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EaaS: Electricity as a Service?

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Abstract

Purpose: Like a number of other traditional industries, the energy industry is undergoing a major transformation. With the advent of smart grids, the industry is transforming from a centralized energy system to a distributed energy network, and from the traditional product-based to a service business model. An essential question is "What types of value creation and value capture opportunities emerge at the level of ecosystems as the energy and smart grid industry shifts from the existing product-based business model to a greater service orientation?"

Design: The study utilizes the 4C ecosystemic framework and the XaaS (Everything as a Service) digital service business model typologies, and collects business model case data from 15 EU Horizon 2020 innovation projects. The research uses a two-stage approach that includes interpretive case analysis and action research to analyze and create an ecosystemic business model framework.

Findings: The paper uncovers the following business model typologies for the digitalization of the energy business ecosystem: Connection as a Service (CaaS), Supply as a Service (SaaS), Data as a Service (DaaS), and Energy Application as a Service (EAaaS).

Research limitations/Implications: A key outcome is the proposition of the Electricity as a Service (EaaS) concept for the energy sector, proposing a new service business paradigm for the energy ecosystem. One limitation is that the research has a strong regional focus on European cases.

Originality / Value: The study adopts a value-based and service-dominant lens focused on business model research at the ecosystemic level. For the first time, the study introduces the XaaS service business typology, investigating how this well-established ICT (Information and Communication Technology) business framework can enable the digitalization of the energy industry.

Keywords: business model, business ecosystem, service-dominant logic, value-based strategy, XaaS, SaaS, smart grid, electricity-as-a-service.

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Introduction

New and innovative business models have been transforming and disrupting traditional industries at an unprecedented speed (Downes and Nunes, 2014). The energy industry is no exception (Amin, 2011). Traditionally, the industry has a dominant business model with the sole responsibility to generate electricity at central power plants and distribute the energy to end consumers through transmission and distribution networks. This responsibility of delivering power is now being transformed into a dynamic mode of operation due to the deployment of smart meters, the diffusion of renewables and distributed generations, and the development of smart energy applications (Zahedi, 2011).

Smart grid technology enables a shift from the old, centralized production and distribution energy system to a modern network incorporating two-way, end-to-end communication, and decentralized management of generation, transmission and distribution (Xu et al., 2016) (Reuter, Loock, & Cousse, 2019), covering four technological layers, infrastructure/hardware, platforms/data, equipment/devices, and applications/services (Moqaddamerad et al., 2016). The European Union (EU) and the United States (US) define the functions of a smart grid as enabling new products, services, and markets while operating and optimizing assets efficiently (Amin, 2011; Gajic and Eli, 2013). With the advent of smart grids, energy firms have the potential to seize novel business opportunities. What new forms of business models arise for firms in the energy industry is a question of central concern addressed in this paper.

To address that question, we build on the BRIDGE initiative of the Horizon 2020 program, which was launched by the European Commission in 2016. The BRIDGE initiative provides an opportunity to witness novel forms of value creation and of value capture first-hand, as it observes the impact of the technological, commercial, and regulatory transitions that take place in the energy industry at the European level. The program focuses on smart grid and energy storage projects to create a structured view of the innovations and cross-cutting issues that are encountered in the demonstration projects. The energy business model and consumer engagement are two of the four key interest areas addressed in this large-scale initiative, with 31 major Horizon 2020 energy research projects to date (as the time of this research). Through a collaborative review of business models in the energy field, we discover an emerging pattern of new and innovative business models in the energy and smart grid ecosystem: there is a visible shift from product-based business models towards service orientation.

At the same time, Furr (2016) points to similar transitions in a number of digitalized industries such as e-commerce (Amazon), search engine and online advertising (Google), and smart energy (Nest). Hui (2014) differentiates the service-oriented business model from the product-based business, suggesting that new opportunities for value creation and capture emerge which are not limited to physical product sales. Other revenue streams over the customer lifetime become possible after the initial product sale, including value-added services, subscriptions, and apps, which can remarkably exceed the initial purchase price, creating new value for both companies and their customers. Yet, there are inherent tensions between the two business logics, fundamental distinctions between an asset and transaction revenue model, and between differentiation strategy and network-based competitive advantage (Furr, 2016). At a general level, and compared to the classic product business, service-based businesses build on different types of value creation and value capture.

Theoretical research gaps related to the energy and smart grid industry

Through reviewing the extant business model literature, we identified a number of gaps related to business model research in general as well as to energy and smart grids in particular: 1) the lack of a unified explanation about the value created and how such value is captured in the context of industries that transition from product to service businesses. Multiple terms of business models are used (Zott, Amit, and Massa, 2011) without further clarification of what exactly are value creation and value capture, such as Chesbrough's (2007) revenue mechanism, Johnson et al.'s (2008) profit formula, and Osterwalder and Pigneur's (2010) cost structure and revenue streams; 2) the lack of ecosystem thinking when large and complex industries (e.g., the energy sector) require firms to pay attention to ecosystem-level relationships and interactions (Iansiti and Richards, 2006), as value is created by the network of business models co-existing in an ecosystem

(Jansson et al., 2014: 3). The existing business model literature has extensively studied how a focal company creates and captures value for itself, by means of its own operation (Magretta, 2002) or by interactions with external partners (Amit and Zott, 2001; Osterwalder and Pigneur, 2010; Casadesus-Masanell and Ricart, 2011) or by utilizing an extended network (Moore, 1996; Iansiti and Richards, 2006). However, how value is created and captured at the level of an ecosystem (or the systemic value in the energy industry) has rarely been investigated (Xu et al., 2017). Yet at the level of entire ecosystems, new opportunities for value creation emerge that build upon the complementarities among collaborating partners. As such, an enhanced understanding of what these sources of value creation are and how they may be captured is of crucial concern.

