Freie Universität Berlin

Forschungszentrum für Umweltpolitik

Environmental Policy Research Centre

# Mapping the Regulatory Features Underpinning Prosumer Activities in Germany

## The case of residential photovoltaics

Kerstin Tews

FFU-Report 02-2016

Forschungszentrum für Umweltpolitik
Freie Universität Berlin
Fachbereich Politik- und Sozialwissenschaften
Otto-Suhr-Institut für Politikwissenschaft

## Publisher

Freie Universität Berlin
Forschungszentrum für Umweltpolitik
Ihnestraße 22
14195 Berlin
Web: www.fu-berlin.de/ffu

ISSN 1612-3026
FFU-Rep 02-2016

# Mapping the Regulatory Features Underpinning Prosumer Activities in Germany. The case of residential photovoltaics

This case study has been written as a contribution to the Norwegian research project "Power from the People? Driving forces and hindrances". The project is led by the Norwegian Center for International Climate and Environmental Research Oslo (CICERO) and aims to improve the understanding of differences and similarities in the prosumer policies in the UK, Germany and Norway to draw respective policy lessons for the development of a Norwegian prosumer policy.

*Many thanks to all involved project partners for the constructive debates, which helped to improve mutual understanding of the diverse country specifics. I particularly thank Tor Håkon Jackson Inderberg (Fridtjof Nansen Institute Oslo), Britta Turner (Durham University), and my colleagues at the FFU, Rosaria Di Nucci and Sibyl Steuwer for their profound feedback to this case study.*

## Author

Dr. Kerstin Tews
kerstin.tews@fu-berlin.de

The Environmental Policy Research Centre (FFU) has been publishing its *FFU reports* since 1993. *FFU reports* encompass both academic papers and policy-oriented studies. All *FFU-reports* are either peer-reviewed internally or have been reviewed by other project partners and/or the commissioning client. The views expressed are solely the authors' and do not necessarily reflect those of the FFU.

## Abstract

This report maps the regulatory features underpinning prosumer activities in Germany. It is structured according to a case study design which was developed to compare different countries and to draw respective lessons on policies which enable the prosumer uptake.

With a total installed capacity of 38 GW (2015) PV power has reached a stage of systemic importance for the whole power system. Although residential PV (<10 kWp) accounts for only 13 percent of total installed PV capacity, it is an important segment for several reasons. “Prosuming” — although never defined as an official term in Germany — is both a subject and a driver of the adaptive legislation on the RES support scheme and on system integration of RES. It is the result of a dynamic incentive structure set by both regulatory provisions as well as by market developments and the permanent interplay between these factors, rather than as a result of a targeted prosumer policy. Thus, the challenge this case study is confronted with is to map these factors and their respective interplay over a rather long period of time.

## Contents

## List of Figures



## List of Tables

## Introduction

Germany is perceived as a frontrunner in the transforming of its electricity system from a fossil and nuclear fuel-based system into an energy system based on renewables. Key legislation which has shaped the specific course of Germany's energy transition was first enacted back in 2000. It has since been adapted several times to meet the new requirements of system and market integration of renewables and further market and societal developments. These developments have also had implications for the occurrence and growth of prosumers.

This report maps the regulatory features underpinning prosumer activities in Germany. It is structured according to a case study design which was developed to compare different countries and to draw respective lessons on policies which enable the prosumer uptake.

The first section of this paper provides background information about the wider energy context within which the development of prosuming took place in Germany. The second section focuses on particular policies, regulatory provisions and market developments specific to the growth in the number of prosumers, specifically domestic solar PV system owners.

The most striking feature of the German energy transition is, that it is characterized by the rise of new, decentrally organized energy actors, specifically small-scale investors in renewables such as private households, farmers and citizen energy cooperatives. This is particularly so in the segment of photovoltaics in which the above mentioned actors accounted for about 46 percent of installed PV capacity in 2012 (trend:research/Leuphana 2013). Photovoltaics is the fastest growing renewable energy source in the *residential sector* not only in Germany, but worldwide.

Most German residential PV system operators *meanwhile* also consume a certain proportion of the electricity they have produced on-site. Thus, they fulfil the main criteria for being characterized as prosumers according to a commonly used definition: The term "prosumer" emerged in the 1980s in the digital business industry, where it was used to describe users who also created their own online products and services (IEA-RETD 2014: 13). Adapted to electricity industry the term refers to consumers who also produce *their own* power from on-site generation (ibid.).

However, the concept of a prosumer has not yet been officially used in German energy policy. Although the political incentives that were set triggered in particular micro-generation by households, their main objective was in fact to stimulate RES production more widely. The German renewable energy policy is motivated by climate protection concerns, and specifically the desire to transform a $CO_2$-intensive energy system into a low carbon energy system without further use of nuclear power. Households and other small-scale actors were more responsive than the established actors in the energy field to the regulatory framework which included a support scheme for renewables.

Prosuming in Germany needs to be analyzed against the backdrop of the core motivation of German energy policy: to organize a low carbon transformation of the whole energy system. With this motivation in mind, it appears understandable that a dedicated stimulation of prosumer uptake has never been the overarching goal of energy transition efforts. In fact, up until 2009 it was mandatory to feed into the grid any renewable electricity remunerated within the German Feed-in-Tariff scheme.

Consequently, the self-consumption aspect, which is a constituent element of the term “prosuming” (see above), was never explicitly desired in Germany in the early phase of the transition process (with the exception of a short period of time for grid stability reasons). However, the achievement of grid parity in around the year 2012 provided the economic rationale for self-consumption of residential PV power and, consequently, prosuming became a new business model for the whole solar branch in Germany.

In current debates on what is required to manage the challenges Germany is confronted with right at the beginning of a new phase of the power system transformation process, however, prosuming is not uncontested. Distributed power generation on the one hand, and a more decentralized consumption in the form of a certain degree of grid defection on the other, has consequences for the future architecture and functioning of a formerly centralized electricity system, as well as for the respective actor structures in the energy field. The consumers’ engagement in the production and self-consumption of electricity causes changes in their established relationship with traditional actors in the energy field — the energy utilities and grid operators — dependent on the level of production and the degree of self-consumption or “autarky”.

The current German debate on prosuming consequently centers on the issues of grid stability, system integration of the increased amount of distributed and volatile renewable energy sources and on grid-optimized demand and feed-in management, as well as on the societal costs of the transition.

Meanwhile, prosuming has established itself in Germany. It is the result of a dynamic incentive structure set by both regulatory provisions as well as by market developments and the permanent interplay between these factors, rather than as a result of a targeted prosumer policy. Thus, the challenge this case study is confronted with is to map these factors and their respective interplay over a rather long period compared, for example, with the very recent efforts in Norway to stimulate a prosumer uptake.

Against the backdrop of the lack of a targeted prosumer policy and of a formal use or even definition of the term “prosuming” in Germany this study, furthermore, had to solve the problem of identifying relevant data as official statistics do not refer to the term. The following approach was used for the purpose of this study in order to select and to combine relevant data concerning residential PV prosumers.

The typical size of *residential small-scale* PV systems is a maximum PV system’s capacity of <10 kWp. This nominal capacity is relevant, as all official statistics in Germany on installed capacity of RES distinguish according to the system size and not according to ownership. Thus, the PV system size of <10 kWp will be used in this paper as a proxy for residential PV.

In 2014 this segment below 10 kWp accounted for 56 percent of all PV systems installed in Germany, which is in practice an absolute figure of 850,000 PV systems (1.5 million PV systems in total). In terms of the *total* installed PV *capacity* in 2014 (around 38 GW) the segment of PV systems below 10 kWp accounts for 13 percent (5,062 MW).

# 1 Mapping the contextual background of the national energy sector

## 1.1 Historical developments and national energy transition efforts[1]

Since the 19th century coal constituted the main energy source for power generation in Germany. The Ruhr Valley mining area became Germany's core industrial region, shaping cultural and economic development at that time. In the 1950s the use of oil and nuclear power became more common, while the use of coal started to decline. In the 1970s nuclear power began to become the target of major national public protest and a grassroots movement evolved.[2] In the aftermath of the 1986 Chernobyl disaster and triggered by the greening of the electorate, in the 1990s Germany began to establish a legal framework in order to promote the deployment of renewable energies. With the Electricity Feed-In Act of 1991 and the adoption of the Renewable Energy Act (EEG) in 2000, the basic policy instruments were created to politically prioritize green over conventional power (Hake et al. 2015).

The first agreement to phase-out Germany's nuclear plants was reached in 2000 under the Social Democrat-Green coalition. Even though this decision was reversed in 2010[3] by the then new conservative-liberal government, the nuclear disaster in Fukushima one year later prompted the same government — driven in particular by Chancellor Merkel's responsiveness to the anti-nuclear public mood — to agree on a renewed nuclear phase-out.

Although key legislation regarding the energy transition, such as the Renewable Energy Act, were enacted a decade earlier, the policy known worldwide as the *Energiewende* (energy turnaround) is often attributed to the decisions made in 2011 by the conservative-liberal government. Immediately after the Fukushima disaster, the government shut down

---

[1] For an excellent and detailed overview of the historical background of the German energy transition please see Hake et al. 2015.

[2] The German anti-nuclear movement evolved into one of the origins of the Green Party, which was founded in 1980 in West Germany.

[3] In 2009 the Christian Democrats and Liberal Democrats were elected. Under pressure from the new liberal coalition partner (FDP), the new government decided to follow a market-oriented approach to energy and climate policy that treats all low carbon technologies equally instead of "discriminating" in favour of some technologies in order to achieve climate targets. Consequently the government rejected the nuclear phase-out and announced significant extensions to the lifetimes of existing nuclear power plants.

the country's seven oldest nuclear power plants and appointed an "Ethics Commission for a Safe Energy Supply", which was mandated to prepare a political consensus on nuclear policy in Germany after Fukushima (see Schreurs 2014). The commission's recommendation to phase out nuclear energy by 2021 legitimized the final phase-out of nuclear power, adopted by a decision by the cabinet in June 2011.

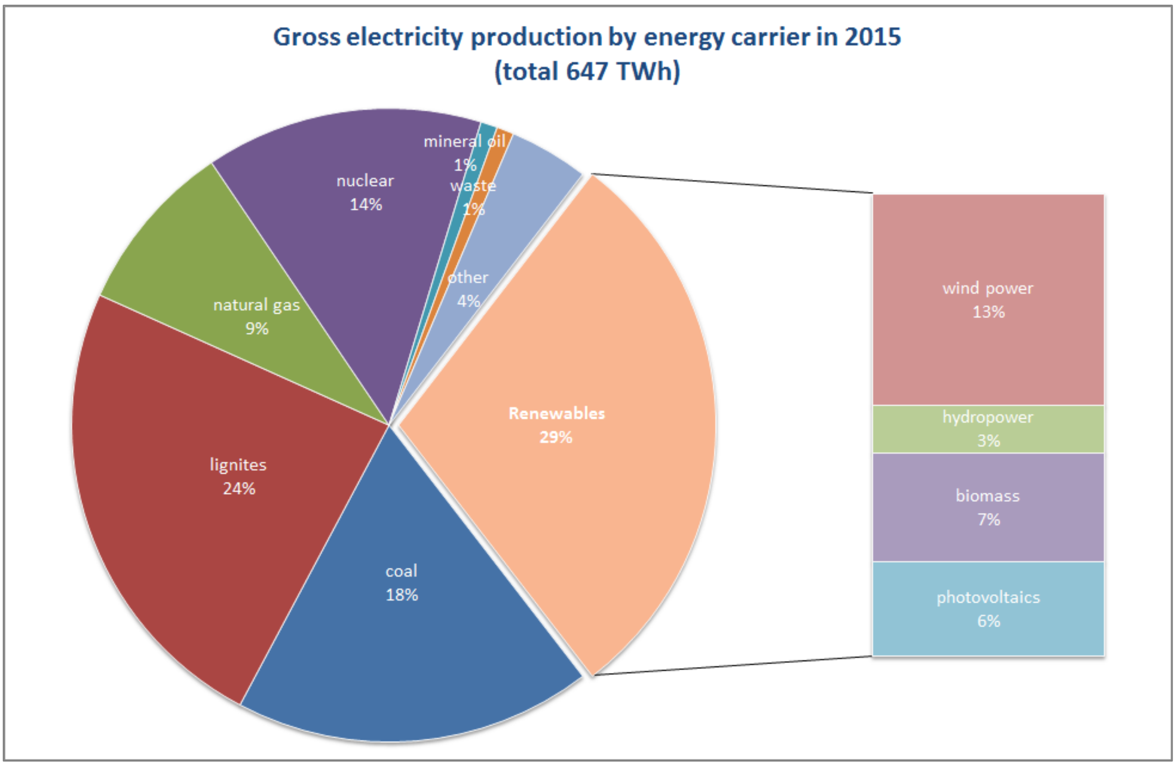
On the basis of the Ethics Commission's recommendations and important policy decisions made by the German Bundestag, the pathway to a low-carbon energy system was to rely upon the following milestones: a nuclear phase-out, an increase in RES in the energy mix, and increased energy efficiency. In 2013 the new "Grand Coalition" government adjusted the official target, which had been adopted in 2011, to increase the share of renewable energies in the German power mix to 40-45 percent by 2025 and 55-60 percent by 2035. The coalition added legal provisions for the definition of corridors or caps on annual capacity additions by RES technology.

