Chapter 11: Prosumers' Digital Business Models for Electric Vehicles: Exploring Microfoundations for a Balanced Policy Approach

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Abstract
Mäkinen et al. provide an indispensable view of business model opportunities for electric vehicle (EV) prosumers in the future energy market. The digitalization of the energy markets has started a transformation to smart grids where information flows bi-directionally end-to-end between energy production and consumption. The chapter explores how prosumers can create, deliver, and capture value with EVs in future energy systems. Focusing on prosumers' digital business models (DBMs), the chapter illustrates the complex interdependencies between various activities and actors needed in the development of an energy system. In addition to demonstrating prosumers' EV DBMs and the current state of readiness in value creation, delivery, and capture, Mäkinen et al. develop a balanced policy approach that is based on these DBM microfoundations.

Transformation of Energy Markets

The energy system is undergoing a big transformation that comes from at least three sources. First, smart meters and other digital solutions increase the amount of information in the system and create possibilities for new business models. Second, increasing shares of renewable energy (RE) sources in the energy system require flexible energy resources, including energy storage, alongside them. Third, the introduction of new loads, like electric vehicles and heat pumps, can create peak demands in the energy system if not managed properly.

This energy transition can be looked from different perspectives (Meadowcroft, 2009). On one hand, an energy transition can be described as the shift from a top-down supply system to a multi-level exchange system (Schleicher-Tappeser, 2012). The traditional energy system has five components: energy source, generation, transmission, distribution, and end user (Richter, 2012; Rodríguez-Molina et al., 2014). It is characterized by centralized energy production, one-way communication and energy flows, a small number of data and sensors, manual control, and only a few user choices. In contrast, a distributed energy system means small-scale energy generation, two-way real-time communication, and extensive control systems (Zame et al., 2017). On the other hand, energy transition can mean the shift from fossil fuels to clean energy sources. This perspective highlights the shift on the generation side instead of adaptation efforts on the demand side or changes in actors and their roles.

A systemic change like the energy transition can be viewed from different theoretical perspectives. The multi-level perspective (MLP) looks at interlinked changes at niche, regime, and landscape levels from a longitudinal perspective (Geels, 2002). The technological innovation systems (TISs) perspective emphasizes the structures, functions, and inner dynamics of the innovation systems (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). The strategic niche management (SNM) perspective is close to the MLP but looks more precisely at how innovations can be shielded, nurtured, and empowered (Smith & Raven, 2012). Other important concepts in transition theories are path dependencies, lock-ins, and path creations, which are tightly interlinked with the theories mentioned. However, these perspectives lend little help to scrutinizing transitions at the micro-level.

The drivers for the energy market transition come from a combination of interventions on the micro- and macro-levels. The transition management governance theory builds on such a balanced approach (Loorbach, 2007). Micro- and macro-level policies address the problem in a coordinated manner with an attempt at balancing between a hierarchy and a free-floating market with the right timing for interventions. A balanced approach requires taking into account provision of knowledge and demand-side activities, providing constituents the required legislation/regulations and support for the innovation system and the firms operating in it (Edquist, 2014).

In the energy transition, the landscape has changed on the macro-level to mitigate climate change. The Paris agreement and other political commitments have mandated governments intervene in energy markets with attempts, like the emission trading system (ETS). Other policy objectives of the energy trilemma (i.e., measures for accelerating the energy transition), security of supply and energy equity, are also taken into account by implementing different energy-capacity mechanisms and market deregulation.

These modifications have changed consumer awareness and behavior on the micro-level (Balcombe, Rigby, & Azapagic, 2013). Responding to the bottom-up movement, governments have fostered the diffusion of RE technologies by mitigating the biggest barriers to consumers' adoption of RE technology (Painuly, 2001). In successful transitions, local regions' own dynamics like labor skills, culture, and opposition to top-down policies, are taken into account (Loorbach, 2007). In the case of solar photovoltaic (PV) systems or EVs, demand has been created by financial subsidies, for example. Subsidies have sometimes proven to be tricky instruments by causing too weak a demand or boom-and-bust cycles in the market. For instance, Spain and Denmark monitored and changed the course of their solar PV markets after high and sudden expenses (IEA-PVPS, 2016). The interplay between companies and institutions in this meso–macro link has been shown to be important for the creation of new institutions; for example, advocacy coalitions have legitimized the new technologies in the regime (Jacobsson & Lauber, 2006). This has led to the standardization of technologies and procedures, property rights, and market structure and regulation (Scholten & Künneke, 2016).

Finally, this trajectory has opened up the energy market to complementary technologies and activities that are needed in integrating the distributed energy resources (DERs) in the system. Thus far, market structures for valuing demand response (DR) and flexibility properly have changed in many countries (SEDC, 2017). Incumbents and new entrants in the energy markets, like aggregators, are incentivized to build creative processes and business models. Market structure changes are further accompanied by offering data and networking possibilities to the actors in the markets. For instance, home energy management systems (HEMSs) can gather information about the whole energy community and in that way optimize the use of local resources (Koirala, Koliou, Friege, Hakvoort, & Herder, 2016). Increasing competition co-evolves with consumers' preferences and has given consumers the power to steer investments for better efficiency overall. All of this has created a dynamic playing field where the micro-, meso-, and macro-levels of the energy system are closely interlinked and co-evolving, and at the same time, the evolution of national systems is constrained by lock-ins and path dependencies. In this chapter, we investigate the micro-level transition from consumers to prosumers and seek microfoundations for a balanced policy approach especially focusing on how EVs might engage prosumers in creating various digital business models.