Empirical challenges related to the energy and smart grid industry

In particular, and like in a number of other industries, new sources of value creation and value capture emerge as industries shift to a "smart" and digital age. Today's companies fundamentally rethink their business models and logic about value creation and value capture (Hui, 2014), as they seek to take advantage of Information and Communication Technology (ICT). In particular, the inception of the smart grid is an indicator that the energy industry has shifted towards greater digitalization and that information-based competition has come (Wessel et al., 2015). In this new era, the implications for business model innovation are huge. To take advantage of Information and Communication Technology (ICT)-based opportunities, today's companies will need to fundamentally rethink their business models and logic about value creation and value capture (Hui, 2014; Reuter et al., 2019). For instance, in a connected world, products are no longer stand-alone. Over-the-cloud updates enable new features and functionality to be pushed to the connected consumer devices on a regular basis. The products can now be connected with other products, leading to new data and information (Wessel et al., 2015), new services (Hui, 2014; Reuter and Loock, 2017), and new customer experiences (Hokkanen et al., 2016). As stressed by Wessel et al. (2015), despite the inevitability of this "smart" future, most large companies struggle to get the most out of the digital age, such as the amounts of data they have collected through smart meters and sensors or the Internet-of-Things (IoT).

Energy companies are required to recognize and seize the opportunities for new value creation and capture. They need to update the decades-old management mentality and systems to embrace new digital opportunities (Wessel et al., 2015). The shift from the classical energy product and commodity business to greater service-orientation is huge for the traditionally asset-intensive energy companies. Compared to other industries, such as retailing or media, energy firms face new standards as regards customer services. Metering, installation, energy management are just a few examples of service opportunities, through which energy firms have the potential to create novel value going forward.

Empirical case analysis shows that traditional energy players face inherent challenges in making that transition. Key observations are that new and industry-remote players (e.g. telecommunications firms) enter the market in offering innovative energy services. This may be due to the lower asset intensity of the service business and lower barriers to market entry. Moreover, traditional energy players (with energy as commodity business) tend to have a low customer orientation. A shift towards greater service orientation requires energy players to know their customers better, to be able to craft services accordingly. They need to learn how to monetize service with completely new revenue models. As such, new capabilities are required that are by definition remote from the classical energy product business. That said, energy firms do make the transition towards greater service business. Yet, it occurs slowly and with many challenges.

To address the above empirical and theoretical issues and challenges, we utilize the value-based perspective on a business model conceptualization in combination with the layered ICT ecosystem framework to propose and investigate the service-dominant logic and XaaS (Everything as a Service) business model typologies for the energy industry. By doing so, we expand the theoretical and empirical frontiers of business model studies, going beyond the conventional single actor-focused and product-based business models of the industry.

After discussing a number of theoretical and empirical research gaps that surround the conceptualization of the service business model in smart grids in the following section, we identify an essential question for the transition in the energy industry: "**What types of value creation and value capture opportunities emerge at the level of the ecosystem, as the energy and smart grid industry shift from the existing product-based business model to a greater service orientation?**" To address this research question, we follow a two-stage approach, including an interpretive case study for case analysis and an action research approach for the development of the EaaS framework. Section 4 will present the detailed research methodology.

The rest of the paper is organized as follows. Section 2 presents related literature on the business model, business ecosystem, and service-dominant logic discussion in general. Section 3 provides a discussion on energy and smart grid business models. The research methodology is explained in Section 4. A mapping and aggregated analysis of 51 energy business model cases is given in Section 5 to present key findings of the study, including the identification of four types of Energy as a Service (EaaS) or service-oriented business model typologies in the energy and smart grid ecosystem. Finally, the theoretical and empirical implications arising from the study are discussed in Section 6.

The value-based perspective on the business model and service dominant logic

This section starts with the value-based view on the actor-focused business model and expands to the service dominant logic on the ecosystem and business model.

Understanding business model concepts

The concept of business model has attracted tremendous attention and raised profound debate among scholars concerning how to define and conceptualize the business model (Jensen, 2013). For instance, Chesbrough and Rosenbloom (2002) conceive of business models as focusing devices that explain how economic value could be extracted from a technology or business idea. Morris et al. (2005) define the business model as a set of decision variables that are interconnected to create a sustainable competitive advantage. Other conceptualizations include examples such as an architectural model (Timmers, 1998), a narrative model (Magretta, 2002), a design model (Demil and Lecocq, 2010; Amit and Zott, 2001), a dynamic system (Casadesus-Masanell and Ricart, 2011), and conceptual tools (Osterwalder and Pigneur, 2010; Ahokangas et al., 2014; Lüttgens and Diener, 2016; Martins, Rindova, & Greenbaum, 2015). (Martins, Rindova, & Greenbaum, 2015)

Referring to several studies (Ahokangas and Atkova, 2015; Xu et al., 2016), the origin of business model can be traced back to the business idea: "what a company offers to whom and how" (Normann, 1977). It consisted of components such as resources and competencies, an internal and external organizational structure (Demil and Lecocq, 2010), a customer value proposition (Chesbrough, 2007; Johnson et al., 2008; Zalewska-Kurek et al., 2016), and a cost and revenue structure (Osterwalder and Pigneur, 2010).

Overall, we identify the business model as a boundary-spanning unit referring to value creation and capture, opportunity exploration and exploitation, and company performance improvement and competitive advantage establishment (Chesbrough, 2010; Zott et al., 2011; Onetti et al., 2012; Zott and Amit, 2013; Xu et al., 2017).

Value-based perspective on the business model

The notions of value, value creation and value capture are inherent in the definition of a business model (Lund and Nielsen, 2018) (Reinhold, Reuter, & Bieger, 2011). According to Nielsen and Lund (2015), integrating the aspect of value has tremendously influenced the existing streams of business model studies. One of the common definitions of business model is "the logic of the firm, the way it operates to create and capture value for its stakeholders" (Casadesus-Masanell and Ricart 2010, p. 196). Zott et al. (2010) suggest business model as a construct that conceptualizes the value creation and value capturing of a firm. To go one step further, Hui (2014) defines value creation of the business model as involving the performing activities that increase the value of a company's offering and encourage customer willingness to pay, which is in line with Brandenburger and Stuart's (1996) value-based perspective. Therefore, value is the sum of the firm's profits and consumer surplus (Casadesus-Masanell and Llanes, 2011).

As initially discussed in the strategy research domain, Porter (1996) addresses the importance of a strategic "position" that brings value. Porter (1996) also adopts a value activity approach to strategy, considering the firm as a cluster of activities responsible for bringing a product to market. These "activity systems" can be designed well or poorly; well-designed systems include activities that are complementary and perform better together than they do individually (Casadesus-Masanell and Zhu, 2013).

