Potentials of the Sharing Economy for the Electricity Sector regarding Private Capital Involvement and Decarbonisation

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Abstract

Reaching the central objective of the Paris Agreement requires additional strategies in the European energy sector towards the (financing of) decarbonisation of electricity production. Sharing approaches imply a shift to a decentralised structure in the energy sector and deliver a possibility for the reduction of greenhouse gas emissions. Main drivers and barriers for increased involvement of private capital and decarbonisation through sharing approaches in the electricity sector are addressed in this paper. Definitions, descriptions and characteristics of sharing economy in general and in specific for the electricity sector are investigated. Moreover, a multiple case analysis examines three selected case studies regarding their fit with sharing economy's characteristics. Main drivers for the increased private capital involvement are lower investment levels and a higher degree of independence from centralised electric utilities due to the decentralised infrastructure of renewable electricity generation technologies. The main barriers are missing financial incentives for local energy and high requirements for small electricity suppliers which reduce the attractiveness for private capital involvement. We found that the integration of renewable energies and the visualisation of costs in the sharing economy concepts can lead to an increased decarbonisation rate and further environmental benefits. Consequently, we impose policy makers to consider a more favourable market environment for renewable generation capacities in sharing economy approaches to support the benefits involved.

1 Introduction

The political and societal will to limit the increase of the global average temperature has induced massive changes to the European electricity sector. Although the first steps towards the decarbonisation of the sector have been implemented and led to promising results, further efforts are needed to limit the temperature increase to 1.5 °C and thus to achieve the central objective of the Paris Agreement. In order to succeed in the long term expansive and additional strategies are required that support the necessary change of the fundamental structures of the European electricity sector.

A major pillar of the decarbonisation of the electricity sector is the steep increase of the share of renewable energies in gross final electricity consumption as for example the European Commission describes within its Energy roadmap 2050 (European Commission, 2012). In contrast to the so far predominant central and mostly fossil power plants, many renewable technologies implicate a shift to decentral structures. Whereas for example in Germany most of the conventional power plants are owned by energy utilities, about 40 % of the renewable power plants are projects in the hands of private citizens, co-operatives or fonds with civic participation. (Heinrich-Böll-Stiftung *et al.*, 2018)

The trend to decentralise economic activities can be observed in other sectors as well and there often belongs to approaches from the sharing economy. Besides rather strict definitions of the term that limit sharing economy to peer-to-peer, platform based transactions with temporary access[1], many profitable business models have emerged (e.g. CouchSurfing in the hospitality sector and Uber in the transportation sector). Not all sharing approaches in practice fit the (strict) definitions provided by scientists. In recent times, sharing approaches have also emerged within the electricity sector. Examples can be found in many different countries, e.g. Brooklyn Microgrid in the United States of America, Piclo in the United Kingdom, Ènostra in Italy, Vandebron in the Netherlands, sonnenCommunity and Heidelberger Energiegenossenschaft in Germany.

The business models from the sharing economy like CouchSurfing and Uber incorporate a high involvement of private capital by exploiting idle capacities (e.g. cars, rooms) owned by private citizens. Many authors argue that the utilization of idle capacities is furthermore the major reason for environmental benefits associated with sharing economy[2]. Nevertheless, the actual environmental benefits achieved by approaches from the sharing economy are still unknown and subject to research (Frenken and Schor, 2017; Acquier *et al.*, 2017; Martin, 2016; Frenken, 2017).

In order to lay the ground fur further research, we address approaches from the sharing economy in the electricity sector and provide first answers to the following questions:

- What are main drivers and barriers for increased private capital involvement through approaches from the sharing economy in the electricity sector?
- Which of these drivers and barriers are important for a simultaneous reduction of carbon emissions?

After a short literature review on the sharing economy with special focus on the energy sector on the one hand and environmental aspects on the other hand we introduce three case studies. Result of this section is the extent to which the cases fit to the sharing economy. The following sections further analyse the cases regarding drivers and barriers for private capital involvement and for decarbonisation through the sharing approaches. In each section drivers and barriers from literature are shortly described and the identified barriers and drivers of the cases are being presented. Upon this, a first generalisation of the results is provided. After a critical review policy implications are discussed and the need of further research is derived.

2 Sharing Economy

Defining the term sharing economy is challenging as besides different definitions and descriptions also several terms are used by authors. Nevertheless, the concepts behind the terms “Mesh”[3], “Collaborative Economy”[4], “Collaborative Consumption”[5], and “Sharing Economy”[6] overlap and comprise the same general idea. Thus, we consider all of them for the following overview of definitions and descriptions.