## 1.2 The technical system and the energy market

### 1.2.1 Electricity production

In 2015 Germany's total gross electricity production reached around 647 TWh. With a share of approximately 42 percent, coal (hard coal and lignite) still dominates the power mix, but the importance of renewables is increasing, with a share of 29 percent. Nuclear power, which is to be phased-out by 2022, has become less significant, accounting for only 14 percent of the total power production in 2015 (see Figure 1).

**Figure 1: The German Power Mix in 2015**




Source: Own illustration based on BMWI Energiedaten, (n.d.) version 05.01.2016, table 22.

Germany is the country with the highest share of renewable power — mostly photovoltaics (PV) and wind — in Europe in terms of installed capacity. Distributed over 1.5 million power plants, the total nominal power of installed PV increased to approximately 38.5 GW in the year of 2014, thereby contributing significantly to Germany's power supply (Fraunhofer ISE 2015).

### 1.2.2 Consumption and electricity prices

*Consumption pattern*

Electricity consumption by industry accounts for half of the total consumption, whereas the residential sector and smaller business customers each account for about a quarter of electricity consumption (Agora Energiewende 2015). Electricity in private households accounted for 19 percent of final energy consumption in the household sector (Arbeitsgemeinschaft Energiebilanzen 2014).

Compared to 2008, Germany aims to reduce its gross electricity consumption by 10 percent by 2020. In 2014, gross electricity consumption was 576.3 TWh, which was 3.8 percent less than in 2013 (Agora Energiewende 2015). Although electricity consumption in general has been declining for about a decade (BDEW 2014), the electricity consumption of private households in the period of 1990 to 2013 rose by 18.1 percent (Bundesumweltamt 2015). However, the increase of electricity consumption in the household sector can be attributed to the increase in the *number* of households, while the *average household size* is decreasing. According to statistical data in 2014 there were 40.2 million households in Germany, single and two-person households accounted for 75 percent. Single households account for 41 percent of all German households, their share increased in the last 10 years by about 9 percent (Destatis 2016). The average electricity consumption in the German household sector is about 3,100 kWh/a.

About half of German households live in rented apartments or houses. The home-ownership rate was just 52.5 percent which, compared to other European countries, is rather low (Eurostat 2013).

*Electricity prices*

Electricity prices have risen for both households and industrial customers over the past years. A great portion (but not all) of these price increases can be attributed to the cost of the energy transition — in particular increases in the so-called EEG surcharge[4]. The burden of the EEG surcharge is distributed among the various consumer groups, whereby non-

[4] The EEG surcharge is added to the price of electricity per kWh consumed and serves to cover the additional costs of promoting electricity generated from renewable energy sources.

privileged consumer groups[5], such as private households bear the highest economic burden (Mayer and Burden 2014; see Figure 2).

The debate on the social acceptability and affordability of the energy transition in Germany has focused on the level of the EEG surcharge and its fairness. Against the backdrop of the lack of a comparably fierce public debate on rising prices for other household energy carriers (gas, heating oil, petrol) it becomes obvious that the strong governmental regulation of electricity prices serves as a kind of invitation to politically renegotiate administered price components, while other price components or rising prices for other energy carriers that are contingent on anonymous market mechanisms escape such influence (for a critical discussion see Gawel et al. 2016).

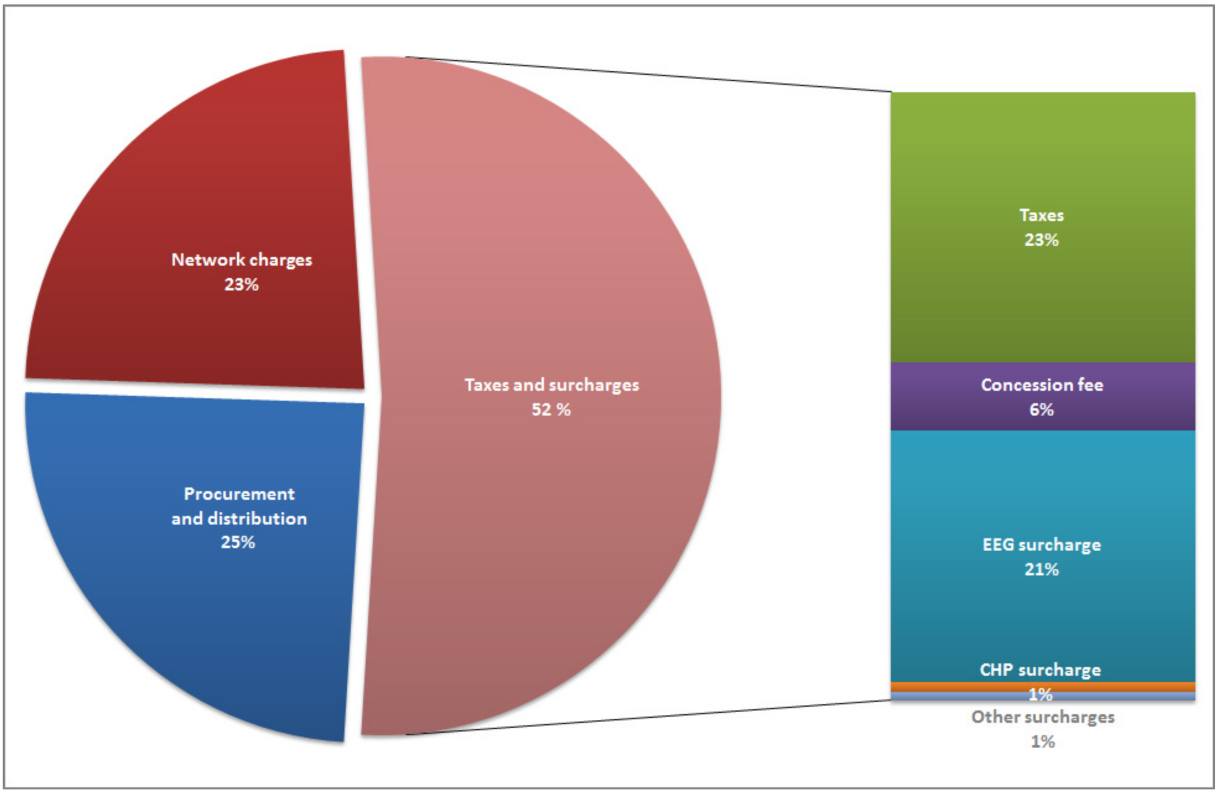
In general, German's residential consumers pay among the highest electricity prices in Europe, topped only by household electricity prices in Denmark.

**Figure 2: Development of German average household electricity prices 2007-2015**


Source: Own illustration based on BDEW 2015

5 Non-privileged consumers are those who pay the full EEG surcharge. In contrast to these consumer groups exemptions to the EEG surcharge are granted to German electricity-intensive companies for reasons of international competitiveness.

**Figure 3: Composition of the German average household electricity price in 2015**




Source: Own illustration based BDEW 2015

### 1.2.3 Status of smart meter rollout in Germany

The main driver for the introduction of smart metering was the EU regulation on the liberalization of the electricity market, energy efficiency policy and – associated with both – the legal provisions for the introduction of smart tariff structures, which offer customers active participation in the liberalized market and/or electricity suppliers and energy service providers active demand-side management.[6]

[6] Directive 2006/32/EC (Art 13) on energy-use efficiency and energy services envisages the introduction of *"…individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use."* Directive 2005/89/EC of the European Parliament and of the Council from 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment also envisages, among other measures to be taken by Member States, the "encouragement of the adoption of real-time demand management technologies such as advanced metering systems" (Art 5, 2d). Additionally, the Directive 2009/72/EC concerning common rules for the internal market in electricity states in Article 3 (11): "*In order to promote energy efficiency, Member States, or when the Member State has so provided, the regulatory authority shall strongly recommend that electricity undertakings optimise the use of electricity, for example by providing energy management services, developing innovative pricing formulas or introducing intelligent metering systems or smart grids where appropriate*". In addition, Member States have to "*ensure the implementation of intelligent metering systems that shall assist the active participation of consumers in the electricity/gas supply market…*". Furthermore, the EC Directive 2009/72/EC obliged each Member State to carry out a cost-benefit assessment (CBA) to evaluate the feasibility of a large-scale smart meter rollout (at least 80 percent of consumers subject to smart metering by 2020).

Via an amendment of the German Energy Industry Act (EnWG) in 2008 and the introduction of a law on the liberalization of metering, the regulator transposed basic EU provisions into German law. The regulator exclusively relied on market dynamics, in particular on the demands of final electricity users (Tews 2011a: 22pp). However, it became clear relatively early, that this was far too minimal an incentive to trigger a large-scale rollout of smart meters.

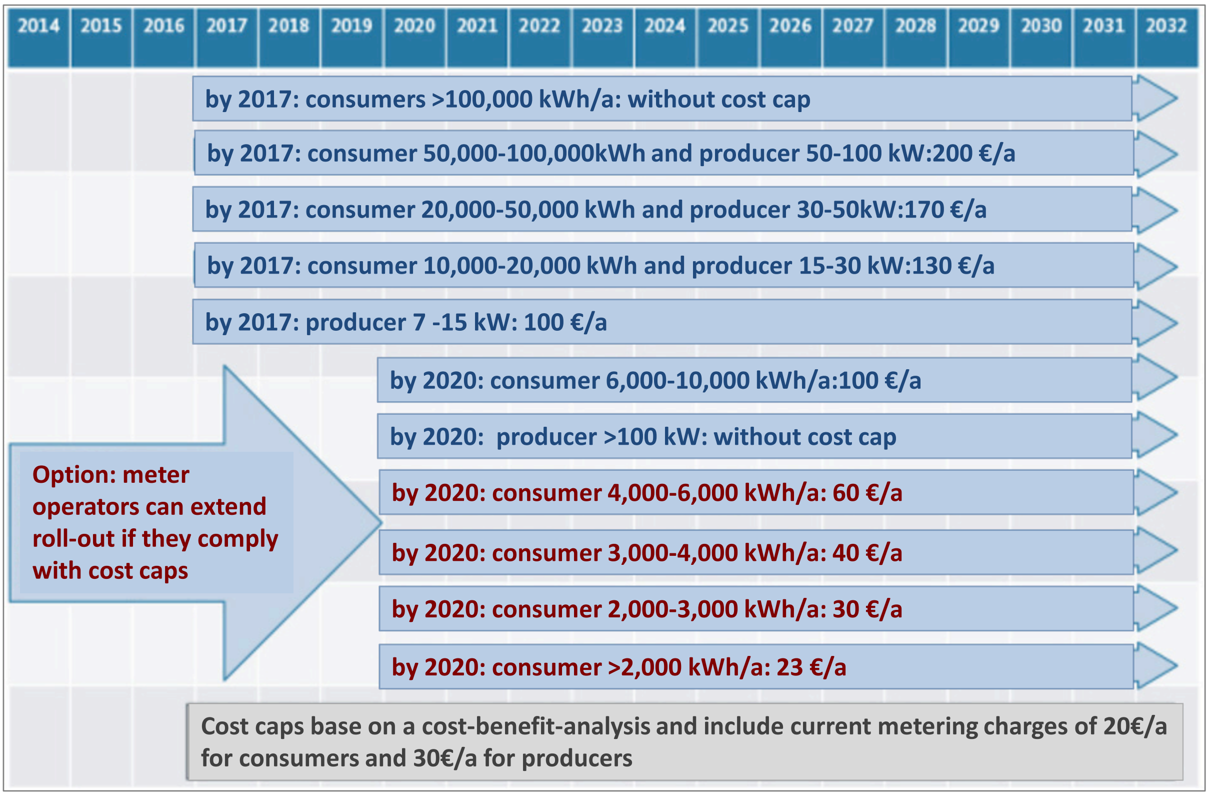
Thus, since the amendment of the Energy Industry Act (§21c, EnWG) in 2011 the regulator has an obligation to install smart meters for the following cases:

- final consumers with annual electricity consumption over 6000 kWh,
- *new* generation facilities pursuant to the national Renewable Energy Act and the Combined Heat and Power Act with an installed capacity of >7 kWp, and
- final consumers in new and renovated buildings (this provision is due to be abolished by the next reform of the EnWG).

