3rd International Conference on Energy and Environment: bringing together Engineering and Economics
Porto, Portugal
29-30 June, 2017

Assessing energy policies drivers of the deployment of distribution generation: A review of influencing factors

Max Staib Ramalho[1*], Lorrane Câmara[1], Patrícia P. Sílva[2 3 4], Guillermo Pereira[2 3] and Guilherme Dantas[1].

[1] Electric Sector Research Group, Federal University of Rio de Janeiro, Brazil
[2]Energy for Sustainability Initiative, MIT Portugal Program, Faculty of Sciences and Technology, University of Coimbra, Portugal
[3]INESC Coimbra, Institute for Systems Engineering and Computers at Coimbra, Portugal
[4]CeBER, Centre for Business and Economic Research, Faculty of Economics, University of Coimbra, Portugal

* Corresponding author: max.ramalho@ppge.ie.ufrj.br, Federal University of Rio de Janeiro, Av. Pasteur, 250, room 235, Brazil

KEYWORDS: Public Policy, Distributed Generation, Photovoltaics

ABSTRACT

Increasing the share of renewables in electricity consumption has been the focus of energy and climate policies around the world. This motivation has resulted in different approaches across industrialized and developing economies for supporting the diffusion of renewable distributed generation. In this sense, this article compares eight different cases (Belgium, Brazil, Italy, Japan, United Kingdom, California, Germany and Portugal) and their policy trajectories in relation to photovoltaic energy deployment, in order to evaluate the drivers of their success rates. More precisely, this study identifies the main incentive policies, evaluates the motivation supporting their adoption and the factors that influence, or ultimately, determine their success, or failure. Much of the discussion surrounding the success of incentive policies for renewable energy technologies has focused on a narrower comparison between specific policies such as feed-in tariffs, net metering, renewable portfolio, tradable certificates, etc. This approach neglects to identify the wider framework of policy instruments that determine the success of a greater diffusion of renewable energy technologies. Thus this paper will offer a broader approach, by identifying a multitude of criteria that will help to identify the underlying causes for the successful expansion of these technologies.

INTRODUCTION

The 21st century has witnessed an impressive rise in the deployment of renewable energy technologies. In recent years, perhaps, the greatest progress has been related to the case of photovoltaic energy technology, which over the past 5 years has undergone fast growth in terms of installed capacity. A key force driving the success of this energy technology has relied on specific public policy initiatives that support and incentivize its investment and deployment. Public policy decisions may result from diverse motivations, but there is a consensus towards the importance of tackling climate change and assuring security of supply.

Thus, today, a majority of countries have adopted some type of policy instrument in order to push the diffusion of these energy technologies. The distinctive approaches and mechanisms used vary between countries or regions, providing a valuable framework to compare the outcomes of those policy implementations and, thus, assess their effectiveness.

This review focuses on photovoltaic distributed generation technology deployment, (as the most popular form of distributed generation) which is part of current targets to promote the deployment of renewable energy not only in Europe but also in other countries worldwide. While there are several studies on photovoltaic (PV) distributed generation technology criteria, a research gap exists because energy policy makers on across the world are quite diverse, and even in the subset of the European markets, these exhibit different stages of maturity. This article conducts a critical review of the literature on the support policies for photovoltaic distributed generation technology in order to answer the following questions: (1) to what extent can findings from studies about PV distributed generation adoption criteria be generalized from one country to another? and (2) what insights does the literature offer on factors that might explain the differences in adoption patterns between countries within and outside of the European Union?

The paper is divided um into two main sections: the first discusses and introduces methods and motivations for supporting photovoltaic energy technologies. It starts by presenting the diversity of support mechanisms that exist, followed by “economic” and finally socio-political motivations behind the adoption of certain support policies. The second section, will try to exemplify some of these tendencies, arguing for the difficulty and particularity of each countries motivation and policy trajectory. The aim is to illustrate, that the success, failure and reasons behind the adoption of distributed generation can stem from a multitude of different policy clusters that are often strongly rooted in the individual context of each country.

