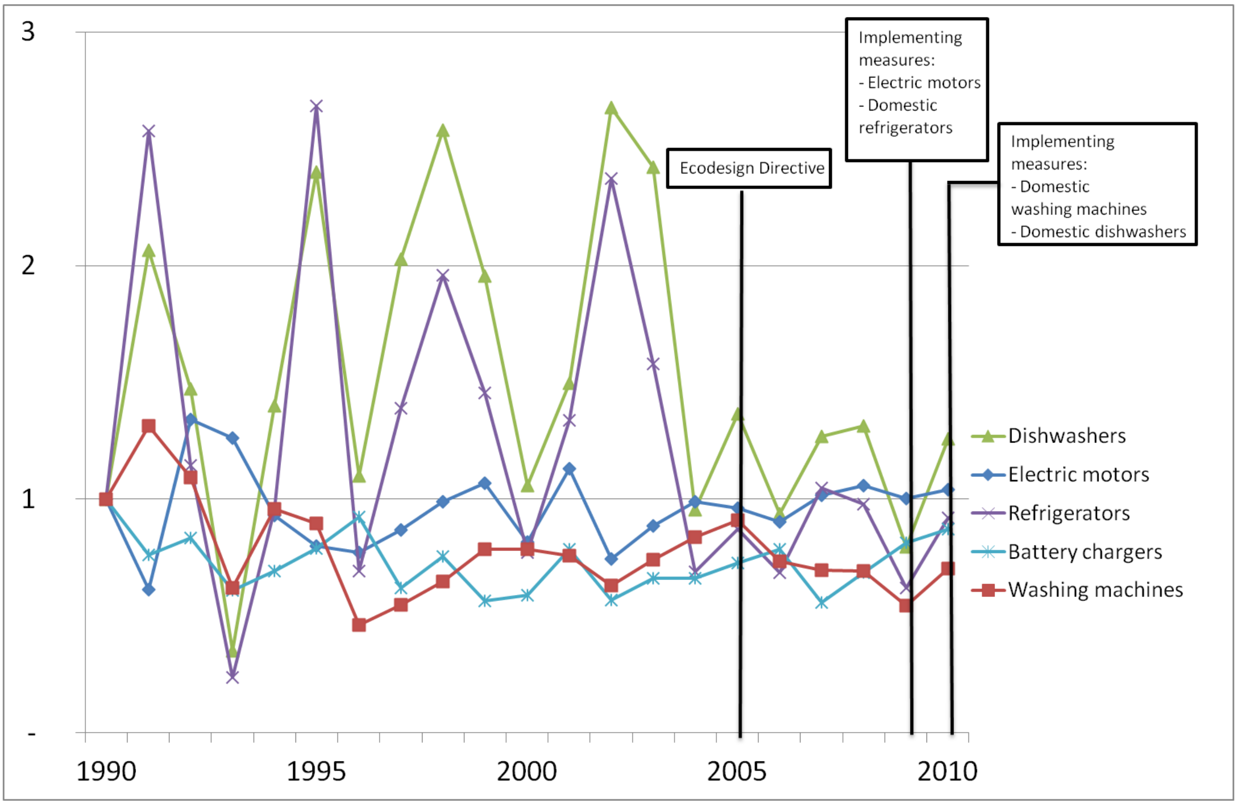

FIGURE 1: INCREASE OF THE RELATIVE NUMBER OF ENERGY EFFICIENCY RELATED PATENTS WITH RESPECT TO BASE YEAR 1990. THE NUMBERS ON THE Y-AXIS ARE NORMALIZED TO 1 IN THE BASE YEAR.

Table 1 displays the energy efficiency gain (see Section 2.1) and the standard deviation for the five products displayed in Figure 1. The assessment of the innovation impact in the last row of Table 1 follows the methodology outlined in Section 2.1. The analysis shows that no significant impact is observed for four products, and a low negative impact is observed for the remaining product.

TABLE 1: 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	no	no	No	no	low negative

The patent analysis shows that for the products that were analysed, to date, the Ecodesign and Labelling legislation have not had a significant impact on the relative number of patents related to energy efficiency. This result was also confirmed in the case study interviews, where most interviewees stated that the effects of the legislation on innovation activities were more apparent on the later stages of the innovation process.

