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EXPERIENCES OF HOUSING COMPANY-BASED ENERGY COMMUNITIES

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TALOYHTIÖMUOTOISTEN ENERGIYHTEISÖJEN KOKEMUKSIA

Vuonna 2020 Suomen lainsäädäntöön lisättiin Euroopan Unionin ohjauksessa uusi käsite, paikallinen energiayhteisö. Asetus mahdollisti jakeluverkkoyhtiöiden tarjota hyvityslaskentapalvelua, joka parantaa taloyhtiöiden oman sähköntuotannon kannattavuutta siirtomaksujen ja verojen jäädessä pois. Tutkimuksia aiheesta etenkin taloyhtiömuotoisten energiayhteisöjen osalta on melko vähän. Siksi opinnäytetyöni aiheeksi valikoitui taloyhtiömuotoisten energiayhteisöiden kokemukset. Tämän työn tarkoituksena oli kartoittaa taloyhtiömuotoisten energiayhteisöjen nykytilannetta ja kokemuksia eli etuja ja haasteita, taloyhtiöille ja jakeluverkkoyhtiöille. Lisäksi tarkasteltiin liiketoimintamahdollisuuksia, joita energiayhteisöt voisivat tuoda mukanaan ja selvitettiin hyvityslaskentapalvelun saatavuutta.

Vaikutuksia tutkittiin sekä taloyhtiöiden että jakeluverkkoyhtiöiden näkökulmista, koska ne molemmat kytkeytyvät vahvasti taloyhtiömuotoisiin energiayhteisöihin. Ne ovat molemmat toimijoita hajautetun energiantuotannon piirissä ja energiayhteisöjen vaikutukset kohdistuvat kumpaankin osapuoleen. Tutkimus toteutettiin kyselyinä ja puolistrukturoituina haastatteluina, joiden kohteena oli neljä olemassa olevaa taloyhtiömuotoista energiayhteisöä, yksi suunnitteluvaiheessa oleva energiayhteisö sekä 23 jakeluverkkoyhtiötä.

Tutkimuksessa selvisi, että edut kohdistuivat energiayhteisöille ja haasteet jakeluverkkoyhtiöille. Jakeluverkkoyhtiöiden haasteiden nähtiin poistuvan keskitetyn tiedonhallintapalvelu Datahubin myötä. Hyvityslaskentapalvelua tarjosi seitsemän jakeluverkkoyhtiötä, jotka sijaitsivat pääosin eteläisessä Suomessa. Taloyhtiöille kohdistuneet etuja olivat pienentyneet energiakulut sekä tunne siitä, että on tehty luonnolle hyvää. Haasteet koskivat tiedon puutetta tai lainsäädäntöä, jonka nähtiin tukevan pieniä ja keskisuuria taloyhtiöitä jättäen suuret yhtiöt konseptin ulkopuolelle. Jakeluverkkoyhtiöiden etuja olivat asiakastyytyväisyys ja uusiutuvan energian lisääntyminen. Haasteina nähtiin tietojärjestelmien sopimattomuus hyvityslaskentapalveluun ja niihin liittyvät kustannukset. Taloyhtiömuotoisten energiayhteisöjen syntymistä hidastivat konseptin heikko tunnettuus sekä hyvityslaskentapalvelun rajallinen saatavuus.

Uutta liiketoimintaa voisi syntyä konsultointipalveluista, energian myynnistä sekä aggregoinnista. Myös mahdollisuuksia alentaa ostoenergian kustannuksia löydettiin. Tämän opinnäytetyön tuloksia voidaan hyödyntää pyrittäessä lisäämään taloyhtiömuotoisia energiayhteisöjä ja sitä uusiutuvan energian tuotantoa.

ASIASANAT:

energiayhteisö, hajautettu energiantuotanto, jakeluverkkoyhtiö, taloyhtiö, uusiutuva energia

MASTER'S THESIS | ABSTRACT

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EXPERIENCES OF HOUSING COMPANY-BASED ENERGY COMMUNITIES

In the year 2020, guided by the European Union, a new term, a local energy community was introduced into the Finnish legislation. This made it possible for the distribution system operators to offer a new service: the credit calculation service. It increases the profitability of self-produced energy in housing companies as transfer fees and taxes can be avoided. The topic of local energy communities, especially from the housing company-based energy communities' point of view has not been studied much. For this reason, the experiences of housing company-based energy communities were selected as the topic of the present thesis. The purpose of this thesis was to chart the present situation and the experiences of energy communities within a housing company in Finland. In addition, business possibilities emerging from the housing company-based energy communities and the availability of the credit calculation service are discussed.

The experiences are studied from the housing company and distribution system operator viewpoints. They are both actors in the distributed energy production and the effects touch both. The research was performed by carrying out surveys and semi-structured interviews to four existing energy communities, one energy community in planning phase and 23 distribution system operators. The benefits are mostly accrued to the energy communities and the challenges to the distribution system operators. However, the implementation of the centralized data handling service, Datahub was seen to remove the challenges. The credit calculation service was available from seven distribution system operators, mainly operating in the Southern Finland.

The benefits for the housing companies were lowered energy costs and a feeling of doing good for the nature. Challenges were information based or connected with legislation, which was seen to be directed to small or medium sized housing companies omitting the large ones. The distribution system operators benefitted from the improved customer satisfaction. Challenges appeared in the IT- systems struggling with the credit calculation service and costs linked to them. It was seen that the number of housing company-based energy communities is low as the concept is not known

A set of new business possibilities emerged in consulting, energy sales and aggregation. Also, direct cost savings were seen to be gained. The results may be used to increase the number of energy communities and thus increase the production of renewable energy in housing companies.

KEYWORDS:

Distributed energy production, distribution system operator, energy community, housing company, renewable energy

CONTENTS

ABBREVIATIONS AND VOCABULARY

ARA	The Housing Finance and Development Centre of Finland, ARA, implements Finland's housing policy. It is an administrative branch of the Ministry of the Environment. (ARA, 2021)
ARA-funding	Interest-subsidy loans for the new construction, renovation and purchase of housing. Granted by ARA.(ARA, 2017)
Centralized energy production	Large-scale generation of electricity at centralized facilities usually located away from end-users and connected to a network of high-voltage transmission lines. (*Centralized Generation of Electricity and Its Impacts on the Environment | US EPA*, n.d.)
Connection point (electric grid)	A point where the distribution grid is connected to the main switchboard of a house.(Vantaan Energia Sähköverkot, n.d.)
Credit calculation service	A way to calculate that small-scale energy producer either buys or sells power at the same time. One phase can take power and another phase pushes it to the grid. The net sum of these is calculated and result is either selling or buying power.(Vantaan Energia Sähköverkot, n.d.)
Datahub	A centralized data-exchange system where e.g. data of electricity contracts, locations of use and amounts of consumption/production are in on (*Mikä on Datahub? - Fingrid*, n.d.) all vital operators.(Fingrid Oyj, n.d.-d)
Distributed energy production	Energy production where electric, thermal and cooling energy is produced near the site of use.(Hoviniemi et al., 2010, p. 6)
Distribution system operator	Is responsible for distribution of electricity and maintenance of the power grid (Energiavirasto, n.d.)

EU -directive	*“A "directive" is a legislative act that sets out a goal that all EU countries must achieve.”* (European Commission, n.d.-b)
GDPR	General Data Protection Regulation. Regulates the collection and handling of personal information of European Union citizens.(Wolford, n.d.)
Finnish Government	The broad organizational entity consisting of the ministries and the government plenary session format. (Finnish Government, 2021)
Housing company	A limited company who owns and maintains a real estate, e.g. a block of flats.(Kiinteistöliitto, n.d.)
Islanding	The condition where a generator e.g. a solar power plant continues to feed power to a location, although the distribution grid is out of power. (*What Does Islanding Mean?*, n.d.)
Renewable energy	*“Energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas”* (Directive (EU) 2018/2001)
Shareholder (in energy community)	Participants (members) of an energy community. They share the costs and profits from the energy community.

1 INTRODUCTION

As it is commonly brought out, the Earth is in the middle of a rapid climate change. This change is said to be caused by the ever-increasing amounts of carbon dioxide, methane and nitrous oxide gases, the greenhouse gases. These gases are released from human activities such as energy and food production and traffic. The European Union has implemented several measures to lower the emissions of the greenhouse gases and one of them is a transition from fossil energy to renewable energy. In order to hasten this transition, the European Union has implemented legislation which allows the common citizens to be an active part of energy production by forming energy communities. The energy communities set up by citizens would produce renewable energy. The increased production of renewable energy would then replace fossil energy production and lower the greenhouse gas emissions of energy production. An energy community does not need large investments, or they can be divided between several shareholders making it more accessible to people.

The purpose of this research was to study the present situation of housing company-based energy communities and their experiences and the effects to the housing companies and distribution system operators in Finland. The main points of interest were the availability of the credit calculation service, the amount of housing company-based energy communities, their location and the benefits and challenges they had faced. Also, the possibilities for new businesses were charted. Despite of the fact that the energy communities are not designed to give special benefits to the distribution system operators, the communities have an effect to them. The distribution system operators must be aware of the amounts of power production and power quality in their grid. They also may offer a new voluntary service i.e. the credit calculation service, which may have economic effects. The credit calculation service will be mandatory in 1.1.2023 but then the Datahub will take care of the service. The distribution system operators were also in a crucial role when studying the spread of the credit calculation service and the total amount of housing company-based energy communities.

The focus is on housing company-based energy communities because of the European Union's effort to increase the amount of renewable energy production by increasing the citizen's participation in the energy production. The energy communities studied were connected to the national power grid and islanding was not possible.

The experiences of housing company-based energy communities and distribution system operators were seen to be a topical subject as the Finnish legislation was renewed in 1.1.2021 by the Government decree Amending the Government Decree on the Settlement and Metering of Electricity Supplies (2020/1133).(Government Decree Amending the Government Decree on the Settlement and Metering of Electricity (2020/1133), 2020) This decree added the definition of a local energy community into the Government Decree on the Settlement and Metering of Electricity Supplies (2021/767).(Government Decree on the Settlement and Metering of Electricity Supplies 2021/767, 2021)

The housing company-based energy communities were thought to become more attractive via this decree. The experiences from these housing company-based energy communities are yet rare, so there was seen to be a need to study them. From the results, it might be possible to find out points for development in the legislation or policies.

The main research questions of this study were:

- What kind of experiences do the existing housing company-based energy communities and distribution system operators have from the concept of energy communities and the credit calculation system?
- What kind of business possibilities the housing company-based energy communities may provide in Finland?

There were also auxiliary questions to aid finding answers for the main questions. The auxiliary questions were about technical solutions in the housing companies and future visions on the concept of housing company-based energy communities. Also, the spread of the possibility to set up an energy community using credit calculation service was studied.

The research was performed by two questionnaires with semi-structured interviews. One questionnaire to the energy communities another to the distribution system operators in Finland. The data for this research was obtained from 18 distribution system operators all around Finland and five energy communities, of which four were existing ones and one was in the planning phase. The role of distribution system operators is crucial, because the Government Decree on the Settlement and Metering of Electricity Supplies 2021/767 obligates the energy communities to register to the distribution system operator of their area.(Government Decree on the Settlement and Metering of Electricity Supplies 2021/767, 2021)

In the beginning of this thesis, some key definitions are explained such as the concept of energy community and its connection to the Finnish electricity system and electricity market. After that, there is a section where the research methodology and results of the questionnaires and interviews are presented. The emerged business possibilities are handled next and in the final chapter are the conclusions and suggestions for further studies.

2 A HOUSING COMPANY-BASED ENERGY COMMUNITY

The term energy community can have more than one meaning, depending on which directive or law is inspected. In the European Union's Renewables Directive (EU) 2018/2001 (Directive (EU) 2001/77) is defined **a renewable energy community** and in the Electricity Directive (EU) 2019/944 (Directive (EU) 2019/944) is a definition of **a citizen energy community**. In the Finnish Electricity Market Act (2013/588) (Electricity Market Act 2013/588, 2013) and Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021), the energy community is defined as **a local energy community**.

In the Appendix 1 are presented the definitions in the EU and Finnish legal texts. According to the project Compile's report (Roberts et al., 2019, p. 7) the renewable energy community can be seen as a subset of a citizen energy community. However, in this thesis they are treated individually in order to clarify the form of the Finnish local energy community.

The main differences and similarities of the energy communities in the EU and in Finland are presented in the Table 1. The table is compiled from Caramizaru's and Uihlein's report (Caramizaru & Uihlein, 2020, pp. 7–8). Similarities between the different energy community types are highlighted with cyan colored background.

Table 1. Similarities and differences of energy communities in the EU and Finnish legal texts.

	Renewable energy community (Renewables Directive)	Citizen energy community (Electricity Directive)	Local energy community (Finnish legislation)
Energy source	Renewable energy only	Renewable and fossil energy possible	Renewable and fossil energy possible
Locality	Local	No geographic limits	Local
Control and decision making	Controlled by individuals, small/medium scale companies or municipalities etc.	Medium and large-scale enterprises can participate, but not take part into decision making.	Controlled by individuals, small/medium scale companies or municipalities etc.
Aim	To gain economic, social and environmental benefits.	To gain economic, social and environmental benefits.	To gain economic, social and environmental benefits.

There are clear similarities between all three of them, but also some differences. According to Caramizaru & Uihlein (Caramizaru & Uihlein, 2020, p. 8) and the Energy Community Secretariat (Grbić, 2021, p. 5) the citizen energy community is focused on the production of electricity and it may do so using renewable or fossil energy sources, whereas the renewable energy community is to produce electricity and heat from renewable sources only. In the Finnish local energy community, the form of energy source used or produced are not specified. However, one gets an idea from the on Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021, Chapters 1 & 4) that electricity is the form of energy produced as only electricity is handled in the chapters where local energy community is mentioned.

