

AN AGENT-BASED APPROACH TO ANALYZING RENEWABLE ENERGY ALLOCATION: THE GERMAN SUCCESS STORY

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Abstract

This article argues that insights from agent-based analysis can be key to successful implementation of renewable energy programs. Following the general introduction, a formal framework and the key elements for an agent-based analysis are put forward along with a heuristic description of the energy landscape. The methodology for the case study is presented followed by details of the conceptual agent-based structure. The framework is applied to renewable energy policies in Germany from 1991-2007.

Key Words: renewable, energy, taxation, agent-based, Germany

1. Introduction

Coincident with on-going debate concerning sustainable development, international interest in diversifying from conventional energy sources continues to be a popular topic amongst politicians and economists. With some exceptions, attempts to implement renewable energy programs have fallen short of expectations. Germany is one country moving rapidly towards grid parity for wind power and working on this objective for other forms of renewable energy as well. For this reason, Germany and the German approach is presented as a case study. Apart from one another, agent-based analyses and renewable energy are familiar topics. This article brings together and relates the two subjects. In energy studies, agent-based analyses explain interactions within a dynamic system that are not necessarily accounted for in the traditional linear analysis seen in neoclassical economics. Observing a dynamic system such as the energy industry in using the concepts of agent-based analysis and analyzing case studies reveals phenomena often ignored in traditional theories such as increasing returns, path dependence, and technology lock-in. By evaluating complex, nonlinear economic effects, new insight may be added to the body of knowledge as to why renewable energy diffusion has been relatively slow compared to its potential. Broader analytic perspectives are needed in order to achieve more positive developments in the analytic and policy arenas. This paper contributes to the literature by presenting a conceptual application of an agent-based structure to energy policy analysis. It focuses directly on understanding successful policy development and implementation beyond the framework of conventional neo-classical microeconomics and the paper develops a formal case study for German energy policy and analysis. The organization of this article is as follows. Section 2 discusses the theoretical foundations of an agent-based approach for understanding developments in the energy policy arena. Section 3 describes the methodology and applies the framework to the German case study. The focus is on application of agent-based analysis to describe the impact of renewable energy policies in Germany from 1991-2007.

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2. An Agent-Based Approach

Following Axelrod (1997), the agent-based approach adopted in this paper refers to the simulation of agents and their interaction.¹ This approach is used to understand properties of complex social systems in which agents interact through simulation, sometimes resulting unpredictable outcomes. While this paper does not present a formal simulation it is thought that the fundamental approach and structure of agent-based models is useful for building a conceptual understanding of the topic at hand, i.e., development of renewable energy programs and energy diffusion.

A Heuristic Network: For heuristic purposes, the economic structure is envisioned in terms an energy landscape consisting of three agents: (1) consumers of electricity (2) providers of electricity and (3) government. This structure complex and is continually trying to adapt to the stresses and strains that are put on it by the three agents and their different strategies. At different points in time, different agents put more or less influence on the structure, causing it to adapt in different ways.

The basic model is described in terms of the following elements.

Agents: An energy structure consists of a variety of interacting players. This paper will focus on the three dominant agents. These agents are consumers of energy, producers of energy and the government.

Strategies: Under conventional assumptions consumer strategy is to maximize self-interest by making consumption choices subject to a budget constraint. This paper places the restrictive assumption of “passivity” on the consumer as discussed below. Alternatively stated, consumers are assumed to be environmental parameters. On the firm side, the objective is to maximize profit or minimize cost, that is, to maximize total revenue over total cost subject to resource/production or other constraints (such as regulatory constraints) that exist. The most obvious implication of this structure is that any optimum attained will not be a true Paretian optimum. Rather, the optimum will belong to the class of second best.²

Artifacts:As indicated above, consumers are constrained to behave as passive agents. We consider that passivity does not preclude or eliminate the possibility than consumers are behaving “as if” to satisfice. It is recognized that this is a limitation of the model framework; the theoretical consequences with respect to an anticipated equilibrium will be second best. In this research, the assumption has been made simply to avoid complexity in addressing the inclusion of a consumer-sector reaction function of sorts. Issues relative to constrained behaviour can be addressed ably using a more formal, quantitative framework. Demand-side issues will be considered in future work.

