Defining the Business Ecosystem of Peer-to-Peer Electricity Trading

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Abstract

Purpose: The purpose of this paper is to introduce the value proposition and structure of the business ecosystem of peer-to-peer electricity trading through a future oriented approach.
Design/Methodology/Approach: This study follows a qualitative approach. It conducts conceptual analyses by utilizing previously validated tools in similar contexts. First, different views on business ecosystems are introduced and an argument is made to justify an ecosystem perspective for peer-to-peer electricity trading. Second, the value proposition of the peer-to-peer electricity trading ecosystem is identified by utilising a meta-model which consists of four elements: end customer value, business value (shareholder value), collaborative value (business value to the supply chain) and societal value (value creation in the supply chain and control of negative externalities). Third, based on the structural view of business ecosystems, the study identifies actors, positions, links, and activities in the traditional electricity trading. And last, (structural) changes of the ecosystem for peer-to-peer electricity trading are discussed.
Findings: This paper elaborates the business ecosystem of peer-to-peer electricity trading and highlights the structural changes it imposes to the status quo.
Practical and social implications: The ecosystem construct adds insights into actors' ecosystem strategy regarding their business models for peer-to-peer electricity trading as well as into the governance of this type of trading. It provides a comprehensive view for policy makers. It enhances the research designs in detailed aspects of the peer-to-peer electricity trading by providing a wide lense.
Originality/Value: The identified business ecosystem of peer-to-peer electricity trading provides a comprehensive, multi-stakeholder perspective to incorporate complexities and include externalities.

Key words

Business ecosystem, peer-to-peer electricity, value network, business model, value chain

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I. Introduction

The electricity generation and consumption paradigm was (and still is mostly) based on central electricity production from non-renewable (e.g. fossil-fuel, nuclear, gas, etc.) and renewable (wind, hydroelectric, etc.) resources in power plants. Electricity, in a one-directional flow, passes through the transmission grid, transformed from high to low-voltage, and is delivered to consumers through distribution grids. Primarily, governments were the single-player for generation to delivery of electricity. Liberalization of the electricity market has brought competition to some parts of the value chain, namely to generation and supply. This paradigm, however, is changing in relation to the proliferation of distributed renewable electricity resources (e.g. solar panels, etc.) and batteries owned by prosumers as well as the possibility of easier communication by (and between) smart devices (e.g. smart meters, etc.). Prosumers are defined as consumers who are equipped with renewable energy resources and batteries (Montakhabi, Van der Graaf et al., 2020). Peer-to-peer electricity trading is an opportunity to trade prosumers' surplus electricity with other consumers and prosumers (Montakhabi, Madhusudan, et al., 2020). Figure 1 shows the evolution of electricity production and trading. Peer-to-peer electricity trading is changing the electricity generation and consumption paradigms which reflects on the value creation (Morstyn et al., 2018) and capturing by actors in electricity markets.

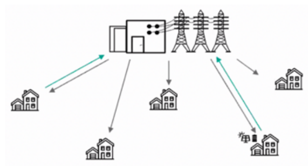
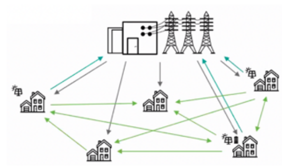
Yesterday	**Today**	**Tomorrow**
		
• Centralized production • One directional flow of electricity	• Increasing number of smaller, distributed electricity generators	• Peer-to-peer electricity trading

Figure 1. Evolution of electricity production and trading (Tiefenbach, 2019, n. p.).

Even though peer-to-peer electricity trading potentially forms a considerable share of transactions in future electricity markets, there is still no comprehensive vision emerging. Furthermore, consequences of peer-to-peer electricity trading have not been sufficiently and thoroughly elaborated. The complication of peer-to-peer electricity trading increases the interdependency among actors. It challenges the current structure of actors, activities, links, and positions. These all make the requirement for taking a wider lens to incorporate several stakeholders and consider externalities (e.g. emissions). Without considering the socio-economic and sustainability aspects of the peer-to-peer electricity trading from a multi-stakeholder perspective, it is difficult to develop these systems meaningfully (Leviäkangas and Öörni, 2020). The 'business ecosystem' concept is a promising means to address and remedy this.

The concept of 'business ecosystem' is one of the powerful means to comprehensively elaborate new models of value creation and capture. The interdependence of stakeholders has been exemplified by increase and ease of communication in the Internet era (Le Gall, et. al, 2015). This concept is able to illuminate complicated interactions and interdependencies which is the case for multilateral settings like peer-to-peer electricity trading. The concept has received much scholarly attention over the past three decades, and moved quickly from a theoretical concept to deployment. Furthermore, it is applicable not only for the world of high-tech but also for low-tech industries (Adner, 2017).

Given this context, this paper seeks to answer this question: "*How can the ecosystem framework be deployed in affording peer-to-peer electricity?*". In order to examine this, the following sub-questions are tackled sequentially: Does an ecosystem approach make sense for peer-to-peer electricity trading and why? What is the value proposition of the peer-to-peer electricity trading business ecosystem? What is the structure of the business ecosystem of peer-to-peer electricity trading?

In analyzing the electricity market by use of the business ecosystem concept, this paper contributes to peer-to-peer electricity trading and business ecosystem literature. On the one hand, the findings assist existing and emerging actors in the electricity market to adjust their business models for peer-to-peer electricity trading. On the other hand, it supports policymakers to develop a holistic perspective (Gomes, et. al, 2019) of all the stakeholders in the current and future electricity trading so to devise policies that can unlock the benefits of peer-to-peer electricity trading while considering the risks this may impose on the whole ecosystem. The ecosystem view assists policymakers to realize ways to enhance public benefit of electricity as a public good by facilitating value creation throughout the ecosystem (Leviäkangas and Öörni, 2020).