Brandenburger and Stuart (1996) coined the term "value-based" strategy, suggesting that value comes from creating "added value" by any actor within the entire value chain or industry. The "added value" from a focal actor is defined as the value created by all the actors in the vertical value chain, deducting the value created by all the other actors except the focal actor in question, as illustrated in Figure 1. The key to value capture (or value appropriation) is the possession of a positive added value. Such positive added value from the firm can be generated from sources that lead to the creation of value asymmetries, including maximizing customer's willingness-to-pay or minimizing opportunity costs of the suppliers, or the combination of both. The accrued value is seen as the wedge between customer's willingness to pay and supplier's willingness to sell (Brandenburger and Stuart, 1996) and how value would be captured as profit.

With regard specifically to value creation, the extant literature builds on Porter's (1996) theory, conceptualizing it as the representation of the activity system including the actions responsible for inbound logistics, operations, outbound logistics, marketing and sales, service, and support activities. These value-adding and re-enforcing activities create value, as each is applied successively to another (Brandenburger and Stuart, 1996; Casadesus-Masanell and Zhu, 2013).

Development in the literature on value capture distinguishes between two essentially different processes (Brandenburger and Stuart, 1996; MacDonald and Ryall, 2004). On the one hand, firms have "bargaining power" that assures them some cut of the value that has been created, which has to do with how much added value they create and how easily they can be replaced. On the other hand, there is a margin of value that goes uncaptured, even after various slices have been allocated to various players. Because creating value is a cooperative process and everyone has a claim to what is left, firms cannot rely on their "bargaining power" to secure a share of these "leftovers"; instead, they must utilize their value-capture ability (Grennan, 2013; Casadesus-Masanell and Zhu, 2013).

Value capture in the business model is the monetization of customer value, the proportion of the value created that is appropriated by the company (Hui, 2014; Casadesus-Masanell and Llanes, 2011). To this end, what embodies value capture in a business model can be Chesbrough's (2007) revenue mechanism or Casadesus-Masanell and Zhu's (2013) profit function. Menychtas et al. (2014) provide a comprehensive view of these elements in the business model: 1) The revenue model, which measures the ability of a company

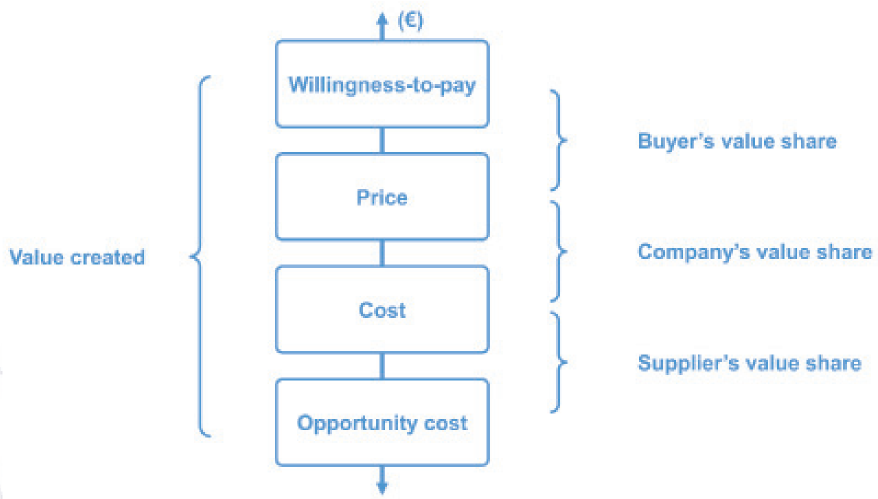


Figure 1: Value creation and the division of value (adapted from Brandenburger and Stuart, 1996).

to translate the value it offers to its customers into money and therefore generates incoming revenue streams (Dubosson-Torbay et al., 2002). 2) The costs structure, which measures all the costs a firm incurs in order to create, commercialize, and deliver value to its customers (Kashef and Altmann, 2012). For instance, directly used products generate costs for their value proposition usage. 3) The profit model, which is the difference between the revenue model and the cost structure (Hamilton, 2004). Thus, the profit model is the revenue that is generated from the revenue model minus the costs that are generated from the cost model (Menychtas et al., 2014).

The rise of business ecosystem thinking

A review of the business model literature shows that the majority of the modern frameworks remain focused on the company level. However, the competitive landscape of modern business has changed to a highly networked economic environment. This is further exacerbated in digitized industries, as digital platforms enable cooperation among complementary firms. In this context, ecosystems and business models within ecosystems are emerging as a new domain of strategy research (Iivari et al., 2016). Moore (1996) defined the concept of the business ecosystem as an economic community of organizations and individuals, including producers, suppliers, competitors, and other stakeholders that produce goods and services that generate value for the customers and users. Iansiti and Richards (2006) describe business ecosystems as highly complex, interdependent, cooperative, competitive, and convolutional in pursuit of innovations.

Importantly, as the unit of analysis shifts from single companies to entire business ecosystems among collaborating companies, classical analyses of value creation and value capture become obsolete. Instead, new approaches are needed that account for the cooperation among complementary firms. In this vein, Amit and Zott's (2001) study on sources of value creation in e-businesses highlights how value is created at the level of transactions among suppliers, partners and customers. Based on a cross-case analysis of e-businesses, they identify efficiency, complementarities, lock-in, and novelty as key value drivers of e-businesses. From this perspective, a business model refers to the design of transaction content, structure, and governance, as it seeks to exploit business opportunities in an ecosystem.

Shifting to the service-dominant logic of the business ecosystem

As the first generation of ecosystem thinking, Moore (1996) presents an individual company-centric view of the business ecosystem (core enterprise, extended enterprise, and ecosystem), where the business ecosystem is created to serve a focal company, or the keystone (Moore, 1996). Jansson et al. (2014) expand the business ecosystem concept towards a more systemic perspective, viewing business ecosystem as a bundle of business models where the interlinked process of value co-creation, co-capture, co-opetition, and co-evolution prevails, conceptualizing the ecosystem as a network of individual business models. A true systemic view of a business ecosystem and an associated ecosystemic business model is proposed by Vargo and Lusch (2016) in recent marketing literature, highlighting not only the importance of systemic and institutional perspectives but also their convergence. The concept of the service ecosystem describes a business ecosystem as "a relatively self-contained, self-adjusting system of resource integrating actors connected by shared institutional arrangements and mutual value creation through service exchange" (Vargo and Lusch, 2016, p. 10-11). Zalewska-Kurek et al. (2016) further argue that customers are essential to developing the core element of the business model, and they should not be viewed just as an audience but as a valuable "actor."

