D8.12 Lessons learnt to draw business models in use case #4
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EXECUTIVE SUMMARY

Small-scale distributed production becomes increasingly common in many parts of the globe. This creates a new situation for the power grids which they are not optimized for, neither the controlling strategies, pricing and more. To rebuild and reinforce the grid in a way that would manage this new situation would be costly for the DSOs. For this deliverable, E.ON is using small-scale local production to simulate a Peer-2-Peer (P2P) energy market were E.ON would act as a service provider for the local energy system. The main focuses of this report are given below.

Managed in the correct way, a P2P market could be a win-win relation between P2P market providers and homeowners becoming members in the Peer2Peer market. Until such an equilibrium is found, DSOs must be compensated as the service enabler. To provide a realistic and scalable trading strategy for the P2P market were mainly two methods tested to produce the P2P markets trading zones. Both methods were base occurring grid topology and geographic. A variety of tariffs were also looked at for the P2P market that today uses tariffs from that area but adapted for this new market. The trading logics of the P2P market are in line with both national and company bylaws.

From the customer perspective could trade through a P2P market have several benefits, for example the feeling of togetherness within the neighbourhood that the P2P market provide. The P2P market distributes the excess energy from the prosumers among Simris consumers. During periods with high power output compared to usage, relative few suppliers can provide substantial amount of the total energy need. The energy is distributed according to a combined strategy using geographical, and grid topological, boundaries as input parameters. The strategies of power distribution should to some extent be evaluated based on local conditions. It is argued that power traded within the P2P market would not be influenced by taxation as power is traded within the P2P community, the savings distributed among the participants. The benefits would however not be evenly distributed as prosumers within the market would generally receive the biggest gains, naturally depending on available power and the regional electricity price.

To make Citizen Energy Communities (CECs) a more appealing option would require a combined understanding between parties on a series of questions such as legislation, taxation, tariffs, power distribution and more. To clarify what are required by CECs is believed to be key to increase the number, as well as having informed and interested residents.

Regulation needs to propose alternative solutions to change the CAPEX-based remuneration in the future. If more weighted to the OPEX of the DSO, the DSO could provide more adapted and better services (i.e. flexibility issues).

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1. INTRODUCTION

1.1. Scope of the document

The aim of this deliverable report is to examine the impact of a Peer2Peer platform, how this type of platform could work by enabling the active participation of customers in a local energy market. By developing this platform could the importance and influence of several parameters be explored to develop a realistic and well-functioning market, such as power distribution and P2P-member prioritization. Another key element is tariffs, how they should look to create a fair and attractive market for all parties. Testing and twisting the market model lead to some findings of what is important to create a scalable and well-functioning platform, these are presented throughout the deliverable.

1.2. Notations, abbreviations and acronyms

The table below provides an overview of the notations, abbreviations and acronyms used in this report.

Table 1-1 - List of notations, abbreviations and accronyms

B2C	Business to Consumer
CDC	Codes on Demand Connection
CEC	Citizens Energy Communities
EV	Electrical Vehicle
EMS	Energy Management System
DER	Distributed Energy Resources
DES	Distributed Energy System
DSO	Distribution System Operator
DSR	Demand Side Response
DG	Distributed Generation
LEC	Local Energy Communities
LES	Local Energy System
NPS	Net Promotor Score
RES	Renewable Energy Sources
RfG	Requirements for Generators
TSO	Transmission System Operator
V2G	Vehicle-to-grid
P2P	Peer-2-Peer
HEMS	Home Energy Management System

2. DESCRIPTION OF USE CASE

This use case aims at demonstrating a business model for a P2P market and examine to understand the impact of a P2P platform in enabling the active participation of customers in a local energy market.

This use case focuses the entire village of Simris were the 140 residential households makes up the market, thus representing buyers and sellers in the Peer2Peer market. Residential PV assets are the source of Peer2Peer generation which are the potential sellers in the market. The buyers are all households with a net power input for a given period. Several aspects most be considered to create a functioning and unbiassed market. Aspects as how sellers and buyers should interact and be prioritised within the market, different tariff constructions to investigate current market rules and legislations. Also, challenge these to find new potential improvements for future Peer2Peer markets.

3. BACKGROUND

3.1. Market

The Swedish energy market and market players, especially the DSO's, are currently limited by constraints within CEC and flexibility services, e.g. congestion management, curtailment, peak shaving, with only some local and limited services available today. At the same time there is an increasing need for flexibility services and introduction of a new market for energy communities.

The Clean Energy Package (CEP) and similar EU energy directives influences national standards for the use of flexibilities. On the 29th of November, The Swedish Energy Inspectorate will present the result from the ongoing inquiry how the Clean Energy Package will be implemented in Swedish law. Expectations are that it will be mandatory in future grid planning to take into consideration the flexibility service as an alternative to today's traditional grid investments and hereby also CEC.

The EU Network Codes, for example the Network Codes on Demand Connection (DDC) and Requirements for Generators (RfG), stipulate different criteria connecting to the grid. The standardization and demand for more data will increase the possibility to use different flexibility sources.

In a near future, plans are to modify current situation regarding flexibility units as a provider of network services. In Sweden the need for grid capacity has increased dramatically due to the political goal of 100 percent renewable production by year 2040, but also due to new electricity intensive industry (for example data centers), electrical vehicles and urbanization. Already today, capacity restraints in the transmission grid are a fact. This will take many years to solve with traditional grid investments. Thereby, the regulator has changed the revenue cap model to give the DSOs an incentive to use more flexibility services.

Regarding financial compensation for congestion management: When the subscription to overlaying grid (TSO) cannot be raised, the costs are regarded as "pass through" in the next regulatory period 2020-2023. The regulation constitutes a risk because it is today unclear what the regulator will regard as reasonable remuneration. Today national legislation is not clear on the possibility for the DSO using flexibility for a more efficient use of the grid. Today's revenue regulation incentivizes building grid before using "local services".

The CEC is considered as one of the tools that incentivizes a wider penetration of DER on residential level and as a part of the mitigation of the overall market hurdles discussed above. A P2P market will be added to the current market, adding complexity that has to be managed.

3.2. Customer perspective

The “old traditional” electricity market customer is a pure consumer of energy. This view of a customer (both from outside and from the introvert perspective) is changing to a new type of customer who is willing to be a part of a community and wants to be more active in the energy domain. This new persona of a customer can participate as a vital part in the flexibility market as prosumers and P2P contributor in a CEC.

As developing a LES in Simris, all households were given a possibility to participate and take an active role within the energy community. Deals on subsidised steerable assets were presented. All 140 households in Simris are included by the LES but for those who chose to actively participate in the project does the LES more or less resembles a CEC, where voluntarily participation by citizens within the community with a renewable energy project. Surveys done among Simris residents clearly shows a positive trend of customer engagement. 20 households in Simris are active participants with 9 of them have installed PV. When these households produce a surplus of electricity are they considered as a seller by the Peer2Peer market. If they do not produce a surplus are they considered a buyer along with all households without PV.

Customer behaviour have changed in a positive way in terms of level interest, active engagement and customer satisfaction along the project. This is clearly measured in the both response frequency and result of customer questionnaires where we see an increase of NPS by 11. However, there are still difficulties in engaging customers to be active and invest private funds in a DER and DSR assets to the level needed.

3.3. DSO perspective

Swedish DSOs today have access to the flexibility units, both generation and consumption profiles. The DSO own the meter in the connection point and have access meter data with different time resolution and thereby the ability to create generation/consumption profiles for grid operation purposes such as optimize and fine tune the delivery and the potential to buy in to flexibility services.

In Use Case 4, the DSO uses bilateral contracts for production and consumption steering, but in a near future there will be aggregators to intermediate the flexibility service. These contracts are stipulated only on civil law agreements.

Distributed Generation (DG) units produce energy that will be used to cover a certain demand from different consumers in the electric power system. This energy may be sold according to the local regulation. Energy storage in the form of batteries connected to the grid or EVs with V2G (Vehicle to Grid) capability can also buy and sell energy at different time periods in a new way. Modified regulations enables P2P as a new market tool and with it facilitators for such a service, these could for example be DSOs, energy trading companies or new players.

The so-called wholesale market includes the balancing market. Today, only Balance Responsible Parties (BRPs) can participate in the Swedish balancing markets. A new role, Balance Service Provider (BSP), will be introduced at the turn of the year 2019/2020, at the earliest. The balance services provider will subsequently be responsible for submitting bids to Svenska Kraftnät (the Swedish TSO). Nevertheless, there are today ongoing pilots (pilot projects) in different areas in Sweden to establish local markets for flexibility and other ancillary services.

According to the Swedish legislation (Energy Act), power outage is allowed for a duration of maximum 24 hours. There are also additional regulations for power outage above 2 MW with more strict demands on restoration time for power interruptions/outages. In order to facilitate for flexibility service there has been a proposal to remove the additional regulation. The Energy Act has priority over civil law and thereby limits the agreements that can be made with flexibility providers.