Measures of Success: Under the passivity assumption, consumer utility maximization, or at least satisficing, is assumed to be achieved in as much as consumers receive reliable service from the electric utility combined with reasonable (subject to budget constraints) electricity bills. This rather abstract notion is often reflected in consumption/switching behaviour or satisfaction polls assessing provider service.

Populations and Types: The consumer population and types of consumers in the population are assumed to be homogeneous.

Interaction and Variation: In terms of interaction and variation, consumer behaviour is held constant. Therefore, the two agents left to proactively interact with one another are firms and government. With one government agent and an oligopoly structure over utilities, communication takes place overtly or covertly via the market or regulatory processes. This type of behaviour will be termed as collusive/adaptive interaction and

variation. As a consequence of adaptation, strategic behaviour or strategies will change over time. The feedback loop between agents connected by interactive behaviour and evolving strategies is referred to as variation.

Selection: The dynamics in determining selection, or the extent to which agents or agent actions become more or less prevalent, result from the interplay between firms and government. Firms are assumed to take strategic and tactical actions in order to adhere to regulatory standards. Selection on the government side comes from responding to and acting toward success or failure as a result of certain policies and regulations. If a particular strategy (policy) is successful, then that strategy is likely to occur again in the future.

Adaptation: On the consumer side, demand is assumed to be price inelastic in the short run. Firms are assumed to adapt based on changes in government regulations. Government, on the other hand, adapts their policies according to the level of success they realize with their strategy (i.e. successful diffusion of renewable energy technologies).

Using the theoretical framework of network economics creates a unique foundation for this research. The key variables of interest are shown in Table 1.

Table 1. Key Variables.
Decreasing costs/increasing returns

Variable	Definition
Price depression	Decrease in price paid to renewable energy generators to reflect improvements in technology and economies of scale

Path Dependency

Variable	Definition
Contract length	Average length of contract offered to renewable energy generators. Longer contracts represent a reduction in risk to investors and enhance path creation. Shorter contracts have the opposite effect.
Price paid to RE generator	Fixed or variable price offered to renewable energy generator at a rate that either ensures a profit or results in a loss. Fixed prices represent stable path creation while variable prices represent more risk to the investor. Guaranteed prices for the life of the contract enhance path creation.
Evolution of prices paid to RE generators	Absence or presence of price changes over the life of the FIT to reflect economies of scale and/or technology learning.
Policy changes	Absence or presence of changes in policy strategy based on success/failure of previous policy.
Purchase obligation	Requirement by utility to purchase all renewable energy from a given RE generator.

Technological Lock in

Scope of Technologies	Number and type of renewable energy and traditional technologies prevalent during the given time period
Technical compatibility	Presence or absence of renewable energy technical compatibility with existing electricity grid, whether paid for by the utility or renewable energy generator.

Firm Behavior

Variable	Definition
Renewable energy production	Amount of renewable energy generation as a percentage of total electricity

3. Methodology and the German Case

Methodology

The article will focus on a descriptive unique case study analyzing the expansion of renewable energy technologies in Germany from 1990 to 2007 and represents a case where the expansion of renewable energy has been successful in terms of the overall renewable energy generated in Germany as a percentage of total energy generation for the country. The German case study will be used to describe key policy initiatives in the context of agent-based structure.

The case study protocol that follows outlines the phenomena observed in electricity production that underlie the application of agent-based analysis to the German case. The variables related to these phenomena will be analyzed individually to reveal and understand the “paths” that lead to certain outcomes and determine how these complex relationships and interactions can be modified in order to direct to alternative paths and outcomes.

In theory, decreasing costs/increasing returns is recognized as occurring in network based industries such as energy. Under some conditions mechanisms related to increasing returns/decreasing costs can lead to inefficiency even under suitable initial conditions or random fluctuations. Increasing returns tend to show common properties and raise similar difficulties and issues wherever they occur. Economists typically seek measures to correct deviations from Pareto optimality.

In terms of path dependency and technological lock-in, neoclassical economics recognizes the “path” and treats it as a sequence of equilibrium conditions defined by long run and short run average cost and marginal costs curves. The sequence of equilibria is presumed to be in accordance with consumer, firm and society’s short and long run economic well-being.

