Firm type, feed-in tariff and wind energy investment in Germany: An investigation of decision making factors of energy producers regarding investing in wind energy capacity

Abstract: The development of renewable and sustainable energy is advanced by public financial support. Particularly so in the German *Energiewende*, which seeks to replace nuclear and fossil electricity generation with wind, sun, and biomass. We study the impact of the (changes in the) feed-in tariff policy on the investment in wind electricity generation capacity in Germany in the period 2000-2014. We estimate a generic investment model which includes this support mechanism, the cost of capital, investment risks like wind and price volatility, and manufacturing costs. We discuss specific features for different types of wind energy investors, such as the incumbents, small private investors, diversified companies, and independent power producers. We find that a change in the feed-in tariff has a negative impact on investment capacity regarding the generation of wind energy: a one monetary unit increase in the variation of the tariff is to be associated with a decrease by 0.17 MW wind capacity installed. We argue it is policy uncertainty that makes investors shy away from making real investments. We also argue that the drivers for wind energy investment can differ along different types of firms. For the traditional power producers, especially electricity price volatility, construction costs, and carbon prices seem to matter. But for the other investor types, the feed-in tariff is crucial indeed.

Keywords: firm type; investment; wind energy; Germany; feed-in tariff

Introduction

Massive public financial support is provided for energy production and consumption. With renewable energy, this mainly comes via production or producer subsidies. In this respect, the treatment of German wind energy installations has led to intense academic and political debate (von Hirschhausen, 2014). In this paper, we investigate how German firms account for public policy support via the feed-in tariff for wind energy next to other investment decision factors.

The main arguments for public financial support of wind energy projects are related to two types of market imperfections, which may both lead to underinvestment in wind projects: spillovers or incomplete appropriation and financial constraints (Nelson, 1959; Arrow, 1962). Firstly, due to the (marketable) public-good nature of wind energy production (Wolsink, 2007), the benefits of spillover to other households are only partially appropriated by innovators (see Groba and Breitschopf, 2013). Then, private returns from wind energy investment are probably smaller than their social returns. As a consequence, firms may invest less in wind energy than would be desirable from a social welfare perspective. Secondly, the entrepreneur typically has superior information about the nature and economic potential of the investment project compared to financiers and other stakeholders. This asymmetry may be amplified if firms do not disseminate the experience with their projects. As a consequence, the cost of external funds to finance wind energy may be higher than the cost of financing more conventional investments (Akerlof, 1970). Especially with relatively new technologies, this effect will be exacerbated as the financiers will be hesitant about financing innovate projects (Hall and Lerner, 2010).

From January 2000 until March 2014 German wind capacity rose from 4,500 megawatt to 34,300 megawatt (MW). In 2000, wind energy sources had an overall share of 1.6 per cent, which rose to 8.2 percent in 2012 (AGEE-Stat, 2013). In 2012, about half of all German renewable energy producing plants (46%) was owned by small-scale individual investors, including farmers and cooperatively owned wind parks. Medium sized enterprises, funds and banking institutions, and project developers, which specialize in the investment and operation of renewable energy plants, owned about one seventh each, while the four main electricity producers together owned a share of 5 per cent (Klaus Novy Institut, 2011). Germany’s main financial support policy for renewable energy is the feed-in tariff (FIT). This support instrument is based on the ‘Act on Granting Priority to Renewable Energy Sources’ (in German: *Gesetz für den Vorrang Erneuerbarer Energien*, hereafter EEG). The EEG guarantees the basic FIT payment for a duration of 20 years from the date of a plant’s installation. The feed-in tariffs differ between the technologies used in order to adjust for differences in the costs between production techniques. Furthermore, these tariffs are regionally differentiated to especially support wind power installations in regions with more favorable wind conditions. Grid operators have to connect newly installed wind energy projects to the grid and must feed in all produced electricity. Any plant specific installation costs are borne by the plant owner or operator, while grid operators are required to provide a sufficient capacity of the electricity grid. This raises the question of how important policy support of feed-in tariffs actually is for wind energy investors’ decision making. We will investigate this issue in our paper.

Several studies stress the importance of financial constraints as a barrier to renewable energy investment and innovation (Carreira and Silva, 2010; Hall and Lerner, 2010). Hoffman et al. (2014) argue that the competitive advantage from industrial ecology can accrue through drivers like cost savings, enhanced revenues, improved brand positioning, product differentiation, gains in market share, organizational know-how, ability to attract and retain talent, and gaining an advantageous position in an industry’s evolving structure (Hoffman et al., 2014, p596). This seems rather general but it reveals that access to finance or subsidies and tax advantages is not explicitly being recognized as a ‘value driver’ in the industrial ecology literature so far. In this respect, it is of interest to report that González et al. (2005) find that most subsidies go to firms that would have invested anyway. Furthermore, Aschhoff (2010) finds that firm’s size increases the probability of entering in the funding schemes. Huber et al. (2004) study EU support schemes and conclude that well-designed feed-in tariffs implemented among the EU-15 countries are the most efficient ones. Meyer (2007) observes that energy policies are likely to change, which is likely to induce regulatory uncertainty which in turn can impact both the size and timing of investments. Dinica (2006) and Mitchell et al. (2006) argue that financing costs play an important role in investment decisions. Furthermore, our study relates to the analysis of industrial ecology, specifically to studies trying to detect the factors that might drive the development of new industrial clusters and markets. In particular, we connect to the research of Andrews and DeVault (2009), Held et al. (2009), Moore and Wüstenhagen (2004), Lüthi and Wüstenhagen (2009), Price and Kendall (2012), Hoffman et al. (2014) and Dewulf et al. (2015), who suggest several factors might play a role, such as climate conditions, production costs, market movements related to conventional energies, intangible characteristics of the investor and his/her social environment, and the life cycle of wind energy installations.