Given the above and the general role of the DSO would it be likely that the DSO would be a mail stakeholder as P2P markets are introduced to their grid. Believes are that customers in a CEC will most likely not acquire the local grid to establish a P2P market, and a P2P market should be able to co-exist naturally within the grid topology as a financial tariff driven market.

4. APPROACH

4.1. Development

4.1.1. Market

Initiatives from the DSO are required. The DSOs are clearly enablers who can build and develop this market. However, today the DSO is not allowed to sell electricity to the market, only use the storage in case of power outages. This means that new functionality must be undertaken by other actors than DSO's in the market, for example operators of storage facilities in the grid.

Operators are most likely to be organized within the following roles:

- Aggregators
- Industrial consumers
- Local Energy Communities (LES), or Citizens Energy Communities (CEC)
- Power producers

Members of LECs or CECs must be able to sell their aggregated flexibilities, under regulated conditions in the wholesale market, through contracts with suppliers or aggregators, through a P2P market.

The approach in Simris has been to launch a tool for the active customers, where they are able to analyse the level of autarky and origin of electrical energy.

The approach taken to create the mechanisms of the market is multi-perspective by the following:

- P2P prosumers (contributors) and consumers (users)
- Resolution of measurements
- P2P domain strategy
- Network structure

- Tariff constructions

P2P prosumers and consumers

The P2P members exists of two basic personas:

1. Prosumers
   The prosumers contributing by selling their energy surplus electricity in the P2P market.
2. Consumers
   The consumers are accessing the peer and buying the energy surplus from the prosumers available in the P2P market.

These personas can change during time between each measurement, i.e. a prosumer can switch between being a consumer and a contributor depending on current surplus or shortage of energy.

For the sake of creating a logical market model, the contributors chosen are PV owners and their battery or any other consequence of activation of DSR equipment are taken out of the equation in terms of optimisation for P2P purposes, however the DSR's are affecting the result from executing the islanding control strategies. This fits the trend of the residential customers of Sweden being more willing to invest in PVs prior to other equipment. The PV market in Sweden is currently increasing, hence the focus on PV owners in terms of contributors (prosumers).

Resolution of measurements

To test the market behaviour, three different intervals of measurements for measure production and consumption (i.e. the joint state of prosumers and consumers). These intervals are set, to as shown below, in accordance to the Swedish Energy Markets Inspectorate requirements of future electricity meters[1]:

- <u>2-minute intervals</u>
  2 minutes interval is chosen from requirement #4 of the 2025 metering requirements proposed by EU and adopted by the Swedish regulator body. Requirement #4 states that 2 minutes is the maximum duration of individual polls of meter data from a single meter

- <u>15-minute intervals</u>
  15 minutes interval is chosen from requirement #5 of the 2025 metering requirements proposed by EU and adopted by the Swedish regulator body. Requirement #4 states that 15 minutes is the highest resolution of meter data to collect

- <u>60-minute intervals</u>
  60 minutes interval is chosen from requirement #5 of the 2025 metering requirements proposed by EU and adopted by the Swedish regulator body. Requirement #4 states that 60 minutes is the lowest resolution of meter data to collect

1) *Energimarknadsinspektionen*
   https://www.ei.se/Documents/Publikationer/rapporter_och_pm/Rapporter%202015/Ei_R2015_09.pdf

P2P domain strategy

P2P domain strategy is the approach to include and limit customers possibilities as members in a P2P-market. This has two clear dimensions

1. By choice
   By choice is simply giving all eligible customers the opportunity to in an easy way enrol or opt out as members in the P2P market. From results of prior analysis in the project a customer is more willing to participate when activeness is easy and painless. This approach solved this partly by letting the customer enrol and opt out with very few limitations, by both functions and requirements for time of membership.

   See Figure 4-1 - Enrolment process and Figure 4-2 - Opt out process below.

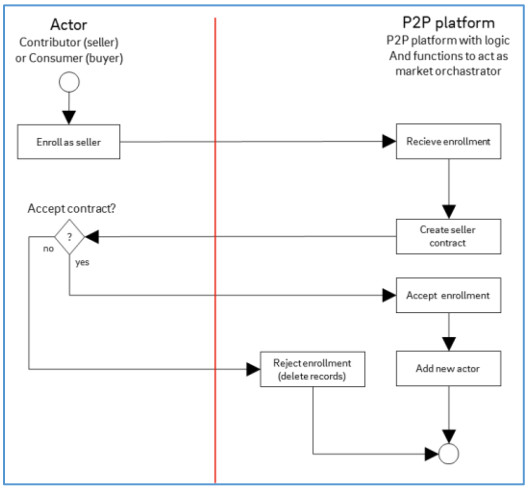


Figure 4-1 - Enrolment process

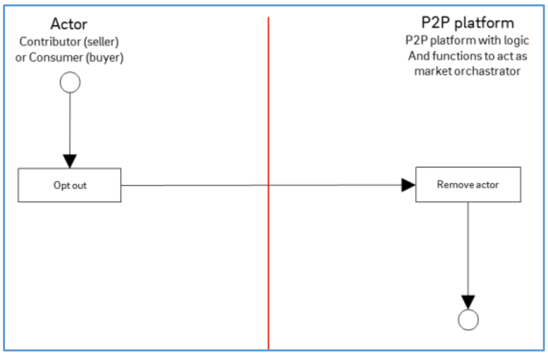


Figure 4-2 - Opt out process

2. By location
   By location means that the point of delivery (i.e. meter location) is a constraint for involvement as member in the market. Two different models can be considered:

   a. Location by geographical range
   b. Location by grid topology

Location by geographical range

Location by geographical range is to enable a P2P market relationship by distance between points of delivery where distance is measured within an area of a circle with the radius [x] from the so-called base point. This can be done in several way or rather from different perspectives

- Equal focus
  When a P2P area is created by a circle from every actor, seller or buyer, as the centre point of the area/circle

- Buyer focus

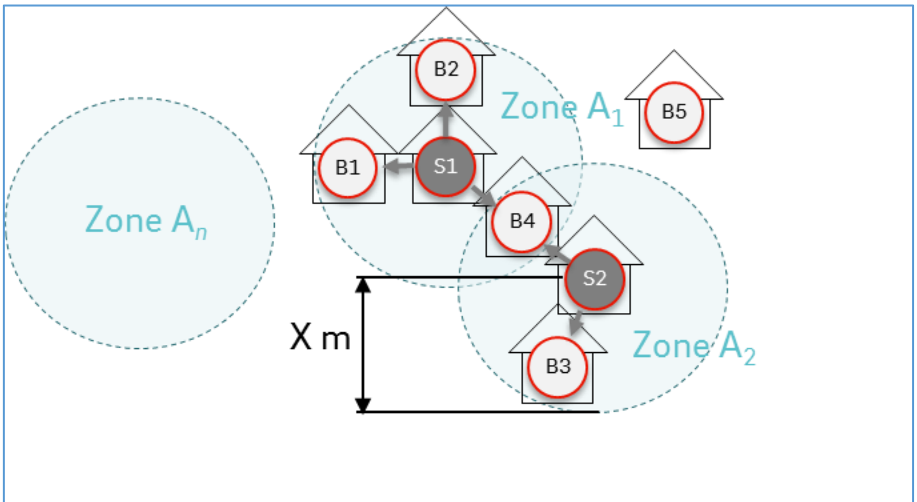
  This focuses on the buyers. Each P2P area is created by a circle from every buyer as the centre point of the area/circle

- Seller focus

  This focuses on the sellers. Each P2P area is created by a circle from every seller as the centre point of the area/circle

Seller focus is seen as the most logical perspective, due to the fact that without sellers there is no market, equal focus is from a scalability point-of-view more complex.

Figure 4-3 - P2P area by geographical range below illustrates a seller focused marked based on the geographical range, where S_n are sellers and B_n are buyers.