The paper is structured as follows: First, the rationale for elaborating an ecosystem view is discussed. Then, the concept of business ecosystems and two main views, ecosystem-as-affiliation and ecosystem-as-structure, are introduced. This is followed by a discussion on why an ecosystem view makes sense for peer-to-peer electricity trading as well as the elements of business ecosystem-as-structure are identified. Second, the methodology of this study is introduced. Third, the findings are presented in two parts: The first part introduces the value proposition of peer-to-peer electricity trading by using a meta-model which is built on the hierarchical relationship between business models, value chains, and ecosystems. The second part discusses the changes in the business ecosystem resulting from peer-to-peer electricity trading. Fourth, key insights are presented. Finally, discussion, conclusions, and opportunities for further research conclude the paper.

A. Why Business Ecosystem Amongst Other Views?

Value generation and capturing have increasingly become more complex. Hence, appropriate tools have been developed to address this. An evolution of tools that lead to emergence of business ecosystems can be traced in the literature. The 'business model' was initially understood as a firm-centric concept, related studies aimed to evaluate profitability and were focused on the financial value (e.g. Porter, 1985). The value chain concept could complement the business model thinking by providing a broader insight on the process of value generation and the importance of positions in the process of competitiveness. Businesses could occupy a competitive position, to increase profitability through cost reduction and by using the value chain concept. As the value generation and capturing became more complex, it was not enough to only focus on a single actor's profitability; A single actor's profitability became more and more tied to the profitability of other related parties which weren't necessarily direct competitors. It required a collaborative view rather than solely competitive view (Arend 2013). This gives birth to the value network concept as a network of actors in which profitability of single actors is required but not sufficient for value generation. While value network is an extremely useful tool to trace value generation, the need for a wider view that could incorporate value capturing and include a wider range of stakeholders was clear. The business ecosystem is a tool to address this need. It can provide a comprehensive view and is able to highlight externalities (Leviäkangas and Öörni, 2020). As the utility of tools broadened, their theoretical basis did as well.

Electricity market incorporates various stakeholders with complex relations and contrasting agendas. It generates enormous resistance for structural changes toward the peer-to-peer electricity trading. There have been several calls to investigate the peer-to-peer electricity trading model through a multi stakeholder view (Global Observatory, 2019). Montakhabi, Zobiri, et al. (2020) studied the transition from the traditional electricity market to the peer-to-peer market by utilizing the value network concept. Nevertheless, to get insights of the value capturing and governance of peer-to-peer electricity trading, an application of the ecosystem view is necessary.

B. Two Views on Business Ecosystems in Literature

The term "business ecosystem" was initially introduced by Moore (1966). It originated from a biological metaphor, challenged the traditional strategy literature, and extended strategic analysis which was limited to competitive analysis within boundaries of industries.

Theoretically, the business ecosystem concept incorporates the agency and stakeholder theories as two main competing theories (Leviäkangas and Öörni, 2020). On the one hand, the agency theory (Blyth et al., 1986), which is supported by theories of investment (Jorgenson, 1963), assumes that the existence of an organization is only justified if it increases the wealth of its shareholders. On the other hand, in a broader view, stakeholder theory considers firms responsible to their stakeholders and the whole society (Freeman et al., 2004). Furthermore, the business ecosystem concept embraces complexity theory (Peltoniemi and Vuori, 2004) and systems theory (Marín, 1997). The business ecosystem is used as a concept to study complex systems. It is based on the requirement of an understanding of the whole rather than merely discovering the parts. An ecosystem is always more than the sum of its components. There is a synergic surplus of value as the result of collaboration between ecosystem-members that goes further than a simple aggregation of elements (Xu, Kemppainen, and Pikkarainen, 2020). Competition and cooperation simultaneously exist in a business ecosystem. Noteworthy relevant concepts that came from the complexity theory to the business ecosystems theory are self-organization (Mitleton-Kelly 2003), emergence (Mitleton-Kelly 2004), coevolution (Pagie and Mitchell, 2002), and adaptation (Merry, 1999). Business ecosystems are said to grow through self-organization, emergence, and coevolution. These assist them to attain adaptability.

Two mainstreams are detectable in the business ecosystem literature. The first stream defines ecosystems as networks of affiliated organizations (e.g., Iansiti and Levien, 2004; Autio and Thomas 2014; Rong and Shi, 2014; Jacobides, Cennamo, and Gawer, 2015). This approach, ecosystem-as-affiliation, takes an actor-centric view; Belonging to a network, or affiliation to a platform builds communities of actors that form a business ecosystem. The second stream, ecosystems-as-structure, defines a business ecosystem around a core value proposition (e.g., Adner, 2013; Adner and Feiler, 2019; Adner and Kapoor 2010). In this view, actors' interaction serves the fulfillment of the core value proposition of the ecosystem taking an activity-centric view. The value proposition, as the cornerstone of the business ecosystem, requires a set of activities to be accomplished. Furthermore, it is the value proposition that defines the boundaries of the ecosystem. Table 1 shows definitions of the business ecosystem in the literature. It is worth considering that despite the methodological differences between the two views, they are mutually consistent.

Author	Definition	Ecosystem as affiliation vs. structure
Moore (1996)	"An economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organism also includes suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the direction set by one or more central companies. Those companies holding leadership roles may change over time, but the function of ecosystem leader is valued by the community because it enables members to move toward shared visions to align their investments, and to find mutually supportive roles."	Affiliation
Power and Jerjian (2001)	"A system of websites occupying the world wide web, together with those aspects of the real world with which they interact. It is a physical community considered together with the nonliving factors of its environment as a unit."	Affiliation
Iansiti and Levien (2004)	"Loose networks of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations [that] affect, and are affected by, the creation and delivery of a company's own offerings."	Affiliation
Iansiti and Levien (2004)	"A large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival."	Affiliation
Peltoniemi and Vuori (2004)	"A dynamic structure which consists of an interconnected population of organizations. These organizations can be small firms, large corporations, universities, research centers, public sector organizations, and other parties which influence the system."	Structure
Den Hartigh and Van Asseldonk (2004)	"Network of suppliers and customers around a core technology, who depend on each other for their success and survival."	Affiliation
Quaadgras (2005)	"A set of complex products and services made by multiple firms in which no firm is dominant."	Affiliation
Adner (2006)	"the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution"	Structure
Teece (2007)	"the community of organizations, institutions, and individuals that impact the enterprise and the enterprise's customers and supplies"	Affiliation
Zahra and Nambisan (2012)	"A group of companies that interacts and shares a set of dependencies as it produces the goods, technologies, and services customers need"	Affiliation
Kapoor and Lee (2013)	"Interdependent activities carried out by [firm's] customers, complementors, and suppliers"	Structure

