Dissemination Potential in Germany of Peer-to-Peer Energy Trading and Local Electricity Markets as an Option for Decentralized Energy System

by

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Abstract

Peer-to-peer energy trading and local electricity markets have been widely discussed as new options for the transformation of the energy system from the traditional centralized scheme to the novel decentralized one. Moreover, it has also been proposed as a more favourable alternative for already expiring feed-in tariff policies that promote investment in renewable energy sources. Peer-to-peer energy trading is usually defined as the integration of several innovative technologies, that enable both prosumers and consumers to trade electricity, without intermediaries, at a consented price. Furthermore, the techno-economic aspects go hand in hand with the socio-economic aspects, which represent at the end significant barriers that need to be tackled to reach a higher impact on current power systems. Applying a qualitative analysis, two scalable peer-to-peer concepts are presented in this study and the possible participant´s entry probability into such concepts. Results show that consumers with a preference for environmental aspects have in general a higher willingness to participate in peer-to-peer energy trading. Moreover, battery storage systems are a key technology that could elevate the entry probability of prosumers into a peer-to-peer market.

1. Introduction

The current energy systems worldwide are making efforts on new decarbonization paths to prevent the consequences of climate change. For example, Germany's government approved an amendment on the Climate Change Act 2021 which proposes reaching climate neutrality in the year 2045 [1]. An integral solution from all energy-consuming sectors must be put into practice to accomplish this ambitious goal. Alone in 2019, almost 40% of the German renewable energy systems (RES) installed capacity was owned by the private sector, namely, private households and farmers; in contrast, barely a 6% of the RES installed power is owned by the biggest three power providers [2]. This forces the introduction of not just technical solutions but also innovative market solutions that involve the participation of the private sector in a more active way. Power grids have operated traditionally in a centralized basis, however, nowadays with the inclusion of several prosumers into the distribution grids, the solution of a more distributed power grid becomes a necessity [3]. Microgrids alongside with local electricity markets (LEMs) and peer-to-peer-energy trading (P2P-ET) have the potential to offer a solution for achieving a more decentralized and resilient power system, moreover, it can stablish a platform that allow prosumers to participate more actively in the electricity market [4]. P2P-ET is defined as the integration of several technologies, namely, information and communication technologies (ICTs), distributed energy resources (DERs) and distributed ledger technologies (DLTs), that enable both prosumers and consumers to trade electricity, without intermediaries, at their consented price [5].
In our study we focus on P2P-ET in Germany and evaluate the current participation potential into such concepts, considering supralocal areas such as regions, states or country-wide extent. The results and methodology proposed with this study is as follows:

- The most promising types of scalable P2P concepts derived from literature
- Content analysis defining the probabilities of the prosumer participation rate in entering mentioned P2P concepts.
- Outlook and future work with a focus on modelling of energy systems

2. Classification of P2P – ET schemes

Generally, a P2P network is composed by two layers: the virtual or market layer and the physical layer. The first one has elements such as, market platform, information system and market price formation, whether the second one comprises basically the power grid or connection infrastructure between participants or peers [6]. This study focuses mainly on the market layer. The main P2P market designs according to their degree of decentralization are divided in centralized, decentralized and distributed [7]. These market designs are analysed, adapted and depicted in figure 1. For all of them the presence of the platform provider is proposed and may take different roles and responsibilities depending on the market type. A further subdivision is illustrated for each market relating how these concepts can be deployed in practice. The production and consumption block can be constituted by either pure energy producers and consumers or prosumers, it is illustrated this way for providing clarity in the contract relationships between participants. Moreover, DLT (e.g. Blockchain) can be employed in each market type with the aim to track transaction between peers by generating Smart Contracts and even add a crypto currency system for completing the financial transactions [8].

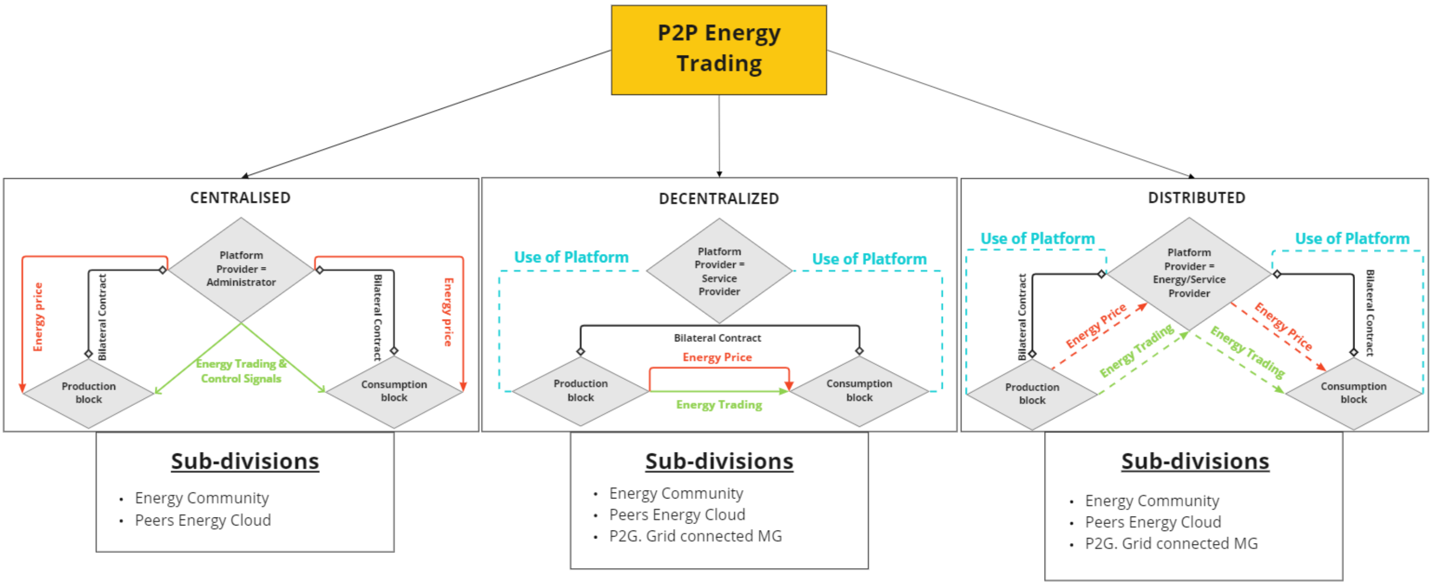


Figure 1: P2P-ET markets adapted from source [7]

In the centralized market the platform provider has an active role, acting as an administrator rather than a facilitator; moreover, he coordinates and controls the prosumer's DERs and even fixes the LEM price, sending the information then respectively to the producer and consumer. At the end the market participants are only allowed to contract with the administrator without the possibility of performing direct bilateral contracts between each other. The main advantage of the centralized option is that the overall economy of the market can be maximised and the balancing on the LEM is performed easier, since the coordinator controls energy import and exports; on the other hand, the main disadvantage is related to the peer autonomy and privacy, since he is not able to control his own DER and shares all the information required by the coordinator.