Bode and Michaelowa (2003), Fleten, Maribu and Wangensteen (2007), Donovan and Nuñez (2012), Sadorsky (2012) and Peňa et al. (2014) specifically assess the investment costs for renewable energy projects. The estimations of costs and revenues suggest that profit maximizing investors mainly utilize the method of net present value and weighted average cost of capital (WACC) to assess alternative investment opportunities. Masini and Menichetti (2012) find that renewable energy investors prefer to commit to more mature technologies, as they are risk averse and evaluate opportunities over a relatively short time horizon. In addition, financiers perceive technology effectiveness, the political support level and its length as the most important factors, and they regard the level of political support still as inadequate, whereas the length and stability of such support is deemed important (Masini and Menichetti, 2012). This result is in line with that found by Moore and Wüstenhagen (2004), Held et al. (2009) and Lüthi and Wüstenhagen (2009) and specifies the setting of the industrial ecology regarding renewable energy generation.

We also connect with the research by Enzensberger et al. (2002), who investigate the characteristics of stakeholders in the renewable energy industry and particularly how policy schemes can influence the investors. Stakeholders that are affected by policy schemes either directly or indirectly include non-governmental organizations, policy makers on different levels, in particular bankers, plant suppliers, and project investors (Agterbosch et al., 2004; Bergek et al., 2013). For policies to be effective, a long term vision seems highly relevant (see also Masini and Menichetti, 2012). And innovation and investment are only sustained if firms have sufficient ‘planning security’. As wind energy is capital intensive and plants are commonly depreciated over a time frame of ten to twenty years, secured income in the form of guaranteed price premiums is a crucial condition for especially small and less experienced entrepreneurs.

Our paper fits in with these strands of literature on the role of financing constraints, investment drivers, energy policies, and investor type in relation to investments in wind energy capacity. The contribution of the study is that it specifically goes into the interaction between environmental policy and financial conditions and discusses the role of investor type. We investigate the sensitivity of wind energy investment for (changes in) policy support and we offer the perspective of differentiation along various investor types regarding the specific role of this support. We do so for Germany, whose feed-in tariff policy has been regarded as highly successful regarding the installation of wind capacity (von Hirschhausen, 2014). Our prospective contribution is to establish the role of the wind energy support mechanism in relation to other – more conventional – investment considerations in the case of different types of business.

We find that in general a change in the feed-in tariff has a negative impact on investment capacity in Germany: a one monetary unit increase in the variation of the tariff is to be associated with a decrease by 0.17 MW wind capacity installed. This suggests that policy uncertainty makes investors shy away from making real investments. We also argue that the drivers for wind energy investment can differ along different types of firms. For the traditional power producers, especially electricity price volatility, construction costs, and carbon prices seem to matter. But for the other investor types, the feed-in tariff is very important. These findings complement the industrial ecology analysis of Andrews and DeVault (2009) and Hoffman et al. (2014) as we show that different types of wind energy investors are driven by different factors, that alternative business models may outcompete the incumbents, and that finance does play a significant role too.

Method and data

To find an answer to the question of how important feed-in tariffs are for investment decisions in wind energy capacity, we rely on a conventional general investment model. The model includes the usual suspects from the corporate finance literature (investment risk, cost of capital; see Tirole, 2006), specifics about wind energy (Fleten et al., 2007; Sadorsky, 2012), as well as the policy support mechanism (in this case the FIT under the EEG; see also Dinica, 2006; Mitchell et al. 2006):

$$C_i = \beta_1 + \beta_2 F_i + \beta_3 R_i + \beta_4 \sigma_{Wi} + \beta_5 \sigma_{Pi} + \beta_6 S_i + (\beta_7 + \cdots + \beta_{19})\theta_i + \varepsilon_i \tag{1}$$

where C_i measures the newly installed capacity in month i, measured in megawatt. The main independent variables are the average feed-in tariff F_i to be paid over the guaranteed compensation period of 20 years granted through the EEG and the weighted average cost of capital R_i, which simulates the cost of external capital for energy investors. The investment risks are divided into production and market risks (Tirole, 2006), which entails the volatility of the wind σ_{Wi}, estimated by the change in the average wind-index for Germany W_i (Mulder and Scholtens, 2013), and the volatility of the market price for electricity σ_{Pi}, as traded on the European Energy Exchange (see Fleten et al., 2007) respectively. The manufacturing costs are proxied by the monthly average iron and steel price index S_i (see for example Tirole, 2006). The random error term ε_i includes all additional factors that might cause the amount of installed capacity to change, e.g. personality traits of investors, availability of land resources or amounts of installed wind energy plants in the near surroundings (Andrews and DeVault, 2009; Price and Kendall, 2012; Dewulf et al., 2015).

We hypothesize that the FIT will have a positive impact on the installed capacity, as a higher guaranteed price will yield the investment more productive. We expect that production risk, i.e. wind index volatility, is negatively related to installed capacity. More uncertainty about production may reduce the investors' appetite to invest in wind capacity. Cost factors, i.e. the weighted average cost of capital and the index for iron and steel prices, are expected to be negative as well, as their increase will reduce the revenues for investment projects as they impact on a project's capital expenditures as well as on its operational expenditures. Due to the guaranteed prices through the FIT scheme, market risks in the form of electricity price volatility is expected to have a positive impact. This is because increased price risk may drive investors towards projects where prices are guaranteed and because higher price volatility especially benefits those who produce at the lowest marginal costs. The coefficients for the monthly dummy variables are expected to have an increasingly positive magnitude, the more the year progresses. This captures the preference of investors to implement projects later in the year, before the yearly degression reduces the FIT.