Scenario A P2P trade possible?		To (Buyers)						
		S1	S2	B1	B2	B3	B4	B5
From (Sellers)	S1		No	Yes	Yes	No	Yes	No
	S2	No		No	No	Yes	Yes	No

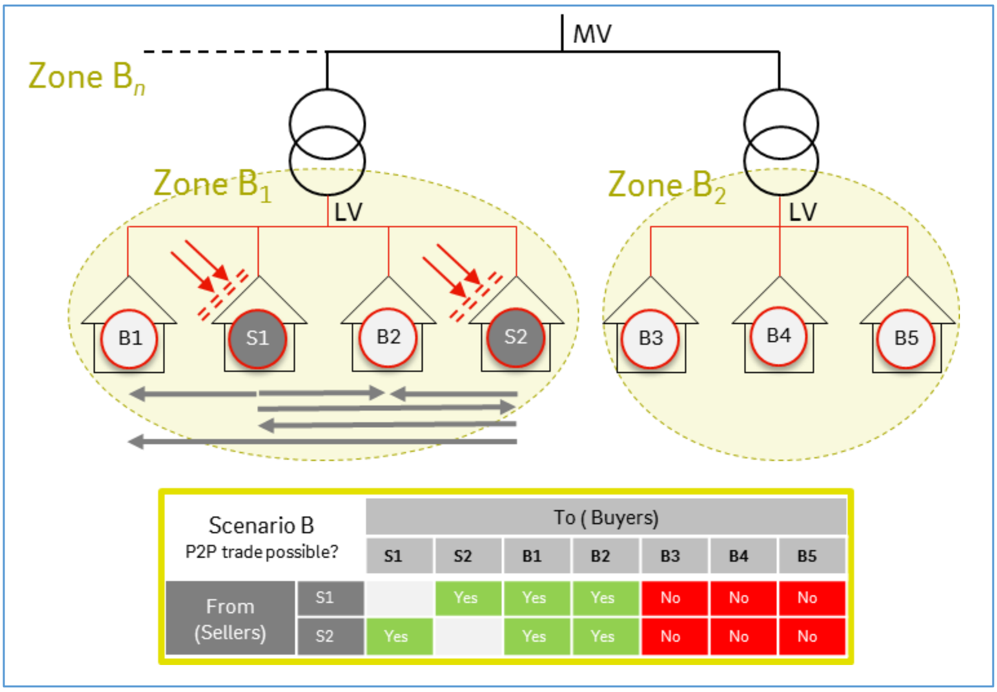
Figure 4-3 - P2P area by geographical range with seller focus

The complexity increases with geographical ranged model as one actor can create trading with several P2P-areas at once. However, this model is easier explained to the customer.

Location by grid topology

Location by grid topology is from a DSO perspective the most logical way to arrange and define the P2P areas in a P2P market, as it takes in consideration energy exchange within the LV grid and does not incorporate P2P energy distribution on the MV grid.

In this model a substation is the P2P area divider and defines the boundaries. See example below in Figure 4-4 - P2P area by grid topology.



Scenario B P2P trade possible?		To (Buyers)						
		S1	S2	B1	B2	B3	B4	B5
From (Sellers)	S1		Yes	Yes	Yes	No	No	No
	S2	Yes		Yes	Yes	No	No	No

Figure 4-4 - P2P area by grid topology

The complexity is decreased with grid topology limitation and is from a distribution cost perspective a more logical, fair and efficient model. This model does not risk an actor creating coherence between different P2P-areas. On the other hand are customers unaware of grid topology, it could be more difficult for them to understand this model.

Network structure

Network structure explains the communication needed in order to create transactions between the P2P actors in a P2P-area. The chosen route to manage the P2P domain strategy (i.e. by geographical range or grid topology) implicitly implies the network structure if an actor adds coherence by existing in more than one P2P-areas.

Two different approaches have been investigated

- Point-to-point network structure
- Hub-and-spoke network structure

Point-to-point network structure

In a point-to-point network structure, all included nodes communicates with each other. The different states in this structure are one-to-many, many-to-one, many-to-many. See Figure 4-5 - Point-to-point structure with different states below.

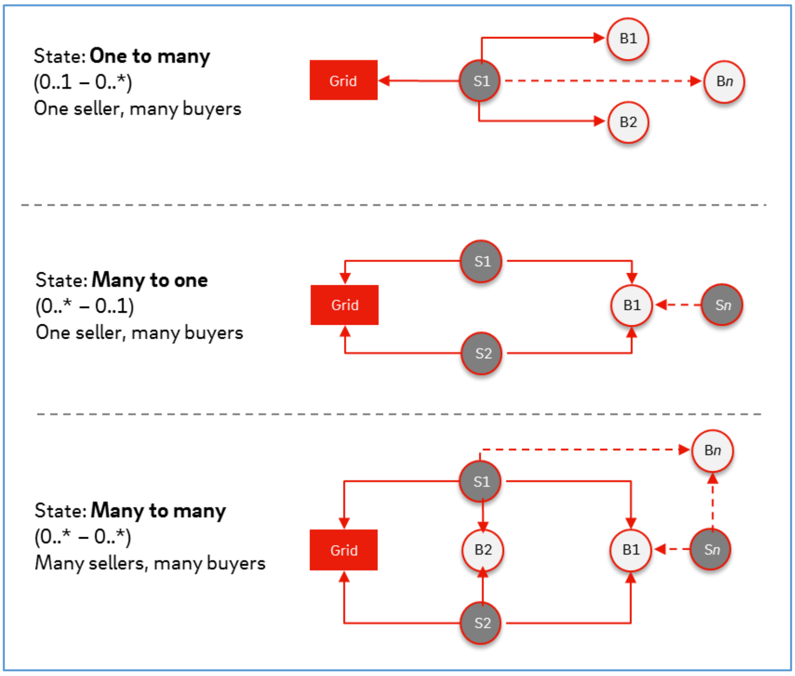


Figure 4-5 - Point-to-point structure with different states

The complexity of this approach is increasing by every node that adds to the P2P network. For every new node, the possible transactions between actors increases by $\frac{n(n+1)}{2} - n$ (semi faculty). This model approach is considered to be less scalable.

Hub-and-spoke network structure

The hub-and-spoke network structure reflects the P2P-area more as a community, whereas the model approach treats the combined P2P-generated electrical energy surplus or shortage from a community perspective by communicating (virtually) via a hub. See Figure 4-6 - Hub-and-spoke network structure below.

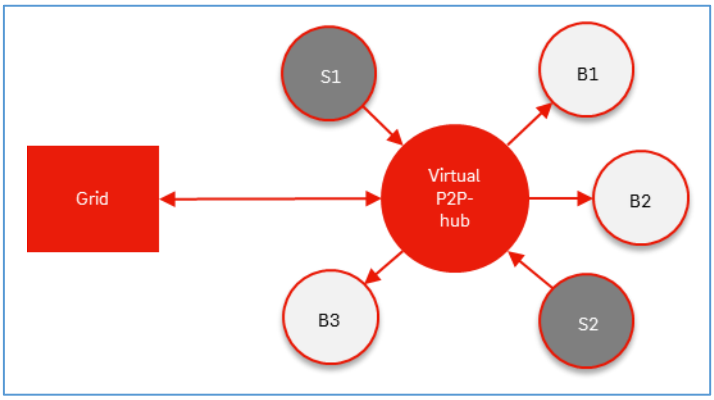


Figure 4-6 - Hub-and-spoke network structure

The complexity of this network is <u>not</u> increasing notable by every new node (new consumer or supplier) that adds to it. For every new node the, possible transactions between actors increases only by +1.

This model is considered to be easily scaled. Hub-and-spoke, as a network structure, allows for a greater flexibility through a concentration of flows.

The hub-and-spoke network structure adds the proper community driven touch by reflecting the community also by the energy flow with its hub. Each transaction for all actors is related to the hub (i.e. the combination of all actors; prosumers/sellers and consumers/buyers). See example Figure 4-7.

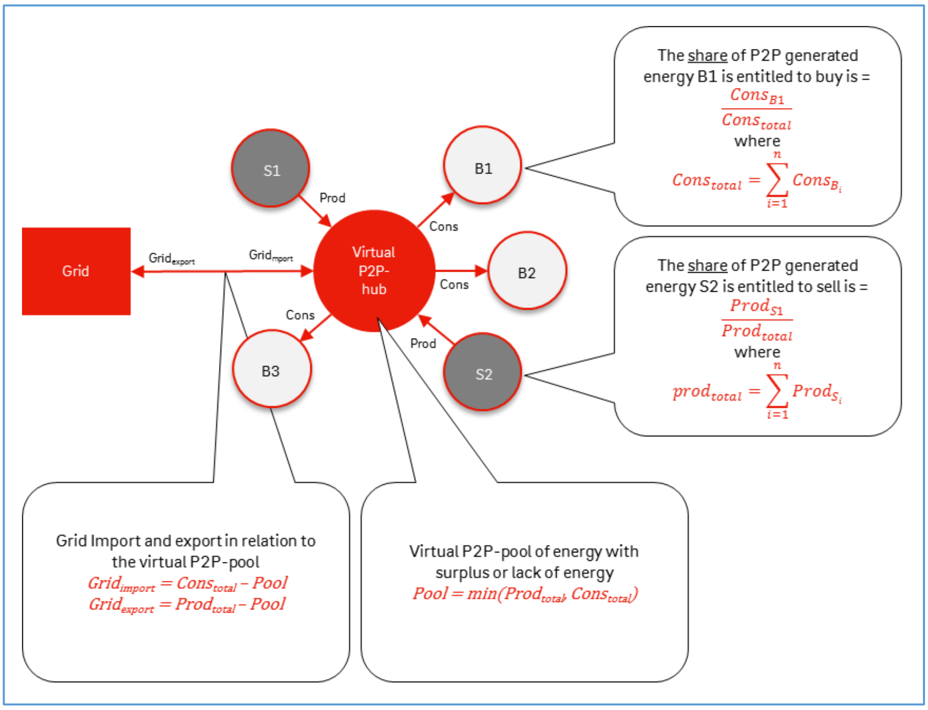


Figure 4-7 - Hub-and-spoke community logic for exchange

Considering scalability and community logic the hub-and-spoke structure is the preferred solution. This implies that grid topology is the preferred choice for P2P domain strategy rather than geographical due to sub-stations are natural location in the grid for the creation of hubs.