Contrary to the centralized scheme, the role of the platform provider in the decentralized market is rather passive than active, since he only provides and maintains the online platform that enables a prosumer to market and advertise its produced energy, and the consumer to choose its preferred energy supplier. Moreover, the allowance of performing direct energy bilateral contracts at an agreed price, not imposed by the platform provider, is an option for this type of market. Privacy and autonomy issues are not a disadvantage for this market option as peers can control their own DERs. However, the balancing of the market represents a challenge, because of the active participation of several peers. This could provoke a market instability if not properly addressed. It is for this reason that the optional participation of a third party as an auditing agent is recommended with the aim to provide more stability in the LEM operation.

Additionally, a combination between the centralised and decentralised market is derived and represented as a distributed market. In general, the platform provider has the role of an energy and service provider, however, without being able to control the DERs of prosumers. The contractual relationship is performed with the platform provider, both for the producer and the consumer. Although the energy price is defined by the producer, the platform provider charges a fee for maintaining the online platform and to cover service related fees that can derive from forecasting, billing, metering and similar tasks; hence, the final energy price for consumer can be higher than originally defined. The energy trading is then being transmitted from production block to the platform provider and at last to the consumption block. Sharing the responsibilities between platform provider and market participants can create a stable LEM operation which is an advantage of this market scheme. A potential disadvantage, is that if the proper market price mechanism is not selected, it could jeopardize the transparent operation of the LEM as well as the social welfare.

In relation to the exposed P2P market schemes, the centralized one is not considered as a scalable option because of the autonomy or freedom of choice characteristic that is removed from market participants. Due to the autonomy that the decentralised and distributed markets provide, these two can be preferred by the potential LEM participants and therefore, are also considered more scalable into regionwide and countrywide area, especially if the presence of a certified supervising entity is present, such as transmission system operator (TSO), distribution system operator (DSO), balance responsible party (BRP) or energy utility company. Currently, there are various consolidated companies, start-ups and pilot projects which are already operating in a similar manner to these P2P concepts. An overview of some of these demonstrators located in the European region is illustrated in Table 1.

Table 1: Overview of P2P demonstrators in Europe.

P2P Demonstrators	Demonstrator Type	Country	Market type/Information flow			Blockchain	
			Centralised	Decentralised	Distributed	Yes	No
enyway	Start-up	Germany		X		X	
Tal.Markt/Tal.Markt Live	Company	Germany			X	X	
stromodul	Company	Germany			X		X
sonnen	Start-up	Germany	X				X
LAMP	Pilot Project	Germany	X			X	
NEMoGrid	Pilot Project	Germany, Switzerland, Sweden			X	X	
e.on - Simris	Pilot Project	Sweden	X				X
Quartierstrom	Pilot Project	Switzerland		X		X	
Powerpeers	Company	Netherlands			X		X
SunContract	Company	Slovenia		X		X	

Along with the P2P demonstrators, several innovative market solutions that consider even sector coupling between energy sectors have been proposed in the theory. The concept of federated power plants (FPPs) aims to encourage prosumers to participate in the upstream electricity market by bringing together P2P transactions into a virtual power plant (VPP) [9]. Using several clustering algorithms, the grouping of small prosumers into virtual micro grids (VMG) with a novel integration of a market actor such as an aggregator is proposed in [10]. Considering the role of battery storage systems (BSSs) as a flexibility, [11] proposed two market designs, a decentralized and a centralized option, demonstrating savings up to 30%. [12] evaluates the integration between residential and commercial sector using an energy optimization model, which results in reduction of total system costs, electricity imports and total emissions. [13] modelled an optimal power flow problem from energy communities that considers bilateral contracts between its prosumers under a decentralized market, taking also into consideration the distribution network constraints.

3. Prosumer clustering and participation rate in P2P

Assessing qualitative and quantitative data summarized from ten different studies in Europe, a thematic analysis focusing on socio-techno-economic aspects evaluating the prosumer and consumer willingness to participate in P2P-ET is performed. A summary of the reviewed literature with their key aspects is showed in Table 2.

Table 2. Summary of reviewed studies for assessing entry probabilities into P2P markets

Source	Methodology	Sample size	Focus and key aspect of the study	Geographic area
[14]	Data collection via survey study	830	LEM design, customer segmentation, preferred technologies.	Households
[15]	Quantitative and qualitative survey	181	Autarky aspiration in three defined P2P trading scenarios	Households – small town
[16]	Agent based model simulation	100	LEM with Feed in Tariff, autarky and prosumer and consumer clusters	Households
[17]	Survey study with structural equation model	195	Prosumer clustering with three preferred preferences	Households – country wide
[18]	Hierarchical multiple regressions	4148	Consumer and prosumer preferences towards P2P electricity trading products	Regional – state
[19]	Quantitative and qualitative survey	249	Energy autarky and autonomy in four defined P2P trading scenarios	Households – neighbourhood
[20]	Survey study with multilevel model	301	Prosumer cluster with probability estimation for entering in P2P trading in a community	Households – community
[21]	Survey study with adaptative choice-based conjoint analysis	656	Willingness to participate in LEM focused in regional and country wide area	Regional – country wide
[22]	Platform usage using Google analytics and heat maps	35	Evaluated participants behaviour from real P2P market in Switzerland	Households - neighbourhood
[23]	Literature qualitative analysis	—	Evaluation of the benefits of LEM in the electricity system in Germany	Regional – country wide

Based on the performed literature analysis, a prosumer clustering methodology is defined and showed in Fig. 2. The studies from Table 2 were reviewed and then selected for evaluating a determined group of prosumers with a determined main motive, preference and technology.

