Adoption and Diffusion of Renewable Energy Technologies: Influence of the Policy Mix in the Manufacturing Industry

Katharina Mattes, Simon Müller, Angela Jäger, Nadezda Weidner, Ute Weißfloch*

**Corresponding author: katharina.mattes@isi.fraunhofer.de, Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany*

Abstract
Rising energy prices and political goals which address climate change, such as the reduction of greenhouse gas emissions, increase the importance of using renewable energies and technologies for generating these. Since the manufacturing industry is one of the major energy consumers in Germany, this paper focuses on the diffusion of renewable energy technologies to generate power in the manufacturing industry. Using data from the *German Manufacturing Survey* 2012 for 1,594 firms, we analyse the relation between the usage of renewable energy technology and firms' characteristics, also accounting for structural determinants. In addition, the reasons for the decision to use these technologies and, in particular, the relevance of the political framework are examined. Our findings show that the producers of end-consumer goods are more likely to use renewable energy technologies compared to other manufacturing firms. The availability of resources plays a substantial role, whereas the energy intensity of the firm is less important for the introduction of renewable energy technologies. When considering the chosen reasons for adoption, firms mentioned most frequently that they anticipate rising energy prices. The policy mix, however, is less often mentioned and mostly together with other reasons.

Keywords: renewable energy technologies, manufacturing industry, technology adoption, diffusion of innovations, quantitative analysis

Introduction

The use of renewable energy technologies (RETs) to generate electricity is becoming increasingly important for both the manufacturing industry and households, due to rising energy costs and the growing awareness of the necessity to reduce emissions for climate protection. In general, the potential and functionality of RETs for electricity generation is widely examined and – as a consequence – well known. Different authors have analysed the application possibilities and the potential of the integration of RETs in industrial

production processes e. g. (Kalogirou 2003; Taibi et al. 2012). However, the factors which influence the adoption of RETs by firms of the German manufacturing industry (GMI) has not been examined yet since no empirical data on the diffusion of RETs in the GMI has been available.

The GMI accounts for 28 percent of the final energy consumption and is the second largest energy consumer within the German energy economy (Energiebilanzen e.V. 2011). Hence, it is of particular interest to analyse the diffusion of RETs for electricity generation among these companies and to identify the structural characteristics of the adopting firms, such as company size or position in the value chain. Moreover, firms might have various reasons to adopt RET technologies, such as e. g. the expected development of energy prices and the political framework, which is valid for eco-innovations, e. g. (Henriques and Sadorsky 1996; Arvanitis and Ley 2010). By using a broad empirical database of German manufacturing companies, the following research questions are answered:

- How have RETs for electricity generation diffused within the GMI since 1980?
- How do firm characteristics influence the adoption of RET?
- Why do firms of the GMI use RETs? What are the important reasons for companies to adopt the RETs? In particular, what is the relevance of the policy mix?

The paper is structured as follows. In the second chapter, a short literature overview is given and the hypotheses are derived. Section three describes the data used. In the following chapter the results of the empirical analysis are presented. The final chapter summarizes key findings and draws conclusions.

RETs in the manufacturing industry

The diffusion of RETs

The diffusion of technologies is understood as the process by which innovations, such as products, processes or organizational concepts, are spread within an economic system by being adopted by companies, e. g. (Baptista 1999; Hall 2005). An adoption decision results from various factors, such as specific characteristics of an adopting company, an adoptable technology as well as the environment of a company (van Dijken 1999).