In this context, Germany and California can be considered pioneers in the application of incentive policies and consequently demonstrate some of the highest level of renewable energy diffusion. Italy, Portugal and Belgium represent a second wave of cases that adopted more substantial incentive policies, during the second half of the 2000s. Finally, Japan, the United Kingdom and Brazil represent a third wave of cases, which implemented stronger incentive policies during the first half of this decade and which have demonstrated mixed results. In this sense, this article broadly compares these eight case studies in order to evaluate the drivers of their success, or failure rates.

PHOTOVOLTAIC ENERGY POLICY LITERATURE OVERVIEW

Much of the debate over successful policy instruments for photovoltaic (and renewable distributed generation, in general) diffusion has adopted a singular approach to. That is to say, that policy makers and academics have evaluated renewable energy policies through a binary lens, focusing on specific policy mechanisms. A popular focus has been the comparison of net-metering schemes (which are popular among states in the United States) and feed-in tariffs (FiT) (which have been pioneered and are widespread among European countries). While such a comparison has its advantages, they fail to encompass the diversity of policy mechanisms, which make up the majority of renewable energy policies.

Consequently, in order to better understand the entirety of factors that characterize photovoltaic energy support policies, one needs to investigate the wider framework of policy instruments that determine the success of a greater diffusion of photovoltaic energy technologies. Regarding the support schemes adopted around the world, their most relevant regulatory policies are: feed-in tariff/premium payment, electric utility quota obligation/RPS (renewable portfolio standards), net-metering, tradable renewable energy certificates (REC) and tendering. When it comes to financing the investment in photovoltaic systems, the last decade has seen a lot of different fiscal incentives and public financing: capital subsidies, VAT reduction, taxes credits, public investment, loans, or grants, among others. (Dusonchet and Telaretti, 2014).

The academic literature offers an abundance of ways of categorizing support mechanisms for renewable energy sources. Battle et al. (2012) broadly divides these policies into direct and indirect support mechanisms. In addition, Battle et al. (2012) and Haas et al. (2011) further distinguish between direct mechanisms that are quantity-driven and those that are price-driven. Table 1 illustrates this categorization, identifying different policy tools for each category. Jenner et. al (2012) offer an alternative categorization, which replaces direct and indirect methods, with investment (tax credits and investment subsidies) and generation (feed-in and net metering).

Table 1: RES-E Support Schemes

<table>
<tr><td>Indirect methods</td><td colspan="2">R&D subsidies
Net metering
RES-E obligation for new housing</td></tr>
<tr><td rowspan="2">Direct methods</td><td>Quantity-driven</td><td>Green Certificates (GCs)
Tendering schemes</td></tr>
<tr><td>Price-driven</td><td>Feed-in-tariffs (FiTs)
Capital Grants
Fiscal incentives
Green loans</td></tr>
</table>

Source: De Boeck et al. (2015)

In the process of exemplifying their categorization, they argue that the two most popular policy types for encouraging renewable energy generation in industrialized countries are (FiT) and quotas, also known as renewable portfolio standards (RPS) or green certificates (GCs). De Boeck et al. (2015) confirm that the main quantity-based subsidy scheme in the residential PV market is GCs. On the other hand, in regards to indirect methods, net billing, net-metering and self-consumption are the most common support mechanism for distributed generation. In the case of price-driven support scheme the feed-in-tariff is the most popular.

Yet, while this article seeks to explore the diversity of support policies, which are in place in most countries around the world, and not focus on a singular policy tool such as FiT or net-metering, one should not interpret them as having a homogenous policy design. Instead they offer some main design characteristics, which differ from case to case. Jenner et al. (2012) identify six main characteristics through which the design of FiT policy differs:

i. Fixed-price or premium tariff: the former guarantees a set price for the electricity generated, while the latter adds a bonus to the wholesale market price received by the generators;
ii. Cost allocation: the generators sign a contract, which guarantees remuneration for their electricity production. The difference between the remuneration guaranteed, and the market price of electricity is re-distributed among electricity consumers or paid for by the government;
iii. Cost containment: in some cases the total capacity that may be installed, or the total tariff award under the FiT policy each year, may be capped;
iv. Contract duration: the duration over which remuneration is paid to generators can vary from country to country. The duration of contracts usually varies between 10-25 years;
v. Tariff/remuneration amount: The remuneration received by generators may vary depending on system size and energy source and
vi. Digression rate: it is common for FiT policies to have a built-in digression rate, in order to gradually reduce the remuneration levels in accordance to changes in overall diffusion levels, cost reductions and technological progress.

