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TECHNOLOGY, COMMUNICATION AND TRANSPORT

HOW TO UTILIZE ENERGY COMMUNITIES IN THE FUTURE IN FINLAND

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SAVONIA UNIVERSITY OF APPLIED SCIENCES | THESIS Abstract

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Abstract

Energy communities play an important role in making the shift to fully green electricity production easier. Energy communities are considered as one of the key components for achieving the EU's energy transition by 2050.The purpose and goal of this thesis was to increase knowledge about energy companies at Tietoevry as a basis for development of new solutions in the energy sector. At the same time the thesis gathered information on the current state of energy communities in selected EU countries and how energy communities could be utilized in the future in Finland. The objective was to study the definition of energy communities, benefits, challenges, and what is the current status of existing energy communities in Finland and in the selected EU countries and what kind of business models could be used with energy communities. The thesis was done for Tietoevry Oyj.

The research method of this thesis was qualitative research with literature review. The research was conducted by utilizing electronically accessible analyses, reports, legislation, websites and other sources. Results related to the research subject and research question were achieved through document analysis. The thesis explored an overview of energy communities in Finland and in the selected top six EU countries. Based on that overview, a summary of potential actions to improve energy community utilization in Finland was presented. Improvement actions were divided into six different categories. Those categories are financial aspects, energy system modelling, increasing knowledge, software systems, acting with new roles and geographical location. The thesis also presented what kind of business models could be used with energy communities and how energy communities in Finland could generate more revenue in the future.

The research results showed that it is obvious that changes in current legislation are needed so that the number of energy communities in Finland can be increased. The only improvement that can be implemented immediately is related to knowledge sharing.

Keywords

energy communities, distributed energy communities, energy + rural areas, virtual energy communities, business models for energy communities and microgrids, EU energy communities

PREFACE

I am very thankful for my working company Tietoevry for providing me with the opportunity to pursue my academic goals while continuing to work. I also appreciate my colleagues who have been patient with all the questions I have asked about energy communities. I also want to thank my thesis tutor Nina Fowler and thesis supervisor Teija Honkanen for their help and encouragement during the process of writing this thesis.

Finally, I want to express my gratitude to my family for their constant love and support. This accomplishment would not have been possible without their motivation and patience.

Kuopio 4.2.2024

Jaana Kanabro

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LIST OF ABBREVIATIONS

BESS	Battery Energy Storage System
BMC	Business Model Canvas
CEC	Citizen Energy Community
CRM	Customer Relationship Management
DSO	Distribution System Operator
EC	Energy Community
EV	Electric Vehicle
IEMD	Intern Electricity Market Directive (2019/944)
P2P	Peer-to-Peer
PV	Photovoltaic
REC	Renewable Energy Community
REDII	Revised renewable Energy Directive (2018/2001)
RES	Renewable Energy Source
SMA/SMB	Surplus Method A or Surplus Method B
SME	Small and Medium-sized Enterprises
TEM	Ministry of Economic Affairs and Employment of Finland (Työ- ja elinkeinoministeriö)
TSO	Transmission System Operator, in Finland Fingrid
VPP	Virtual Power Plant

1 INTRODUCTION

The Nordic countries are working towards a green transition, especially through their power systems. In 2019, the European Commission released a package to promote clean energy for all Europeans. This package introduced the concept of Citizen Energy Communities (CEC) and Renewable Energy Communities (REC). These communities aim to promote the use of distributed energy technologies, enhancing consumer participation in energy markets, and prioritize local electricity production from renewable sources. Members of the energy community can contribute by producing, consuming, sharing, or selling electricity, offering flexibility services, and operating the electricity grid if chosen by member states. (European Commission, 2023)

Energy communities are a hot topic in the energy sector now. Finnish Datahub started to handle energy communities in the beginning of year 2023 and the number of energy communities will arise in the future. Distributed energy communities are something new and Finnish Ministry of Economic Affairs and Employment energy community working group have just released an end-report about different lines/possibilities in the future (TEM, 2023a).

In the final report by TEM, the working group explored and assessed the advantages of distributed energy communities, proposing specific measures through which these communities could foster active engagement in electricity markets. An energy community has the potential to facilitate investments in its own renewable electricity production and enhance energy efficiency, for instance. If electricity sharing is enabled for distributed energy communities, the financial benefits for community members can increase compared to a model where all electricity is procured from an external supplier. For instance, the installation of a solar power system is generally profitable. However, it's crucial to appropriately size the production to optimize the benefits (TEM, 2023a).

1.1 Importance of energy communities

Energy communities play an important role in making the shift to fully green electricity production easier, and they act as both an incentive and a reward for doing so. This transition is anchored in three main elements: the increased production of electricity from renewable energy sources within energy collectives, an elevated public awareness about renewable energy systems, and a decrease in electricity consumption. The final element is not entirely confirmed yet and appears to be strongly influenced by factors such as the proportion of electricity consumption that is self-generated and the initial motivations for self-consumption (Bergren, et al., 2023).

Energy communities are considered as one of the key components for obtaining the EU's energy transition by 2050. Energy communities create new possibilities for end customers to participate actively in energy markets.

1.2 Tietoevry Oyj

This thesis is a research work for Tietoevry related to the current status of energy communities. Tietoevry is a leading software provider for the development of digital products and business models for its customers. Tietoevry is specialized in five end-to-end businesses and designed to create business transformation in the era of data, cloud and automation. Businesses are Tietoevry Care, Tietoevry Industry, Tietoevry Banking, Tietoevry Create and Tietoevry Tech Services. This thesis is done for Tietoevry Industry and on sector Energy & Utilities. (Tietoevry, 2024a)

Energy & Utilities are building a zero-carbon society by providing next-generation energy solutions for energy industry and related stakeholders. They enable energy companies to run operations in the Nordic energy sector market, power grid companies (DSOs) to manage society’s most critical infrastructure and energy companies and industries to optimize their energy usage. Energy & Utilities digitize the value chain, use data for intelligent management, and offer cloud-based modules. Three business domains are Customer Information Systems, Asset & Data Solutions and Consultancy support, that supports the market with industry specific software and consultancy, delivering E2E solution and services. They also study Nordic energy trends and work on e-mobility digitalization. (Tietoevry, 2024b)

The assignor for this work is my working company Tietoevry and the supervisor at work is product owner for our DES -solution (Distributed Energy Solution).

2 RESEARCH IMPLEMENTATION

The framework for this work has been literature research. It formed the basis for formulating the thesis questions and methodology. Qualitative research method has been used in this study because detailed knowledge about energy communities and the recent research results was needed to be able to answer the research questions. This research relies on previous reports, analyses, surveys, legislation, directives, and various other sources in the field, which have been used to gather comprehensive information about the studied topic.

2.1 Objectives and content of the thesis

The purpose and goal of this thesis work is to increase knowledge in our company (Tietoevry Industry – Energy & Utilities) about energy communities as a basis for developing new solutions for the energy sector. At the same time this thesis gives the current state of energy communities in EU countries and how energy communities in Finland could possibly be utilized in the future. This thesis work is related to my working life, and we can utilize this information when we are developing future solutions for our energy customers.

Energy communities for housing cooperatives are something new in Finland now and this thesis will explore what kind of new energy communities could be utilized in the future in Finland. This study will first focus on different definitions related to energy communities, then examine their benefits, challenges, and mitigation actions. After that analyze what is the status of energy communities in Finland. Thesis will also investigate what kind of energy communities exist in other countries and what kind of business models there are available for energy communities.

Following research questions have been analyzed: "*What is the status of energy communities in Finland?*", followed by *"How energy communities have been used in other countries?"* and *"What kind of business models could be possible when using energy communities in Finland?"*

Results for what is the current status of energy communities in Finland, is presented by legislation, examples of energy communities and the number of energy communities. Results for how to utilize energy communities in Finland will be based on the overview of energy communities' status in selected countries. Results for new business models will be presented based on how revenue could be generated with energy communities.

2.2 A mind map of energy community terms

A mind map has been created during this thesis study. In the mind map is gathered all the terms and definitions that are discussed in this thesis. This mind map is illustrated in figure 1, and an overall picture of all terms related to the energy community can be seen there. As can be seen from the mind map, energy community is a complicated term that has many dependencies. This mind map has evolved during this thesis work, and it has been updated regularly. A more detailed figure can be found in Appendix 1.