The locality aspect is included here, because the renewable energy community is meant to give benefits to the local community as it is mentioned in the Renewables Directive (Directive (EU) 2018/2001). The Finnish local energy community does not have geographic limitations mentioned in the Finnish Government decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021). The reason behind the locality, according to the European Commission (European Commission, 2020) is the EU's aim to improve the availability of renewable energy, increase the social wellbeing of local communities and ease poverty by better energy availability and lower costs. The citizen energy community does not have geographic limitations according to the Electricity Directive definition.

From the Table 1, it can be deduced that the Finnish local energy community would be closer to the renewable energy community of the EU legislation.

The control and decision making are similar in the renewable energy community and the Finnish local energy community. Excluding the larger entities from the decision making is based on the idea of empowering local communities to participate in the decision making of their own areas (European Commission, 2020).

The aim of all types of energy communities is the same, to gain social, economic and environmental benefits. These benefits, defined by the Energy Community Secretariat (Grbić, 2021) are presented in the Figure 1.

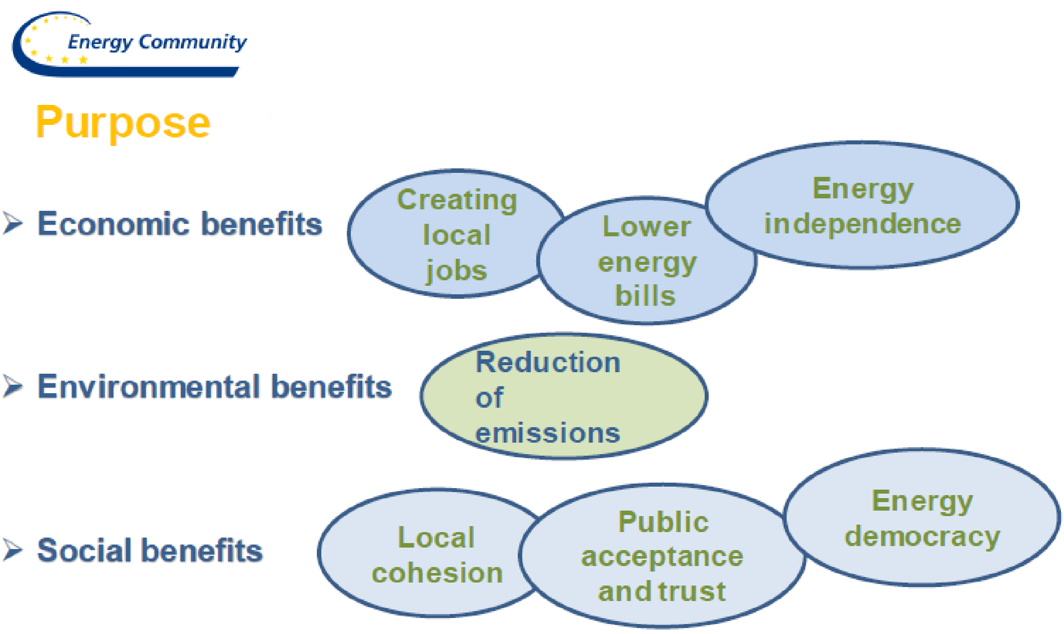

Figure 1. Aim of energy communities in European level.(Grbić, 2021)

The Finnish local energy community has similar aims.

2.1 The three types of local energy communities in Finland

According to the energy community handbook, by VTT and Elenia (Elenia & VTT, 2021, p. 7) a local energy community in Finland can be actualized in three ways. However, the Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021) does not directly indicate the three ways of actualization. These energy community types are more like present ideas of what the legislation allows.

2.1.1 An energy community within a housing company

The first type of energy communities to be presented is called an *energy community within a housing company*. This means, according to the Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) 2021/767, 2021, Chapter 1(3)) that the energy production and consumption sites are located on the same real estate. This is the only type of local energy communities which is written in the Finnish legislation so far.

An example of an energy community within a housing company is presented in the Figure 2. It was modified from a publication of the Ministry of Economic Affairs and Employment (Pahkala, 2019, p. 3)

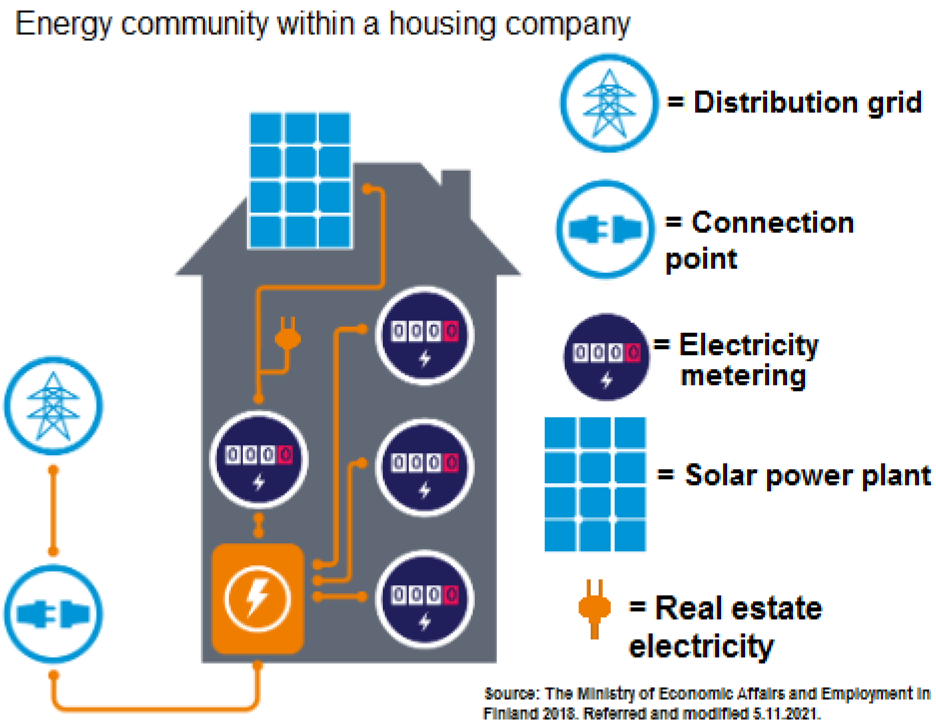

Figure 2. A local energy community within a housing company. (Pahkala, 2019, p. 3)

An energy community within a housing company is for example a block of flats where the power plant is a solar panel array on the rooftop of the building. The electricity from the solar panels is used firstly as real estate electricity, such as elevators, lighting of hallways, etc. The excess power can then be distributed to the residents. Each flat has an electricity meter which follows the amounts of used electricity so, that the credit calculation service can be used. There is also a housing company meter, which follows the amounts of real estate electricity. The overproduced electricity is finally sold out to the retail seller(s) of the energy community or its shareholders as it is forbidden to produce electricity to the grid if there is no buyer for it (Motiva, 2022).

2.1.2 An energy community crossing property boundaries

Another possibility according to the Energy community handbook (Elenia & VTT, 2021, pp. 19–20) for a local energy community is *an energy community crossing property boundaries.* In this version, the electricity production site is not on the same real estate as the site of consumption.

As an example of an energy community crossing property boundaries is presented a housing company which cannot build a power plant at its own real estate, but it would be possible for the neighboring real estate. The housing company can make an agreement with the neighbor that they set up a power plant to the neighboring real estate and the electricity is then transferred to the energy community via a separate line. Normally only the distribution system operators are authorized to build transfer lines, i.e. electric grid at their areas of responsibility. However, in case of a small-scale electricity production the Electricity Market Act (2013/588) (Electricity Market Act 2013/588, 2013, Chapter 3) makes it possible for others to build transfer lines as well.

The possible excess electricity is again sold to the retail seller who the housing company or shareholder(s) have made the sales contract with (Motiva, 2022). A schematic of an energy community crossing property boundaries is presented in Figure 3 which was modified from a publication of the Ministry of Economic Affairs and Employment (Pahkala, 2019, p. 3)

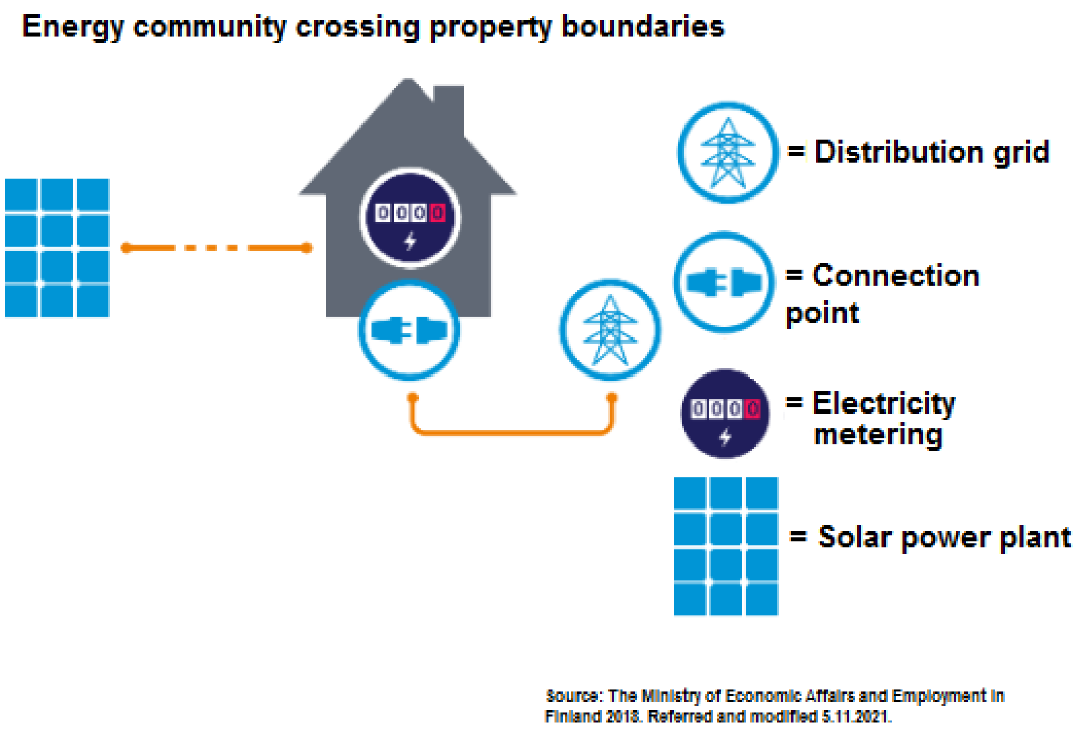

Figure 3. A local energy community crossing property boundaries. (Pahkala, 2019, p. 3)

2.1.3 A distributed energy community

A third option for energy communities is a distributed energy community. In this model, for example a housing company can produce electricity anywhere in Finland. In this case the electricity is transferred to the housing company via distribution grid owned by the distribution system operators and the housing company must pay for the transfer costs and taxes.

According to the Smart Grid Working group (Pahkala et al., 2018) a distributed energy community means a community in which the energy can be produced at geographically separated locations within the boundaries of Finland. In this case, the transferring costs are to be payed to the system operator as well as energy taxes according to the regulations. An example of this type of community could be a person, who owns a summer cottage in another part of the country and has solar power plant installed at the cottage. This person can, by forming a distributed energy community, produce electricity at the cottage and use it in his/her home. Also, larger communities are possible. An example of a distributed energy community is represented in Figure 4. The picture was modified from a publication of the Ministry of Economic Affairs and Employment in Finland (Pahkala, 2019, p. 3).

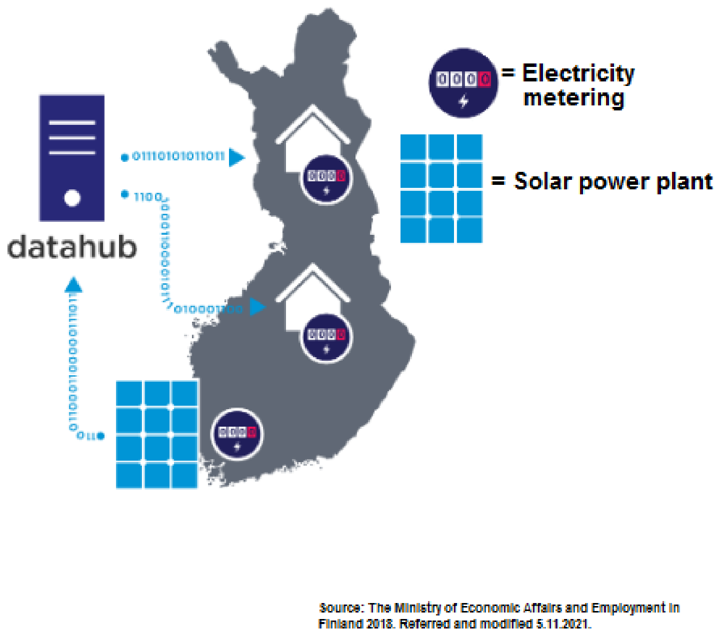

Figure 4. A distributed energy community. (Pahkala, 2019, p. 3)

3 ENERGY COMMUNITIES IN THE ELECTRICITY MARKET

The housing company-based energy communities are a new entity in the Finnish electricity market, and they have an influence on it. In this chapter is presented the present situation in the Finnish electricity market and how the housing company-based energy communities are linked to it.

The Finnish power system is governed by Fingrid, which is the national transmission system operator. It is owned by the state of Finland and Finnish insurance companies and financing companies (Osakkeet Ja Osakkeenomistajat - Fingrid, n.d.). Fingrid governs the high voltage transmission grid, whereas the distribution system operators govern the lower voltage grids. (Fingrid Oyj, n.d.-b).