Utilizing Gummesson's (2011) dynamism argument, service ecosystem scholars (Wieland et al., 2017) replace labels such as buyers and sellers and refer only to actors interacting with other actors. Similarly, adopting this actor-to-actor perspective, the service-dominant logic researchers suggest all ecosystem actors, such as end users and firms who engage in exchange, are integrating resources and exchanging services to achieve value co-creation. While the network perspective of the business ecosystem and business model recognizes the importance of collaboration among companies, this view is still wrapped around the focal company and overlooks the systemic participation of actors in the dynamic value co-creation among actors.

Instead, the service ecosystem perspective sees the shift from company-centricity and the sole production of outputs to activities and processes in which ecosystem actors participate in service exchange (Vargo and Lusch, 2016). A service ecosystem is also aligned with

Brandenburger and Stuart's (1996) value-based strategy, in the way that the institutionalization of the new norm and value increases consumer's willingness-to-pay (or willingness to engage in exchange) in the ecosystem, while actors' (companies') opportunity costs are reduced, thanks to the co-creation activities and shared access to resources within the ecosystem.

Smart grid ecosystemic business model

Prior to introducing the service-dominant logic and service ecosystem view to energy and smart grids, Xu et al. (2016) identify that when analyzing the transition of the utility-led centralized energy system to a distributed smart grid system, the traditional company-centric business model conceptualization and tools do not suit the purpose. On the other hand, this research gap is rarely studied in the business model literature or addressed in energy-related studies. Xu et al. (2016) systemically study the categories of value that can be created and delivered by the adoption of a smart grid in today's energy system, suggesting that the use of the ecosystemic business model in the smart grid domain can unlock and create five types of value in the energy ecosystem and society in general.

The categories of value include economic (e.g., reducing unnecessary cost and investment in constructing backup generation capacity), environmental (e.g., facilitating the integration of renewables), reliability (e.g., the use of next-generation ICT technologies to improve network reliability), energy security (e.g., ramping up renewables to reduce reliance on depleting fossil fuel resources), and consumer engagement and interaction (e.g., turning consumers into prosumers, facilitating active market participation). The discussion of how these categories of value are created with a smart grid ecosystemic business model is presented in the following sections 3.1 and 3.2.

The 4C ecosystemic business model for smart grids

Incorporating the service ecosystem logic for this study, we first adopt a typological 4C framework (Wirtz et al., 2010) that is used to study ICT-enabled digital ecosystems such as 5G (Yrjölä et al., 2015) and smart grids (Xu et al., 2016, 2017).

One reason behind the utilization of the 4C ecosystemic model is related to Vargo and Lusch's (2016) service ecosystem thinking, showing that the transition of smart grid is a performative process, in which business models, technologies, and markets are developed and continually shaped by a broad range of actors influencing the value creation and capture practices. In this circumstance, business models cannot be studied in isolation. The separation of a business model from its technological and economic context is less suited for investigating the interdependence of the companies and actors that are evolving in the same business ecosystem (Alanne and Saari, 2006), as in the case of smart grids.

The 4C framework consists of four essential business models, each with different value propositions and revenue mechanisms: connection, content, context, and commerce (Table 1). Yrjölä et al. (2015) suggest a key characteristic of the 4C framework is that the upper layers can be enabled by lower layers in an ICT ecosystem. Four typological value propositions (value of connection, value of content, value of context, and value of commerce) are utilized to describe the value structure of the business ecosystem. The value embedded in the value propositions can be created and captured in individual layers, multiple layers, and combinations of different layers (Yrjölä et al., 2015; Xu et al., 2016, 2017), which can be seen as "value-in-layers" with the main value in certain layers and the enabling value in other layers. The detailed demonstration and adaptation of the 4C framework in the energy industry and smart grids are presented in Section 5.1.

Layer	Description
Commerce	Service providers offer all stakeholders an application or marketplace for trading alternative connectivity solutions, content, or context data.
Context	Service providers offer data and information-related context services.
Content	Service providers offer any content the customers would want or need.
Connection	Service providers offer connectivity solutions to one or several networks.

Table 1: The 4C ecosystemic business model and value framework (adapted from Wirtz et al., 2010; Xu et al., 2016, 2017; Moqaddamerad et al., 2017).

Moreover, to illustrate the different types of value that may be related to ecosystem thinking, this paper utilizes Xu et al.'s (2016) study of multiple value streams to be recognized and realized in the context of the energy industry and smart grids. Referring to Xu et al. (2016), business models need to create not just economic value, but also environmental value, reliability value, energy security value, and consumer engagement/interaction value in the energy ecosystem.

XaaS service business model typologies

In the traditional product business, creating value is associated with identifying enduring customer needs and manufacturing well-engineered solutions. The competition was primarily feature-versus-feature warfare. When product feature improvement and innovation become too incremental, price competition arises and eventually makes the product obsolete. In contrast, the service business is seen to create continuous value or multiple revenue streams rather than sales of the product (Hui, 2014). In the digital services domain, the notion of XaaS (Everything as a Service) gains popularity for digitally enabled systems (Lenk et al., 2009). In this direction, a large number of digital service providers can be identified to offer a variety of cloud-based services across the cloud stack layers. According to Mell and Grance's (2011) model, the most widely accepted digital service models are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Various characteristics, such as virtualization of hardware, rapid service provisioning, scalability, elasticity, accounting granularity, and cost allocation models, enable the proliferation of XaaS, and the notion of XaaS (SaaS, PaaS, and IaaS) is completely changing the way software is produced, consumed, and distributed. Consumers do not buy licenses for software products anymore; they pay for its usage on a pay-per-use basis (Giessmann and Stanoevska-Slabeva, 2013).

The SaaS layer is the most visible service of cloud computing, which makes software applications accessed directly by the end users (Stanoevska-Slabeva and Wozniak, 2009). These applications are deployed and executed in cloud systems and can be accessed from various client devices through a client interface such as a Web browser (Mell and Grance, 2011). The IaaS layer offers computing resources such as processing, storage, networks, and other fundamental computing resources that can be obtained as a service (Mell and Grance, 2011). Connecting the IaaS and SaaS layers, the PaaS layer is a Web-based development platform which is open to external developers for new component and application development (Giessmann and Stanoevska-Slabeva, 2013).