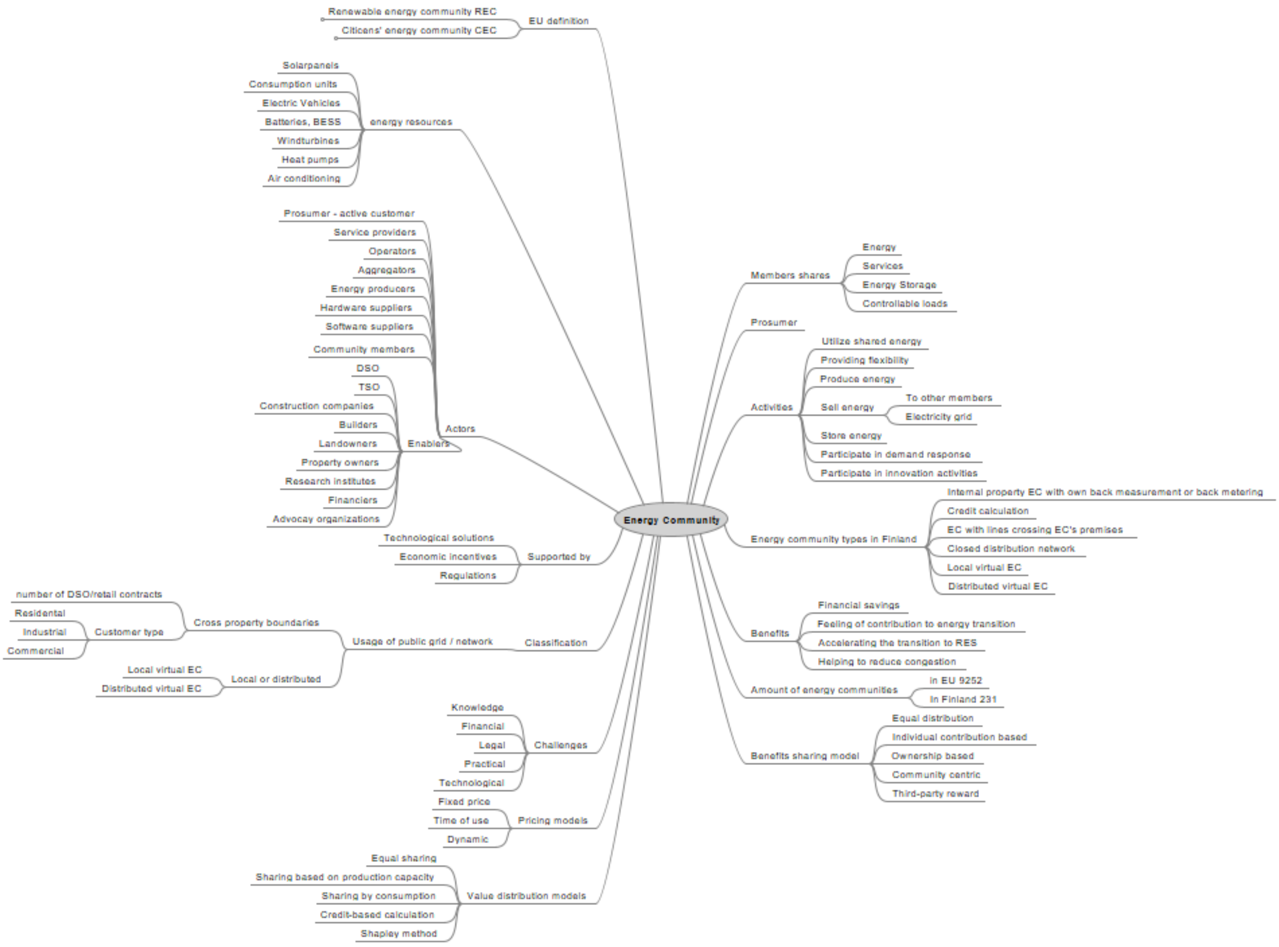

Figure 1. A mind map of energy community terms (Kanabro, 2023)

2.3 Literature review

Method for this master's thesis has been literature review. Acceptance criteria for research articles are done based on research questions. Pretesting of acceptance criteria before final research data selection would improve the reliability of the literature review. Table 1 presents acceptance criteria for research articles that are selected in this thesis. Research articles that do not fullfill these acceptance criteria are excluded from this research.

Table 1. Acceptance criteria

Acceptance criteria for research articles
Material includes information about energy communities and how energy communities have been used in certain country
Material from 2022 – 2023
Full text available
Research results answers the research questions
Language is English or Finnish
Electronically available
Databases: IEEE and ScienceDirect
Material: research paper, EU repository, EU web pages, EU directives
Material only from EU countries

The focus has been on the most recent research papers about energy communities, because energy communities are changing rapidly, and their number is growing constantly.

Material have been collected from ScienceDirect and IEEE with keywords; energy community, energy + rural areas, distributed energy communities, virtual energy communities, EU energy communities, business model for energy communities and micro grids. Keywords have been changed and improved during this thesis writing process.

Focus has been on English and Finnish research papers and most of the research papers are from 2022 and 2023. Focus has been on articles that are available electronically. Books about this topic would have only outdated information. Material has also been gathered from EU Energy Community repository (EU, 2023a; EU, 2023b) and EU rural energy community Advisory Hub (European Commission, 2023).

Articles have been selected only from the EU area, because the focus has been on EU countries. The countries that have been chosen for further investigation are countries that have the most energy communities in the EU. The following six countries have been chosen: Germany, Netherland, Denmark, Austria, Sweden, and Norway. Other countries with fewer energy communities, such as Spain, Italy, and Croatia, are also included. (EU, 2023c; Gjergii, 2023)

Further analysis was done based on acceptance criteria and after that based on the title of the research paper, reading the abstract and conclusion chapter. A more detailed analysis was done by reading the whole article. After all these analysis of research papers, the following four publications that are presented in table 2 are chosen for further investigation.

Table 2. Chosen research papers.

Research article	Published	Reference
Energy Communities: a review on trends, energy system modelling, business models, and optimisation objectives from Barabino et. al	October 2023	(Barabino, et al., 2023)
Energy Community report from Nordic Energy Research group in August 2023	August 2023	(Bergren, et al., 2023)
Measures and business models approaches to facilitate the diffusion and integration of energy communities from Fina & Monshberger in August 2023	August 2023	(Fina & Monshberger, 2023)
Final report Prosumer Centric Energy Communities towards Energy Ecosystem (ProCemPlus) from University of Tampere, Applied Science from Tampere and VTT	November 2021	(ProCemPlus, 2021)

Several research has been focusing on energy communities and benefits on country level, but there has not been much research how to utilize energy communities in Finland based on other countries examples. This is understandable because energy communities for housing companies are new in Finland, starting from beginning of January 2023.

In a recent study from October 2023 Barabino et al. (2023) have analyzed latest energy community literature and they found out that following keywords in figure 2 are most used in energy community studies and indicate the main research directions and current values. They went through 136 research papers that contained 590 different keywords and found out that the most recurring keywords are community, energy community, business model, renewable sources, and optimization.

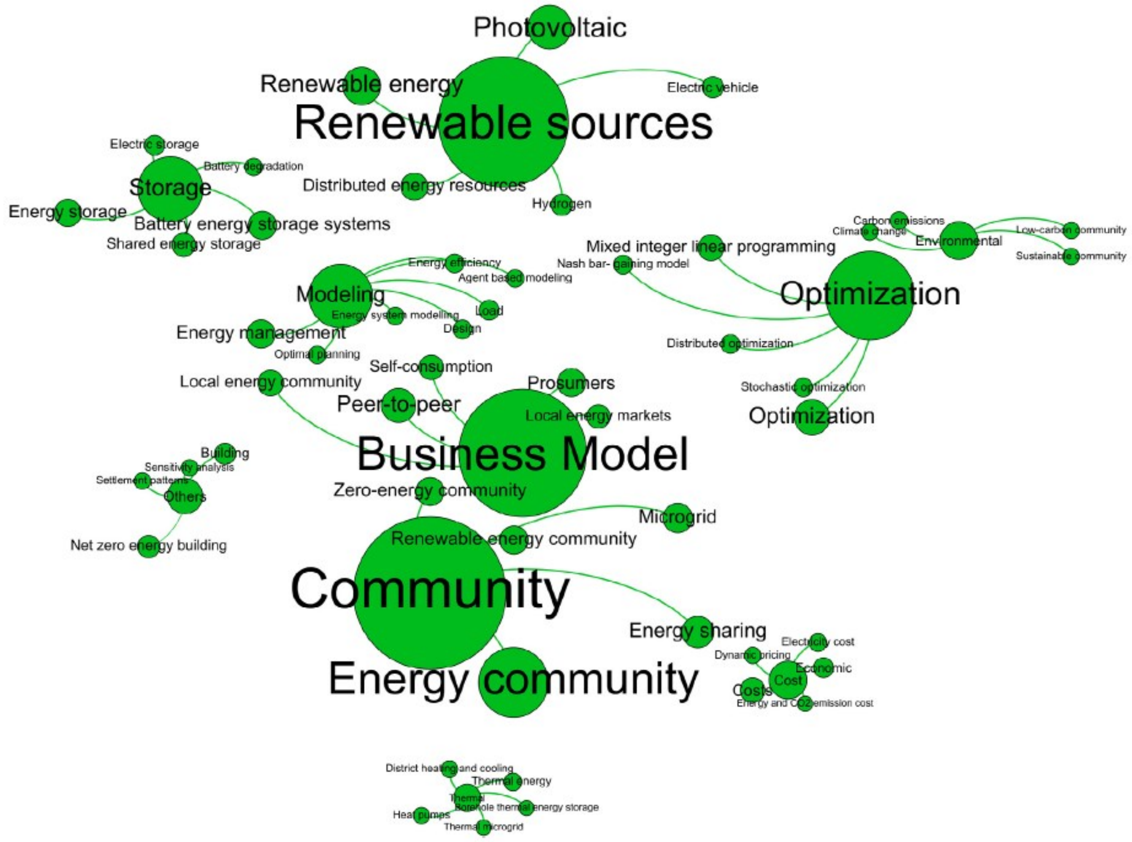

Figure 2. Common keywords used in EC literature (Barabino et al., 2023)