The production and consumption of electricity in the grid must be in balance all the time. In other words, the supply must meet the demand and vice versa exactly, in order to keep the state of the power system within the set limits. According to Fingrid, the electricity market is an effective way to ensure that. (Fingrid Oyj, n.d.-c)

The following description of the electricity market is based on a video made by the national transfer system operator Fingrid (Fingrid Oyj, 2018). The electricity producers and consumers trade in the electricity market. The market operates followingly: An estimate of consumption and production of electricity for the following day is made on the present day. This is called day-ahead market and in Finland it closes daily at 13.00.

Naturally, as the amount of electricity is only an estimate at this point, a mechanism securing the balance of the grid is needed. This balancing mechanism is called intraday market. In the intraday market, the bidding of purchase and sell of electricity happens within a 1-hour interval. If there still occurs imbalance between the production and consumption, Fingrid can activate balancing market offers to adjust either production or consumption, depending on the need. These balancing offers are made specifically for this purpose.

The price of electricity is formed through the bidding in the electricity market. When the price the producers will accept meets the price the consumers will accept, the price for electricity for an agreed time period is fixed.

3.1 The role of housing company-based energy communities

Housing company-based energy communities have two roles in the electricity market. Firstly, by purchasing electricity from its retail seller and secondly by selling its excess self-produced electricity to the retail seller. Naturally, if there is no excess electricity produced, the energy community or any of its shareholders only purchase electricity.

Especially, when the electricity is produced with weather dependent energy forms such as wind or solar power, the production fluctuation can be large and sudden. This makes it difficult to estimate the daily production in advance. This again causes more need for balancing mechanisms. (Fingrid Oyj, 2018)

The housing company-based energy communities operate, at least at the moment, as small scale producers and consumers so they are not directly participating in the bidding of the electricity market, but indirectly, like households, according to Fingrid (Fingrid Oyj, 2018) who affect the market through the retail seller they purchase their electricity from or sell it to.

Finnish legislation, more detailed the Government Decree on the Settlement and Metering of Electricity Supplies 2021/767, obliges that a party of the electricity market must have an open supplier, whose responsibility is to operate as a balance responsible party. The balance responsible party is responsible for the balancing production or consumption of electricity. This applies also to the housing company-based energy community or its individual shareholders. (Government Decree 2021/767, 2021, Chapter 2)

According to the Government Decree on the Settlement and Metering of Electricity Supplies 2021/767, an energy community or its individual shareholders must have an open supplier, which means for example one's retail seller. An energy community, or an individual must make a sales contract with one's retail seller, so that all possibly produced excess electricity is purchased by this company. The retail seller then acts as a balance responsible party on behalf of the energy community or any of its shareholders. (Government Decree 2021/767, 2021, Chapter 2).

The Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021) also obliges that an energy community must register to the distribution system operator which oversees the metering of the energy community in question. An example of a registration form can be found from the website of Järvi-Suomen Energia, a distribution system operator from Mikkeli, Finland. (Järvi-Suomen Energia Oy, n.d.). The present address of the website is https://www.jseoy.fi/energiayhteisot-kiinteiston-sisalla/#e808211f

3.2 Credit calculation service and phase netting

Orienting from the concept of energy communities, the system operators have got a new task, called credit calculation service. This task is, however, temporary, as after 1.1.2023 the Datahub will be responsible for this service (Hiekka et al., 2021). The aim of the service is to make renewable energy investments in housing companies more attractive by avoidance of grid fees and taxes and also by avoiding the need for housing companies to buy their own electricity metering systems.(Auvinen, 2020, p. 9).

With the credit calculation service, the shareholders of an energy community can get more financial benefit from the self-produced electricity. Without the service, an energy community would have either to sell the electricity to the national grid with the market price or if the electricity would be used in the apartments, they would have to pay for the grid fees and taxes. It is possible to avoid the grid fees by installing meters, which are owned by the housing company. In this case, the distribution system operator meters only the consumption and production of the whole housing company. This system is omitted from this study because it is seen rather complicated and costly in the Finsolar final report. (Auvinen, 2020, pp. 6–8)

According to the Finnish legislation (Electricity Market Act 2013/588, 2013, sec. 22) a system operator is responsible for metering the electricity produced and used by the housing company-based energy community. A system operator is also responsible for sharing the produced electricity between the energy community's shareholders and the housing company. This operation of metering and sharing the power is called credit calculation service. As mentioned before, this operation is to be made by the Datahub after 1.1.2023. (Hiekka et al., 2021)

For the system operator to be able to perform the credit calculation service, it needs metering data. The electricity meter is located between the distribution grid (= network in the Figure 5) and the site of usage e.g. the apartments of a block of flats. See Figure 5. (Vantaan Energia Sähköverkot, n.d.)

The electricity meter must be able to meter and record data from the production and consumption of electricity in the real estate and the system operator must be able to read the meter remotely. This is obliged in the Government Decree on the Settlement and Metering of Electricity Supplies 2021/767(Government Decree 2021/767, 2021, Chapter 6).

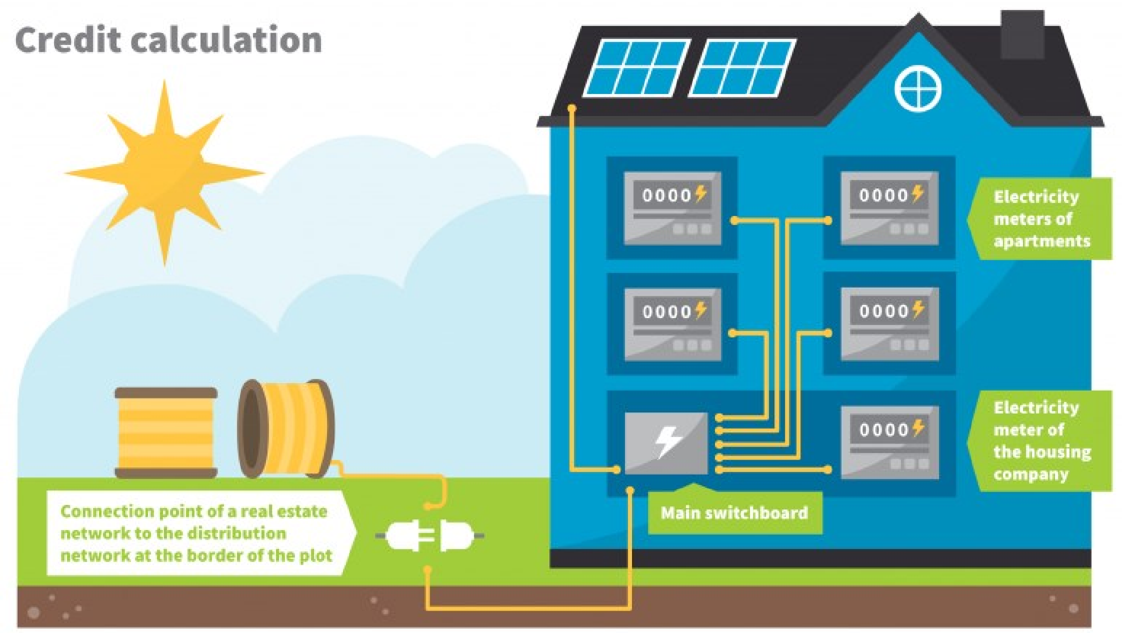

Figure 5. Locations of electricity meters in credit calculation service.

The credit calculation system basically meters the electricity consumed and sold out to the grid. The distribution system operator subtracts the electricity sold to the grid from the electricity used. This way the self-produced electricity lowers the amount of electricity the energy community or its shareholders have purchased. (Vantaan Energia Sähköverkot, n.d.)

With the credit calculation system, a metering system called phase net calculation is introduced. This is explained with the following example.

This example is modified from Auvinen's example (Auvinen, 2019) Let's say we have a whirlpool bath with a heater, and it is connected to one phase. At the same time, a solar power plant at the rooftop of the house produces power to all three phases. The whirlpool bath heater is taking power more than the solar panels can give to that one phase. The two other phases are being fed with power, which is sold out to the grid, because there is no use for that power in the house at that specific time. In reality, the house is producing and using electricity simultaneously. These production and consumption amounts are summed up together so that for one hour, there can be either production or consumption of electricity. This process is called a phase net calculation.

Without this process, the self-producer of electricity would have to pay for the power purchased from the one phase, added with transfer costs and taxes. This system is presented in the Figure 6.

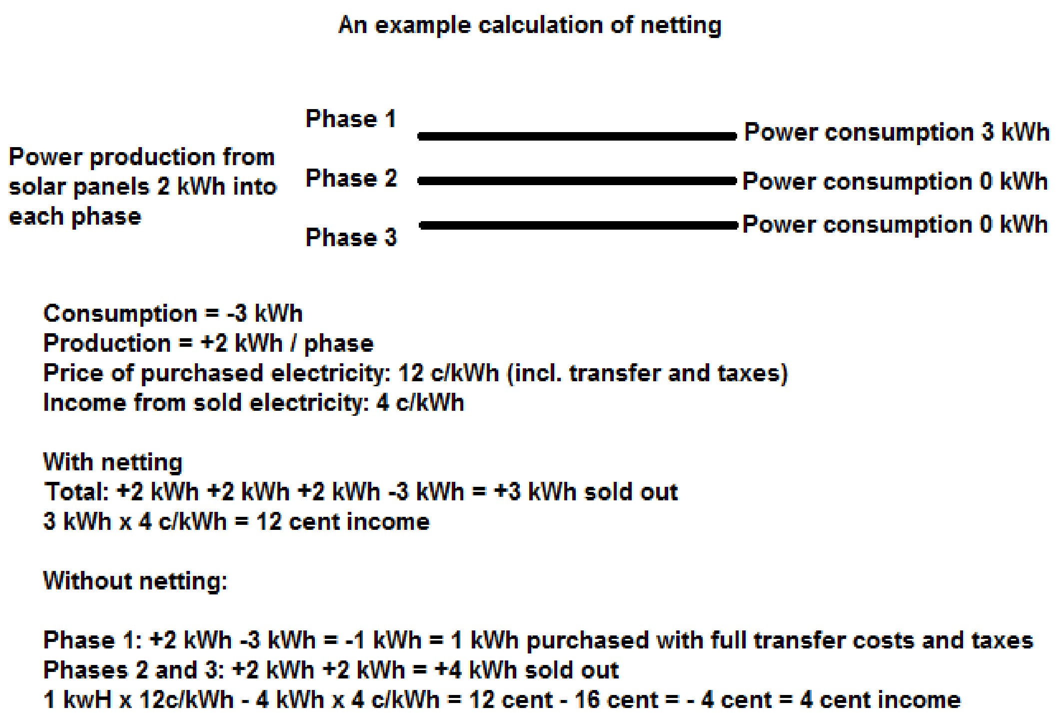

Figure 6. An example of hourly netting calculation.

The credit calculation service uses the figures gained from the phase net calculation and the total amount of self-produced electricity is retracted from the total sum of purchased electricity. The possibly remaining self-produced electricity is mathematically divided between the shareholders apartments of the energy community. The division fractions to the shareholders are for the housing company to decide, according to the Government Decree on the Settlement and Metering of Electricity Supplies 2021/767 (Government

Decree 2021/767, 2021, Chapter 4). Also, if there is still excess amount of electricity produced after all consumption of the community has been retracted, the excess electricity is sold out to the grid.

3.3 Datahub

There are many different operators in an electrical system such as in Finland. The power plants, system operators and end users produce data which are needed to keep the power system in function. The quality of electricity must be within certain specifications, the amounts of produced and used electricity must be in balance, the end users must have correct energy bills so that they pay only from the power they have used, etc. Until recently, this information was being transferred between the different operators of the electric system and it was slow.(Fingrid Oyj, n.d.-d)

This information transferring system has changed as the concentrated data exchange system was built. This system is called Datahub and its purpose is to make the data transfer faster and easier. It started operating on the 18th of February 2022. The Datahub is governed by the national transfer system operator Fingrid Oyj. With the Datahub in action, the authorized parties can obtain all essential information from one place instead of several operators. (Fingrid Oyj, n.d.-a)

One of the Datahub's tasks will be the credit calculation service offered to the energy communities. (Hiekka et al., 2021). This means that the distribution system operators may offer the service only until 13.12.2022 and after that the Datahub will offer the service.

4 METHODOLOGY AND RESULTS

The research was performed as a combination of quantitative and qualitative methods: a questionnaire with semi-structured interviews via telephone and Microsoft Teams. A questionnaire was selected, because it is a fast and cheap method to gather comparable data. A questionnaire is easy to use at a specified target. The anonymity of the respondents was an important factor because the questions handled personal opinions which the respondents might not want to give publicly. Naturally, there was a risk of getting the wrong kinds of answers due to interpretation differences. A representant may understand the question differently as the maker of the questionnaire. (Cleave, 2021)

The semi-structured interviews were performed using the questions of the questionnaires, especially with the energy communities. The interviews were seen important because the respondents from the energy communities were suspected not to be energy sector professionals and some of the definitions might have been difficult to understand and would need to be explained. Also, a larger amount of data was thought to be obtained by personal interviews than with only a questionnaire. As Saaranen-Kauppinen & Puusniekka (Saaranen-Kauppinen & Puusniekka, n.d.) say, with a semi-structured method the interviewees are given the boundaries in which the interview should stay. In this study, the boundaries were set in order to focus on the studied energy community and to avoid irrelevant information.

The required data contained both numerical, quantitative information as well as more qualitative, experience type of information. The reason for this type of approach was due to the multiplicity of the information wanted. Numerical data from e.g. nominal power, production amounts, number of energy communities, etc. were clearly obtainable by a quantitative method, whereas the experiences and future visions were clearly to be treated as a qualitative type of information. According to Heikkilä (Heikkilä, 2014, p. 15), a quantitative research answers to questions like What, Where, How much How often and a qualitative research answers to questions like Why, How, What kind of. In this research both types of questions are included in the research questions, hence the selection of research methods. A questionnaire was selected as the research method because both types of questions can be answered with that.