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[1] e.g. Eckhardt and Bardhi (2016), Frenken and Schor (2017)

[2] e.g. Harmaala (2015), Acquier *et al.* (2017), Ritter and Schanz (2019)

[3] used by e.g. Gansky (2010)

[4] used by e.g. Owyang *et al.* (2013), Kostakis and Bauwens (2014)

[5] used by e.g. Botsman and Rogers (2011), Belk (2014), Binninger *et al.* (2015), Martin *et al.* (2019)

2.1 Short overview of definitions and descriptions of sharing economy

Early and recognized publications describing the idea of a sharing economy have been provided by (Gansky, 2010) and (Botsman and Rogers, 2011). (Gansky, 2010) uses the term "Mesh" and characterises Mesh businesses by four central aspects: something that can be shared, with a focus on physical goods, under the use of advanced web and mobile data networks for information purposes, and the transmission of offers, news etc. largely by word of mouth (including social networks). Under the term "Collaborative Consumption" (Botsman and Rogers, 2011) also consider lending, renting, gifting, and swapping which other authors strictly exclude from their definitions (e.g. (Belk, 2014)). They organise the approaches in three main systems: product service systems, redistribution markets, and collaborative lifestyle with the underlying principles of critical mass, idling capacity, belief in the commons, and trust between strangers. (Botsman and Rogers, 2011)

A comprehensive typology of sharing systems developed by (Lamberton and Rose, 2012) uses the criteria exclusivity and rivalry. A broad variety of activities is considered and the following four types are derived: Public Goods Sharing (e.g. public parks), Access/Club Goods Sharing (e.g. book clubs), Open Commercial Goods Sharing (e.g. car sharing), and Closed Commercial Goods Sharing (e.g. cell phone sharing plans) (Lamberton and Rose, 2012).

(Owyang *et al.*, 2013) provides a rather short definition in comparison to the concept descriptions and frameworks given by many other authors: "The Collaborative Economy is an economic model where ownership and access are shared between corporations, start-ups, and people. This results in market efficiencies that bear new products, services, and business growth." (Owyang *et al.*, 2013)

(Belk, 2014) distincts the terms sharing economy and collaborative consumptions but identifies two commonalities within the approaches: on the one hand the "use of temporary access non-ownership models of utilizing consumer goods and services", and on the other hand "reliance on the internet" (Belk, 2014) In contrast (Sundararajan, 2016) shows a broader understanding of the term sharing economy. He considers it as an umbrella concept (like e.g. (Heinrichs, 2013)) with the characteristics: largely market based, high-impact capital, crowd-based "networks" rather than centralized institutions or "hierarchies", blurring lines between the personal and the professional, and blurring lines between fully employed and casual labour, between independent and dependent employment, between work and leisure. (Sundararajan, 2016)

(Frenken and Schor, 2017) base their framework on the aspects temporary access and utilization of idle capacities as central characteristics of sharing economy. Furthermore, they use consumer-to-consumer interaction and a physical good to distinct sharing economy from other types of platform economy (Frenken and Schor, 2017).

Recently, (Ritter and Schanz, 2019) published a comprehensive business model framework for the sharing economy. They derive a four-field matrix using the different dimensions of value creation and delivery on the one hand and of value caption on the other hand: The ideal-type sharing economy business model either belongs to (1) Singular Transaction Models, (2) Subscription-Based Models, (3) Commission-Based Platforms or (4) Unlimited Platforms.

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[6] used by e.g. Lamberton and Rose (2012), Sundararajan (2016), Frenken and Schor (2017), Ritter and Schanz (2019)

2.2 Definitions and descriptions of sharing economy in the energy sector

In addition, to general definitions and descriptions some author focus on sharing economy in the energy sector. Besides papers about specific applications[7] conceptual works have been published.

(Crosby, 2014) focuses on the power sector and identifies peer-to-peer platforms with a central backbone and increased asset utilisation as essential elements for the sharing of distributed energy resources. Regulatory issues are identified as a barrier that needs to be overcome (Crosby, 2014). An examination of regulatory issues of sharing energy with a focus on a possible regulatory disconnect is provided by (Butenko, 2016) at the example of the Dutch energy law. Major result of her work is, that a regulatory disconnect is only problematic when it leads to regulatory failure (Butenko, 2016).

In addition to a literature review of sharing economy business models in the energy sector, (Plewnia, 2019) uses five workshops with companies to derive his results. Following (Plewnia and Guenther, 2018), he characterises sharing business models in the energy sector along the four dimensions shared good, market orientation, market structure, and industry sector. Hereon he analyses the applicability of defining characteristics of the sharing economy in the energy sector (see Table 1).

Table 1: Characteristics of sharing economy and their applicability in the energy sector (Plewnia, 2019)

Aspect	**Application in the energy sector**
Platform-based	Digital energy platform companies which do not own many assets themselves, but instead offer services of coordination and optimization.
Leverage on digital technologies	Digital coordination mechanisms as the backbone of the energy infrastructure, especially with increasingly fluctuating energy supply and need for demand or storage management.
Consumer-to-consumer/ peer-to-peer interaction	Distributed decentral renewable energies, energy storage, and smart management devices offer potential for increased C2C interaction. Local microgrids and digital platforms as spaces for increased C2C exchange of energy, money, information, and knowledge.
Access instead of ownership	Traditional core principle of energy system. Now increasing ownership of energy production, storage, and management devices in households and small businesses. Potential for optimization by sharing among decentral actors.
Under-utilized resources	Not applicable for renewable energy generation facilities as these have little to no idle capacities. Batteries and electric vehicles can be used more efficiently if shared in districts or energy communities.
Shared values/ mission driven	Important factor for sharing business models in the energy sector to compensate for lack of cost advantages. Possibly even more pronounced in local sharing activities.