Thus, FiT needs to be analyzed and understood in a case by case basis, in order to comprehend the particularities of each policy.

Net-metering schemes follow the same idea. Although it is usually treated as a “one fits all” policy, there are determinant features that vary from case to case and also play a central role regarding the results achieved in each country, they are (Barbose et al., 2016; Heeter et al.,2014; Wan, 1996):

i. Aggregate cap: limits the total amount of net metered systems that can be installed in a utility service territory or in a state, for example. The aggregate cap can be defined as a percent of peak demand, a fixed number of MW, a percent of non-coincident peak demand (sum of individual customer peak demands), or through other methods and criteria;
ii. System sizes allowed: most net-metering schemes set a cap on eligible individual generating capacity. This criterion can vary from a limit as low as 10 kW, as it was the case of California for a long period, to a cap as high as 5 MW, as in Brazilian case;
iii. Compensation for grid exports: determines how the electricity exported do the grid is priced. It is usually based on retail rates, allowing a one-for-one compensation. However, other valuation frameworks, such as the wholesale electricity prices, and the value of solar have been widely discussed and
iv. Treatment of net excess generation: this criterion determines if, and how, net excess generation is compensated at the end of a billing period. Most net-metering schemes require utilities to buy back this amount, by a specific rate, but there are also some cases in which no compensation is required.

Furthermore, as Gawel et al. (2017) point out, there is an important discussion to be held, on whether remuneration for renewable electricity generation – i.e., price premium per kWh – should be differentiated on the basis of inter- or intra-technology differences, or if it instead should be technology-neutral.

A popular critique from proponents of technology neutral support policies towards a technology-specific approach to renewable energy support has been that they make the attainment of higher levels of renewable energy diffusion, unnecessarily costly (see, e.g., Frontier Economics, 2012; Frontier Economics, 2014; and r2b 2013; Fürsch et al., 2010; Jägemann, 2014; Jägemann et al., 2013).

Yet, a number of studies (e.g., Azar and Sandén, 2011; Jacobsson and Bergek, 2011) have challenged this line of criticism, often by pointing out the importance of technology-specific approaches in promoting technological development. The argument goes further by stressing that considering future risks and uncertainties, regulators should in general avoid supporting “single winners”, and instead provide support for several emerging renewable energy technologies (that are not perfect substitutes) (e.g., Aalbers et al., 2013; Azar and Sandén, 2011).

This hints towards another difficulty that arises when discussing the effectiveness and success of support policies for renewable energy technologies. What criteria should be used in order to evaluate the success of such a policy, and consequently, what aims has this policy pursued? A simplistic approach in the form of “growth in installed capacity”, might fail to recognize a multitude of benefits and by products which might have resulted from and been the aim of certain policy mechanisms. As touched upon previously, renewable energy support can ultimately have the effect of supporting technological progress (through R&D investments, learning-by-doing, learning-by-using, spill over effects etc.), creation and strengthening of national renewable technology markets and industries, energy security (through diversification of energy sources, decentralization of energy generation, reduction of energy imports etc.), growth and expansion of renewable energy capacity and environmental protection, among other things. With this in mind, it becomes evident, that much of this effect is difficult to measure, challenging to control and direct, and problematic to trace back to specific, isolated policy mechanisms.

A further dimension, which needs to be taken into consideration, when trying to understand the adoption of certain support policies for renewable energy, is the socio-political, cultural and historic context. In order to attempt to discuss and evaluate the adoption of certain policy frameworks supporting renewable energy, one requires an understanding of the diversity of support mechanisms available, the challenges and strategy of evaluating the policy results, and finally the political, social and historic motivations. These latter elements are very difficult to quantify, identify and are extremely case dependent. They can be a response to economic pressures, growing political concerns over pollution or/and environment issues, natural or/and manmade catastrophes etc. Nonetheless, they are an important element when trying to attain a holistic understanding of the motivations behind pursuing certain renewable energy policies.