Detailed data on renewable energy technologies and their current development status is scarce. There is no publicly available database and we had to collect data from different sources for the analysis (Appendix A). Data for the variables could be obtained for a time frame between June 2000 and December 2013. For investments in wind energy, newly installed capacity of wind turbines per month was chosen as the dependent variable. Capacity is measured in megawatt (MW) and on a monthly basis for the country (see Hitaj et al. (2013) for geographical allocation analysis of wind energy capacity). Towards the second half of the year, newly installed capacity substantially increases. This may be explained by the degression aspect of the regulation, which reduces the tariff by the first of January of each year. As a result, investors will usually be eager to install their plants before the end of the year. Due to repowering activities (replacing two or three small mills with a newer wind mill with larger capacity) the monthly installed amounts cannot be summed up to arrive at the overall wind capacity.

The average feed-in tariff is paid over the guaranteed compensation period of 20 years. The average FIT identifies the percentage of yearly degression of the basic compensation. The initial compensation is granted for only the first five years and afterwards it is extended on the basis of the relative performance of the windmill. On the basis of data from BMWi (2014), the higher initial amount is paid for 11.67 years if the wind mill performs around 120 per cent of its reference performance, which is the performance of an average location. The average feed-in tariff was calculated as follows:

$$F_i = \frac{11.67 * (F_{in} + S) + (20 - 11.67) * F_{ba}}{20}$$

F_i	average feed-in tariff
F_{in}	initial compensation
S	system service bonus
F_{ba}	basic compensation

In order to estimate the cost of capital for wind energy projects, a weighted average cost of capital (WACC) needs to be computed. The WACC includes both cost of debt and equity according to their weights in the financing of a project, while accounting for the tax shield. European commercial wind energy projects are usually financed with a debt-to-equity ratio of 80/20 (Deloitte, 2013). Chaves-Schwinteck (2010) finds that raising the share of debt financing increases the rate of return of a project, which justifies the low share of equity for wind energy products. To estimate the cost of equity for the whole wind energy industry, we use the capital asset pricing model (CAPM). This model describes that the return of an investment equals the risk free rate, which in our case is estimated by ten year government bonds, plus an industry beta multiplied by the market premium, which compensates investors for systemic risk. We follow Cleijne and Ruijgrok (2004) who suggest an industry beta of 0.69, based on independent wind energy developing firms. Estimates for market risk premiums were taken from Deloitte (2013), who suggest an average risk premium of 5.5% for the German market. The cost of debt financing is represented by the data for a medium-term yield corporate bond index. These corporate bonds observe a similar risk distribution as with energy projects. Here, the data is taken from Bundesbank publications of the daily yields of corporate bonds, from which a monthly average was generated. Lastly, the corporate tax rate is included in the cost of capital calculation, reducing the cost of debt, as interest is tax deductible. Thus, the cost of capital for the regression model is calculated according to:

$$WACC_i = 0.2 * (G_i + 0.69 * 5.5\%) + (1 - t_j) * 0.8 * R_i$$

G_i	percentage yield of 10 year government bond in month *i*
R_i	percentage yield of Bundesbank corporate bond index in month *i*
t_j	corporate tax rate in year *j*

We want to stress that the results of the analysis of the project viability may be sensitive to the discount rate in the net present value and return on investment estimates and, hence, on the WACC calculation. Peňa et al. (2014) point out that discount rates are critical in investment decisions and, as such, the method to create the WACC is critical. They do show so in their analysis of the profitability of wind parks in Portugal (Peňa et al., 2014).

Wind-index data is a measure of wind speed in a certain location or area. The average of wind speeds from 1996 until 2009 is set at 100. All monthly data is given as a percentage of the deviation from this reference value to capture production risk. The speeds are measured and submitted by plant operators each month and aggregated for a specific index per region by the consultancy firm Enveco GmbH. In order to retrieve the volatility of wind for the analysis, the monthly change of the aforementioned percentage of deviation was calculated and used in the regression model.

Despite the guaranteed fixed payment to wind energy owners via the FIT, market prices also may influence the investment decision as it relates to the opportunity costs of energy producers. Furthermore, the share of owners that sell the generated electricity directly to the electricity market has increased in recent years and policies have attempted to strengthen this development further (Hitaj et al., 2013). The direct sale on the electricity market makes wind electricity more competitive. We use the German price for electricity on the European Energy Exchange as an estimate for such market volatility. Daily data of the PHELIX Base rate is readily available and was transformed into a monthly variable by calculating the monthly standard deviation. Similar to the data of newly installed capacity, the electricity prices are subject to seasonal fluctuations. Another cost factor is the initial construction costs for the wind plants. About 50 per cent of these costs are for raw materials, which are heavily influenced by the steel and copper prices (Kitzing and Weber, 2014). Therefore, the monthly average of the Dow Jones Iron and Steel price index for Germany was chosen as our proxy for manufacturing costs.