Tariff constructions

The incentives for a customer to participate in a Peer-2-Peer market are driven by several factors. Both costs related- and environmental aspects are key factor according to a study preformed with the participants in the Simris P2P-market[2]. This differs of course for different geographical areas in Sweden, Scandinavia and Europe, also by other ethical and religious believes which this study has not investigated. The natural tool for creating incentives is thus the tariff.

Four different tariffs have been approached in the project

1. Traditional tariff: Alignment with current B2C-tariffs [T1a]
2. Power based tariff: Alignment B2C-tariff strategy [T1b]
3. Traditional tariff + P2P: T_{1a} tariff with net settlement for grid exchange (tax) [T2a]
4. Power based tariff + P2P: T_{2a} tariff with net settlement for grid exchange (tax) [T2b]

2) *See appendix 1*

These for tariff constructions are illustrated in Figure 4-8 - Tariff constructions Figure 4-8 - Tariff constructions below:

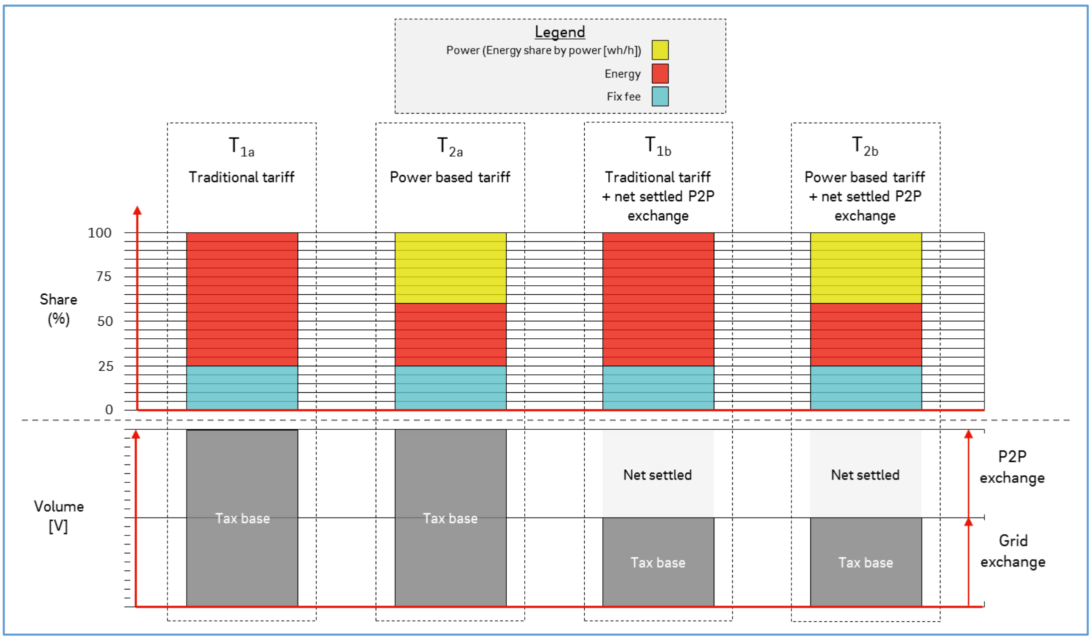


Figure 4-8 - Tariff constructions of possible alternatives for a Peer-2-Peer market

4.1.2. Customer perspective

From a customer perspective we early in the project identified the need of a system solution as tool to enable the customers in a P2P-market interaction, both near real time integration/interaction and simulated activities.

As a step to understand the approach taken, and yet to be taken further, a proposal canvas was created. The proposal canvas highlights the following base topics:

- Solution
  What is being developed/tested?
- Objective
  What are the goals of development/testing?
- Business case
  Why are we doing this? What are the benefits? What are the risks of not doing it?
- Target group
  Who are our users?
- Methodology
  How do we conduct the development/testing?
- Segmentation
  How do we segment our customers (users)?

Table 4-1 - Overview of proposal canvas

Solution	Business case	Target group	Segmentation
• Develop an Energy community with defined B2[P2P]2C functions rather than B2C + C2C	Why? • Create a P2P solution in order to test functions and engagement Benefits: • Validate P2P for Simris • Functionalities at concept level prior to development Risks: • User Acceptance • Technical solution	• Energy Communities • PV (& Battery owners) • Community Windfarms	Owners of: • Smart Meters • Solar Panels Personas of: • Eco First • Personal comfort • Informed choice • Without effort • Save money
Objective		Methodology	
• Functionality and UI for P2P-market concepts		• Focus groups • Validate hypothesis with users framing survey questions based on gains and needs.	

4.2. Implementation

4.2.1. Market

Technical challenges are solvable. However, in the actual business model, and from the concept of how this market will develop, conceptual assumptions have to be made to support a solution to test, analyse and develop to the next level. The real challenges lay in the future business model development, with more learnings fed in to the concept.

Implementation of market consists of a theoretical market model which is based of today's regulation and expected future development of the market.

From a conceptual overall perspective, the below listed market variables affecting market behaviour have been identified based on the existence of P2P-actors in the personas of participating consumers, participating prosumers and non-participating consumers/prosumer:

1. P2P-market actor: residential contributors ()
2. P2P-market actor: residential consumers (consumer/ prosumers/seller buyer)
3. Local "commercial" generation
4. Grid treated as a virtual battery (grid exchange with the Virtual P2P-hub)
5. Non-participating customers in the community

This is visualized in Figure 4-9 - P2P markets - Energy Communities below. All of the above elements (with the exception of number 5) are implemented in Simris, the fifth element does not exist as all Simris residents are included within the P2P market.

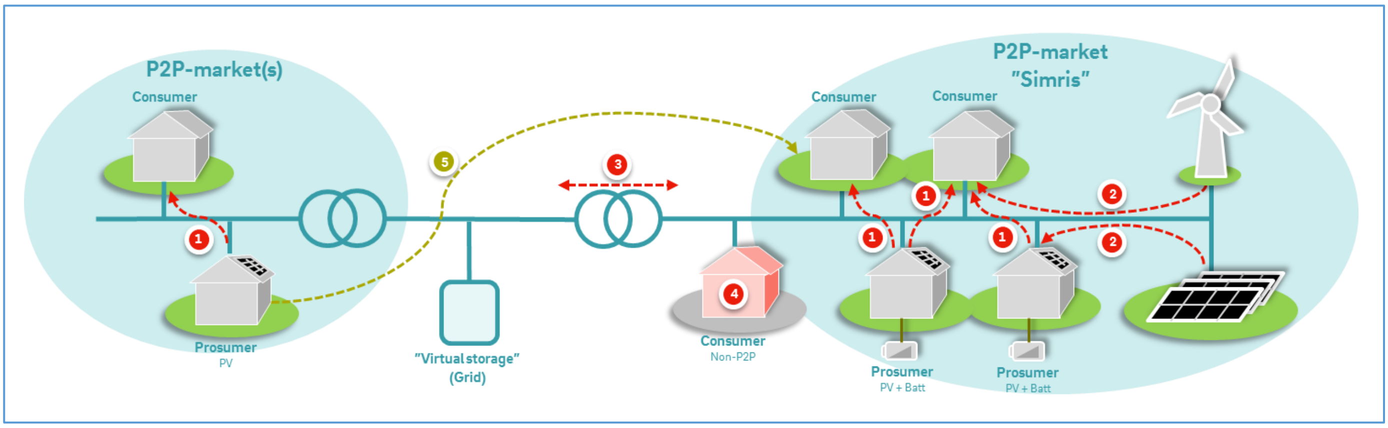


Figure 4-9 - P2P markets - Energy Communities

Looking at the P2P market from the above described concept, and from the perspective of today's marked rules and regulation together with the overall challenges, several topics must be defined with a set of rules from the following parameters:

- Tariffs in Energy Communities
- Tax regulation in Energy Communities
- P2P virtual hub
- Virtual grid storage

See Figure 4-10 - P2P market parameters below which includes only the customers.