3.2 CASE STUDY RESEARCH

Among the companies that were interviewed, the majority stated that both Ecodesign and Labelling have an influence on their innovation behaviour (see Figure 2). 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.

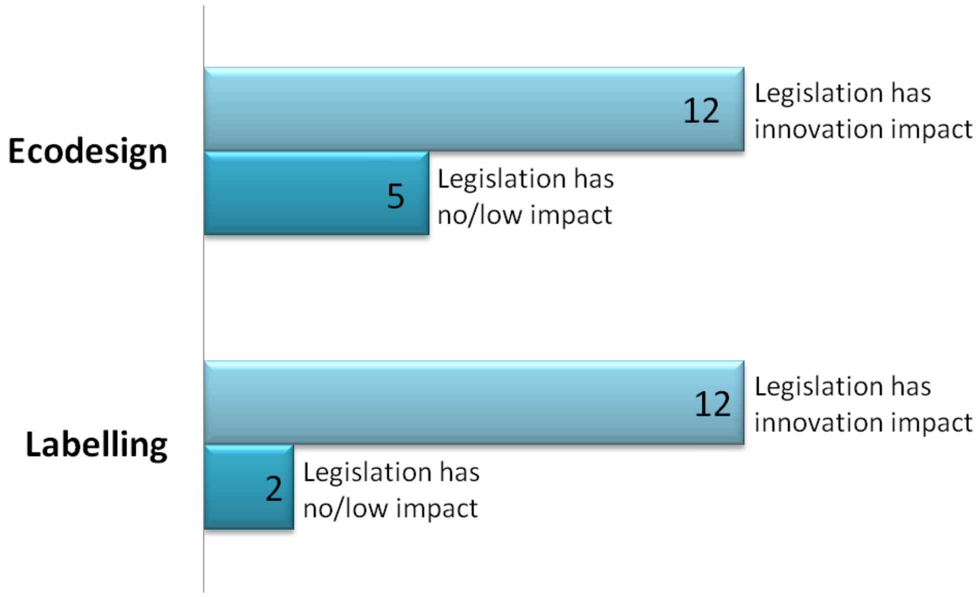

Figure 2: Results of our case studies: Distribution of companies that stated that the legislations have an impact on their innovation activities and companies that did not.

It is important to keep in mind that the distribution of companies displayed in Figure 2 depends on our case selection and would be different for other case selections. The aim of the case selection was not to create a statistically relevant sample, but to get an in-depth understanding of the mechanisms and the factors that influence the innovation impact of the directives.

The majority of innovation activities that were named in the interviews were rather incremental changes to the production processes of energy efficient products already in their portfolio and/or incremental improvements of the products. For both Ecodesign and Labelling, the innovation activities that are influenced are mainly found at the deployment and commercialisation stage.

For Ecodesign, we observed a rather direct relation between the ambition of the requirements and the innovation impact (Figure 3, left). The ambition of the requirements is reflected in the share of products that are excluded from the market when the regulation is adopted and varies widely between the different products. For example, for circulators, 90% of the market at the time of adoption did not meet the efficiency requirements. In contrast, by the time the television regulation came into force the majority of the market was above the requirements.

For products where the Ecodesign implementing measures define stringent requirements in relation to the market, the innovation impact is strong. In our case studies, companies that are affected by ambitious requirements (e.g. circulators, lighting) confirmed that Ecodesign is a strong measure to induce innovation. For such implementing measures, the first priority for the companies is to adapt their product portfolio to comply with the regulatory requirements.

By contrast, 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 requirements.

For Labelling, the relationship between the ambition of the levels and the innovation impact is not so straightforward (Figure 3, right). As was the case for Ecodesign, if the ambition of the Labelling classes is low the innovation impact is limited. Evidently, if most products are in the highest class the implementing 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. In contrast to Ecodesign, where the producers cannot sell products that do not comply, we observed that some firms reported that they had not upgraded their products in order to reach the higher Labelling classes.