RETs are technologies which have received political support and governmental subsidies regarding their implementation and usage for a long time (Jacobsson and Lauber 2006). When the electricity feeding act was passed in 1990, it offered and guaranteed that small electricity generators can be connected to the grid and provided considerable financial incentives for investors. The renewable energies act (REA) of 2000 repealed the feeding act and created further significant improvements for owners of small energy systems by offering feed-in tariffs fixed for 20 years depending on the used technology. By introducing the 1st amendment of the REA in 2004, significant new incentives for bio-mass and small hydro plants were added. The funding rates for photovoltaic systems were increased and thus photovoltaic systems became commercially attractive without any additional monetary support. This development led to a solar boom in 2004 and supported the further diffusion of RETs in Germany (Mez 2005). Due to the strong expansion of wind power and biomass, in 2009 the 2nd amendment of the REA focused on solar power. The adjustments arranged the refinement of performance classes

which led to a shift from funding large systems to funding small systems and brought further investment incentives especially for small investors (Hermanns 2008). In 2012 the revision of the REA aimed at limiting the funding for photovoltaic applications due to the strong expansion of this source in the past.

Firm characteristics

Since the adoption decision is influenced by a variety of different factors, the following section identifies several firm characteristics which might have an impact on using RETs. The company size is often mentioned as an important influencing factor for the adoption of new technologies. STONEMAN (2002) argues that larger firm size yields greater returns. Other authors refer to the simplified access to external capital as a result of the company size. Due to more diversified product portfolios, larger companies entail lower credit default risks, e. g. (Schleich 2009). In this context, HECKER (1997) argues that larger companies often employ a higher number of qualified experts than smaller companies and, therefore, have better chances to understand complex technologies. Due to the better overall conditions for large companies in terms of financial and human resources, this leads to the assumption that it is easier for big companies to handle and deal with RETs than it is for small companies.

Compared to fossil based energy supply, renewable energy technologies have currently higher total costs because of the necessary investment, operation, maintenance and – in the case of bioelectricity – the fuel costs. Depending on the technology, renewable energies can be very capital-intensive (del Río 2011). According to JORDAN (2007), the access to external capital is an initial barrier to the market entry for renewable energies. Moreover, she argues that initial investments play an important role in this context. The fact that RETs require high initial investments leads to the assumption that the financial strength of a firm has an influence on the adoption of RETs. This leads to the following hypotheses:

Hypothesis 1a: *Bigger firms are more likely to adopt RETs than other firms.*

Hypothesis 1b: *Companies with higher capital resources are more likely to invest in RETs than other firms.*

Using renewable energies in companies is becoming increasingly important not only to diversify the own energy supply but also to use green electricity within the company's marketing mix as part of a differentiation strategy (Wüstenhagen et al. 2003). In this context PROFIR (2008) argues that renewable energies were initially used more by business-to-consumer (B2C) industries, however, several business-to-business (B2B) entities are now turning to green power as well. Furthermore, BUNSE et al. argue that the consumer preference for environmentally friendly manufactured goods is rising and that reputational and competitive advantages of manufacturing companies can be achieved through superior environmental performance (Bunse et al. 2011). This leads to the assumption that the usage of RET within firms is becoming increasingly important for marketing purposes as well, especially within companies with B2C relationships, and the following hypothesis is derived:

Hypothesis 2: *Companies in the field of B2C are more likely to adopt RETs than companies in the field of B2B.*

Structural characteristics

Regarding the different RETs for electricity generation, photovoltaic systems are a suitable opportunity for using renewable energy sources at various scales due to their rather facile installation processes and their modular design (Quaschning 2011). With approximately 1.3 million installed facilities photovoltaic is the most widely used form of renewable electricity generation in Germany (Bundesverband Solarwirtschaft 2013). Since there is an uneven distribution of solar radiation in Germany, there are different usage potentials within the federal states of Germany.[1] Hence it is assumed that the location of a firm influences the diffusion of RETs for power generation and thus has to be considered in the analysis.

Due to the various influencing factors, diffusion processes differ between the sectors (Stoneman 2002). Another important aspect, which is taken into account, is the energy intensity of a manufacturing sector. Especially for energy-intensive industries[2], which consume large amounts of energy, the costs of energy supply play an important role and, therefore, these industries have dealt with energy issues for a long time. Due to the awareness of energy efficiency issues, their energy saving potential is further developed and therefore lower than in industries with less energy-intensive production processes (Schröter et al. 2009). Hence, it is estimated that the diffusion of RETs differs in regard to the energy-intensity of the sector. Accordingly, it is assumed that the structural characteristics play a role regarding the diffusion of RETs.