Table 2. Case Study Protocol

Observed Phenomena in Electricity Production Industry	Explanation: Agent-Based behavior and networks
Decreasing costs/Increasing returns in consumption	Recognizes decreasing costs/ increasing returns as prevalent in knowledge-based network industries
Path dependency	Path may be at deviance with social welfare function in the long run. Path may be in accordance with short term consumer and firm strategy.
Technological lock in	Society may be locked into a path resulting in lock-out of alternative technologies. Leads to non-maximization of society’s welfare function. Because of reliance on existing capital equipment and technical compatibility issues, inferior technology may dominate the market.
Explanation of firm behavior	The more a particular technology is adopted, positive feedback increases its lead, leading to further adoption of the dominant technology.

This paper recognizes a dynamic view of path dependency and technological lock-out. The path may be in accordance with short term consumer and firm strategy, but it may be at deviance with social welfare in the long run if it does not account for

externalities. There is no way to guarantee that the technology selected among the many alternatives will represent a superior technology. Moreover, once “random economic events select a particular path, the choice may become locked-in regardless of the advantages of the alternatives.” An inferior technology may therefore come to dominate the market, especially when there are large capital investments in infrastructure that prove difficult to displace.

The German Case

One country which has realized exceptional success is Germany. Work completed at the International Energy Agency under the direction of Dr. Kenneth Friedman (U.S. Department of Energy) clearly indicates that path dependency and technological lock out are of key importance in understanding and overcoming the barriers to renewable energy diffusion stating that “The sunk costs of capital are enormous. Capital stock does not turn over rapidly particularly when talking about expensive equipment. This is an industry that doesn’t just give up on its equipment.” Friedman confirmed that technical compatibility plays a key role since there is no standardization of transformers for an electrical grid. Germany, in Friedman’s opinion, had experienced tremendous success because of federal-level government mandates that overcame the network economic issues of renewable energy diffusion.

The strength and robustness of Germany’s renewable energy policies was not the product of one master plan. Rather it was the outcome of incremental strategy changes based on the results of previous successful policy measures and adaptation in response to other agents’ behaviour. Even the German government’s most optimistic projections of renewable energy diffusion have been surpassed. The original government objective of meeting 12.5% of gross electricity consumption from renewable sources by 2010 had already been surpassed by 2007 when its renewable energy contribution reached 14.2% of electricity consumption.³

Table 3 summarizes the German case based on the structure described above: For the German government, the main artefact employed to realize an increase in renewable energy technology diffusion is a policy tool known as a Feed-In Tariff (FIT). Recognizing the need to overcome the network issues of increasing returns/decreasing costs of its locked-in dominant energy system; the German government implemented a national renewable energy feed-in tariff (Street) in 1991.⁴ A FIT is a government law that requires utilities to connect renewable energy plants to the transmission grid at no cost and buy their electricity at a premium fixed-price which is guaranteed in a ten to twenty year contract.⁵

In the case of Germany the FIT was designed to jump start a process that would encourage rapid growth in renewable energy.⁶ The model that Germany currently utilizes contractually obligates utilities to buy renewable energy from producers through long-term, fixed-price contracts.⁷ Germany’s FIT policy, implemented first in 1991(Street) and updated/adapted in 2000 and 2004 (EEG), ignited a self-reinforcing dynamic that put Germany on the path to overcome the technological lock-out of the dominant energy system.

Table 3. Structure Overview

Agent	<u>Consumer</u>	<u>Firm</u> (Utilities + Renewable Energy Generators)	<u>Government</u>
Strategy	Utility maximization subject to budget constraints. Second best solutions acceptable if best solution not possible.	Profit maximization / cost minimization subject to regulatory constraints.	Optimize social welfare subject to constraints (renewable energy diffusion)
Artifacts	Held constant – passive agents	Management of the factors of production (capital equipment and energy resources)	Regulatory Policy (Feed-In Tariff)
Measure of Success	Utility maximization (low electricity bills and reliable service)	Profit maximization	Diffusion of renewable energy
Population	Homogeneous	Four utilities + Multiple renewable energy generators	One government
Types	Homogeneous	Homogeneous	One government
Interaction	Fixed	Collusive/adaptive	Collusive/adaptive
Variation	Fixed	Collusive/adaptive	Collusive/adaptive
Selection	Held constant	Adaptation based on regulatory constraints	Success or failure of policies (FIT succeeds in encouraging renewable energy diffusion)
Adaptation	Fixed	Adaptation based on changes in government policies	Feed-In-Tariff Law of 1991 updated in 2000 to Renewable Energy Law (EEG)