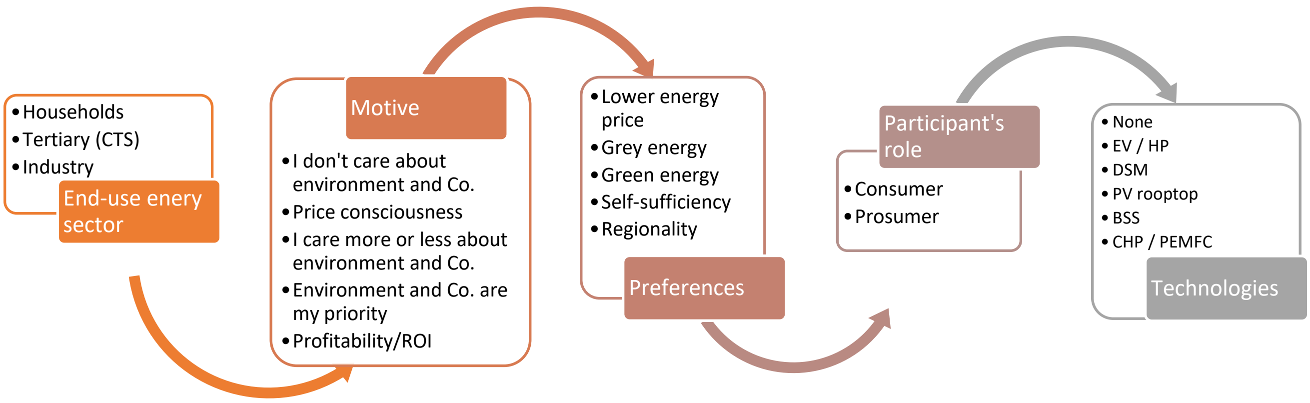


Figure 2. Prosumer clustering methodology

Once the prosumer clustering was defined, the participation rate or entry probability for two selected P2P markets was established. We compare two different geographic areas a local / regional and a regional / supraregional, considering the two selected P2P scalable market structures, meaning that these could be decentralized or distributed according to Figure 1. The whole prosumer clustering table can be found in Annex A1. In the following subsections the prosumer clustering method with its respective P2P entry probability will be explained and represented graphically for each end-use energy sector. The plots and graphics were built using the seaborn visualization library from python.

3.1. Residential sector

A further subdivision of the residential sector was made in two aspects: the private households and the story buildings or communities. For this research however, we consider the residential sector as a whole since specific entry probability values for each subcategory were not directly found in literature.

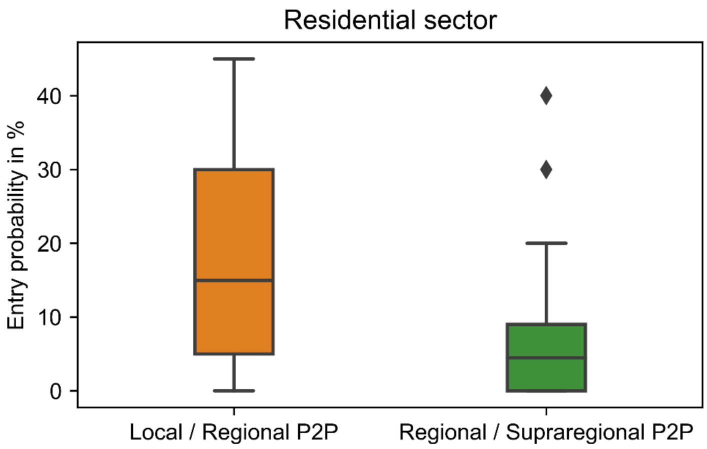
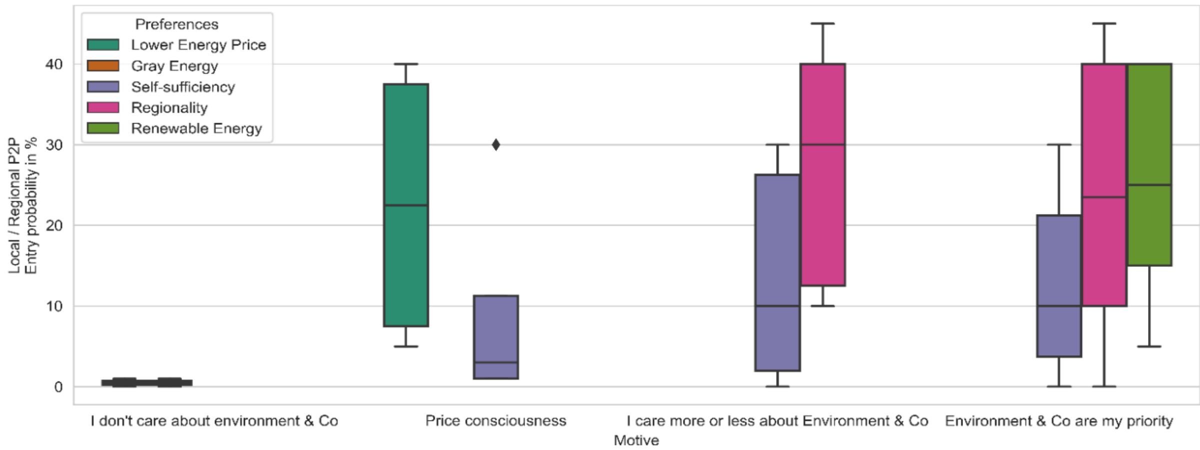
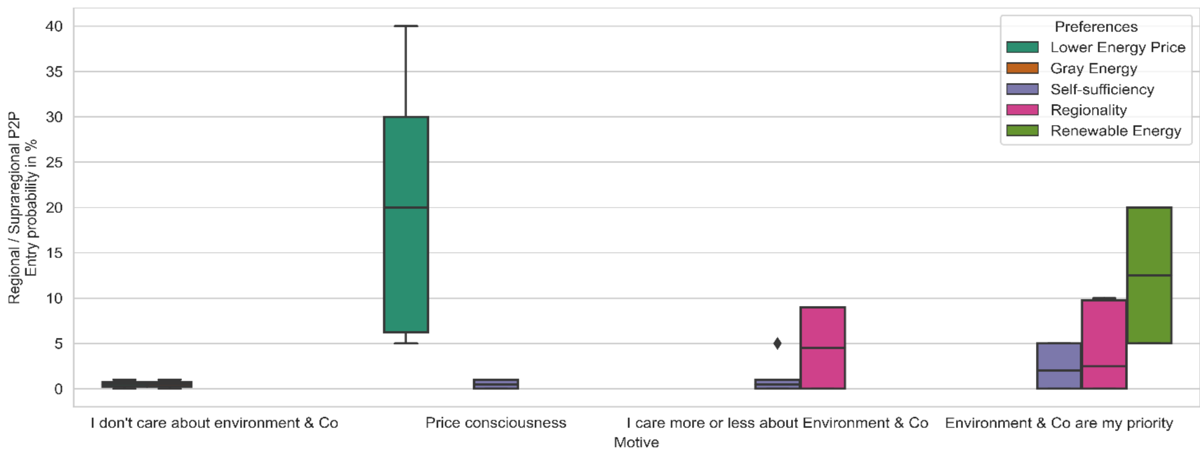


Figure 3: Overview of P2P entry probability in the residential sector



(a)



(b)

Figure 4: P2P entry probability in function of motive and preferences in the residential sector

It can be inferred from Figure 3 that the mean entry probability into local / regional P2P is of around 18%, and has an interquartile range (IQR) of 5 – 30% being the maximum entry probability of about 45%. In contrast, for regional / supraregional concepts the mean entry probability is reduced by a factor three, the IQR has bandwidth of 4.5 – 9% and with a maximum entry probability of 40%.