(Tietze, 2019) compiles characteristics of sharing economy and compares these to the characteristics of the energy and electricity sector. Drivers and constraints for sharing economy in the energy sector (see

[7] e.g. Rahbar *et al.* (2016), Qi *et al.* (2017) and Kalathil *et al.* (2019)

Table 2) are derived by analysing the characteristics shared item, information channels, utilization, and ownership and access. A major constraint for sharing economy in the energy sector is that electricity, heat and natural gas are consumed indirectly via energy services and the sharing possibilities of these energy services are restricted. Sharing approaches at earlier stages of the value added chain (e.g. sharing generation capacities) are more promising. A major driver is the transition of energy systems to high shares of renewable energies. The decentralised structure of renewable technologies fits well to the characteristics of sharing economy in terms of crowd-based networks and peer-to-peer approaches. (Tietze, 2019)

Table 2: Drivers and constraints for sharing economy in the energy sector (Tietze, 2019)

Drivers	**Constraints**
- high level of automation and mechanisation of the energy sector - energy transition to high shares of renewable energies - grid access - smoothed aggregated load profiles - development of storage technologies	- electricity itself cannot be shared - electricity is a low-interest product - high investment in infrastructure - complicated and diverse regulations in the energy sector

2.3 Sharing economy and the environment

The environmental benefit of approaches from the sharing economy has been addressed by several authors, mostly in terms of the environmental dimension of sustainability. Nevertheless, in many cases the benefits are stipulated and not analysed[8]. For example (Heinrichs, 2013) suggests a rather broad understanding of the concept of the sharing economy as he considers it a potential new pathway to sustainable development. When deriving further research needs with regard to sustainable development he argues that especially the interface between product service systems, redistribution markets and collaborative consumption is relevant. (Heinrichs, 2013)

Besides (Heinrichs, 2013) and (Plewnia and Guenther, 2018) also (Curtis and Lehner, 2019) define the term sharing economy in the context of sustainability. In contrast to the broad definitions proposed by the first authors they propose a rather narrow understanding using the following characteristics: ICTmediated, non-pecuniary motivation for ownership, temporary access, rivalrous and tangible goods.

(Daunorienė *et al.*, 2015) develop a methodological approach for the analysis of the sustainable performance of sharing approaches. The environmental sustainability is represented by the perspectives materials and energy, water and air, built-form and transport, emission and waste using a nine-point scale from critical sustainability to vibrant sustainability. The exemplary application of the methodology to a peer-to-peer clothes selling, buying and swapping company shows a mid-point level of sustainability. (Daunorienė *et al.*, 2015) (Leismann *et al.*, 2013) analyse the resource efficiency potential of sharing approaches. They confirm a general resource-saving potential but - just as (Daunorienė *et al.*, 2015) - they conclude that the environmental benefit is case specific (Leismann *et al.*, 2013).

[8] An exception to this is car-sharing, see e.g. Ferrero *et al.* (2018)

The impact of sharing cities on a more sustainable environment is questioned by (Harmaala, 2015). The result indicates many possibilities for a more sustainable development in cities but is still inconclusive (Harmaala, 2015). (Martin *et al.*, 2019) provide a life cycle analysis of a peer-to-peer product sharing platform in Sweden. They identify the avoidance of production as main driver for the reduction of environmental impacts. Due to the sensitivity of life cycle analyses to methodological choices and assumptions they claim the need for further environmental assessments of sharing approaches. (Martin *et al.*, 2019)

In a comprehensive work, (Martin, 2016) analyses six different framings of the term sharing economy, two of it with direct reference to sustainability: sharing economy as a more sustainable form of consumption and sharing economy as a pathway to a decentralised, equitable and sustainable economy. These framings are more used by niche actors whereas regime actors tend to frame sharing economy commercially. Thus, a transition to a more sustainable development by sharing approaches is questionable. (Martin, 2016) (Acquier *et al.*, 2017) analyse the paradoxes of sharing economy and contrast aspects that assist sustainable development (better leverage of natural capital, producers' responsibility for environmental externalities) with aspects that hinder sustainable development (moral hazard, incentives and information asymmetries, rebound effects).

Important first analyses on the environmental impact of sharing economy have been provided by several authors. The papers mostly concentrate on conceptual issues and the drivers and barriers for environmental impact in practice are subject to research.

3 Three cases and their fit to the characteristics of the sharing economy

Within a multiple case analysis, three selected case studies will be examined regarding their fit with sharing economy's characteristics. The cases Piclo, SonnenCommunity and Heidelberger Energiegenossenschaft are chosen with regard to diversity in the approaches. The analysis is divided into several steps according to (Hoffmann, 2016), which include the selection of the examination units, collection, processing and evaluation of the information and finally a comparison of the case studies to the characteristics of sharing economy.