We provide descriptive statistics in Table 1 and Table 2. Table 1 displays the summary statistics of our variables. In Appendix B-D, we graph the costs of capital, FIT, wind volatility, and electricity price volatility. To investigate whether our data suit the estimation method, we had to perform various tests. We first tested the data for stationarity before we conduct the regression analysis. We use the combination of variables that are integrated of order zero (capacity, wind volatility, electricity price volatility) and of order one (FIT, cost of capital, steel price) in the regression model, which as a whole is stationary. For the estimations, the raw data are normalized to allow for comparison and to avoid that dimensioning would impact on the results. Table 2 shows the correlation coefficients of the main variables. It turns out that these are very low.

[Insert Table 1 and 2 about here]

Data limitations include mainly the lack of a unified source for the average feed-in tariff. Additionally, test statistics might be influenced by the seasonal patterns of some variables and the break in the series for the FIT, when it was raised by more than one cent/kWh through the implementation of the EEG 2009. The investment model described above was estimated by means of a straightforward multiple regression model and takes the following form after the stationarity amendments:

$$C_i = \beta_1 + \beta_2 \Delta F_i + \beta_3 \Delta R_i + \beta_4 \sigma_{Wi} + \beta_5 \sigma_{Pi} + \beta_6 \Delta S_i + (\beta_7 + \cdots + \beta_{19}) \theta_i + \varepsilon_i \qquad (2)$$

Thus, compared to equation (1), it shows we cannot include the level of FIT, cost of capital, and steel prices in the regression model because of the nonstationarity problem. Hence, we have to provide additional hypotheses regarding the changes in these variables. In this respect, we hypothesize that the coefficient for the changes in the FIT is negative as it affects the ‘rules of the game’ and as such negatively impacts investor confidence and, hence, could have a negative impact on wind capacity investments (Enzensberger, 2002; Madlener et al., 2005; Dinica, 2006; Fleten et al., 2007; Carreira and Silva, 2010; Hall and Lerner, 2010). The same reasoning holds for changes in the cost of capital and in those of steel, which are used as a proxy for manufacturing costs.

Results

The aim of this study is to investigate the impact of the feed-in tariff policy on investment decisions in wind energy projects in Germany alongside other determinants of wind energy capacity. We estimated the model for all investors at once as well as for the ‘Big

Four’. Due to lack of data, we could not do so for the other investor types. Table 3 shows the overall result for the estimation and also depicts the results for the incumbents. In all significance tests, we allow for the 95% level of significance. After a discussion of the results, we will also go into the potential role of the FIT policy for wind energy investments for the other types of investors, namely the small private investors, diversified companies, and independent power producers. Please note that the discussion regarding the latter can be of a qualitative nature only due to lack of detailed information.

[Insert Table 3 about here]

Table 3 reveals that the volatility of the electricity prices is not statistically significant. Wind volatility which also happens to be statistically non-significant in the estimation of the model. However, the changes in the FIT do show to have an impact that is both material from an economic point of view and which are statistically significant. It appears that these changes do have a negative impact on installed capacity. More specifically, we find that a change in the feed-in tariff has a negative impact on investment capacity: a one monetary unit increase in the variation of the tariff is to be associated with a decrease by 0.17 MW wind capacity installed. This is in line with findings elsewhere in the empirical literature that suggest that investors shy away from changes in policies, even if they are beneficial (Meyer, 2007; Campiglio, 2014). Cost of capital is not statistically significant. Changes in construction costs, as depicted by steel prices, do only have a marginally statistically significant and negative impact. Hence, we conclude that we can confirm our hypotheses regarding the impact of changes in policy support and manufacturing costs. We do not find support for the hypotheses regarding investment risk and costs of capital though. Next, we turn to focus on how the model performs for one particular group of investors, namely the ‘Big Four’.

Big Four

The ‘Big Four’ consists of the four main electricity distributors in Germany, namely RWE, E.ON, EnBW and Vattenfall (see Kungl, 2014). Together they provide around 42 per cent of German households with electricity. In the renewable electricity market they play a minor role, with only around five per cent ownership of all production plants. Of 30,000MW installed capacity in Germany, the ‘Big Four’ own 1,290MW of onshore wind energy. Being the only group that is able to utilize sufficient capital internally, the main decision for utility-scale firms is whether to retain commitment to fossil fuels or to change towards more renewable energy production (Backer, 2009). Due to data limitations, we had to make some amendments and additional assumptions in order to arrive at estimation results for the 'Big Four' with respect to model (2). Most important is the inclusion of CO_2 emission trading to which these companies are subject. We hypothesize that higher carbon prices will make wind energy investment relatively more appealing to the conventional power companies. As CO_2 emission trading data and interest rates were only available for a limited timeframe, the model is estimated for the period between June 2010 and June 2012. Furthermore, for practical purposes, we assume that the incumbents owned five percent of overall wind capacity throughout. Therefore, the four firms' share of the newly installed capacity was calculated by using the data mentioned before, retrieved from Fraunhofer IWES, and multiplying the values with a factor of 0.05. The assumption made is that the utility-scale firms have the same timely planning preferences as other investor groups, which showed strong seasonal fluctuation. Weighted average cost of capital is calculated using different proxy values for the industry beta and the cost of debt financing. As an estimate for utility-scale firms' cost of debt capital, we used an interest rate for corporations, published by the Bundesbank. Whereas smaller companies do not have the resources and expertise to engage in carbon trading, this can be a source of competitive advantage for the utility firms (Söderholm and Klaassen, 2007; Söderholm et al. 2007). Hence, this variable is included for the 'Big Four' in the estimation of the investment model. As with the basic analysis, we need to account for stationarity with the result that we had to include changes in carbon prices instead of the levels. We do hypothesize that uncertainty regarding these prices, as reflected in changes, will induce the incumbents to increase their investments in wind energy capacity for the similar reasons as discussed above: It will make them wary to invest in their traditional business and they may find it worthwhile to 'hedge' by building up wind capacity.

