

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

[Special session „Renewable Energy Technologies, Innovation, and Policy Mix – first results from the GRETCHEN project”]

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(1) Overview

The use of renewable energy becomes increasingly important not only for private households, but also for the manufacturing industry, due to rising energy costs and the growing awareness of the necessity to reduce emissions for climate protection. The German manufacturing industry is the second largest energy consumer, accounting for 28 percent of the final energy consumption within the German energy economy (AG Energiebilanzen 2011). Therefore it is of particular interest to analyze to what extent these companies use renewable energy technologies and which factors support the use of these technologies.

In general, the potential and functionality of renewable energy technologies (RET) for the generation of electricity and heat is widely examined and – as a consequence – well known. Different authors analyzed the application possibilities and the potential of the integration of RET in industrial production processes (e. g. Taibi, et. al., 2012, Kalogirou, 2002). However, there exists no thorough empirical analysis about the influencing factors of the adoption and the diffusion of RET in the German manufacturing industry. Until now, there is very little knowledge whether the drivers and barriers influencing the adoption of technological innovations (e. g. Rogers, 2003) by companies are applicable and transferable to the adoption of RET by firms of the manufacturing sector. Moreover, also political framework conditions such as funding measures or the internalization of external costs can influence positively the adoption of RET. Together with administrative barriers or a lack of rentability due to inappropriate funding it can be seen as a policy mix addressing the use of RET. Hence, the following research question is formulated: In what way does this resulting policy mix influence the adoption decision of companies for using RET?

This paper sheds light on the various determinants that influence the adoption of RET by companies of the German manufacturing sector. A broad literature review revealed a bundle of relevant factors: These factors can result from structural characteristics, such as company size, financial resources or the position in the supply chain. In the B2C area the strengthening of customer relationships can be of advantage by showing a green image (Profir, 2008). In addition, various authors refer to the lack of competitiveness of RET in comparison to conventional energy generation or the lack of access to capital and high discount rates (Jordan, 2007, Mautz, 2006). This access to capital is even more difficult for smaller enterprises (Stoneman 2002). Besides, the use of organizational concepts such as total costs of ownership concepts, energy management systems or environmental performance indicators can influence the adopter decision. Additionally, the further development of RET led to new applications that were not given previously, e. g. the direct use of biomass for process heat (Taibi et al., 2012). This correlates with the access to renewable resources, e. g. biogenic remnants and the quantity of insolation can be an influencing factor for the decision to implement RET as well. Moreover, in Europe one of the major drivers are political instruments, such as feed-in tariffs and emission allowances (del Río, 2010). Some authors also refer to the diversification of energy sources to hedge against fluctuating fossil fuel prices (Profir, 2008).

(2) Methods

To answer the research question and test the hypotheses, a broad empirical database, the German data of the *European Manufacturing Survey 2012*, is analyzed. This survey covers 1,594 German manufacturing sites and provides a representative database for the manufacturing sector of Germany including firms of the sectors 10 to 33 according to the "Nomenclature statistique des activités économiques dans la Communauté européenne" (NACE REV. 2) with more than 20 employees (Jäger/Maloca 2013).

By means of the German data of the *European Manufacturing Survey 2012* the diffusion of RET for electricity and heat generation within the German manufacturing sector can be examined as well as specific reasons for and against the adoption decision. The questionnaire covers also different determinants of the company such as size, location and usage of organizational concepts which might influence the adoption. In a multivariate analysis the influence of these characteristics on the application of RET is determined. Consecutive logit models have been calculated for each of the two energy sources: The base model only controls for structural characteristics and organizational concepts which could support the decision for RET. In the following three models, the influences of different specific reasons to use or not to use RET for the two energy sources are analyzed alternatively. The aim is to compare their relative input on the model of using RETs. First, the concept policy mix is tested using two indicators, one conceptualized as a positive influence of political framework conditions and one conceptualized as a negative one

measuring administrative barriers or the lack of profitability due to political framework conditions. Secondly, the influence of the reason 'independence of the company from energy price or energy suppliers' is tested. Thirdly, the impact of the construct 'environmental awareness' or 'creation of a green image of the company' is analyzed. In each of these models, the number of reasons indicated is controlled for.

(3) Results

The diffusion analysis revealed that more firms implemented RET for electricity generation (18 %) than for heat generation (8 %). According to the results of the multivariate analyses for the two energy forms the use of RET seems to depend on different factors.

For the generation of electricity, the basic model shows that the chance to adopt RET rises for those companies which are located in the five states in Germany with the highest insolation. There also seems to be a correlation between the height of financial resources and the adoption decision. This especially occurs under control of the policy mix concept and the aim of independence from energy suppliers. The results show, that – under control of the policy mix concept – the greater the financial resources are, the higher are the odds to adopt RET. The other two drivers – independence from energy supplier and environmental awareness – diminish the chance of adoption. These argumentations were rather used from companies which do not use RET yet. For all three consecutive models, the odds to adopt RET increased with the number of reasons named for the adoption and decreased with the mentioned number of reasons against adoption. The more reasons are perceived to adopt and the less barriers are seen, the higher are the odds to adopt RET for the generation of electricity.

Regarding the heat generation, the odds of adopting such a technology rose significantly for those sectors which have at least a medium volume of biogenic waste in their production. The consideration of the different drivers showed no significant impact. However – like the analyses of the electricity generation – the more reasons for the application were mentioned, the higher the probability for the use of these technologies and vice versa.

(4) Conclusions

Our results, based on a large empirical sample of the German manufacturing sector, provide a deeper understanding which determinants stimulate the adoption and diffusion of RET. It can be concluded, that the access to renewable resources has a major influence on the adoption of RET. The odds to apply RET increases, if the companies are situated in a region with higher solar radiation (regarding electricity generation) or dispose of biogenic waste (regarding heat generation). The policy mix concept only plays a decisive role for power generation. In this case, the positive aspects of the political and legal framework enhance the odds to adopt RETs. In contrast to that, perceived barriers regarding profitability or administrative efforts do not necessarily hinder the adoption of RET. Rather it seems that adopters are more aware of those aspects of the policy mix. This leads to the conclusion that problems which can arise within the adoption process are not necessarily barriers for implementing RET. Still, they could be improved to facilitate expansions of the installed base.

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