Based on these microfoundations, we explore a balanced approach to the governance of the change in energy systems and sustainable development taking into account individual prosumer behavior and the institutional environment and its change (Spaargaren, 2011; Liedtke, Buhl, & Ameli, 2013). In essence, the balanced approach requires policy makers to set an agenda, coordinate change plans, incentivize individuals and corporations to desired actions in plans, and furthermore, induce follow-up measures to reinforce change (Akenji, 2014; Liedtke, Buhl, & Ameli, 2013). We concentrate on exploring micro-level digital business models that EV prosumers could have in the future following a similar approach of micro-level measurement as in Saari, Baumgartner, and Mäkinen (2017). In doing so, we explore opportunities to link the micro- and macro-levels (Coleman, 1990) in a balanced approach to achieving the sustainability goals for changes in the energy system.

Measuring micro-level phenomena to understand macro-level phenomena has been presented in sociology as a preferred approach instead of focusing purely on macro-level factors and understanding (Coleman, 1990; Raub, Buskens, & Van Assen, 2011). Prosumer-level digital business models have an impact on the meso- and macro-levels and lead to market change and possibly, to sustainable development if properly guided. At the meso-level, prosumers are directly linked to other actors, like traditional energy market actors, and at the macro-level, prosumers' digital business models challenge the institutional role of regulators and structures; the consumer institution in itself is pressured to change to prosumer, etc. Thus, macro-level changes are outcomes resulting from the interdependence of actors on different levels (Raub, Buskens, & Van Assen, 2011).

The Evolving EV markets

The EV market is still a fraction of the total global car sales, but market shares are increasing rapidly. The two biggest markets are China and the United States (US). In Europe, the biggest markets are Norway, the United Kingdom (UK), France, Germany, the Netherlands, and Sweden (IEA, 2017). In Norway, EVs accounted for more than 39% of the market in 2017, which is by far the largest in the world. In 2017, China's EV market grew 71% compared to 2016 as more than 600,000 vehicles were sold. China's market is almost completely closed to foreign brands as non-Chinese car manufacturers reached only 4% of sales. China is also leading the market for electric buses although sales decreased 23% to 90,000 busses in 2017 (Dixon, 2018). Europe's market in total grew 38% from 2016 to 306,000 registrations in 2017 (Shaham, 2018). In the US, approximately 200,000 EVs were sold in 2017 meaning growth of 26%. The growth of the EV market seems destined to continue as an increasing number of car manufacturers are introducing EV models and are investing in the technology. The price parity of EVs compared to internal combustion engines (ICEs) is expected to hit around 2025, but the estimates vary.

Political interventions have been the main driver for the diffusion of EVs. Many governments see EVs as a way to reach environmental and energy independence goals. In 2016, 14 countries (including China, Germany, and the UK) set EV targets and even mandates (IEA, 2017). The targets are important in the policy strategy as they also form the level and scope for the choice and implementation of the policy instruments. In total, these 14 countries set a target of 13 million EVs on their roads by 2020. These countries do not include many potentially major markets for EVs, such as India, which has expressed ambitious plans for 100% EV sales in 2030. Estimates for the total number of EVs on the road by 2025 vary from 40 million to 70 million (IEA, 2017). However, the rollout of EVs will vary across countries even inside the European Union (EU). For instance, it is estimated that sales in central and eastern Europe will not increase until 2030.

The increase in the EV market poses opportunities and challenges for car manufacturers, especially the incumbents. To achieve the deployment targets, 60% annual growth in overall EV production is needed (IEA, 2017). Until recently, the global market has been dominated by Chinese original equipment manufacturers (OEMs) that accounted for 43% of the global production of EVs in 2016 (Hertzke, Müller, & Schen, 2017). Accordingly, several global OEMs have announced targets for bringing new EV and plug-in hybrid electric vehicle (PHEV) models to the market. Some manufacturers aim at a certain annual sales figure whereas others target a certain number of models or a certain share of cars in the cumulative sales figures. These figures are currently determined by the emission standards and targets in different countries. For example, in Europe, the average emissions standard by 2021 is 95 CO_2 g/km (European Commission, 2017).

As some markets aim to thrive as leaders, the charging infrastructure and energy markets will experience the biggest impact. The European Commission target is one charging point per 10 EVs. Several countries like France and Germany are estimated to miss this target even if they manage to reach their EV deployment targets (Electromobility platform, 2018). To foster the development and deployment of EV charging infrastructure, governments use, for example, subsidies and public–private partnerships (IEA, 2017). The growing demand for charging infrastructure accompanied by low wholesale prices in the energy markets have driven incumbent utilities and oil companies to compete in the EV charging infrastructure market. Incumbents like Enel, Engie, Total, and Shell, for instance, have invested in EV charger providers and aggregators (Foehringer Merchant, 2017).

EV charging can potentially have a major impact on the electric grid at certain locations if charging is not managed smartly. This is highlighted by the fact that the current EV penetration is concentrated in certain areas. Notably, about 40% of the world's electric vehicles are located in only 20 cities worldwide (Hall, Moultak, & Lutsey, 2017). However, lead markets also show that the majority of households that own an EV have it as a second car that is used for everyday commuting whereas ICE cars are driven more often during holidays (IEA, 2018). The need for charging infrastructure co-evolves with consumer preferences and behavior, which also forces traditional energy supply utilities to be more agile in their investment planning.

