Increasing power self-sufficiency of German households – Implications for energy companies' business models**

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Abstract: With shrinking costs for local production plants and rising retail prices for electricity, the decentralized generation of electricity and its direct consumption is getting increasingly attractive. At a first glance, the tendency towards power self-sufficiency displays a threat to energy companies since it reduces the amount of electricity sold and challenges their traditional business models. Starting from this observation, the overarching research question is how companies can respond to households' power self-sufficiency. More specifically, the paper explores the relevance of regulatory features, adjustment needs for existing business models, stakeholders' role in implementing these adjustments, and the profitability of the new business models. The findings are based on a review of the extant literature, on interviews with decision makers from eight companies in Germany in 2015, and on net present value (NPV) calculations for the respective business models, including sensitivity analyses for the key factors.

Accordingly, the German energy transition ('Energiewende') has led companies to employ new business models and to become active in the field of residential power self-sufficiency, in particular. The new business models focus on the two consumer groups: homeowners and tenants. They strongly vary in their extent and complexity. In contrast to the conventional way of making business, this involves rather small-scale and more customized offers. The analyses in this paper show that the profitability of such offers depends on the technology used and the customers served as well as on company specific features.

Keywords: business model, energy company, energy supply, power self-sufficiency, energy transition

** This paper is based on Hillenbrand (2015).

1 Introduction

1.1 Background information on the topic

The German 'Energiewende' and technological progress cause big changes in the energy sector. With shrinking costs for local production plants (Nestle and Kunz 2014) and rising retail prices for electricity (StBa 2015a) the decentralized generation of electricity and its direct consumption gets increasingly attractive. This tendency towards satisfying own demands by self-produced electricity is also encouraged through government incentives since autonomous suppliers often do not or not completely have to pay the taxes and levies included in the electricity price (Bardt et al. 2014). In accordance with these developments the traditional business model of utilities, i.e. the generation of electricity in large centralized power plants and its delivery for a fixed price per kWh to passive consumers, is contested. The energy providers' role of being a commodity supplier has already started to change and new business models have emerged.

Based on an exploratory, qualitative analysis this paper depicts the energy companies' strategies towards increasing power self-sufficiency in the household sector. At first glance, the tendency towards autonomous electricity supply displays a threat to energy suppliers because it reduces the amount of electricity sold. This paper explores whether and how business models may be adjusted to turn this threat into an opportunity. Focusing on the household sector implies particularly two different groups of end-consumers: households owning their houses and tenants living in apartment buildings. The decisive difference between both is that homeowners are able to buy or lease the decentralized energy plant and hence are able to become the plant operator, while tenants depend on the owners of their buildings to make 'Mieterstrom' concepts available.

1.2 Research questions and structure

The overarching research question of this paper is how energy companies can respond to households' power self-sufficiency in Germany. It is further broken down into the following sub-questions:

1. Which regulatory features have to be considered?
2. What are the business models in the field of residential power self-sufficiency in Germany?
    a. Which players are involved and how are they related?
    b. What are the main characteristics of the business models?
3. What does a closer look at the profitability of the business models reveal?

Methodologically, the paper relies on case study interviews and concepts from the business model literature, in particular the business model canvas (BMC) (Osterwalder and Pigneur 2010; Sabatier et al. 2010). To assess the profitability of the business models, NPV analysis is used.

The remainder of the paper is organized as follows: Relying on a review of the literature chapter 2 offers definitions and explores the legal framework conditions. Chapter 3 presents the methodology for the market exploration and the profitability assessment. Chapter 4 assesses the outcomes of the interviews with respect to the involvement of relevant players in the implementation of business models for power self-sufficiency, thereby exposing relations and jurisdictions. In addition, business models for market dealing with homeowners and tenants and their main characteristics are worked out. Chapter 5 takes a closer look at the profitability of such business models for solutions including PV and combined heat and power (CHP) systems as well as possibly storage solutions. We thereby distinguish between two exemplary cases dealing with both homeowners and tenants. The final chapter 6 concludes.