Reasons for RET adoption

Companies might have various reasons for using RETs to generate electricity: the policy mix, economic aspects or an environmental strategy. The policy mix focuses on the political or legal framework conditions. It covers different perspectives of the climate, environmental as well as innovation policy and is composed of policy strategies as well as policy instruments (Rogge and Reichardt 2013), such as e. g. specific governmental objectives, legislation, regulation and subsidies. As mentioned above, RETs have received governmental support for a long time. Moreover, in the literature on eco-innovations legislation and regulation are estimated to be some of the main drivers for firms to conduct environmental activities (Agan et al. 2013; Henriques and Sadorsky 1996; Porter and van der Linde 1995). Regarding economic aspects, rising energy prices have a positive impact on the usage of energy-saving technologies (Arvanitis and Ley 2010). PICKET-BAKER (2011) emphasizes the influence of the energy price. Moreover, she mentions the importance of energy security concerns, which are reflected in an independent energy generation.

The third dimension is an environmentally friendly strategy of the firm. Since customers demand more environmentally friendly products, firms estimate the usage of

---

1 Classification according to http://gmao.gsfc.nasa.gov/merra/ (checked: 25.06.2013).

2 According to http://www.energieintensive.de/, the energy-intensive industries cover the sectors chemical industry, metal industry, manufacturing of coke and refined petroleum products, manufacturing of paper products and the manufacturing of non-metallic mineral products.

green energy as an effective driver for differentiation. Hence the usage of RETs might lead to a competitive advantage (Bunse et al. 2011; Agan et al. 2013). Lastly, RETs are an environmentally friendly technology and, as a consequence, can improve the firm's carbon footprint by reducing greenhouse gas emissions (Picket-Baker 2011).

Empirical Research

Database

For the empirical analyses a quantitative approach was chosen. To answer the research question, the database of the *German Manufacturing Survey* 2012 is used, which is the part of the *European Manufacturing Survey* (EMS) captured in Germany. The survey provides a large set of data on firms in the German manufacturing industry including information on implementation of innovative technologies, organizational practices, performance indicators and company data. Therefore, the survey enables the examination of the diffusion of RETs for electricity generation within the German manufacturing industry. Moreover, it provides opportunities to analyse the relation between an adoption decision and various firm determinants as well as specific reasons for and against the adoption decision.

The standardized, multi-topic mail survey of modernization trends in the manufacturing sectors in Germany has been carried out every two to three years since 1995. The 2012 survey covers 1,595 firms based in Germany and provides a representative database for the German manufacturing industry including firms of the sectors 10 to 33 according to the NACE classification Rev. 2 with at least 20 employees (Weißfloch et al. 2013). As representatives of their firm, the production managers or the CEOs were contacted and asked to complete the questionnaire.

Methodology

To determine the impact of the firm characteristics on the usage of RET, a multiple analysis is applied. As a first step, it was possible to obtain indications for the assumed relations by examining bivariate results. To gain a deeper understanding, a multiple logistic regression was used, which enables the examination of the effects of a certain firm's characteristic on the technology adoption by considering the effects of the other determinants, as well as accounting for the structural characteristics.

The outcome of the analysis is the usage of RET to generate electricity. The variable is binary and indicates whether a renewable technology was adopted by a company. Firms' characteristics, such as size of a firm, its financial strength and position in the value chain, are considered as main determinants in the model. The size of the firm is operationalized by categorizing the companies into two groups: Bigger firms with 250 or more employees and small- and medium sized firms with less than 250 employees. The variable financial strength of the firm was not directly captured. Hence, for operationalizing the construct the net value added (NVA) per employee of the firm can be used. NVA is calculated as the difference between turnover and advanced payments. The NVA per employee is calculated by dividing the NVA by the numbers of employees,. It represents a certain financial strength by equalizing differences in firm size. So as not to overestimate higher values, the financial strength is expressed as the logarithm of the NVA per employee. Finally, to explore the differences in RET usage related to the position in the value chain, companies operating in the field of B2C and firms, which do

not produce goods directly for the end-consumer, were distinguished using a binary variable.