The pricing model of XaaS is classified into four categories by Menychtas et al. (2014) as (1) Subscription: Customer pays for a time frame during which the product can be used; (2) Pay-Per-Use Event: Customer pays for the event of interaction with the service; (3) Pay-Per-Use Time: Customer pays for the time (duration) of the actual interaction with the service; (4) Pay-Per-Use Quantity: Customer pays for the quantity of resources consumed by interacting with the service.

To conclude the above discussion in Section 3.1 and Section 3.2, we see that XaaS represents a holistic view to digital service architecture, which is embodied in three digital service business model typologies (SaaS, PaaS, and IaaS). By combining XaaS service business model typologies and the 4C ecosystemic framework, we conduct mapping and analysis of the innovative business model cases identified by experts from the EU BRIDGE initiative.

Research design and data collection

This study follows the methodology of the interpretive case study (Walsham, 2006; Andrade, 2009; Bhattacharya, 2012) to analyze the energy business cases in the first stage and action research to construct the EaaS framework in the second stage. The study is carried out as the joint research work of two EU-level energy innovation research projects. One project studies the peer-to-peer technical platform that facilitates decentralized energy market design and the peer-to-peer energy exchange of smart grid, while the other develops a local marketplace and innovative business models to encourage micro-generation and the active participation of prosumers to exploit the flexibility created for the benefit of connected local grids.

In the first stage, the study embarks on a systematic analysis of 51 innovative business cases that have launched new business models. Based on the theoretical background previously outlined, the cases are analyzed and mapped in the proposed 4C framework and in the XaaS typology in order to address our research question posed at the outset. This approach enables us to gain insight into what types of value are created in smart grid ecosystems and the related business model typologies in the energy and smart grid industry. Some succeeded in radically changing the industry.

In the second stage, the study takes an action-oriented approach (Eden and Huxham, 2006; Koshy et al., 2011) to construct the Energy-as-a-Service logic through the XaaS typology. The emphasis is on the use of a service-dominant logic. According to Bahari et al. (2015), action research methodology in management science leads to producing scientific knowledge that can serve the action; and it enables the formalization and contextualization of models and tools, leading to new knowledge capable of facilitating organizational change.

The data is collected from the BRIDGE initiative of the European Commission, a collaborative initiative for major European smart grid and energy storage projects, of which 15 projects contributed energy business cases to BRIDGE's Business Model Working Group. The data is retrieved in the form of business model cases, which are provided by a wide range of energy experts, business enterprises, policymakers, and research institutions with expertise and knowledge of the smart grid and energy landscape internationally. The study includes a total of 34 business model cases from the BRIDGE program and is further complemented by 16 cases from the two Horizon 2020 projects that are both participating in the BRIDGE and have authored this paper. The cases cover a wide spectrum of the smart grid ecosystem, including distribution network, aggregation platform, virtual power plant, energy storage, smart home service, trading platform, and blockchain-enabled energy solutions.

Overall, the data utilized in the research is provided by the aforementioned parties and participants in 2016 and 2017, which ensures a timely study and analysis of the state-of-the-art business models in energy and smart grids. In the next section, we present the key takeaways from our research and suggest how they can help innovators transform the energy industry.

Findings and Discussion

This section presents the results of the study with the proposition of the EaaS ecosystemic framework.

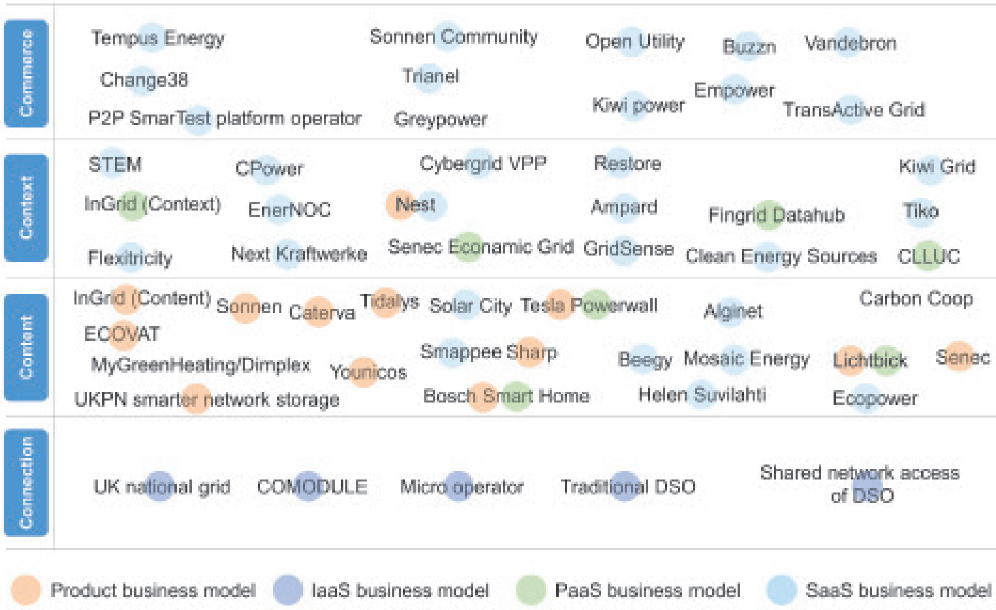
Mapping of business models in the 4C ecosystemic framework

By mapping a range of successful business cases in the proposed 4C framework and in the XaaS typology, we could gain insight into what types of value are created in smart grid ecosystems. The emphasis has been on the value that is created from a service-dominant-logic standpoint and the related business model typologies (Figure 2). The four layers of connection, content, context, and commerce are organized into four verticals. It is necessary to note that the unmarked cases mainly represent a certain part that is required to form the smart grid ecosystem but does not have a major digital component in their business models.

Connection is the first layer in the 4C ecosystemic framework. The role of a connection business in smart grids is to build and manage facilities for massive network operations. The imperatives of the infrastructure business are about economies of scale, creating the value of reliability, and security. Connection business models are traditionally operated by the energy network operators, such as distribution system operators (DSOs), who focus on delivering electricity at lower cost and satisfactory power reliability. The UK national grid is an example of a DSO that manages private distribution grids, providing grid-scale storage and offering commercial maintenance services.

The content layer presents the value propositions that focus on power quality, renewable energy integration, and consumption feedback. Balancing energy supply and network constraints is a prime focus; thus the businesses in this layer exhibit more collaborative behavior. There are product-based companies such as Caterva, a German startup that offers batteries to residential customers directly through selling or renting. There are also product-service hybrid companies like the US-based SolarCity (developing turnkey solutions for residential solar panels and providing on-going support services).