The results are provided in Table 3, under 'Big Four'. Firstly, the model is overall statistically significant and 72 per cent of all variations in the data can be explained by the model. It shows that electricity price volatility is just marginally statistically significant (95% significance level) for the conventional electricity producers, as are the changes in steel prices. Very interesting is that the carbon price changes also are statistically significant. A change of carbon prices by one Euro will increase wind capacity installed by the 'Big Four' by 0.4 MW Furthermore, changes in steel prices turn out to be (marginally) significant. The three other factors are not statistically significant. The seasonal effects were captured by dummies and happen to show a statistically significant impact of the first and last quarter (not reported in the table).

Small private investors

Small private investors include private individuals and agricultural entrepreneurs who use their own land for the construction of wind energy plants. Small scale investors with limited individual financial capability have become the main drivers of the German energy transition. According to the Agency for Renewable Energy, 47 per cent of all installed renewable electricity capacity in 2012 was in the hands of private investors (35%) or farmers (11%). For wind energy, the ownership and actual electricity production may even be higher, at around 50 per cent. In 2012, individual farmers invested €18.2 billion into renewable electricity plants, six per cent of this amount into wind energy plants (Agency for Renewable Energy, 2012). Electricity production is a source of supplementary income and investment decisions might be restrained by the choice between expanding core business activities and the engagement in wind energy production. Due to limited availability of equity and their dependence on external financing, they probably are more risk averse than other investor groups. According to Bode and Michaelowa (2003), individual investors attribute a considerable importance to the internal rate of return in their comparison of project alternatives. Individuals will choose the project with the highest internal rate of return. Other evaluation criteria include cost of risk and financing (Kahn, 1996) and expected revenues (Muñoz et al., 2009). Risk aversion and a desire for long term planning security indicate the need for long term policy and price guarantees. Additionally, other concerns such as those of farmers in particular, include in the long term management of natural resources and preservation of traditional family values which gives individual investors a far less profit driven motivation, but rather a more idealistic reason to support renewable energies (Bergek et al. 2013; Williams and Schaefer, 2013).

Diversified Companies

The core business of these non-specialized commercial players is outside the production of electricity. Often, medium or large scale firms which possess own resources of land and seek means to improve energy efficiency or reduce costs decide to enter the RE industry. Large agricultural cooperatives may be included in this group due to the substantial scale of their investment. Just like individual investors, diversifying companies face capital resource constraints and need to rely on external financing sources. In Germany, these strategic investors have significant ownership of renewable electricity plants. Companies that expand into the business of renewable electricity production are limited by the choice between investing in production factors that might increase profitability of core business activities and the commitment to renewable electricity. Renewable electricity has certain advantages such as a guaranteed stream of income and the potential to use it for own production processes. Big electricity consuming companies, such as in the manufacturing industries, pay a lower electricity price in Germany. Investing in (own) renewable energy plants therefore might prove beneficial for medium-sized companies which are not eligible regarding these subsidies. However, due to the lack of experience in the energy market, these companies could also face inefficiencies that give rise to additional costs. Enzensberger et al. (2002) finds that diversified companies are as risk averse as private investors because they face similar information, experience and finance related constraints. One important difference however, lies in the amount of intrinsic motivation of the companies. This is assumed to be lower than that of individual investors, and could even result from external pressures, similar to the case of the ‘Big Four’. Some companies might incorporate the idea of sustainability in their business values and firm strategies; others however, simply see a revenue and profit raising opportunity or even as a marketing ploy. True investment objectives will be very difficult to observe. As investment drivers are usually related to profit maximization considerations, Bergek et al. (2013) identify operational costs and political risks as the main investment decision factors.

Independent Power Producers

Independent power producers are smaller project developing firms that focus their core business activities on renewable energy investment. Their development started in the 1990s and varies from small project developers with only a dozen employees to larger firms with around 100 employees. The specific knowledge about the renewable energy business gives them a certain competitive advantage, which makes them a group of enormous importance for the German renewable energy development. With about 14 per cent ownership of all renewable energy plants they possess a large amount of economic power in the green energy industry. As electricity production is their only source of income and large amount of capital and employees depend on the profitability of realized projects, planning security is of huge importance. Enzensberger et al. (2002) acknowledge a high risk that is due to the lack of a security net in form of revenues from other operations; however, he also mentions the advantages of being more specialized. Project developers can mitigate risks due to their higher efficiency and better knowledge of the industry more effectively than other investor groups and are therefore able to invest more profitable. In order to be considered attractive, a project usually is required to observe sufficiently high returns as these independent power producers face fixed costs that cannot be covered by profits from other operations, as is the case for investors that diversify their assets by investing in wind energy. They therefore conclude that intrinsic motivation of independent power producers is high, as they must constantly enlarge and diversify their portfolio. Furthermore, most of these firms were founded due to idealistic reasons and because entrepreneurs support the renewable energy development. Donovan and Nuñez (2012) identify the return on investment as a main decision variable for renewable energy firms. Additionally, market conditions such as grid capacity and demand projections are of crucial importance and can therefore influence the timing of the investment decision (Madlener et al. 2005). As project developers face constraints in terms of available resources, both capital and land, investments might be made only to secure resources from competing investors. The key decision making factor is the specialized experience this investor group brings into the market. Although their energy market experience might be limited, most entrepreneurs most likely possess a long history of business management in general.