Autio and Thomas (2014)	"A network of interconnected organizations, connected to a focal firm or a platform, that incorporates both production and use side participants and creates and appropriates new value through innovation"	Affiliation
Adner (2017)	"the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize"	Structure

Table 1. Definitions of business ecosystem in literature

The two approaches construct a business ecosystem from two completely opposite directions. Each approach has its own merits. Depending on the case and the capabilities of each approach, the approach is selected. It is worth considering that the starting point in the ecosystem-as-structure is identifying a focal actor and then by following the ties to this actor, identifying other affiliated actors, and finally determining the value proposition that the ecosystem is capable of generating. In this view, positions result from links; Hub-and-spoke, brokers, and platforms are some of the familiar characterizations in this view. In the ecosystem-as-structure approach, the value proposition for the ecosystem is identified, and by following the supporting activities, actors are identified. The former approach is interested in the actors with a direct tie to the focal actor, but the latter may end in actors with no direct tie to the focal firm or even the ecosystem may have no focal actor. The requirement of alignment dictates links and positions in a business ecosystem (Jacobides, et al., 2018).

Even though in a mature stage, ecosystems are mostly known by their focal actors and it is easier to discuss them as affiliation, in the inception stage it is easier to study ecosystems by their focal value proposition through identifying their structure. Considering that the ecosystem of peer-to-peer electricity trading is (to a large extent) a non-existing one yet; it makes sense to imagine the inception of a peer-to-peer electricity trading ecosystem around a focal value proposition rather than a focal actor. Hence, this study analyzes the peer-to-peer electricity trading based on the ecosystem-as-structure view. It follows Adner's (2017) view which identifies an underlying value proposition that determines the structure of interdependent activities. So, for the purpose of this study, a business ecosystem is defined as:

"*The alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*" (Adner, 2017, p. 42)

C. Does Ecosystem View Make Sense for Peer-to-Peer Electricity Trading? Why?

Referring to the selected definition for a business ecosystem in this study, for the ecosystem construct to be of relevance four requirements are necessary (Adner, 2017). In the absence of these requirements, there would be no specific value to appealing an ecosystem view. To identify whether an ecosystem perspective adds to the understanding of peer-to-peer electricity trading these four requirements are reviewed and reflected upon for the peer-to-peer electricity trading case:

1. **Alignment structure**: This is the degree of mutual agreement between members of a business ecosystem regarding their positions and activity flows. It is not necessary that all members of a business ecosystem have and follow the same goals. But for an ecosystem's success, all members must be pleased with the positions they occupy in the ecosystem. Hence, the alignment includes both compatible motivations and a constant understanding of the configuration of activities amongst actors. This requirement relates to the debates of the political economy theory (Ballon, 2009).

When there is no alignment required between actors, either because the value creation by the focal actor does not require partners, or because the alignment already exists and no shift is necessary, the ecosystem view will not add any value. In the case of the electricity market before liberalization, the focal firm, which was mostly government-owned, did not need partners to generate value. The government was the sole market player and was handling everything from electricity generation, transmission, distribution, etc. in a hierarchical order. Liberalization of the electricity market opened the way for competition but still the critical roles are played by Transmission System Operators (TSOs) and Distribution System Operators (DSOs) which are usually state-owned entities. However, in the liberalized electricity market, partners' alignment was necessary, which has been reached during past decades. However, the challenges of peer-to-peer electricity trading necessitates a shift in partners' alignment. Peer-to-peer trading challenges and seemingly changes roles and activities in the future electricity markets. It likely opens up opportunities for the emergence of new roles (Montakhabi, Zobiri, et al., 2020) and requires a new alignment structure.

2. **Multilateralism:** This refers to the existence of multiple partners with relationships that are not just an aggregation of bilateral interactions. In other words, multilateral ties which can be split into simple (in-)direct bilateral ties do not require an ecosystem approach. Transaction cost economics (Williamson, 1975) and relational contracts (Dyer and Singh 1998) are two out of many theories to discuss bilateral relationships.

In an ecosystem, a critical interaction across relationships is necessary. As an example, in the peer-to-peer electricity trading case, one of the main multilateral relationships is between prosumers, consumers, and retailers. A successful contract between a prosumer and a consumer is affected by the contract between the consumer and retailer. Analyzing the relationship of consumers and prosumers in isolation from retailers would lead to false conclusions. This is just one of many imaginable multilateral relationships in peer-to-peer electricity trading. In scenarios that require the emergence of new actors, the probability of multilateral relationships is higher.

3. **Set of partners:** This highlights the necessity of the existence of partners in an ecosystem. Partners are defined as actors whose participation is necessary for the value proposition of the ecosystem to materialize. Partners may or may not directly link to a focal actor or deliver the final product or service to consumers but as members of the ecosystem, they all have a joint value generation effort as an underlying goal. It is usual and to some extent expected that several actors pursue different plans and have different perceptions of the composition of partners in a business ecosystem.

Peer-to-peer electricity trading, by nature, requires the participation of different partners. It is partly because of the construction of the electricity market after liberalization. Some activities are legally monopolized for specific (mostly public) actors (e.g. distribution system operators do the metering, transmission system operators take care of the balancing of the electricity grid, etc.). So, peer-to-peer electricity inherently entails the existence of a set of partners to materialize.