According to the provisions of the EnWG (2011) smart metering should enable consumers to better participate in the market by offering them a choice of smart tariffs (time-of-use, etc.). Furthermore, it should ensure transparency and control of the electricity consumption by the final user in order to tap energy efficiency and cost saving potentials.

In November 2015 the cabinet adopted the government's draft bill on "The Digitization of the Energy Transition". In contrast to most other EU member states, Germany will not pursue a large-scale rollout of smart meters or smart metering systems. The German cost-benefit analysis according to EU Directive 2009/72/EC (Ernst & Young 2013) did not recommend such a large-scale rollout targeting all households by 2020 as the costs of smart metering systems for final users with low levels of annual consumption would far outweigh the average potential for annual energy and cost savings. A rollout of at least basic smart meters and/or advanced metering systems is expected to start in 2017 in a step-by-step manner. It will prioritize large consumers with greater energy saving and load shifting potentials. The installation of at least basic smart meters, however, should be finalized for all consumers by 2032. The draft bill also introduces price/cost caps for the installation and operation of smart meters, based on a cost-benefit analysis, which considers the cost of the smart meters and the benefits they offer in terms of savings and load-shifting (see Figure 4 and Table 1, page 22). Following public consultation the law has been adopted by parliament (Bundestag) on the 23$^{th}$ of June 2016. The Federal Council (Bundesrat) is scheduled to finalize the law on the 8$^{th}$ of July 2016.

**Figure 4: Time schedule and cost caps for smart meter rollout according to governmental plans[7]**




Source: Illustration adapted (translation) from BMWi – homepage: FAQ concerning draft bill on the “Digitization of the energy transition”: http://www.bmwi.de/DE/Themen/Energie/Netze-und-Netzausbau/intelligente-messsysteme,did=726780.html?view=renderPrint, accessed, 09.02.2016.

## 1.3 Main actors in the energy field at a glance

### 1.3.1 Energy policy actors

The regulatory framework for energy policy is developed at federal level. However, Germany is a multilevel federal system, thus, the subnational level does not only implement federal law, but also enjoys legal, administrative and budgetary competencies. States, counties or municipalities can, for example, specify their own renewable energy policy targets and adequate policies and measures to achieve them. Particularly relevant for the deployment of RES — especially for those renewables with a spatial impact — are the subnational level’s competencies with regard to spatial planning.

The most obvious political challenge of the current energy transition process is a lack of multi-level coordination, due to the multiplicity of renewable energy expansion strategies made by municipalities, counties, regional states and the federal government, which often hardly relate to one another. So far, governments in different jurisdictions have primarily

7 The adopted bill now contains some deviations to the schedule defined in the draft bill which are relevant for small prosumer installations below 7 kWp. See section 2.3.4)

followed their own interests when making decisions about renewable energy targets and implementation policies (for more information see Ohlhorst et al. 2013; Klagge and Arbach 2013; Schreurs and Steuwer 2015).

At the federal level, primary responsibility for the electricity sector lies with the Federal Ministry of Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie, or BMWi), although the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, or BMUB) has some competencies in the electricity industry as well.

### 1.3.2 Independent regulatory authorities

In the course of the liberalization of the European energy markets, the German electricity market began to open up in 1998, allowing new actors to enter the market for the sale of electricity and provision of services. In addition to the core EU-level regulation, the supervision of competition at all levels of the market continued to be responsibility of the Federal Cartel Office (Bundeskartellamt, or BkartA). The Federal Network Agency (Bundesnetzagentur, or BnetzA) is responsible for the regulation of natural monopolies such as grids, telecommunications, postal services, etc. The BnetzA's central task in the energy field is to ensure non-discriminatory third-party access to the grids and to authorize calculations on the network charges made by grid operators. The BnetzA and the regulatory authorities at the state level are responsible for expansion and/or optimization of the electricity grids. Both agencies fall under the authority of the BMWi.

### 1.3.3 Energy industry actors: incumbents and challengers

Even though Germany has unbundled large parts of its electricity generation, transmission, distribution and retail activities, the four large power companies E.ON, RWE, EnBW and Vattenfall are still the "big" players in the power market. However, due to the growing share of renewables in the power mix, the ownership profile of electricity production has changed. The price-based support scheme for RES (Renewable Energy Act, see section 2.1.1) functioned as a shelter, allowing small-scale renewable electricity producers to develop in a niche. For the "big four" the returns on investment were apparently not seen as high enough to encourage investment in the then niche segment of the electricity market. However, faced with increasing losses in their traditional business and with RES becoming less niche, these incumbent actors realized the need to adapt their strategies to the new reality of the electricity market (Kungl 2015). It is important to note that in Germany there is still a substantial difference between the ownership profiles of conventional and renewable electricity generation. Whereas the "big four" own most conventional generation, they only hold a share of 5 percent of renewable resources (Agora Energiewende 2015). New actors have challenged established patterns of domestic energy policy interaction through experimentation and innovation at a decentralized level (Beermann and Tews 2015). According to a survey carried out by trend:research GmbH and the Leuphana Universität Lüneburg (2013) nearly half (46.6 percent) of the total RES capacity installed in Germany is owned by citizens and citizens' energy cooperatives.

In the transmission sector, the key players are the four regionally fixed transmission grid operators (TGO) TenneT TSO GmbH, Amprion GmbH, 50 Hertz Transmission GmbH and TransnetBW GmbH.

The distribution and the supply branches are more complex and are characterized by a vast number of companies. Approximately 900 distribution grid operators (DGO), including the four major companies, as well as around 700 municipal utilities (Stadtwerke) currently serve 20,000 municipalities (Agora Energiewende 2015).

There is an ongoing trend to *re*-municipalize distribution grids, i.e. energy services are being returned to public municipal management. This move has been buttressed by the expiry after 20 years (since the Energy Industry Act (EnWG)) of many of the so-called "concession agreements" - private law contracts between municipalities and contractors for the use and operation of local distribution grids. Several thousand "concessions" for operating electricity grids will be newly awarded within the next few years. A number of municipal utilities (Stadtwerke) have become crucial drivers for local innovation. In some cases municipal energy utilities have even been re-founded by citizens and local political actors to serve as decentralized local innovator in support of the renewable energy transition from below and to create added value at the local level (Beermann and Tews 2015).

# 2 Prosumer-relevant framework conditions in Germany

This section identifies the regulatory features and predominantly politically induced market developments that are relevant for prosuming, as there are regulations and market developments that:

- enable or constrain private household investment in on-site RES, and in particular PV
- enable or constrain connection to the grid for the feeding in of RES power, and
- enable or constrain self-consumption of power produced.

## 2.1 Incentives for households to invest in micro-generation

As early as 1990 the German government and the sub-national states (Bundesländer) had adopted a globally unique PV subsidy program in order to test the practical functionality of small, decentralized, grid-connected PV systems, the "1,000 roofs program". Addressees of that program were first-mover households, for whom up to 70 percent of the costs of a small PV system (1-5 kWp) were subsidized. This program ran until 1995 and induced around 2,000 PV installations on the roofs of detached and semi-detached houses. The subsidy was linked to an obligation to submit the yield data of one's system for scientific evaluation of the maturity of the technology. Despite the rather high funding rate of 70 percent, households still had to make a personal contribution of on average around 10,000 EUR for a small 2.6 kWp PV system (Hoffmann 2008). Therefore, it is worth highlighting that this investment was mainly made by early “pioneer” adopters without a realistic expectation of financial returns.

Another predecessor of the cost-covering remuneration scheme and a further milestone in the upscaling of PV in Germany was the Feed-in-Law (Stromeinspeisegesetz) passed in 1991, which set the first remuneration for PV electricity fed into the grid at an average of 8.5ct/kWh. Compared with the then PV power generation costs of 90 ct/kWh this first feed-in-tariff was not really meant as an economic incentive to attract a large number of investors. It was the pioneers, who engaged in this “uneconomic” investment. However, in 1999 a new grant program was enacted — the so-called “100,000 roofs program”. The program supported the installation of PV systems larger than 1 kWp. Loans, with interest rates of 4.5 percent below market conditions, were offered with a repayment period of ten years and two years of deferred payments. The program aimed to develop 300 MW of additional capacity. At the end of the program in July 2003 55,000 installations and 261 MW of additional capacity had been supported.

The most fundamental shift from experimentation to a broader market diffusion program of this technology occurred in 2000 with the adoption of the Renewable Energy Act (EEG). It was from the very beginning a very fine-tuned legal framework, which mixed diverse policy instruments to stimulate the wide deployment of renewable energy sources.

### 2.1.1 Basic provisions of the Renewable Energy Act enabling investment in RES by households

The rapid increase of RES in Germany’s power mix over the past decades can be attributed to favorable political framework conditions and is a key component of the country’s well-known energy transition (“Energiewende”).

The EEG is the main instrument for stimulating RES deployment in Germany. The EEG was adopted in 2000 and so far underwent four amendments in 2004, 2009, 2012 and 2014.

The basic provisions of the law comprise:

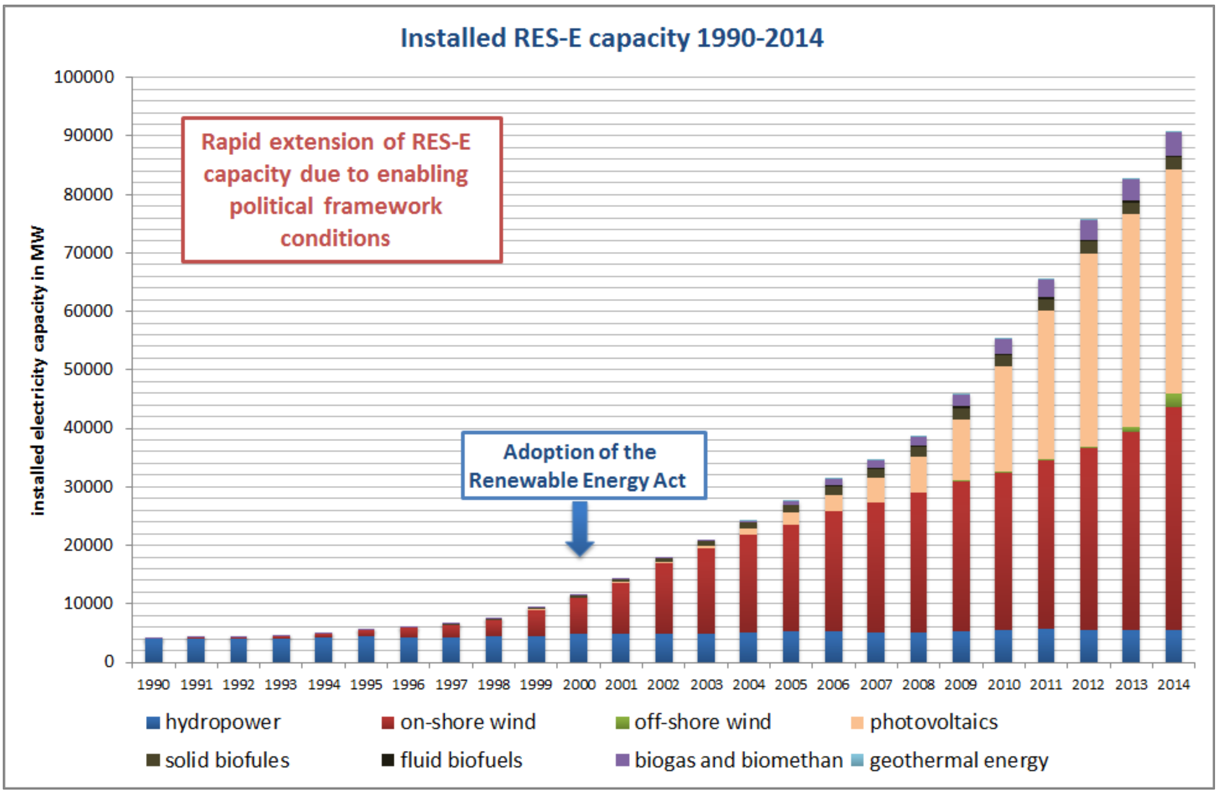
- a support scheme for electricity from renewables
- a purchase obligation for grid operators, and
- the solidarity principle in bearing the cost for RES deployment.