Charging of EVs needs to be coordinated so that local grid problems can be avoided (Clement-Nyns, Haesen, & Driesen, 2010). Possible problems for the local grid in the form of voltage deviations, increased need for transformers, electrical losses, etc., will increase as the EV penetration increases, and therefore, intelligent and coordinated charging is needed (García-Villalobos et al., 2014). Plug-in electric vehicles (PEVs) may also be linked bi-directionally to the electric power system, and then they are referred to as vehicle-to-grid (V2G) solutions. This leads to additional efficiency in the electricity grid, reduces transportation emissions, facilitates the use of RE sources in local energy production, etc. (Sovacool et al., 2018).

However, as the PEV penetration increases with decentralized energy, production information and communication technologies also need to be integrated into existing electricity networks to facilitate a two-way flow of information (Kotilainen, 2016c). Recent advances in the digitalization of smart meters have enabled the creation of smart grids that can deliver electricity in a controlled way from the generation to consumption points (Siano, 2014). However, no business models have yet been developed for the smart grid environment (Niesten, 2016), and the prosumers' role in smart grid development is still in its infancy (Kotilainen et al., 2016a).

Therefore, the smart grid infrastructure as a whole facilitates the transition of energy systems to a more efficient and effective innovation ecosystem that integrates transportation in a holistic system. Furthermore, smart grid functionalities allow the creation of new services, and new actors are needed to develop new sets of activities and business models (Niesten, 2016). Prosumers' roles are central in the development of digital business models that all the actors in the energy ecosystem need, and the activities in the business models need to be aligned between the different roles (Kotilainen et al., 2016b). Furthermore, it has been shown that few archetypes of business models dominate electric vehicles (Bohnsack et al., 2014) mainly due to path dependencies. As these lock-ins require new activities on the part of policy makers, as well as other actors (Kotilainen & Saari, 2018), digital business models facilitate these changes.

Business models (BMs) essentially describe how value is created, delivered, and captured by activities (Teece, 2010). One way of structuring a business model is according to the BM canvas (BMC) consisting of the value proposition, customer segments, customer relationships, key resources, key activities, key partners, key channels, revenue streams, and cost structure (Osterwalder & Pigneur, 2010). These elements describe the needed resources and the activities that need to be aligned with revenues streams and costs, and how the economic entity is planned according to the function. The term digital business model refers to a collection of activities in the BMC that are or can be fundamentally changed by changes in digital technologies or functionalities (Veit et al., 2014). A digitalized energy system provides point-to-point possibilities for monitoring and controlling all the devices in the grid, and this facilitates the creation of new services and business models for all the actors involved (Giordano & Fulli, 2012).

Energy consumers are turning into energy prosumers within local energy production systems as EVs are connected to the grid and act as energy storage. This transition means that consumers become active actors who need a business model for their activities and transactions in the energy production system. Digital business models transform the business processes (Weill & Woerner, 2013) of a prosumer in energy production, store, and use. In this chapter, we consider the prosumer digital business model from three use case perspectives. Prosumers can use energy to drive, charge, store and share energy in the location of the EV (see Fig. 1). Naturally, there is also the possibility of producing energy (e.g., with solar panels or wind energy), but we leave this side of prosumerism out of the analysis.

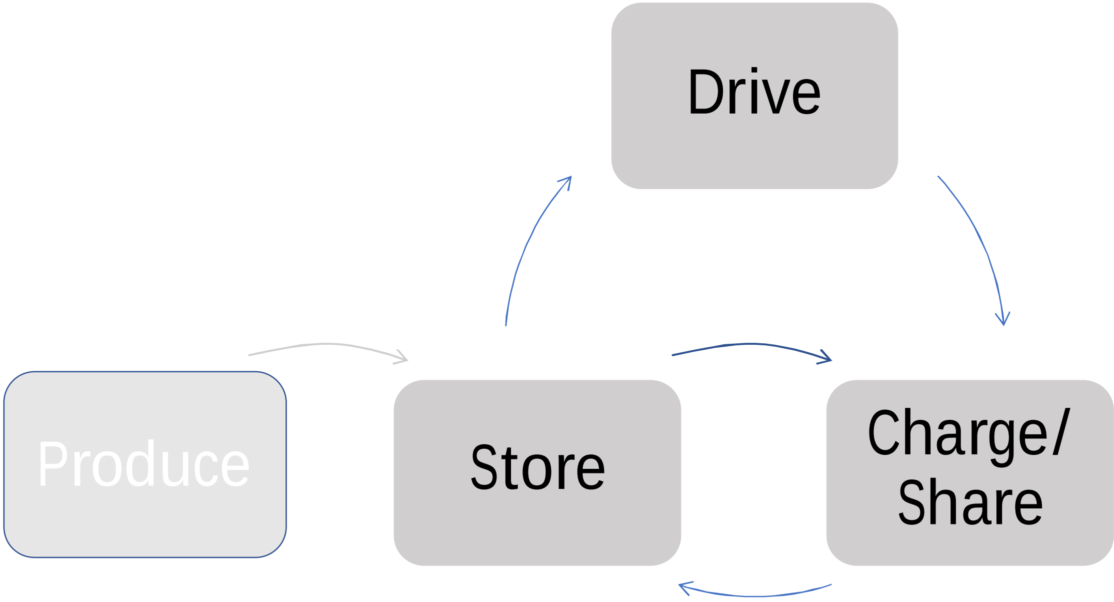

Figure 1. Three use case perspectives of the analysis.