Figure 4a and 4b show the entry probability for both P2P concepts in function of the motives and preferences respectively. Participants who have the preferences of lower energy prices, regionality and renewable energy have higher willingness to participate in local P2P concepts, with an average value of 25%. The maximum value of entry probability is 40% for the prosumers with preferences of regionality and renewable energy. The participants with a preference for self-sufficiency are in general less willing to participate in P2P-ET with an average value of about 5%. For supraregional concepts the entry probability is much lower, showing an average value of 10%. Participants that has a preference of lower energy price may have a higher willingness to entry P2P-ET with a mean value of 20 %. Interest in renewable energy provide willingness to participate of 10% in average.

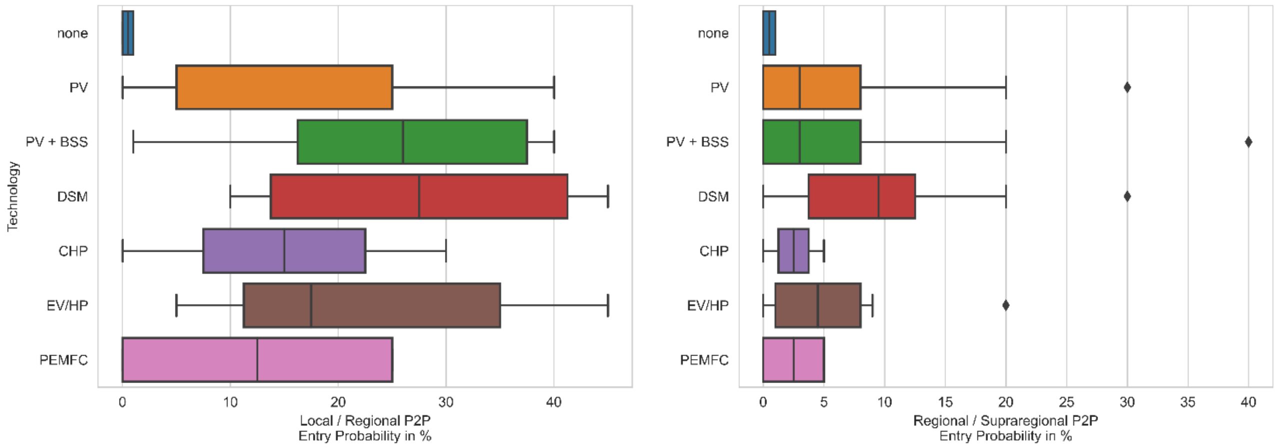


Figure 5: P2P entry probability in function of employed technologies in the residential sector

Figure 5 shows the P2P entry probability for each technology preferred by participants. In general DSM measures along with PV rooftop combined with a BSS have the highest probabilities of participation into P2P. For local / regional concepts these are represented by roughly 25% in average, as for regional / supraregional concepts the mean value is of 5 to 10 %. Consumers with any technology have in general more willingness to enter P2P compared to the prosumers. For regional / supraregional concepts the higher willingness to participate is for consumers who employ DSM measures, being in average of about 10%.

3.2. Tertiary sector – CTS

Studies that provide indications of the entry probability into P2P for the tertiary sector were not found and is also considered as one of the research gaps in the topic. The entry probability for this sector was therefore, derived from the ones of the residential sector.

Figure 6 shows that the mean entry probability into local / regional P2P is of 15%, and has an IQR of 5 – 30% being the maximum entry probability of about 45%. For regional / supraregional concepts the mean entry probability is reduced to a mean value of approximately 5%, the IQR has bandwidth of 0 – 9% and with a maximum entry probability of 40%.

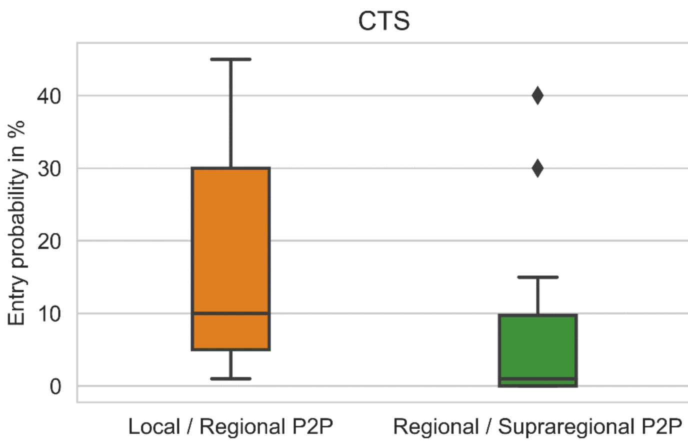
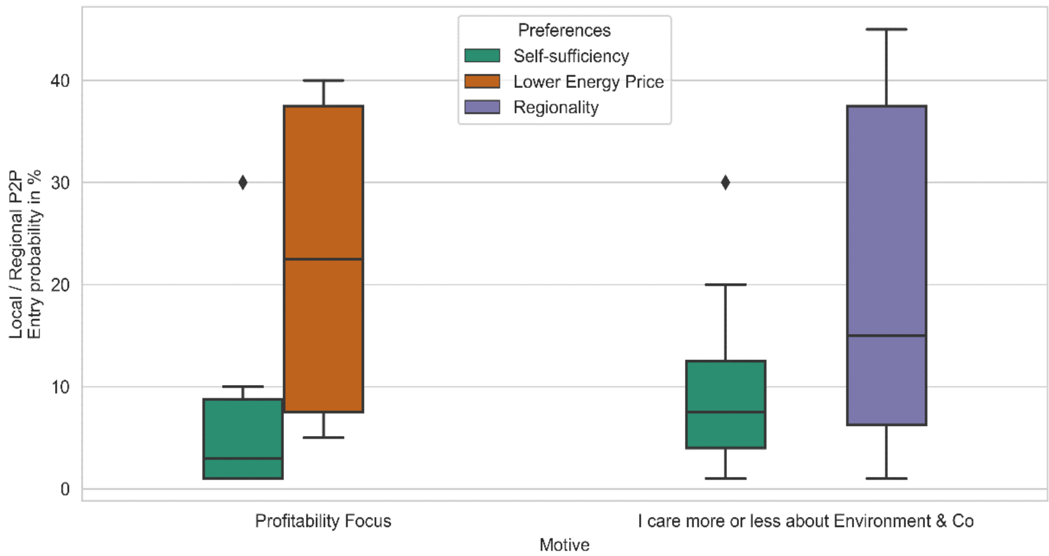
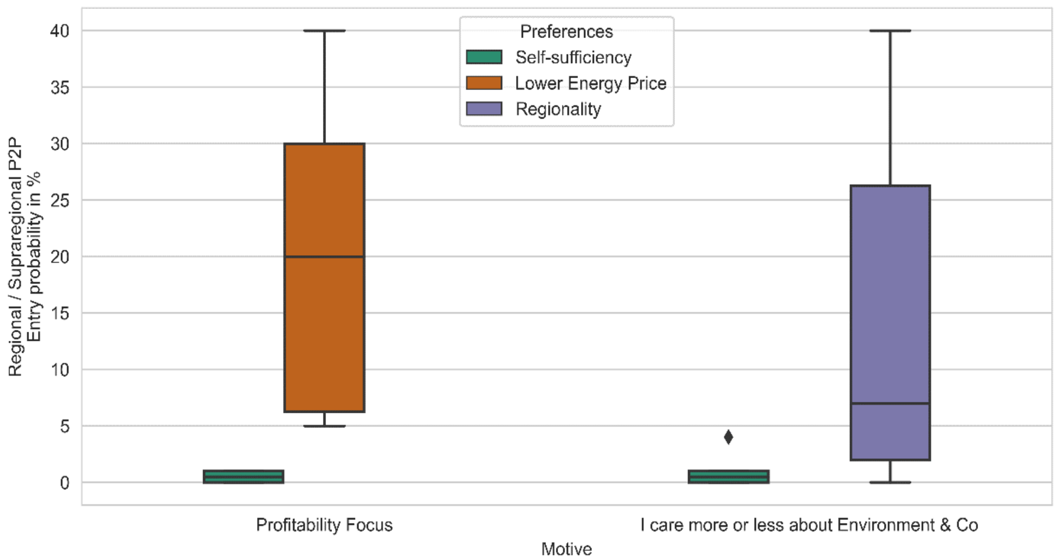