The 1991, Street was a basic one-page bill that obligated utilities to connect renewable energy generators to the grid and buy their electricity at a rate of 65-90% (varying based on the type of renewable energy) of the average tariff charged per unit by the utilities to their customers. The main beneficiaries of the StrEG were wind and hydro plants since the defined rates exceeded their average cost of energy production and ensured profitable business. By contrast, solar PV installations did not benefit since the rates dictated by the StrEG barely covered production costs and deterred potential investors.⁸

Due to the nature of percentage-based tariffs, profits for renewable energy producers decreased after deregulation in 1998, resulting in a reduction of energy prices.⁹ Nonetheless, it can be said that the StrEG strategy was successful as a starting point for overcoming the barriers to renewable energy expansion in Germany. The StrEG was then updated in 2000 with the introduction of the EEG. Specifically, the EEG was necessary as a reaction to the deregulation of the German electricity market in 1998 and to take advantage of the momentum that the StrEG had created in furthering Germany down the path of renewable energy expansion.¹⁰ Over time, the

laws outlined above assured that the path to renewable energy diffusion continued unfolding in a sustainable manner.¹¹

Today the German FIT offers a fixed price and provides a total payment per kWh of electricity produced by a renewable energy generator. The fixed price is calculated by taking the cost of generating electricity with a particular renewable energy technology and adding a small percentage on top to ensure that the renewable energy developer will make a profit from the FIT.¹² Additionally, long-term FIT contracts utilized by Germany provide a predictable revenue stream since the fixed price is guaranteed to the renewable energy generator over the life of the contract.¹³ In Germany, the minimum contract is 20 years for all technologies except certain hydropower plants that have 15 year contracts. The fixed price is guaranteed for the life of the contract. This makes the risk of the investment very low, which can also reduce the interest level on loans for the capital costs of the plant.¹⁴ An appropriate contract term limit was an important part of the German government's strategy in order to reduce the overall costs of the FIT system. Specifically, restricting payment to a certain number of years speeds up the innovation cycle by replacing old technology with new and more efficient equipment.¹⁵ The combination of long contracts and guaranteed fixed prices encourages additional firms to invest in renewable energy plants. Increasing profits have been reinvested in technological developments, which in turn have increased their shares in the world market.¹⁶ In turn, the German government achieves its goal of expanding renewable energy diffusion in line with its strategy.

Technical compatibility with access to the electric transmission and distribution grids is a key component of network economic effects and is included in Germany's FIT. If the renewable energy plant is not technically compatible with and connected to the electricity grid, its electricity cannot be delivered to the utility's consumer base. In Germany, the FIT guarantees that grid interconnection is paid for by the utility, reducing the overall cost to the renewable energy developer and improving the financial incentives of a FIT contract. The renewable energy developer's investment is reduced, resulting in less risk.¹⁷ The cost of grid interconnection in the case of Germany is passed onto the consumer base and is another piece of the overall cost of the FIT program.¹⁸ Germany's FIT is also designed with a purchase obligation.¹⁹ Purchase obligations require the utility to buy electricity from the renewable generators with FIT contracts. This extra guarantee reduces the risk of investing in a renewable plant by ensuring a reliable revenue stream. FIT opponents argue that this can make the policy more expensive for the consumer by making the utility buy renewable electricity even when there is not enough consumer demand to use it. The arguments in favor of a purchase obligation are that it reduces the risk to the investor and ensures that they will be able to sell as much renewable energy can be produced.²⁰ Without the obligation, the risk of investing in intermittent sources like wind or solar plants would be even higher because income would only be guaranteed if the sun or wind were able fuel the plant when there was enough electricity demand to necessitate the utility's purchase.