4. **For a focal value proposition to materialize**: This puts the materialization of the value proposition in a business ecosystem at the center of attention. It helps to identify effective activities that support the value proposition. It consequently extends the analysis to recognize a set of partners in an ecosystem. In an ecosystem what the final target of the collective effort receives is more important than what an individual actor offers. Emphasis on the materialization of the value proposition requires a minimum coordination among actors. This minimum coordination level defines how

much divergence of interests and perspectives are tolerable in an ecosystem as long as the value proposition is being materialized.

The value proposition of peer-to-peer electricity trading is discussed in detail in the Findings section. In short, as suggested by its name, peer-to-peer electricity trading promises that it would allow prosumers with excess electricity produced by their renewable energy resources (e.g. solar panels, etc.) to trade with other prosumers and consumers. Central generation in power plants, transferring the electricity through the transmission system, then transforming it to low voltage electricity before delivery to the distribution network is the traditional paradigm of electricity generation and delivery. The novelty is to trade the electricity from distributed electricity resources and deliver it through the distribution grid.

From a technical perspective, peer-to-peer trading aims to keep the distributed generated electricity from renewable resources at a local level. As a result, transmission losses are minimized, making local communities more robust against failures of the electricity grid. From an economic perspective, it enhances the efficiency of the utilization of dispersed resources. From a socio-environmental view, it is said to increase social resiliency and enhance sustainability (Murkin, et al., 2016).

D. Elements of Business Ecosystem-as-Structure

Activities, actors, positions, and links are the constructing elements of a business ecosystem as a structure. Aligned configuration of the four elements is necessary for the focal value proposition of an ecosystem to exist.

- ***Activities*** are the required tasks that should be fulfilled to materialize the value proposition.
- ***Actors*** are responsible to do the activities. In an ecosystem, an actor might be responsible for several activities and an activity might be undertaken by several actors.
- ***Positions*** define the configuration of different actors in the activity flows.
- ***Links*** show the flow of deliverables between actors. Money, physical products, data, and influence are a few types of deliverables that can flow through links in an ecosystem.

II. Methodology

This study follows a qualitative approach. It conducts a conceptual analysis by utilizing previously validated tools in similar contexts. The study is built on Adner's (2017) work which defines a business ecosystem as a structure. A business ecosystem is identified by its value proposition and illustrated by four constructing elements which are actors, activities, positions, and links (see section D for further information). The study uses Leviäkangas and Öörni (2020)'s meta-model to identify the value proposition of the peer-to-peer electricity trading (see section A in Findings for further information). The data is systematically collected through a literature review which takes into account state-of-the-art publications including books, journal articles, and conference papers about peer-to-peer electricity trading. The gathered data from the literature review process is enriched, triangulated, and validated by interviews conducted in the context of the SNIPPET[1] project. Research strategy includes comparison and assessment of data from different mentioned sources, and finally formation and reasoning of the research team’s interpretation.

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[1] https://www.esat.kuleuven.be/cosic/project/snippet/

Twenty-three semi-structured interviews were conducted in the context of the SNIPPET project. Interviews were planned to cover several aspects of the current and future structure of the electricity market, actors in the market, their responsibilities, resources, objectives, etc. Interviews were conducted face to face and via Skype. Each interview took forty-five minutes on average. The interviewees are academics and practitioners in the electricity market. They were selected from several stakeholder groups to provide a comprehensive view of the electricity market. Semi-structured interviews were guided by the questions about the value proposition and the structure of the current electricity trading as well as peer-to-peer trading. Interviews were recorded and transcribed afterwards. If the interviews were not recorded, due to the interviewees' preferences or technical problems, notes were taken. Data is coded based on the elements of the selected frameworks. Reported findings are the interpretations of the research team of the coded data. To support the findings, direct quotes are inserted in the findings section. The interviews were conducted between October 2019 and March 2020. The results are validated by two expert members of Global Observatory on Peer-to-Peer (P2P), Community Self-Consumption (CSC), and Transactive Energy (TE) Models, who are researchers on peer-to-peer electricity trading.

III. Findings

A. Value Proposition of Peer-to-Peer Electricity Trading Business Ecosystem

This section identifies the value proposition of the peer-to-peer electricity trading ecosystem. To do so, the study uses a meta-model proposed by Leviäkangas and Öörni (2020). The meta-model is built on the relationship between business models, value chains, and business ecosystems as a hierarchical structure. The model was initially developed in response to the need for new governance in the mobility sector. This need is mainly imposed by four disruptive forces which are technology disruption, changes in governance structure, challenges concerning environmental impacts, and transport poverty. The same forces, as discussed below, are present and impact the electricity market as well. This justifies the utilization of the model for the peer-to-peer electricity trading ecosystem.

- ***Technology disruption:*** It is revolutionizing the ways businesses are run and actors communicate with each other and with their customers. Technology disruptions not only change business models, but also value chains and networks. In the electricity sector, bilateral communication by use of internet-based services has made the communication between prosumers and consumers possible. Smart devices (e.g. meters, home energy management systems, etc.) let tracing electricity consumption and production in short intervals possible. Furthermore, batteries and solar panels are becoming widely available in higher capacities and lower prices. These are a few examples of technological disruptive forces in the electricity market that pave the road to peer-to-peer electricity trading.

  > "I think, as we said, climate change and through incentives from authorities, we need to see changes in terms of energy assets in the market. Technology is needed to manage these assets."

- ***Governance structures***. The provision of electricity from distributed renewable energy sources at consumers' premises, the possibility of energy self-consumption, and the emergence of energy communities are changing the traditional logic of trading in the electricity market. While in the past all the investments were made by the public sector (in most cases governments), by the emergence of peer-to-peer electricity trading, private investors seek opportunities for financial returns not only in household buildings but also in office buildings and business complexes.