2 Power self-sufficiency in the German electricity market

2.1 Definitions

<u>Power self-consumption vs. direct power consumption</u>

Besides the feature that **self-consumption (Eigenverbrauch)** requires the direct usage of self-produced electricity there are imprecise specifications of its concrete design. Taking a look at the regulatory framework, indicators for power self-consumption are: (1) plant operator and electricity consumer is the same person, (2) electricity is consumed in direct spatial context, and (3) the public grid is not used (§ 5 No. 12 Erneuerbare-Energien-Gesetz (EEG) 2014). The personal identity condition (1) focuses on the plant operation. Therefore, besides possessing the plant also leasing it is in line with this requirement, since then the economic risk is transferred from the owner to the leaseholder. In the household sector, this premise limits self-consumption to homeowners who are able to buy or rent the decentralized energy plant. This is not possible for tenants living in multi-family houses which belong to another party. To differentiate between power self-consumption and circumstances where the personal identity requirement is not fulfilled another term is introduced: **direct power consumption (Direktverbrauch)** (HEG 2015). In contrast to the direct marketing (Direktvermarktung) of electricity, this refers to situations where electricity is sold to a consumer in immediate spatial proximity without using the grid (§ 5 No. 9 EEG 2014). The difference between the terms **self-supply (Eigenversorgung)** and **direct supply (Direktversorgung)** has to be understood accordingly. Another reason for the different understanding of self-consumption or direct consumption is that the term ‘direct spatial context’ (condition 2) is not defined in the EEG 2014 making delimitation difficult.

<u>Self-consumption rate or direct consumption rate vs. self-sufficiency rate</u>

The **self-consumption rate (SCR) (Eigenverbrauchsanteil)** valid for homeowners or **direct consumption rate (DCR) (Direktverbrauchsanteil)** referring to tenants indicates the proportion of the electricity which is directly consumed or stored in a battery relative to the total electricity output of the facility (Weniger et al. 2015). In contrast to that, the **self-sufficiency rate (SSR) (Autarkiegrad)** relates to the share of the end-consumer’s annual electricity consumption which is covered by locally produced power or discharging a battery.

<u>Self-sufficiency and auto-supply</u>

In this paper **self-sufficiency (Selbstversorgung)** is the term for households consuming electricity produced in or on their buildings and increasing their independence from the energy market. Similarly, **autonomous supply** also refers to the supply of end-consumers with decentralized electricity which is not conducted through the grid. Thus, both self- and direct consumption that is the provisioning of homeowners and tenants are subsumed under these items.

2.2 Effects of power self-sufficiency on the electricity price

In total, levies and taxes included in the end-consumer price for electricity account for more than 50 % of the total retail price in Germany (BDEW 2015). As the analysis of the legal framework has shown, most of the statutory levies do not have to be paid if the public grid is not used:

Erneuerbare-Energien-Gesetz

Since 01 August 2014, every self-supplier using a new plant is generally charged with the EEG levy (6.17 ct / kWh in 2015). If plant operator and end-consumer is the same person and produces power in a renewable energy or a highly efficient CHP plant (§ 61 para. 1 EEG 2014), the following percentages of the EEG surcharge have to be paid:

- 30 % for electricity produced between 01 August 2014 and 31 December 2015,
- 35 % for electricity produced between 01 January 2016 and 31 December 2016, and
- 40 % for electricity produced from 01 January 2017 onwards.

The EEG levy does not need to be paid for the first 10 MWh of self-consumed electricity per year if generated in a small installation with a capacity < 10 kW_{el} (§ 61 para. 2 EEG 2014).

Kraft-Wärme-Kopplungsgesetz

The costs for paying surcharges to operators of CHP plants are nationwide evenly distribution via the cogeneration levy. Transmission grid operators balance the supplementary payment incurring according to the volume of power sold to the end consumers in their jurisdiction (§ 9 para. 3 Kraft-Wärme-Kopplungsgesetz_2014). This means that directly consumed electricity which is not delivered by the transmission grid operator, is not included in the load balancing. As a consequence, provided that the grid of the general supply is not used, there is no duty to pay the cogeneration levy (Bardt et al. 2014, 18).