Until the most recent reform of the Renewable Energy Act (EEG) in 2014, Germany has applied a price-based support scheme for RES.[8] Support schemes for renewables can general-

[8] In 2014 the support scheme underwent a fundamental instrumental shift. Direct marketing became mandatory for all newly installed renewable energy facilities with a capacity of more than 500 kW (by August 2014) and 100 kW (by January 2016). In addition, instead of the existing feed-in tariff or premium tariff, by 2017, the level of support granted will be determined by a competitive bidding process. Thus, Germany has introduced a volume-based auction system, which differs fundamentally from the previous price-based support scheme with administratively fixed prices for RES. However, small-scale residential RES producers are still exempted from this instrumental shift (for more details on drivers and implications of this instrumental shift, see Tews 2015).

ly be divided into either price-based or volume-based schemes (ecofys 2014). In contrast to volume-based support schemes that determine quantity targets for the expansion of RES (e.g. quota and auction systems), the support level for price-based schemes is administratively fixed; either independently of the market price by a set remuneration for every kWh of RES electricity produced, as in the case of a guaranteed feed-in tariff (FIT), or linked to the market price with an additional fixed or floating premium, the so-called feed-in premium (FIP). For a long period, the German support scheme was based solely on a FIT, which guaranteed producers a set remuneration depending on the specific RES technology for a certain time period (usually 20 years). In 2012 the FIT was supplemented by the introduction of a floating FIP, which producers could choose as an option, in order to stimulate the market integration of RES.

**Figure 5: Total installed RES-E capacity 1990-2014**




Source: Own illustration based on data from BMWI Energiedaten (n.d.)

This price-based support scheme was complemented by a purchase guarantee and priority feeding into the grid of renewable electricity. Thus, grid operators were obliged to accept renewable electricity from third parties, feed it into the electricity grid and pay RES producers fixed prices.

The support scheme is financed by the so-called EEG surcharge on electricity consumed in kWh (solidarity principle). The EEG surcharge has to be paid by all electricity consumers who are not exempted by means of a special regulation (e.g. energy intensive industry). The surcharge is calculated annually by the transmission grid operators and reflects the differential between the grid operator’s expenditures for funding payments to RES operators and their revenues from selling RES electricity on the wholesale market. As of 2016, the surcharge amounts to 6.354 euro-cent/kWh (see also Figure 2).

The provisions of the EEG (as introduced in 2000) offered conditions that enabled private households' investment in on-site RE capacity.

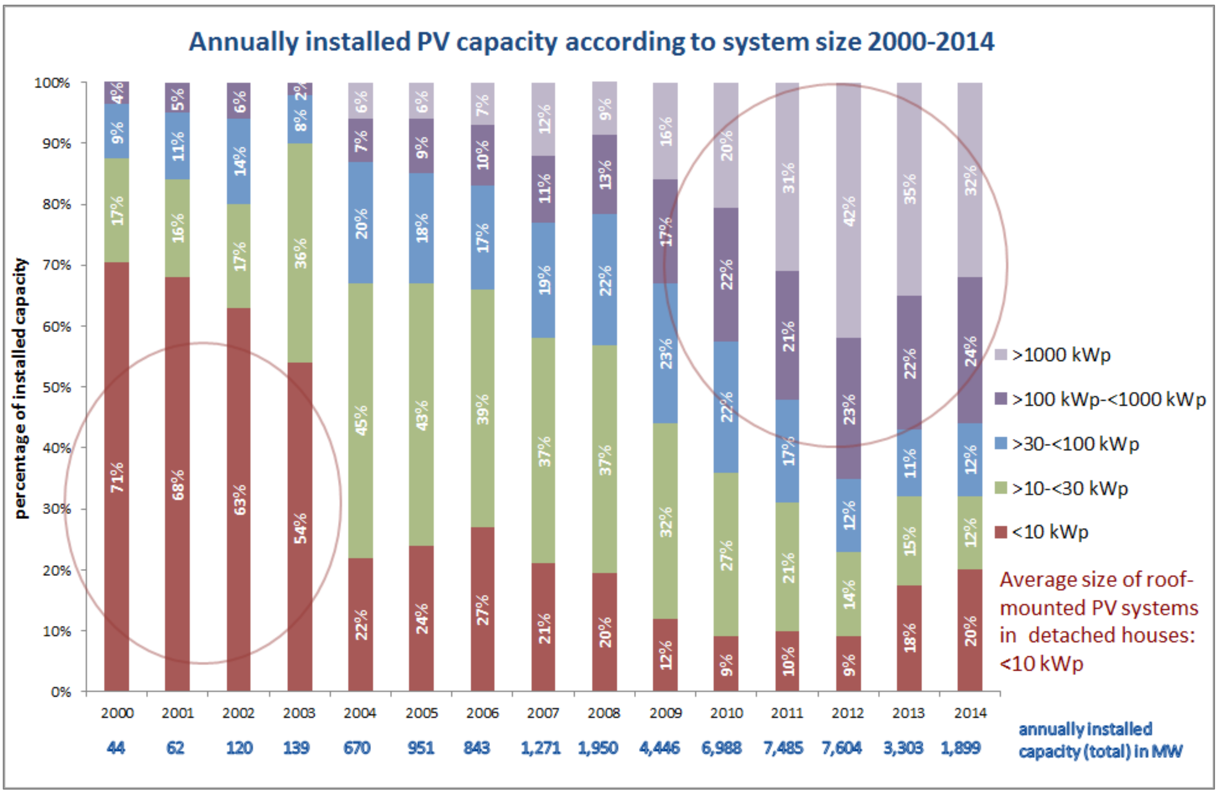
Firstly these provisions reduced the risks for investors through:

- fixed prices per kWh fed into the grid over 20 years, and
- technology-specific remuneration rates according to maturity of the technology.

As risk reduction is most relevant for those actors who cannot diversify risk, these provisions offered favorable conditions for investment in RES by small actors, such as households or small enterprises.

Secondly, further provisions, such as the purchase obligation for grid operators and the priority access for RES to the grid, minimized the transaction costs associated with the selling of RES. Low transaction costs in the trading of power are particularly relevant for new actors who are unfamiliar with the established rules in the energy field or market.

**Figure 6: Annually installed PV capacity according to system size 2000-2014—changes in structures (investors?) of newly added PV capacity/a over time**




Source: Own illustration based on data compiled from ZSW 2014 (2000-2013) and Proteus Solutions GBR (2014) and BMWI Energiedaten (n.d.) (total installed PV capacity/year in MW)

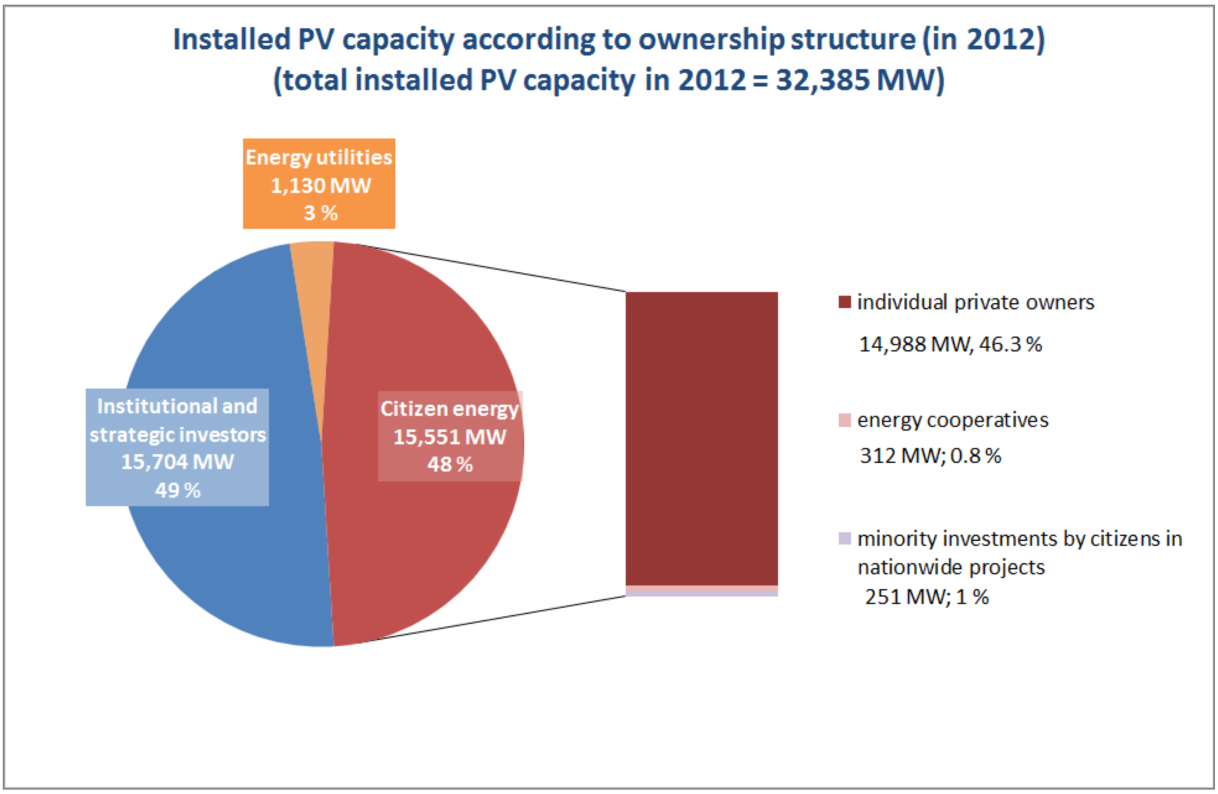
Thus, the Renewable Energy Act has offered a high degree of planning security for investors. It has sheltered small-scale and new actors' investments and fostered small-scale RES-growth in a niche for over a decade.

This can be seen in the development of annually installed capacity according to system size (Figure 6).

While at the beginning of the process newly added capacity mainly took the form of small-scale PV systems, the situation has since changed. In 2014 small-scale investment accounted for only 20 percent of newly added *capacity*. However, regarding the absolute number of annually added installations, systems below 10 kWp still very much dominate.

Figure 6 clearly shows how important the provisions of the EEG were in stimulating small-scale investment by private actors. The EEG politically pushed the market diffusion of this technology; small-scale actors' — in particular German households' — investments in roof-mounted PV encouraged further technological innovations in PV systems and decreased the price of PV systems.

**Figure 7: Almost half of installed PV capacity is "citizen energy"/"power from the people"**




Source: Own illustration based on trend:research/Leuphana 2013.

*Annotation*: The group "*citizen energy*" comprises individual private owners (single households, farmers and small cooperatives which install an RES plant/PV system in their region). Energy cooperatives are only characterized as such in cases where the citizen's investment is at least 50 percent and investors come from the region where the RE plant is installed. The group "*institutional and strategic investors*" comprises investors such as banks, funds and insurance companies as well as players from industry and business, for example agro-businesses and project developers. The group "*energy utilities*" comprises the traditional "big four" energy utilities as well as regional/municipal and international energy utilities.

This is one of the most striking features of the German energy transition; that it was mainly driven by new actors — private individuals and energy cooperatives — producing so-called “citizen energy”. According to the only available ownership analysis of the German RES market, in the photovoltaic segment “citizen energy” accounted for almost 50 percent of total installed capacity in 2012 (trend:research/Leuphana2013) (Figure 7).

### 2.1.2 Diverse additional grants for PV at the federal and sub-national level

In contrast to other countries which replaced grant-based financial support for renewables with more comprehensive economic instruments, such as volume- or price-based support schemes for electricity fed into the grid, in Germany parallel to the FIT/P scheme there still exist diverse investment support schemes at the federal and sub-national level for PV, CHP generation or other techniques and technologies relevant to the reduction of $CO_2$ emissions. The current grant for PV system installations offered by the public KFW bank[9] is applied only for grid-connected systems and is additionally coupled with the requirement for a storage system or DSM enabling technology. The current program design reflects the requirements of a new phase in the transition process — to integrate distributed electricity into the system for security of supply reasons.

### 2.1.3 Regulatory developments which worsen investment conditions for households

The Renewable Energy Act has from the very beginning involved a kind of degression in the remuneration rates according to the decreasing system costs, i.e. the maturity of the respective technology. Thus, the feed-in tariff an investor can expect depends on the time at which the PV system/plant was commissioned. From this point on the investor receives this specific remuneration over the coming twenty years.