Regarding the interrelation of the two above-mentioned forces, on the one hand, technology disruption often enables new ways of governance. On the other hand, governance structure can open new prospects to use technology disruptions by innovative investors.

> "[…] current markets where you trade electricity, they are just for really big players. It's not a democratic setup […]."

- **E*nvironmental impacts:*** Electricity generation power plants, especially those generating electricity from fossil fuel, gas, and nuclear energy, generate severe environmental adversities. Furthermore, they considerably contribute to climate change. They emit harmful pollutants; According to the United States Environmental Protection Agency, power plants that use non-renewable energy sources are the main emitters of mercury (50 percent), acid gases (over 75 percent), and many toxic metals (20-60 percent) in the United States. Emissions of power plants cause adverse impacts on the climate, flora, fauna, and humans. Advanced filtration systems have improved purifying the emissions and controlling the adversities but power plants still cause a considerable share of emissions worldwide.

> "Oh, it's extremely simple, it is climate change. We need to get rid of a lot of fossil based plants and we need to bring in a lot more renewable energy resources. We need to go through electrification of transport and heating. Transport and heating is 80% of all the energy used today and those need to be electrified. That's going to put an enormous strain on the power grid and electricity production. So climate change is driving this was a very simple answer."

- ***Energy poverty:*** The European Commission defines energy poverty as "a situation in which a person has difficulty obtaining the necessary energy in their home to meet their basic needs because of inadequate resources or living conditions." (Energy poverty, 2021).

> "[…] if you want to go to a very modern country or a very modern system, people should not be thinking about electricity use, it should be a basic […]."

Issues regarding energy poverty (González-Eguino, 2015; Middlemiss et. al, 2019) and inclusiveness of energy systems regarding accessibility to electricity are more and more emerging.

In a similar vein to the mobility sector, all the above-mentioned challenges impact the energy sector as well and call for new initiatives. New technologies to enhance accessibility, decrease negative externalities, and new approaches to electricity production and trading are more than welcome. Due to environmental and social demand and technological push, the electricity ecosystem is open to accept initiatives like peer-to-peer electricity trading which have the potential to address the above-mentioned challenges.

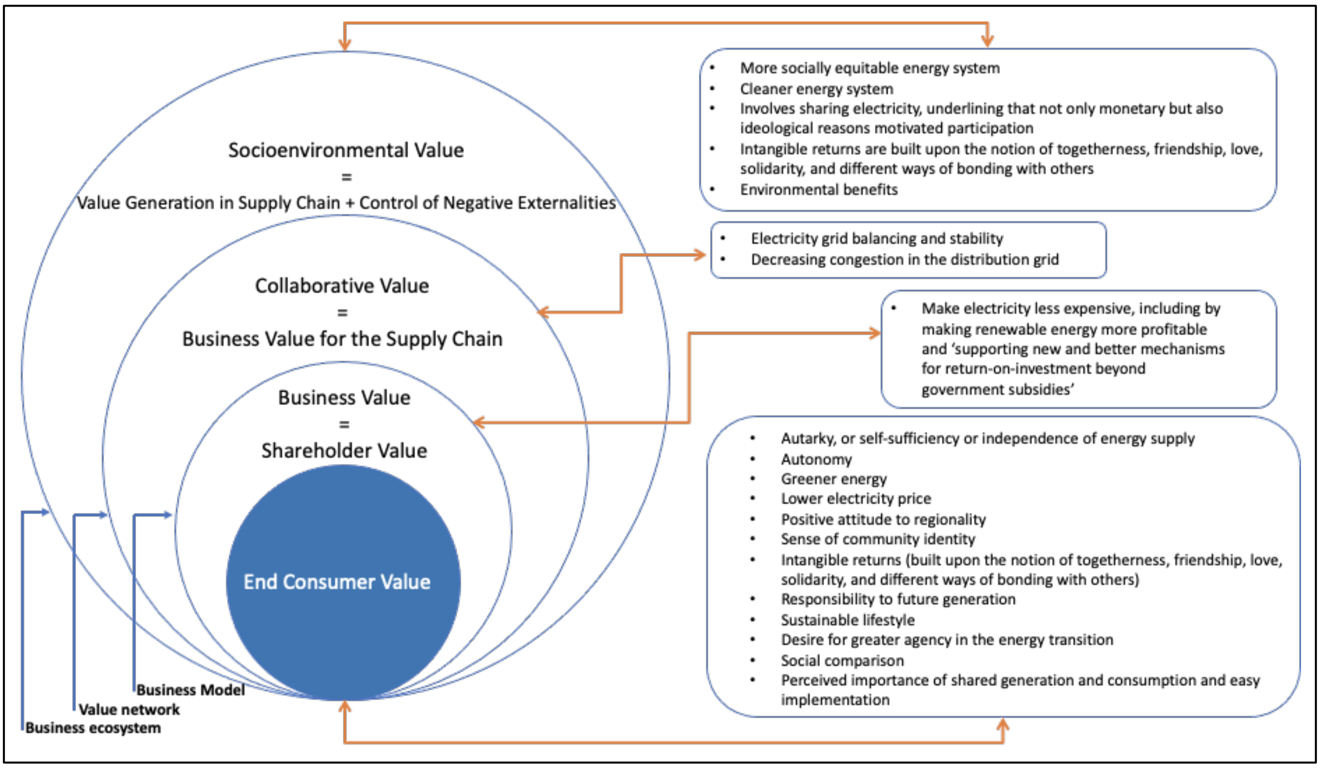
The meta-model for defining the value proposition of the business ecosystem consists of four elements: 1) end customer value, 2) business value, 3) collaborative value, and 4) societal value; The first element represents the value proposition to consumers, the second element is about the value proposition to shareholders in the firm level, the third element is about the business value to the supply chain, and the fourth one is about value creation in the supply chain and controlling the negative externalities.