THE UNEVEN DIFFUSION OF PHOTOVOLTAIC SUPPORT POLICIES: 8 CASE STUDIES

The case study analysis was the result of a set of *in situ* interviews and literature survey. After surveying the global photovoltaic market in 2015, and collecting data directly from stakeholders, including representatives from National Renewable Energy Laboratory (NREL), California Public Utilities Commission (CPUC), Pacific Gas and Electric Company (PG&E) and Public Utilities Commission of Nevada (PUCN), through a set of local interviews held in December of 2016, it becomes evident, that photovoltaic technologies are still drastically dependent on support policies in order to succeed. In 2015, 98.7% of the global photovoltaic market takes advantage of some kind of support scheme or adequate regulatory framework. Astonishingly, this number has increased from 96%, verified in 2014, demonstrating that photovoltaic technologies are strongly driven by incentives and regulations (PVPS, 2016). The numbers undeniably demonstrate the dominant role that FiT schemes (59.7%) play in supporting the adoption of photovoltaic technologies (followed by subsidies aiming at reducing the upfront investment or tax breaks with around 16% of the installations, and incentivized self-consumption including net-billing and net-metering at 14.9%).

When analyzing the eight cases used for the purposes of this article, the heterogeneity of each support policy framework should become clear. It illustrates the importance in adopting a more holistic understanding of incentive policies. Hence, Table 1 shows that no country, within our chosen sample, relies solely on one policy tool.

Table 1: overview of renewable energy support policies

	Feed-in tariff/ premium payment	**Electricity Utility Quota Obligation/ RPS**	**Net metering**	**Tradable REC**	**Capital Subsidy, grant or rebate**	**Investment or Production tax credits**	**Public investment, loans or grants**
Belgium (Flanders)	No	Yes	Yes	Yes*	Yes	Yes	No
Brazil	No	No	Yes*	No	No	Yes**	Yes**
California	No	Yes	Yes*	Yes	Yes*	Yes	Yes
Germany	Yes*	No	No	No	Yes**	Yes**	Yes**
Italy	Yes*	No	Yes**	Yes**	Yes**	Yes*	Yes**
Japan	Yes*	Yes**	Yes**	Yes**	Yes**	No	Yes**
Portugal	Yes	Yes	Yes[1]	No	Yes	Yes	Yes
UK	Yes**	Yes**	No	Yes**	Yes**	No	Yes**

*the policy has been revised; **on national level

[1]Portugal has currently an instantaneous net-metering, as the compensable is possible just when the energy is consumed at the same time of production.

Source: Adapted from (KPMG, 2015)

In fact, the countries have adopted different patterns and forms of financing distributed generation, which include capital subsidies, VAT reduction, taxes credits, green certificates, net-metering and feed-in tariffs. Following Dusonchet and Telaretti (2014) argument, the case of California falls into the broader U.S. approach to supporting photovoltaic generation, which mainly relies on tax credits and net metering (in the example of distributed generation).

There is a rich literature offering different approaches in quantifying the attractiveness of investment in photovoltaic systems within different countries. This is interesting, because it demonstrates how different policy constellations can create similarly strong economic incentives. De Boeck et al. (2015) create a model, in order to calculate the investment attractiveness (in the form of payback) of distributed generation (i.e. residential photovoltaic systems) in four major photovoltaic markets, among which are Flanders (Belgium), Germany and Italy. These three countries have adopted very different support policies, which the study identifies, have resulted in diverse outcomes.

De Boeck et al. (2015) conclude that Italy is by far the best performer, showing a payback time of only 6 years, being the most profitable for residential investors. The combination of net-metering with a very generous tax credit of 50% has lead to some of the highest levels of profitability and of the lowest payback period. However, the authors argue that an internal rate of return (IRR) of 16-18% is much higher than should be necessary to attract investors, and wastes budget resources. Campoccia et al. (2009) argue that the success of Italian support policy is also due to the very high electricity cost in the country.