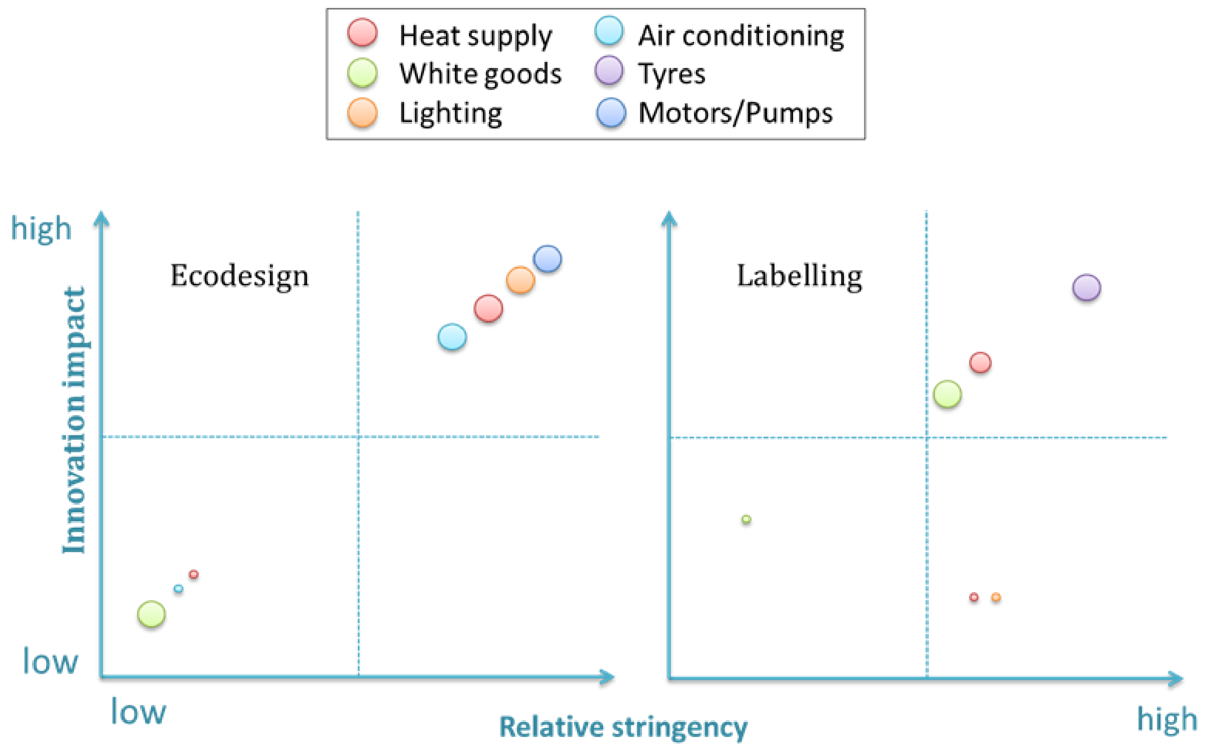

Figure 3: Relationship between the relative stringency and the innovation impact for Ecodesign (left) and Labelling (right). The size of the circles reflects the number of companies that confirmed the statement within each of the different product case studies.

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 addressed adequately by the legislations, whereas in the business-to-business market, barriers related to split incentives are addressed mainly by the Ecodesign legislation.

SUMMARY AND CONCLUSIONS

The results of our case studies show that the directives have supported market transformation towards more efficient technologies, mainly by facilitating the introduction of already existing high-efficiency technologies. Most of the companies that were interviewed stated that both Ecodesign and Energy Labelling have an influence on their innovation behaviour. The innovation impact is stronger on the deployment, commercialisation and diffusion of innovative energy efficiency technologies and is rather limited in the R&D related stages. Our patent analysis found that at the current stage, the Ecodesign and Labelling legislation had no significant impact on the relative number of patents related to energy efficiency. However, it is possible that as the efficiency requirements of the regulations successively increase, the long-term effect on the earlier stages on the innovation process may become more visible.