4.1 The questionnaire to system operators

The questionnaire form (Appendix 2) was sent to 23 system operator companies. 21 of them were, according to the turnover in 2019, the largest companies providing services to private customers (Energiavirasto, 2020). Two companies providing services to industrial customers only, were left out of this survey as energy communities in housing companies are not relevant to them. One company was selected because it has been very active in implementing energy communities in their area and another one from Åland was selected in order to get the whole country covered.

18 answers were received by the given deadline, giving a response rate of almost 80 %, which can be kept a good one even though here one answer would change the percentage by 5 % in either direction. Normally, the response rate in this type of survey has been often below 60 % (Heikkilä, 2014, p. 63). One system operator company from the Lapland region gave answers by telephone.

The results from the system operator questionnaires were divided by their regions of operation instead of more accurate location. This division to regions was made in order to get an overview of the situation in the country without pinpointing any system operator company and to protect the anonymity of the respondents.

4.2 Questionnaire for the energy communities

Another questionnaire was sent to the representatives of the housing company-based energy communities. In the questionnaire following aspects were asked:

- Location
- Number of apartments/shareholders
- Type of building (block of flats, detached house etc.)
- Type of energy community (whole housing company or active clients)
- Metering, distributing the costs and profits
- Financing and operating costs, payback time
- Type of energy production (solar panels, wind etc.) and nominal power of the plant
- Expected and obtained production/profits, energy sold out the power grid
- Energy storage (physical or virtual)

- Reasons to set up an energy community
- Benefits for the housing company/energy community
- Challenges for the housing company/energy community
- Availability of information about setting up an energy community
- New business possibilities for housing companies/energy communities

A semi-structured interview was performed with each four of the energy communities studied as a complementary source of information.

4.3 Results from the questionnaire for system operators

From the answers of the distribution system operators could be seen that their role in the concept of housing company-based energy communities is rather small and will get even smaller in the future. They only register the energy communities and perform the credit calculation system until the Datahub take control of that in 1.1.2023. Therefore, the results from the questionnaire are concentrated and irrelevant issues are omitted.

The system operator companies defined their main region of operation. The answers came from 14 out of 18 regions in Finland. The regions of operation are presented in picture 7. Also, the amount of answers per region is presented in numbers in the same picture.

From the results, it could be thought that credit calculation service is available almost through the whole country, but this is not actually the case. There are 87 distribution system operators in 19 regions of Finland, and this means that in one region can be several system operators. In Figure 7 is illustrated the operating areas of all distribution system operators in Finland. The borders of distribution system operators' areas do not always follow the regional borders.

Therefore, it is possible that only one system operator from a region offers the credit calculation service and others do not even a whole region is marked as one with credit calculation service.

The regions in Figure 7 are colored according to the availability of the credit calculation service. If the service is available now the color is green and the ones without the availability were colored red. In the regions of Southwest Finland, Uusimaa and Kymenlaakso were given both answers, therefore they are striped red with green bottom. This means that the availability of the service depends on the system operator at the specific area. Answers for 5 regions were not received, so they were left blank.

The map is presented in Figure 7.

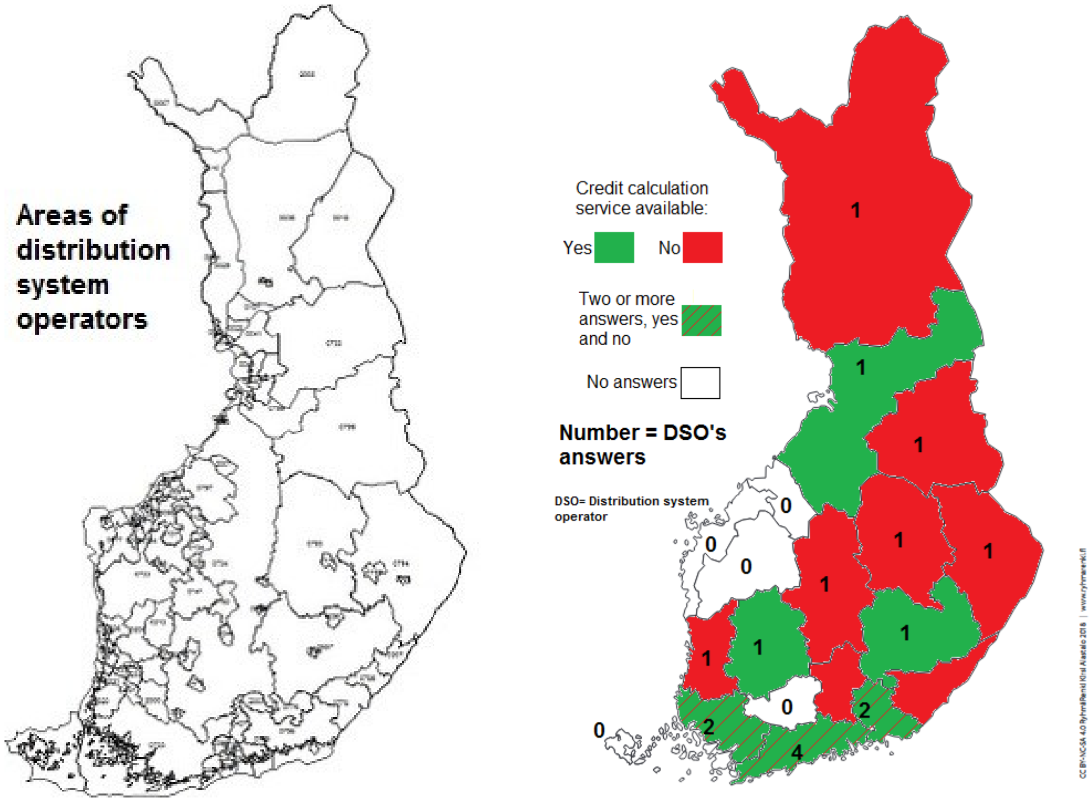

Figure 7. Areas of distribution system operators in Finland (*Sähköverkkoyhtiöt - Energiateollisuus*, n.d.) and availability of credit calculation service regionally in Finland in 09/2021.Map of regions from Alastalo (Alastalo, 2018)

The total number of regions, where credit calculation service is available was 6 and the number of regions where it was not yet available was 8. Number of system operators offering the service were 7, while 11 said to start the service in 2022 or by 1.1.2023, when the service is taken care by the Datahub. These are presented in the Table 4.

Table 4. Schedule of credit calculation service implementation

Schedule	Distribution system operators
Already available	7
During year 2022	6
1.1.2023 (with Datahub)	5

Housing companies had shown some interest in the energy communities and it was emphasized at the beginning of the year 2021, when the new legislation came into power. Only in Uusimaa, one system operator said that there are clearly interested housing companies. From one system operator came an answer saying that there are several housing companies, which already have own small scale electricity production and they could set an energy community up only by majority vote in a shareholders meeting but for some reason they have not done so. The system operator proposed that the landlords/housing companies might not know about the possibility of credit calculation service or an energy community altogether.

The total number of existing housing company-based energy communities in the studied system operators' areas were about 20. An accurate number could not be given, as the answers were not accurate. There were answers which said, "about ten" and "less than ten". Distribution system operators in Uusimaa, Southwest Finland and Pirkanmaa had existing energy communities, one operator in each region. One operator in Uusimaa had an experimental energy community and one system operator in Satakunta had one energy community in planning phase. The regions of existing, experimental and planning phase housing company-based energy communities are presented in Figure 8. The regions with existing energy communities are colored green, the one with the experimental one in green with yellow stripes and the one with the planning phase energy community yellow. The number of energy communities is marked in the regions. From the picture can be seen that the existing energy communities are clearly concentrated in the southern Finland.

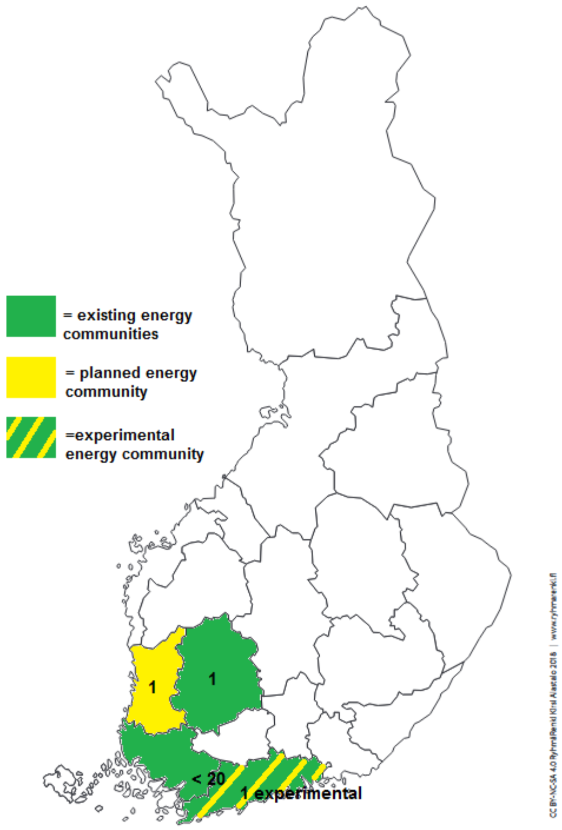

Figure 8. Existing housing company-based energy communities in Finland.

Customer satisfaction and image improvement were the only benefits for system operators. It became clear that distribution system operators cannot really benefit from the energy communities or credit calculation service, but rather suffer extra costs providing the service. The benefits found in the answers are presented in Figure 9.

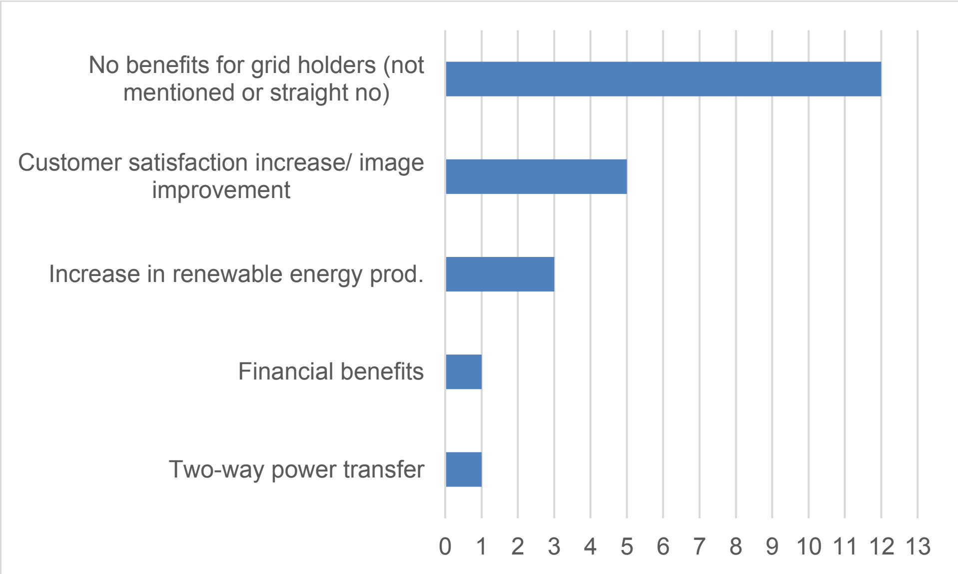

Figure 9. Benefits for system operators, according to the answers to the questionnaire.

The system operators did, however, find benefits for the energy communities/customers. They answered that the energy community decree will make own energy production more profitable for housing companies and that solar electricity production will increase more than without the effort of housing companies.

The challenges were more visible, and one challenge, especially rose from the answers. The adaptation of information systems was the main challenge for the system operators. In total eight system operators mentioned this challenge. This problem was thought to be helped when the Datahub system is in function by five system operators. Other types of problems which were in the answers are presented in the following list:

- Calculations “break” if an electric meter needs to be changed at the location of use
- Compatibility of information systems
- Timetables of system providers
- Calculating correction bills in case of metering errors
- Data maintenance and system changes caused by it
- Investments in the information system properties (two answers)
- Present information systems are not compatible with the demands of an energy community
- Increased bureaucracy when the amount of maintained information increases
- Increased number of customer contacts

Increased operating and investment costs were mentioned by five system operators. The costs in the answers formed from investments in the information system. Energy communities do not provide income to the system operators, only costs.

The concept of energy communities was seen as a new and strange thing for the housing companies by one system operator. One distribution system operator had done their own research and said that in the information system they use, it is possible that the calculations will break, if an electricity meter at a consumption point is changed. More detailed description of this problem was not given. They expect their system provider to fix this problem at some point. They also said that the implementation of the Datahub must not be delayed, so the fix for this problem might be secondary in their worklist. The answers were given before the Datahub as in use. Two distribution system operators answered that there are no challenges. One company said the concept of credit calculation service is straightforward and the specifications are clear. This differed clearly from the other answers.

The challenges are presented in Figure 10.

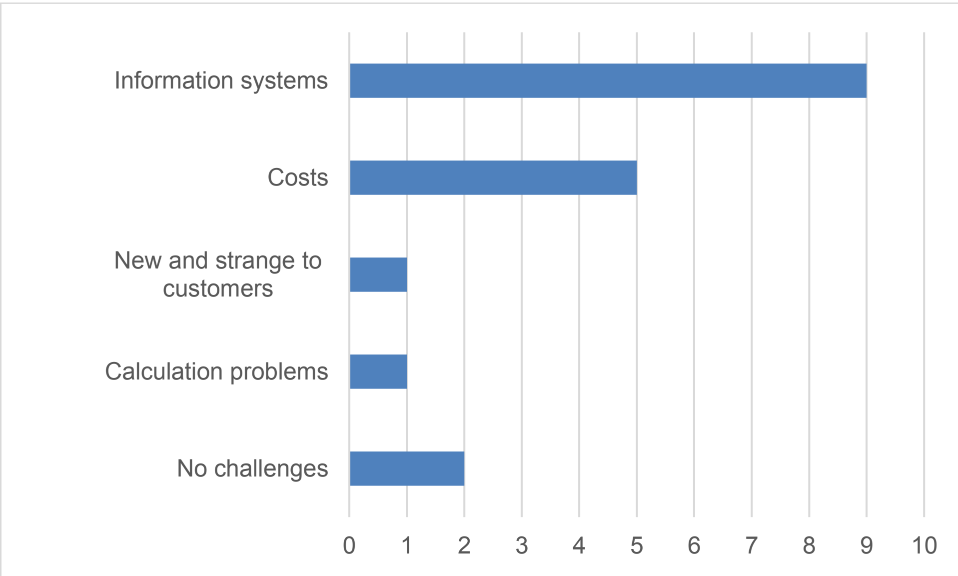

Figure 10. Challenges for system operators.

