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Can Germany's energy system cope with even more PV electricity in the future?

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ABSTRACT

In recent years, Germany has seen impressive growth in its PV market. From a virtually non-existent market based on the 1,000 roof support program at the end of the 1990s, Germany now represents the world's biggest PV market and has created a strong PV industry base. With approximately 17GW of installed PV capacity at the end of 2010 – accounting for 2% of its electricity consumption, Germany has become a solar super power and triggered market growth and technology development worldwide. Nevertheless, the innovative scheme of feed-in tariffs (FiT), which provided incentives for solar PV installations and helped to ramp up an unknown cycle of innovation, will have to evolve towards more diversified ways of supporting system transformation of the electricity market and PV market integration until full competiveness of PV technology is reached in Germany, anticipated for 2017.

Current restrictions of the PV market in Germany

With 7.4GW of newly-installed capacity, Germany reached an all-time high of PV installations in 2010. Nevertheless, the notable production of PV electricity has sparked discussions about the grid's technical capacity to integrate large amounts of fluctuating PV electricity as well as the surcharge for the electricity consumer resulting from the FiT payments. Many responsible industry players in Germany have understood these constraints and have committed themselves to the German PV Industry Roadmap 2020, a strategy paper that has been developed in a process that began in mid-2010 by the German Solar Industry Association BSW-Solar. The paper was realized with the support of the strategy consulting companies Roland Berger and Prognos [1]. In accordance with the German government's national action plan, representatives of the industry agreed at aiming for the creation of a sustainable PV market growth of between 3 and 5GW per year until 2020 in order to enable Germany to at least attain the EU National Action Plan goal of 51GW of PV installations [2].

With that said, the industry is also committed to doing its share in the race towards halving the per-watt PV-system cost and to actively contribute to changing the electricity system to become more capable of absorbing at least 10% of solar electricity, while also distributing a significantly increased portion of electricity from other fluctuating sources, especially wind energy. In the long term, the macroeconomic balance of cost for ramping up this industry sector is overall very positive, and looks set to generate more than €50 billion in 2030 as a result of industry and job creation as well as energy savings in Germany.

Over a long duration, however, such a strategy often involves costly upfront investments. The PV market in Germany is stimulated by apportionment for producing

Source: BSW-Solar/SunTechnics

Figure 1. In Germany, small PV systems play an important role in the transformation of the energy system towards a decentralized, competitive and environmentally-friendly system.

electricity from renewable energy sources (RES-E), borne by the electricity rate payer. This apportionment, commonly known as feed-in tariffs (FiT), is a sensible issue as unnecessary expenses must be avoided for electricity rate payers in Germany. (The term 'feed-in tariff' is rather misleading, as it creates the impression among those unfamiliar with the industry that it is a form of tax or tariff, though it is, in effect, a bonus for the production and provision of clean electricity.)

In addition, no industry player is interested in creating a boom-and-bust market spurred by investors aiming at excessive profits, as recent developments in Spain, the Czech Republic and Slovakia have shown. These countries, like many others in the world, had adopted their own version of Renewable Energy Legislations, working with FiTs or Production Premiums.

Evolvement and development of the German FIT

FiTs were first adopted in Germany in 1990's "Renewable Energy Feed-in-Act", with only a few different groups of tariffs for renewable technologies. Wind and solar electricity were in one tariff category. The new law also guaranteed privileged electricity grid access, which was an innovation in the then centralized and state-owned electricity sector. The system was further specified in the year 2000 within the Renewable Energy Sources Act (abbreviated to EEG in German). This new law differentiated between the FiTs with respect to the different renewable energy technologies, taking into account their specific costs as well as their cost reduction potentials.

Furthermore, the tariffs were set independent from the current electricity consumer prices which gave more investment security to the financing companies. In their original version, FiTs were paid for each kWh produced using renewable energies being fed into the grid. By setting a fixed price for the generation and distribution of renewable energy sourced electricity (RES-E) that is paid to the producer over a fixed period, these FiTs provide a stable investment option for technologies that still need time to become cost competitive, but which are needed