Exploring the Digital Business Model for Prosumers

This section presents the outcome of a multidisciplinary expert workshop where company representatives and academic researchers brainstormed and ideated digital business models related to prosumers and EVs in a future energy system. The role of a prosumer is still new in the energy sector, and how prosumers as EV users can create, deliver, and capture value businesswise in smart grids remains to be explored. The aim of this study is to provide new innovative ideas for testing later in conjunction with a research project focusing on the concept of social energy and the creation of a prosumer-centric energy ecosystem (ProCem). The result of the workshop is a compilation of the participants' expertise and know-how. To explore potential new prosumer-centric value propositions, the workshop participants sketched business models according to the key elements included in the BMC (Osterwalder & Pigneur, 2010).

First, we briefly describe how workshops can be used as a research method and the approach we used in the workshop to facilitate the discussion and collect input from the participants. Second, we introduce the workshop participants and their areas of expertise. Then we report the results from the three working groups and the business models that were developed by the participants. Finally, we discuss how the ideas and business models created in the workshop could be developed further based on a cross-case analysis of the models.

Workshops can be analyzed from three different perspectives: practice, means, and research methodology (Ørngreen & Levinsen, 2017). Workshops can be considered as a means to achieve a goal, for example, strategic prospective workshops (Durance & Godet, 2010). Alternatively, workshops can serve as a way to cooperatively develop a solution, a design, or a process for future use (e.g., participatory research; Wakkary, 2007; Wiek et al., 2014). Finally, workshops can be utilized as a research methodology to achieve a research target and produce relevant data about the research domain (Ørngreen & Levinsen, 2017). The participatory methods applied in workshops support the application of the knowledge and experience of the participants and thus, produce valuable results (Öberg & Hernwall, 2016).

Workshops can be used in research as forums for finding and exploring key elements in complex fields, including processes implemented with ICT technology (Ørngreen & Levinsen, 2017).

Generally, workshops are prepared and planned beforehand so that they achieve a purpose that has been decided before the workshop was conducted. Workshops last for a certain limited time, the participants often work in the same field, and the facilitation of the workshop is the responsibility of someone who has experience in the domain. The number of participants is usually small which permits all the participants the possibility to actively contribute to the discussion and group work (Ørngreen & Levinsen, 2017).

A multidisciplinary workshop focusing on new business models for energy prosumers and EVs was held at the beginning of 2018 at the Tampere University of Technology. The workshop participants included four company representatives from four companies operating in the energy sector and eight representatives from the Tampere University of Technology, including professors, researchers, and doctoral students. Three working groups were formed so that there was at least one company representative and two academic representatives in every group. The workshop lasted 3 hours altogether including the initial introduction to the topic and the briefing on the target of the group work (1 h), the group work discussions (1 h), and the final presentations by the three working groups and the wrap-up of the workshop (1 h). Each group was given one EV use case to analyze from the prosumer perspective, and the group's task was to design a business model with a strong prosumer-led value proposition that would fit that particular scenario. The first group focused on driving an EV, the second on scheduled charging, and the third on storing energy and offering it to the energy markets, for example, via V2G or vehicle-to-home (V2H) connections.

Energy storage, such as an EV battery, is the central feature that unites energy prosumers, EV users (who in many cases are the same individual or a member of a household), and the smart energy grid. Prosumers generate energy and store any excess energy in a battery, which can be the battery of an EV. Prosumers may also opt to share energy in a smart grid, energy communities, or even peer to peer (P2P). The EV user drives the vehicle, charges it, and may opt to store and share energy with the power grid.

The working groups were each presented an empty BMC template on which they were asked to note ideas on how prosumers could add value in the different phases and what is required for the implementation in the energy system according to the BMC content elements (Osterwalder & Pigneur, 2010). In addition, the groups discussed who can benefit from the prosumers in the energy system and what types of partners, infrastructure, and technology are required to implement the ideas. After the group work, the three groups presented their work to each other and discussed the ideas further. The discussions were audiotaped, and the analysis was conducted by researchers who were present at the workshop.

The company representatives were from four different companies operating in different parts of the energy sector.

- Company A is one of the largest service providers in Finland, and it operates in the Nordic and Baltic countries. Company A offers power network services, telecom network services, industry services, and information management. The company participates in all the different stages of the energy sector life cycle offering design, construction, installation, maintenance, and hosting services.

- Company B is a Finnish IT company that provides digital software services targeted to industrial systems and platforms, including solutions for cross-platform systems, communications systems, and monitoring systems. Company B has created, for example, a software tool and platform for the Internet of Things (IoT) that enables big data analytics. The tool facilitates the creation of IoT applications and business models that are based on tracking data, for example, on users in the network and their energy consumption.
- Company C is a Finnish electricity distribution and heating company, that is, a distribution system operator (DSO) that manages energy distribution in the smart grid, which allows two-way information and energy flows, invoicing of electricity usage based on real-time consumption, and many possibilities for consumers to track their electricity consumption on a daily or hourly basis. The company cooperates with different industrial operators in Finland so that the operators can feed their surplus energy in the company's network which improves energy efficiency.
- Company D is a small energy company that is a subsidiary of a heat production company. Recently, the company invested in a smart decentralized energy production system for an industrial area based on a smart grid in central Finland. The target of the company is to produce renewable energy (electricity and heat), for example, from large solar panel parks and other sources, such as natural gas.