Figure 6: Overview of P2P entry probability in the CTS sector



(a)



(b)

Figure 7: P2P entry probability in function of motive and preferences in the CTS sector

Figure 7a and 7b show the entry probability for both P2P concepts in function of the motives and preferences. For the CTS sector, a reduced number of motives and preferences are considered when compared to the residential sector. Participants who have the preferences of lower energy price and regionality are more willing to participate in local P2P concepts, with an average value of 20%; the maximum value of entry probability is of roughly 45%. For supraregional concepts the entry probability is lower, showing an average value of 10% and maximum of also 40%. Participants that has a preference of lower energy price may have in general a higher willingness to entry into P2P with a mean value of 20 % in comparison of those who prefer regionality.

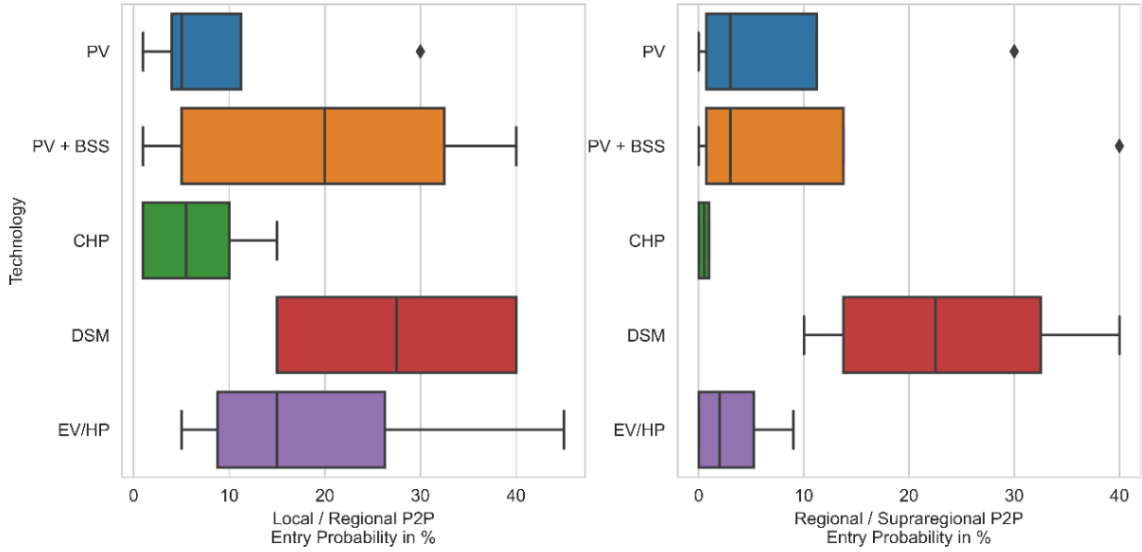


Figure 8: P2P entry probability in function of employed technologies in the CTS sector

Figure 8 shows the P2P entry probability in function of the participant's preferred technology. In general participants employing DSM measures have the highest participation probabilities. For both P2P concepts these are represented by roughly 25% in average. Prosumers who have PV combined with BSS have also a significant entry probability of 20 % for local / regional P2P. For regional / supraregional concepts the higher willingness to participate is for the same prosumers with in average of about 10%.

3.3. Industry sector – SMEs

Just like in the CTS sector, studies that provide indications of the entry probability into P2P for the industry sector were not found and further research in this topic is needed. The entry probability for this sector is therefore, closely related to the one of the CTS sector, having as a main difference that the motive which interests the industry sector is solely the focus on the profitability, i.e., return of investment.

Figure 9 shows that the mean entry probability into local / regional P2P is of 15% with an IQR of 5 – 30% being the maximum entry probability of about 40%. For regional / supraregional concepts the mean entry probability is reduced slightly to a mean value of approximately 9%, the IQR has bandwidth of 0 – 9% and a maximum entry probability of also 40%.

Figure 10a and 10b show the entry probability for both P2P concepts in function of the motives and preferences in the industry sector. Participants who have the preferences of lower energy price are more willing to participate in P2P concepts, with an average value of 20%; the maximum value of entry probability is of 40%. In contrast, the entry probability for participants with a preference for self-sufficiency is low with a mean value of 5% for local / regional P2P and 0% for regional / supraregional concepts.