Further levies

The usage of the grid for the general supply is the condition for paying more levies like grid fees, § 19 para. 2 Stromnetzentgeltverordnung 2014, offshore liability levy (§ 17f Energiewirtschaftsgesetz 2014), levy for deferrable loads (§ 18 Verordnung zu abschaltbaren Lasten 2012), and the concession fee. If the grid not the needed, the payments need not to be made.

Electricity tax

The electricity tax is about 20.50 € per MWh (§ 3 Stromsteuergesetz 2015). If electricity is produced in a renewable energy plant or in a plant with a capacity of maximum 2 MW and is consumed in direct spatial context, the electricity tax is omitted (§ 9 Stromsteuergesetz 2015).

In figure 1 the government-imposed components of the electricity price which arise in case of conventional electricity supply, direct electricity supply (‘Mieterstrom’) and self-supply are contrasted (BMWi 2015). It becomes obvious that electricity consumption on-site offers a considerable cost-saving potential.

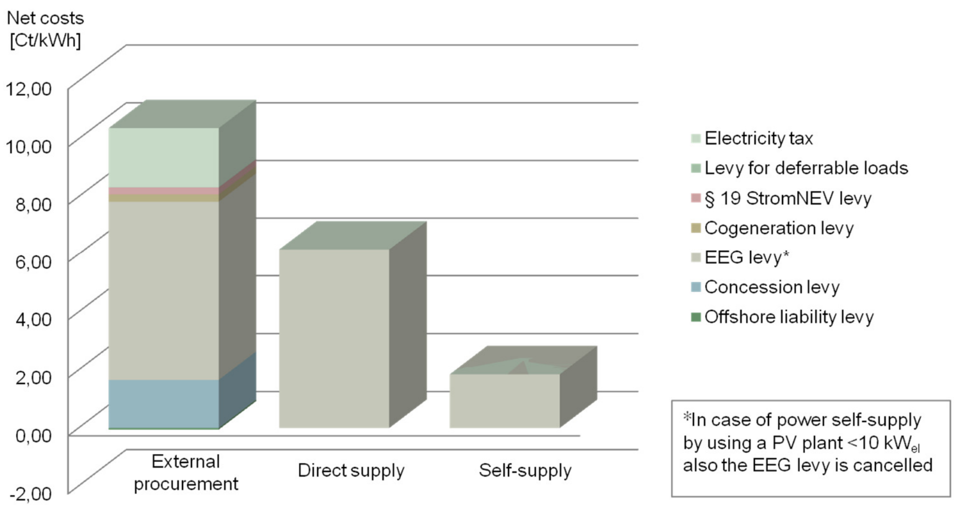


Figure 1: Different ways for power supply of households and their influences on government-imposed levies and taxes

Source: BDEW (2015), own calculations

3 Methodology

To answer the research questions a qualitative, exploratory methodology has been selected. A case study implying eight companies has been conducted and interviews have been carried out personally and per phone. The companies' names and offerings as well as the date of the interview and workshop are shown in table 1. Complementarily, a literature and online research has been done. Based on a general market overview, for the in-depth analyzes business models have been chosen covering the variety of the market for residential power self-sufficiency. Relevant criteria for the selection process have been the customer group served (homeowners, tenants), technology used (PV, CHP, storage), type of company (start-up, cooperative, established energy company), complexity of the offering and the availability of information. The data evaluation has been based on the BMC concept of Osterwalder and Pigneur (2010). It contains the four pillars: 'value proposition', 'customer interface', 'infrastructure', and 'financial aspects'. For taking a closer look at the profitability of different business models, the NPV method has been applied because this dynamic approach takes account of the medium to long-term perspective and is strongly accepted in science and practice (Götze 2014). The economic analysis has been done for two representative projects encompassing both customer groups: homeowners and tenants.