The analysis makes use of various criteria to describe the case studies. Ensuring a logical link to the research question, the criteria are based on publications on the topics of energy, electricity and sharing. In this work we follow the framework provided by (Plewnia and Guenther, 2018) which examine sharing approaches in general. (Plewnia, 2019) connects these criteria to the energy industry. To ensure the construct validity of the analyses, criteria provided by (Zhang *et al.*, 2017) and (Bocken *et al.*, 2014) are furthermore considered.

The criteria can be subdivided into four dimensions: general information, shared good, market orientation and market structure (Plewnia and Guenther, 2018). General information contains data such as the goal, basic operations and key activities. The category shared good includes information to e.g. the shared material, product service system, space, resources and technology, data and information, knowledge and education as well as expandability. In addition, the market orientation category serves to reveal the economic orientation of the respective case study. The customer segment is taken up in the category market structure. (Plewnia, 2019; Zhang *et al.*, 2017; Bocken *et al.*, 2014) On the basis of this structured description of our cases we use the main characteristics of sharing economy in the energy sector (see Table 1) to assess the fit of the cases to the concept of sharing economy.

3.1 Case Piclo

Piclo was launched in 2016 as collaboration between the technology company Open Utility and the renewable energy company Good Energy in the UK (Open Utility, 2019). The project is of national size and belongs to the energy sector (Open Utility, 2016). Table 3 offers further information on Piclo for the criteria described above.

Table 3: Main characteristics of case Piclo (Open Utility, 2016, 2018)

Aspect	**Identified characteristics**
General Information	Piclo is a peer-to-peer energy trading platform. It uses smart meter data, producer prices and consumer preferences which include, for example, location, generation technology, ownership, and producer costs. Consumers prioritize suppliers and with this information, supply and demand are matched by an algorithm every half an hour. Thereby, customers receive the largest share of their electricity from the producers with the highest priority. In addition, power suppliers also have control over the buyers of their electricity.
Shared good	The material is tangible as the capacity of renewable generation plants is shared and can be used for a certain period of time. The production facilities are exclusively owned by the producers. These need the equipment and have to create the space for it whereas consumers only need a connection to the power grid. The participants receive data visualizations and analyses. Over time, they can see from whom they purchased their electricity or to whom they supplied their electricity. Piclo offers a visualization of fees, to motivate consumers to postpone and reduce their usage during peak hours as the fees are higher during peak periods.
Market orientation	Profit-oriented: Electricity suppliers pay a fee to Open Utility in order to use the platform. They offer a portfolio of renewable energy sources. Consumers also pay usage fees which will cover the costs of the distribution system operator for the electricity supply.
Market structure	B2B (energy producers and commercial electricity consumers)

Piclo corresponds to the characteristics of a sharing economy according to (Plewnia, 2019) as described in Table 1. The generated marketplace enables a platform-based peer-to-peer energy trading. Thus, the aspects platform based, peer to peer interactions and transactions can be confirmed. The platform relies on digital technologies, such as smart meters and an algorithm, which is supposed to match supply and demand. In addition, the members don’t have to be owners, because a short term access to renewable energy generation facilities is possible. Piclo’s mission is a sustainable energy system that provides its users with clean, affordable and abundant electricity (Open Utility, 2016). With renewable energies, the company is aiming for a sustainable planet with a renewable, decentralised energy supply (Open Utility, 2018). Due to the use of renewable energies, the characteristic of under-utilized capacity is not applicable. All in all, Piclo’s market behaviour is consistent with all points of a sharing economy according to (Plewnia, 2019).

3.2 Case SonnenCommunity

In 2015, the German battery manufacturer Sonnen GmbH founded the sonnenCommunity, which represents a national network within the energy sector (sonnen GmbH, 2019c, 2019b, 2019d). Several Information to general issues, shared good, market orientation as well as market structure are given in Table 4.

Table 4: Main characteristics of case sonnenCommunity (sonnen GmbH, 2019c, 2019b, 2019a, 2019e)

Aspect	Identified characteristics
General Information	SonnenCommunity is a peer-to-peer online community platform that forms a decentralized energy community. Its members are virtually and intelligently connected. They are able to feed excess electricity into the grid as well as to draw electricity from it. They can exclusively excess energy that can't be stored in their sonnenBattery. A centralised software determines how much electricity is produced and consumed and decides how much electricity can be fed or must be drawn from the grid. The community also includes larger decentralised energy producers such as wind turbines, biogas plants or large photovoltaic plants. They join the solar community and feed their electricity to the grid in order to provide the community members with enough electricity at any time.
Shared good	The shared good is tangible as solar systems or wind turbines with connected electricity storage are shared between the community members. The shared generation and storage technologies create a virtual storage capacity that is individually distributed to the owners of the solar battery storage and bundled into a single unit. Members get access to information about the individual consumption and production via the online portal. The website offers information on the German energy transition, renewable energies, photovoltaics and electricity storage. The prosumers need space on the roof or in the garden for the solar system or a wind turbine and within the house for the battery (modular design in 2 to 2.5 kWh steps).
Market orientation	Profit oriented: Prosumers who feed their excess electricity to the SonnenCommunity receive a higher fee in contrast to selling their energy to major power companies. Members who draw their electricity from the community get cheaper electricity compared to the tariffs of major power companies. By means of the intelligent meters, the community system can be accounted for and excess electricity can be traded on the stock exchange. Community members pay a monthly basic fee called SonnenFlat which allows obtaining the required electricity for free. However, this applies only to an annual consumption including own consumption between 4,250 kWh and 8,000 kWh. Further electricity needed is supplied to 23 cents/kWh.
Market structure	C2C and B2C