For both legislations, we observed a rather direct relationship between the stringency of the requirements and the innovation impact. The ambition of the requirements is reflected in the share of products that are cut off 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. In our case studies, companies that are affected by ambitious requirements confirmed that Ecodesign is a strong measure to induce innovation, as products that do not comply cannot be sold. However, most of the interviewees highlighted the importance of market control, as ambitious regulation can only support innovation if it is properly enforced.

In order to define ambitious requirements, it is essential to take into account the different innovation dynamics in the various sectors that are covered by Ecodesign and Labelling. In sectors with rapid technological advancement and short product development cycles, such as consumer electronics, the rather long regulatory processes face serious challenges to follow the innovation dynamics, often resulting in rather lax requirements.

For Energy Labelling, the long-term incentives for companies to innovate depend on the consumer response to the legislation. Labelling has the potential to raise awareness of consumers regarding the total cost of ownership of an appliance, including the energy use during its lifetime. However, the role of Labelling in consumer decision making depends on a variety of factors and differs between products, households and member states. Whereas Labelling can address information-related barriers, complementary measures are required to address the remaining barriers. An example for this would be innovative financial schemes to address the lack of upfront capital availability, which poses a serious barrier especially for low-income households.

Summarizing, our study shows that the Ecodesign and Labelling regulations can potentially drive innovation towards higher energy efficiency, where the innovation impact depends strongly on the specific implementation of the legislations. In order to achieve a green and at the same time competitive economy, it is essential to take environmental aspects as well as innovation into account in policy design and to further develop methodologies to analyse the innovation impact of environmental policy.

References

Allcott, H., & Greenstone, M. (2012). Is there an energy efficiency gap? *Journal of Economic Perspectives , 26* (1), S. 3-28.

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2011). The Porter Hypothesis at 20: Can Environmental Regulation enhance innovation and competitiveness? *Resources for the future discussion paper* .

Ambec, S., Cohen, M., Elgie, S., & Lannoie, P. (2011). *The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness?* Resources for the Future Discussion Paper.

Blind, K. (2012). The Impact of Regulation on Innovation. *NESTA Compendium* .

ECEEE. (2013). Seminar on Ecodesign and Innovation. Brussels.

Edler, J. (2013). Review of Policy Measures to Stimulate Private Demand for Innovations: Concepts and Effects. *NESTA Compendium* .

Edler, J., Cunningham, P., Gök, A., & Shapira, P. (2013). Impacts of Innovation Policy: Synthesis and Conclusions. *NESTA Compendum* .

Foxon, T. J., Köhler, J., & Oughton, C. (2008). *Innovation for a low carbon economy.* Edward Elger Publishing Limited.

Frondel, M., Horbach, J., & Rennings, K. (2007). End-of-Pipe or Cleaner Production? An Empirical Comparison of Environmental Innovation Decisions Across OECD Countries. *Business Strategy and the Environment , 16*, 571–584.

Gibbert, M., Ruigrok, W., & Wicki, B. (2008). What passes as a rigorous case study? *Strateg. Manage. J. , 29*, S. 1465-1474.

Jaffe, A., & Stavins, R. (1994). The energy efficiency gap: what does it mean? *Energy Policy , 22* (10), S. 60-71.

OECD. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data The Measurement of Scientific and Technological Activities .*

OECD. (2005). The Measurement of Scientific and Technological Activities.

Popp, D. N. (2010). Energy, the Environment, and Technological Change . In H. Bronwyn, & R. Nathan, *Handbook of the Economics of Innovation* (Bd. 2, S. 873-937). North-Holland.

Porter, M. E., & Van der Linde, C. (1995). Green and Competitive: Ending the Stalemate. *Harvard Business Review* .

Schiellerup, P., & Atanasiu, B. (2011). Innovations for a low-carbon economy- an overview and assessment of the EU policy landscape. *IEEP Report* .

Schumpeter, J. A. (1939). *A Theoretical, Historical and Statistical Analysis of the Capitalist Process.*

Yin, R. (2002). *Case Study Research: Design and Methods.*

Acknowledgements

The results were developed within the context of a project initiated and funded by the European Commission. The authors are grateful for the valuable contributions of all the researchers and consultants involved in the consortium including Fraunhofer ISI, Ecofys, Triple E Consulting, Sea Green Tree and SoWatt.