Table 1: Companies analyzed in detail

Company	**Business model**	**Type & date of contact**
MVV Energie AG	Strombank (Homeowners)	Personal interview, 12.06.2015
MVV ImmoSolutions GmbH	Mieterstrom (Tenants)	Personal interview, 23.06.2015
MVV Energie AG	BEEGY Solar (Homeowners)	Personal interview, 08.07.2015

BEEGY GmbH	BEEGY Solar (Homeowners)	Phone interview, 20.07.2015
DZ-4 GmbH	DZ-4 Easy, DZ-4 Autark (Homeowners)	Phone interview, 19.08.2015
Heidelberger Energiegenossenschaft (HEG) eG	Direct power supply of tenants (Tenants)	Workshop, 12.09.2015
Engynious Deutschland GmbH	Solar Plus Power (Tenants)	Phone interview, 29.09.2015
LichtBlick SE	ZuhauseStrom (Tenants)	Phone interview, 19.10.2015
RWE Vertrieb AG	Solar offering (Homeowners)	Phone interview, 06.11.2015

4 Identification and comparison of players and business models for the power self-sufficiency of households

4.1 Players and responsibilities

Setting up business models for self-sufficiency solutions requires the integration of several players from different fields. In the center of such concepts are end-consumers and building owners, which may be the same persons. In the event of power self-supply, the energy plant is typically bought or leased by the homeowner, the end-consumer, who then becomes the plant operator. In this case the EEG levy has to be paid only partially or is eliminated. If the homeowners themselves invest, they receive financial support, e.g., by the KfW bank, Umweltbank or through regional support programs. Tenants do not have the opportunity of buying or leasing a decentralized energy facility. Constellations like founding a civil law partnership attempt to establish a relationship between rental units and energy facility in order to use further privileges, but are highly disputed and difficult to implement.

Such innovative energy concept may be realized by the homeowners or with the help of a solution provider, which may be a (green) energy supplier, a utility, an energy service provider, a project developer and the like. Further, the market analysis shows that to implement such models, the solution providers frequently cooperate with local craftsmen and producers of the power plant or its components. Since the household has to be integrated in the general energy market another group of players is involved in the successful operation of such self-supply concepts: authorities of the energy market. Setting up an appropriate metering system, fulfilling reporting obligations and caring for registration are tasks which have to be handled in coordination with them. In particular, the set-up of metering systems appropriate for smooth billing processes and for differentiating between tenants preferring ‘Mieterstrom’ and those taking conventional electricity is a complex issue.

4.2 Business models for power self-sufficiency

4.2.1 Business models for the power self-supply of homeowners

At a first glance several companies seem to be active in this field. However, taking a closer look reveals that only a few focus on more than the local electricity production. Mainly young companies and start-ups, such as DZ-4 and BEEGY, are involved. Recently, more established energy companies, like MVV Energie and RWE, join the market. Some utilities, like EnBW and MVV Energie, realize this by participating in start-ups. In the following the main characteristics of these business models are explained by referring to the BMC method.

Value proposition

All companies aim at enabling homeowners to produce and consume electricity decentralized in a convenient and environmentally friendly way. However, the scope of the value propositions differs. Among the most active companies in this area is the start-up DZ-4 offering a service to its customers that covers the whole value chain (see figure 2). The core of the service provided by the young company BEEGY is guaranteeing financial savings of 50 % compared to the electricity bill of the previous year. For not missing the connection, some of the established companies in the energy sector participate in newly founded businesses or have isolated offerings. Examples for this are EnBW owning 15 % of DZ-4 and MVV Energie conducting the pilot project 'Strombank' and being co-founders of BEEGY. There are different ways for implementing and managing the PV plants. They may be sold to the customers, like it is done by RWE, or leased like DZ-4 does. Another difference is whether a complete power supply is assured (e.g., DZ-4) or a partially electricity supply is provided. Because this is a rather new market, the already existing solution providers aim at improving and expanding existing business models, while other companies have just started with a single or pilot project or include spatial limitations. Due to this, today's design of these services can be seen as starting points in a trial phase aiming at earning first experiences and winning customer acceptance.