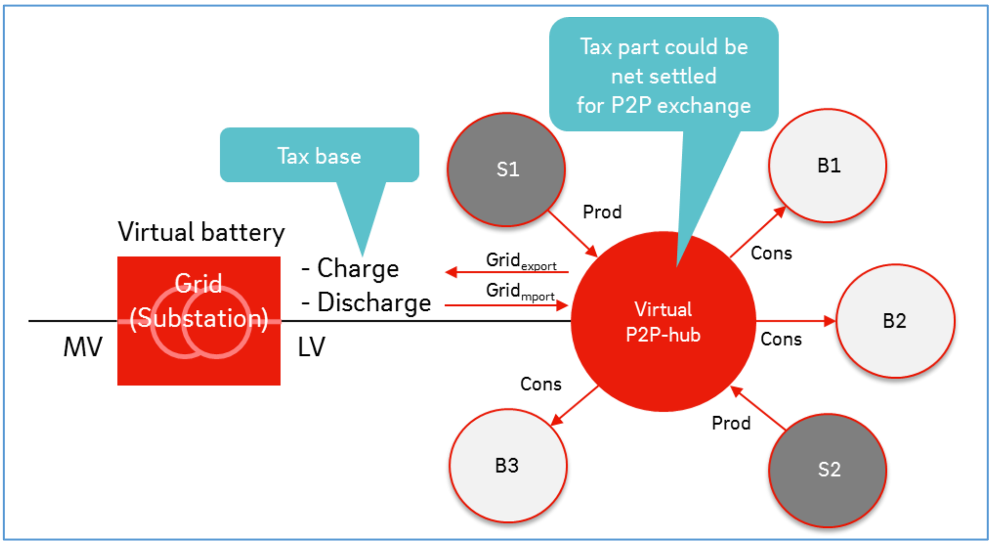


Figure 4-10 - P2P market parameters

To enable the P2P-market the implementation and tests of the tariff constructions are essential. The tariff construction implemented includes the previously discussed:

- Resolution of measurements

- P2P domain strategy, by location
- Network structure

This is described in Figure 4-11 - Tariff construction implementation below.

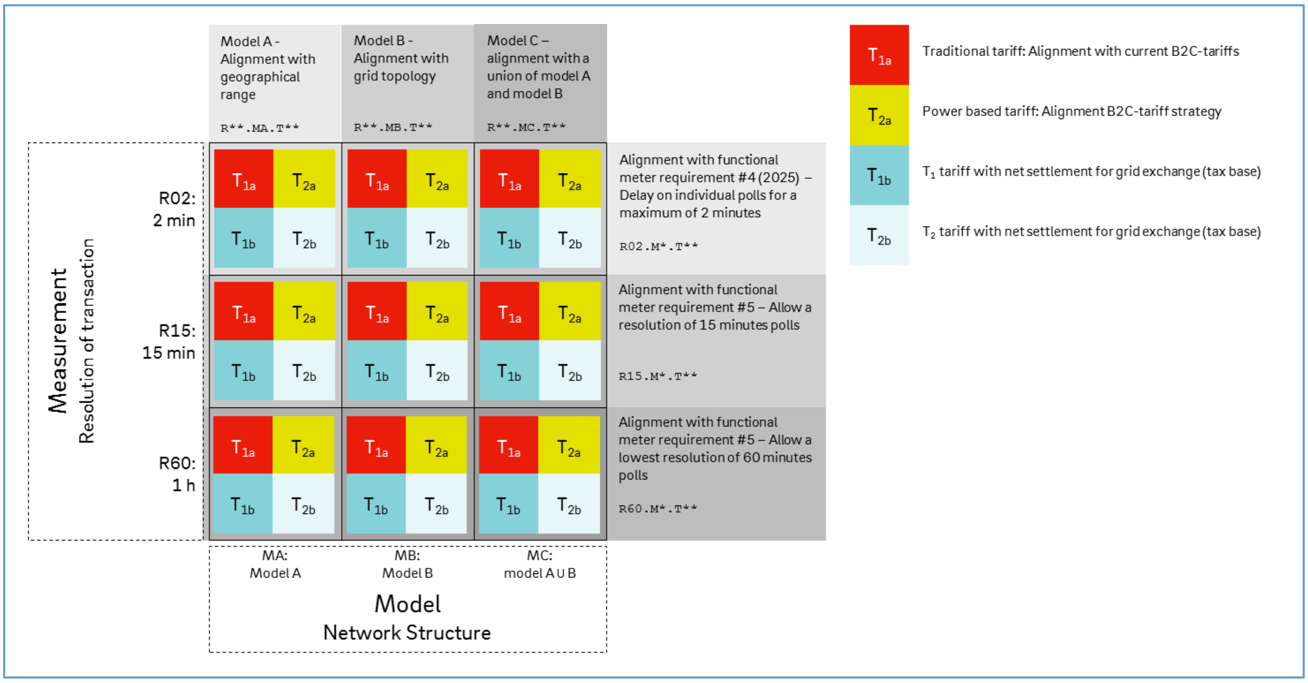


Figure 4-11 - Tariff construction implementation

4.2.2. Customer perspective

All customers in Simris having a fuse < 63 A are treated as members to the conceptual P2P market created in this use case. All active customers in Simris having PV panels installed are measured every 2-minute. In this interval both production and consumption is measured.

From a customer, or rather P2P market member, perspective the role of a prosumer can differ in between times of measurements. A prosumer can go from surplus to shortage of energy, by doing so the prosumer is changing its role from P2P market seller to P2P market buyer.

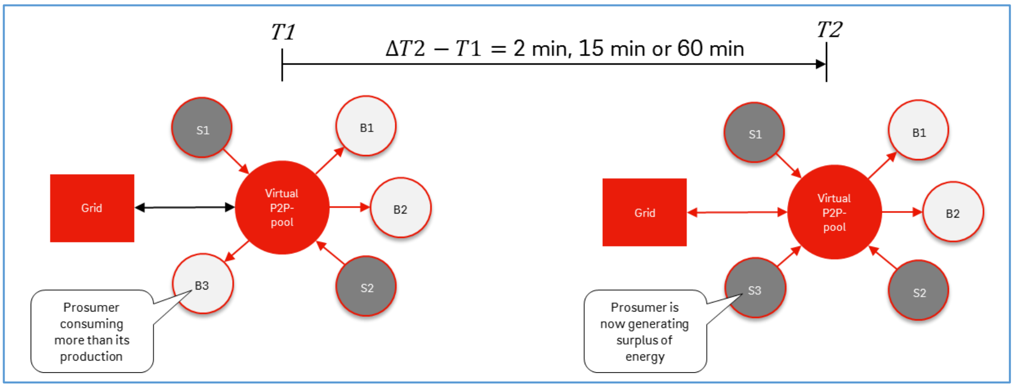


Figure 4-12 - P2P prosumer change of role

5. RESULTS

5.1. Data

To investigate the approach and to compile a result from the implementation, both measured data and calculated data were used.

- Measured data
  For all prosumers we have used measured data for local production and consumption. This data is collected every two minutes.
- Calculated data
  For consumers (passive customers) in Simris where we haven't been able to get 2-minute data hourly data have been used and 2-minute interval have been simulated (randomized)

In Simris we have just above 140 sites. In this analysis we have removed all sites having a fuse size equal to, or above, 63 A. This gives a community of the following:

- Prosumer
  Number of prosumers = 9.
  This group is considered as both sellers and buyers depending on current production/consumption provided by the prosumer. This group can provide to the virtual P2P trade hub.
- Consumers
  Number of consumers = 130.
  This group can only be buyers. This group can only take advantage of the virtual P2P trade hub.

In the analysis it was decided to use the entire Simris Local Energy System as a P2P domain for the P2P market model. Furthermore, the Simris Local Energy System Micro Grid with its utility scale assets is not a part of the simulated P2P market model. The reason for this is to have a model that can be put in place anywhere without a Micro Grid with energy storage.

To be able to do the analysis we have divided our data into four different groups

1. Grid Export
   This is the amount of energy exported to the grid (i.e. P2P domain surplus)
2. P2P Generation
   This is the amount of energy generated by the active customers in Simris with residential PV panels.
3. Grid Import
   This is the amount of energy imported from the grid
4. P2P Consumption
   This is the amount of energy from P2P Generation consumed by the P2P actors (all customers in Simris)

To get a fair result were data used from an entire year, from September 2018 until August 2019. The 2-minute interval data is then aggregated the into months (net sums), by doing so were the calculations limited, prices with tariffs based on energy was used and power tariffs was excluded. See Figure 5-1 below.

Table 5-1 - P2P energy exchange

Month	Grid Export [kWh]	P2P Generation [kWh]	Grid Import [kWh]	P2P Consumption [kWh]
September-18	0.00	1 564.50	92 985.22	1 564.50
October-18	0.00	849.82	129 875.10	849.82
November-18	0.00	83.08	175 519.63	83.08
December-18	0.00	24.22	230 471.03	24.22
January-19	0.00	28.67	249 106.05	28.67
February-19	0.00	168.04	256 763.69	168.04
March-19	0.00	478.63	264 735.43	478.63
April-19	0.00	4 821.80	152 289.48	4 821.80
May-19	0.00	3 925.75	107 121.88	3 925.75
June-19	0.00	4 258.98	87 777.06	4 258.98
July-19	0.00	3 739.39	76 380.50	3 739.39
August-19	3.61	3 485.79	64 838.08	3 482.18
Total	**3.61**	**23 428.68**	**1 887 863.16**	**23 425.06**
Average	**0.30**	**1 952.39**	**15 7321.93**	**1 952.09**

5.2. Tariffs

For this analysis the following two tariffs are compared

1. T_{1a} - Traditional tariff: Alignment with current B2C-tariffs
2. T_{1b} - Tariff with net settlement for grid exchange (altered tax base)

See Figure 5-1 below.