Table 2 shows how peer-to-peer electricity trading generates value at different levels of the meta-model. The value proposition of peer-to-peer electricity trading is partially discussed in previous studies, but using a unifying framework, like what is used in this study (Leviäkangas and Öörni, 2020) is missing in the literature.

End customer value	Business value	Collaborative value	Socio Environmental value
• Autarky, self-sufficiency or independence of energy supply (Ecker, Spada and Hahnel, 2018; Fell, Schneiders and Shipworth, 2019; Hahnel *et al. 2019*; Spasova, Kawamoto and Takefuji, 2019; Ableitner *et al.*, 2020; Smale and Kloppenburg, 2020; Wörner *et al.*, 2020) • Autonomy (Ecker, Spada and Hahnel, 2018; Ableitner et al., 2019; Mengelkamp et al., 2019; Hackbarth and Löbbe, 2020; Löbbe et al., 2020; Smale and Kloppenburg, 2020; Wilkins, Chitchyan and Levine, 2020; Wörner et al., 2020) • Greener energy (Kubli, Loock and Wüstenhagen, 2018; Ableitner et al., 2020; Smale and Kloppenburg, 2020) • Lower electricity costs (Kubli, Loock and Wüstenhagen, 2018; Hahnel et al., 2019; Mengelkamp et al., 2019; Löbbe et al., 2020; Plewnia and Guenther, 2020) • Positive attitude to regionality (Mengelkamp et al. 2019; Ableitner et al., 2020; Hackbarth and Löbbe, 2020; Löbbe et al., 2020; Wörner et al., 2020) • Sense of community identity (Mengelkamp, Staudt, et al., 2018) • Intangible returns (built upon the notion of togetherness, friendship, love, solidarity, and different ways of bonding with others) (Singh et al., 2017; Singh et al., 2018) • Responsibility to future generation (Smale and Kloppenburg, 2020) • Sustainable lifestyle (Wilkins, Chitchyan and Levine, 2020) • Desire for greater agency in the energy transition (Scuri et al., 2019; Ableitner et al., 2020; Wilkinson et al., 2020; Wilkins, Chitchyan and Levine, 2020) • Social comparison (Scuri et al., 2019; Ableitner et al. 2020; Smale and Kloppenburg, 2020) • Perceived importance of shared generation and consumption and easy implementation (Hackbarth and Löbbe, 2020)	• Make electricity less expensive, including by making renewable energy more profitable and 'supporting new and better mechanisms for return-on-investment beyond government subsidies' (Kirchhoff and Strunz, 2019; Mengelkamp et al., 2019; Ableitner et al., 2020; Löbbe et al., 2020; Wilkins, Chitchyan and Levine, 2020)	• Electricity grid balancing and stability (Smale and Kloppenburg, 2020) • Transmission losses are minimized so making local energy communities more robust against failures of the electricity grid (Murkin, Chitchyan, and Byrne, 2016)	• More socially equitable energy system (Scuri et al., 2019; Wilkinson et al., 2020) • Cleaner energy system (Wilkinson et al., 2020) • Involves sharing electricity, underlining that not only monetary but also ideological reasons motivated participation (Hackbarth and Löbbe, 2020; Löbbe et al., 2020) • Intangible returns are built upon the notion of togetherness, friendship, love, solidarity, and different ways of bonding with others *(Singh et al., 2018)* • Environmental benefits *(Mengelkamp, Staudt, et al., 2018; Ableitner et al., 2020; Hackbarth and Löbbe, 2020)*

Table 2. Value created by peer-to-peer electricity trading at different levels of the meta-model

Figure 2 unifies the information from Table 2 and highlights the limits of previously discussed tools. Each circle represents the conceptual border of a tool. The model has end consumers' value in the core of value recognition. It shows how going from the basis towards the ecosystem view expands the recognition of the value proposition. Consumer value is a combination of financial and nonfinancial benefits which satisfies consumers' needs. The next layer is the business value which is the value that actors generate for their shareholders. It represents itself in profit or capital gain and materializes through revenue increase and/or cost reduction. Actors pursue business value maximization for their shareholders through profitable business models as an intrinsic tool. Another way to increase the business value is through collaboration by appropriate positioning in the value network. To generate collaborative value, actors open their business models in different ways. Shared research and development plans, alliances, and licensing technologies are a few examples of open business models. Despite the costs that open business models impose as the result of more coordination, actors follow them when the expected benefits overweigh the costs. Generating collaborative value requires an exogenous approach rather than the intrinsic approach to generate business value in the previous layer. Last but not least is the socio-environmental value layer. It widens the value domain further than the values for shareholders to stakeholders (Vladimirova, 2019). Social and environmental values are discussed in this layer.



Note: Each circle represents the limits of different tools (see the left bottom of the picture)

Figure 2. Meta-model composing of business models, value networks, and business ecosystems for identifying the value proposition of peer-to-peer electricity trading

Peer-to-peer electricity trading has the potential to generate value in different ways which makes it a good case for applying the meta-model. First, since peer-to-peer electricity is produced from renewable energy resources and requires consumers' involvement, it generates environmental benefits and has the potential to generate societal benefits as well. Second, successful implementation of peer-to-peer electricity trading requires collaboration among different stakeholders. Complexities of peer-to-peer electricity trading requires collaboration between several actors in the value network. Third, large scale peer-to-peer electricity trading is still expected. Identifying the value proposition of the peer-to-peer electricity trading in different layers, by using the meta-model, provides a clear and comprehensive understanding of the business ecosystem around peer-to-peer electricity trading.

B. Business Ecosystem of Peer-to-Peer Electricity Trading

In this section, first, the business ecosystem of traditional electricity trading is reviewed and then the peer-to-peer electricity trading is discussed. For centuries, the basic elements (activities, actors, positions, and links) of the electricity ecosystem have been unchanged: Electricity has been centrally generated in power plants; the high-voltage electricity transmits through the transmission grid. Then the high-voltage electricity is transformed to low-voltage before being distributed through the distribution grid. Finally, Retailers sell the electricity to end consumers. Technological advancements and liberalization of the electricity market demonstrate their effect on the intra-actor competition level. In Figure 3(a) traditional electricity ecosystem is shown by its characterizing elements. It illustrates actors' relative positions in the ecosystem and links between critical activities.