Customer interface

While young companies (i.e. startups, newcomers, new market entrants) aim at acquiring new customers the importance for more established ones (i.e. the incumbents) lies mainly in keeping existing consumers and increasing customer satisfaction. It is focused on very close relationships and customers are regarded as partners and co-creators instead of pure energy consumers. This is necessary since in most cases the offers are supposed to be expanded in the future and to be further customized. While most business models are looking for customers without PV system yet, others want to reach households which already have a decentralized power plant since they aim at offering expansions, like battery storages, service contracts or smart metering devices (e.g., 'Strombank' offered by MVV Energie). Ways for attracting customers are in particular via internet, participating in events and using promotion partners. A peculiarity was an extensive advertising campaign from RWE conducted from April to June 2015.

Infrastructure management

Concerning the infrastructure management of the business models, the key activities can be taken from the value chain (figure 2). To what extent they are covered by the different companies differs according to the set scope. However, energy-related know-how and facilities, i.e. PV plants, storage systems or smart energy devices, always belong to the key resources. Additionally, cooperations with different partners, such as local craft producers, sales partners, green electricity suppliers, etc., are entered.

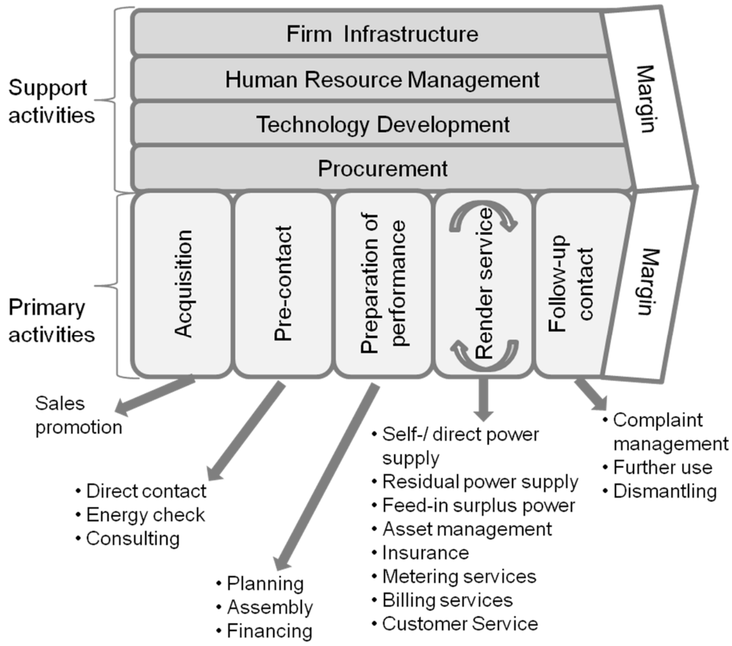


Figure 2: Value chain of offers for the power self-sufficiency of households
Source: Adjusted according to Porter (2010) and Spiegel (2003)

4.2.2 Business models for the direct power supply of tenants

Looking at 'Mieterstrom' offerings, besides young companies, also some established players can be found. The latter often expand their heating contracting agreements based on CHP units by the supply with electricity produced in the same plant (e.g., MVV ImmoSolutions). The design of such 'Mieterstrom' concepts is introduced hereinafter by relying on the BMC concept.

<u>Value proposition</u>

Generally, the value proposition is about making electricity produced in residential buildings available for tenants. How far companies cover the value chain (see figure 2) on their own and cooperate with others varies strongly. For instance MVV ImmoSolutions, Engynious and HEG are responsible for most of the activities including the financing. Others, like LichtBlick, provide a service contract to plant operators which may be real estate companies, contractors or cooperatives. While the plant operators enable the tenants to use the electricity produced on-site, LichtBlick cares for the residual power supply. Techem takes a different approach not changing its existing business model (Techem 2015). As before, Techem installs and operates CHP units and delivers the generated heat to the tenants. However, the additional feature is that the electricity is sold to Stadtwerke Aalen which offers a mixture of CHP and conventional power to the tenants.