According to Barabino et al., energy community studies have more than tripled in the last year. In their study they analyzed the latest energy community literature and found out that 91 % of studies are dealing with PV technologies. They also analyzed the current collaboration in the EC fields and reviewed technologies and models used in EC studies. They found out that EC project have been categorized with following pricing models: fixed price, time of use pricing or dynamic pricing. EC earnings can come from many sources depending on the market where ECs are participating, like incentives or flexibility market contracts. (Barabino, et al., 2023)

Benefits in EC initiatives can be categorized by the following methods: equal distribution, individual contribution based, ownership based, community centric or third-party reward. Equal distribution means that everyone gets the same number of benefits regardless of their participation. Individual contribution means that benefits are shared based on individual contribution. Ownership based means that those who have invested most in infrastructure will receive a larger portion of the benefits. Community centric means that benefits will be shared to the whole community and could be for example used to fund new investments. Third-party reward means that benefits will be shared for third parties, like energy service providers or private investors. Energy communities' energy systems modelling have been divided to PV plants, battery energy systems (BESS), electric vehicles (EV), wind turbines and heat pumps and air conditioning. (Barabino, et al., 2023)

In Barabino et al. (2023) studies they discovered that ECs are usually operated by virtual platforms or "home managers" software, that can schedule shiftable devices, like washing machines and controllable devices, like air conditioning. These kinds of platform provide day-ahead scheduling, or they could be managed autonomously the load demand on the electric market. They also identified six electric demand side management models. The first model is flexible demand group where a device can be scheduled. The second model is a simple flexible group, where a device cannot be scheduled. Third one is non-interruptible demand group, which means those devices that can't be shifted. The fourth model is interruptible, and it is non-interruptible, but devices can be stopped during the duration window. Fifth model is a bounded, that means devices have a minimum and maximum power, and if there are deviations penalties must be paid. The sixth group is a rule-based model that is predetermined beforehand, like load percentage for devices.

The energy community work group of the Finnish Ministry of Economic Affairs and Employment published a final report of the energy communities and separate lines in April 2023. According to the energy community work group's recommendation, it should be easier for Finland to develop distributed energy communities over all in Finland. That would enhance consumers' opportunities to engage in the electricity market more effectively. (TEM, 2023a)

2.4 Strengths and weakness of the method

Strengths of this literature method is increased knowledge of energy communities and business models. It has improved my critical thinking and analytical skills. Nowadays it is now much easier to get the relevant information from the research paper. I have also been able to see some gaps in research papers, like the definition of energy community. Literature review is effective method to obtain the latest information on new research topic.

Weakness of this method is that it is difficult to decide when enough information and research papers have been collected. New research papers will be popping up every day and someday it is needed to decide that now it is enough. In this study research documents have been collected during the whole writing time; latest one is from this week (18.1.2024). The number of research papers also takes lots of time to read through, in the beginning it is not possible to know how valuable the information is, so the whole research paper must be read. This could be dealt with by skimming or reading in reverse order. It is challenging to identify relevant sources, but if the focus is only on academical sources then it is not a problem.

What should I do differently with next master's thesis writing? If the method would be the same, I would decide in the beginning how many research documents I would select and agree about the time frame when that should happen. I would also document more precisely why I did not select some research papers and what was the reasons for those papers that I selected.

3 ENERGY COMMUNITIES

An energy community can be based on many types of energy related cooperation. An energy community produces energy with shared equipment and distributes the generated energy among the members of the energy community. Energy communities utilize shared energy resources. Energy resources can be production units, like solar panels, consumption units, electric vehicles, and energy storage like batteries. Figure 3 shows a simple illustration of an energy community. It illustrates that the energy community is central and interacts with electric vehicles, buildings, solar panels, power plants, batteries, rural areas, and mobile device control. (European Commission, 2023)

Figure 3. Illustration of energy community (Reschool, 2023b)

According to the European Commission definition, an energy community consists of various actors, including the active customer, prosumer. A prosumer is a consumer who also produces energy and actively participates in the energy communities' operations. Prosumers can generate energy, sell it either to the electricity grid or directly to consumers, store energy in batteries, engage in demand response and contribute to innovation activities (European Commission, 2022).

An energy community is a group of members that can utilize their own joint electricity production to reduce electricity bills of the community members. The role of prosumers in energy communities and future energy ecosystems also includes other activities, such as providing the flexibility needed by the energy system. Prosumers can produce energy, sell it either to the electricity grid or directly to consumers, store energy, for example in an electric car battery, participate in demand response and innovation activities. The activities of prosumers and the energy communities formed by them are supported by various technological solutions, economic incentives, regulation and are also guided by the prosumers' own starting points and motivations. (ProCemPlus, 2021)

Energy communities are usually connected to local distribution grid, but there exist also energy communities that are completely disconnected from the distribution grid. In those cases, the energy community takes care of all functionalities and no connection to the electricity market or agreements with other operators are needed. Differences in the operation of the communities relate to the ownership of resources and the distribution of the cost between the members. (ProCemPlus, 2021)

According to a Finnish research report jointly prepared by the Ministry of Employment and the Economy's Smart Grid Working Group, and Elenia and VTT, three different energy communities have been identified in Finland: an internal property energy community, a cross-property energy community and a distributed energy community, i.e., a virtual energy community. The ProcCemPlus project defines distributed virtual energy communities into local virtual energy communities and distributed energy communities. More detailed information about different energy community types can be found in chapter *3.3 Different energy community types*. (TEM, 2018b; ProCemPlus, 2021; Elenia, 2021)

Energy communities can be defined with various definitions. In the following chapters some definitions will be explained in more detailed way.

3.1 EU definition for energy community

Currently within the EU, there are two primary definitions for energy communities.

According to EU directive 2018/2001 Article 2, **renewable energy communities (REC)** are a legal entity:

(a) "which, in accordance with the applicable national law, is based on open and voluntary participation, autonomous, effectively controlled by shareholders or members 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 the local areas where it operates, rather than financial profits"* (Directive 2018/2001/EU).

RECs are required to be legal entities taking the form of energy communities, and their production must be derived from renewable energy sources. Besides electricity, renewable energy communities also include other types of energy. (Directive 2018/2001/EU)

The concept of **citizens' energy community (CEC)** is defined in the EU directive 2019/944 Article 2 as a legal entity:

(a) "that is based on voluntary and open participation, effectively controlled by shareholders or members who 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 to the local areas where it operates rather than generate financial profits; and*

(c) *may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging service for electric vehicles or provide other energy services to its members or shareholders"* (Directive 2019/944/EU).

CEC is an energy community type limited to consumers and small businesses at the distribution network level. The directive specifically outlines the rights and obligations of energy communities, with a particular focus on CEC. Energy communities of larger companies are outside the scope of EU regulation and do not need to be subject to the same rules. (Directive 2019/944/EU)

According to the EU definition energy communities can be defined as collective initiatives driven by citizens to participate in the transition towards clean energy. These communities strive to enhance energy efficiency and promote the utilization of renewable energy sources within their localities. Through their collaborative efforts, energy communities play a crucial role in advancing the clean energy transition at the grassroots level. Energy communities have the potential to also enhance participation and contribution to flexibility of the electricity market. By implementing demand response and storage solutions, these communities can play a vital role in balancing the supply and demand of electricity. (European Commission, 2023).

It is stated in the EU that energy communities can be established as any type of legal entity, such as an association, cooperative, partnership, non-profit organization, or small/medium-sized enterprise. This allows citizens to collaborate with other market players and jointly invest in energy assets. Therefore, energy communities can help to reduce carbon emissions and make the energy system more adaptable by operating as a unified group and participating in all relevant energy markets on the same terms as other market players (European Commission, 2023).

Relationship between CEC and REC are illustrated in figure 4, as can be seen REC can be seen as a subset or type of CEC. Differences between CEC and REC are presented in table 3. (REScoop.eu, 2023).