In addition to the above-mentioned explanatory variables, the model controls for structural firm characteristics which favour the use of an RET for electricity generation and, thus, enhances the chance of adopting an RET. To measure the availability of resources for the usage of RETs, the location of the company is used as an indicator. A higher potential for the usage of RETs for electricity generation from solar power is given in the federal states of Germany with a comparably higher average solar radiation. The firms were categorized into two groups according to their location indicating high average solar radiation for Bavaria, Baden-Wuerttemberg, Berlin, Saarland and Rhineland-Palatinate[3] compared to less average solar radiation in the other federal states. To capture the energy intensity of a firm, the average energy intensity of the sector is used as a proxy. The sectors with high energy intensity[4] are the chemical industry, the manufacturing of basic metals (metal industry), the manufacturing of coke and refined petroleum products, the manufacturing of non-metallic mineral products and manufacturing of paper and paper products. By using a binary variable, this sector group is compared to all other manufacturing sectors with less energy needs.

The final step is the analysis of the reasons for using RETs. Multiple answers were possible and the surveyed firms were able to select from the reasons listed below:

1. Expected development of the energy price
2. Strategic reasons (e. g. “green image”)
3. Reduction of greenhouse gas emissions
4. Own energy generation to expand the sources for energy supply
5. Political or legal framework conditions.

In the descriptive analysis the relevance of the various reasons is compared against each other. Of particular interest is whether the policy mix is most frequently mentioned as a decision criterion regarding the adoption of renewable energy or not.

Results and Discussion

Diffusion of RET in the manufacturing industry

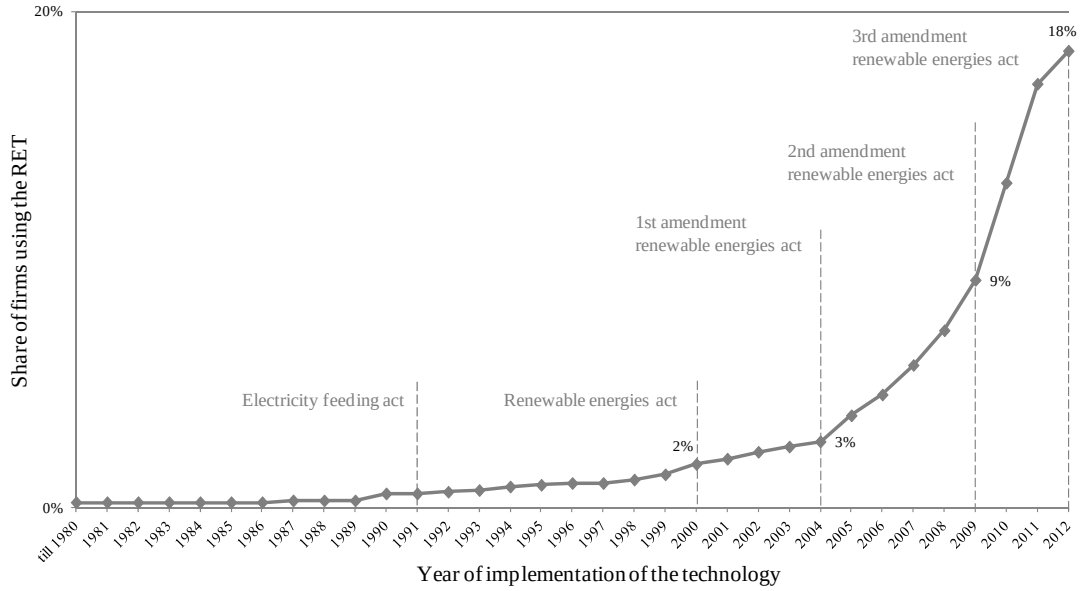
Up to the time of the survey in 2012, 18 percent of the firms of the manufacturing survey use RETs to generate electricity (cf. *Figure 1*). The diffusion process of RETs can be divided into three parts. Before 2004, the adoption rates of the RETs were very low. Nearly 3 percent of companies used renewable technologies to generate electricity by 2004. From 2004 to 2009 there was a major increase in RET users of up to 9 percent. In the last three years, the number of RETs users has grown even faster, and their share among the manufacturing companies has doubled.