<u>Customer interface</u>

Although the value proposition primary refers to tenants, in a first step, the customers of the solution providers are the representatives from the real estate sector owning the buildings. They take the decision for installing a decentralized power facility and so enable residents to be supplied with locally generated electricity. It is aimed at establishing a close relationship with them. Only in a second step, the end-consumers are addressed, either by the energy or by the real estate company. Sometimes, there is no direct communication between solution provider and final consumer. Typical requirements which customers have to fulfill refer to the size of the building. MVV ImmoSolutions for instance looks for residential buildings with 8,000 to 10,000 m² while LichtBlick focuses on at least 20 rental units. Regarding the distribution channel, it is often the case that companies operate single projects which are announced and explained in the press releases on their homepages rather than in their portfolio of products and services. Therefore, 'Mieterstrom' concepts offered to any interested party is often not given.

<u>Infrastructure</u>
Taking a look at the value chain in figure 2, most of the key activities deal with energy-related issues and respective know-how has to be available. However, since these services are more complex than traditional ones, additional activities and knowledge is required and often introduced by partners. Generally, all of these business models at least include two partners: one responsible for the energy related tasks and one providing the required location and coming from the real estate sector. Also investors may be involved (e.g., HEG and Grüner Strom Label e.V.). The network may be expanded by companies handling the billing processes, metering or customer services, etc. The most important resource is the personnel as well as the hardware. Looking at multi-family houses decentralized electricity plants in form of PV or CHP units are typically used. But, compared to the offerings for homeowners the integration of storages for increasing the self-consumption share is not very common. Additionally, smart metering devices may be part of the key resources, especially in the future.

5 Profitability analysis of power self-sufficiency solutions

The NPV method has been chosen to calcualte the profitability of business models or projects in the field of power self-sufficiency. Generally, projects with a positive NPV are beneficial since under consideration of the whole running time, the anticipated earnings generated by such projects then exceed the anticipated costs (Götze 2014). The NPV calculations are based on a set of assumption. It is focused on a four-person household living in a single-family house with an electricity consumption of 4,900 kWh per year (Frondel et al. 2015). Looking at business models related to tenants, the object under consideration is an apartment building with 100 rental units. Assuming the average German household size of two persons and an electricity consumption of 3,440 kWh as well as a connection rate of 50 %, the electricity demand of the rental units participating in the 'Mieterstrom' offering is about 170,000 kWh (BDEW 2013; StBa 2015b).

The profitability of the project depends on various factors such as the technology used. A first determinant is the return expectations of the investors presented as a discount factor. Since determining these from the outside is difficult, discount rates are varied from 0 % to 10 % for the basic calculations. Second, the DCR or SCR needs to be defined. Since both vary considerably by project, the DCR / SCR taken for the calculations in this paper start at 20 % (PV systems) and 40 % (CHP units) and lead up to 100 % in the basic analysis. Further, analyzing projects dealing with PV plants has shown that irradiance and investment costs are decisive factors for the profitability, whereas operational costs are only of minor importance. For cogeneration plants the CHP bonus of 5.41 Ct / kWh_{el} is critical for the profitability of respective ‘Mieterstrom’ concepts. In general, the higher the SCR or DCR, the more profitable the projects are.

The findings in this research suggest that operating PV-based business models focusing on homeowners is already profitable when only 20 % of the output is self-consumed. The internal rate of return (IRR, i.e. ‘i’ in figures below) in this case is about 2 % and hence similar to the interests available on the market. Looking at offerings focusing on tenants, a DCR of 40 % needs to be achieved for reaching the break-even point. If returns of 2 % and more shall be earned, the DCR needs to rise up to 65 %. The results are shown in figure 3. Such business models are significantly more profitable if operated in areas with a higher irradiance (figure 4). Also the investment costs have a strong influence leading to the presumption that such approaches may become more profitable in the future if costs for the facilities continue to decline. Hence, from an economic point of view, becoming active in promoting PV systems for self-consumption or direct supply is to be recommended.