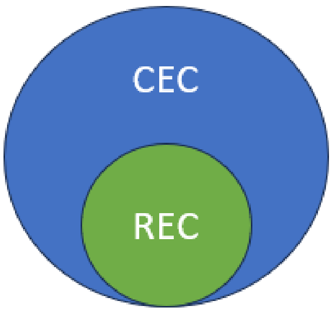

Figure 4. Relationship between CEC and REC (Kanabro, 2023)

Table 3. Differences between CEC and REC (REScoop.eu, 2023)

Differences between CEC and REC		
Aspect	**CEC**	**REC**
Activities	Participate across the electricity sector	Focus on renewable energy sources
Eligibility to participate	Participation is open to organizations of all sizes	Limit participation to micro-, small, and medium sized enterprises
Autonomy	Not mentioned	Must make decisions with greater autonomy and democracy
Effective control	Must be properly managed by individuals, local authorities, or small and micro enterprises	Must be effectively controlled by members in close proximity to the community's project, regardless of size
Legal entity	Do not need to be autonomous	Is autonomous
Relationship	Not a subset	Can be a subset or type of CEC

3.1.1 Status of REC and CEC

The European Federation of Energy Cooperatives (REScoop.eu) have launched a transposition tracker that is continuously updated. The aim of this tracker is to evaluate the progress of how each country adapts the rules on definitions for REC and CEC. The current situation of REC and CEC definition can be seen in figure 5. Green means that there is strong support for the energy community, high transparency, and no support for fossil fuels and definitions are implemented in legislation. Italy, Belgium, Denmark, and France are in category green. Orange means some positive energy community reforms, medium transparency and some or limited support to fossil fuels, but the definitions are not fully implemented in legislation, for example the difference with CEC and REC is not clearly stated. Bulgaria, Croatia, Estonia, Finland, Hungary, Luxembourg, Malta, Portugal, Romania, and Slovakia are in category orange. Yellow color means average progress in definitions, that could mean legal entities are not mentioned in legislation. Cyprus, Germany, Greece, Ireland, Latvia, Lithua, Netherlands, Slovenia and Spain are in category yellow. Red color means no support to energy community, lack of transparency and potential support to fossil fuels. For example Sweden have not formally proposed legislation transposing energy communities and in Czechia there is no legislation related to energy communities. (REScoop.eu, 2024)

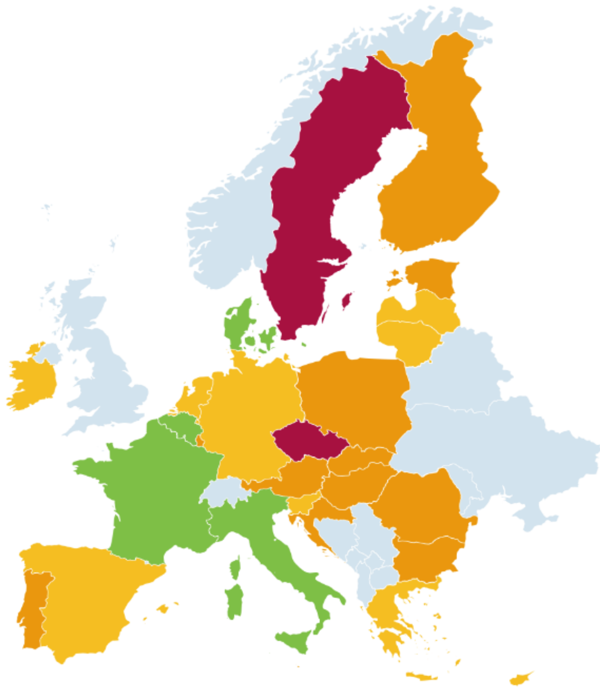

Figure 5. Current state of REC and CEC definition in Europe 3.2.2024 (REScoop.eu, 2024)

In the Nordic countries, the implementation of the REDII (Directive EU 2018/2001) and the IEMD (Directive 2019/944) varies. These directives have become part of the legal systems of Finland and Denmark, but Sweden and Norway still need to adopt the appropriate concepts into their legislation. In Denmark, the legislation promoting renewable energy incorporated RECs in 2021. The executive order that defined RECs and CECs more clearly was also included in the law that regulates electricity supply. This demonstrates Denmark's commitment to promoting renewable energy and empowering citizens and communities to participate in the transition to a more sustainable energy system. (Bergren, et al., 2023)

The implementation of the REDII and IEMD in European countries other than the Nordic ones is also different. Austria has made a lot of progress in implementing the EU directives. In the Netherland, they have combined the CEC and REC definitions into one idea called energy community. In Germany, there is no single definition for CEC or REC. (Bergren, et al., 2023)

3.2 Energy community classification by criteria

ProCemPlus program (ProCemPlus, 2021) classifies energy communities with various criteria, these can be seen in figure 6 in form of a decision tree. The first criteria are usage of public or private grid/network. The second criteria are local or distributed virtual energy community. A distributed virtual EC is like a virtual power plant (VPP) and it can operate geographically nation-wide. A virtual power plant is a decentralized network that aggregates and manages distributed energy resources as a single entity. Distributed energy resources could be solar panels, wind turbines, controllable devices, or batteries. Third criteria are inside or crossing boundaries property. The fourth criterion defines the number of contracts between retail and distribution system operator (DSO) companies. The fifth criterion describes the customer type, if it is a regular customer, industrial or commercial customer. The sixth criteria take account of who owns the energy resources, is it commonly owned or is it members own resources.

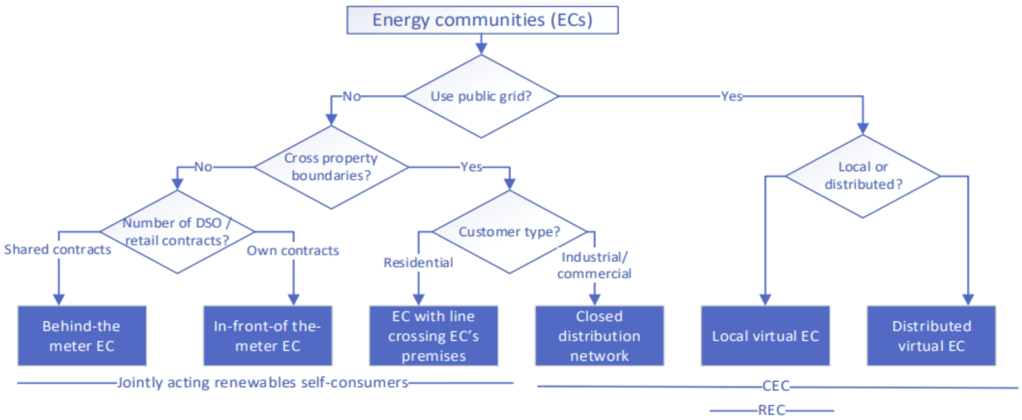

Figure 6. Decision-tree on the EC typology and related EU directives (Valta, et al., 2021)

3.3 Different energy community types

According to ProcemPlus (2021) program there are six different energy community types: inside property with own back measurement or back metering, credit calculation, production connected with own separate lines, closed distribution network, local virtual energy community and geographically distributed virtual energy community. Classification is done based on legislation and the role of different players in the energy market. (ProCemPlus, 2021)

3.3.1 Properties internal energy community

Back metering/measured energy community is property's own internal EC who is responsible for members electricity measurement and production and batteries measurement and billing. Individual members of the EC do not have their own agreements with retailer and distributor energy companies. For example, in a housing cooperative a joint procurement of electricity for users of the property are needed. In communities based on back metering, the internal value distribution model is not as rigid as in the case of compensation calculation, but the community can more freely determine the billing bases suitable for it. (ProCemPlus, 2021)

Definition **property's internal** energy community means that all parties and production and energy batteries are in the same property area or property area group. Local energy community is behind one same electricity delivery point where the energy community is a legal person and energy metering is fulfilled with credit calculations. Example could be a housing cooperative, office building or campus area. For example, in housing cooperatives every member of the EC has own contract with electricity retailers and distribution company, or EC could have only one common contract with electricity retailer and distribution company. Credit calculations enable the production of common energy resources to be shared among the members of the EC according to predetermined sharing ratios, and electricity billing is based on a calculated netted value. Therefore, it is no longer necessary to pay a distribution network fee and taxes for own production because you use the electricity inside the EC and do not use distribution network. (TEM, 2023a; ProCemPlus, 2021)

A back-metered community solution enables dynamic and real-time power management and, in addition to the provision of flexibility, also better sector integration, including the measurement of heat and water and the integration of parking space charging into the community's operations, which increases the cost-effectiveness of the solution. This requires a service provider, which on the other hand offers new business opportunities for current service providers. (ProCemPlus, 2021)

As **credit calculation** is based on fixed sharing ratios, this type of EC focuses specifically on maximizing the consumption of own production. Members could utilize their flexibility potential by shifting their consumption to times when there is a lot of production, but credit calculation does not allow for other functions based on flexibility. In compensation calculation, value distribution is based on a pre-announced distribution ratio and subsequent calculation, and it does not allow for so-called neighbor compensation either. In a compensation calculation community, the total power management of the property's network connection is not included in the community's entirety in the same way as in back metering, where the community can have several functions, some of which can also be based on the utilization of flexibility, either for example to reduce peak power or to be sold on the flexibility market. (ProCemPlus, 2021).

All invoicing components of properties internal energy communities are affected, like energy costs, transfer fees and taxes. These transfer fees and taxes are not paid for self-produced electricity.

3.3.2 Network owned energy community/Crossing property boundaries

A network owned EC means a community who owns the distribution network in its own area and network have several properties in that area. Crossing property boundaries EC is an energy community that can be implemented via a separate line. That means that we can connect energy production from other properties to the energy community.