The academic researchers included two professors (one from Electrical Energy Engineering and one from Automation and Hydraulic Engineering), two researchers (one from Automation and Hydraulic Engineering and one from Industrial and Information Management), and four doctoral students (two from Industrial and Information Management, one from Electrical Energy Engineering, and one from Pervasive Computing).

Results

We first report the results individually from the three working groups and then provide a holistic cross-case analysis of the combined business model including all three EV use cases. The *EV prosumer* is used to describe the user of an EV who may generate energy and store it, drive the vehicle, charge the vehicle, and share its battery as a flexible resource with the smart grid.

Results from Group 1 focused on driving and moving the mobile energy storage unit are mapped according to the BMC content elements.

<u>Value creation</u>

- *Value proposition.* The eco-friendliness of the parking garage and the possibility of sharing energy with other EV drivers are some of the key benefits of driving for EV users. In addition, when the EV is connected to the smart grid of a shopping mall, the EV helps to reduce the spikes in the energy consumption of, for example, the center's cooling system. A novel concept created in the group work, Bring Your Own Energy (BYOE) describes how the energy provided by EV prosumers can be used for cooling, heating, and producing special experiences. EV prosumers could provide energy at festivals and social events. EV prosumers can also use the EV to optimize their own energy consumption at a holiday cottage. Another way to make use of the EVs is to use them as an extension of the infrastructure by connecting them to an electric ferry, so that the ferry would use the EVs' batteries. Even a truck for transporting EVs could be designed, forming a collective battery, which allows EV prosumers to work during the trip on the truck.

- *Customer segments*. The potential could be extended from EV drivers to other prosumers, stores, shopping malls, and inhabitants in small communities in rural areas.
- *Customer relationships.* Relationships are formed between communities and institutions, and together, these form a larger infrastructure and system for EV prosumers.

Value delivery

- *Key resources.* The EV is a mobile storage unit, and the V2G loadings are tracked as anonymous transactions.
- *Key activities.* The EVs would serve as enablers for community events even in remote areas where there is no power supply. In addition, EVs could be used as power sources for smart grids.
- *Key partners*. Transportation companies, shopping malls, stores, festival organizers, and ferry operators would be the main partners in utilizing the EV as a power source.
- *Key channels.* The network for EV prosumers can be provided via the facilitating community, the transportation companies that own the trucks, and the ferries that transport the EVs.

Value capture

- *Revenue streams.* The time EV prosumers save when they can concentrate on their work instead of driving is an indirect source of revenue in the form of savings. In addition, there are savings on the energy price and a reduction in the price of transportation.
- *Cost structure.* In the cost calculations, one needs to take into account in addition to the EV itself, the charging costs and replacement of the EV and the worn-out battery. When the mode of transportation is a truck or a ferry, the costs of transforming the equipment for compatibility with the docking stations for EVs must be taken in account. If the EV prosumer belongs to a community, there may be a membership fee as well.

Results from Group 2 focused on scheduled charging and flexibility are mapped according to the BMC content elements.

Value creation

- *Value proposition.* Charging an EV offers, for example, for shopping malls, an energy source that they can control and optimize according to their own usage and thus, result in a more stable electrical load. At departure, the EV battery is full.
- *Customer segments.* Shopping malls, EV parking spaces at the workplace, and sports clubs are potential customers that can be connected to EV prosumers.
- *Customer relationships.* The EV prosumer has a close relationship with the aggregator, and a more random relationship with parties that are involved when charging, such as at shopping malls. The relationship can be dedicated in the case in which the EV prosumer has a scheduled parking space arrangement, such as with a sports club. The parking space is reserved beforehand for a certain fixed time period regularly and is available for the EV prosumer then.

Value delivery

- *Key resources.* The EVs and mobile applications for tracking the charging rate and level are the most important resources.
- *Key activities.* Charging EVs that are parked while the EV owners are running personal errands.
- *Key partners.* Aggregators and HEMS owners and providers are the main partners.

- *Key channels.* Availability of parking spaces with charging capability can be checked and reserved with a mobile application that offers real-time data also on the schedules when the spaces are reserved or free and can be reserved.

Value capture

- *Cost structure.* The major costs come from the replacement of the worn-out EV battery.
- *Revenue streams.* A regular charging time based on a deal with the property owner enables lower charging costs for the EV prosumer.

Results from Group 3 that focused on the EV battery as a storage unit connected to the power grid are mapped according to the BMC content elements.

Value creation

- *Value proposition.* The storage capability of EVs adds flexibility to the network, as they can receive surplus electricity and thus, also stabilize the network. For example, if a DSO is having problems fulfilling electricity demand, EV prosumers can help with distribution and thus, prevent a power outage and a potential fine (if there is damage to electric distribution due to storms and power outages that last for longer than stated in the customer's power purchase agreement).
- *Customer segments.* The DSO, the transmission system operator (TSO), the aggregator or electricity reseller, and individuals (e.g., neighbors) are the main customers.
- *Customer relationships.* There are different kinds of relationships with prosumer to consumer (P2C) via prosumer to business (P2B) channels.

Value delivery

- *Key resources.* Solar panels, the EV driver, and the energy storage unit are the main resources.
- *Key activities.* Energy acquisition, the reception of orders, and maintenance of the flexibility capability in the network are the main activities. These are enabled by a navigation platform that offers P2C electricity. An automated system could offer P2B electricity.
- *Key partners.* The partners include providers of the platform, producers of EV batteries, and EV producers.
- *Key channels.* A direct relationship exists with the aggregator on the energy market, neighbors, and DSOs. An indirect relationship is formed with, for example, the TSO.