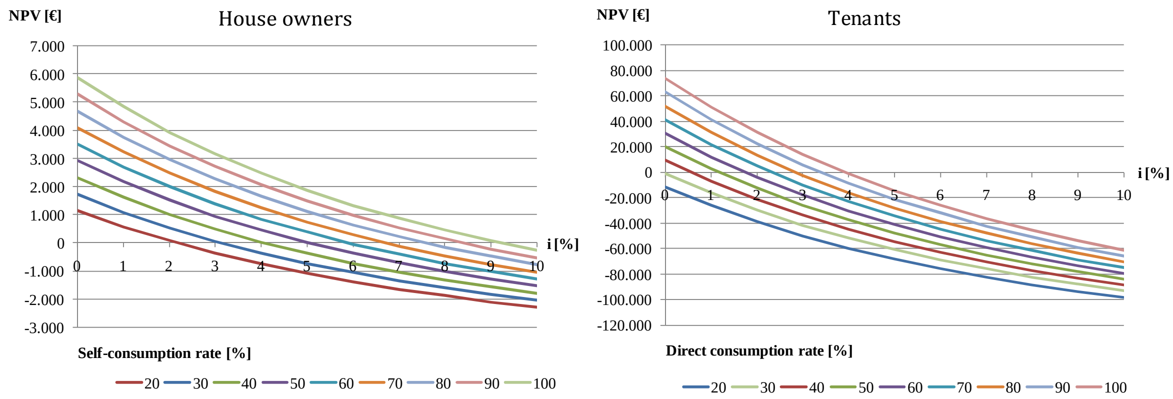


Figure 3: NPV of projects comprising PV systems for residential power self-sufficiency depending on discount factor and SCR or DCR

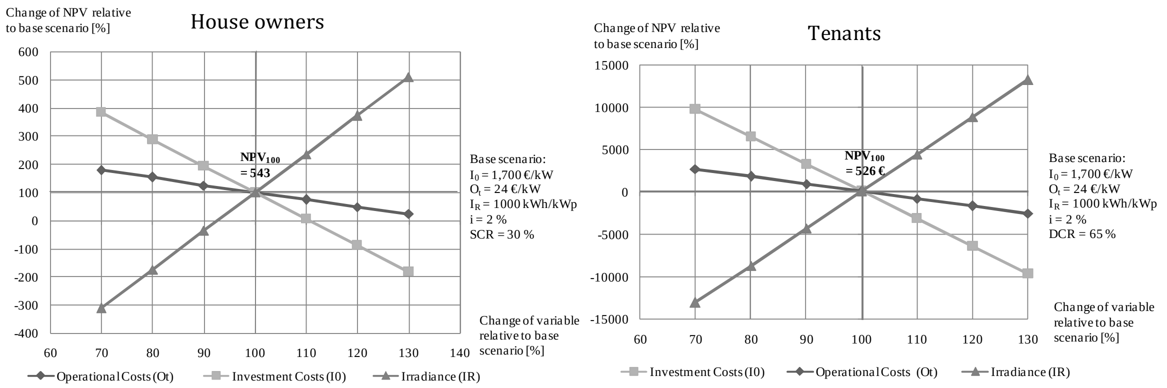
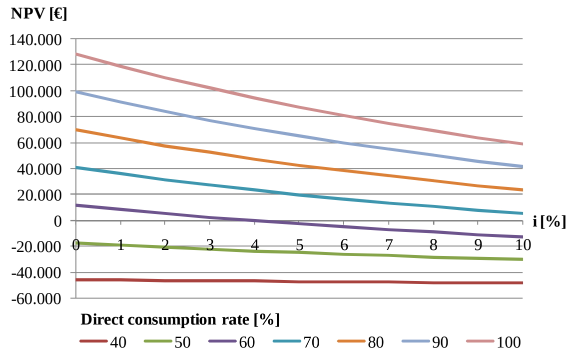


Figure 4: Influence of different variables on the NPV of PV-based business models

Projects based on cogeneration plants are feasible if a DCR of at least 60 % can be achieved. The IRR is just below 4 %. For the reference object in this paper this requires a connection rate of the rental units of about 64 %. The sensitivity analysis revealed that the profitability is strongly linked to the CHP bonus. Therefore, whether business models in this regard will stay profitable from a company’s point of view is likely to depend on the design of the regulations. The results are visualized in figures 5 and 6.