EU directive 2019/944 gives EU members the option to let citizens energy communities join in distribution networks activities. Finland has chosen not to permit this for now. Currently DSOs have monopoly in Finland and if Finland would permit this, it would require changes in legislation. (ProCemPlus, 2021)

Closed distribution network requires a separate electricity license, which can be granted if electricity network operations are carried out in a geographically limited industrial or business area or in an area providing common services where electricity is not supplied to consumers. The EU Directive 2019/944 has given member states the opportunity to use closed distribution networks in energy communities, which means that closed distribution networks can be CEC if they meet both the criteria for closed distribution networks and citizens' energy communities (TEM, 2023a).

In Finland we have some closed distribution networks, for example Google's Hamina data center industry area (ProCemPlus, 2021).

3.3.3 Distributed energy communities so called Virtual energy community.

Virtual energy community is an EC that operates via public distribution network. Distributed energy communities mean a community that does not locate only on one property or property group and is not an EC that crosses property boundaries. Distributed energy communities can also be called virtual energy communities. (ProCemPlus, 2021)

Both distributed energy communities use public distribution network, but local virtual EC locates only on one distribution network area. Distributed virtual EC can be located on several distribution network areas. Local virtual EC is a community that does not only exist on one property area but still within same distribution network area and all connection points are located via same substation or distribution transformer. Geographically distributed virtual EC members can be located anywhere as can be seen in figure 7. In Finland it means that they do not have to be on same area with distribution grid company. Distributed virtual energy community uses public distribution grid for electricity usage.

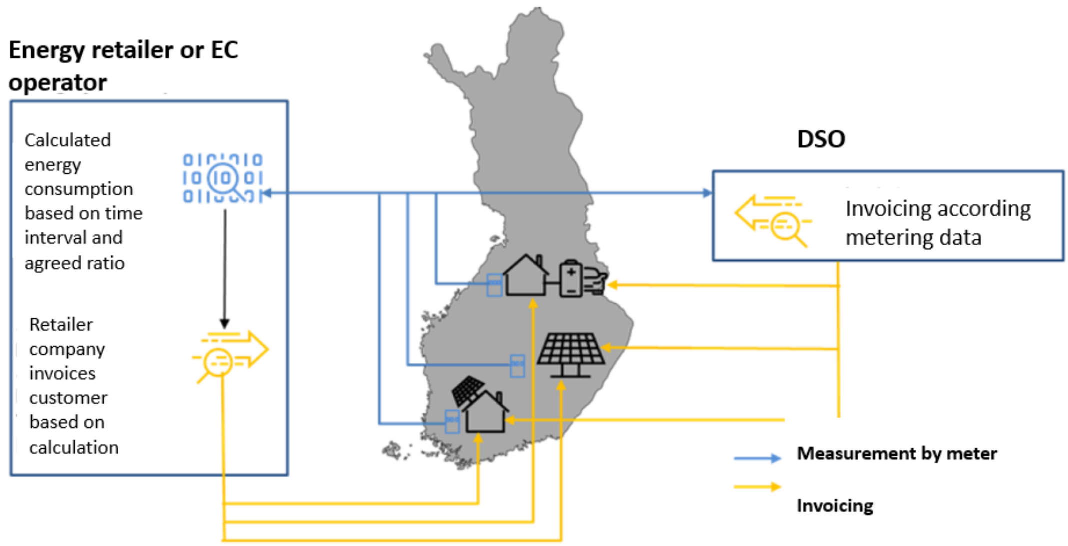

Figure 7. Geographically distributed energy community, modified from (ProCemPlus, 2021)

From the distribution network company's perspective, the members of the energy community are ordinary customers and are invoiced according to normal tariffs based on usage site measurement and electricity tax is paid normally. With the electricity retailer, the virtual energy community can make any desired agreements. Both virtual energy community types can participate in the flexibility markets by forming a virtual power plant (VPP).

Some other countries have implemented different rules for local virtual ECs and ECs are not limited by property boundaries. In Netherland the area is limited to same postal code area. (Iazzolino, et al., 2022)

3.4 Energy community classification according to TEM

Energy communities can be used in sector integration and other forms of energy can also be used in energy communities, but in TEM's report the only focus was on electricity. (TEM, 2023a)

According to TEM latest report energy communities can also be divided by the usage of the distribution network, it could be use of a private network or public network. They have also identified three different energy community types. The first one is an internal property energy community, second one is a property boundary crossing energy community and third one is a distributed energy community, also known as virtual energy community.

Energy communities that use a private network are those that utilize an internal property network or a property boundary-crossing network. Communities that utilize an internal property network are called internal property energy communities and can be further divided into communities that use compensation accounting and those that use back-metering. Property boundary-crossing communities can be implemented using a separate line or closed distribution networks, which are subject to licensing. Energy communities that use a public network are distributed or virtual energy communities, which can be further divided into local and distributed virtual energy communities. (TEM, 2023a). This classification is similar to ProCemPlus classification (ProCemPlus, 2021).

An example of a property's internal energy community is an apartment house with solar panels on the roof. Energy from solar panels will be distributed to all the community members. Example of crossing boundaries energy community is solar panels that exist on different properties and energy will be used in different property.

Distributed or virtual energy communities are not limited to one property or group of properties and can be divided into two different types of virtual energy communities: local virtual energy community and distributed virtual energy community. Within the framework of current legislation, the members of a virtual energy community appear as ordinary consumption/production customers to network companies and other electricity market participants, as well as in the balance settlement. The members of a virtual energy community do not own the network and electricity distribution takes place through the public distribution network. The network company is responsible for metering with its own meters. (TEM, 2023a)

Members of distributed energy communities can locate anywhere in Finland. The benefits of communities are that production of electricity can be implemented in better places, for example solar panels can be on a summer cottage in Lapland and the electricity can be used in Kuopio premises. Virtual energy communities utilize public distribution networks, so there is no need to pay all electricity fees, like tax and transfer fees.

According to TEM, current legislation does not recognize distributed energy communities. Such energy communities can be established within the existing national framework, but there is no specific regulation to promote the proliferation of distributed energy communities. Under current regulation, distributed energy communities are also unable to share energy regionally or nationally in such a way that electricity taken from the grid and self-produced electricity would be netted directly within the balance period. Financial incentives are necessary for distributed energy communities, without them, there will be no formation of distributed energy communities (TEM, 2023a)

The Finnish working group suggests that energy distribution by local energy communities and proactive customers should be made easier across Finland. Local energy communities can help consumers to take part more actively in the electricity market, as they can offset their electricity use within the balance period in local energy communities as well. At the same time, the compatibility of tax laws with local energy communities needs to be studied. The working group thinks that information about energy communities, such as different kinds of communities, how to set up an energy community and how to operate, should be enhanced. (TEM, 2023a)

4 BENEFITS, CHALLENGES AND MITIGATION ACTIONS ABOUT ENERGY COMMUNITIES

4.1 Benefits

Numerous benefits have been linked to energy communities according to Nordic Energy research (Bergren, et al., 2023). Benefits cover financial, environmental, cultural, and social dimensions. Most of these benefits are applicable for both RECs and CECs.

The main motivations and benefits for members to join energy communities are financial savings and a feeling of contribution to energy transition and enhancing sustainability. The financial savings aspect seems to be more relevant now, due to the connection to the energy crisis, increasing costs and the threat of energy poverty.

The ability to generate and deliver energy in isolated and countryside areas improves the dependability of the local source. For example, in Norway, isolated islands frequently experience harsh weather conditions that can result in power outages. The ability for these areas to maintain local energy production through an independent microgrid would guarantee a steady electricity supply, even when the main grid is compromised. (Bergren, et al., 2023)

Secondly, one of the most substantial advantages of energy communities is their role in the shift towards Renewable Energy Sources (RES). Energy communities promote the democratization of the electricity market and boost the independence of citizens in comparison to other participants in the energy and electricity markets. Being able to manage one's own electricity supply, storage, and distribution gives citizens more power and a bigger role in the market. (Bergren, et al., 2023)

Additionally, the robustness of a decentralized and independent energy system has been underscored. A reduced dependence on a centralized grid could assist in mitigating the impacts of external disturbances such as cyber-attacks, sabotage on gas pipelines, or weather-related disturbances. (Bergren, et al., 2023)

Regarding terms of energy or electricity supply, energy communities could benefit the electricity market in several ways. The most discussed benefits include accelerating the transition to RES, increasing capacity and resilience, and helping to reduce congestion. (Bergren, et al., 2023)

By generating and using electricity locally, grid congestion can be lowered by decreasing the demand for transportation through the shared grid. The type of technology used often affects this in Nordic countries. Given that the Nordic regions often face grid congestion in winter, and the Nordic conditions lower the performance of Photovoltaic (PV) systems in this season, having many PV systems in communities could reduce some of the benefits on grid congestion. (Bergren, et al., 2023)

Figure 8 shows a summary of all the benefits that energy communities can offer.

Figure 8. Benefits of energy communities (EU, 2023b)

4.2 Challenges

Nordic Energy research (Bergren, et al., 2023) identifies various challenges that can affect energy communities, such as knowledge, financial, legal, practical, and technological challenges. The following chapters explain the challenges related to energy communities in more detail.