According to Dusonchet and Telaretti (2015), in UK photovoltaic systems are profitable only for building-integrated segment, mainly due to the self-consumption regulatory scheme. FiTs for large-sized PV systems (higher than 250 kW), however, are very low, not able to compensate for the low radiation levels in the country. This result is confirmed by the strong spread of residential and commercial PV systems, compared to a lower diffusion of larger installations.

In the case of Germany, electricity prices are so high, that the savings possible from self-consumption are the highest here. Until 2012, the IRR is lower than in the other countries. However, it is also clearly the most stable subsidy scheme with the IRR at a constant level between 6-8%. Since after many reforms the German FiT is now much lower than the household electricity price, self-consumption is strongly encouraged. When comparing the studied countries, the stability of the German support system should be encouraged, as this reduces government's support costs and investor uncertainty.

In the case of Flanders, Beliën et al. (2013) make the conclusion that that PV in Flanders was over-subsidized during this period. This helps explain why the Flemish Energy Agency (VEA) abolished green certificates with the argument that they were no longer necessary in order to guarantee at least a 5% return on the investment. Germany's support system has arguably been the most balanced over the period studied.

If we consider attractiveness of investment in distributed generation as a proxy for successful support mechanism, then this shows that there is no universally effective policy arrangement but that there are many possible options. Furthermore, the available support mechanisms are constantly adapting and changing, as the example of the abolishment of green certificates for small systems in Flanders illustrates. This also points out that attractiveness of investment is not a good proxy for measuring the success of support policies, but that instead there are other important underlying motivations, which come into play when adopting certain policy designs and frameworks.

Picking up on the earlier discussion on the benefits of technology specific support, one can observe that a great majority of countries adopted for example, photovoltaic specific remuneration rates and categories. Gawel et al. (2017) uses the German case, to exemplify the concerns of the government in implementing support policies in order to address “structural discrimination of new technologies” (from official records of parliament: Bundestag, 1999:7, translated by Gawel et al., 2017). Furthermore, technology-specific regression rates for remuneration were established to follow technologies’ specific progression down the learning curve (Bundestag, 1999:9; 2008a, pp. 51). Explanatory statements (Bundestag, 2008, 2014) further specify, not only the logic, that support policies should be continuously aligned with the technologies’ state of development to set incentives for further innovations but also that supporting specific, innovative technologies (such as is the case of photovoltaic) can be a crucial element towards building competitive advantages in global technology markets and increasing employment.

Finally, when trying to identify the motivation and trajectory behind certain support policies for distributed generation, one needs to acknowledge the important influence of socio-political, cultural and historical realities. Nothing perhaps exemplifies this more than the recent 2011 Fukushima nuclear crises in Japan.

For Japan itself, the crises ushered in a strong socio-political consensus in pushing for the support of renewable energy sources as a whole, and a distributed generation model in particular. As Mochizuki and Chang (2017) argue, these disasters can be opportunities for change, and in the case of Japan, the country adopted a stronger FiT in 2012, the year following the crises. Still, other countries were also motivated by the tragic events of 2011, to reinforce their commitment on alternative energy sources. One example of this has been Germany, who according to The Economist (2012), referring to the energy transition in the country, wrote “…sped up after the Fukushima disaster in March 2011.”

The case of California is also a good example regarding the impact of social consensus over the importance of renewable energy on the effectiveness of a support policy, or a range of policies. The data collected through interviews and technical visits made to Californian stakeholders proves that such a high photovoltaic diffusion was reached in the state not only because of the policies implemented, but also due to the strong consensus regarding the necessity of building a greener, and more sustainable economy.

The Brazilian case, on the other hand, proves that the lack of this kind of societal consensus can be an obstacle to the development of distributed generation. A great example of this issue is the tax treatment of net-metered systems. Although a law conceiving tax exemption for the electricity exported to the grid was approved, in 2015, the decision of adopting (or not) the new regime was left to the states. Currently there are five states (19%) which still have not joined the exemption, reinforcing the lack of a national consensus over the importance of distributed generation. Thus, in these five Brazilian states, the distributed generation fiscal regime reduces the rate of return of the investment, preventing the DG diffusion.