These turning points go hand in hand with significant changes in the policy mix, as described above. The first initiatives to promote the diffusion of renewable power generation technologies (Electricity Feeding Act) seemed to be quite successful and the first companies were motivated to invest in such technologies. In 2004 the first

3 Classification according to http://gmao.gsfc.nasa.gov/merra/.

4 Classification according to http://www.energieintensive.de/ (checked: 07.06.2013).

amendment of the renewable energies act was introduced and brought further promotion for RETs, especially for wind- and photovoltaic energy systems. In 2009 it became even more attractive to invest in small photovoltaic systems with the second amendment of the renewable energies act. Thus, considering the development in the usage rates of RETs over time, an association between the policy mix and the use of those technologies can be assumed. However, besides the policy mix, there might be plenty of other factors which might affect the diffusion of RETs as well, e. g. technology maturity, learning rates, or cost effectiveness. These reasons need to be researched more thoroughly in future.



German Manufacturing Survey 2012, Fraunhofer ISI

Figure 1: Diffusion of RETs for electricity generation in Germany

Influence of company determinants

When examining a connection between a firm's size and the usage of RET, it appears that there are 21 percent RET users among the companies with 250 and more employees, compared with 18 percent among the firms with less than 250 employees. The difference is, however, not significant at the 95 percent level of confidence. Similarly, firm size has no significant effect on the adoption decision when controlled for other relevant impact factors. This could be explained by the fact, that the variable firm size is an aggregation of different determinants which influence the adoption decision, e. g. (Dreher 1997). Even though in the literature firm size is often mentioned as a driver and facilitator for early adoption due to economies of scale and as being less risk-averse, small companies might be more flexible regarding decision processes (Karshenas and Stoneman 1993).

Renewable technologies are very capital intense since their adoption is accompanied with high overall costs. The bivariate analysis of the NVA per employee reveals that companies using RETs to generate electricity have on average a slightly higher NVA per employee (97,000€) than companies which are not using such technologies (92,000€). The multiple analysis shows that the companies with higher NVA per employee are more

likely to use renewable technologies. The result is only significant at a level of 10 percent. Thus, an effect related to the NVA can be identified, albeit it is not statistically significant at the 95 percent level of confidence. This result leads to the assumption that a higher financial strength might influence the adoption, yet other factors such as belief in the technology might be relevant as well. As a consequence, further research on this topic should be taken into consideration.

With regard to the firm's position in the value chain, the bivariate analysis demonstrates that 25 percent of manufactures of end-consumer goods (B2C) use the renewable technologies to generate electricity compared with only 17 percent among the manufacturers of other goods (B2B). The regression analysis confirms the bivariate findings and indicates that B2C producers have higher chances of an RET adoption. In particular, when comparing two firms of the same size with a comparable financial strength and operating in the same region and sectors with similar energy intensity, a B2C producer is more likely to use an RET than B2B producer. The results are statistically significant for both the bivariate and the multiple analyses. Thus, the findings reveal an important role of the firm's position in the value chain for the technology adoption. This can be explained by the importance of manufacturing firms in the field of B2C to improve their reputation regarding green production and the positive influence aligned with RETs on their reputation and image.

As mentioned in the theoretical part of this paper, besides the main effects, structural characteristics were included in the model in order to capture the uneven distribution of solar radiation in Germany, as well as the differing energy intensity of the manufacturing sectors. The bivariate analysis shows that 23 percent of companies located in the federal states with high average solar potential use RETs to generate electricity compared to a usage rate of 15 percent in the states with less solar radiation. The logistic regression shows a positive statistically significant effect, which implies that the use of RET is highly dependent on the resource availability. The energy intensity of the sectors, though, does not show a statistical significance. Consequently, the availability of the necessary resources and the ease of energy generation seem to be more important than the demand for energy resources.