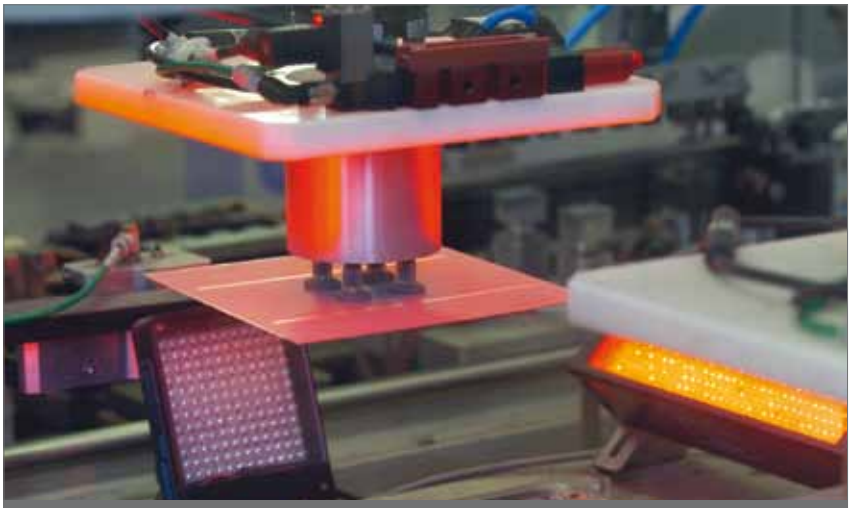
due to other considerations such as climate change, scarcity of resources, etc.

Further noteworthy and vital aspects of the system are the fact that the producers are afforded priority access to the electricity grid and while there is a degree of obligation on the part of the conventional utilities to buy all RES-E, the electricity consumer is also obliged to pay an additional surcharge to refund the extra costs. In this way, a 'polluter-pays' system for excessive energy use is set up, which also incentivizes energy efficiency. A strong motivation for cost reduction is being provided by reducing the FIT for the different technologies by a specified percentage each year. In Germany, this base gradual decrease has been 9% for solar PV in the last few years.

This rather simple but clever legal framework has triggered the creation of the world's largest market for PV and greatly boosted R&D and industrial mass production. Furthermore, awareness of PV's potential has been raised among stock companies as well as domestic users, with the latter having financed and installed a large share of the currently-installed one million PV systems in Germany. The contribution of the integration of RES-E to increasing energy prices has been very limited during most of this period, and has even alleviated some of those increases due to merit-order effects of RES-E at the energy market. The strong increase in energy prices in Germany since the mid '90s is primarily a result of a failed market liberalization in 1998 that established oligopolistic market structure. Other factors for these price increases included rising coal, gas and uranium prices as well as increased energy taxation [3].

Development of a PV industry in Germany

In the early years of Germany's PV industry, many PV products were imported mainly from the then-leading nations of Japan and the USA. A thriving industry quickly emerged on the market in the form of Germany, ramping up its production to 3.2GW at the end of 2010. Since the PV market's shift from a supply to a demand model at the end of 2008, competition among producers and installers has been followed by steep cost reductions. Technological improvements and economies of scale had to be handed down to the private and institutional investors in order to guarantee the attractiveness of PV investments with ever-faster decreases in FiTs. Since mid-2006, the price of a typical crystalline-based PV solar rooftop system (<100kWp) has more than halved in Germany, currently (Q2 2011) coming in at less than €2,500/kWp. This decrease, coupled with lean administrative processes, bankability as well as experienced companies and installers, makes Germany one of the most competitive markets for PV in the world [4]. The strong price decrease for solar PV has obliged the German legislator to conduct unprecedented additional FiT cuts in the past two years. These measures aimed at framing the market size into a determined corridor-of-growth – still without a cap – as well as limiting investors' margins to reasonable levels and thus the surcharge for the energy consumer. A reasonable level of return on a PV investment is considered one above the market interest rate for safe options, such as that of a bank account but lower than more risky options such as stocks, etc. As a matter of political – though unwritten – consensus, a range of 4 to 7% is considered acceptable, with slightly higher rates for institutional investors. One of the strongest aspects of the EEG for many years has been its reliability for investors, making investments in RES-E both predictable and bankable. It is exactly this reliability aspect that is in danger of being threatened by fickle political decision-making.



Source: BSW-Solar

Figure 2. Germany provides most of the machine equipment for PV systems production, and is also a leading producer of high-quality PV systems.

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These new insecurities are, on the one hand, the result of success from a grown-up industry and willing investors. Industry players have developed the capacity to quickly upscale production and massively reduce costs. Nowadays, professional installers and EPC companies can install MW parks within months. On the other hand, the traditional process of setting FiTs had to become more flexible and reactive due to those new production capacities threatening to undermine the intentions of the responsible politicians. Policy makers have come to understand this, and started to become more innovative in reforming the EEG with close support of the industry as of 2008.