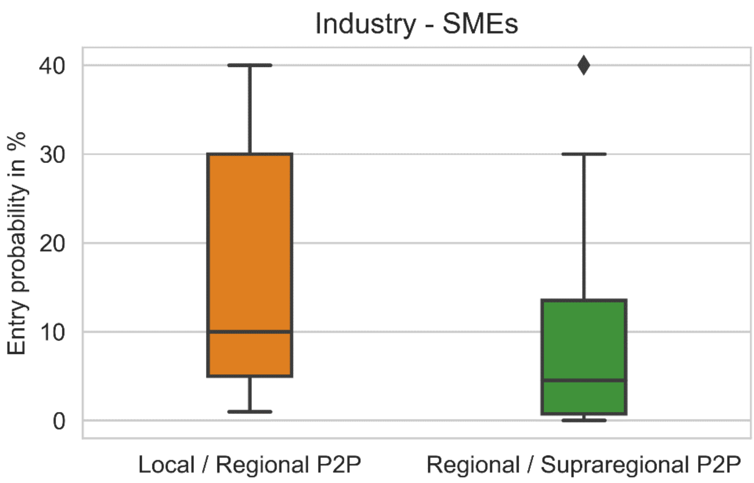


Figure 9: Overview of P2P entry probability in the industry sector

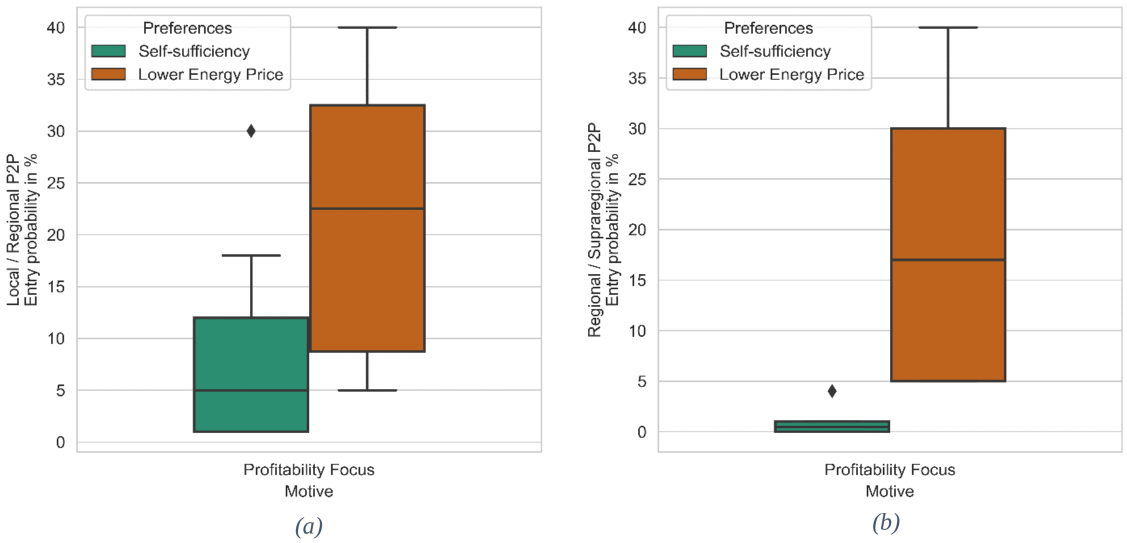


Figure 10: P2P entry probability in function of motive and preferences in the industry sector

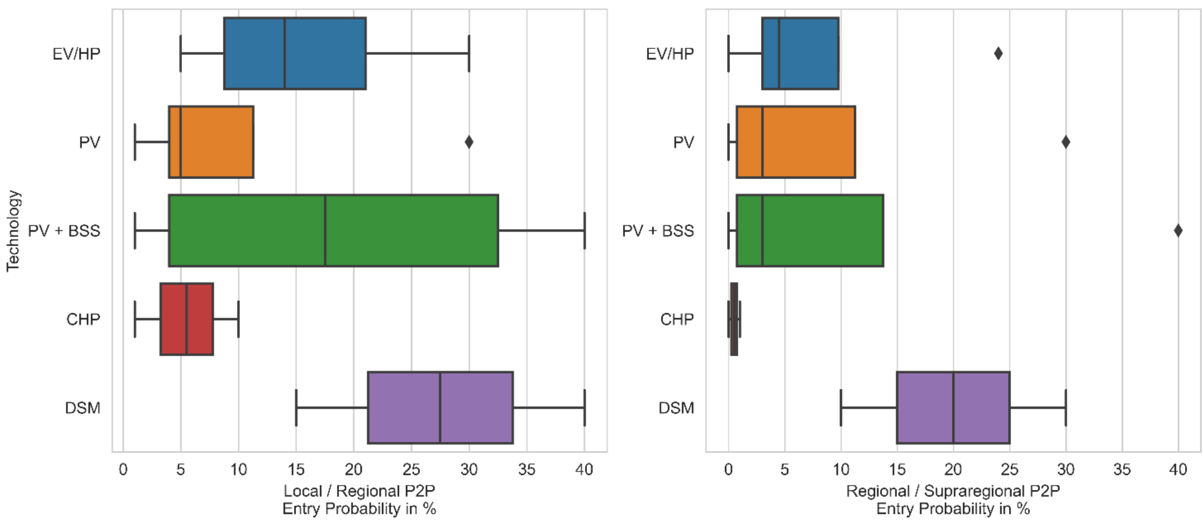


Figure 11: P2P entry probability in function of employed technologies in the industry sector

Figure 11 shows the P2P entry probability in function of the participant's preferred technology. In general participants using DSM measures present the highest probabilities of participation into P2P. For local / regional P2P this is represented by an average of 25% and for regional / supraregional P2P by an average of 20%. Prosumers owning a PV combined with BSS have an entry probability for local / regional P2P of an average of 15%. The same type of prosumers has an average entry probability for regional / supraregional P2P of 5%.

4. Outlook and future work. Modelling focus

Game theory, which can be divided in cooperative and non-cooperative games, has been widely employed for modelling P2P-ET schemes, as it has advantages for modelling the user's behaviour and can also be combined other data processing techniques, such as Internet of Things and machine learning algorithms. Paper [24] presents an overview of game theory applied to the energy domain. Another approach for P2P modelling is the agent-based modelling methods, which simulate simultaneous operations and transactions between multiple agents with the intention to recreate and explain the complexity of the energy system [16]. The agents can be either individual or collective entities such as organizations or groups. It suits specially the P2P network modelling as in these schemes, several individuals with different preferences meet at a virtual layer. A method which has been also used for modelling physical constraints in a P2P network is the optimal power flow (OPF). These method can also be combined with tariff schemes for situations when a prosumer or consumer violates a technical constraint in the grid like in [13]. Related as well with penalty schemes for the distribution grid use, the price mechanism plays a vital role in P2P-ET network. As stated in [3], the price mechanism is one of the main components when designing a LEM. [7] provides examples of different pricing mechanisms such as, time of use tariffs, real time pricing or critical peak pricing, which are being used also around the world. Dynamic pricing mechanisms can provide incentives to consumers for shifting demand into times of higher renewable energy production and this again promotes the participation into P2P-ET. Last but not least, the development of consistent scenarios that can be represented at the same time in energy system model tools, is crucial for achieving better results in simulation and optimisation tools. Cross Impact Balance (CIB) analysis provides methodology that can build consistent scenarios based on qualitative, quantitative factors that surrounds a determined topic [25]. This method can then produce consistent scenarios for P2P-ET, which involve the combination of social, technical, economic and political external factors with its individual development options in the future.