Value capture

- *Cost structure.* The costs are generated from the equipment, energy acquisition, working hours, service costs, and implementation of the platform.
- *Revenue streams.* In the power purchase agreement, the total is the sum of the subscription and a flat rate cost. The unit used in energy sales could be Kwh × km. The sources of revenue are P2B and P2C contracts, possible road service, and services that have pay-per-use rates.

After the workshop, the researchers conducted a high-level cross-case analysis of the BMC content elements of the three business models created for the different EV use phases. A cross-case analysis allows to compare the commonalities and differences in the elements which is required for further exploration of micro-foundations for the balanced policy approach (see Table 1).

Table 1. A summary of the cross-case analysis of the workshop results.

BMC content element	Drive: Mobile energy storage unit (Group 1)	Charge: Scheduled charging and flexibility (Group 2)	Store: Connected storage (Group 3)
Value proposition	- sharing energy with other EV drivers - BYOE (bring your own energy) - transportation of EVs that form a collective battery - focus on small communities	- control and optimization of the energy source according to own usage - more stable electrical load - at departure, the EV battery is full	- offers flexibility to the network. - can receive the surplus electricity and thus stabilize the network - eliminates bottlenecks in the network
Customer segments	- other prosumers - stores and shopping malls - EV drivers -small communities in rural areas	- shopping mall - EVs at a workplace	- distribution system operator (DSO) - transmission system operator (TSO) aggregator/electricity reseller - neighbor
Customer relationships	- community --> institution = infrastructure and system	- tight relationship with the aggregator - random charging, e.g., at shopping malls - dedicated and scheduled parking space arrangements	- different kinds of relationships with P2B and P2C customers
Key resources	- mobile storage unit - anonymous transactions	- EV - mobile apps	- solar panels - EV driver - energy storage
Key activities	- enabler for communities connected to smart grids - V2G	- charging at certain time - keeping storage opportunity open (for quick balancing) - V2G	- energy acquisition - reception of the orders - maintenance of the flexibility capability - navigation P2C platform - automated P2B system - V2G (vehicle-to-grid)
Key partners	- transportation companies - stores - festival organizers - ferry operator	- aggregators - home energy management systems (HEMS)	- provider of the platform - producer of batteries - producer of EVs
Channels	- facilitating community - trucks - ferries - DSO - TSO	- DSO - TSO	- aggregator/energy market - neighbor - DSO - TSO
Cost structure	- charging - EV - truck, ferry - wear out of the EV and the battery - community membership	- replacement of the EV battery	- equipment - energy acquisition - working hours - service costs - platform
Revenue streams	- saved time - savings in energy price - reduction in the price of transportation - peak avoidance benefit	- lower charging costs	- power purchase agreements (PPAs) - P2P and P2C contracts - road services

The most striking similarity across the use cases is that the value proposition is similar in its core: Storage creates value in all use cases. DSOs and TSOs have similar roles in being the channel, but this is not necessarily pre-determined as the utilization of bi-directional information may be device dependent due to standardization issues, intellectual property rights (IPR) agreements, etc. In addition, the V2G connection mode emerged as an important activity across the use cases as without this connection the whole digital business case becomes obsolete. This, however, requires multiple activities from many partners.

The value propositions can be viewed very differently depending on the stakeholders, although the proposition itself remains similar across use cases. For example, storage facilitates low-cost charging at surplus production peaks which is in a sense multi-sided market where all actors can simultaneously benefit from the consumption of energy, but the value is different for different actors. EV prosumers can have lower prices, and the DSO can receive network stability.

Customer relationships exhibited multiple different perspectives across use cases. This underlines the differences between the drive, charge, and store use cases. The use cases present multiple avenues for delivering value to different actors in the system. Key partners also vary considerably between use cases. Although DSOs and TSOs have necessary roles, these channels do not determine the nature of prosumers' activities.

The cross-analysis of the BMC results reveal that the value creation elements differ in each case. However, the value capture part has similar elements. For example, the cost structure and concerns related to wearing out the batteries were shared in all cases. The analysis of the Group 3 value creation, value delivery, and value capture shows that the value creation is solid; the utilities are looking for flexibility, and the EV prosumers could offer that as the value proposition. In addition, the needed resources, including key technologies, are becoming available, with some short-term limitations related to V2G availability, and key activities could be implemented in the near future. However, the value capture part is not looking well balanced for EV prosumers as the cost structure is heavy, and potential revenue streams are unclear and seem narrow. Based on the current understanding of, for example, the demand response, compensation for households does not promise a rewarding revenue compensation for flexibility. A summary of the cross-case analysis from the value creation–value delivery–value capture perspective is shown in Table 2.

Table 2. Summary of the value creation-delivery-capture in the use cases.