Since the cost of producing electricity with different renewable technologies varies, the FIT price varies to reflect this. The highest price (i.e. the most expensive renewable energy to produce) is usually reflective of the least mature technology. In most cases solar PV costs the most due to the high cost of materials like silicon and the relatively low efficiency of the cells.²¹ Germany's FIT pays anywhere from 33-43 euro

cents per kWh (varying by size of installation) for electricity produced by solar photovoltaic cells. The FIT for onshore wind, by contrast, starts at 9.2 euro cents per kWh.²² An additional element of the German FIT is an extra premium paid on top of the solar prices for building integrated PV, which is a more costly and less efficient version of the more common roof or ground mounted PV panels. This premium exists to encourage development of solar PV.

The FIT price in Germany also varies based on the quality of the renewable resource, the plant size or the fuel type. For example, the German FIT contracts for offshore wind farms receive a higher price than onshore wind farms due to the higher cost of construction.²³ Wind farms also receive a lower price for the highest quality wind sites, and a higher price for the lower quality wind sites. The policy was designed in this manner to encourage widespread wind power development throughout Germany rather than overdevelopment of the most sought after, high quality wind sites. Overdevelopment of high quality wind sites could eventually degrade the quality of the resource by placing too many turbines in the wind flow and reducing the overall electricity produced per turbine.²⁴

The FIT price eventually undergoes a price depression based on the evolution of costs. Presumably, as technologies gain more widespread use, their costs come down to technology learning. Economies of scale and increased experience among the manufacturers of renewable energy technology and their installation crews leads to a decline in the price of the technology over time.²⁵ Reducing tariff rates in a systematic and predictable manner encourages cost cutting and technological innovation by renewable energy generators.²⁶ This approach has jump-started the solar industry by causing a rush to install solar PV early and take advantage of the highest FIT prices.²⁷ This rapid growth contributed to reductions in the price of solar PV technology and its installation through economies of scale.²⁸ Since the tariff price reflects the cost resource curve of the individual technology, renewable energy generator profit is reduced and the cost to society is lessened.²⁹

Germany undertakes a Fit policy review every four years. Such regular reviews are required, in part, owing to the difficulty in accurately predicting long-term cost changes to different technologies. The consequence of incorrectly predicting long-term cost changes could result in either too much or too little price depression. If the price depression is too steep, the result could be a FIT contract that isn't profitable for the renewable energy developer. If the price depression is not steep enough, however, the outcome would be windfall profits for the renewable producer and increased cost to the electric consumer.³⁰

The cost of Germany's FIT program is paid for with an extra charge on all monthly consumer electricity bills. Since Germany has a deregulated electricity market and four different utilities, an even dissemination of the FIT program costs are distributed to avoid unfair burdens on some consumers.³¹ The transmission grid operators track the costs that the German utilities incur from the FIT program and redistribute them evenly to all consumers so that customers from one utility aren't paying more for the FIT program than customers of the other utilities. If these costs were not evenly distributed, consumer strategy would likely involve switching to the cheapest utility, and over time, the utilities with the larger FIT cost burdens would go out of business. In countries without deregulated markets, the cost of the FIT program

can cause a disproportionate burden on customers in areas with better renewable resources. The utilities in these areas would presumably end up funding more FIT contracts than the utilities in areas with weaker renewable resources, leading to higher costs for the consumers in the areas of strong renewable resources.

4. Conclusions

Following Axelrod, Axelrod and Cohen, and others, agent-based analysis lends considerable insight into issues surrounding the implementation of renewable energy. It is key to recognize that as energy is a networked industry, costs decrease as the network becomes more efficient and the network size increases. Because of the multi-dimensional characteristics of networks, issues of increasing returns/decreasing costs and changes in the production function over time with respect to technology, the network model describes phenomena occurring in the energy industry. By drawing on agent-based analysis further insight can be attained around the barriers to renewable energy in terms of how agents interact to achieve their strategies.

The German case study shows how one country expanded its use of renewable energy technologies by recognizing the relevant network issues and putting in place policies designed to overcome them. Renewable energy resources do not currently enjoy decreasing costs/increasing returns like their fossil fuel counterparts. The network associated with renewable energy resources is underdeveloped to the point where lock in is not a consideration. In some cases, the state of technology relevant to the output side of renewable energy is incompatible with the current technology associated with traditional resources.