5. Discussion of results

The studies assessed for this research differ strongly from the methodologies employed and also from the demographics of the evaluated sample size in the surveys, particularly in studies [14, 17, 18], the sample sizes are biased as they do not represent the general population of the country. Moreover, the summary of studies provides both quantitative and qualitative results which are difficult to interpret into an absolute P2P participation probability. Studies [15, 19] provide values of willingness to pay for P2P electricity in form of a surplus price that a participant would probably pay for different virtual scenarios such as: neutral, autonomy and autarky. Related to the previous papers, [21] established the willingness to participate in a LEM considering the possible increase or decrease of the monthly electricity bill of a participant based on several trading scenarios. For the previous studies exposed, assessing a real P2P participation probability was not possible, taking the assumption of just a 1 – 5% entry probability into a P2P market. Insights of a favourite agent to supervise or manage the P2P trading is deduced from the reviewed papers. The surveyed expressed in general a strong inclination for municipalities and energy utility companies as the preferred agents to oversee the LEM.

The preferred technologies from participants differ quite significantly as well, being Photovoltaic (PV) rooftop systems, BSS and smart technology the most common ones. Smart technology can be defined as energy management systems that can provide load shifting, peak shaving, i.e., demand side management (DSM) measures. Combined heat and power (CHP) units, heat pumps and wind turbines are barely considered as preferred technologies in the reviewed literature. Although PEMFC was considered in this study, this technology lack of economies of scale and it is related with high investment costs ranging from 4600 – 10000 $/kW, the same applies for micro CHP with 3000 $/kW [26]. Moreover, with the ultimate development of the fossil fuel prices, gas fired CHP may present a less attractive option for any participant and must be considered in a separate study.

P2P-ET can have the potential to contribute to the solution of the issues like: green energy certificate of origin, regional energy certificate, avoidance of construction of power distribution and transmission structures, regional supply of electricity, transparency in electricity price. Nevertheless, is also usually related to social aspects that need to be overpassed in order to achieve a higher market dissemination. Some of these social aspects may be: privacy issues, i.e., participants that do not want to exchange personal data, such as consuming behaviour, social welfare or community welfare, not in my backyard (NIMBY) problem, environmental consciousness, social acceptance of modern ICT, coverage expenses from metering infrastructure migration (from old meters to modern or smart metering). Among the mentioned social aspects, there also exist legal barriers to be handled, such as political incentives strategies for promoting RES, relief of electricity taxes, relaxation of grid fees in electricity bills to encourage local or regional consumption, suitable pricing mechanism for P2P electricity.

6. Conclusions

The present research presents an overview of possible scalable P2P market structures, a methodology that defines entry probability to P2P-ET based on the participants motives, preferences, role in the market and technology employed for consumption or production of energy and outlook and future work on the topic regarding modelling of energy systems.

Although we proposed two scalable P2P concepts, these markets are by nature limited to a local geographical area, at most to a regional zone. It must be highlighted that the actual configuration of the distribution grid must be thoroughly considered in order to correctly apply compensation schemes for use of distribution grids or eventually penalty schemes for peers that violate technical constraints, e.g., distance constraints, voltage constraints, thermal overload in lines or economical constraints, like overpricing of P2P electricity. It is proven that P2P-ET has benefits such as reduction of electricity bills, social welfare and can even impact the distribution grid expansion costs as demand and generation can be balanced in a local or regional area by energy communities. However, country-wide P2P is strongly related to grid allocation costs and heavy use of network therefore, not providing a relief on the distribution and transmission grid. The geographical extent should be carefully defined and analysed to evaluate whether P2P really has a positive contribution in grid decongestion and on grid expansion costs.

The presence of an intermediary or an additional agent seems to be unavoidable in a renewable-only P2P electricity market, due to the intermittency of RES and other technical factors such as secure use of the grid, congestion management and market clearing mechanism, e.g., merit-order and re-dispatch measures. In modern market models, it has been already established the presence of few actors and by which companies or third parties can be these roles acquired. To mention a few: TSOs, DSOs, BRPs, energy utility companies, municipalities, and technological companies, such as Tesla or Siemens, are just examples of groups who could provide agents that perform the supervising role of a P2P trading scheme.

In relation to the prosumer clustering, the entry probabilities derived from the literature review were evaluated carefully as the methodologies differ intensely. Moreover, the results show strong bias in relation to demographics of the countries where the surveys were concluded. In general, for each established probability a +/- 20% uncertainty factor is to be considered. Some of the results were derived from demonstrator results report, which may have provided economic incentives to participants, such as: adjusted grid-use tariffs, free technology installation or monetary reward in general. Furthermore, studies which assess the willingness to participate in P2P for the energy sectors CTS and industry were not found. A research gap evaluating specifically these two sectors and the possible technologies for participating into P2P-ET was identified within this study. In general, it can be concluded that the entry probability for local /regional P2P is higher than for supraregional P2P. Consumers show in general more willingness to enter P2P markets than prosumers, however, prosumers with PV and BSS have the higher willingness to enter P2P as the flexibility provided by BSS promotes participation in P2P.