In the early phase of the support scheme, the remuneration rates for PV were rather high, according to some critics they were much too high, which instigated a boom in the PV market. But this boom also caused a large increase in the EEG surcharge, and thus a lot of discussion about over-subsidization, social fairness and the erosion of the solidarity principle.

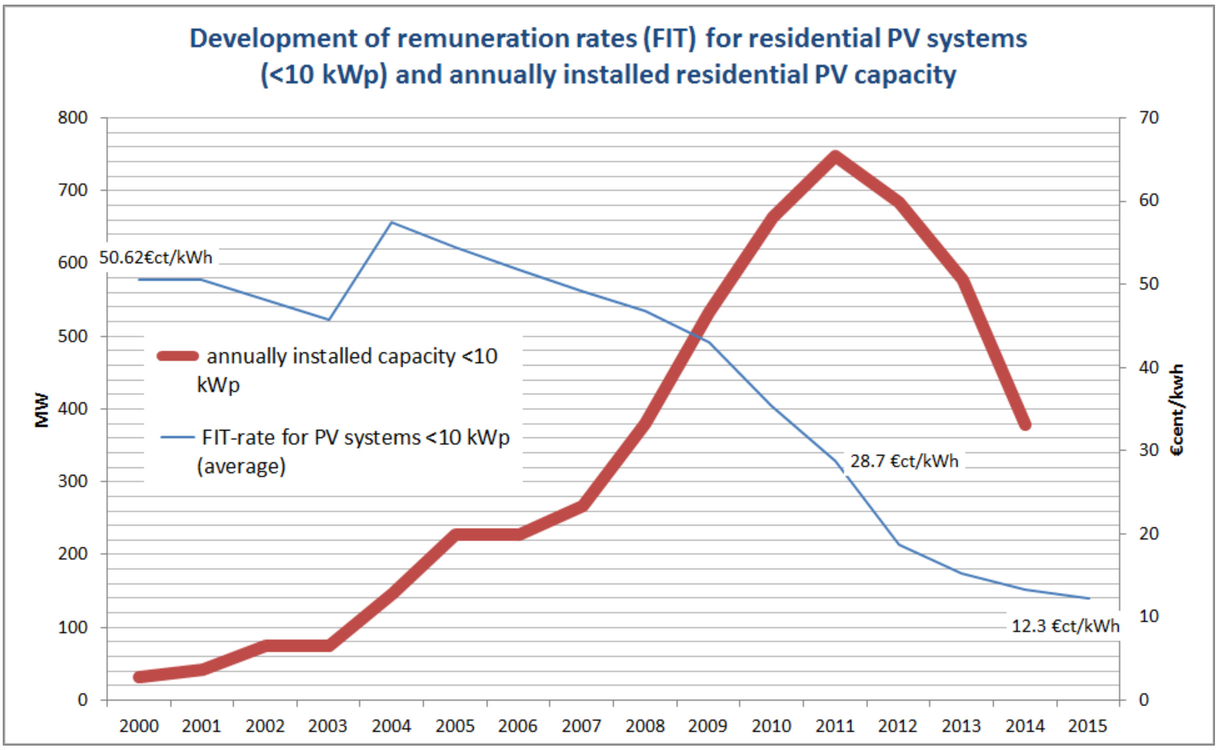
Consequently, the government announced in 2012 that the FIT for PV would be discontinued when a total cap of 52 GW installed PV capacity is reached (at the moment 38 GW PV have been installed). In addition the government introduced in 2014 a soft cap of 2.4-2.6 GW per year and a *responsive* degression framework, i.e. a decline in the FIT on a monthly basis in response to the performance of the cap (flexible ceilings/corridors); these measures were both to stay in place until the point that the total cap was reached.

---

[9] The German Bank KfW (“Kreditanstalt für Wiederaufbau”) is one of the world’s leading promotional banks. It is committed to improving economic, social and ecological living conditions in Germany and around the world on behalf of the Federal Republic of Germany and the federal states.

If the rate of solar power expansion is placed within this defined annual corridor, then a basic degression in the remuneration of 0.5 percent per month is defined. However, if more PV power is added beyond the defined annual cap, the degression of the FIT will be raised too. Should less PV be added than defined in the annual corridor then there will be a degression lower than 0.5 percent or no degression at all (§13 EEG 2014). The rate of degression is calculated by the German Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur). Since September 2015 the remuneration rate for small residential PV systems of <10kWp has not changed and remains at 12.31ct/kWh (Bundesnetzagentur 2016). This indicates a lower amount of annually added PV than defined in the annual corridor: between December 2014 and November 2015 only 1.4 GW of PV power was added (ibid).

**Figure 8: Decrease in annually added PV capacity due to the degression in remuneration rates**

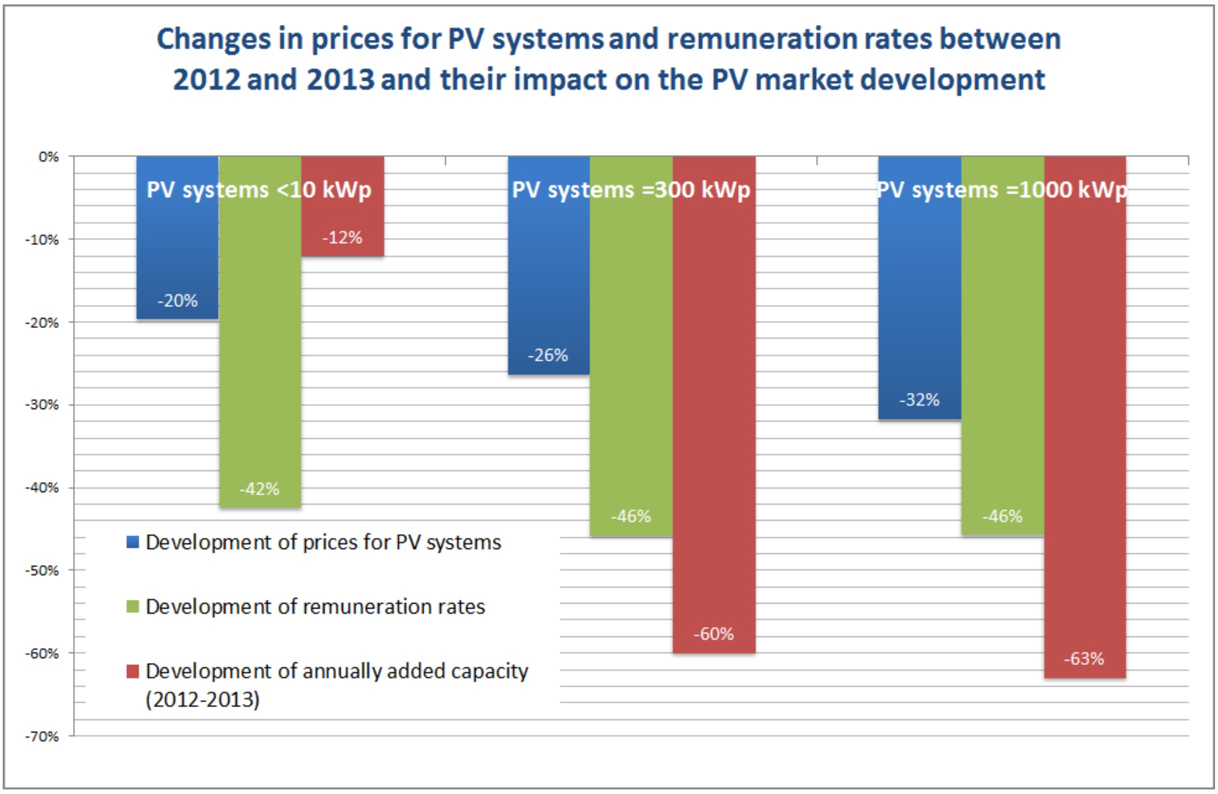



Source: Own illustration based on data from https://www.netztransparenz.de (remuneration rates); ZSW 2014 (installed PV capacity <10 kWp/year).

In the past, in particular since 2012, the degression in the remuneration rates has already caused a massive drop in investment in PV capacity in the residential sector (Figure 8). This can be interpreted as a rise in uncertainty among residential investors as the revenue calculation becomes increasingly risky due to (theoretically) monthly changing remuneration rates and very low remuneration rate for PV.

The drop in the PV market is, however, not restricted to small residential PV systems but applies also to larger PV systems. Remuneration rates decreased to an extent, which cannot be compensated by the equally decreasing PV system prices (Figure 9). Thus, there is in general greater economic uncertainty across the entire German PV market. For residential systems, a study has even calculated that newly installed small systems can no longer operate economically without a relatively high share of self-consumption (ZSW 2014: 37).

**Figure 9: Uncertainty in the PV market due to the decrease in remuneration rates**



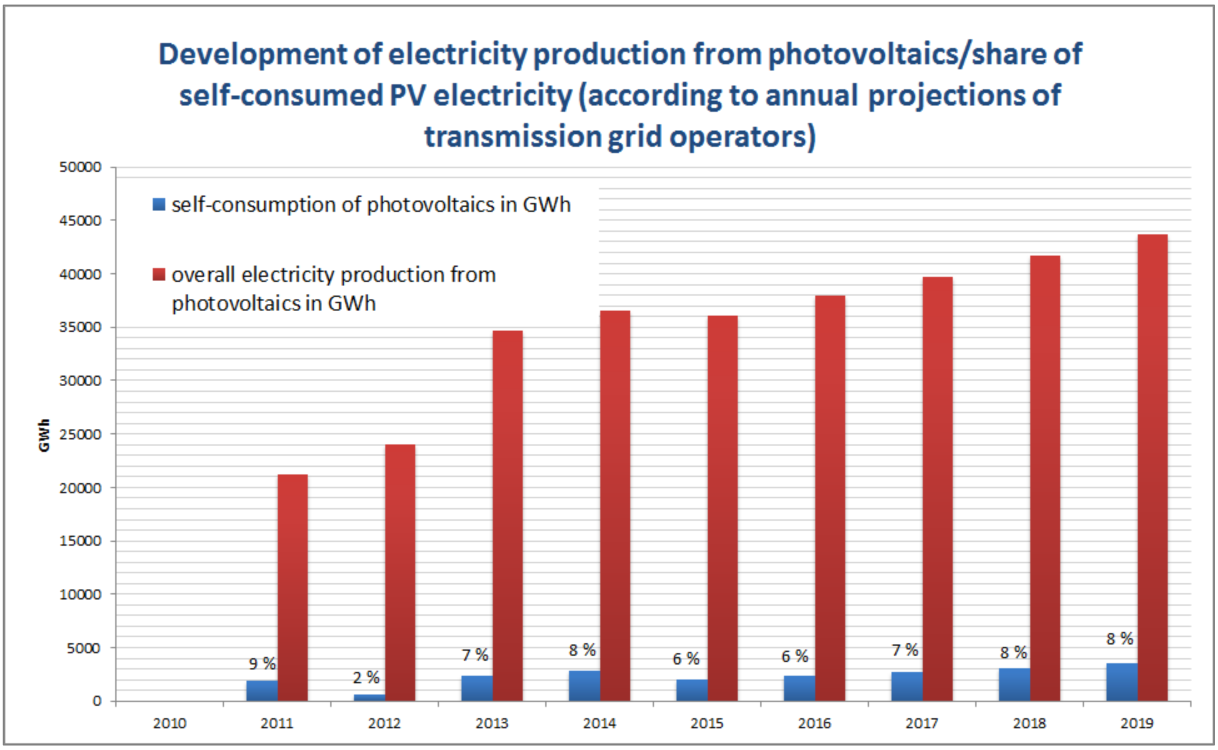

Source: Own illustration based on an illustration in BSW Solar 2014: Positionspapier des Bundesverbandes Solarwirtschaft e.V. zur EEG Novelle 2014, May 2014, page 1.

## 2.2 Incentives that enable or restrict households' self-consumption of the electricity they produce

Almost all PV systems in Germany are grid-connected systems instead of off-grid systems. Originally self-consumption was not intended when the regulator introduced the Renewable Energy Act in 2000. All generated electricity, subject to the EEG-support scheme, was obliged to be fed into the grid. According to the transmission grid operators' projections, self-consumption in the *whole* PV segment will also be marginal in the future (Figure 10). For smaller PV systems, the situation has completely changed compared to the earlier phases of the FIT-scheme – now self-consumption becomes necessary to operate economically.