Sonnen fits the characteristics of the framework for sharing economy in the energy sector provided by (Plewnia, 2019). The case example presents a peer-to-peer online community platform that forms a decentralised energy community. Through this platform, the prosumers interact with each other. The platform relies on digital technologies such as smart meters and the virtual pooling of storage capacities. Members of the SonnenCommunity must have a renewable generation plant as well as a battery storage as the shared capacities are distributed among the members of the community. The website contains information on the German energy transition and renewable energies. The online portal provides information on consumption and generation for users. However, no indication to support the understanding of their own energy consumption is visible. Again, the characteristic of under-utilized resources is not applicable due to the use of renewable energies.

3.3 Case Heidelberger Energiegenossenschaft

The HEG Heidelberger Energiegenossenschaft eG (HEG) was founded in 2010 by a student group initiative called Unisolar (HEG, 2017). HEG is a typical example for the manifold energy cooperatives that developed in the German energy sector. Table 5 sums up the main characteristics of HEG.

Table 5: Main characteristics of case HEG (HEG, 2017, 2011)

Aspect	Identified characteristics
General Information	HEG is a crowd-based network. Citizens become members through buying shares and the cooperative distributes the economic benefit between its members. Purposes of HEG are the initiation of projects to use renewable energies on local, regional and inter-regional level, the participation in renewable energy projects, the generation and selling of renewable energy and the provision of services in the field of renewable energy, energy efficiency, and climate change locally and regionally. HEG has a strong focus on photovoltaic projects, but also invests in wind parks.
Shared good	The shared item within HEG is renewable energy generation capacity from photovoltaic modules (with and without battery), charging stations for electric vehicles and shares in wind parks. Whereas the photovoltaic modules and charging stations constitute tangible physical goods, shares in the wind parks have to be seen as a financial product. It is only in exceptional cases that ownership (membership in HEG) and access (electricity contract through the cooperation partner Bürgerwerke eG) are combined in certain projects. HEG furthermore provides the possibility for all members to purchase electricity from the cooperative via their cooperation partner, but without a link to a certain project. Thus, HEG members only need financial resources (and no spatial resources). HEG owns all assets.
Market orientation	Profit-oriented: Member shares amount to 100 € and each member can hold up to 200 shares. Depending on the annual result members receive a dividend.
Market structure	C2B

HEG has only a minor fit with the main characteristics of the sharing economy in the energy sector. It is a crowd-based network that owns the assets which contradicts the description of a peer-to-peer platform that offers services instead of owning assets. There is no use of digital technologies that go beyond the standard use in the energy sector and furthermore, the consumer-to-consumer interaction is only given for selected projects. For these projects ownership and access are shared but in general, HEG does not fit to the principle of access instead of ownership. Due to the focus on renewable energies the category of under-utilized resources is not relevant. The only characteristic that HEG completely fulfils is the claim of shared values. Besides the general target of any cooperative to distribute economic benefits between its members the specific target of contributing to climate protection on a local level unites HEG's members.

Whereas Piclo and sonnenCommunity have a general fit to the applied characteristics of the sharing economy HEG only has a minor fit. As the discussion about definitions and characteristics of sharing economy is still ongoing we will nevertheless not exclude HEG from our further analyses but will critically discuss the results in this context.

4 Drivers and Barriers for private capital involvement through sharing approaches in the electricity sector

In their World Energy Investment Outlook the International Energy Agency calculated the necessary investment to achieve the goal of limiting the global average temperature increase to 2 °C: The estimate accounts to an investment of approximately 53 trillion USD in energy supply and energy efficiency over the period to 2035. (IEA, 2014) During a workshop in 2011 a multi-disciplinary expert group analysed past energy transitions and identified financial markets and the access to capital as drivers and the lack of capital a clear constraint for the enabling of transitions. (Fouquet and Pearson, 2012) Thus, in order to reach the tremendous investment necessary for the ongoing energy transition besides public sources also significant private capital is needed.

To attract private capital in general an attractive risk-return-profile of an investment project is needed (see e.g. (Anbumozhi *et al.*, 2018)) and thus a general driver. For green investments in many cases the return is still a barrier as it is limited and the investment risks are considered too high. The limited return is generally assigned to subsidised fossil fuels whereas the investment risks need closer examination due to their diversity: investment risks can be related to regulation, technology and financing. (Lindenberg, 2014) Plenty authors describe regulatory issues as the major remaining barrier for private capital involvement in many countries (World Bank, 2007; Mathur *et al.*, 2017; Anbumozhi *et al.*, 2018; Justice, 2009). This opinion is underpinned by recent figures provided by the International Energy Agency: investment in renewable energies is depending strongly on regulated instruments (IEA, 2018). In addition, the individual investor needs to be taken into account. Besides risk and return of a project also cognitive aspects (type of investor and prior investments) are relevant in terms of being a driver or barrier. Individual preferences lead to perceived risks and expected returns of the projects. (Wüstenhagen and Menichetti, 2012)

Due to the rather mature state of the British and German electricity markets and the already high private capital involvement we focus our analyses to direct capital involvement by private citizens. Thus, we exclude investments from institutional sources and via stock exchanges from our analyses. In the following, we will analyse the three cases in order to

1. describe the incorporated mechanisms of private capital involvement,
2. determine whether this investment leads to additional infrastructure, and
3. derive assumed drivers and barriers for private capital.