Another influential factor, in behind the motivation of adopting distributed energy generation in Europe, has been the increase in political support for these policies, often associated with the rise of environmental movements and “green parties”. It is little coincidence, that Germany began adopting stronger FiT under the first “green party” government. Additionally, the rise in distributed generation has popularized the increase in energy cooperatives and private investments in photovoltaic technologies. This has led to an increased support and acceptance of these technologies, and

their support policies among the population. It has given rise to the idea articulated by Foxon (2013) of the "Thousand Flowers" vision. The idea that "Energy cooperatives and local energy autonomy would render any large energy infrastructure, and hence big utilities, superfluous. In this "Thousand Flowers" view, decentralized and socialized provision of energy will clear the path for an aspired participatory form of democracy (Strunz, 2014:154)."
On the other hand, financial and economic crises, have caused some countries to abandon or drastically reduce their support policies for distributed generation. This is to show, that the political and historical circumstances, which are often very particular to each country, have a tremendous influence on the motivation and adoption of certain support mechanisms.

CONCLUSIONS AND FURTHER RESEARCH

This article illustrates the necessity to recognize the complexity of factors influencing the adoption of distributed generation. Traditional attempts of analyzing the success of certain policy tools, while very useful, often lack an appreciation for the multitude of circumstances and elements, which contribute to this success of failure. As the article shows, most countries have adopted a vast amount of different support policies and it is difficult to identify a standard, as even the policy designs can differ greatly from case to case. The political motivation and context in which these decisions have to be made are also very particular to each specific case, and this makes it difficult to identify a single best-practice example. Another difficulty arises in the attempt of identify a common definition for what a successful support mechanism looks like. Thus the main contribution of this work has been to exemplify the struggle and risk of determining solitary factors that explain the success of support policies for distributed generation.

ACKNOWLEDGEMENTS

This work was supported by Portuguese National Foundation for Science and Technology (FCT) through grants: PD/BD/105841/2014, UID/MULTI/00308/2013, and SAICTPAC/0004/2015-POCI-01-0145-FEDER-016434, as well as by the Energy for Sustainability Initiative of the University of Coimbra

BIBLIOGRAPHY

Aalbers, R., Shestalova, V., Kocis, V., 2013. Innovation policy for directing technical change in the power sector. Energy Policy 63, 1240–1250.

Azar, C., Sandén, B.A., 2011. The elusive quest for technology-neutral policies. Environ. Innov. Soc. Transit. 1, 135–139.

Barbose, Galen, et al.. On the Path to Sunshot: Utility Regulatory and Business Model Reforms for Addressing the Financial Impact of Distributed Solar on Utilities. Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory.

Batlle, C., Pérez-Arriaga, I.J. and Zambrano-Barragán, P., 2012. Regulatory design for RES-E support mechanisms: Learning curves, market structure, and burden-sharing. Energy Policy, 41, pp.212-220.

Beliën, J., De Boeck, L., Colpaert, J. and Cooman, G., 2013. The best time to invest in photovoltaic panels in Flanders. Renewable energy, 50, pp.348-358.

Bundestag, 1999. Drucksache des Deutschen Bundestages 14/2341 vom 13.12.1999: Entwurf eines Gesetzes zur Förderung der Stromerzeugung aus erneuerbaren Energien (Erneuerbare-Energien-Gesetz – EEG) sowie zur Änderung des Mineralölsteuergesetzes.

Bundestag, 2008. Drucksache des Deutschen Bundestages 16/8148 vom 18.02.2008: Entwurf eines Gesetzes zur Neuregelung des Rechts der Erneuerbaren Energien im Strombereich und zur Änderung damit zusammenhängender Vorschriften.

Bundestag, 2014. Drucksache des Deutschen Bundestages 18/1304 vom 05.05.2014: Entwurf eines Gesetzes zur grundlegenden Reform des Erneuerbare-Energien- Gesetzes und zur Änderung weiterer Bestimmungen des Energiewirtschaftsrechts.