Comparison

Table 4 summarizes the investment decision, resource constraints and motivational aspects of the four investor groups. Independent power producers have to account for external factors more than others, as they have to work with entirely external resources and have no additional business activities to dampen profit losses. Diversified companies and individual investors actually face similar constraints and characteristics, as they must both decide between producing their own electricity (and investing in capacity) and purchasing it on the market. While they have to source capital externally, this group often possesses their own land resources where plants can be installed. The main difference ultimately lies in the motivation for undertaking the investment, which is assumed to be higher for small scale investors and farmers in particular. However, due to the financing costs these investors face, policy support is more important for them than for diversified companies. Lastly, as already discussed above, the ‘Big Four’ decide whether to invest in renewable energy capacity or in conventional power plants. They are the group which is most affluent and can often source capital internally. Furthermore, they are highly influential in politics. Nevertheless, they must also compete for the most profitable locations and cost efficiency is a crucial issue, and their intrinsic idealistic motivation seems low to begin with.

[Insert Table 4 about here]

Conclusion

We investigate the drivers of wind energy investment for different types of firms in Germany. We find that financial support still plays an important role in the decision to invest in wind energy projects, although not for the incumbent power companies. Despite wind energy's mature technology and increasing ability to compete with conventionally produced electricity, the German feed-in tariff provides stability regarding the cash flows that is especially important for small-scale investors.

Treating all wind energy investors as a homogenous group yields the result that the changes in the FIT and construction costs turn out to be statistically significant. Running the model for the 'Big Four' power producers shows that changes in electricity price volatility, construction costs, and carbon prices do so. The Big Four's investments in wind capacity are not statistically significantly affected by changes in feed-in tariffs. It seems somewhat surprising that the weighted average cost of capital has not a significant impact on newly installed capacity. We assume this might reflect the role of public support and investors' intrinsic motivation. We analysed three other investor groups (small private investors, diversified companies, independent producers) on the basis of the literature and we made a qualitative comparison regarding the impact of (changes in) feed-in tariffs. We argue that regulatory changes especially impact independent power producers, as this group's existence depends on the success of the renewable energy projects they execute. Small-scale investors are expected to be affected less, as they have sufficient intrinsic motivation to execute projects also under a lower compensation by the state.

We need to point out some limitations of our approach. Several variables need further specification in order to arrive at a satisfactory conclusion regarding the exact determinants for the different types of firm and the implications for policy makers and practitioners. Further, the analysis cannot be used to arrive at making predictions as we could not include expectations in the model. A drawback is the lack of a consistent database that offers information about financial variables, ownership structure and capacities of wind energy projects. This will require the construction of consistent databases regarding the development of different types of renewable energy with various firm types. Future research on the topic might combine quantitative and qualitative findings of different investors' decision-making processes and therefore contribute to the improvement of an efficient policy support scheme.

Our study complements the existing literature. More specifically, we show how the German FIT policy actually impacts wind energy capacity and this contributes to previous studies such as Huber et al. (2004), Meyer (2007), Hitaj et al. (2013). We specify the role of finance in relation to wind energy policy and this illustrates the case for wind energy, which complements the studies of Carreira and Silva (2010), Hall and Lerner (2010), Peňa et al. (2014). We also find that there is a role for finance and costs in the shaping of industrial ecology and as such we complement the views by Hoffman et al. (2014). We triangulate the FIT policy, finance and wind energy investment and as such link up with the work of Dinica (2006) and Mitchell et al. (2006). Lastly, we provide empirical illustration of the different role of investment drivers in the industrial ecology (Andrews and DeVault, 2009) by accounting for the type of organization (Bergek et al., 2013).

As a policy implication, we infer that policy makers should continue to focus on reducing risks for all investor types, especially by being transparent and consistent. The research has shown that the actual amount of the tariff does not have as much of an impact as might have been expected. Additionally, policies should focus on improving market conditions for renewable sources for electricity production and establishing a liberal electricity market where market entry is free and where different technologies are able to compete fairly, i.e. at a level playing field.

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Appendices

Appendix A - Data sources

Newly installed capacity:
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Volatility of electricity price:
PHELIX Base 0-24h on European Energy Exchange 2000-2014. retrieved via Datastream [Accessed on 30th April 2014]