Furthermore, from the general drivers and constraints for sharing economy in the energy sector we deduce further possible drivers and barriers for private capital involvement.

As being a matching platform Piclo does not lead directly to more private capital involvement by private citizens. Investment in additional infrastructure is not necessarily part of the business model: Retailers can offer electricity for a fee and customers can select the suppliers they prefer by assigning priorities based on several criteria (e.g. location, technology type, ownership, and cost). (Open Utility, 2018) Thus, for private citizens as customers the major difference between Piclos's offer and a standard electricity supply contract is the possibility to select the electricity generators to be supplied from. It needs to be mentioned though, that the first commercial application of Piclo is currently restricted to business customers and does not involve private citizens (good energy, 2018).

Even though Piclo does not directly increase the investment made by private citizens it offers an environment that facilitates private capital involvement. For private investors in decentralised electricity generation capacities the possibility emerges to merchandise their electricity using several competitive differentiators that go beyond the characteristic "green electricity". As new technologies in the beginning develop in niches due to the fact that they offer an additional characteristic specific customers are willing to pay for (Fouquet and Pearson, 2012) the possibility to differentiate from other offers is assisting private investment. This assumption is in line with analyses of costumers' motivation for the participation in peer-to-peer platforms: Currently, financial incentives for contracting local energy are missing and the reason for participation is the support of ecologically conscious customers for local low carbon electricity generators (Open Utility, 2018).

SonnenCommunity's business model incorporates the investment of private citizens: Participants invest in photovoltaics modules and battery storage to become a member of sonnenCommunity. In the ideal case the members receive all electricity from the sonnenCommunity, pay a monthly basic fee and no charges per kWh occur. SonnenCommunity members so become independent from electric utilities as the electricity they cannot take from their own infrastructure is provided by another sonnenCommunity member. (sonnen GmbH, 2019c) SonnenCommunity strives for private capital investment in order to scale up the overall capacity. Again, the independence from electric utilities is a motive for the private citizens to participate in the sonnenCommunity and in this case constitutes also a driver for private capital involvement. A further driver for private investment in this case is a clear risk-return profile for each project and so for each individual investor. On the basis of his individual conditions (roof size and orientation, electricity demand, location) a sound investment appraisal for the lifetime of the assets is possible. Whether a membership with sonnenCommunity leads to a higher return of the project remains nevertheless unclear.

HEG also leads to more investment from private citizens into the energy sector. Private citizens buy shares of the cooperative and due to the purpose of HEG this money is used amongst others to support and to initiate renewable electricity generation projects (HEG, 2011). A driver for the private investment in this case can be seen in the clear (and limited) risk, as members are only liable in form of their share. All members of the cooperative are equally entitled to vote, so each individual member (and also investor) can influence the infrastructure to be invested in. As the projects are only partly located at the premises of members, the own consumption of the generated electricity and thus the independence from utilities is not generally incorporated in the projects. Nevertheless, besides ecological considerations the desire to be more independent from multinational energy utilities constitutes a motive to become a member of an energy cooperative (Volz, 2012). A speciality of HEG is that it enables private citizens without the spatial requisites to invest into renewable energy generation technologies. People living in tenancy get access to active involvement in the energy transitions. A clear driver for private capital investment in this case is thus the enabling of private investment independent from owning space (e.g.

rooftops). In combination with HEG's partner Bürgerwerke eG members of the cooperative at least virtually can access electricity generated by HEG.

Summing up, we derive the following potential drivers for increased private capital involvement from our cases:

- better market differentiation (e.g. local photovoltaics instead of a general renewable offer)
- the possibility to become (more) independent from electric utilities
- the provision of a clear risk-return profile
- the enabling of private investment by citizens without real estate.

With regard to the drivers and constraints provided by literature the approaches from the sharing economy thus assist to both a clear risk-return profile and primarily to the better consideration of individual preferences of the investors. Concerning the general drivers and constraints for sharing economy we conclude that our cases incorporate drivers belonging to the aspects

- renewable energies (all cases),
- storage technologies (sonnenCommunity and HEG in some projects),
- sonnenCommunity is based on different generation profiles from different locations which can be in general be assigned to the driver of smoothing load (or in these case generation) profiles.

Furthermore, the approaches assist to overcome the barriers of

- electricity being a low-interest product (Piclo by enabling further market differentiation, all three by supporting the independence from centralised utilities) and
- high investment in infrastructure (esp. HEG by sharing the investment).