	Group 1: Drive	Group 2: Charge	Group 3: Store
Value creation	Value proposition has potential for further elaboration. Sharing energy with others in parking lots, on special occasions, or with a shopping mall for peak demand reduction can offer value but includes uncertainties. More focused segmentation should be done to find potential regularity in driver behavior. The relationship requires a lot of trust and has to be institutionalized at least in larger solutions.	The EV prosumer can control and optimize the use of energy, the electrical load is more stable, and at departure, the EV battery is full. All of these are part of the value proposition. Customers include regular EV prosumers at shopping malls and EV owners who park at their workplace or home. The relationships vary depending on the customer type—a close relationship with the aggregator but a random relationship with shopping malls.	Value proposition (P2B) is strong as the potential customer segments (DSO and an aggregator) see EV flexibility as important for the grid stability, especially peak load balancing. Prosumers would be an important resource for aggregators that could consolidate the offerings for the grid. The P2C proposition is novel, and there is no evidence of customer demand for it. However, P2C potentially could offer value.
Value delivery	V2G and its servitization are under constant development but are not ready. Key partners like shopping malls and festival organizers	The EV is the main resource required in addition to mobile applications that track the EV's charging status.	The technology required for connecting EV battery to the grid is ready but not widely available. There are gaps in offering aggregation services or a platform for selling prosumer services.

	have to be engaged in becoming frontrunners. The channels do not exist yet.	Charging happens while EV prosumers are running personal errands. The potential future partners are aggregators and HEMSs. The channels do not exist yet.	Channels are under development.
Value capture	The cost structure, including the replacement of a worn-out battery, finding compatible equipment, and possible membership fees, is high. Revenue streams include savings from energy prices and time savings but remain low compared to the cost structure.	The main costs come from the EV battery wearing out. The value comes from savings resulting from lower charging costs.	The cost structure is high compared to the potential revenue as compensation for flexibility. Battery wear-and-tear concerns have not been addressed.

Discussion and Conclusions

The DBMs developed in the workshop revealed that EV prosumers added value to the energy network for the value creation part in the business model. However, in value delivery and value capture, major issues prohibiting realization of value remain. In value delivery, the uncertainty comes from customer behavior and the rate at which the use of EVs will diffuse among users. In addition, the development of a technical infrastructure involving incumbents such as DSOs and TSOs and facilitating new entrants in future energy markets is still in its infancy. Another factor complicating the development of DBMs for EVs is that the coverage of EV charging stations in many countries is still very sparse and concentrated in major cities and a few small towns. In addition, there are competing alternative fuel vehicles, such as those based on natural gas. Finally, the value capture seems to be hard to materialize as there are costs from the technical investments and implementation, and the actual amounts of energy offered to the markets would be fairly low, at least in the initial phase, when the number of EVs is still low. The value creation-delivery-capture readiness is summarized in Figure 2.

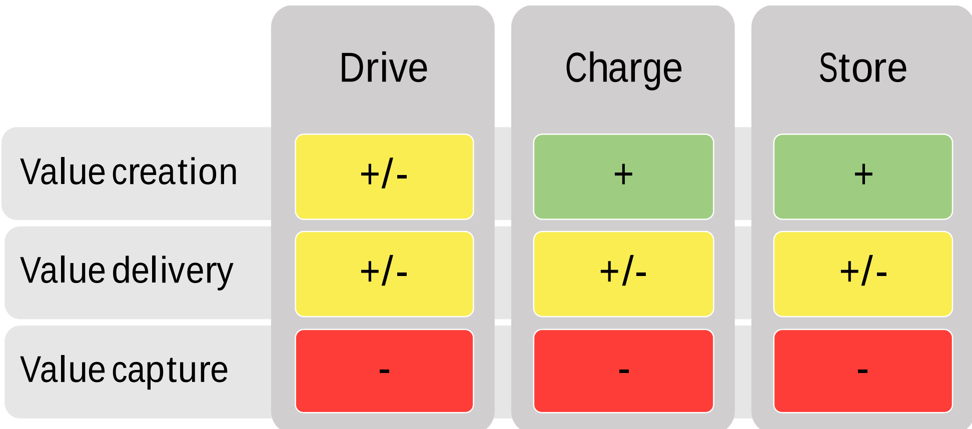

Figure 2. Summary of the current state of the value creation-delivery-capture readiness of EV DBMs for the prosumer.

The role of digitalization is crucial for the implementation of any of the phases where EV prosumers contribute to the energy system. Real-time follow-up of the charging level of a battery and the uploaded amount of energy to and from the grid need to be tracked for each EV prosumer. This can best be implemented with an IoT where each EV is tracked and provides data to the prosumer, to the smart grid provider, as well as the other actors in the network. In smart grids, electricity is produced, distributed, and optimized locally for consumers, and thus, is an optimal method for integrating renewable energy resources in communities and facilitating the contribution of EV prosumers to the community network.

Despite the similarities in the use cases, there are significant differences that would require a digital platform that unifies the user experience across use cases. To build a digital business model for EV usage that includes driving, charging, and storage, the results of the group work indicate that there is a need for a digital system that is continually updated and close to real time so that EV users acting as prosumers can monitor and control the energy usage of their EVs. The digitalization of the processes for tracking EV prosumers in a smart grid network could possibly be based on the initial business models created in the workshop. In addition, automation and artificial intelligence–based monitoring and operation may be needed for the system as a whole to remain stable. Thus, large-scale adoption of EVs and DBMs for EVs would require improving the user experience with easy-to-use applications that unify different services and DBMs for the prosumer with a single interface.

Based on the digital business models from the workshop, we designed a balanced policy framework that would take into consideration the microfoundational change mechanisms and requirements revealed in the analysis above. The goal of the framework (see Figure 3) is not to be a normative guideline but to draw attention to three issues: the process of developing a future sustainable energy system, the multi-level nature of the changes needed, and causal dependencies between levels and phases. In Figure 3, the phases of the energy system evolution in EVs are depicted as starting with the research and development conducted by meso-level organizations. This leads to the market diffusion phase of EVs as more and more user segments adopt EVs. Furthermore, large-scale adoption is followed by integration of various services and products to provide better and better functionalities for EV prosumers. Finally, efficient use of EVs as part of the energy system leads to incremental evolution of services and products in the EV innovation ecosystem. Thus, we depict possible routes of institutional evolution from the early technology-driven market with a subsidy-driven policy leading to microfoundations of prosumer behavior and finally, to a sustainable future energy system.