However, self-consumption of PV is highly contested in the debate about the cost-efficiency and social fairness of the German transition process – for different reasons. This section will, first, provide a brief overview of the development of the regulations, which are relevant for self-consumption against the backdrop of the economy of self-consumption. It will then discuss relevant framework conditions, e.g. how to increase the rate of self-consumption, and finally the pros and cons of self-consumption, with special reference to the German debate.

**Figure 10: Share of self-consumption of solar power in Germany**



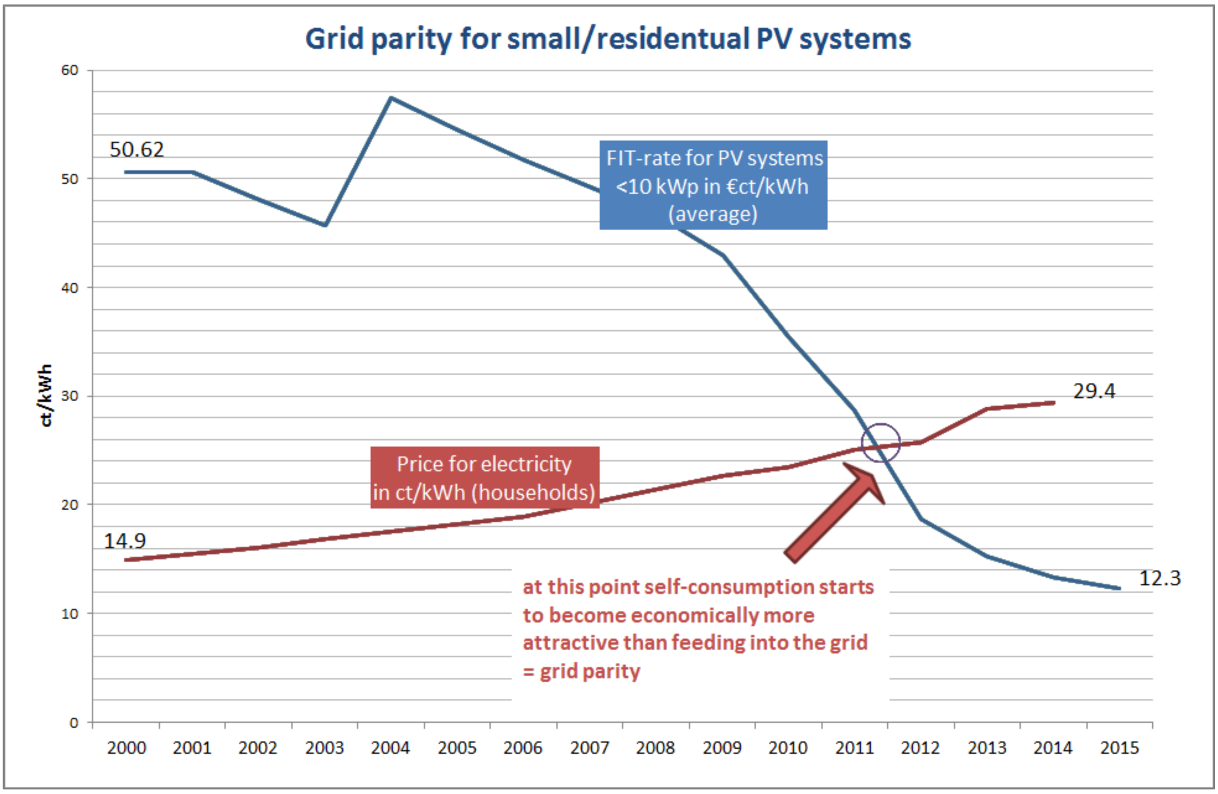

Source: Own illustration based on the transmission grid operators' annual projections (PROGNOSE DER EEG-UMLAGE NACH AUSGLMECHV, 2010-2015) and https://www.netztransparenz.de/de/file/2014-11-11_EEG_Mifri_bis_2019.pdf 2016-2019).

### 2.2.1 Interplay between regulation and market development relevant for self-consumption of PV power in households

Up until 2009 all PV power had to be fed into the grid. High remuneration rates have triggered an extreme increase in PV production, especially from smaller distributed PV systems (compare Figure 6). Compared to the massive expansion of new distributed and volatile power capacities, the distribution and transmission grids were not sufficiently adapted to the challenges associated with integrating these volatile capacities at the same speed. Thus, in 2009, a so-called "self-consumption bonus" was introduced by the regulator in the context of the second reform of the EEG. This bonus was intended to stimulate self-consumption in order to prevent grid overload. The self-consumption bonus even allowed producers of solar power to receive a payment from the support scheme (a reduced FIT rate) for the power they did not feed into the grid but consumed at home.

For prosumers, thus, it became economically more attractive to consume a portion of their own electricity instead of feeding all PV power into the grid, as the self-consumption bonus, plus the reduced costs for electricity purchased from the grid, guaranteed a surplus. However, the intended effect of reducing the risk of grid overload was not achieved — and perhaps is not achievable. Most of the PV system operators could not significantly increase the rate of self-consumption due to the absence of storage capacities (high cost of battery systems) or due to the low potential for load shifting in the household sector. Therefore, the self-consumption bonus predominantly caused windfall effects.

**Figure 11: The economy of self-consumption: grid parity**



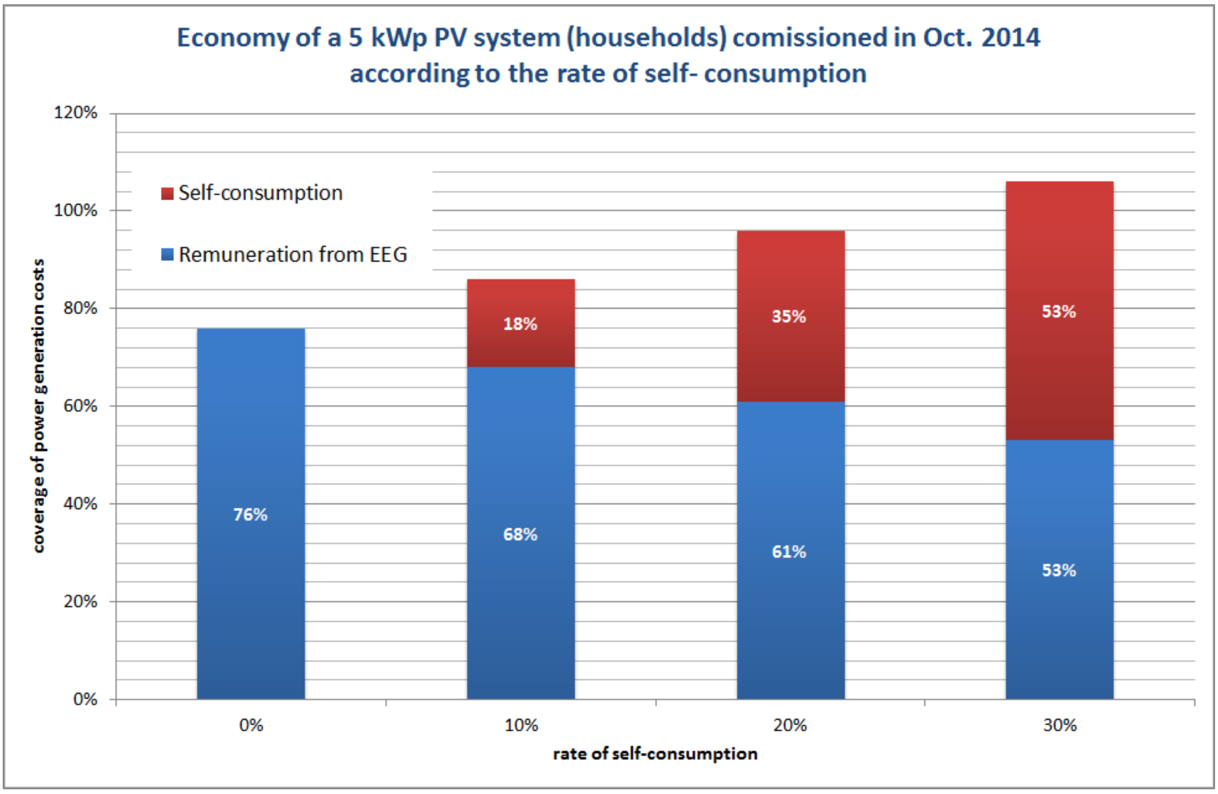

Source: Own illustration based on BMWI Energiedaten (n.d.) (prices) and https://www.netztransparenz.de (remuneration rates).

*Annotation:* Retail prices for electricity in Germany traditionally consist of a basic component, which is independent of the amount of consumed, and a price per kWh consumed, the "working price". For an exact calculation of the grid parity it would have been better to use only the "working price" for electricity consumed, as also prosumers will always have to pay the basic component as long as they consume power from the grid. However, due to a lack of available data and transparency on the composition of the retail price, I have used the retail price as it is as a proxy for this illustration of grid parity.

Consequently, the self-consumption-bonus was phased out in the third reform of the EEG in 2012. The bonus was no longer necessary as self-consumption had become economically attractive. Grid parity was reached in around 2012 for small residential systems: increasing retail prices for electricity and decreasing remuneration rates provided the economic rationale for self-consumption (Figure 11).

In 2014 with the adoption of the fourth reform of the EEG, the government introduced an EEG surcharge on self-consumed electricity. However, this surcharge was less than the general EEG surcharge (in 2015 it was 30 percent of the regular EEG surcharge, in 2016 35 percent and in 2017 40 percent). This provision was a reaction to the fear of an erosion of the solidarity principle in bearing the cost of the renewable energy support scheme. The argumentation is that as self-consumers satisfy their electricity needs partly with their own power, they do not pay the EEG surcharge for all the electricity they consume, but only for the electricity they purchase from the grid. As an effect, all remaining consumers, who cannot or will not produce their own power have to bear more of the total cost for the support scheme, and this would result in an increase of the EEG surcharge[10].

**Figure 12: Economy of small-scale PV systems according to the rate of self-consumption**




Source: Own illustration (translation) based on data and illustration in ZSW 2014: 37.

According to calculations in a study commissioned by the German Energy Ministry it became clear that small-scale PV systems cannot operate economically without both self-consumption *and* remuneration (ZSW 2014:37). Even with the current maximum rate of self-consumption (currently 20 percent is feasible) a residential PV system cannot operate economically without remuneration (Figure 12). Consequently, the study recommends not to extend the surcharge on self-consumed electricity to small PV system operators (ibid.). The regulator followed this recommendation and decided to exempt residential PV systems below 10 kWp from the EEG surcharge on self-consumption.

[10] Although the logic of the argument is understandable at first glance, it neglects the fact that the solidarity principle has already been eroded by those legal provisions, which exempt an extensive number of (more or less) energy-intensive companies from paying the (full) surcharge due to reasons of competitiveness.

### 2.2.2 Opportunities and barriers to increasing the rate of self-consumption in Germany

By reaching grid parity self-consumption became, of course, the most important business model for the further expansion of residential PV power in Germany. However, grid parity alone does not suffice in significantly scaling up the rate of self-consumption. As a reminder: only a maximum rate of 20 percent self-consumption is currently feasible for small-scale residential PV systems without significant changes in consumption patterns (AEE 2014). The economically attractive operation of a residential PV system, on the other hand, is only feasible with a higher rate of self-consumption, i.e. 25 percent or more (ZSW 2014: 37, see Figure 12).

Technical studies suggest that an optimal match of the on-site demand can only be achieved with battery systems. With these storage capacities the rate of self-consumption can be scaled up to 70 percent. Other opportunities to increase the rate of self-consumption, such as smart load or smart consumption management, are estimated to increase this rate up to just 30 percent (AEE 2014). Both these options, however, are currently still characterized as economically unattractive for small prosumers for the following reasons:

*a) Potential to switch consumption patterns in households is low*

Households have the potential to save electricity, in part simply triggered by a visualization of, and the feedback on, their own consumption patterns (Fischer 2008, Vine et al. 2013, Fraunhofer ISE 2011). Households are equally able to shift consumption to a certain degree in order to respond to market signals given by load- or time-variable tariffs (e.g. Fraunhofer ISE 2011). However, studies have shown that these potentials are rather low.