4.2.1 Knowledge challenges

Nordic Energy research found that a frequent challenge faced by many countries is the gap in knowledge and awareness among policymakers at different levels and the public. The general public's lack of knowledge creates challenges because it is hard to get local citizens to support energy communities, this kind of problems has realized in Germany. Another problem has been that it is difficult to attract enough participants for energy community projects, this problem has realized in Norway. (Bergren, et al., 2023)

Certain technical skills are required to set up an energy community. A common challenge in many countries, such as Sweden, the Netherlands, Germany, and Norway, is that the members of the energy community do not have enough technical and legal knowledge, especially at the early stages. This knowledge gap poses challenges for energy communities, as gaining the necessary knowledge can be a daunting and time-consuming task for the members. (Bergren, et al., 2023)

4.2.2 Financial challenges

While RECs and CECs may not primarily aim for financial profit, savings often serve as a markable incentive for members to initiate or join an energy community. The establishment of an energy community necessitates substantial initial investments, which can pose financial challenges for prospective community members, particularly those with less wealth. Even if the long-term financial outlook for an energy community seems promising, the initial investment can pose a significant barrier. This hurdle can hinder the establishment of energy communities, particularly when subsidies, funding, or loans are not easily available. (Bergren, et al., 2023)

4.2.3 Legal challenges related to energy sharing

A study by Nordic Energy research group (Bergren, et al., 2023) shows that there are different ways to share energy within energy communities. It is important to know that energy sharing does not only mean the direct and physical transfer of energy between community members. The energy sharing can also involve the administrative allocation of energy, distributing electricity through the shared grid, balancing energy components, sharing benefits, and adjusting tariffs. When an energy community is granted permission to operate as an communal grid, it also needs to take on the duties, responsibilities, and roles of Distribution System Operator (DSO), according to the EU directive.

Austria has the most well-established governance framework that facilitates energy sharing. However, even in Austria, the administrative management of energy sharing is quite complex. In Denmark, regulations governing energy sharing permit the distribution of electricity within a singular entity, such as a housing cooperative. However, the only way to send electricity beyond the boundaries of a building is through the shared network and it depends on the current fees and taxes. (Bergren, et al., 2023)

Both Finland and the Netherlands allow communities to share energy only if they use administrative methods to create a hypothetical situation of energy sharing. The energy goes through the grid and members must pay the usual fees and taxes. In Sweden, energy sharing can only happen when a company or a DSO sets up a microgrid in a building. (Bergren, et al., 2023)

In Norway, energy community members must establish an electricity production enterprise and engage as shareholders in this enterprise to be able to share the energy. Energy communities in Germany are hindered by the absence of a legal framework for sharing energy or providing electricity from owners to renters. (Bergren, et al., 2023)

Some energy communities aim to establish a microgrid withing their community with the goal of sharing electricity among members. The feasibility for this varies from one country to another. Typically, DSOs hold a monopoly on the establishment of regional and local distribution grids. In Finland, only DSOs are legally authorized to construct separate electricity grid lines that cross property boundaries. However, a legal exception permits energy communities to construct separate lines of up to 2 MW, thereby connecting small-scale electricity production to its intended point of consumption. If a single owner possesses multiple properties, a network can be established among these properties. (Bergren, et al., 2023)

In Sweden, a legal exemption also exists, but it is only relevant to small internal networks within a clearly specific area. Some pilot projects have received authorization to establish shared energy systems for residential zones.

In Norway, the development of distribution grids is exclusively allowed for DSOs, which restricts the potential to establish larger communities capable of generating and sharing energy. In Germany, entities other than DSOs are also eligible to apply for local electricity grid concessions. Therefore, many energy communities have the capability to control their own electricity grid. In Austria, the possession of a community's infrastructure is reliant on the certain model of the energy community. Associations structured as communities typically do not own the infrastructure, instead they rent it. Conversely, communities that are managed by large cooperatives often possess of their own infrastructure. (Bergren, et al., 2023)

Energy communities that set up their own microgrid in the Nordic countries could cause the network operators to lose some or all the revenue that they now get from the community members as payments for the shared grid.

4.2.4 Practical and Technological challenges

In several countries, technological obstacles exist due to a digital infrastructure gap. For instance, in Germany, the insufficient digital framework is a major obstacle for renewable energy communities. Some of the challenges that Germany faces due to insufficient digital infrastructure are slow roll out of smart meters, inadequate provision of necessary infrastructure like bidirectional meters by grid operators, and lack of experts who can install renewable energy systems. Similar challenges related to the digitalization of the grid are also present in Norway and Austria. Another issue is the slow nationwide rollout of smart meters in some countries, such as Germany and Austria. This hinders the possibilities for precise monitoring or measurement of energy supply or use at the community or household level. (Bergren, et al., 2023)

4.3 Mitigation actions for challenges and obstacles

According to Nordic energy research (Bergren, et al., 2023), various case study countries, are either implementing or planning to introduce new legislation in the coming years to support energy communities. Austria introduced a new law in 2019, Denmark introduced new regulation in 2023, and the Netherlands is expected to introduce new laws in the coming years. Finland has established a working group to determine if further regulatory changes are needed to promote energy communities.

To mitigate obstacles to energy sharing, locally differentiated tariffs can be introduced. An investigation in Denmark resulted in the establishment of communal tariffing for energy communities, enabling the tariffs to be customized according to each community's input to the shared grid. This resulted in a new regulation that came into effect in 2023 (Bergren, et al., 2023).

The obstacles stemming from insufficient understanding among local, regional, and national decision-makers can be lessened through the assistance of advocacy groups representing energy communities. Such a representative entity can operate as a conduit for knowledge exchange between energy communities and policy makers. This body can instruct policymakers about the benefits of energy communities and provide education to current and aspiring energy community members. A perfect example of this is the Coordination Office for Energy Communities in Austria. This organization serves as a bridge between energy communities and Austria's federal stater, the relevant ministry, and other key actors, providing support to both energy communities and policymakers. (Bergren, et al., 2023)

The escalating energy prices at present are making the business strategies for energy communities more lucrative, especially in nations that predominantly depend on fossil fuels for their energy needs. Government support in the form of financial aid or subsidies can also contribute to alleviate financial obstacles. For instance, in Austria, the Coordination Office for Energy Communities establishes funding programs for the creation of energy communities. The Netherlands has a program that gives financial support to energy communities so that their energy cost stays within a certain limit. This program protects the business model of the energy community from potential drops in energy prices. Such a subsidy program can encourage banks to provide financial support for energy communities, as it strengthens the solidity of their business proposals and offers a source of financial capital for the initial investment. (Bergren, et al., 2023)

5 OVERVIEW OF ENERGY COMMUNTIES IN OTHER COUNTRIES

According to Fina & Monshberger in the past, Europe has seen a variety of energy community initiatives. For instance, energy cooperatives have been established in Italy (like Nostra), Spain (such as SOM Energia), and Belgium (Ecopower) to name a few. Different types of cooperatives exist for renewable energy, from simple ones that enable joint investments in green energy sources, to more complex ones that function as electricity providers, distributing the generated electricity to their members. In some countries, such as Austria, Germany, and Switzerland, there have been small-scale EC initiatives for single buildings or nearby ones. These initiatives provide more autonomy than energy cooperatives, but they are restricted by national and geographical factors.

Community-based energy projects, like those in Scotland, depend a lot on their specific circumstances, which makes them hard to reproduce. However, Spain has seen the growth of local energy communities that are confined to certain areas. With the adoption of rules for RECs and CECs at an international level, and the requirement of all EU member states to include these rules in national laws, a certain standard can be set at least at the EU level. Some aspects, such as the ‘proximity constraint’ for RECs, are not clearly explained and could have different meanings, such as a certain distance, at district/municipality level, by grid levels (as done in Austria), or otherwise. This gives some room for maneuver within the scope of these initiatives. (Fina & Monshberger, 2023)

5.1 Number of energy communities in Europe

According to Gjergii there is a total of 9252 energy communities in the EU countries, but the distribution is very unequal among the member countries. Germany has more than half of energy communities, while Bulgaria, Romania and Hungary have only one each. Number of energy communities are presented in figure 9 and energy communities located on a map in figure 10. Top five countries are Germany, Netherlands, Denmark, Irland and Austria. The amount of energy communities is rapidly growing in the EU. (EU, 2023c; Gjergii, 2023)