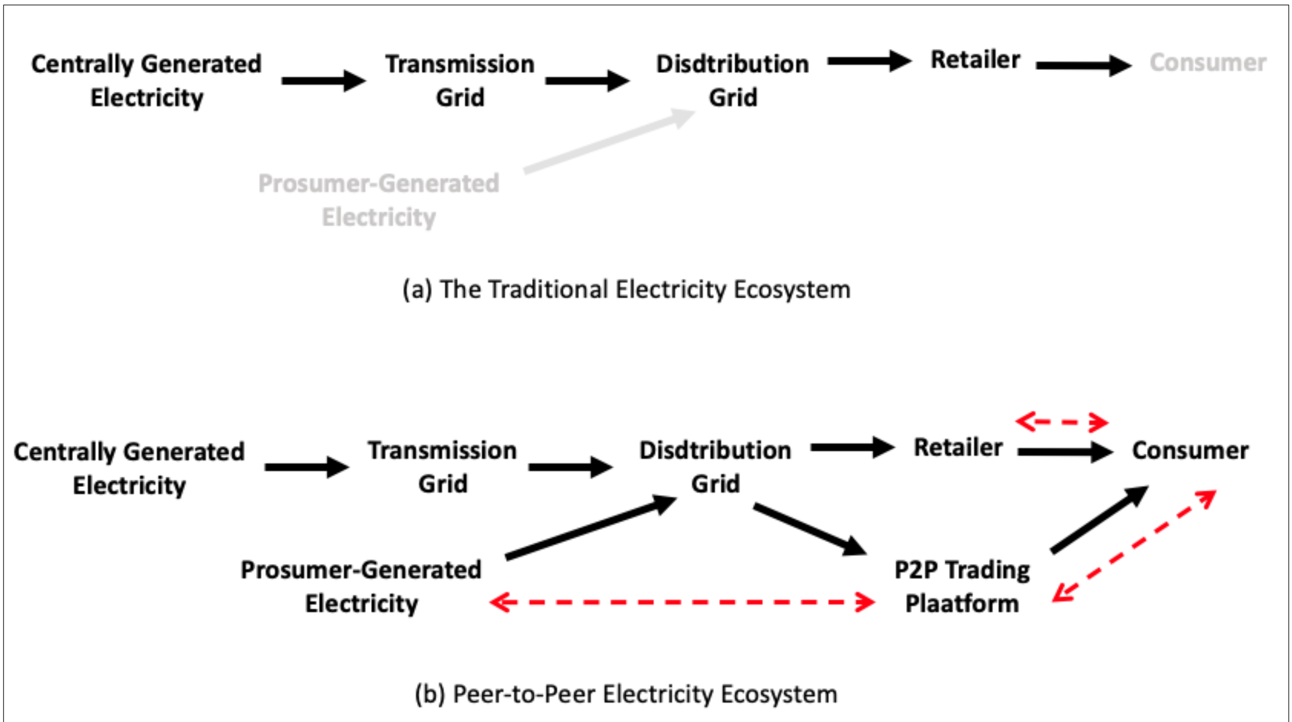


Figure 3. Blueprints for the traditional and peer-to-peer electricity ecosystems

Despite the involvement of several actors in the traditional electricity trading value proposition, it is possible to analyze the relationships between actors bilaterally, in isolation, and without impacting other relationships. Some of the identified (bilateral) relationships are more active (black in Figure 3a, e.g., retailers promote their service packages to influence consumer's consumption behavior at different hours of a day) and some are more passive (grey in Figure 3a, e.g., prosumers do not have any other option except delivering their excess electricity to the distribution grid without bargaining power regarding the price). Because traditional electricity trading lacks multilateralism, which was the second requirement for ecosystem view as discussed in section B of the Introduction, there is no merit in using the business ecosystem logic to understand its dynamics.

> "[…] current markets where you trade electricity, they are just for really big players. It's not a democratic setup […]."

Figure 3b shows the peer-to-peer electricity trading situation. On the contrary to traditional electricity trading, the value proposition of peer-to-peer electricity trading, as discussed in section A of Findings, entails reconfiguring activities and multilateral relationships. Hence, it necessitates the deployment of ecosystem logic to understand its dynamics. In the peer-to-peer electricity trading, electricity is purchased from fellow peers rather than retailers which were the sole electricity sellers in the past. Furthermore, despite the centralized generated electricity at power plants, which passes through the transmission grid before reaching to the distribution grid, the peer-to-peer traded electricity is directly delivered to the distribution grid. The value proposition of the peer-to-peer electricity trading requires some key activities' positions to shift; *the electricity production is distributed, not central; the distributed produced electricity is mostly generated from renewable resources; it is being delivered directly to the distribution grid not passing through the transmission grid; and it is being traded between peers through the peer-to-peer trading platform, not sold through retailers.* Furthermore, peer-to-peer electricity trading imposes new requirements. It requires new links between activities and actors in other positions in the business ecosystem as well, such as it requires a secure and privacy-friendly platform for communication and trading to be developed.

> "[…] We need to go back to where basically mathematics is keeping the balance of the grid […]."

> "[…] It is more going to be algorithm based optimization […]."

It may seem straightforward from a technical point of view, as all the technologies are in place, but it is complicated from data protection and privacy perspectives.

The requirement of a trading platform highlights another requirement for peer-to-peer electricity trading: Peers should participate in the trading through the platform. Consequently, consumers who were latent members in the traditional electricity trading setting, shift to potential active participants who can decide about the level of their participation (Montakhabi et al., 2021).