Amendments to the EEG: 2009 to 2011

A first step for such an innovative policy was a more flexible and gradual decrease system with the 'corridor of growth' that was first introduced with the EEG amendment in 2009, but which had to be adjusted twice. Additional feed-in cuts in Germany were introduced to limit market growth. A bonus for direct consumption of electricity was newly introduced in 2009 for small systems below 30kWp and extended to systems up to 500kWp. A direct consumption bonus is a slight production bonus for PV electricity that is consumed at the site of production, diminishing the discrepancy between production and demand. This bonus makes it more attractive to directly consume electricity if the kWh rate for household electricity is above 19.49¢(€). In this way, incentives are being set to self-consume locally produced electricity and to adapt the size of the PV system to the actual size of the building as well as to integrate means of storage, especially e-mobility. Local production and consumption will avoid transportation costs and grid extension and provide incentives to construct systems according to electricity use in the future.

This 'direct consumption' approach was one way of reducing the grid load of the production of PV electricity in areas with little consumption, whilst creating incentives for approaching PV system size to local demand. An obligation for remote control applications for solar systems of more than 100kWp had been

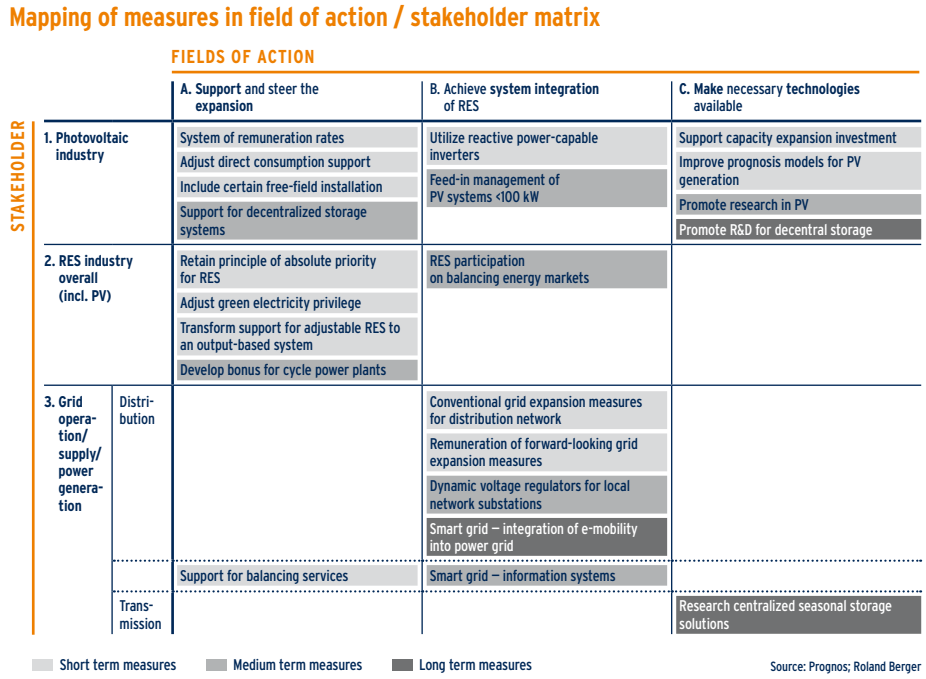

Figure 3. Mapping of measures in field of action / stakeholder matrix.

planned, but could not be realized due to inadequate technical specifications. In 2010, construction limitations for ground-mounted systems were also introduced, partly to avoid conflicts with agricultural land use and local rejection of such projects, but it also heavily limited market growth of this sector.

Some of these new approaches had been formulated with the support of the German Solar Industry Association with the aim of creating a sustainable market growth. Nevertheless, the further integration of fluctuating RES-E such as PV will have to go far beyond those first approaches and challenge Germany's electricity infrastructure, placing it and its companies in the first row of the future energy revolution.

How will the energy system have to change in the future?

In its industry Roadmap for 2020, the German Solar Industry Association identified a series of fields of action, whereby the support scheme for RES-E should be adapted in the short term to provide incentives to alleviate certain shortcomings of the existing regulations for a more even generation of PV electricity. It gives clear indications regarding which areas of the electricity system need to be restructured and where contributions to technology modifications of the PV and the RES-E industries and other stakeholders are required. The different measures have either short-, mid- or long-term perspectives; some of these have been implemented in the meantime since the November 2010 completion of the Roadmap.