On top of the content layer, the contextual value is created and captured in the "context" layer. Flexibility is the primary value, thus requiring coordinated activities among



Note: the un-marked cases mainly represent certain part that is required to form the smart grid ecosystem, but do not have a major digital component in their business models.

Figure 2: Mapping of energy business models in the 4C ecosystemic framework.

the ecosystem actors. Here, the context-related value is refined to fit specific use cases, such as flexibility forecast and network load feedback (Xu et al., 2016) (Helms, Loock, & Bohnsack, 2016). The main offerings in this layer are usually the efficiency and flexibility services. Energy aggregator is a viable business model that optimizing energy consumption at the customer site while providing customers with energy management tools such as energy monitoring, peak control, and demand response (DR). InGrid is another context business case that builds a technical platform to facilitate the integration of renewables and distributed generation (DG) in the main power grids.

Data has been identified as playing a critical role in the context layer; and firms employ different approaches to keep data accrued in their operations in closed, partially open, or fully open manners. For instance, Restore is an aggregator of industrial and commercial energy customers, who partially opens its data to allow grid operators to tap into its customers' reserve, providing a balancing service for the grid operators while rewarding the flexibility providers.

In the commerce layer, open energy trading platforms are emerging. Trading service providers, such as Vandebron, Empower and Open Utility, allow the participation of smaller customers having restricted access and participation in the energy market due to regulatory barriers. For instance, Vandebron enables small-scale renewable energy producers to trade green energy directly with end customers. Yet, the actual operation of open energy trading platforms are still limited due to regulatory restrictions (Loock, Reuter, & Cousse, 2017; Loock, Reuter, & vanderTann, 2016).

It is worth noting that in the content and context layers, there are a few business cases that involve creating both content and context value due to their unique business models. For instance, InGrid does not only produce hardware and storage systems for renewable integration in the smart grids, but also develops software solutions to help manage the power grids in different contexts. InGrid's business model covers both content business and context business. In this case, we give InGrid a unique identifier for each layer and map the case, as does InGrid (content) for its content business and InGrid (context) for its context business, in order to support a more granular analysis of how XaaS business models can be applied to each individual value unit or value proposition in an integrated business model.

The Table 2 below summarizes the five value categories (name) identified and mapped across the four 4C ecosystemic layers.

Economic value		**Categories of value in the smart grid ecosystem**				
		Environmental value	Reliability value	Energy security value	Engagement/ Interaction value	
Value related to the 4C ecosystemic layers	Commerce-related value	Enabling prosumers to participate in energy market and trading	Enabling the trade of small-scale renewables			Lowering barriers for end customers to interact with the energy producers
	Context-related value	Reducing economic costs arising from network constraints	Enhanced use of renewables and distributed generation	Reliability stemming from forecasting and providing flexibility to the grid		Customer engagement and interaction in smart grids
	Content-related value		Integrating different renewables	Power quality		Feedback on energy consumption
	Connection-related value	Economies of scale to provide economic benefits		Network reliability	Security of energy supply and the energy network	

Table 2: The mapping of the value categories across the 4C ecosystemic layers.

From XaaS to EaaS: service business typologies in a smart grid ecosystem

After the mapping and analysis of energy business model cases in the 4C ecosystemic framework, the research moves on to aggregate the business cases and construct a service-oriented framework at a higher abstract level with the three business model typologies of XaaS. We identify how an energy and smart grid ecosystem is shifting to a service-dominant logic with service-oriented business models. By adapting to the XaaS logic, we propose four Electricity as a Service (EaaS) business model types (Figure 3). Generally speaking, the EaaS business models follow the 4C ecosystemic framework's "value-in-layers" structure, in which there are main value layers and the enabling value layer. The enabling value layer is usually the connection layer at the bottom of the framework as a foundation of the digital ecosystem. However, depending on the case, other layers can also become such layers to enable the main value creation and capture.

First, the connection business is very similar to the IaaS business typology. In smart grids, the incumbent DSOs have adopted the service business model by building and maintaining an electricity network to enable the delivery of energy through the electrical network at different voltage levels. These DSOs charge a network usage fee, capturing value through a subscription-based pricing mechanism that is often regulated by regulators and policymakers. Depending on the regulation, such pricing is either incorporated into a single energy bill or a separate network usage bill (such as in Finland) for consumers. However, it is important to stress that such a DSO model is mainly applicable in liberalized markets such as the EU, Australia, New Zealand, and some states in the US. In other countries and regions, the integrated utility business model remains dominant, where DSO is an integrated function in the entire utility operation, from electricity generation to transmission and distribution and to retail. In the case of an integrated utility business model, product-oriented logic is still being utilized, as both energy costs and network costs are aggregated in the final energy bill.

The emerging concept of Shared Network Access (SNA) for DSOs (Li et al., 2016) shows further servitization

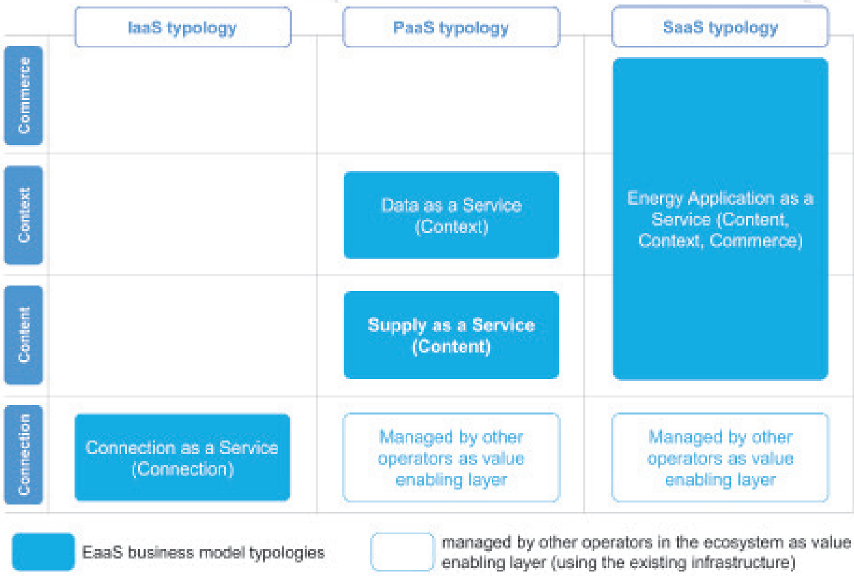


Figure 3: EaaS business model typologies.

potential for the connection business. Essentially, SNA is a business model that incentivizes the incumbent DSOs to give up its exclusive access to the network asset and operations, leasing the spare and under-utilized capacity to licensed independent third parties. The ownership of assets is retained by the incumbent DSO, while competition is introduced in the operation of the spare capacity. The new secondary DSOs can introduce new service offerings and create more value without having to own the physical energy distribution network, thus becoming a provider of "Connection as a Service" that enables universal accessibility.