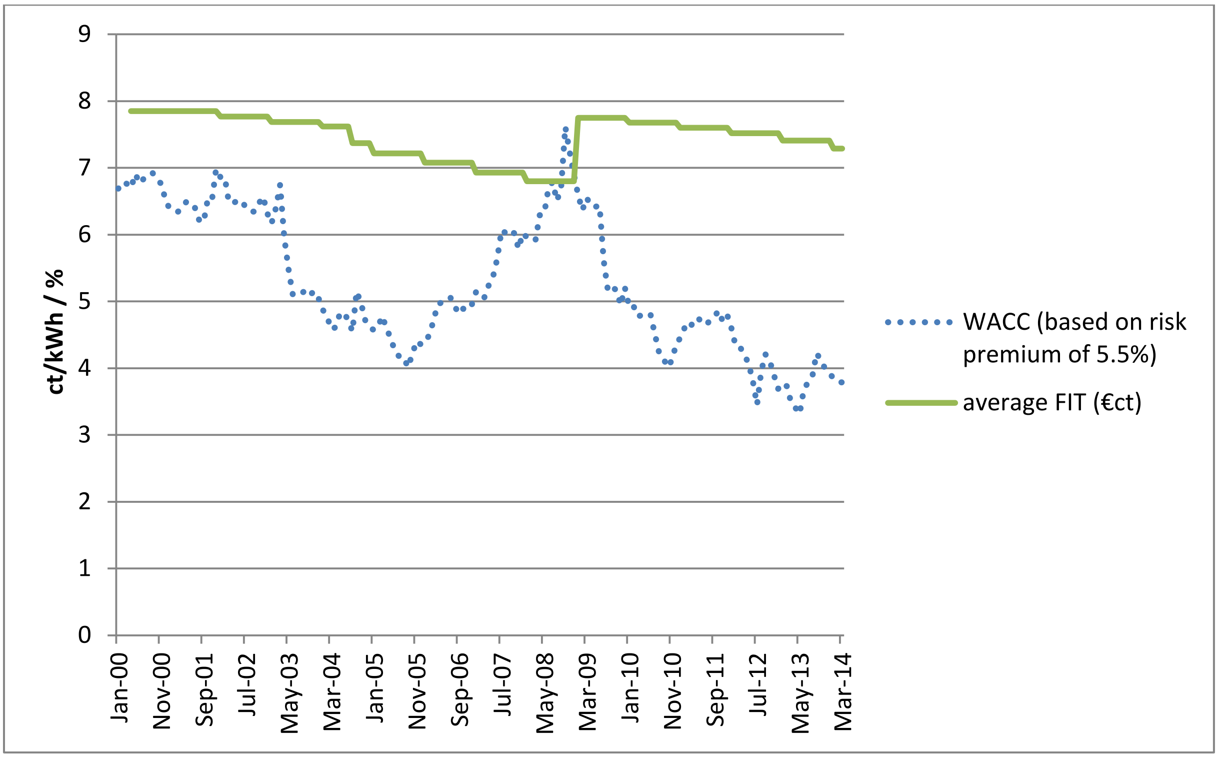
Iron and steel price index:
Dow Jones Iron & Steel Index 2000-2014. Retrieved via Datastream [Accessed on 20th May 2014]

DAX Utilities Index:
DAX Utilities (XETRA) – Price Index retrieved via Datastream [Accessed on 30th April 2014]

CO_2 Emission Prices:
EEX-EU CO2 Emissions on European Energy Exchange 2010-2012. retrieved via Datastream [Accessed on 30th April 2014]

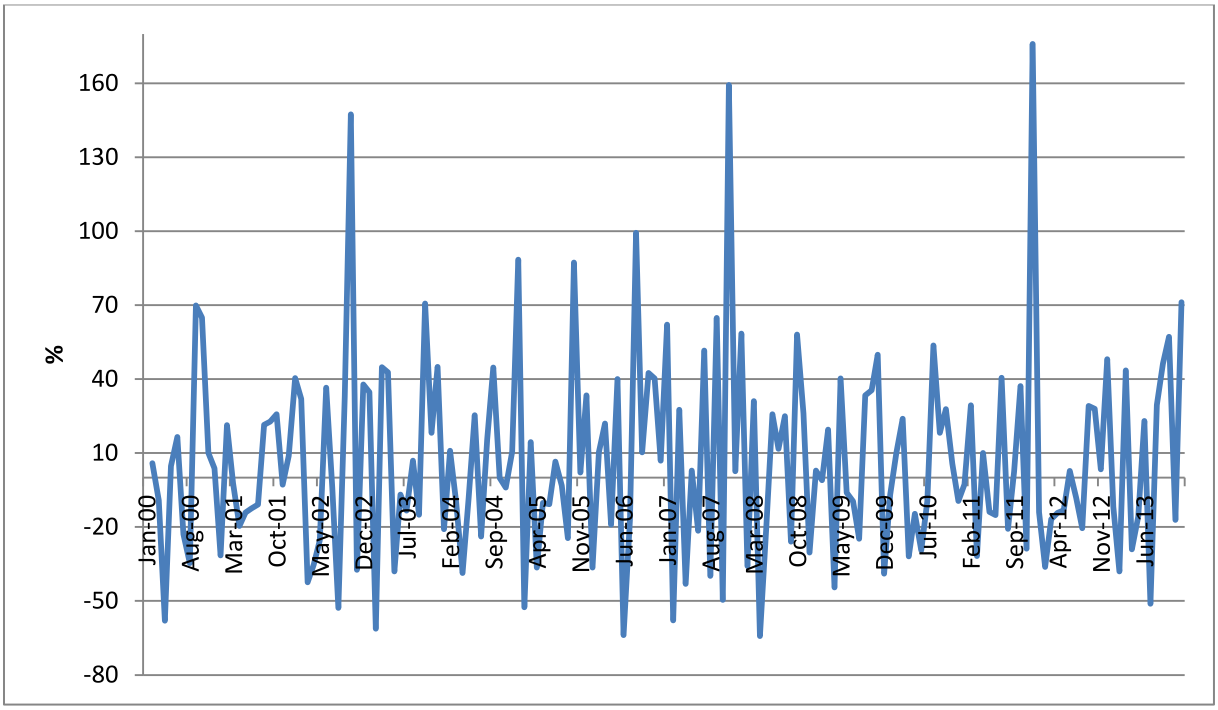
Appendix B

Development of Feed-In Tariff (in ct/kWh) and weighted average costs of capital (in percentage) in the period January 2000 – December 2013