Table 1: Usage of a RET for electricity generation: Multiple logistic regression with the firm's characteristics, adjusted for structural determinants

Independent variable	Odds Ratios	95 % Confidence Interval	
		Lower	Upper
Firm's size			
Bigger companies with 250 and more employees	1.124 n.s	0.709	1.780
(Small- and medium-sized companies with less than 250 employees)	-		
Net value added per employee (logarithm)	1.305+	0.976	1.746
Position in value chain			
B2C producer	1.533*	1.076	2.185
(non-B2C Producer)	-		
Resource availability			
Federal states with high average solar radiation	1.597**	1.176	2.168
(Federal states with less average solar radiation)	-		
Energy intensity			
Sectors with high energy-intensity	1.068 n.s	0.700	1.631
(Sectors with lower energy intensity)	-		

Level of significance: p<0.1(+); p<0.05(*); p<0.01(**); not statistically significant (n.s)
Source: *German Manufacturing Survey* 2012, Fraunhofer ISI, own calculation

Reasons for RET adoption

In the previous section it was examined whether the specific firm's characteristics are associated with the adoption of RET. This section focuses on five specific reasons, which might be considered by the companies when they decide in favour of technology adoption.

The bivariate analysis of the reasons reveals that for companies the expected development of the energy price is the most important argument for adopting the technology; 76 percent of the surveyed firms that use an RET stated this reason. Strategic reasons, e. g. related to a "green image", are rated as second important with 58 percent. The reduction of greenhouse gas emissions was mentioned as a reason for the usage of RETs by 49 percent of the using firms. Meanwhile, the political and legal framework conditions together with the expansion of the own energy generation are cited less often (42 percent vs. 41 percent). This result indicates that energy prices, "green image" and the reduction of greenhouse gas emissions are the most decisive criteria for the adoption of RETs. The policy mix, on the other hand, is less important.

Since the survey allowed multiple answers regarding the reasons for using RETs to generate electricity, most of the companies selected more than one reason. This is true for the policy mix as well. Most often the policy mix was mentioned in combination with one or two other reasons (18 percent and 29 percent). Energy prices and strategic reasons are the main accompanying reasons for the policy mix.

A further detailed analysis on the selection of the policy-mix as a decisive factor in

regard to different types of RET users was conducted. The results, nevertheless, have shown no evidence that bigger firms or firms with more financial strength mention policy mix more often than the other firms. Similarly, no relation has been found between the selection of a policy mix as a reason and the availability of resources, the energy intensity and the firm's R&D intensity.

Even though the energy price, which is influenced by the policy mix, was mentioned by the majority of the technology users, the presented facts indicate that the policy mix is not the primary reason for companies adopting RETs. Nonetheless, the policy mix is perceived by many firms as an important factor for the adoption and, thus, shows its effectiveness for firms in the GMI.

Conclusions and further research

By using data of the *German Manufacturing Survey* 2012, this paper provides a representative picture of the usage of RETs to generate electricity in the manufacturing industry. It is shown that already 18 percent of the firms in the manufacturing industry use RETs to generate electricity. Moreover, the findings reveal that the position in the value chain, specifically B2C producers, use RETs more often than other firms which do not produce for end-consumers. However, the size of the firm and its financial strength do not demonstrate a significant impact. The availability of resources is another relevant explanatory factor, whereas the energy intensity of the sector did not affect the usage of RETs. Consequently, the results of this paper indicate that, for instance, governmental funding measures should focus on regional target groups in order to increase the diffusion of RETs in the manufacturing industry.