Campoccia, A., Dusonchet, L., Telaretti, E. and Zizzo, G., 2009. Comparative analysis of different supporting measures for the production of electrical energy by solar PV and Wind systems: Four representative European cases. Solar Energy, 83(3), pp.287-297.

De Boeck, L., Van Asch, S., De Bruecker, P. and Audenaert, A., 2016. Comparison of support policies for residential photovoltaic systems in the major EU markets through investment profitability. Renewable Energy, 87, pp.42-53.

Dusonchet, L. and Telaretti, E., 2015. Comparative economic analysis of support policies for solar PV in the most representative EU countries. Renewable and Sustainable Energy Reviews, 42, pp.986-998.

Foxon, T.J., 2013. Transition pathways for a UK low carbon electricity future. Energy Policy 52, 10–24.

Frontier Economics Ltd, London. Frontier Economics, 2014. Technologieoffene Ausschreibungen für Erneuerbare Energien. Ein Bericht für EFET Deutschland.

Frontier Economics Ltd., London. Frontier Economics, r2b, 2013. Effizientes Regime für den Ausbau der EE, Weiterentwicklung des Energy-Only-Marktes und Erhaltung des EU-ETS. Ein Bericht für die RWE AG. Frontier Economics Ltd., London.

Frontier Economics, 2012. Die Zukunft des EEG – Handlungsoptionen und Reformansätze. Bericht für die EnBW AG.

Fürsch, M., Golling, C., Nicolosi, M., Wissen, R., Lindenberger, D., 2010. European RES- E Policy Analysis - A model based analysis of RES-E deployment and its impact on the conventional power market. Energiewirtschaftliches Institut an der Universität Köln, Köln.

Gawel, E., Lehmann, P., Purkus, A., Söderholm, P. and Witte, K., 2017. Rationales for technology-specific RES support and their relevance for German policy. Energy Policy, 102, pp.16-26.

Haas, R., Resch, G., Panzer, C., Busch, S., Ragwitz, M. and Held, A., 2011. Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources–Lessons from EU countries. Energy, 36(4), pp.2186-2193.

Heeter, J., Gelman, R., Bird, L., 2014. Status of Net Metering: Assessing the Potential to Reach Program Caps. National Renewable Energy Laboratory. Technical Report.

Jacobsson, S., Bergek, A., 2011. Innovation system analyses and sustainability transitions: contributions and suggestions for research. Environ. Innov. Soc. Transit. 1, 41–57.

Jägemann, C., 2014. A note on the inefficiency of technology- and region-specific. Renewable Energy Support: The German Case. Z. für Energ. 38, 235–253.

Jägemann, C., Fürsch, M., Hagspiel, S., Nagl, S., 2013. Decarbonizing Europe's power sector by 2050 — Analyzing the economic implications of alternative decarbonization pathways. Energy Econ. 40, 622–636.

Jenner, S., Groba, F. and Indvik, J., 2013. Assessing the strength and effectiveness of renewable electricity feed-in tariffs in European Union countries. Energy Policy, 52, pp.385-401.

KPMG, 2015. Taxes and incentives for renewable energy. KPMG International, Swiss.

Mochizuki, J. and Chang, S.E., 2017. Disasters as opportunity for change: Tsunami recovery and energy transition in Japan. International Journal of Disaster Risk Reduction, 21, pp.331-339.

PVPS, I., 2016. Trends 2015 in Photovoltaic Applications—Survey Report of Selected IEA Countries Between 1992 and 2015. Paris: IEA PVPS.

Schwägerl, C., 2011. Germany's unlikely champion of a radical green energy path. Environment 360 (9 May, 2011. Available at http://e360.yale.edu/feature/germanys_unlikely_champion_of_a_radical_green_energy_path/2401/).

Strunz, S., 2014. The German energy transition as a regime shift. Ecological Economics, 100, pp.150-158.

The Economist, 2012. Energiewende. Germany's energy transformation. De Economist 28 (July, 2012. Available at http://www.economist.com/node/21559667).

Wan, Yih-huei, 1996. Net Metering Programs. National Renewable Energy Laboratory.