In question 8., the free comments section, 8 system operators found benefits for the housing companies which are presented in the Chapter 4.4.2.

4.4 Results from the questionnaire for the energy communities

In this research, it was very difficult to get into contact with any energy communities. The distribution system operators, who have the contacts, could not give the contact information without the consent of the energy community representatives as the GDPR-regulations prohibit that. However, a total number of four existing energy communities and two communities in planning phase were able to be contacted for the questionnaires and interviews. The contact information was obtained from one distribution system operator and via social media groups.

The questionnaires were sent to the energy communities via email and the semi-structured interviews were performed via telephone and Microsoft Teams. The results from the questionnaires are presented in Chapter 4.4.1 and comments from the system operators are presented in Chapter 4.4.2.

4.4.1 Answers from the questionnaires of energy communities

The energy communities were anonymized to secure the privacy of the representative persons. The communities were named and numbered in the ascending order of the nominal peak power of the plant, i.e. the smallest one is introduced first. All communities which were questionnaired located in Helsinki, in the Uusimaa region.

There were clear similarities in the four existing energy communities. The most relevant content is presented in the Table 5.

Table 5. Information from the questionnaired housing company energy communities.

Question	Community 1	Community 2	Community 3	Community 4	Development phase community
Type of building	Block of flats & row house	Rowhouse	Block of flats	Block of flats	Block of flats
Number of shareholders (apartments)	34	20	109	55	483
Type of electricity metering	Credit calculation service	Credit calculation service	Credit calculation service	Credit calculation service	Credit calculation service
Power plant technology	Solar panels	Solar panels	Solar panels	Solar panels	Solar panels
Direction of panels	East-West	South-East	South	South-South-East	All directions
Nominal power of power plant	12.2 kWp	13.2 kWp	21.6 kWp	28.5 kWp	180 kWp
Energy storage	None	None	None	None	None

Community 1

This energy community has started operating in 2017 as an experiment in a project called Finsolar. The project aimed towards producing a model in which housing companies could produce solar electricity in an economically profitable way. The implementation of the credit calculation service was also an aim of the project. (Auvinen, 2020)

It is formed by a housing company consisting of two blocks of flats and one row house with 34 apartments. The energy community is formed by all shareholders of the housing company.

This community is the smallest one in terms of nominal peak power in this study. The nominal peak power of the solar power plant was started with 8.74 kWp, but it has now risen to 12.2 kWp due to the addition of new solar panels. The panels are installed in the east-west direction on both slopes of the roof. The produced and used/sold energy is calculated by credit calculation service and that was the method during the experimental phase as well. They do not have an energy storage in physical or virtual form.

Community 2

This energy community has a solar power plant with the peak power of 13.2 kWp. It is formed by a housing company of 20 apartments in row houses. The power plant consists of 33 roof installed solar panels directed to the southeast. They are using the credit calculation service because they it is free, and they find it and easy. They do not have a physical or virtual energy storage.

The predicted annual energy production for this power plant was 11.355 MWh/a but this could not be confirmed because the power plant had been operating for less than three months. From July 22nd, 2021 to October 12th, 2021 the plant had produced 2687 kWh of electricity, which was used in the housing company.

The housing company got the idea to form an energy community from the chairman of the board who had had knowledge of the possibility due to experience of information systems of the energy industry. The financing for the plant investment was included in a loan taken for a ground heat pump investment. It was calculated that dropping out of district heating and producing the needed heat with ground heat pump, the housing company saves in energy costs so much that the loan could be paid by the savings. In that way the monthly costs for the residents would not increase.

The residents had discussed installing a solar power plant previously, so there were no objections towards the energy community. The reasons for setting one up were financial, i.e. savings in electricity costs and environmental.

Community 3

The third energy community consists of 109 apartments in two blocks of flats. The energy community is formed by the whole housing company. The electricity is produced by 54 south-facing panels on the roof. The nominal peak power is 21.6 kWp and the expected annual production was said to be slightly under 20 MWh/a. The plant has been operating since August 2021 and has produced about 5 MWh by October 18th, 2021.

The community uses the credit calculation service as it is free and easy for them. Most of the self-produced electricity is used by the housing company and very little is sold out.

The financing came from the residents with 75 % share and ARA-financing 25 %. The solar power plant was installed in the same energy renovation with a ground heat pump. The housing company dropped out of district heating and started to produce heat with three ground heat pumps.

The idea to set up an energy community came within the board members. The chairman had read about energy communities from a magazine by the Finnish Real Estate Federation (=Kiinteistöliitto) and the housing company board had had a discussion about setting up an energy community.

The benefits were said to be economic and environmental. The savings in the electricity bill were considered to be relatively good.

They found no major challenges in setting up an energy community. In the beginning the concept of the credit calculation system was found to be confusing. They thought that the distribution system operator was not fully aware of the energy community system because the concept was new for them as well. Also, the reason for the sales contract with the retail seller was left unclear. After the start, everything went automatically.

They have no physical nor virtual energy storage.

Community 4

This energy community produces solar electricity for 55 apartments in a block of flats in Helsinki. The nominal peak power of their power plant is 28.5 kWp. They have 85 pieces of 335 W panels on the rooftop facing south-south-east. There were no specific annual production estimates.

All electricity produced is planned to be used at the housing company. They have a ground heat pump which uses most of the electricity produced and the over-production goes to a slightly “over-heating” of three 750-liter water heaters and to the apartments.

The financing came from the shareholders with 75 % share and from ARA-financing with a share of 25 %. The solar power plant was a way to increase the energy efficiency improvements large enough for the ARA - funding terms.

Community 5 (in development phase)

If realized, this energy community would produce solar electricity for 483 apartments. The nominal peak power of the power plant is planned to be 180 kWp. No electricity is planned to be sold out, but all is to be used in the housing companies.

The solar power plants will be an addition to air-water heat pump system which are to be installed as a part of a larger energy renovation. The air-water heat pumps will be the main heat source, but district heating will remain as a backup. The funding is 75 % of a loan and 25 % of ARA-funding. The estimated savings in energy bills are large enough to cover the monthly costs of a loan payback.

4.4.2 Answers from system operators concerning housing companies

Although, the systems operators were not asked about the effects of energy communities to housing companies, they gave following answers.

1. Small scale production is more profitable and attractive
2. Savings in energy costs

4.4.3 Benefits and challenges for energy communities in total

The interviewed energy communities had similarities in many aspects. They were all located in Helsinki, the solar power plants and the energy communities were set up as a part of a larger energy renovation project. The benefits and challenges were similar in all the studied communities. The benefits found from the questionnaires and interviews are presented in Figure 11. The most important benefit was seen to be savings in energy bills. This may, however, be a little misleading, as the electricity production itself was only a small fraction of the total savings in energy costs in all the studied housing companies. The change from district heating to heat pumps brought most of the energy bill savings.

The increase in estate resale value was seen to happen due to the large renovations of the buildings, modern energy production technology installations and lower energy costs. This also affected or was suspected to shorten the resale time of apartments. All in all, the energy renovations were seen to make the apartments more attractive to home buyers. Therefore, the resale time would be shorter than before the renovation /setting up the energy community.

Two answers said that producing clean energy gives a feeling of doing good for the nature.

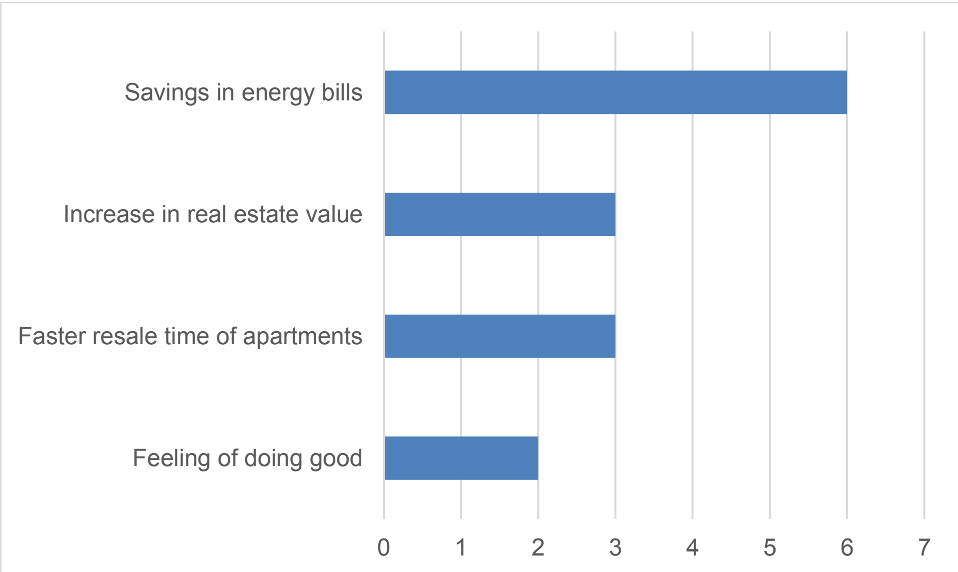

Figure 11. Benefits according to the studied energy communities

There were not too many challenges found by the energy communities' questionnaire. Even though setting up an energy community was seen to be easy, there were answers saying that there was not enough information on the concept of energy communities.

From the interviews it was found out that one needs to be active in finding the information in order to successfully set up an energy community. In case of the studied energy communities the chairmen of the housing company boards were already aware of the possibility of an energy community and they were actively involved in energy savings and renewable energy production issues.

The sizing of the solar power plant was thought to be difficult by one housing company. The sizing is normally suggested by a power plant supplier, but the final decision is to be made by the customer, here the housing company. The problem behind the sizing was to figure out how much electricity could be produced to own use; how much would be sold out and what would that mean in terms of payback time and investment costs.

One housing company said there were no challenges whatsoever.

The representative of Community 5 told that the setting up of the energy community is delayed because of a problem in the legislation. This housing company has 14 buildings and each building has its own connection point of the electric grid. The Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021, Chapter 1(3)) declares, that an energy community must be connected to the grid by one connection point. This means, that this housing company must, in order to get the benefits of the credit calculation service, set up 14 energy communities. This, according to the housing company representative, causes a lot of extra work for them. The housing company has talked about this problem with the Energy Author of Finland (=Energiavirasto) who have forwarded the issue to the Ministry of Economic Affairs and Employment (=Työ- ja elinkeinoministeriö). Possible changes in the decree will take time and the result is uncertain. It might be that the housing company must set up 14 energy communities after all.

Naturally, they could leave out some buildings from the energy community, but then they would break the law (Limited Liability Housing Companies Act 2009/1599, 2009, Chapter 10) by discriminating the equality of all shareholders of a housing company.

The representative told also about another problem derived from this property of the Government Decree on the Settlement and Metering of Electricity Supplies (2021/767). He said that a housing company cannot build the most energy and cost-efficient solar power plant because every building must have panels on their rooftop if they want to be a part of an energy community. It is not possible to install solar panels to the best, most efficient rooftops and then distribute the power to all buildings. In this case the connection point of the grid is crossed, and the situation would be like in a distributed energy community, where they would have to pay the grid fees and taxes.

4.4.4 Points of interest from THEMA Consulting Group's study

In this chapter are presented some relevant issues from foreign energy communities. The information was gathered from a study made for The Norwegian Water Resources and Energy Directorate (NVE) by THEMA Consulting Group.

The study showed that the energy communities generating energy in Norway, Germany and Sweden (Hentschel et al., 2018, pp. 18–24) were significantly larger than the housing company-based ones in Finland. Therefore, they are not fully comparable with the counterparts in my study in terms of size and production amounts. The positive and negative impacts, however, can be compared with the Finnish housing company-based energy communities as the aims of the energy communities are similar in both occasions.

Their findings on the positive and negative impacts i.e. benefits and challenges are compared to the findings of this study in Chapter 5.

The THEMA Consulting Group searched for positive and negative impacts of energy communities. A compilation of their findings is presented in the Table 7.

Table 7. Positive and negative impacts of energy communities (Hentschel et al., 2018, p. 29)

Positive impact	**Negative impact**
Lowered costs (power purchase & grid costs)	Financial (investment costs)
Improved energy efficiency	Increased governance costs
Local job creation	Not in my backyard attitudes
Reduced emissions of energy production	

The lowered costs consist of savings in energy costs and transfer costs and taxes. The need to purchase electricity is smaller when part of it is produced in the housing company's own power plant. Also, from the self-produced electricity, no transfer costs or taxes need to be payed. It was said in the THEMA's study that energy efficiency in total could increase due to the awareness of energy issues and energy renovation projects inspired by that.

It was seen that new business would arise from wide spreading renewable energy production, creating new jobs at local level.

Naturally, the emissions would reduce when renewable energy is produced.

The negative impacts were seen to be financial i.e. large investment costs and governance costs in housing companies, but also attitudes of people might get into the way of producing renewable energy in a community. Not in my backyard means that a person supports something, in this case renewable energy in principle, but does not want to have a power plant (e.g. a wind turbine) near one's own home.