The fit of the decentralised structure of renewable electricity generation to the principles of the sharing economy is thus one of the major drivers for capital involvement of private citizens. This is of special importance as (Wolff, 2018) describes that due to the small scale of these projects there is lacking interest of bigger investors.

5 Drivers and Barriers for the reduction of carbon emissions

The sharing economy seems to promise increased sustainability (Zhou *et al.*, 2018). However, it is meanwhile criticised that the sharing economy is classified as not exclusively environmentally friendly as the environmental impact is considered unclear. (Martin, 2016) dealt with this topic with regard to the overall phenomenon of the sharing economy.

The methodological approach in this section is divided into the following steps: Initially, the three cases will be analysed for possible environmental effects in terms of CO_2 emissions. The information provided in Table 6 and Table 7 is taken from the multiple case analysis. Thereby, drivers and barriers that enable or prevent decarbonisation are identified. The potential impacts on decarbonisation are subsequently compared to findings in literature in order to derive a generalisation for further cases. General drivers and barriers going beyond the cases are furthermore included.

Table 6: Drivers for decarbonisation in the case studies

Example	Effect
sonnenCommunity: Members are virtually and intelligently connected. HEG: Production and sales of renewable Energies.	Increasing all over renewable energy consumption through sharing.
sonnenCommunity: Centralized software determines how much electricity is consumed. Piclo: Supply and demand are matched by an algorithm.	Higher efficiency through flexible matching and balancing.
Piclo: Offers a visualization of grid usage fees. Motivates consumers to postpone and reduce their usage.	Motivates energy savings and thus CO_2 savings.
HEG: Direct supply of living quarters by PV (including storage plus charging station) sonnenCommunity: Consumers can choose local supplier.	Local consumption that prevents transmission losses.
HEG: Project new home Nußloch: Tenants can buy shares and purchase cheap solar power.	Low-income households have access to renewable energies.
HEG: Project Bauhof Ladenburg: In addition to the solar system, the project includes a charging station. sonnenCommunity: Expandable construction of the battery.	Extensibility of the system.
sonnenCommunity: Each member of the community needs a renewable energy plant and battery storage.	Increasing renewable energy consumption due the implementation of a battery storage.

Table 7: Barriers for decarbonisation in the case studies

Example	Effect
sonnenCommunity: Each member of the community needs a renewable energy plant and a battery storage.	Capital is divided between the battery storage and the solar system.
sonnenCommunity: SonnenFlat for community members allows to obtain the required electricity for free up to a certain limit.	Flat rates may lead to increased electricity consumption.

The level of self-consumption, which can increase as a result of the joint use of energy production facilities in the cases Piclo and SonnenCommunity, has a positive effect on CO_2 savings due to lower transmission losses. In microgrids based on local energy supply, transmission and distribution losses can be reduced by an increased on-site consumption (Sun *et al.*, 2018). An increase in self-consumption can occur especially when the community consists of different users with different habits and members using their electronic devices at different times (Tang *et al.*, 2019). Smart Grids or rather flexible matching devices used by Piclo and SonnenCommunity enable the efficient operation of energy systems using distributed, independent computing. The intelligent grids allow reliable information on feed-in values and grid status information. Balancing supply and demand can be made more flexible and therefore more efficient. Energy consumption is thereby reduced sustainably according to (Schultze, 2017). Sharing approaches in the field of electricity (applicable for all cases) help to increase the share of renewable energies in the power grid. The abandonment instead of adding conventional power generation leads to CO_2 savings (Kröhling, 2017). Smart meters and online platforms accessible to Piclo's sharing users will ensure energy transparency. This transparency is the prerequisite for consumer education in terms of energy savings. As an example, users can recognize saving potentials through visualized data and optimize their energy consumption. For instance, battery storages can be used as feedback tools that inform the users about their power generation and consumption (Griese *et al.*, 2016). The sharing approaches offer people with less equity the opportunity to source electricity from decentralized renewable energy or to invest in projects (Tang *et al.*, 2019). In this way, HEG promotes the expansion of decentralized renewable energy generation and thus supports CO_2 savings. Due to the possible extensibility of existing systems, it is not necessary to emit CO_2 for producing completely new systems, but only for the additional needed components (Griese *et al.*, 2016).

However, if it is possible to export electricity to neighbouring consumers in a virtually lossless network, the CO_2 savings will decrease with the size of the battery, due to charge and discharge losses as well as emissions that occur during production (Sun *et al.*, 2018). Risks of sharing approaches are possible rebound effects due to a change in consumer behaviour. These have the potential to reverse the CO2 savings or environmental benefits of energy savings (Kröhling, 2017). If battery storages are installed in addition to photovoltaic systems, the photovoltaic system is often designed to be smaller than possible, because the capital is divided among the different components. As a result, not all of the available capital is invested in the solar system (Griese *et al.*, 2016). Otherwise, instead of an electricity flat rate as offered within SonnenCommunity, the sharing offer could be reshaped with a reimbursed flat rate. The subsidiary innogy of the German energy provider RWE offers a flat rate, which provides an incentive to save energy. The company rewards its customers with a refund and lowers monthly amounts when energy savings are made as the limit of tolerance is undercut (Innogy SE, 2019).