Furthermore, based on the findings, it is assumed that economic aspects are the strongest driving force for the usage of RETs. From a range of five reasons to adopt an RET to generate electricity, the majority of technology users mentioned that they anticipated rising energy prices. In contrast, the political framework seems to be less important and is cited often in combination with other reasons. Since the manufacturing industry is a promising and beneficial target group for expanding energy generation based on RETs, it is, thus, recommended to target the policy mix more specifically at the manufacturing companies to increase the share of RET users.

To understand the effects of the policy mix on RET adopters of the GMI more thoroughly, further research on this issue is needed. This could be done by a qualitative research approach to detail the adoption decision. Moreover, as already mentioned in the results section, future research could focus more thoroughly on the determinants affecting the diffusion of RETs, such as learning effects and economies of scale, as well as the influence of the financial strength and the NVA per employee. Lastly, it would be interesting to compare the diffusion and adoption patterns with other countries to gain more insights into the different drivers for adoption.

Acknowledgements

This paper is part of a research project funded by the Federal Ministry of Education and Research under the funding label Econ-C-026, whose support we gratefully acknowledge. The authors are responsible for the content of this publication.

References

Agan, Y.; Acar, M. F.; Borodin, A. (2013), "Drivers of environmental processes and their impact on

performance: A study of Turkish SMEs", *Journal of Cleaner Production*, Vol. 51, pp. 23-33.
Arvanitis, S.; Ley, M. (2010), *Factors Determining the Adoption of Energy-saving Technologies in Swiss Firms – An Analysis based on Micro Data*, KOF Working Papers No. 257, ETH Zurich, Zurich.
Baptista, R. (1999), "The Diffusion of Process Innovations: A Selective Review", *International Journal of the Economics of Business*, Vol. 6, No. 1, pp. 107-129.
BMWi, BMU (2012): *Erster Monitoring-Bericht „Energie der Zukunft"*, Berlin.
Bundesverband für Solarwirtschaft (2013), *Statistische Zahlen der Deutschen Solarstrombranche (Photovoltaik)*, available online: www.solarwirtschaft.de/presse-mediathek/marktdaten.html, checked on: 25.06.2013.
Bunse, K.; Vodicka, M; Schönsleben, P.; Brülhart, M.; Ernst, F. O. (2011), "Integrating energy efficiency performance in production management - gap analysis between industrial needs and scientific literature", *Journal of Cleaner Production*, Vol.19, No. 6–7, pp. 667–679.
del Río, P. (2011), "Analysing Future Trends of Renewable Electricity in the EU in a Low-carbon Context", *Renewable and Sustainable Energy Reviews*, Vol. 15, No. 5, pp. 2520–2533.
Dreher, C. (1997), *Technologiepolitik und Technikdiffusion: Auswahl und Einsatz von Förderinstrumenten am Beispiel der Fertigungstechnik*, Karlsruher Beiträge Zur Wirtschaftspolitischen Forschung, Vol. 5 Nomos Verlagsgesellschaft, Baden-Baden.
Taibi, E.; Gielen, D.;Bazilian, M. (2011), "The Potential for Renewable Energy in Industrial Application", *Renewable and Sustainable Energy Reviews*, Vol. 16, No. 1, pp. 735-744.
Energiebilanzen e.V. (2011), *Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2011*, online available: www.ag-energiebilanzen.de/viewpage.php?idpage=139, checked on: 24.06.2013.
Hall, B. H. (2005), "Innovation and Diffusion", in Fagerberg, J.; Movery, D. C.; Nelson, R. R. (Eds.), *The Oxford Handbook of Innovation*, The Oxford University Press, Oxford, pp.459-484.
Hecker, F. (1997), *Die Akzeptanz und Durchsetzung von Systemtechnologien: Marktbearbeitung und Diffusion am Beispiel der Verkehrstelematik*, Dissertation, University of Saarbrücken, Saarbrücken.
Henriques, I.; Sadorsky, P. (1996), "The Determinants of an Environmentally Responsive Firm: An Empirical Approach", *Journal of Environmental Economics and Management*, Vol. 30, No. 3 pp. 381-395.
Hermanns, S. (2008), *Das Erneuerbare Energien Gesetz 2009 (EEG 2009): Novellierung sowie Hintergrund und Verlauf der politischen Debatte am Beispiel der Solarenergie*, GRIN, München.
Jacobsson, S. and Lauber, V. (2006), "The Politics and Policy of Energy System Transformation - explaining the German Diffusion of Renewable Energy Technology", *Energy Policy*, Vol. 34, No. 3, pp. 256-276.
Jordan, K. (2007), *Barierren Für Den Ausbau Erneubarer Energien*, online available: www.fu-berlin.de/presse/publikationen/fundiert/2007_01/07_01_jordan/index.html, checked on: 24.06.2013.
Kalogirou, S. (2003), "The Potential of Solar Industrial Process Heat Applications", *Applied Energy* Vol. 76, No. 4, pp. 337-361.
Karshenas, M.; Stoneman, P. (1993): "Rank, Stock, Order, and Epidemic Effects in the Diffusion of New Process Technologies: An Empirical Model", *the RAND Journal of Economics*, Vol. 24, No. 4, pp. 503-528.
Mez, L. (2005), "Renewable Energy Policy in Germany - Institutions and Measures Promoting a Sustainable Energy System", *Solar Cities for a Sustainable World*, Daegu, Korea 2005.
Pickett-Baker, J. (2011), "Domestic adoption of renewable technologies: Innovativeness, adoption behaviours and individual needs", *DIME-DRUID ACADEMY Winter Conference 2011*, Comwell Rebild Bakker, Aalborg, Denmark.
Profir, D. (2008), "Advancing Corporate Demand for Renewables: Why Are Companies Switching to Green Power", *Climate Action Programme*, online available: http://www.climateactionprogramme.org/news/advancing_corporate_demand_for_renewables_why_are_companies_switching_to_gr/, checked on: 24.06.2013.
Porter, M. E.; van der Linde, C. (1995), "Green and competitive", *Harvard Business Review*, Vol. 73, No. 5, pp.120-134.
Quaschning, V. (2011), *Regenerative Energiesysteme: Technologie – Berechnung – Simulation*, 7. aktualisierte Auflage, Hanser Verlag, München.