We define the activeness or passiveness of an actor by the fact whether an actor firstly has options to decide and secondly can decide between different options. For example, when prosumers can only inject their excess electricity into the distribution grid and cannot negotiate on the price, they are considered to be passive. But when they can select and negotiate to whom and at what price to sell, they become active participants in the ecosystem.

By putting prosumers and consumers in the role of active participants in the business ecosystem, peer-to-peer electricity trading gives rise to new links in the ecosystem. The first is observable between prosumers' and consumers' participation in the peer-to-peer electricity trading which entails the adoption of the peer-to-peer trading platform. The second is the consumers' incentive and retailers' offers; T*he more consumers participate in the peer-to-peer electricity trading, the less they are willing to purchase from retailers*. It has already given rise to the offerings of retailers. To decrease consumers' incentive to participate in peer-to-peer trading of electricity, retailers are offering green electricity, of course at a higher price, to environmentally concerned consumers. If there is not enough incentive from the consumer's side to actively participate in the peer-to-peer trading platform, there would not be enough motivation for prosumers to participate in the peer-to-peer trading of electricity.

> "[…] I think the risk is the status quo that there's too many strong big companies with established business models that will try to prevent this from happening. […]."

Table 3. presents main differences between the traditional and the peer-to-peer electricity trading business ecosystems.

	Current ecosystem	**Peer-to-peer ecosystem**
Electricity production	Centralized	Distributed
Source of electricity generation	Mostly non-renewable resources	Mostly renewable resources
Way of delivery	Passing through the transmission grid	Directly to the distribution grid
How trade happens	- Retailers sell to consumers - Prosumers sell to the distribution grid	Between peers
Selling through	Retailers' platform	Peer-to-peer trading platform
Type of user-involvement	Passive	Active

Table 3. Main differences between the traditional and the peer-to-peer ecosystem

IV. Takeaways from Theory and Findings

In the following, some important takeaways from the theoretical review and findings on the peer-to-peer electricity trading are presented.

1) The business ecosystem is an extremely useful concept for comprehensively studying both value generation and capturing. It takes a multi-stakeholder perspective and incorporates all influencers.
2) The business ecosystem is not only a useful concept in the world of high technology but also for other areas that specific structure of interdependence enforces multilateral settings.
3) Peer-to-peer electricity trading gives rise to new links in the ecosystem. Hence, it structurally changes the electricity trading ecosystem.
4) Ecosystem-as-affiliation and ecosystem-as-structure are two main views of business ecosystems in literature. The former defines an ecosystem as a network of organizations around a focal actor. The latter focuses on the focal value proposition and its required activities.
5) The peer-to-peer electricity trading ecosystem is still in its infancy. So, identifying the focal value proposition is easier than a focal actor. Hence, ecosystem-as-structure is a better tool to study peer-to-peer electricity trading at this stage.

V. Discussion, conclusions, and opportunities for further research

Comparing Figures 3a and 3b as the representations of the traditional and peer-to-peer electricity trading, illuminates structural differences between the underlying value propositions. When a change in relationships in, at least, one of the four elements of an existing (ecosystem) structure (activities, actors, positions, and links) occurs, the ecosystem approach will be an insightful tool. Peer-to-peer electricity trading not only introduces new activities and new actors in the electricity trading structure, but also influences links and positions in a way that requires new interactions. The changes peer-to-peer electricity trading impose on the elements of the electricity trading structure highlight the necessity of an ecosystem characterization. Although the prosumer position does not shift, the requirement of new links in peer-to-peer trading noticeably influences the prosumer's impact on value generation. Furthermore, the introduction of a peer-to-peer trading platform entails new activities, most likely new actors, new links, and new positions.

In situations where the value proposition of the ecosystem enforces alteration of the structure, alignment comes into consideration more than ever. How should actors which may not be directly linked to each other - or even to the focal actor which imposes the change - get encouraged to change? Implementing an ecosystem strategy requires a perfect understanding of ecosystem boundaries and dependencies between actors. In a peer-to-peer electricity trading case, it is not easy to make any assumptions about who will run the platform. Since it entails dealing with personal data, legal barriers, security, and privacy as well as data protection concerns extend the question from "Who has the business motivation and capabilities?" to "Whom is legitimate and trustworthy (D'Hauwers, et al.,2020) enough from prosumers and consumers' perspectives to undertake this role?". Although technological solutions (e.g. blockchain, etc.) pave the road to decrease the requirement of trust, questions remain that make any robust assumptions about the candidates impossible.

Peer-to-peer electricity trading entails a structural departure from the long history of electricity trading (e.g., wholesale, retail, day-ahead). Despite traditional electricity trading which conforms to existing strategy constructs, describing and evaluating peer-to-peer electricity trading requires a business ecosystem view.

The ecosystem perspective, which has been presented in this paper, provides a holistic view of peer-to-peer electricity trading. It helps to develop and consequently govern the system as a whole rather than concentrating on single elements in isolation (Leviäkangas and Öörni, 2020). Understanding the surrounding ecosystem helps actors in peer-to-peer electricity trading to adjust their positions in the value network and to enhance their profitability through their business models, while having a bigger share in capturing value. The ecosystem perspective helps actors in decreasing their risks through the right collaborations. These are possible as the result of understanding broader demands which spread outside the immediate sphere of a single actor's activities. Moreover, the ecosystem perspective makes it easier to identify the broader external effects of an actor. Last but not least, it can assist actors to undertake social responsibilities.

In the next step, this study seeks to answer questions at the ecosystem and actor levels. Main questions at the ecosystem-level are about the potential for scalability, type (adaptive or centralized) of the appropriate ecosystem (Furr and Shipilov, 2018), structural interdependencies and complementarities in the ecosystem (Jacobides et al., 2018; Kapoor, 2018), barriers and constraining mechanism (Almpanopoulou, et al., 2019), the best sequence to build and leverage the value proposition (Adner, 2012), and terms of access and exclusivity (Jacobides, 2019). Important questions at the actor-level are about the role (Jacobides, 2019), timing for move, and position of each actor in the ecosystem.

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