A. Supporting and steering the expansion of RES-E

The objective of this first set of measures is to incentivize, through modified support schemes, a continued growth of fluctuating electrical energy production and their integration into the existing electricity grid from a market perspective. Such a modified support scheme should enhance decentralized RES-E production close to consumption, create an even regional distribution throughout Germany and establish a control infrastructure for the electricity grid through measures such as:

- Further expanding incentives for direct consumption of electricity to reduce the additional expenses for the electricity consumer and to reduce grid use, especially on the low voltage level.
- Integrating ground-mounted plants into the direct consumption incentive schemes in order to exploit bigger peak saving potentials at commercial and industry level.
- Enhancing regional distribution and production of PV electricity due to a geographically more diversified FiT scheme according to varying irradiation levels in Germany.
- Integrating a scheme to support combined power provision from multiple RES-E sources, which, as a whole, produce non-fluctuation electricity and make commercialization of such combined RES-E power provision easier, as these amounts are currently too small to be tradable.
- Furthering the development and use of decentralized electrical storage systems such as cheap but potent batteries in houses or electric mobility.
- Creating a regulatory control framework for RES-E power provision to control grid stability, e.g. by installations of compulsory power production measures and their connection to remote control tools.
- Legalizing and establish incentives for anticipatory planning and construction measures of the grid operators, who are obliged to adapt the electricity grid according to requirements deriving from EEG-electricity sources.
- Introducing incentives for the provision of storage capacity at regional level.

B. Improved technical integration of PV and RES-E into the electricity system

The expansion of PV and renewable energies leads to a system transformation, from the central power supply that has existed thus far to a decentralized supply structure. Up to now, power grids have been set up for centralized power supply. The increasing connection of fluctuating and de-centrally fed-in renewable energies leads to new technical challenges that

require an adjustment of the supply system. Technical recommendations for enhancing the integration of RES-E into the electricity grid have the following aims:

- To provide grid system services through renewable energies, e.g. with inverters providing reactive power, remote control technology to reduce the power to ease peak load and develop appropriate communication technology.
- To replace local electrical transformers that change the voltage level with dynamic voltage controllers, which better cope with different voltage levels.
- To install remote control software for PV systems smaller than 100kWp, thus enabling grid operators to regulate electricity-producing systems in times of thread to the electricity system.
- To work on improvements of the European cross-border high-voltage interconnections to make use of varying RES-E sources across Europe.
- To develop more seasonal storage solutions such as pump storage, compressed air, etc.

C. Increased R&D support to develop new technologies

In order to make the quickest possible progress via approaches A and B, but also to limit the conversion costs and to remain competitive on the international market, new technologies must be made available at an early stage. These measures must focus on innovations that will be necessary in creating a 100% RES-E provision and have a rather long-term focus.

Such measures will include:

- Improved prognosis models for PV generation.
- Improved R&D in PV, decentralized and centralized storage.

The proposals made by the German Solar Industry Association have been widely acknowledged by policy makers as providing a comprehensive overview of goals, commitment of the industry and, for the first time, explicit measures detailing how to achieve those goals. Some of the proposals have been reconsidered to amend laws concerning the structure of the electricity grid and respective incentives, and go far beyond amendments of the EEG.

The new EEG for 2012 and perspectives for the future

With its July 2011 decision upon the amendment of the EEG, the German government has started to consider some of the aspects proposed in the Roadmap, though it is focusing mainly on reducing the costs of further PV plants by tight yet gradual decreases according to market size. (Acceptance of this new EEG 2012 has yet to become law by being published in the Official German Federal Law Gazette.) Nevertheless, remote control technology for newly constructed and existing PV plants will become compulsory at different stages in 2012 for eligibility for FiT payments. Direct consumption is being considered as a useful way to change the incentive structure of PV; as a result, its applicability period has been extended. Public programs to enhance R&D in the industry – such as the so-called "Innovation Alliance for PV" – were started in late 2010, while a program to develop energy storage has come to fruition in 2011. E-mobility is a big topic for Germany's government and car makers, and will give rise to a number of R&D programs in the near future. Further minor amendments of the legal basis of the energy grid are currently under discussion. Thanks to the PV-Roadmap, the technical discussions are on their way, although different interest groups require a degree of involvement in the process, leading to an extension of its duration.

The government's decision to fade out Germany's nuclear energy use by 2021, which was made in response to the Fukushima nuclear disaster, will have stimulating effects for developing a different energy infrastructure that is more appropriate to integrating RES-E. Germany's policies and innovative and committed RES-E industry has lent the country the opportunity to master these disruptive changes to the energy system. For the PV industry in Germany, as well as the entire economy, a change in the energy system holds the potential to develop entirely new technologies in one of Germany's core competencies – engineering complex systems and control technology processes. This process, although costly in the first instance, creates first-mover advantages and might well create generic knowledge for those participating companies – and possibly eventual benefits for the entire society.

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About the Author

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