**Table 1: Electricity-saving and load-shifting potential in households with smart meters**

| Consumption/a | Saving potential in % | Load shifting potential in % | Cost savings in EUR/a and meter | |
|---|---|---|---|---|
| | | | Mean | Maximum |
| < 2,000 kWh/a | -0.5 | 0.25 – 5 | 2.0 | 4.50 |
| 2,000 – 3,000 kWh/a | -1.0 | 0.5 – 10 | 10.00 | 17.00 |
| 3,000 – 4,000 kWh/a | -1.5 | 0.75 – 15 | 20.00 | 35.00 |
| 4,000 – 6,000 kWh/a | -2.0 | 1 – 20 | 39.00 | 66.00 |
| > 6,000 kWh/a | -2.5 | 1.25 – 25 | 75.00 | 130.00 |

Source: Ernst & Young 2013: 159, own translation.

In their cost-benefit analysis for a German rollout of smart metering systems Ernst and Young (2013) have summarized the findings of several studies and pilot projects to assess the impact of smart meters on energy saving and load shifting according to the amount of electricity used in households (Table 1). Their analysis shows that the potential to save electricity or shift consumption — and, thus, save money — is in general rather low and determined by the amount of electricity used. Households with high levels of consumption have in principle a higher potential. The spread of the respective potential within a given consumption class characterizes the variety of further factors which determine the potential to save electricity or to shift consumption, such as for example the type of feedback, the duration of the feedback, the tariff design and the type of electrical appliances in a household.

*b) The required technical infrastructure and price incentives are not in place*

Residential prosumer systems are already obliged to have meters or metering systems for:

- power consumed from the public grid (consumption meter)
- the number of kilowatt hours that are fed into the public grid and remunerated according to the EEG (feed-in meter), and
- the number of kilowatt hours produced by one's own PV-system (yield meter).

These meters guarantee a certain transparency and feedback on one's own consumption pattern, but the majority of these meters are not smart in the sense of enabling intelligent communication with smart home appliances or an external control center to steer smart consumption or load patterns. Furthermore, the necessary smart appliances for such intelligent communication are usually not in place, are costly and — for data security reasons — are also suspect for many private customers. Additionally, the required electricity tariffs which might trigger load shifting or electricity saving behavior are not offered by electricity providers due to established accounting rules for residential customers and the lack of adequate intelligent metering systems (see section 1.2.3). This results in a negative incentive structure for electricity providers to offer tailored tariffs for residential customers (Tews 2011a).[11] With the bill on "The digitization of the energy transition" adopted in June 2016, the government introduces a step-by-step rollout of smart metering systems, which also have to be installed mandatory from 2017 in all residential prosumer systems with a capacity of >7 kWp. However, the primary reason for that provision is not to better match on-site demand with on-site production from the prosumer's perspective, but rather to better match distributed feed-in of volatile renewable electricity with the grid's capacity — and this especially from the security of supply perspective (see section 2.3.4).

[11] Electricity providers usually apply the Standard Load Profile (SLP) as an accounting rule for residential consumers in Germany. SLP is used for approximating the customer's electricity consumption, i.e. the consumption pattern is fixed. Providers have no advantages in procurement based on SLP to pass on to customers. The lack of "smart" metering infrastructure to "individualize" consumption patterns prevents them from developing attractive tariff options (see Tews 2011a, for an English summary of the study see Tews 2011b).

c) *Investment in storage capacity is still risky but early adopters seem to pave a way forward*

Currently, the market for stationary energy storage[12] is still in its infancy. The acquisition costs for PV storage systems are currently relatively high. Investments in residential battery systems are still risky from an economic perspective due to the uncertainty of future returns, which depend on the development of variable factors, such as household electricity prices, remuneration rates for feed-in and surcharges on self-consumption.

However, “early adopter” prosumers have started to invest in stationary storage capacities. Their motivation is rather to increase self-sufficiency and thus to reduce their dependence on electricity from the grid instead of maximizing returns. Furthermore, with public grants for battery storage for systems <30 kWp being offered by the public KWF bank since May 2013 an additional market incentive was set.

According to experts, further technological advancement of battery systems and the potential decrease in storage prices will reduce investment costs and make them economically attractive from the prosumer’s perspective in the near future (Fraunhofer Umsicht/Fraunhofer IWES 2014). Combined with a further decline in EEG remuneration rates and rising household prices for electricity, a high growth potential for the storage market is expected. However, pioneer developers of storage and storage control systems (e.g. Tesla and Lichtblick) currently complain greatly about a range of uncertainties imposed by the over complex, partly unclear or unattractive German regulatory framework concerning electricity from battery storage.

d) *Concerns about the environmental desirability of certain options to increase the rate of self-consumption*

Some of the technical opportunities to increase self-consumption are ecologically undesirable such as the concept of “Power to Heat”. Although it can increase the rate of self-consumption, the $CO_2$ emission factor ($CO_2$/kWh) of German electric power is — due to the German electricity mix (see Figure 1) — twice as high as the $CO_2$ emission factor for heat. Thus, it is argued that PV power should replace fossil fuel power and be fed into the grid instead of being transformed into heat.

## 2.3 Other relevant regulation

In general, the German legislation on the deployment of renewable energy sources for the first phase of the energy transition process was intentionally designed to reduce the risks and the specific transaction costs for (potential) operators of a RES installation.

[12] The market for *mobile* energy storage (e-mobility) is even earlier in its infancy in Germany. Currently there is a major political debate on adequate instruments to stimulate e-mobility. The debate focuses on whether to subsidize the purchase via a premium or to better to improve infrastructure for e-mobility and/or the capacity of e-cars’ battery systems.

### 2.3.1 Grid connection provisions

The provisions regarding grid connection, technical requirements, transmission and distribution are regulated by several provisions of the Renewable Energy Act. Provisions in section two of the law ("Connection, purchase, transmission and distribution") clearly regulate the relationship between a grid operator and the operator of a RES installation and their respective obligations.

According to section 8 of the law, a grid operator is obliged to offer the grid connection for installations to generate electricity from renewable energy sources without delay. This obligation generally applies to the grid operator technically suited for connection (grid voltage level) whose distance to the location of the installation is the shortest (linear). In the case of one or several installations with a total maximum installed capacity of 30 kWp which are located on a plot of land with an existing connection to the grid, the point of connection of the plot of land with the grid system shall be deemed the most suitable connection point (informal English translation of the EEG[13]).

- The operator of the RES installation has to place an application for grid connection to the respective grid operator. In reality the firm charged with the installation of the PV system by the private homeowner often assumes this application.
- The grid operators must communicate to those wishing to feed in a precise timetable for the processing of the application to connect to the grid system. This timetable must state:
    - the procedural steps in which the application to connect will be processed, and
    - what information those wishing to feed in must transmit from their field of responsibility to the grid operators so that the grid system operators can determine the point of connection.
- Grid operators must communicate the following information to those wishing to feed in *within eight weeks*:
    - a timetable for the establishment of the connection to the grid system comprising all the necessary procedural steps
    - all the information needed by those wishing to feed in to test the connection point, and — on application — the grid system data required for a system compatibility check, and
    - an estimate of the costs incurred by the installation operators due to the connection to the grid system; this cost estimate shall include only the costs resulting from the technical provision of the connection to the grid system, and in

[13] You can download this translation of the EEG from the official BMWi-Website: http://www.bmwi.de/English/Redaktion/Pdf/renewable-energy-sources-act-eeg-2014,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf

particular shall not include the costs of obtaining permission to use third-party real estate for laying the line to connect to the grid system.

### 2.3.2 Building code regulations

PV installations are subject to building law, which differs between the subnational jurisdictions at state level in Germany (Bundesländer). However, roof-mounted PV systems — as a rule — do not require formal permission. PV installations on the roofs of historic buildings need a permit, but this is granted in most cases if the installation does not disrupt the building or alter its visual quality.

### 2.3.3 Local planning practices

Although the municipalities in Germany have the relevant competencies with regard to the main elements of spatial planning, respective legal provisions are not relevant for roof-mounted PV systems as they do not have a spatial impact.

### 2.3.4 Smart meter requirements

As described in section 1.2.3 Germany is rather a latecomer to the development of smart grids and accordingly to the rollout of smart meters. Up until 2011 there were no smart meter requirements for small PV installations. In 2011 with the amendment of the Energy Industry Act (EnWG) the obligation for *new* PV installations >7 kWp to install smart meters was introduced.

Recently a new legislation on smart meters rollout has been adopted. The scale of the rollout and the purpose of smart meters for prosumer systems were heavily contested in the political debate. Due to the rapid increase in volatile renewable generation capacities in the German electricity grid and the electricity market, the security of supply argument is becoming ever more important, calling for smart-grid integration of distributed renewable energy generation in order to better balance supply and demand.

Accordingly, the technology and the associated debate on regulatory implications differs between basic bi-directional infrastructure to increased transparency of consumption patterns in order to tap saving potentials (basic smart meters) and advanced intelligent metering systems equipped with a so-called smart meter gateway which allows for remote readout of meters by an external control center (grid operator) in order to control grid-optimized consumption and generation patterns.

The new discussion on smart metering, particularly on integrating small prosumer systems into a smart grid, heated up with the publication of two studies in 2013 and 2014 (Ernst & Young 2013; Dena 1014) which recommended the installation of smart metering systems for the purpose of an "active feed-in-management" (i.e. cut-offs/curtailment of RES systems) by grid operators. These studies recommended the obligatory installation of smart metering systems even for small systems with a capacity of 0.25 kWp, or 0.8 kWp respectively. Both studies argue that these measures of active feed-in management would reduce the economic costs for further grid expansion.

Complaints were heard especially from consumer protection associations, and the Federal Association for Renewable Energies (BEE) that the integration of such small residential systems would impose unreasonably high costs and risks (due to external cut-offs) to these small producers, which would prevent them from a further economically viable operation of their small PV systems. Furthermore they argue that grid operators will not depend on the provision of system services from such small residential producers in order to balance grid stability (VZ NRW 2014, Vzbv 2015, BEE 2015).

In February 2015 the BMWi published its "Key Issue Paper on a Package of Ordinances Regarding Intelligent (Smart) Grids" (BMWI 2015), which included the following recommendations for prosumer systems which clearly refer to the security of supply argumentation: Small systems below 7 kWp are perceived as only *potentially* relevant for system stability in the future. However, PV systems >7 kWp are perceived as relevant for grid stability. Thus, the installation of advanced smart metering system should be obligatory by 2017 for *all (new and existing)* RES and CHP systems with a capacity >7 kWp. Systems with a capacity of between 0.8 kWp and 7 kWp are not obliged to install advanced smart metering systems. The ministry argues that currently the installed capacity of PV systems below 7 kWp accounts only for 7 percent of total installed PV capacity. However, by the year 2021, the ministry intends to evaluate, whether a smart system integration of this residential segment will be necessary from the security of supply perspective and economically feasible.

Accordingly, the draft bill on the "Digitization of the energy transition", published in November 2015, did not mention small residential prosumer systems, neither in the case of mandatory installation of smart meters nor as an option that meter operators can choose if they comply with the defined price caps (see Figure 4).

However, the bill, as it was adopted on the 23$^{th}$ of June 2016 contains a surprising new provision which takes into consideration an amendment of the governmental coalition. For new small distributed installation between 1-7 kWp, the meter operators can optionally choose by 2018 to install smart metering systems if the comply with a price cap of 60 EUR/a. The renewable energy branch, the opposition parties as well as consumer protection organizations were astonished by this last minute change. At time of finalizing this paper a detailed assessment of the background and the implications of this new provision is not yet available.

### 2.3.5 Information practice and the third party market

The degree of bureaucratic complexity and the burden for private households to become prosumers are rather low. Furthermore, due to actors having emerged in the third party market of the solar branch (installation firms, PV leasing firms) and the extensive information provided by several actors, transaction costs have been further reduced. It would go far beyond the scope of this study to describe in detail the information practices offered by formal institutions at different levels of the German federal system, consumer organizations or associations in the solar branch. Thus, only a few examples are given below:

*Individualized energy-related counselling*

The federal consumer organization “Verbraucherzentrale Bundesverband e.V.” and its decentralized member organizations at the state level offer as part of their on-site counselling on energy-related renovations of private homes, information on grant and subsidy programs for PV, renewable warmth and power storage, as well as *individualized* calculations and recommendations regarding the economic benefits of investing in the various measures.

*Online guidebooks and interactive calculation tools*

There are a couple of online guidebooks and interactive tools available to calculate the returns offered by the roof conditions of a specific house. Such web tools are provided by different organizations and platforms in the solar branch. These webpages often directly forward the requests of an interested user to installer firms in their region.

*Solar land maps*

A few municipalities or counties (e.g. the county of Ahrweiler in Rhineland-Palatine) do already offer online solar land registers of their entire city or county. Such tools enable each homeowner to easily get an initial picture of the suitability of a roof-mounted PV system, as these registers show all houses and indicate whether or not a solar system can be operated economically.