Rogge, K.; Reichardt, K. (2013), *Towards a more comprehensive policy mix conceptualization for environmental technological change: a literature synthesis*, Working Paper Sustainability and Innovation, No. S 3/2013, Fraunhofer ISI, Karlsruhe.

Schleich, J. (2009), "Barriers to Energy Efficiency: A Comparison Across the German Commercial and Services Sector", *Ecological Economics*, Vol. 68, No. 7, pp. 2150 – 2159.

Schröter, M.; Weißfloch, U.; Buschak, D. (2009), *Energieeffizienz in der Produktion - Wunsch oder Wirklichkeit? Energieeinsparpotenziale und Verbreitungsgrad energieeffizienter Techniken*, Modernisierung der Produktion, No. 51, Fraunhofer ISI, Karlsruhe.

Stoneman, P. (2002), *The Economics of Technological Diffusion*, Blackwell Publishers, Oxford.

van Dijken, K.;Prince, Y.; Wolters, T.; Frey, M.; Mussati, G.; Kalff, P.; Hansen, O.; Kerndrup, S.; Søndergård, B.; Lopes Rodrigues, E.; Meredith, S. (1999), *Adoption of Environmental Innovations. The Dynamics of Innovation as Interplay between Business Competence, Environmental Orientation and Network Involvement*, Kluwer Academic Publishers, Dordrecht.

Weißfloch, U.; Müller, S.; Jäger, A. (2013), *Wie grün ist Deutschlands Industrie wirklich? Verbreitung von Technologien zur Nutzung erneuerbarer Energieträger im Verarbeitenden Gewerbe.* Modernisierung der Produktion, No. 64, Fraunhofer ISI, Karlsruhe.

Wüstenhagen, R.; Markard, J.; Truffer, B. (2003), "Diffusion of Green Power Products in Switzerland", *Energy Policy*, Vol.31, No. 7, pp. 621–632.