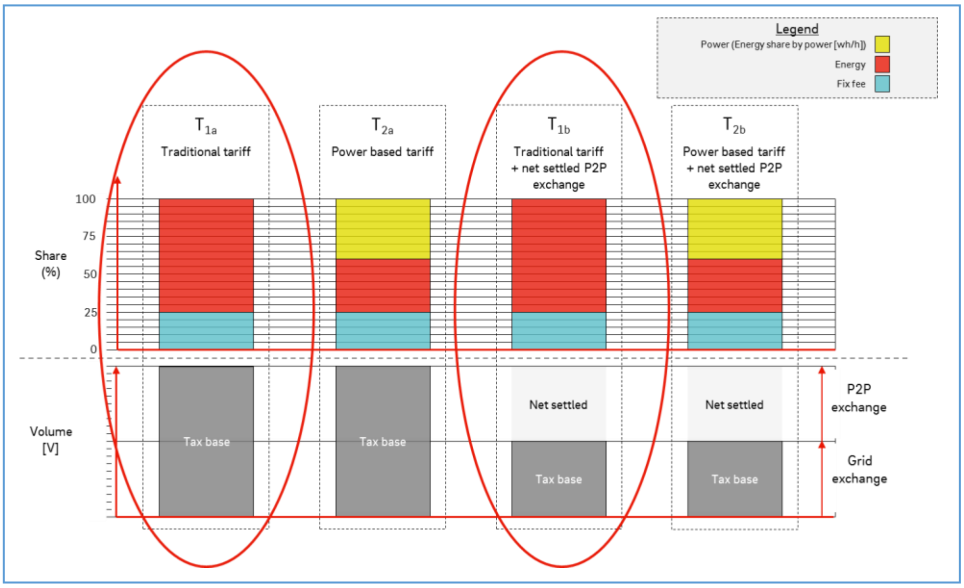


Figure 5-1 - Tariff construction and tax base

To isolate the difference between these two tariffs all, fix fees (for example distribution subscription and sales agreement fix fee) are removed. Furthermore, a reduced distribution cost is applied in P2P tariffs. See Table 5-2 below for explanation of the different tariff constructions.

Table 5-2 - Tariff table with explaining text

	T_{1a} Buy - Grid	T_{1b} Buy - P2P	T_{1a} Sell - Grid	T_{1b} Sell - P2P
(Grid) Distribution Cost per kWh	Consumer distribution cost	Reduced price for P2P consumer (75 % reduction)	Compensation for net losses that can be given by the DSO	Compensation for P2P net losses are removed in P2P trade
(Grid) Energy Tax per kWh	Energy tax according to today's model	Net settled energy tax for P2P trade, so this is removed.	N/A	Net settled energy tax for P2P trade
(Sales) Add-on per kWh	N/A	N/A	Extra revenue per kWh. Today, this differ between different retail companies (typically from 0.0 to 0.4 SEK)	N/A
(Sales) Electricity Cost per kWh	Same energy price is used for all cases			

With the above reasoning the tariff constructions in numbers can look like Table 5-3 below.

Table 5-3 - Tariff table with pricing in SEK

	T_{1a} Buy - Grid	T_{1b} Buy - P2P	T_{1a} Sell - Grid	T_{1b} Sell - P2P
(Grid) Distribution Cost per kWh	0.2640 kr	0.0660 kr (= 0.2640 kr * 0.25)	0.0292 kr	0.0000 kr
(Grid) Energy Tax per kWh	0.4338 kr	0.0000 kr	- kr	- kr
(Sales) Add-on per kWh	- kr	- kr	0.2000 kr	- kr
(Sales) Electricity Cost per kWh	0.5726 kr	0.5726 kr	0.5726 kr	0.5726 kr

5.3. Collective Self Consumption

In the Renewable Energy Directive (REDII). Collective self-consumption (CSC) is addressed in article 21. and defines *renewables self-consumers* and *jointly acting renewables self-consumers* as follows:

- Renewables self-consumer:
  A final customer [...] who generates renewable electricity for its own consumption. and who may store or sell self-generated renewable electricity. provided that. for a non-household renewables self-consumer. those activities do not constitute its primary commercial or professional activity.

- Jointly acting renewables self-consumers:
  A group of at least two cooperating renewables self-consumers [...] who are located in the same building or multi-apartment block". In the following. due to its

> *common use and for simplicity reasons. we maintain the term collective self-consumption (CSC) for 'jointly acting renewables self-consumers.*

In this analysis we consider the virtual P2P hub the connection point for all citizens of Simris. meaning considering Simris citizens as *jointly acting renewables self-consumers*. However. on a larger scale (as a village or multi-apartment building) rather than on the scale of self-contained house.

In an attempt to measure the effectiveness of the collective self-consumption we have chosen to look at the percentage of energy that is shared via the P2P hub over the total amount of energy that is shared between the overlaying grid and the virtual P2P hub.
See Table 5-4 below.

Table 5-4 - Collective self-consumption per month

Date	Collective Self-consumption
September-18	3.26%
October-18	1.29%
November-18	0.09%
December-18	0.02%
January-19	0.02%
February-19	0.13%
March-19	0.36%
April-19	5.96%
May-19	6.83%
June-19	8.85%
July-19	8.92%
August-19	9.71%
Average	**3.79%**

5.4. P2P Trade

The Renewable Energy Directive states that the primary purpose of which is to provide environmental or social community benefits for its shareholders or members or for the local areas where it operates. rather than financial profits. The analysis is based on earlier discussed tariff constructions.
This shows that in our case the P2P-market can give a positive economic perspective for the P2P market members. This is addressed in below Table 5-5, in the last column ("P2P market. total earnings").

Table 5-5 - P2P market comparison seller/buyer per month

Date	Buy from Grid. Normal price (No P2P trade)	Buy from P2P (No energy tax and 75 % off on distribution subscription)	Net sum #1 Buy from grid – buy from P2P	Sell to Grid. Normal price (No P2P trade)	Sell to P2P	Net sum #2 Sell to grid – sell to P2P	P2P market total earnings
September-18	120 115.97 kr	119 127.52 kr	988.45 kr	1 163.05 kr	941.52 kr	- 221.53 kr	766.92 kr
October-18	166 072.94 kr	165 536.02 kr	536.92 kr	631.76 kr	511.42 kr	- 120.33 kr	416.58 kr
November-18	223 085.69 kr	223 033.20 kr	52.49 kr	61.76 kr	50.00 kr	- 11.76 kr	40.73 kr
December-18	292 821.16 kr	292 805.86 kr	15.30 kr	18.01 kr	14.58 kr	- 3.43 kr	11.87 kr
January-19	316 500.75 kr	316 482.64 kr	18.12 kr	21.31 kr	17.25 kr	- 4.06 kr	14.06 kr
February-19	326 406.06 kr	326 299.90 kr	106.16 kr	124.92 kr	101.12 kr	- 23.79 kr	82.37 kr
March-19	336 927.94 kr	336 625.54 kr	302.40 kr	355.81 kr	288.04 kr	- 67.77 kr	234.62 kr
April-19	199 594.18 kr	196 547.76 kr	3 046.42 kr	3 584.53 kr	2 901.76 kr	- 682.77 kr	2 363.65 kr
May-19	141 074.91 kr	138 594.62 kr	2 480.29 kr	2 918.40 kr	2 362.51 kr	- 555.89 kr	1 924.40 kr
June-19	116 922.58 kr	114 231.76 kr	2 690.82 kr	3 166.13 kr	2 563.05 kr	- 603.07 kr	2 087.75 kr
July-19	101 784.31 kr	99 421.76 kr	2 362.55 kr	2 779.86 kr	2 250.37 kr	- 529.50 kr	1 833.05 kr
August-19	86 794.06 kr	84 594.02 kr	2 200.04 kr	2 588.65 kr	2 095.57 kr	- 493.08 kr	1 706.96 kr
Total	**2 428 100.56 kr**	**2 413 300.60 kr**	**14 799.95 kr**	**17 414.19 kr**	**14 097.20 kr**	**- 3 316.99 kr**	**11 482.97 kr**
Average	**202 341.71 kr**	**201 108.38 kr**	**1 233.33 kr**	**1 451.18 kr**	**1 174.77 kr**	**- 276.42 kr**	**956.91 kr**

It is very clear that in Simris location. south of Sweden. the prosumers using PV panels and used in this analysis can provide to the community during a limited period of the year. This is due to solar irradiation level during the different seasons. See Figure 5-2 below.