## 3 Conclusion: Prosuming and the moving targets in the German energy transition process

With a total installed capacity of 38 GW (2015) PV power has reached a stage of systemic importance for the whole power system. Although residential PV (<10 kWp) accounts for only 13 percent of total installed PV capacity, it is an important segment for several reasons: “Prosuming” — although never defined as an official term in Germany — is both a subject and driver of the adaptive legislation on the RES support scheme and on system integration of RES.

From a historic perspective, the generation of PV by new, small-scale residential investors was implicitly intended by the “founding fathers” of the Renewable Energy Act (EEG) in order to dismantle barriers imposed by the hesitant attitude of the established energy actors towards renewable energies (see Scheer 2005).

Thus, the Renewable Energy Act has for a long period offered a high degree of planning security for investors and has sheltered small-scale and new actors’ investments to develop a long-term niche. The risk and transaction cost reductions ensured by:

- the clear regulation of the relationship between PV operator and grid operator, and

- the long–term security of returns achieved by administratively fixing a technology-specific remuneration for 20 years

are especially relevant for those actors who cannot diversify risks and/or are unfamiliar with the established rules in the energy field.

The success of the EEG stimulating precisely these small-scale actors to invest in residential PV forced once again adaptions to legislation and a change in the attitudes and strategies of established energy actors. The rapid spread of residential PV provoked provisions, which introduced incentives to increase self-consumption in order to ensure grid stability. These residential adopters of the new technology became a critical mass and caused not only a rapid diffusion of this technology into the market but also decreasing system prices. The subsequent (rather late) reduction in remuneration rates and rising electricity prices — partly as a consequence of the EEG surcharge — created incentives to increase self-consumption as an economic rationale for operating PV systems. This in turn stimulated research and innovation in storage capacities on the one hand, but on the other the political need to increasingly consider security of supply issues and the solidarity principle in bearing the costs of the transition process.

Future regulations on incentives, which enable self-consumption, as the only economic rationale for operating a residential PV system, will increasingly face the need to differentiate between:

- an optimization of self-consumption rates from the prosumer’s perspective, or
- an optimization of self-consumptions patterns from the system perspective.

While the first perspective would guarantee the economic attractiveness of residential PV for the investor, the latter perspective is relevant for security of supply and would require a grid-optimized operation of prosumer systems.

The latter gains systemic importance for the whole transition process, however it will probably come into conflicts with the interests of the individual prosumers. Such conflicts have to be counterbalanced with a respective incentive structure in order to reward a grid-optimized operation of the residential PV system when required.

## References

AEE (2014b): Eigenverbrauch und regionale Direktvermarktung. Chancen und Herausforderungen. In: Renews Spezial Ausgabe 70 / Februar 2014. Hintergrundinformation der Agentur für Erneuerbare Energien. http://www.unendlich-viel-energie.de/media/file/328.70_Renews_Spezial_Eigenverbrauch_online_apr14.pdf (accessed 30.07.2015)

Arbeitsgemeinschaft Energiebilanzen (2014): Auswertungstabellen zur Energiebilanz 1990 bis 2013. http://www.ag-energiebilanzen.de/ (accessed 13.11.2015).

AG Energiebilanzen (2015): Bruttostromerzeugung in Deutschland ab 1990 nach Energieträgern. http://www.ag-energiebilanzen.de/ (accessed 13.11.2015)

Agora Energiewende (2015): Report on the German power system. http://www.agora-energiewende.de/fileadmin/downloads/publikationen/CountryProfiles/Agora_CP_Germany_webpdf (accessed 04.11.2015).

BEE (2015): BEE-Stellungnahme zum „Entwurf eines Gesetzes zur Digitalisierung der Energiewende“. Bundesverband Erneuerbare Energie e.V. Berlin, 09.10.2015.

Beermann, J. and K. Tews (2015): Preserving decentralised laboratories for experimentation under adverse framework conditions - Why local initiatives as a driving force for Germany’s renewable energy expansion must reinvent themselves. In: FFU Report 03-2015, Forschungszentrum für Umweltpolitik. Berlin.

BDEW (2014): Stromverbrauch im Haushalt. https://www.bdew.de/internet.nsf/id/6966C7CB65D8D8FAC1257D5E0043D565/$file/705_BDEW_Stromverbrauch%20im%20Haushalt_Stand_September%202014.pdf (Accessed 13.11.2015).

BDEW (2015). Strompreisanalyse August 2015. Berlin, BDEW Bundesverband der Energie- und Wasserwirtschaft e.V.

BMWI Energiedaten (no date): Zahlen und Fakten. Energiedaten. Gesamtausgabe. http://bmwi.de/DE/Themen/Energie/Energiedaten-und-analysen/Energiedaten/gesamtausgabe,did=476134.html . (accessed 02.02.2016)

BMWi (2014): Zweiter Monitoring-Bericht “Energie der Zukunft“. http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/zweiter-monitoring-bericht-energie-der-zukunft,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed 04.11.2015).

BMWI (2015): Baustein für die Energiewende: 7 Eckpunkte für das „Verordnungspaket Intelligente Netze“. https://www.bmwi.de/BMWi/Redaktion/PDF/E/eckpunkte-fuer-das-verordnungspaket-intelligente-netze,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf (accessed 03.02.2016)

Bundesumweltamt (2015): Energieverbrauch der privaten Haushalte: Haushalte benötigen auch mehr Strom. https://www.umweltbundesamt.de/daten/private-haushalte-konsum/energieverbrauch-der-privaten-haushalte (accessed 13.11.2015)

Dena (2014): Einführung von Smart Meter in Deutschland. Analyse von Rolloutszenarien und ihren regulatorischen Implikationen. http://www.dena.de/publikationen/energiesysteme/studie-einfuehrung-von-smart-meter-in-deutschland.html (accessed 08.02.2016)

Ecofys (2014): Design features of support schemes for renewable electricity. A report compiled within the European project “Cooperation between EU MS under the Renewable

Energy Directive and interaction with support schemes”. Study by order of: European Commission, DG ENER. Utrecht. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/2014_design_features_of_support_schemes.pdf (accessed 15.09.2015).

Ernst & Young (2013): Kosten-Nutzen-Analyse für einen flächendeckenden Einsatz intelligenter Zähler“, commissioned by the BMWi .

European Commission (2014): Country fiches for electricity smart metering. Commission Staff working paper accompanying the document “Report from the Commission ‘Benchmarking smart metering deployment’”. SWD (2014) 188 final. Brussels.

Eurostat (2013): Housing Statistics: Population by tenure status. http://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics/de (accessed 13.11.2015).

Fischer, C. (2008): Feedback on household electricity consumption: a tool for saving energy? In: Energy Efficiency 1(1): pp. 79-104.

Fraunhofer ISE [ed.] (2011): Intelliekon. Nachhaltiger Energiekonsum von Haushalten durch intelligente Zähler-, Kommunikations- und Tarifsysteme. Ergebnisbericht – November 2011. Freiburg.

Fraunhofer ISE (2015): Recent facts about photovoltaics in Germany. https://www.ise.fraunhofer.de/en/publications/veroeffentlichungen-pdf-dateien-en/studien-und-konzeptpapiere/recent-facts-about-photovoltaics-in-germany.pdf (accessed 04.11.2015).

Fraunhofer UMSICHT und Fraunhofer IWES (2014): Metastudie Energiespeicher. Studie im Auftrag des Bundesministeriums für Wirtschaft und Energie (BMWi). Oberhausen/Kassel.

Gawel, E. Korte, K. and K. Tews (2016): Distributional Challenges of Sustainability Policies — The Case of the German Energy Transition: In: Sustainability, December 2015, Volume 7(12), pp.16599-16615.

Hake, J. F., Fischer, W., Venghaus, S.and C. Weckenbrock (2015): The German Energiewende - History and status quo. In: Energy 92(3): 532–546.

Hoffmann, V. U. (2008): Damals War’s. ein Rückblick auf die Entwicklu8ng der Photovoltaik in Deutschland. In: Sonnenenergie. November-Dezember: 38-39.

IEA-RETD (2014): Residential prosumers - drivers and policy options (re-prosumers). http://iea-retd.org/wp-content/uploads/2014/06/RE-PROSUMERS_IEA-RETD_2014.pdf (accessed 25.07.2015).

Klagge, B. and Arbach, C. [eds.] (2013): Governance-Prozesse für erneuerbare Energien. Hannover: Akademie für Raumforschung und Landesplanung. Arbeitsberichte der ARL Abschlussbericht.

Kungl, G.( 2015): Stewards or sticklers for change? Incumbent energy providers and the politics of the German energy transition. In: Energy Research & Social Science 8: 13–23.

Mayer, J.N. and B. Burger (2014): Kurzstudie zur historischen Entwicklung der EEG-Umlage; Fraunhofer ISE: Freiburg.

Ohlhorst, D., Tews, K. and M. A. Schreurs, M. A. (2013): Energiewende als Herausforderung der Koordination im Mehrebenensystem. In: TATuP - Zeitschrift des ITAS zur Technikfolgenabschätzung, 22(2), 48–55.

Scheer, H. (2005): Energieautonomie. Eine neue Politik für erneuerbare Energien. Kunstmann. München.

Miranda A. Schreurs, Miranda A. (2014): The Ethics of Nuclear Energy: Germany's Energy Politics after Fukushima. In: The Journal of Social Science 77: 9-29.

Schreurs, M. A and Steuwer, S. (2015): Der Koordinierungsbedarf zwischen Bund und Ländern bei der Umsetzung der Energiewende aus politikwissenschaftlicher Sicht. In: Müller,T. and Kahl H. [eds.]: energiewende im Förderalismus, pp. 45-68, Nomos, Baden-Baden.

Statistisches Bundesamt (2015): Gross electricity production in Germany from 2012 to 2014. https://www.destatis.de/EN/FactsFigures/EconomicSectors/Energy/Production/Tables/GrossElectricityProduction.html (accessed 04.11.2015).

Tews, K. (2011a): Stromeffizienztarife für Verbraucher in Deutschland? Vom Sinn, der Machbarkeit und den Alternativen einer progressiven Tarifsteuerung. FFU-Report 05-2011, Forschungszentrum für Umweltpolitik, FU Berlin.

Tews, K. (2011b): Progressive tariffs for residential electricity consumption. An option for Germany? Presentation prepared for the 16th meeting of the REFORM group „Climate Policy after Fukushima", Salzburg – August 29 – September 2, 2011. http://www.polsoz.fu-berlin.de/polwiss/forschung/systeme/ffu/veranstaltungen/termine/downloads/11_salzburg/Tews.pdf (accessed 02.02.2016).

Tews, K. (2015): Europeanization of Energy and Climate Policy: The Struggle Between Competing Ideas of Coordinating Energy Transitions. In: The Journal of Environment & Development, 24(3), 267-291.

Trend research & Leuphana Universität Lüneburg (2013): Definition und Marktanalyse von Bürgerenergie in Deutschland. Bremen, Lüneburg. http://www.buendnis-buergerenergie.de/fileadmin/user_upload/downloads/Studien/Studie_Definition_und_Marktanalyse_von_Buergerenergie_in_Deutschland_BBEn.pdf (accessed online 15.09.2015).

Vine, D., Buys, L. and P. Morris (2013): The Effectiveness of Energy Feedback for Conservation and Peak Demand: A Literature Review. In: Open Journal of Energy Efficiency 2: 7-15.

VZBV (2015): Smart Meter Einbau: Zwangsdigitalisierung durch die Kellertür. Stellungnahme des Verbraucherzentrale Bundesverbandes zum Entwurf eines Gesetzes zur Digitalisierung der Energiewende. Vzbv.e.V. Berlin. 09.10.2015.

VZ NRW (2014): Prosumer gefangen im Smart Grid? Zur Rolle von Prosumer-Anlagen im zukünftigen Smart Grid vor dem Hintergrund der anstehenden EnWG-Novelle und dem „Verordnungspaket intelligente Netze". Postionspapier der Verbraucherzentrale Nordrhein-Westphalen. July 2014, Düsseldorf.

ZSW (2014): Vorbereitung und Begleitung der Erstellung des Erfahrungsberichts 2014 gemäß § 65 EEG. Im Auftrag des BMWi. Vorhaben IIc Solare Strahlungsenergie. Wissenschaftlicher Bericht Zentrum für Sonnenenergie- und Wasserstoffforschung Baden Württemberg. Stuttgart.