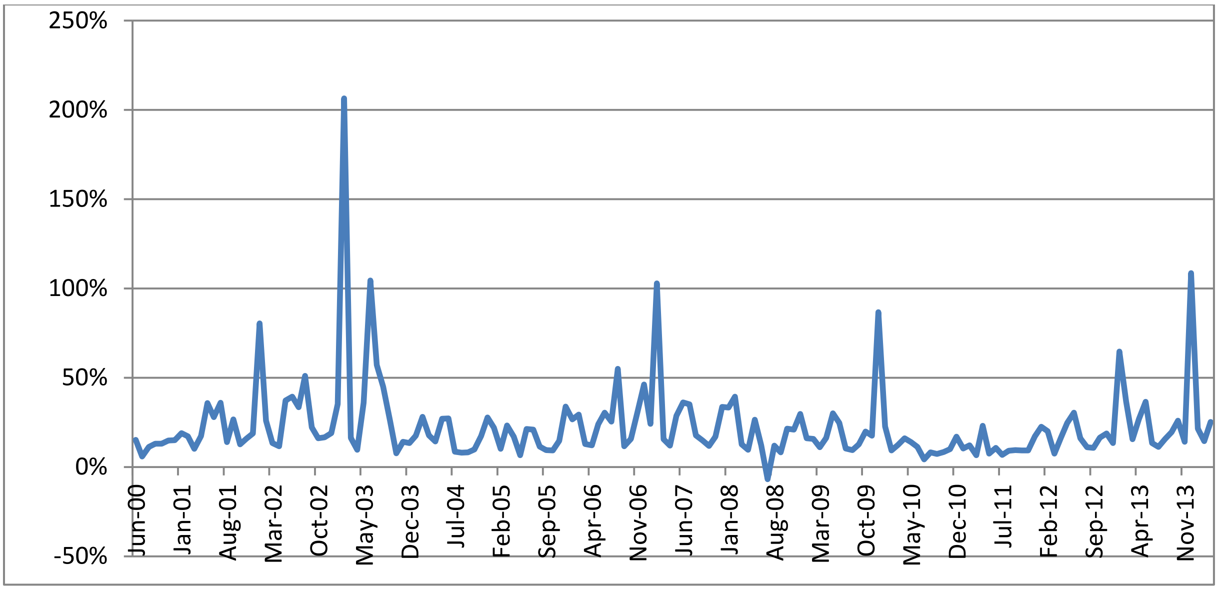
Appendix C

Wind volatility (in percentage)



Appendix D

Electricity price volatility (in percentage)



Variable		Obs.	Mean	Std. Dev.	Min	Max	Dickey-F. Test Prob.
New capacity C_i	MW	163	180.10	99.561	46.35	559.49	0.00
Average FIT F_i	ct/kWh	163	7.4647	0.3316	6.80	7.85	0.38
ΔAverage FIT ΔF_i	ct/kWh	162	-0.0027	0.0824	-0.25	0.95	0.00
Capital Cost	%	163	3.9202	0.6652	2.64	5.82	0.63
ΔCapital Cost ΔR_i	%	162	-0.0068	0.1588	-0.59	0.63	0.00
Wind-Index volatility σ_{Wi}	%	163	0.0735	0.3971	-0.64	1.76	0.00
PHELIX volatility σ_{Pi}	%	163	0.2279	0.2260	-0.07	2.06	0.00
Steel Price Index	€	163	236.95	127.89	81.86	683.19	0.57
ΔSteel Price Index ΔS_i	€	162	-0.2298	29.724	-150.88	86.89	0.00

Table 1: Summary statistics and stationarity test outcomes

	C_i newly installed capacity in month *i*	ΔF_i change in the average feed-in tariff	ΔR_i change in the weighted average cost of capital	σ_{Wi} volatility in wind production	σ_{Pi} electricity price volatility	ΔS change in the steel price index
C_i	1					
ΔF_i	0.0582	1				
ΔR_i	0.0156	-0.0901	1			
σ_{Wi}	0.1618	-0.0464	0.0540	1		
σ_{Pi}	0.1030	-0.0449	0.0414	-0.1133	1	
ΔS_i	0.0915	-0.0166	-0.0223	-0.0739	0.0459	1

Table 2: Correlation matrix

	Overall sample		**' Big Four'**	
	Coefficient	Probability value	Coefficient	Probability value
Change in FIT	-0.17	0.035**	0.219	0.253
Change in cost of capital	-0.07	0.754	0.002	0.299
Wind volatility	-0.85	0.525	0.112	0.273
Electricity price volatility	8.31	0.128	2.438	0.090*
Change in steel price index	-.07	0.063*	-0.163	0.096*
Change in carbon prices	-	-	0.397	0.002***
Constant	2.04	0.000***	7.60	0.001***
R2		0.58		0.73
F-value		9.13		4.38
Prob. (F)		0.000***		0.007***
Obs.		161		24

Table 3: Estimated relationship between wind energy capacity in Germany and potential determinants.

Investor Group	Investment Decision	Resources		Intrinsic Motivation
		Financial	Land	
Independent power producers	Competition for most profitable locations	external	external	High, Environmentalism & profit maximization
Small private investors / farmers	Buy or Make & investing in production factors	external	internal	Very high, Intrinsic motivation for environmentalism
Diversified companies	Buy or Make & investing in production factors	external	Internal/ external	Medium, Energy efficiency, cost reduction
Power companies (The ‘Big Four’)	Between conventional and renewable plant	internal	external	Low, Shareholder interest, regulations

Table 4: Firm type and renewable energy investment decision making