4.5 Short summary of results

The role of distribution system operators in terms of housing company-based energy communities is small and will get even smaller with the Datahub starting to take care of the credit calculation service. The benefit for them at this point is increased customer satisfaction. For the housing companies the benefits were savings in electricity bills, estimated increase in the value of real estate and faster resale time of apartments. As a social benefit the feeling of doing good for the nature via renewable energy production was also mentioned.

The nominal power of the solar power plants of the existing energy communities varied from 12.2 to 28.5 kWp. They were dimensioned so that no electricity would be sold out. This was due to the low price of sold electricity. They had thought that the payback time for the investments would get too long if the plants would have been larger and the investments bigger. The payback times of the present solar panel investments were said to be from 8 to 15 years which is a rather large variance. The 15 years payback time was for an investment made already in 2017 when the prices of solar power plants were higher (Motiva, 2021)This is probably in reality the payback time of the whole energy renovation investment which includes the solar power plant.

The challenges for the distribution system operators were financial due to increased costs from modifications of the it-systems. For the housing companies the challenges rose at the beginning of setting up an energy community. Once that is done, there is very little for them to do. Rigid legislation was seen to hinder the setting up of larger housing company-based energy communities.

The Norwegian study contains similar aspects with this study such as the motivations/ benefits of local energy communities. The role of distribution system operators was larger in Norway than in Finland as the they had started about 30 % of local energy community projects, whereas in Finland this kind of action was not mentioned at all.

5 NEW BUSINESS POSSIBILITIES

From the questionnaires and interviews and the Electricity Market Act 2013/588 (Electricity Market Act 2013/588, 2013) could be seen that for the system operators, the energy communities cannot offer new business possibilities. The tasks and obligations of a system operator are strictly defined in the Electricity Market Act (Electricity Market Act 2013/588, 2013) so they cannot really offer new services outside the credit calculation service.

The sources for the following business possibilities are derived from the results of the questionnaires and interviews of this study, and from my own reasoning.

5.1 Consulting service

In this chapter is presented my own business idea. Naturally, it is probable that someone else has got the same idea, but here it is represented as my own. As it could be seen from the questionnaires and interviews performed in this study, the housing companies need information and guidance in setting up an energy community. The knowledge they need is related to technology, economy, environment and legislation. It would be helpful if all this could be obtained from one place, person or company. The distribution system operator companies do offer some level of help, but there is room for business for others too. As it was seen from the questionnaire the distribution system operators do not seem to benefit from the energy communities. Therefore, it can be thought that they would not be very keen on putting more resources on the advising service. I think that a separate consulting service would be a needed for the housing companies to get the information they need. The consulting service provider would also advertise or market the concept of energy communities to the housing companies and why not to other parties the concept is available for. Municipalities, congregations, shopping centers etc. would be a large customer group.

The idea I had was to stay only in consulting services and not take part in any purchase, power plant installing or similar issues. This way the consultant might have more reliability when the consultant would not be attached to e.g. one power plant supplier or power company.

The housing companies in Finland are listed and the chairmen of their boards can be reached for example through the SIR Database (RPT Byggfakta Oy, n.d.). The contacting would be via letter, email, phone or even door-to-door approach. Also, advertisements in the magazine Kiinteistöposti could be an effective way to reach the housing companies. This would be relatively big workload, especially at the beginning before the information about the consulting service would spread among the housing companies. A similar approach could work in the case of the other possible energy community builders. The relevant personnel of municipalities, congregations shopping centers etc. could be reached personally or via common marketing channels such as local advertisements, newspapers or for example social media.

The service process could proceed from a brief introduction to more detailed conversations and then into decision to set up an energy community or not. The benefits and challenges, including reference sites would be in the key role when discussing setting up an energy community. The discussions would at first take place between the chairman or the board of the housing company and then widen to the whole housing company. If the housing company would decide to set an energy community up, the consultant would start acting as an interface between the housing company and the other parties on the issue. For example, the consultant could be in contact with the system holder, suppliers of power plants and possibly companies offering energy optimization services. Also, the municipal authorities could be in the list.

The consultant would not take part in the actual selection of the equipment or its provider. He/she would simply present different options from which the housing company can make a choice. Some of the interviewed housing company representatives in this study said that this type of service could or even should be offered by the state, town or other public organization. This would make the consultant look out more trustworthy and the work with the housing company representatives would be easier. If the consultant would work for a public company, the costs for the housing company might be lower due to the lower need for profit of public services. In case of a private entrepreneur, the costs would most probably be higher and that might cause challenges in selling the service, especially if there would be competition between a free of charge or cheap public service and a private entrepreneur.

There are already regional energy advisors (Motiva Oy, 2022) who could work as consultants too, but from conversations with one of them, they could not answer the demand due to limited resources. The service of regional energy advisors is free of charge twisting the competition in the business.

In order to get customers, the consultant should be able to provide things that the regional energy advisors might not be able to give. For example, fast service, multiple areas of expertise e.g. power plant technologies, profitability calculation and excellent social and performance skills. The main competitive advance, in my opinion, would be the availability. A regional advisor might not be able to have as many personal in-depth customer relationships as a private entrepreneur. Also, a regional advisor has a larger area of energy issues to cover than the consultant in this business model. The consultant can focus on the energy communities.

The actual work of the consultant would require some amount of traveling even though the video conference tools are commonly used nowadays.

Challenges in the consulting business would be the sufficiency of customers and reasonable pricing. The reputation of consultants within the common people may be on the negative side. This image could be a drag on the business; therefore, the consultant should be called something else. For example, energy helper or even an energy midwife was suggested by one of the interviewees.

5.2 From energy consumer to energy producer

All Finnish housing companies put together have a large potential for solar electricity production. According the Finsolar project's final report (Auvinen, 2020, p. 2) the theoretical nominal power of solar power plants at housing companies is 1094 MW and the annual production potential ca. 983 GWh. This amount was 1.1 % of Finland's annual production in 2018. Hence, the housing companies in Finland might be a remarkable energy producer at least locally.

In the definition of a local energy community at the Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021) the amount of production of a local energy community is somewhat limited in terms of financial profits. In the 1st Chapter, 3rd section and line 5 it is said: The primary purpose of a local energy community, **instead of financial profit**… etc. This means that when the production becomes a business and the financial benefits large, the energy community seizes to be a local energy community. Personally, I would interpret the sentence so that if an energy community makes annually more money than it uses in energy costs, the remaining income is considered a profit. This however does not forbid the housing company to produce and sell electricity.

Other issues to notice are the nominal power and annual production. The self-produced electricity is free of excise tax up to 100 kVA of plant nominal power an annual production of 800 000 kWh. If plant size or production is higher than that, the community must pay the excise tax, and this again would cut the income. Also, according to the decision KHO:2021:20, of the Supreme Administrative Court of Finland T(KHO:2021:20 - Korkein Hallinto-Oikeus, n.d.) a housing company must pay the value added tax (VAT) for all the produced electricity if the purpose of the electricity production is to make an income. Occasional and small sales of electricity are free from the VAT.

The area needed for solar panels must also be taken into consideration. The 100 kVA nominal power would mean that a housing company should install, for example 286 pieces of 350 Wp i.e. 0.350 kWp solar panels or even more if the nominal power of the panels is smaller than the assumed 350 Wp. Here kVA and kWp are considered as same unit to simplify the example. This means that the space needed is rather large and this might be a limiting factor.

$$\frac{100\ \text{kVA}}{0{,}350\ \text{kWp}_{/\text{panel}}} \approx 286\ \text{panels}$$

If housing companies would for example, install solar power plants larger than their own consumption suggests, the excess electricity could be sold out to the national grid. The financial profitability of this scheme should however be examined more detailed

5.3 Selling waste heat

It is mentioned in the Government Decree on the Settlement and Metering of Electricity Supplies (767/2021) (Government Decree 2021/767, 2021, Chapter 1(3)) that an energy community may produce, deliver, consume, aggregate, or store **energy** or provide **energy** efficiency services, electronic vehicle charging services or other **energy** services to its shareholders. This means all forms of energy, not just electricity. Naturally, if the energy community does not produce any electricity, the credit calculation service is not needed. This, however, does not prevent a housing company from setting up an energy community producing heat instead of electricity. The benefits from that, as the credit calculation service is not used could be a topic for a separate study. At least, the savings from self-produced heat or income from heat sold out could be significant as is represented in the following real-life example.

A housing company from Tampere is producing heat and solar electricity. It was questionnaired with the energy community questionnaire and a semi-structured interview via telephone.

They had not set up a local energy community because they were not aware of the concept of energy communities yet. The credit calculation service was familiar, but they saw no benefits in it as all the self-produced electricity was used as real estate electricity.

Their way of operating is to recover heat from the exhaust air in ventilation system and from the housing company's wastewater with heat pumps. They also have solar collectors at the rooftop adding the amount of sustainably produced heat. Part of the electricity needed is produced with 21 kWp solar electricity plant.

The amount of heat recovered/produced is more than the housing company uses and the excess heat is sold out to the district heating company. In the interview, the housing company representative told that in the year 2020, they had produced about 600 MWh of heat, of which they used 400 MWh in the housing company and sold the excess of 200 MWh to the local district heating network. From the interview came up that with this system, their housing company is carbon negative and the maintenance costs have dropped from 2,60 €/m^2 in 2017 to 1,98 €/m^2 in 2019. This type of heat production and selling is not specified as a part of a local energy company legislation, but it is not forbidden either. The Renewables directive of the EU, i.e. Directive (EU) 2018/2001 of the European Parliament and of the Council 2018 on the promotion of the use of energy from renewable sources (Directive (EU) 2018/2001) aims towards increasing overall renewable energy production and therefore this type of heat production would be recommendable. The financial aspects and possible effects on the district heating company's technical systems should be inspected, maybe as a separate study. This system could be viable for other housing companies in Finland as well. According to a study by Gaia Consulting Oy (Gaia Consulting Oy, 2014) small scale heat production in Finland is minimal. I believe solutions to increase the heat production could be found by a development project.

In addition to the financial aspects and possible effects on the district heating system, the cooled wastewater might influence the wastewater treatment process. From an earlier conversation with a wastewater treatment plant operator Matti Piiroinen in Uusikaupunki, Finland. I learned that the microbial purification processes demand a certain temperature level which should not be undercut. Hence, when implemented in larger scale, the temperature of sewage water flowing to a wastewater treatment plant might get too low. Especially when the plant is relatively small, and the heat recovery systems are widespread in the area. The best option would be, in my opinion, to build heat recovery units at the outflow of treated wastewater, after the biological purification phases. This type of system is already functioning in Turku municipal wastewater treatment plant.(*Lämpöpumppulaitos – Turun Seudun Puhdistamo*, n.d.)

5.4 Aggregation

In the Government Decree on the Settlement and Metering of Electricity Supplies (2021/767) (Government Decree 2021/767, 2021, Chapter 3) it is said that an energy community can aggregate and provide other energy services to its shareholders. Therefore, an energy community or a group of energy communities could start to operate as an aggregator.

Aggregation, according to Fingrid, means that several smaller and possibly distributed electricity production and consumption sites, including storages are combined into one or more larger entities, which can be used as a merchandise in the electricity markets. The entities can be used to balance the electric grid. (Fingrid Oyj, 2021)

The European Union has included the role of an independent aggregator in the Clean energy Package (European Commission, n.d.-a) and more precisely in the EU Directive 2019/944 on Common Rules for the Internal Market for Electricity (Directive (EU) 2019/944 in order to enhance the use of distributed energy resources and demand response.

A study by Pöyry Management Consulting Oy (Pearce & Forsman, 2018), defines the role of this independent aggregator followingly:" Introduction of independent aggregator role has been seen as one way to improve the efficiency of the electricity system by facilitating demand-side response, energy efficiency and automation of electricity consumption in general, e.g. by:

- avoiding or shifting consumption to reduce peak demands;
- increasing the consumption during hours of low electricity price; and

- providing balancing services and increasing security of supply.”

A larger energy community, or even a single entrepreneur might be able to become an independent aggregator. It would also be possible that a group of energy communities would form an entity for the aggregation service. It would require that the energy communities have for example loads which can be switched off during the high-power demand times and switched on or kept on for longer or with more power when the demand is low and price of electricity low. This flexibility of consumption could then be financially compensated to the yielding participants. Profitability and actual implementation of an independent aggregator service would need more research and a good business plan. None of the studied energy communities had planned aggregation. I believe it to be yet a foreign subject to housing companies. In my opinion an independent aggregator could include the housing companies/energy communities as a resource instead of the energy communities becoming an aggregator.

5.5 Savings in electricity prices

This is not actually a business as much as a way to increase the savings from electricity costs. An energy community might get a leverage from larger size when purchasing electricity from the retail market. It is probable that an energy community with, for example 100 or more apartments would get cheaper electricity than one apartment alone. A group of smaller energy communities/housing companies could also purchase electricity together. Here must be taken into consideration that the shareholders of a local energy company can make their own contracts with retail sellers. This would mean that although the housing company has a contract of its own, the shareholders are not necessarily included in that. I would see that if the energy community can negotiate a fair price for the purchased electricity, it would be tempting for the individual shareholders as well.

6 CONCLUSIONS

In this chapter are represented the conclusions of the research. The conclusions are based on the answers from the questionnaire and semi-structured interviews with the energy communities and housing companies. Some observations are also presented based on the THEMA Group findings and comparing them with the Finnish local energy community concept.

The main research questions were:

- What kind of experiences do the existing housing company-based energy communities and distribution system operators have from the concept of energy communities and the credit calculation system?
- What kind of business possibilities the housing company-based energy communities may provide in Finland?

6.1 The Distribution service operator’s experiences

The experiences of the distribution system operators appeared to be from neutral to negative. The negative experiences emerged from the additional costs the credit calculation service causes. Especially costs related to information technology arrangements rose. The lack of positive experiences or benefits, in other words, was somewhat anticipated, as their business is highly regulated by legislation. Anyways, I found it interesting to see, if the distribution system operators had found benefits which are not visible to us. From the results it could be seen that there were none.