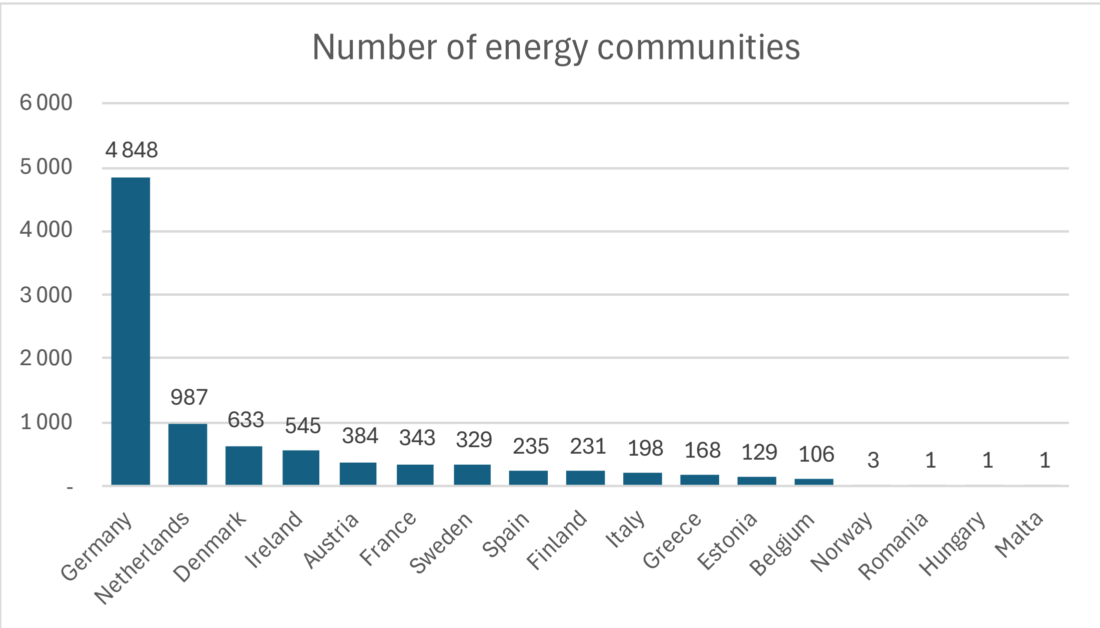

Figure 9. Number of energy communities in European countries, modified from (Gjergii, 2023)

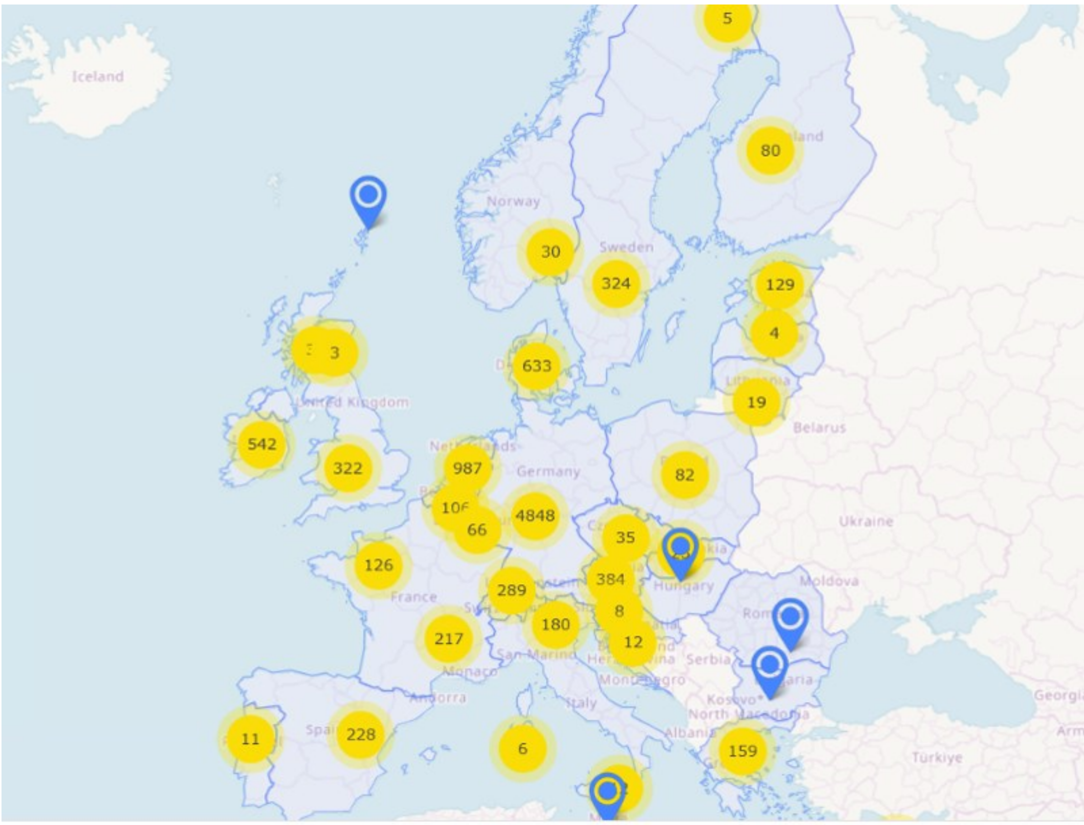

Figure 10. Energy communities in Europe on the map (EU, 2023c)

5.2 Share of energy from renewable sources compared to number of energy communities

According to Eurostat share of energy from renewable sources are high in Norway, Finland, and Sweden in 2022. Table 4 shows how it compares to the number of energy communities. Table 4 is sorted by share of energy from renewable sources. For example, in Norway there are only 5 energy communities but the share of energy from renewable sources are 76 %. In Germany they have very high number of energy communities but the share of energy from renewable sources are only 21 %. Denmark has many energy communities and a high share of energy from renewable sources, at 42%. (Gjergii, 2023; Eurostat, 2023b).

TABLE 4. Share of energy from renewable sources compared to number of energy communities, sorted by renewable sources. Modified from (Eurostat, 2023a; Gjergii, 2023)

Share of energy from renewable sources compared to number of energy communities

Country	**Share of energy from renewable sources %**	**Number of energy communities**
Norway	76 %	5
Sweden	66 %	329
Finland	48 %	231
Denmark	42 %	633
Estonia	38 %	129
Austria	34 %	384
Romania	24 %	1
Greece	23 %	168
Spain	22 %	235
Germany	21 %	4 848
France	20 %	343
Italy	19 %	198
Hungary	15 %	1
Netherlands	15 %	987
Belgium	14 %	106
Malta	13 %	1
Ireland	13 %	545

5.3 Germany

Most of the ECs in Germany engage with electricity production, like PV and wind and heat from biomass. Some of the ECs act also in energy distribution, but there are some ECs that act as a grid operator. The size and the sector of EC project defines what legal framework should be followed. Legal framework for ECs can be cooperatives, limited liability companies and private corporations (Bergren, et al., 2023).

About 55 % of EC are cooperatives and they contribute to 3.5 % of the Germany's energy production. 95 % of these members are private users, but it could also be banks, farmers, municipalities, public institutions, and churches. On average each member contributes with a 560 euro. 80 % of cooperatives are involved in photovoltaic energy production, but 36 % also actively participate in electricity distribution and 30 % in wind energy production. (DGRV, 2021)

Energy Community reviewers identified two factors that contribute to cooperatives sustained long-time market involvement and stability. One factor is that cooperatives should act as social entrepreneurs and offer important services for members. Another factor is that cooperations should work with a larger energy supplier than can guarantee market stability. (Bergren, et al., 2023)

ECs with wind energy production are usually organized with legal framework of limited liability companies, because building a wind park requires more capital. For small projects ECs are organized with legal form of private corporations, because they are much easier to register and establish. In rural areas ECs are usually cooperatives and in cities private corporations are preferred. (Bergren, et al., 2023)

In Germany, the primary business sector of energy communities is the production of electricity, accounting for 86% of their operations. Approximately 100 of these communities manage their own power grids, including bioenergy villages. Additionally, around 150 communities are involved in the distribution of heat and electricity through their own grids, although they do not produce electricity themselves. A smaller portion of ECs distribute electricity or heat without managing their own grid. (Ahlemeyer, Griese, Wawer, & Siebenhuner, 2022)

One real-life examples of energy community are a virtual energy community of "Regionalwerke" that are implemented by Bavarian company. This concept is founded on the principle that multiple municipalities establish a public institution ("Anstalt des öffentlichen Rechts") to collaboratively engage in various economic activities. These activities include, among others, the provision and management of energy and electricity grids. In these ECs all citizens can be participated independently of investments. Currently 35 municipalities are creating a blueprint for these kind of virtual energy communities. (Regionalwerke, 2022)

5.4 Netherlands

In the Netherlands, energy communities have a variety of organizational structures they can adopt. Most of energy communities fits under definition REC. The primary types include cooperatives, foundations, and owner associations, known as Vereniging van Eigenaren. Occasionally, they may also choose to form a company. Currently ECs can integrate with electricity and heat supply. Energy communities in Netherland are presented by own organisation called Energy Together. ECs increase cooperation with neighbours and the profits from EC are invested in the neighbourhood instead of the energy company. If local community are investigating renewable energy from wind turbines, it is accepted more easily than from commercial wind project (European Commission, 2023).

ECs have their own subsidy scheme that ensures energy prices will keep a certain range. If the energy prices will fall, it does not affect the business model of ECs. This kind of scheme has encouraged banks to invest in ECs, because the business case will be more stable. (European Commission, 2023). This kind of subsidy would also be beneficial for Finnish energy communities.

In Finland we could have our own organisation for energy communities that are promoting only EC issues. We should also add heat supply in our assets. Social aspect could be increased by cooperation with EC members and the profits will be invested in neighbourhood so that it benefits all.

Real-life example of EC is Republica Papaverweg and Earth Houses. Republica Papaverweg is an EC in Amsterdam that consists of 6 different kind of buildings and share a smart grid with batteries. Buildings are a house with 20 apartments, a hotel with 116 rooms, a pub and restaurant, rental apartments, and a commercial business space. This EC is based on the principles of circularity and the use of renewable energy resources (Republica, 2023).