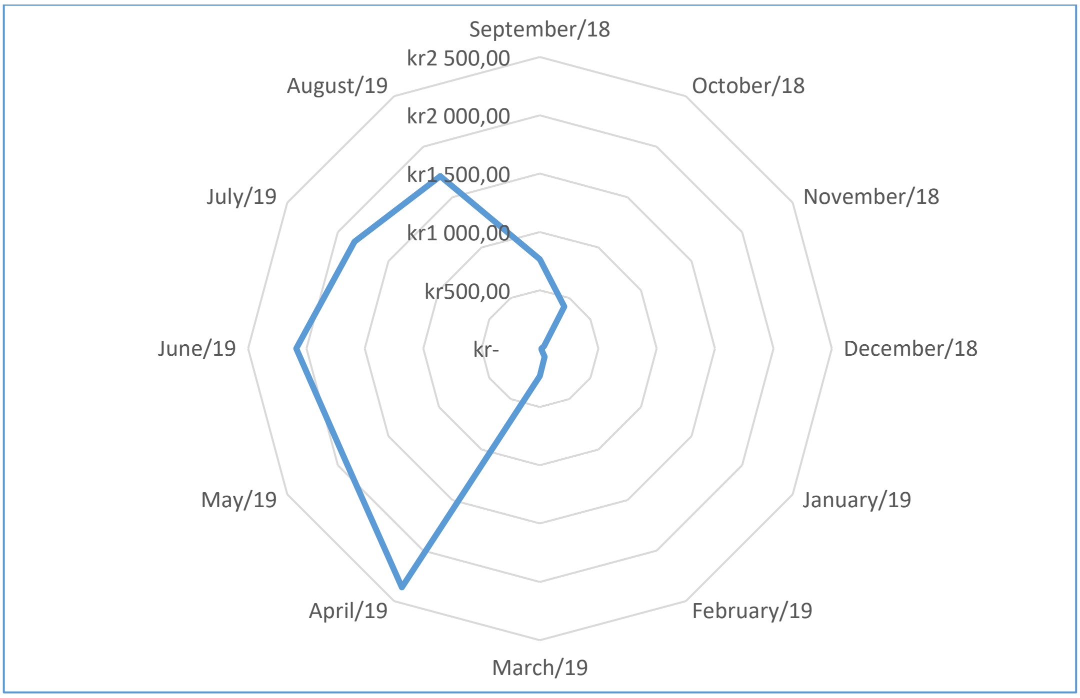


Figure 5-2 - P2P market total earnings over a year

To have a P2P-market it is mandatory to have the prosumers as members. For this reason. the prosumers are promoted (the P2P energy sellers) when sharing the P2P-market total earnings between all actors that are members according to the following:

- Prosumer
  Remuneration is equal to 80 % of P2P-market total earnings. This number (share) is based on fairness. given these are the investors of P2P generation.

- Consumer
  Remuneration is equal to 20 % of P2P-market total earnings.

This results in the following. see Table 5-6 below

Table 5-6 - Result of P2P simulation with earnings in Simris

Date	P2P market total earnings	80% of market earnings to sellers Result per seller (per prosumer)	20% of market earnings to buyers Result per buyer (per consumer)
September-18	766.92 kr	68.17 kr	1.18 kr
October-18	416.58 kr	37.03 kr	0.64 kr
November-18	40.73 kr	3.62 kr	0.06 kr
December-18	11.87 kr	1.06 kr	0.02 kr
January-19	14.06 kr	1.25 kr	0.02 kr
February-19	82.37 kr	7.32 kr	0.13 kr
March-19	234.62 kr	20.86 kr	0.36 kr
April-19	2 363.65 kr	210.10 kr	3.64 kr
May-19	1 924.40 kr	171.06 kr	2.96 kr
June-19	2 087.75 kr	185.58 kr	3.21 kr
July-19	1 833.05 kr	162.94 kr	2.82 kr
August-19	1 706.96 kr	151.73 kr	2.63 kr
Total	**11 482.97 kr**	**1 020.71 kr**	**17.67 kr**
Average	**956.91 kr**	**85.06 kr**	**1.47 kr**

5.5. Result summary

The results above have not taken in consideration fix fees such as distribution subscription fees. Even without using these fix fees as tools to lower costs for the P2P members. the P2P market can contribute with a small-scale economic intensive for the members if energy taxes can be net settled and if the distribution cost per kWh within the P2P market can be lowered. Except for providing environmental and social community benefits the economic benefit can be shown.

According to the analysis done and according to the prerequisites given in this chapter a Simris P2P member with the current prosumer/consumer ratio (~6.5 %) each consumer can save approx. 85 kr (= close to 8 €) per month in average in their energy bill. and each consumer can save approx. 1.50 kr (= close to 0.14 €) per month in average on their energy bill.
Regardless of the size of the savings. analysis shows that challenging the regulation/law by applying net settled tax base for the P2P trade. members can save money while providing to a P2P market as members.

To get an idea what will happen if the share of prosumers increases in the Simris case. a simulation of an increasing share of prosumers were done. This was done without affecting grid export from the P2P generation. See Table 5-7.

Table 5-7 - Scaled P2P-market earnings

Scale factor. scaling share of prosumers	Share of prosumers	P2P market total earnings Avg per month	80% of market earnings to sellers Avg per month per seller (per prosumer)	20% of market earnings to buyers Avg per month per buyer (per consumer)
1	6.47%	956.91 kr	85.06 kr	1.47 kr
2	12.95%	3 827.95 kr	170.13 kr	6.33 kr
4	25.90%	15 312.39 kr	340.28 kr	29.73 kr
8	51.80%	61 250.75 kr	680.56 kr	182.84 kr
16	100.00%	228 286.42 kr	1 313.88 kr	- kr

6. CONCLUSIONS

Innovative technologies will continue enabling DES. The deployment of DES will continue to increase. Small-scale solution like this P2P market will most likely play an important role as the transition and modernisation of power systems are ongoing. Thus. enabling several of well needed improvements towards higher efficiency of the full energy systems.
As the new energy systems are formed. smart solutions can reduce costly investments of infrastructure. This would be a big change compared to the traditional way of constructing power system. building away the transmission problems. P2P technology could be an enabler of smart services with synergies which increases overall utility. DSOs could decrease their investments on infrastructure by using new technology and solutions. Without a new way of using the power grid larger investments would be needed to handle the increasing. distributed and intermittent power production. This could have a substantial impact on how the grid is used.

The revenue model for the DSO would need to better reflect the improvements of efficiency and the quality of the network. As the grid is an absolute necessity for the DSOs there should be less weight on the CAPEX side to promote the efficiency aspect. Relatively small investments in this context could come a long way to implement smart solutions. that could steer clear of problems before they occur. New solutions provide alternatives and could be more cost efficient as they reduce the need for grid upgrades and cost linked to them. The legislation must not directly. nor indirectly. block the technical implementation. Regulations needs to propose alternative solutions to change the CAPEX-based remuneration in the future. If more weight is put to the OPEX. the DSO could provide more adapted and better services (i.e. flexibility issues). Possibilities for DES would also improve the requisites for CECs.

The new possibilities for local markets raise the matter of finding a remuneration for CECs that is fair for all involved participants. i.e. DSOs. government etc. There are different types of tariffs for CECs which have pros and cons. but should reflect the cost. or savings. for the network. Tariffs could vary to be based on different parameters (for example capacity or flexibility). In this deliverable a traditional energy-based tariff is used. and therefor likely to be one of the first alternatives to a P2P-market.

Savings for the prosumer and consumers are derived from the reduction in tax and grid fee that is distributed between them. within the P2P domain. The DSO ends up with lower revenues as income from grid fee is decreased due to power traded within the P2P market. Somethings are clear though. if DSOs are to be an enabler for these markets. they should in some way be compensated for the service/the loss of income over decreased transmission fees. There are a series of parties that would be influenced by a P2P market. energy retailers for example are affected as power that would normally be exported to the grid obtain subsidies based on the amount of energy. In this case the subsidise of 0.2 SEK/ kWh is used. but this varies between companies and should be discussed when building tariffs for P2P markets and CECs.

Similarly. there could be cases were CEC intends to own or lease the network. cost for leasing/owning needs to compensate the ‘real’ value of the network and the investments made by the DSO if any. based on cost benefit analysis performed by the regulatory body of the country in question. In other words. the DSOs should receive a fair compensation from whatever new entity/system operator that takes over. This is just speculative and strongly depends on market development and future legislations but could be a possibility. How such a model could look is not further discussed in this deliverable but seen as future work.

The result of this deliverable indicates that a P2P market have the potential to increase customer participation as there is a profit potential for prosumers and consumers within the P2P market. The financial aspect for the different stakeholders largely boils down to how tariffs and taxation are used. In this case it was by design. to have financial incentives to join the P2P market. even if the financial gains are low. To get participants to join a P2P market. the procedure to do so must be simple and risk minimized and with a guarantee to not exceed normal market price for electricity. Other incentives further induced by the P2P market besides financial are environmental. social and be a “smart grid enabler”.