Only few of the studied distribution system operators offered the voluntary credit calculation service and the reason for that were the excess costs and information technology related problems. Also, the Datahub will take care of the credit calculation system starting from 1.1.2023 so they saw no reason to offer the service at their own costs for two years.

6.2 The energy communities' experiences

The number of housing company-based energy communities in Finland were rather small, only about 20 communities were found within the questionnaired distribution system operators. The small number of the communities could be explained by the small supply of the credit calculation service. Although there is a large potential for housing company-based energy communities, only about 20 housing companies have set one up. The main reason behind that seems to be a lack of information. The housing companies are not aware of the possibility of the concept of energy communities and/or their benefits. This problem could be helped with the type of consulting service presented in this study.

The European Union's aims (European Commission, 2020) of energy communities were achieved to some extent. The benefits the energy communities mentioned were the savings in electricity costs and environmental benefits in terms of replacing fossil energy with renewable one. They did not mention social benefits, but from the interviews it came up that the shareholders of the studied energy communities had become more aware of energy issues and they took a positive attitude towards renewable energy projects. Local jobs were not created, but I think that the amount of energy communities is still so new that not the possible entrepreneurs nor the housing companies have not thought of that. Again, the small number of energy communities has not caused a growth in demand for services.

The way I see it, the Finnish local energy community (especially the housing company-based ones) provide benefits only to the housing company involved and to the supplier of the energy production equipment. The local community outside the housing company gets very little or no benefits from the housing company-based energy production. I believe it would be wise to develop ways to spread the benefits to a larger area. Perhaps, there is a topic for a more detailed study or a development project.

An interesting notice was that all the studied housing company-based energy communities had performed a larger energy renovation and setting up an energy community was more like a bonus on top of that. Perhaps this idea could be used when marketing the energy communities to housing companies. The investment in solar panels is small compared with the total investment of the housing companywide renovation.

6.3 Finnish local energy community vs. international energy communities

The energy communities abroad according to the study made by THEMA Consulting Group (Hentschel et al., 2018) were large and more complex in comparison with the Finnish ones. In the THEMA study an energy community means more a village scale community than the small housing company-based ones. The benefits and challenges, however, were similar. The savings in energy costs and the increase in real estate value or effects on resale time were found in the THEMA study just like in my study.

Not In My Backyard (=NIMBY) effects and increase of local jobs were not seen in my study. I believe, the reason for that is that the solar power plants are quite undetectable compared with, for example, wind turbines used in the foreign energy communities.

It seems to me that the Finnish legislation emphasizes small and medium sized housing companies, but large housing companies are omitted. The large housing companies, especially if they have several grid connection points, would suffer from setting several energy communities up. The reason behind the somewhat one-sided legislation was not revealed during this study. I suspect that the legislators may have been cautious of not causing a major disturbance in the electricity market by allowing large amounts of new energy producers to enter the market.

I believe that by allowing a housing company with several grid connection points to set only one energy community up; the concept would become more attractive to larger housing companies. Hence, the production of renewable electricity would increase. This change in the legislation should be carefully examined in terms of costs for distribution system operators and the energy communities/housing companies.

6.4 Role of business possibilities

I think that the business possibilities suggested in this study, could help to achieve the aim of creating local jobs and increase the economic and environmental benefits. The consulting service could provide jobs, increased energy production would give income to the housing companies and being a part of an independent aggregator’s resources could give financial benefits to the housing company.

The whole idea of local energy communities in Finland seems to be focused on the production of electricity. Another important issue is the heat production. At the moment the amounts of housing company produced and sold heat is very small. There however, could lie a significant potential of renewable energy. I think it might be a good idea to clarify the legislation in terms of heat production and energy communities.

The most needed and perhaps easiest one to start is the consulting service. The housing companies need information of the energy community concept and the service does not need large investments or construction work.

The housing companies had shown some interest in the energy communities in the early 2021 but the interest had diminished since. One reason for this could be that only few of the system operators offered the credit calculation service at that time. From the interviews a need for more aggressive information campaign rose. It seems that the housing companies are not aware of the profitability of solar power and the changes in the legislation. This could be a job for national or municipal energy authorities or organizations or why not even a private entrepreneur like the consultant in this study. Altogether, more marketing should be made in order to make the housing companies set up more energy communities.

6.5 Reliability and validity of the results

A point to be noticed is that all the questionnaired housing companies had included the solar power production in a larger energy renovation, which would have been made even without the concept of energy communities. Therefore, the results from this study might not be completely valid when a housing company would only install a power plant of their own and form the energy community then. The results of this study apply mostly to an energy community within a housing company and the validity of those is reasonably good. The other types of energy communities would require another, detailed study from their points of view.

The results give a relatively good insight of the present situation of housing company-based energy communities in Finland. The percentage of replies from the distribution system operators was high and they represent a large proportion of housing companies' transfer grid operations giving a good perspective on that field. Due to the same reason, the total number (ca. 20) of the existing housing company-based energy communities is most likely reliable.

The actual answers can be kept reliable, as all the questionnaired housing companies and a majority of the distribution system operators were connected beforehand and explained the aims of the research. They were motivated to answer, so the answers can be kept trustworthy.

The results apply to the present time and they may change in time as the legislation and electricity markets may evolve.

6.6 Evaluation of the study

The methods selected for this study were rather straightforward. A questionnaire gave comparable answers, although sometimes they were not very accurate. Some deduction had to be made in order to unify the data from free text parts of the questionnaires.

The questionnaires and the semi-structured interviews were not too time consuming. The largest single time consumer was the search for existing energy communities. As there was no public record or data bank, I was not able to contact them directly, but had to use the distribution system operators as messengers. Luckily, I got contact information for the energy communities handled in this study.

There were no costs except for time making this study. The distribution system operators and representatives of the energy communities and housing companies were very helpful and supportive. They were keen on reading this thesis when finished.

As a learning process, this study has given a lot, I hope that anyone reading this would, if not learn new things but at least get an idea of doing something better. Topics for further studies were found in this study. The improvement of legislation for one.

For increasing the number of energy communities in Finland an information or marketing campaign for the housing companies would be in place. A marketing study could probably be a good idea too. The new business possibilities presented in this thesis would naturally require more detailed study and these might give topics for new theses also.

For a wider perspective in the field of energy communities, further studies would be welcomed. For example, a study considering energy communities in the public buildings would be useful as this study was limited to only, solar electricity producing energy communities within a housing company.

REFERENCES

Alastalo, K. (2018). *Maakuntartat*. Retrieved March 14, 2022 from https://ryhmarenki.fi/wp-content/uploads/2018/06/Suomi-ja-maakunnat-kartta-ei-nimia.pdf

ARA. (2017). *Funding for the improvement of housing conditions*. Retrieved October 27, 2021 from https://www.ara.fi/en-US/Housing_finance

ARA. (2021). *ARA implements Finland's housing policy*. Retrieved November 11, 2021 from https://www.ara.fi/en-US/About_ARA

Auvinen, K. (2019, March 28). *Aurinkosähkön pientuotannon mittaus on saatava yhdenmukaiseksi kaikille*. Retrieved November 11, 2021 from https://www.energiatalous.fi/?p=2392

Auvinen, K. (2020, March 3). *FinSolar taloyhtiökokeilun tulos: aurinkosähkön hyvityslaskentamalli toimii ja sen salliva lakimuuutos on tulossa | Finsolar aurinkoenergiatietoa*. Retrieved November 22, 2021 from urn.fi/URN:ISBN:978-952-60-8988-1

Caramizaru, A., & Uihlein, A. (2020). *Energy communities: an overview of energy and social innovation*. Retrieved February 2, 2022 from https://publications.jrc.ec.europa.eu/repository/handle/JRC119433

Centralized Generation of Electricity and its Impacts on the Environment | US EPA. (n.d.). Retrieved November 15, 2021, from https://www.epa.gov/energy/centralized-generation-electricity-and-its-impacts-environment

Cleave, P. (2021). *Advantages Of Questionnaires In Online Research - SmartSurvey*. Retrieved March 3, 2022 from https://www.smartsurvey.co.uk/blog/advantages-of-questionnaires-in-online-research

Directive (EC) 2001/77. Directive of the European Parliament and of the Council on the promotion of electricity produced from renewable energy sources in the internal electricity market; Official Journal L283, 27.10.2001, p. 33, Celex no 32001L0077. Retrieved December 15, 2021 from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32001L0077

Directive (EU) 2018/2001. Directive of the European Parliament and of the Council of on the promotion of the use of energy from renewable sources; Official Journal L 328, 21.12.2018, p. 82, Celex no 32018L2001. Retrieved November 8, 2022 from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG#d1e1159-82-1

Directive (EU) 2019/944. Directive of the European Parliament and of the Council on common rules for the internal market for electricity and amending Directive 2012/27/EU; Official Journal L 158, 14.6.2019, p. 125, Celex no 32019L0944. Retrieved November 17, 2021 from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0125.01.ENG&toc=OJ:L:2019:158:TOC

Electricity Market Act 2013/588, Finnish Government: Helsinki, Finland 2013. Retrieved November 26, 2021 from: https://www.finlex.fi/fi/laki/ajantasa/2013/20130588

Elenia, & VTT. (2021). *Energiayhteisö-käsikirja*. Retrieved February 2, 2022 from https://www.elenia.fi/files/7de35936c413685a502e8cfe531bdc1e42653201/elenia-energiayhteisokasikirja.pdf

Energiavirasto. (n.d.). *Verkkotoiminnan luvanvaraisuus*. Retrieved October 21, 2021, from https://energiavirasto.fi/verkkotoiminnan-luvanvaraisuus

Energiavirasto. (2020). *Sähköverkkoyhtiöiden eriytetyt tilinpäätöstiedot ja taloudelliset tunnusluvut 2020*. Retrieved November 16, 2021 from https://energiavirasto.fi/verkkotoiminnan-julkaisut

European Commission. (n.d.). *Clean energy for all Europeans package*. Retrieved November 17, 2021, from https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en

European Commission. (2020, December 14). *Energy communities*. Retrieved December 10, 2021 from https://ec.europa.eu/energy/topics/markets-and-consumers/energy-communities_en

European Commission, D.-G. for C. (n.d.). *Regulations, Directives and other acts*. Retrieved November 15, 2021, from https://europa.eu/european-union/law/legal-acts_en

Fingrid Oyj. (n.d.-a). *Datahub tulee-mitä se tarkoittaa toimialalle?* Retrieved March 20, 2022, from https://www.fingrid.fi/globalassets/dokumentit/fi/sahkomarkkinat/vahittaismarkkinoiden-tiedonvaihto/datahub_mita-se-tarkoittaa-toimialalle.pdf

Fingrid Oyj. (n.d.-b). *Fingridin sähkönsiirtoverkko*. Retrieved November 15, 2021, from https://www.fingrid.fi/kantaverkko/sahkonsiirto/fingridin-sahkonsiirtoverkko/

Fingrid Oyj. (n.d.-c). *Johdanto sähkömarkkinoihin - Fingrid*. Retrieved December 14, 2021, from https://www.fingrid.fi/sahkomarkkinat/markkinoiden-yhtenaisyys/johdanto-sahkomarkkinoihin/#

Fingrid Oyj. (n.d.-d). *Mikä on datahub?* Retrieved November 15, 2021, from https://www.fingrid.fi/sahkomarkkinat/datahub/

Fingrid Oyj. (n.d.-e). *Osakkeet ja osakkeenomistajat*. Retrieved November 15, 2021, from https://www.fingrid.fi/sivut/sijoittajat/osakkeet-ja-osakkeenomistajat/

Fingrid Oyj. (2018). *Electricity market explained by Fingrid*. Retrieved February 27, 2022 from https://www.youtube.com/watch?v=dNU8p71p020&ab_channel=FingridOyj

Fingrid Oyj. (2021). *Aggregation Pilot Project in the Balancing Energy Markets*. Retrieved November 18, 2021 from https://www.fingrid.fi/en/electricity-market/market-integration/the-future-of-the-electricity-markets/aggregation-pilot-project-in-the-balancing-energy-markets/

Finnish Government (2021) *About the Government*. (n.d.). Retrieved November 15, 2021, from https://valtioneuvosto.fi/en/government

Government Decree Amending the Government Decree on the Settlement and Metering of Electricity (2020/1133), Finnish Government: Helsinki, Finland 2020. Retrieved October 10, 2021 from https://finlex.fi/fi/laki/alkup/2020/20201133

Government Decree on the Settlement and Metering of Electricity Supplies 2021/767, Finnish Government: Helsinki, Finland 2021. Retrieved November 15, 2021 from https://www.finlex.fi/fi/laki/ajantasa/2021/20210767#L6

Gaia Consulting Oy. (2014, December 15). *Lämmön pientuotannon ja pienimuotoisen ylijäämälämmön hyödyntäminen kaukolämpötoiminnassa*. Retrieved March 7, 2022 from https://docplayer.fi/12489028-Lammon-pientuotannon-ja-pienimuotoisen-ylijaamalammon-hyodyntaminen-kaukolampotoiminnassa.html

Grbić, B. (2021). *Citizen and Renewable Energy Communities*. Retrieved February 2, 2022 from https://www.energy-community.org/dam/jcr:baeeadab-5084-46be-923c-f9cc358a539e/RECG_ECS_citizen.pdf

Heikkilä, T. (2014). *Tilastollinen tutkimus* (9th ed.). Helsinki: Edita Publishing Oy.