Second, we identify that the content and context business models resemble the PaaS typology and can be analyzed in two sub-categories (content business and context business). The content business is primarily focused on building physical platforms on top of the energy infrastructure to facilitate the energy supply that flows in the electrical grid. Such a business model is built upon the existing grid infrastructure to be able to create and capture value, that is to say, the core of such a business model is about combining the grid infrastructure operated by DSOs with an energy supply infrastructure. The examples can be the renewable energy aggregators or the energy storage networks operators such as InGrid, Senec, and Lichtblick. These companies manage network energy generation or storage facilities coupled with ICT technologies to facilitate the ever-increasing supply of distributed energy resources such as solar and wind generations. These business models operate as different platforms to co-create value for the energy ecosystem while competing with each other, since they all fully or partially develop proprietary storage and control technologies that are only compatible if new applications are developed according to their technical standards and specifications. The use cases such as InGrid's flexibility and renewable dispatch service in the context layer, Senec's grid platform, and Lichtblick's SchwarmEnergie all illustrate how these physically oriented platforms can enable new applications. Furthermore, it is evident that all of these physical platforms represent the shift from product-based logic to service-oriented logic in the energy industry, in other words, from microgeneration and energy storage product vendors to platform operators. Well-known players such as SolarCity are adopting service-oriented logic as well. For instance, SolarCity introduces a "zero up-front investment" model for home solar PV and focuses on the maintenance and support service contract to generate cash flow in the long run. All of these content business models are moving towards a "Supply as a Service" logic instead of strictly sales of products and equipment. Within the Empower project, a large-scale survey of customers in Norway, Switzerland, Spain and Germany uncovered customers' interest in energy-related services (Reuter and Loock, 2017).

Another type of PaaS is developed out of the software and data platforms in contrast to the aforementioned physical platforms. Thanks to increasing digitalization in the energy industry, such as the mandated rollout of smart meters in the EU, massive data is captured using ICT technologies, enabling and facilitating the emergence of context services. For example, CLLUC as a software platform developer creates a blockchain platform to remove intermediaries and improve operational efficiency for a number of industries, such as energy and finance (Xu et al., 2017). The platform allows customers and third parties to collaborate and develop new solutions and offerings through its software platform to enable grid flexibility and consumption reporting services. Fingrid's data hub is another example. The open data hub is a subsidiary of Fingrid, the Finnish transmission system operator. This system operator manages the open data hub and provides Finnish energy ecosystem actors with open access to retail electricity and consumption data. By establishing an open platform with "Data as a Service," new smart energy applications and services are expected to be developed, allowing energy ecosystem actors to create and capture new value.

Third, we discover that the SaaS business model typology can find real-life applications in the content, context, and commerce layers. Altogether, we address these applications as "Energy Application as a Service." Vandebron and Open Utility are remarkably new business models that offer commercial service applications. Vandebron operates an "Airbnb-like" open renewable marketplace for smaller generators and prosumers to trade their renewable energy directly to the end consumers. The marketplace itself is not an entity that involves energy trading, but rather empowers a peer-to-peer energy exchange with others. It can be considered as a software-enabled e-commerce application that is built on top of the physical and software infrastructures (e.g., connection, content). Empower is also a similar case within this typology.

Virtual Power Plant (VPP) as an emerging new business model in the energy ecosystem can be categorized within the SaaS typology. Shabanzadeh et al. (2016) suggest that VPP is a cloud-based software control center that takes advantage of ICT and Internet of Things (IoT) devices to aggregate the capacity of heterogeneous energy resources including different types of DG units, energy storage systems, and flexible loads to form an energy resource pooling with the key purpose of providing ancillary services for system operators such as DSOs. VPPs, such as Next Kraftwerke, provide a network balancing service based on contextual data and information, which can be considered as a stand-alone service application in the context layer. Energy service applications can also be found in the content layer. For instance, Helsinki Energia's (Helen's) Suvilahti solar project is a service business model. On the one hand, it allows residential consumers to own and invest in shares of solar generation in a central and optimal location to maximize return on investment and create value for the utility's customers. On the other hand, Helen charges a monthly service fee for managing solar generation on behalf of its customers, shifting from sales of green energy to the provision of renewable energy services.

The ecosystem actors may collaborate on either the value creation side or the value capture side. In the case of smart grids, DSOs and mobile network operators (MNOs) may jointly create a network load feedback service and provide it to aggregators and consumers/prosumers. On the other hand, consumers/prosumers may allow behavioral data to be stored and utilized by DSOs and MNOs, while the true value of such data is captured by aggregators. The aggregators can provide Data as a Service (DaaS) that renders flexibility forecasting service to the network operators (like DSOs) or provides consumption and usage behavioral analytics to enable energy retailers to gain a better insight into user behavior, which in return facilitates more value-added services to be created for the consumers/prosumers. Furthermore, in the case of smart grid DR, VPP operators like cyberGrid can co-create value with consumers and prosumers to provide balancing service to the electric distribution network, benefiting network operators with the value of reliability and security. VPP operators will share the profit with prosumers and consumers by means of monetary rewards or the economic and environmental value. In this way, all parties can create and capture multiple streams of value all together for the ecosystem, which is in line with Vargo and Lusch' (2016) service ecosystem logic.

Conclusion and implications

Generally, the paper shows that Vargo and Lusch's (2016) service ecosystem view can be applied to the energy ecosystem through the 4C ecosystemic framework. In this setting, Vargo and Lusch's (2016) mutual value creation through service exchange is identified as such that different layers within the 4C ecosystem can create value and service offerings that can later enable new types of value and service offerings in other layers of the ecosystem.