The general market matures and adapts to facilitate the energy transition with its new technologies. services and solutions. It is up to stakeholders to make this transition possible were everything from regulation. tariffs and platforms should be aligned. The P2P market will have a role in the energy system of tomorrow. and this needs guidelines.

7. RECOMMENDATIONS AND FUTURE STEPS

The conceptual P2P market in this use case. has shown potential benefits if correctly implemented. The technology scales well. allowing to include more actors to the P2P market. To reach the full potential the market should have a certain ratio of production and consumption. This ratio will vary between different markets depending on several aspects such as consumption patterns. available power production and more. This is something that needs to be understood if the market should spread to areas with various conditions.

To create a realistic and functioning P2P market there should be some sort of incentives for participants to join. which have been brought up in this deliverable. The prosumer has a vital role in the CSC as without prosumers the consumers buy from the grid as usual. The economic incentives seem to be the most likely option to make P2P markets widespread.

A tariff could for this purpose be implemented. This would self-regulate towards the optimum ratio between the number of consumers and prosumers within the local P2P market. The members of the CSC are likely to be interested but are not experts in energy sales. which implies the tariffs to be easily understandable.

The next steps are to form a scalable solution with optimized functionality to meet the market. The first step in this work is to define the workflow of forming the P2P market and future improvement of the strategy. See Figure 7-1 below.

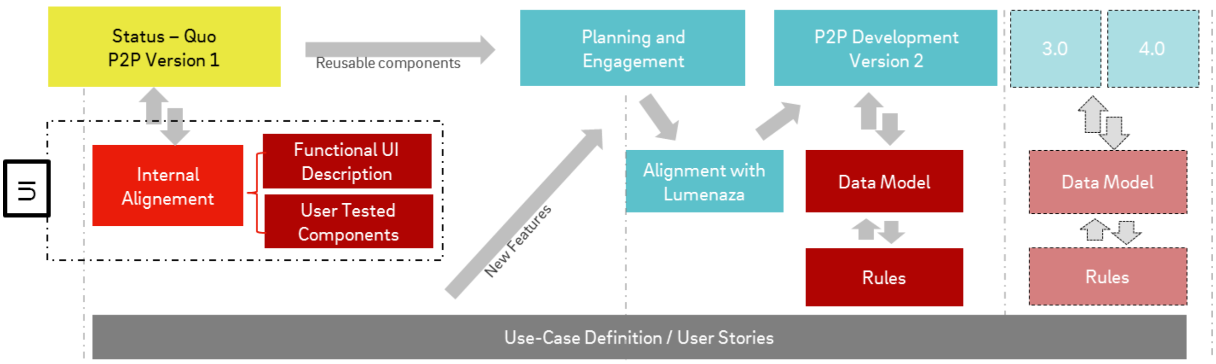


Figure 7-1 - The workflow of forming the P2P market and future improvement of the strategy

8. APPENDICES

8.1. Appendix 1

Appendix 1 includes parts of the 2nd customer survey that was made in demo 4b. This was done during spring 2019.

All persons in the selection have been called by phone. in the conversation they were offered to conduct the interview directly by phone but also via email. 45 interviews were made. 42 over telephone and 3 via a web page survey.

The results of the survey is based on the answers given from the citizens of Simris. The answer sample is shown in X below.

Table 8-1 - Survey sample account

	Count
Total sample	**131**
The person is not available	11
Wrong telephone number	19
Wrong target group	2
Profit sample	**99**
Not reachable	54
Completed interviews – telephone	**42**
Completed interviews – web page	**3**
Response rate	**45%**

Part of the result. relevant to this use case. is shown below in Figure 8-1. Figure 8-2 and Figure 8-3

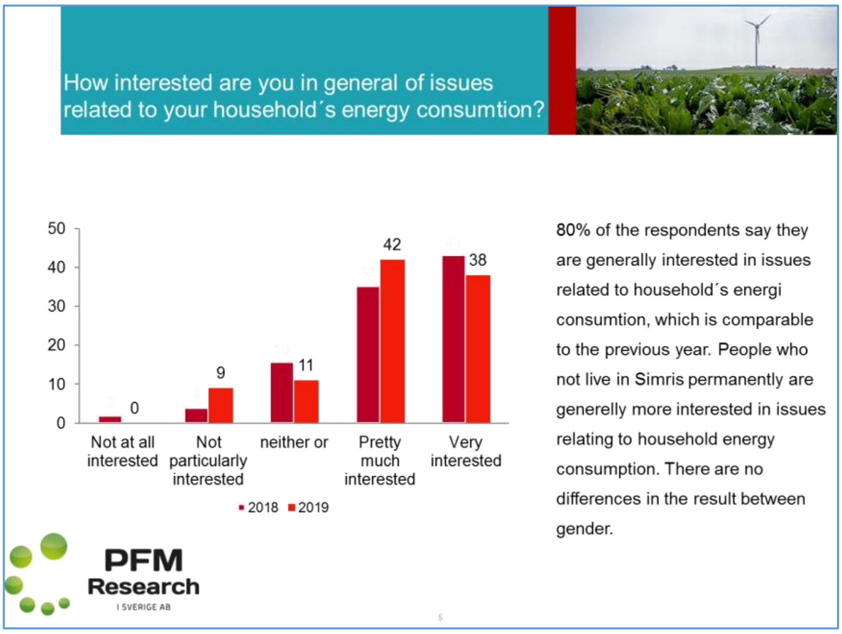


Figure 8-1 - Interest to participate

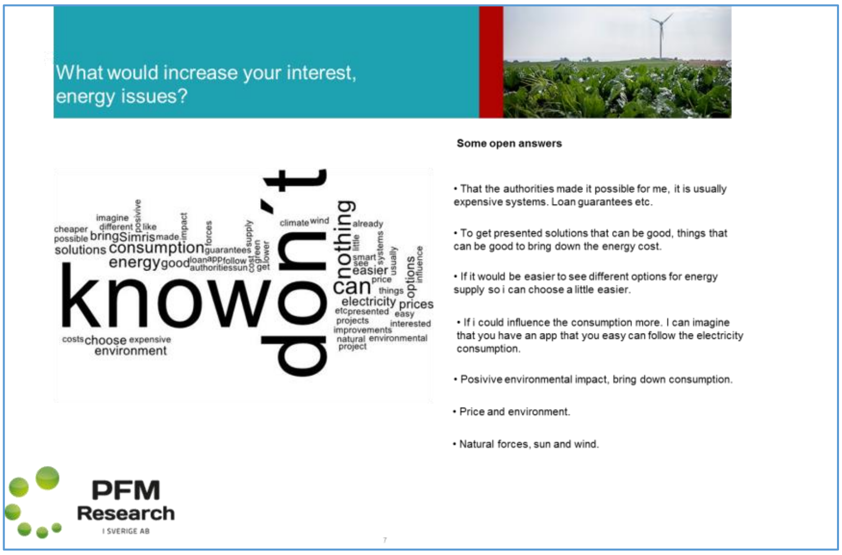


Figure 8-2 - How to increase interest for energy issues

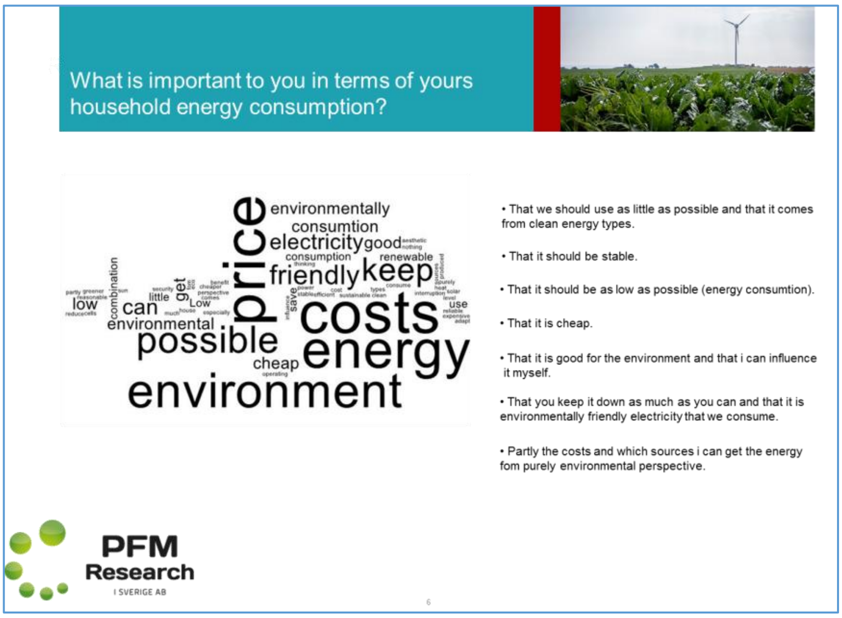


Figure 8-3 - Importance of energy consumption