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Annex A1. Table of prosumer clustering

End-use energy sector	Motive	Preferences	Role	Technology	Justification	Local / Regional	Regional / Supraregional
Residential Sector - Private Households	I don't care about the Environment &	Lower Energy Price	Consumer	none	just when P2P energy price lower than conventional price	<1%	<1%
		Gray Energy	Consumer	none	no interest at the end	<1%	<1%
	Money saving/Price consciousness	Self-sufficiency	Prosumer	PV-Rooftop	low willingness for P2P	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	high willingness if selling price is higher	1 - 30%	<1%
		Lower Energy Price	Consumer	DSM	just when P2P energy price lower than conventional price	15 - 40%	10 - 30%
			Prosumer	PV-Rooftop	only when higher revuenue is achieved	5 - 30%	5 - 30%
			Prosumer	PV-Rooftop + BSS	only when higher revuenue is achieved	5 - 40%	5 - 40%
	I care more or less about Environment & Co.	Self-sufficiency	Prosumer	PV-Rooftop	low willingness for P2P	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	low willingness for P2P	15 - 30%	<1%
		Regionality	Consumer	DSM	higher willingness for P2P	10 - 45%	<10%
			Prosumer	PV-Rooftop	higher willingness for P2P	10 - 40%	<10%
			Prosumer	PV-Rooftop + BSS	higher willingness for P2P	20 - 40%	<10%
	Environment & Co. are priority	Renewable energy	Consumer	DSM	high willingness for P2P	15 - 40%	5 - 20%
			Consumer	EV/HP	Just if energy source is 100% green	15 - 40%	5 - 20%
			Prosumer	PV-Rooftop	high willingness for P2P	5 - 30%	5 - 20%
			Prosumer	PV-Rooftop + BSS	high willingness for P2P	20 - 40%	5 - 20%
		Self-sufficiency	Consumer	EV/HP	If energy is 100% green and self-produce	5 - 20%	<5%
			Prosumer	PV-Rooftop	low willingness for P2P	0 - 5%	<5%
			Prosumer	PV-Rooftop + BSS	low willingness for P2P	15 - 30%	<5%
			Prosumer	PEMFC	low willingness for P2P	0 - 25%	<5%
		Regionality	Consumer	DSM	higher willingness for P2P	10 - 45%	<10%
			Consumer	EV/HP	higher willingness for P2P	10 - 45%	<10%
			Prosumer	PV-Rooftop	higher willingness for P2P	10 - 40%	<10%
			Prosumer	PV-Rooftop + BSS	higher willingness for P2P	22 - 40%	<10%
			Prosumer	PEMFC	higher willingness for P2P	0 - 25%	<5%
Residential Sector - Story Buildings, communities	I don't care about the Environment &	Lower Energy Price	Consumer	none	just when P2P energy price lower than conventional price	<1%	<1%
		Gray Energy	Consumer	none	no interest at the end	<1%	<1%
	Money saving/Price consciousness	Self-sufficiency	Prosumer	PV-Rooftop	low willingness for P2P	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	high willingness if selling price is higher	1 - 30%	<1%
		Lower Energy Price	Consumer	DSM	just when P2P energy price lower than conventional price	15 - 40%	10 - 30%
			Prosumer	PV-Rooftop	only when higher revuenue is achieved	5 - 30%	5 - 30%
			Prosumer	PV-Rooftop + BSS	only when higher revuenue is achieved	5 - 40%	5 - 40%
	I care more or less about Environment & Co.	Self-sufficiency	Prosumer	PV-Rooftop	low willingness for P2P	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	low willingness for P2P	10 - 30%	<1%
		Regionality	Consumer	DSM	higher willingness for P2P	10 - 45%	<10%
			Prosumer	PV-Rooftop	higher willingness for P2P	10 - 40%	<10%
			Prosumer	PV-Rooftop + BSS	higher willingness for P2P	10 - 40%	<10%
	Environment & Co. are priority	Renewable energy	Consumer	DSM	high willingness for P2P	15 - 40%	5 - 20%
			Consumer	EV + HP	Just if energy source is 100% green	15 - 40%	5 - 20%
			Prosumer	PV-Rooftop	high willingness for P2P	5 - 30%	5 - 20%
			Prosumer	PV-Rooftop + BSS	high willingness for P2P	5 - 40%	5 - 20%
		Self-sufficiency	Consumer	EV/HP	If energy is 100% green and self-produce	5 - 20%	<5%
			Prosumer	PV-Rooftop	low willingness for P2P	0 - 5%	<5%
			Prosumer	PV-Rooftop + BSS	low willingness for P2P	0 - 40%	<5%
			Prosumer	PEMFC	low willingness for P2P	0 - 25%	<5%
		Regionality	Consumer	DSM	higher willingness for P2P	10 - 45%	<10%
			Consumer	EV/HP	higher willingness for P2P	10 - 45%	<10%
			Prosumer	PV-Rooftop	higher willingness for P2P	10 - 40%	<10%
			Prosumer	PV-Rooftop + BSS	higher willingness for P2P	10 - 40%	<10%
			Prosumer	PEMFC	higher willingness for P2P	0 - 25%	<5%

End-use energy sector	Motive	Preferences	Role	Technology	Justification	Local / Regional	Regional / Supraregional
Tertiary Sector - Commerce, Trade & Services	Focus on Profitability	Self-sufficiency	Prosumer	PV-Rooftop	low willingness for P2P	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	high willingness if selling price is higher	1 - 30%	<1%
			Prosumer	CHP	high willingness if selling price is higher	1 - 10%	<1%
		Lower Energy Price	Consumer	DSM	just when P2P energy price lower than conventional price	15 - 40%	10 - 30%
			Prosumer	PV-Rooftop	only when higher revuenue is achieved	5 - 30%	5 - 30%
			Prosumer	PV-Rooftop + BSS	only when higher revuenue is achieved	5 - 40%	5 - 40%
	I care more or less about Environment & Co.	Self-sufficiency	Consumer	EV/HP	If energy is 100% green and self-produce	5 - 20%	<5%
			Prosumer	PV-Rooftop	low willingness for P2P	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	low willingness for P2P	10 - 30%	<1%
			Prosumer	CHP	low willingness for P2P	1 - 10%	<1%
		Regionality	Consumer	DSM	just when P2P energy price lower than conventional price	15 - 40%	10 - 30%
			Consumer	EV/HP	higher willingness for P2P	10 - 45%	<10%
			Prosumer	PV-Rooftop	only when higher revuenue is achieved	5 - 30%	5 - 30%
			Prosumer	PV-Rooftop + BSS	only when higher revuenue is achieved	5 - 40%	5 - 40%
			Prosumer	CHP	low willingness for P2P	1 - 10%	<1%
Industry Sector - SMEs	Focus on Profitability	Self-sufficiency	Consumer	EV/HP	If energy is 100% green and self-produce	5 - 20%	<5%
			Prosumer	PV-Rooftop	Focus on best ROI	1 - 5%	<1%
			Prosumer	PV-Rooftop + BSS	Focus on best ROI	1 - 30%	<1%
			Prosumer	CHP	Focus on best ROI	1 - 10%	<1%
		Lower Energy Price	Consumer	DSM	Focus on best ROI	15 - 40%	10 - 30%
			Prosumer	PV-Rooftop	Focus on best ROI	5 - 30%	5 - 30%
			Prosumer	PV-Rooftop + BSS	Focus on best ROI	5 - 40%	5 - 40%

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