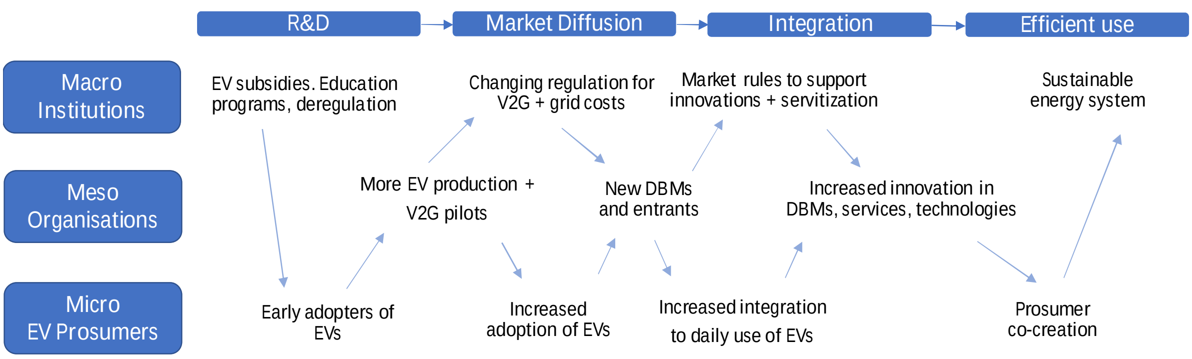

Figure 3. Opportunities for macro-, meso-, and micro-level actions in a balanced policy approach supporting EV DBMs for the energy market transition.

At the micro-level, early adopters of EVs still present rudimentary testing grounds for DBMs as most of the functionalities that EVs might have are still missing, due to a lack of V2G connections or the overall infrastructure. However, the basic functionality of charging-storing-driving will be built and tested leading to new opportunities in providing new services and products as adoption levels increase and value delivery from EV prosumers becomes possible. Later, EVs will be integrated in daily use for prosumers, and value capture will be facilitated in mass markets. At the same time, meso-level companies will develop EV technologies and related infrastructure, but in the early phases, they need external support to increase adoption levels, for example, the chicken-egg problem (no charging-no users-no charging) needs to be solved. Once adoption levels start increasing, more EVs will be produced, and due to learning curve effects, prices will decrease, and the quality and functionality of the EVs will increase. The increased adoption and infrastructure development will lead to new entrants and opportunities for services, like community-based sharing of energy or demand response DBMs for EVs. Further development of the infrastructure will lead to prosumer engagement in service and product development. Finally, at the macro-level, policy guidance and regulations will evolve from facilitating technology development and adoption of EVs to facilitating infrastructure development and new meso-level activities and finally, to engaging all the actors in co-creation.

In summary, the whole process can be described as follows. The start of the balanced approach should support EV adoption and infrastructure so far that manufacturers' production volumes increase leading to a decrease in EV prices and an increase in the quality and usability of technologies for mass market adoption. This leads to a need for supporting grid connections at the institutional policy level, regulation and incentives leading to infrastructure deployment, and new organizations entering the system. This is supported by increased EV adoption by mass market segments. Furthermore, V2G and new DBMs of entrants support the integration of EVs in prosumers' daily use. If at this point prosumers' daily use is supported by macro-level policies to encourage further servitization and innovation, new innovations are co-created at the micro- and meso-levels leading further to efficient and effective implementation of smart grids at the institutional level.

Naturally, this study has several limitations offering some potentially fruitful avenues for future research. One limitation of the workshop approach is the intensive and cooperative environment in which the participants interacted. Depending on one's personal level of motivation and interest in participating in that moment, as well as the extraversion or introversion of the participants, they can be either very active or passive, which has also been noted in focus group discussions (Barry & Stewart, 1997). However, as each group had a facilitator who kept the discussion going, we attempted to minimize this problem. In addition, as the participants had been in contact previously in several project meetings, even the most timid participants should have had the opportunity to participate in the discussion. Another limitation of a workshop approach may be the uneven presentation from different organizations and the hierarchical structure in the academic world that may hinder open communication and flow of ideas (Ørngreen & Levinsen, 2017). However, in this case, as the participants already knew each other well beforehand and referred to each other by their first names (including the professors), this factor did not have much influence on the open exchange of ideas among the workshop participants. Furthermore, our depiction of a balanced policy approach heavily relies on the heuristics of the authors, and therefore, the framework is more of a discussion opening for raising awareness of the possible influence of prosumers' DBMs on the systemic change taking place in energy systems. Our aim is to show that microfoundations as prosumers' DBMs for EVs have significant systemic effects, and these effects should be taken into account when policy issues are considered.

In conclusion, the transformation of energy consumers into prosumers with business models in mind, that is, transforming consumers into entrepreneurs, is a dramatic behavioral change at the individual level and leads to a multitude of institutional changes at the macro-level. This transformation calls for new institutional arrangements and institutions, such as behavioral guidelines for new organizational forms (energy collectives, etc.) and individual behavioral norms (such as flexible commuting due to smart charging, etc.). This transformation may be approached with a balanced policy approach, and for this purpose, we proposed several opportunities for delineating inter-level connections of causalities in order to draw attention to the opportunities in the balanced policy approach.

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