In summary, the major drivers for decarbonisation in the cases are the following:

- the visualisation of power generation and consumption, which may lead to energy savings
- flexible balancing of electricity generation and consumption, which allows more efficiency
- the use of renewable plants instead of conventional energy generation contributes to a reduction in overall CO_2 emissions

However, there are points that may be barriers for a decarbonisation or can be considered contradictory:

- possibly smaller design of photovoltaic systems because of the battery storage invest - but, the shared investment can also be interpreted as an advantage, as the use of an energy storage increases the renewable energy consumption,
- customer benefits such as low electricity costs or flat rates can lead to increased energy consumption and negate CO_2 savings.

All of these points show the contradictory nature of the sharing economy, which can't be considered as exclusively environmentally friendly and the solution for a decarbonisation.

6 Conclusions and Outlook

Sharing approaches in the electricity sector are manifold. The three selected cases from two countries show different characteristics but do not cover the wide range of applications that emerged over the last years. Furthermore, the results presented in this paper are limited due to the theoretical nature of the analyses. The cases and the methodology however served well to derive first results and also to identify further need for research.

The result regarding the fit of the selected cases to the applied characteristics of sharing economy is diverse: Piclo and sonnenCommunity fit well but HEG's fit is poor. HEG's result is in line with previous analyses applying other characteristics for sharing economy (Tietze, 2019). HEG can be considered as a type of crowd-funding for capital projects, a mechanism that according to (Kalathil *et al.*, 2019) all successful sharing economy approaches in the grid have so far been confined to. Nevertheless, the discussion on the defining characteristics of the sharing economy is still ongoing and thus the results regarding the fit with the sharing economy need to be considered preliminary.

Main driver for an increased capital involvement by private citizens in the investigated cases is the incorporation of renewable electricity generation technologies. The decentralised infrastructure fits the idea of the sharing economy and due to the low investment (in comparison to centralised power plants) also fits to the investment of private citizens. The sharing approaches in this field constitute an advantage to the electricity sector as lacking interest of bigger investors for small projects is compensated for. The sharing approaches thus assist the restructuring of the electricity system. Whether the private capital found in the cases is additional investment or would have been invested otherwise in the electricity sector has not been determined.

Another driver found in all cases is the enabling of final consumers to become (more) independent from electric utilities. In the case of HEG (in combination with its partner) this is also possible for private citizens without real estate.

The main barrier in form of regulatory issues has not been directly identified in the cases as major constraint for private capital involvement. In line with (Crosby, 2014) missing financial incentives for local energy however constitute a barrier for the further development of some sharing approaches. Thus, a more favourable regulation especially in terms of financial incentives in this field could also attract further private capital. The same applies to regulations regarding the requirements for suppliers as these hinder the sharing approaches itself: HEG founded the cooperative "Bürgerwerke eG" as supplier of electricity generated in energy cooperatives for final consumers. According to HEG the effort for a single energy cooperative to fulfil all requirements of an electricity supplier is (too) high. Thus, also in this field a more favourable regulation for small electricity suppliers would attract more private capital.

Driver for the decarbonisation of sharing approaches is in all cases the integration of renewable energies, since superseding fossil generation leads to reduced carbon emissions. Furthermore, the visualisation of costs, generation and consumption can increase the awareness of electricity consumption and motivate for lower consumption levels. But electricity belongs to low-interest products (Fischer, 2008) and enduring behavioural change is rare. Nevertheless, lower consumption levels not only decarbonise the system but can also lead to further environmental benefits in terms of e.g. particulate matter and NO_X emissions. The same applies to a more local electricity supply avoiding transmission losses and to the higher efficiency levels through flexible matching and balancing.

Nevertheless, sharing economy is not environmentally friendly or decarbonising without restriction. Increased renewable electricity generation requires more generation capacities due to the lower capacity factors. Thus, additional environmental impacts in the construction phase result (see e.g. (Lazar and Tietze, 2019)). Individual cases should thus be analysed closely for their potential environmental impact. Regarding barriers in terms of decarbonisation, potential negative environmental consequences such as rebound effects, which could be caused by the offer of flat rates, should be firstly critically questioned and secondly optimized by providing an incentive to save energy, as e.g. Innogy does (Innogy SE, 2019).

In general, the major driver for both, private capital involvement and decarbonisation identified in the cases studies is the integration of renewable generation technologies. Overall implications for policy makers thus concern a favourable market environment for the further increase of renewable generation capacities in sharing approaches. A favourable market environment could express itself in cost advantages for private investors, legal subsidies that drive sharing approaches or amended data protection regulations.

The utilization of idle capacities is seen as the major driver for environmental benefit from sharing approaches. As for renewable generation technologies this does currently not apply due to the priority regulations in most countries, the question arises, whether this reasoning also applies to the electricity sector. With regard to our analyses furthermore the question whether the sharing approaches lead to additional renewable capacities remains open and needs further research. In general, the analyses in this paper give first insights but more cases need to be analysed in more detail e.g. by questioning providers and participants of the sharing approaches.

7 References

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