Hentschel, J., Åsmund, J., Borgen, S. T., Jarstein, S., & Duus, H. (2018). *Descriptive study of Local Energy Communities*. Retrieved December 30, 2021 from https://publikasjoner.nve.no/eksternrapport/2019/eksternrapport2019_01.pdf

Hiekka, T., Hellas, T., & Konttinen, E. (2021). *Datahub-webinaari: Datahub 2.0*. Retrieved February 28, 2022 from https://palvelut.datahub.fi/api/documents/file/0-318008-2-415384

Hoviniemi, H., Pesola, A., Vanhanen, J., & Vehviläinen, I. (2010). *Selvitys hajautetusta ja paikallisesta energiantuotannosta erilaisilla asuinalueilla*. Retrieved November 29, 2021 from http://www.motiva.fi/files/7938/Selvitys_hajautetusta_ja_paikallisesta_energiantuotannosta_erilaisilla_asuinalueilla_Loppuraportti.pdf

Järvi-Suomen Energia Oy. (n.d.). *Energiayhteisöt kiinteistön sisällä*. Retrieved November 16, 2021, from https://www.jseoy.fi/energiayhteisot-kiinteiston-sisalla/#e0d1cbc7

KHO:2021:20 - Korkein hallinto-oikeus. (n.d.). Retrieved March 5, 2022, from https://www.kho.fi/fi/index/paatokset/vuosikirjapaatokset/1613470807597.html

Kiinteistöliitto. (n.d.). *Taloyhtiö on osakkaiden omistama asuintalo*. Retrieved November 15, 2021, from https://www.kiinteistoliitto.fi/taloyhtio/

Limited Liability Housing Companies Act 2009/1599, Finnish Government, Helsinki, Finland 2009. Retrieved November 15, 2021 from https://www.finlex.fi/fi/laki/ajantasa/2009/20091599#V22

Lämpöpumppulaitos – Turun seudun puhdistamo. (n.d.). Retrieved November 18, 2021, from https://www.turunseudunpuhdistamo.fi/lampopumppulaitos

Motiva Oy. (2021, October 21). *Aurinkosähköjärjestelmien hinta*. Retrieved March 7, 2022 from https://www.motiva.fi/ratkaisut/uusiutuva_energia/aurinkosahko/jarjestelman_valinta/aurinkosahkojarjestelmien_hinta

Motiva Oy. (2022, February 8). *Energianeuvojat maakunnissa*. Retrieved March 4, 2022 from https://www.motiva.fi/koti_ja_asuminen/kuluttajien_energianeuvonta/energianeuvojat_maakunnissa

Motiva Oy. (2022). *Ylijäämäsähkön myynti*. Retrieved March 4, 2022 from https://www.motiva.fi/ratkaisut/uusiutuva_energia/aurinkosahko/aurinkosahkojarjestelman_kaytto/ylijaamasahkon_myynti

Pahkala, T. (2019). *Energiayhteisöt TEM:n mittauksen taustaryhmässä*. Retrieved November 15, 2021 from https://docplayer.fi/176800490-Energiayhteisot-tem-n-mittauksen-taustaryhmassa-alyverkkoforum-ylitarkastaja-tatu-pahkala.html

Pahkala, T., Uimonen, H., & Väre, V. (2018). *A Flexible and Customer-driven Electricity System Final report by the Smart Grid Working Group*. Retrieved December 20, 2021 from http://urn.fi/URN:ISBN:978-952-327-352-8

Pearce, O., & Forsman, J. (2018). *Independent Aggregator Models*. Retrieved March 20, 2022 from https://tem.fi/documents/1410877/3481825/Itsen%C3%A4isen+aggregaattorin+mallit+26.6.2018/f63589df-49ea-4232-b39a-bb6973407fe2/Itsen%C3%A4isen+aggregaattorin+mallit+26.6.2018.pdf

Roberts, J., Frieden, D., Research, J., Stanislas D'herbemont,), & Eu), R. (2019). *Energy Community Definitions*. Retrieved March 20, 2022 from https://www.compile-project.eu/wp-content/uploads/Explanatory-note-on-energy-community-definitions.pdf

RPT Byggfakta Oy. (n.d.). *SIR Tietokanta*. Retrieved November 24, 2021, from https://sir.fi/

Saaranen-Kauppinen, A., & Puusniekka, A. (n.d.). *KvaliMOTV - 6.3.3 Strukturoitu ja puolistrukturoitu haastattelu*. Retrieved March 7, 2022, from https://www.fsd.tuni.fi/menetelmaopetus/kvali/L6_3_3.html

Sähköverkkoyhtiöt - Energiateollisuus. (n.d.). Retrieved March 14, 2022, from https://energia.fi/energiasta/energiaverkot/sahkoverkot/sahkoverkkoyhtiot

Vantaan Energia Sähköverkot. (n.d.). *Housing companies can now join the credit calculation service*. Retrieved October 21, 2021, from https://www.vantaanenergiasahkoverkot.fi/en/services/housing-companies-can-now-join-the-credit-calculation-service/

What does islanding mean? (n.d.). Retrieved January 4, 2022, from https://www.definitions.net/definition/islanding

Wolford, B. (n.d.). *What is GDPR, the EU's new data protection law?* Retrieved January 4, 2022, from https://gdpr.eu/what-is-gdpr/

Appendix 1.

Article 2(16) Renewables Directive – 'Renewable Energy Community'	**Article 2(11) Electricity Directive – 'Citizen Energy Community'**	**Finnish Government Decree on the Settlement and Metering of Electricity 2021/767 – 'Local Energy Community'**
A legal entity: (a) which, in accordance with the applicable national law, is based on **open and voluntary participation**, is **autonomous**, and is **effectively controlled by shareholders or members that are located in the proximity** of the renewable energy projects that are owned and developed by that legal entity; (b) the shareholders or members of which are **natural persons, SMEs or local authorities**, including municipalities; (c) the **primary purpose** of which **is to provide environmental, economic or social community benefits** for its shareholders or members or for the local areas where it operates, **rather than financial profits**.	A legal entity that: (a) is based on **voluntary and open participation** and is **effectively controlled by** members or shareholders that are **natural persons, local authorities, including municipalities, or small enterprises**; (b) has for its **primary purpose to provide environmental, economic or social community benefits** to its members or shareholders or to the local areas where it operates **rather than to generate financial profits**; and (c) **may engage in** generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders;	A legal entity that: 1) who produces, delivers, consumes, aggregates or stores energy or offers energy saving services to its members or shareholders; 2) is based on **voluntary and open participation**; 3) in which **actual jurisdiction is used by its members or shareholders**; 4) of which the members and shareholders are **natural persons, municipalities or other local authorities** or small/medium sized companies; 5) whose **primary purpose** is, **instead of financial profit, to produce to its members or shareholders or area it is operating benefits connected to environmental, economic, or social community;** 6) whose electricity measurements of the consumption sites of the members or shareholders is in responsibility of the distribution network holder; 7) whose electricity consumption sites are located on the same real estate or corresponding group of estates and are connected to the distribution network holder's grid with the same connection; and 8) whose electricity production equipment and electricity storage belong to the connection referred at point 7.
While not part of the definition, RECS are entitled to ***produce, consume, store and sell*** *renewable energy, including through renewables power purchase*		

agreements, to share renewable energy within the community, and to access all suitable markets		

Appendix 2: Questionnaire for the system operators

Kysymyksiä verkkoyhtiöille

Kyselyn tarkoituksena on kartoittaa energiayhteisöjen nykytilannetta sekä jo toteutuneita tai odotettavissa olevia vaikutuksia verkkoyhtiöille Suomessa. Energiayhteisöllä tarkoitan 1.1.2021 voimaantulleen asetuksen 1133/2020 mukaisia energiayhteisöjä.
Kyselyn tietoja kerätään ainoastaan opinnäytetyötäni varten, eikä tietoja tai tuloksia luovuteta muille osapuolille. Tuloksissa ei tule näkymään vastaajan tai vastaajayrityksen yksilöiviä tai vastaukseen yhdistäviä tietoja. Lista yrityksistä, joille kysely on lähetetty, tulee työhöni näkyviin mutta ei listaa vastanneista yrityksistä. Ainoastaan lukumäärät näkyvät.

Toivon vastauksia 5.10.2021 mennessä.

Kiitän jo etukäteen vastauksistanne, ne ovat työlleni tärkeitä ja toivottavasti teillekin merkityksellisiä.

1.Minkä maakunnan alueella on pääasiallinen toiminta-alueenne?

- ☐ Uusimaa
- ☐ Southwest Finland
- ☐ Satakunta
- ☐ Häme
- ☐ Pirkanmaa
- ☐ Päijät-Häme
- ☐ Kymenlaakso
- ☐ Etelä-Karjala
- ☐ Etelä-Savo
- ☐ Pohjois-Savo
- ☐ Pohjois-Karjala
- ☐ Keski-Suomi
- ☐ Etelä-Pohjanmaa
- ☐ Pohjanmaa
- ☐ Keski-Pohjanmaa
- ☐ Pohjois-Pohjanmaa
- ☐ Kainuu
- ☐ Lappi
- ☐ Ahvenanmaa

2.Onko toiminta-alueellanne energiayhteisön muodostaminen jo mahdollista?

- ○ Kyllä
- ○ Ei

3.Mikäli vastasitte edelliseen kysymykseen ei, milloin energiayhteisön muodostaminen/taloyhtiöiden netotuspalvelu tulee mahdolliseksi?

4.Ovatko taloyhtiöt osoittaneet kiinnostusta energiayhteisöjä kohtaan?

5.Montako energiayhteisöä alueellanne on toiminnassa, mikäli sellaisia siis jo on?

6. Mitkä ovat merkittävimmät hyödyt, joita on saavutettu tai ajattelette voitavan saavuttaa energiayhteisöjen avulla? (teknisiä, taloudellisia yms.)

7. Entä mitä ovat mielestänne haasteet, joita energiayhteisöjen muodostuminen tuottaa tai on tuottanut verkkoyhtiölle?

8. Haluatteko sanoa jotain muuta energiayhteisöihin liittyen?

Appendix 3: Questions for the interviews of the energy communities

Kysymyksiä energiayhteisöille:

1. Sijaintikunta? *Location?*
2. Onko kyseessä kerrostalo, rivitalo, vai omakotitalojen yhteisö*? Block of flats, semi detached house or community of private houses?*
3. Koko taloyhtiö vai aktiivisten asukkaiden ryhmä? *Entire housing company or group of active clients?*
4. Kiinteistön sisäinen, kiinteistörajat ylittävä vai hajautettu energiayhteisö? *Energy community within a housing company, energy community crossing property boundaries or distributed energy community?*
5. Kuinka monta osakasta yhteisössä on? *How many shareholders there are?*
6. Millainen mittaustapa on käytössä? (Takamittarointi vai hyvityslaskenta?) *What is the type of metering? (credit calculation sefrvice or housing company owned meters?*
7. Miksi päädyttiin em. mittaustapaan? *Why the previous method of metering was selected?*
8. Miten tuotot jyvitetään osakkaille (pinta-alan perusteella, osuusmaksun suuruuden mukaan tms.)? *In what way are the profits shared between the shareholders (according the surface area, separate share payment or so)?*
9. Millaisia kustannuksia energiayhteisöstä tulee (kk-maksut hyvityslaskennasta jne*.) What kind of costs the energy community causes? (Monthly fees for the credit calculation service or so)?*
10. Millä teknologialla energia tuotetaan (Aurinkopaneelit, tuuli, biokaasu tms*.)? By what type of technology the electricity is produced (solar panels, wind power, biogas or etc.)?*
11. Jos aurinkovoimalla, mikä on paneelien teho, lukumäärä ja miten ne on sijoiteltu (katolle, seinään, maatelineeseen, ilmansuunta)? *If with solar power, what is the peak power of the panels and how are they installed (rooftop, wall, ground, direction)?*
12. Onko energiavarastoa? Millainen? Kapasiteetti? *Is there an energy storage? What kind? Capacity?*
13. Mikä on laitoksen nimellisteho? *What is the nominal power of the power plant?*
14. Kuinka paljon energiaa jää myytäväksi verkkoon? *How much energy is left over to be sold to the grid?*
15. Käyttääkö yhtiö virtuaaliakkupalveluja? Jos käyttää, mitkä ovat kokemukset palvelusta? *Does the company use virtual battery services? If yes, what are the experiences of the service?*
16. Millaiset tuotto-odotukset laitokselle on laskettu? *What kind of profit/production rates are expected from the power plant?*
17. Millaiset tuotot laitoksesta on saatu? *What are the profits/production obtained from the power plant?*

18. Mistä kuulitte energiayhteisöistä/saitte ajatuksen perustaa sellaisen? *From where did you learn from energy communities/got the idea to set one up?*
19. Millaista tietoa tarvitaan yhteisön perustamiseksi ja sellaista suunniteltaessa? *What kind of information is needed to set an energy community up and when planning one?*
20. Löytyykö tieto helposti? *Is the information easy to find?*
21. Miten rahoitus on järjestetty? (Kaikki osakkailta, energia-avustusta, joku muu…)? *How was the investment funded? (All from shareholders, energy subsidy or something else)?*
22. Millainen takaisinmaksuaika investoinnille on laskettu? *How long is the calculated payback time for the investment?*
23. Oliko yhteisön perustamisen syynä taloudelliset, ympäristöseikat, sosiaaliset vai muut syyt? *Were the reasons for setting up an energy community economic, environmental, social or other?*
24. Tekeekö yhteisö muuta liiketoimintaa energiantuotantoon liittyen ylijäämäsähkön myynnin lisäksi? *Does the community any other business in energy production except the selling of excess electricity?*
    a. Muiden palveluiden osto, kuten huolto, järjestelmän ylläpito jne. *Purchase of other services like maintenance, system governance etc.)*
25. Mitä hyötyjä olette saaneet energiayhteisöstä? *What are the benefits obtained from the energy community?*
26. Mitä haasteita olette kohdanneet energiayhteisön osalta? *What challenges you have met in terms of the energy community?*
27. Muita kommentteja… *Other comments?*