Based on Yrjölä et al.'s (2015) suggestion for the ecosystemic perspective, the 4C typologies are placed as layers where businesses on lower layers are required as enabler and value levers for higher layers to exist. The different stakeholders or actors within the ecosystem can offer businesses alone or as bundled value creation, and the business potential of the entire ecosystem depends on the ecosystem actors' synergy when providing their services to other actors within the ecosystem.

To sum up, an important finding from the paper is related to whether the digitalized energy ecosystem leads to the formation of XaaS, the well-known system design and architecture typology in software and digital business. The research shows that there is a two-way interplay. For instance, Vargo and Lusch's (2016) service ecosystem concept explains that the institutional frictions within the energy industry provide the impetus for the digitalization of the energy industry, the uptake of digitalization of energy industry, and the development of smart grid technologies and innovations. On the other hand, the XaaS concept that is adopted by innovative (digital) energy companies stimulates and steers the industry towards a service-oriented ecosystem, since the collaborative value creation and capture approach enables the companies to tap into new business territories that would not be possible if all actors adopt a closed business mind set (as the aggregator and VPP cases discussed in Section 5 of the paper).

Research implications

The academic contribution of the study is the proposition of a service-dominant logic for the business model and ecosystem research to complement the existing value-based perspective (value creation and value capture) in business model studies. For the first time, the study introduces the XaaS service business model typologies that are widely known in the ICT research domain to the energy sector and investigates how the three service-oriented business model types can be used to enable and facilitate the digitalized transition of the energy industry and smart grids in particular.

The paper studies the service-dominant logic of the energy industry through the investigation of innovative business cases collected by the energy experts from the EU BRIDGE initiative. Through the 4C ecosystemic framework, the paper is able to identify and categorize how these business cases can be recognized and placed in different layers of the energy ecosystem. Then the action research and utilization of the XaaS concept and typology constructs the service ecosystem framework for the digitalized energy business models. Building on these concepts and frameworks, the paper demonstrates how innovative businesses can provide different energy services create value that cross multiple layers of the energy ecosystem with the engagement and involvement of different energy industry actors. Thus, it goes beyond the conventional utility-centric and product-based business model of the energy industry, emphasizing the maximization of ecosystemic value for actors involved in a business ecosystem, in contrast to the conventional wisdom on value maximization for a focal actor of the business ecosystem. As argued by Wieland et al. (2017), this is an issue regarding the unsatisfactory definitions and normative prescriptions of the business model in the extant literature, due to the many researchers adopting the concept with ease. When a scholar or practitioner frames a business model in a dyadic transfer of value for money, this individual is likely to view the value creation, value capture, and value exchange practices with a rather static value. In contrast, when an actor's business model frames the actions of the firms, customers, and other ecosystem actors in a collaborative manner, this actor is likely to actively engage in business model development with a broad range of stakeholders and seek the maximization of mutual benefit and value in the ecosystem. This is suggested as an important step in the further exploration of business models and business model development in a systemic and dynamic context (Wieland et al., 2017).

The utilization of XaaS typology and the 4C ecosystemic framework in an energy ecosystem setting demonstrates evidence that a more general digitalization framework such as XaaS can be used to study conventional industries that have been digitalized or are undergoing the process of digitalization. On the one hand, this study shows that the XaaS typology is a phenomenological business model classification tool for digital business across different sectors (the focal section of this paper is energy). On the other hand, it is necessary to apply or further develop the framework with adaptive thinking: one should not take such a digitalization framework without thinking critically and adapting to the specific context, such as industry, market, or regulation. That is to say, the EaaS framework is an adaptation of the original XaaS typology by taking into account the ecosystem characteristics of the energy industry.

Furthermore, this study derives its findings from the analysis of the real-life business model cases identified by experts from 15 of the EU major energy projects through a collaboration with two Horizon 2020 energy research and innovation projects, providing a solid ground supported by empirical data for business model conceptualization on a large scale.

Practical implications

The study's practical implications relate to the possibility of analyzing the smart grid business models with XaaS and service-oriented logic. The study proposes a new paradigm for energy companies and policymakers to examine the business potential of a future energy and smart grid ecosystem without having to dwell on the old product-based logic, enabling new value creation and capture in the energy industry, as addressed by high-level government bodies such as the EU.

The novelty of the research relates to the proposing of XaaS typologies for the energy industry, including infrastructure-oriented XaaS, or Connection as a Service (CaaS); platform-oriented XaaS, or Supply as a Service (SaaS) and Data as a Service (DaaS); and application-oriented XaaS, or Energy Application as a Service (EAaaS). These typologies as a whole are considered as EaaS. With these new digital service business typologies and the concept of EaaS, we aim to propose and evangelize a service-oriented mind set for the practitioners and actors in the energy ecosystem to innovatively create and capture new value arising in the smart grid era.

Furthermore, the study presents the insight for energy companies and practitioners to explore new avenues of creating and capturing value in service business territories and exploit new growth opportunities arising from the service-oriented transition of the energy industry. Reverting to the first section of the paper, we call for an update of the management mind-set for business executives and practitioners in this digitalized and connected era.

At last, the mapping of the business model cases shows that a number of product-based companies utilize a product-service hybrid model, stacking a service application layer on top of its product business. We recommend further research to study the role of hybrid business models in the business ecosystem: how they create and capture value and contribute to the broader context of industry transition and service digitalization.

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Appendix

Layer	Companies / business cases included in the study
Commerce	Tempus Energy, Sonnen Community, Open Utility, Vandebron, Change38, Trianel, Buzzn, P2P SmarTest platform operator, Greypower, Kiwi power, TransActive Grid, Empower
Context	STEM, CPower, Cybergrid VPP, Restore, Kiwi Grid, InGrid (Context), EnerNOC, Nest, Ampard, Fingrid Datahub, Tiko, Flexitricity, Next Kraftwerke, Senec Econamic Grid, GridSense, Clean Energy Sources, CLLUC
Content	InGrid (Content), ECOVAT, MyGreenHeating/Dimplex, UKPN smarter network storage, Sonnen, Caterva, Younicos, Tidalys, Solar City, Smappee, Bosch Smart Home, Sharp, Tesla Powerwall, Alginet, Carbon Coop, Beegy, Mosaic Energy, Helen Suvilahti, Lichtbick, Senec, Ecopower
Connection	UK national grid, COMODULE, Micro operator, Traditional DSO, Shared network access of DSO

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