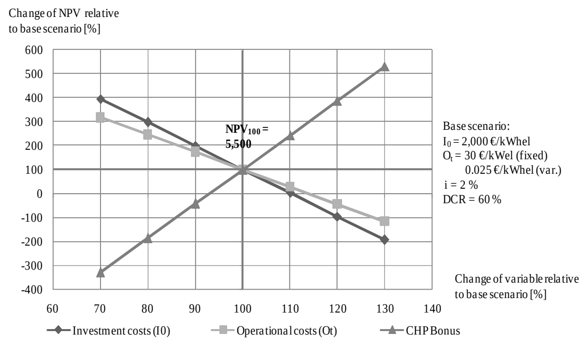


Figure 5 (left): NPV of projects comprising CHP units for the direct power supply of tenants depending on discount factor and DCR

Figure 6 (right): Influence of different variables on the NPV of CHP-based business models for tenants

Today, there are first offerings on the market integrating battery storages to PV solutions. The calculations in this regard have shown that this may be reasonable when focusing on the supply of homeowners. In contrast, using batteries in multi-family houses is not seen as profitable up to now. In case of a supply of tenants it has to be added that households have the right to freely choose their energy suppliers and to switch at least every two years. This leads to the challenge of keeping the required amount of participating units. Changes in both directions – adding and removing participants – are linked to administrative efforts and higher costs.

6 Conclusion and outlook

Coming back to the overarching research question of whether and how companies can respond to increasing residential power self-sufficiency, it was found that some innovative business models have been set up during the last years. Challenged by recent developments on the energy market becoming active in the field of residential power self-sufficiency is seen as a promising business opportunity. The ongoing market growth and the conducted interviews reveal this view. The new business models focus on both consumer groups: homeowners and tenants. They strongly vary in their extent and complexity. In contrast to the conventional way of making business, these new models involve rather small-scale and more customized offers. The analyses in this paper suggest that the profitability of such offers depends on the technology used and the customers served. Further factors influence the companies' strategic decisions related to these new business models. They are closely linked to company-specific characteristics like market position, size, innovativeness, existing customer relations, etc. Start-ups may easily define residential self-sufficiency solutions as their core business. In contrast, established energy companies usually still gear towards selling a maximum amount of power. By amending their business models and enabling consumers to produce and consume their own power, the conventional way of making business is cannibalized. Non-monetary benefits like increasing customer loyalty and gaining valuable experiences for future may be significant for them.

This paper may be seen as starting point for future research. Firstly, the profitability analysis may be expanded to business models for power self-sufficiency of different scopes. Additionally, against the background of the dynamic energy market, it may be interesting to do such economic analyses over a longer time frame taking into account changing legal and technical conditions, investment cost, etc. Secondly, it could be interesting to take the consumer perspective and to think about barriers hindering the implementation of self-sufficiency solutions although it is profitable for end-consumers. Parameters like lack of information, unawareness, high investment costs and long-term commitment or the complexity of the legal regulations may play a role in this regard. For making such business models really successful, a respective market is needed and it may be worth figuring out how to stimulate demand and how regulations have to be designed so that residential power self-sufficiency becomes more attractive. Thirdly, macro-economic effects of increasing self-sufficiency could be analyzed. Among these are distributional effects referring to a changing calculation basis for cost allocation. Auto-consumers are relieved from paying levies and hence, the cost burden for the remaining electricity consumers increases reinforcing the incentive to direct or self-consume power (Bardt et al. 2014). It could be interesting to analyze the potential long-term effects of strongly increasing power self-sufficiency on the effectiveness and efficiency of the energy market.

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