Germany recognized that economic policy solutions employed before 1991 would continue to perpetrate the slow pace of renewable energy diffusion. It abandoned the traditional perspective and instead adopted a network economics framework for understanding the issues and developing policy. By introducing the 1991 StrEG federal feed-in tariff, updating it in 2000 to the Renewable Energy Law and making incremental changes along the way, Germany was able to achieve a share of electricity from renewable energy technologies of 14.2% in 2007. This percentage increased to roughly 17% in 2010. Gross employment in renewable energy amounted to 294,000 jobs, almost 68% (199,700) of which can be attributed to electricity generation.

Germany provides an isolated case study. Extending the success story will require considerable multi-national cooperation. Agent-based analyses can facilitate understanding of initiatives and their consequences. It is unlikely that agents working in isolation will be able to achieve viable and sustainable economies of scale pointing toward the need for macro and micro level interaction and cooperation in the context of a complex, agent-based structure .

ENDNOTES

¹ Robert Axelrod, The Complexity of Cooperation : Agent-Based Models of Competition and Collaboration, 1997, Princeton: Princeton University Press.

² Technically, given explicit and implied constraints, agents in this case will follow strategies which attain a conventional second best optimum. It is well-known in the literature concerning general equilibrium and social welfare dating to the classic work by Lipsey and Lancaster. Cases arise in which a Paretian optimum cannot be achieved owing to the introduction of a constraint, which precludes the possibility that all Paretian conditions will be fulfilled. The

optimum attained is, therefore, second best as it is achieved subject to a constraint precluding the Paretian optimum. Application of second best in general and partial equilibrium analyses are widely understood today, including the difficulties arising from "piecemeal" attempts to achieve Paretian optimality. R.G. Lipsey and Kelvin Lancaster, "The general theory of second best," *Review of Economic Studies* 24, (1956): 11-32.

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⁴ Ibid.

⁵ Ibid.

⁶ Toby Couture and Emily Williams, "A Policymaker's Guide to Feed-in Tariff Policy Design," National Renewable Energy Laboratory, <http://www.nrel.gov/docs/fy10osti/44849.pdf> (accessed September 2, 2010).

⁷ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, 1, <http://www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf> (accessed October 3, 2010).

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⁹ Mario Ragwitz and Claus Huber, "Feed-In Systems in Germany and Spain: A Comparison," *Fraunhofer Institute Systems and Innovation Research* August (2004), http://www.bmu.de/files/english/renewable_energy/downloads/application/pdf/langfassung_ein_speisesysteme_en.pdf (accessed October 3, 2010).

¹⁰ Ibid.

¹¹ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, <http://www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf> (accessed October 3, 2010).

¹² Ibid.

¹³ Ibid.

¹⁴ By contrast, Spain used to implement four year FIT contracts which created a much higher level of risk to the renewable investor. Most renewable generation plants will not reach a positive payback in a four year period.

¹⁵ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, 5, <http://www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf> (accessed October 3, 2010).

¹⁶ Frank Laird and Christoph Stefes, "The diverging paths of German and US policies for renewable energy: sources of difference," *Energy Policy* 37, no. 7 (2009): 2619.

¹⁷ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, <http://www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf> (accessed October 3, 2010).

¹⁸ Paul Gipe, "Model Advanced Renewable Tariff Legislation," Wind-Works, <http://www.wind-works.org/FeedLaws/USA/Model/ModelAdvancedRenewableTariffLegislation.html> (accessed October 4, 2010).

¹⁹ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, <http://www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf> (accessed October 3, 2010).

²⁰ Ibid.

²¹ "2008 Renewable Energy Data Book," U.S. Department of Energy, http://www1.eere.energy.gov/maps_data/pdfs/eere_databook_091208.pdf (accessed September 15, 2010).

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²³ Mario Ragwitz and Claus Huber, "Feed-In Systems in Germany and Spain: A Comparison," *Fraunhofer Institute Systems and Innovation Research* August (2004), http://www.bmu.de/files/english/renewable_energy/downloads/application/pdf/langfassung_ein_speisesysteme_en.pdf (accessed October 3, 2010).

²⁴ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf (accessed October 3, 2010).

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²⁶ Miguel Mendonça and James Corre, "Success story: Feed-In Tariffs Support renewable energy in Germany," E-Parliament, <http://www.e-parl.net/eparlimages/general/pdf/080603%20FIT%20toolkit.pdf> (accessed October 3, 2010).

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