Earth Houses is an EC of 23 homes located in Olst, it is also known as an eco-village. It can also be seen as a microgrid because it can go off-grid and provide electricity in case of outages (Yu, 2021). All the earth houses are built from recycled and natural materials and everyone in this ecovillage wants to live in the harmony with nature (Menezes, 2023).

Alliander a Dutch network company has developed a tool called ENTRNCE Trader, that allows electricity providers and customers to trade directly. Tool can be used with other energy communities and third parties. It provides full transparency to all EC members of energy production and consumption (EU, 2023a). This kind of tool would be good also in Finland.

Another digital tool is Hoomdossier, it is an online reporting tool, meant for energy communities that wants to offer home renovation services and support for their members. (EU, 2023a)

According to (Campos, et al., 2020) in Netherland energy communities can be established geographically in same post code area. These EC members get benefits from tax deductions for self-produced consumption for 0.1333 Euro/kWh up to 10 000 kWh/year for 15 years' time. In Switzerland benefits consists of network tariffs and taxes deductions, energy communities with less than 50 000 kWh/year, pays only 30 % of maximum power tariff. All this could also be applicable in Finland if the legislation would allow this.

5.5 Denmark

Among the nations in the European Union nations, Denmark has one of the highest percentages of energy assets owned by citizens. Denmark has 633 energy communities, that is much more than Finland, Sweden, and Norway together. (Bergren, et al., 2023)

In Denmark, electricity sharing primarily follows two models: 'behind the meter' and 'through the collective grid'. The 'behind the meter' model is limited by regulations, making it applicable only within a single building, such as a housing cooperative with rooftop PV installations. For other types of communities, the only option is to share through the collective grid. Currently, the supply of electricity via the communal grid is governed by standard rates and taxes. (Bergren, et al., 2023).

Energy communities can be organized in various forms, including associations, partnerships, cooperatives, or capital companies. These communities are often initiated by pre-established groups, such as local governments, housing associations or eco-villages. Eco-villages are a prevalent type of community in Denmark. These are generally organized as community institutions with shared ownership, often motivated by a wider objective of attaining self-reliance and fostering sustainable living beyond mere energy usage and production. Their emphasis often expands to include heating, which is not as stringently regulated as electricity distribution. (Bergren, et al., 2023).

Housing cooperatives which have implemented PV systems or hybrid solutions combining PV and heat pumps represent another form of energy communities. Under existing regulations, community members within a single building can share the electricity produced internally, bypassing the need for the collective grid. There are also cases where entire villages and recently formed neighbourhoods structured as energy communities. These communities are often situated in locations that allow them to utilize nearby areas for heat production or wind turbine installation. For these larger communities, the distribution of electricity via the shared grid emerges as the most suitable model for power sharing. (Bergren, et al., 2023).

Two examples of real-life energy community initiatives in Denmark are Karise Permatopia and Københavns solcellelaug. Karise Permatopia is an eco-village that has established a communal geothermal heating system that uses locally sourced renewable energy (Oplev Permatopia, 2023). Københavns solcellelaug is the first solar cell association in Denmark, this initiative provides citizens with the opportunity to purchase shares in urban solar cell plants (Köpenhams solcellelaug, n.d.).

Karise Permatopia an eco-village situated in the southeastern town of Karise, Denmark, is home to 90 terraced houses. The community places a strong emphasis on sustainability, striving for self-sufficiency in energy. An energy supply group within Permatopia is tasked with ensuring that the community's energy supply is 100% renewable. The community aims to operate as a circular energy system as much as possible, maximizing the utilization of energy derived from waste. A communal geothermal heating system heats all the houses and a significant portion of the communal yard, which the community manages. Permatopia owns and manages a wind turbine which generates electricity for the community's geothermal heating system, the shared outdoor space, and the charging stations for the community's electric vehicle. Any excess heat generated by the system is utilized to warming water for the residents and the communal yard. (Oplev Permatopia, 2023).

5.6 Austria

Austria is a fore runner in energy community area, it will be the first country by introducing participating in multiple energy communities at the same time, legislation will allow this, starting in 2024 (Mariuzzo, Bernadette, & Raugi, 2024). Austria has 100 RECs and 3-10 CEC's (Landekarte - Energiegemeinschaften, n.d.). Most energy communities are generating the energy from solar panels.

Nordic Energy Research stated that Austria has three types of energy communities. The first type is Joint or Communal energy communities that were already introduced in 2017. In such a community, multiple individuals can collectively generate and utilize electricity on the same premises, leveraging shared production infrastructure like PV-panels on an apartment building, for the benefit of all residents. (Bergren, et al., 2023)

Second type is local energy communities, that are powered by the same transformer and typically include municipalities and SMEs. In the European context, these are known as RECs and are connected via a common transformer substation and collection point. However, Limited liability companies ("GmbHs") are not allowed to cooperate in these communities (Bergren, et al., 2023).

Third type is nationwide energy communities that are not restricted by geographical boundaries, but members are required to obtain their energy from the same network operator. This model is favoured by families spread across the country who wish to share their electricity, as well as individuals living in grid areas where no REC exists yet. In the European context, a nationwide energy community would be classified as a CEC (Bergren, et al., 2023).

At present, any surplus energy produced is sold back to the network operator. However, if these communities install more energy storage systems, they may be able to potentially have the capacity to store and selectively sell energy to interested buyers in the future. As it stands, an individual producer can sell up to 12,500 kWh without incurring any tax (Bergren, et al., 2023).

Most energy communities which are set up as associations typically do not possess their own infrastructure. Instead, they lease it or utilize the facilities of their members. Conversely, large cooperatives that run energy communities often possess their own infrastructure. Both ownership and leasing models have their pros and cons. Based on Nordic Energy research (Bergren, et al., 2023) interviews, it appears that most energy communities in Austria operate as cooperatives.

Energy communities must choose between a static or dynamic billing model, which are then implemented by the network provider. In a static model, the energy generated by the community is equally shared among its members. In contrast, a dynamic model adjusts the distribution based on each user’s energy consumption. The majority of energy communities sell their energy at a fixed price, with adjustments made occasionally. (Bergren, et al., 2023)

Two real-life examples in Austria are OurPower and Grätzl Energie. OurPower is a cooperative that owns over 250 power plants, with PV sources accounting for 60% of its electricity production, wind contribution 20% and the remaining 20% from hydropower. It manages two joint/communal energy communities and one CEC, which is still in the process of being registered. The Grätzl Energie is a REC located in Vienna and is managed by the energy service provider, Power. It primarily operates within a single district of Vienna, adhering to the proximity criterion common to all RECs in Austria due to the reliance on a shared substation. Grätzl Energie provides leasing models like those offered by OurPower. (Energy communities hub, 2021)

RECs are usually cooperatives, and they are run or owned by another company. RECs currently provide financial benefits such as network tariff discounts for regional use and can also receive support from various funding programs. Additionally, large corporations can participate and get financial gains from the energy market, thereby introducing a new revenue stream to their business model.

Most CECs are managed by a family or a small group. CECs offer the advantage of broader participation compared to RECs, since they are not restricted to a single substation and can include limited liability companies. In the future, CECs could have a significant role in the energy transition, particularly if larger corporations chose to invest and become active participants. Energy communities help to reduce energy poverty by offering members more affordable energy. They also enable members to participate in the energy transition without the need to invest in necessary infrastructure, such as PV panels (Bergren, et al., 2023).

5.7 Sweden

While energy communities, as defined by CEC and REC, have not been established in Sweden, there are existing models that share similar characteristics with CECs. These include wind power cooperatives, solar power communities, eco-villages, and small-scale heating cooperatives, which are currently the most prevalent forms of energy communities in Sweden. (Bergren, et al., 2023)

Over the past two decades, wind power cooperatives have gained significant traction in Sweden. These cooperatives are typically structured as incorporated associations, with members purchasing shares in a wind turbine to collectively bear the cost of energy production. Research indicates that there are approximately 80 active wind power cooperatives in Sweden, with most having between

200 and 300 members. The largest cooperatives boast up to 4000 members (Vindkraftsdelar och vindandelar, n.d; Erikson Bergren, et al., 2023)

Solar power communities are similar with Finland's energy communities, it means that community members are interested in using solar panels for their internal consumption.

Eco-villages represent another prevalent model of energy communities in Sweden. These are usually rural communities with a focus on social, ecological, and economic sustainability, as well as self-sufficiency. The methods employed by eco-villages in Sweden to produce and share energy vary greatly. While the majority prioritize energy efficiency and reduced consumption, a handful have devised innovative methods for generating heating and electricity. Eco-villages are founded on principles of cooperation and social inclusion, and their sizes vary from few up to 50 households per village. (Bergren, et al., 2023)

Communities typically manage small-scale heating systems, which are common in rural villages and communities. These systems are designed to produce and distribute hot water to the residents of the village. While these initiatives are often driven by the financial incentives of the residents, they also serve to strengthen the local ties within the community (Bergren, et al., 2023).

Here are some examples of energy community initiatives in Sweden: Tamarinden, Simris and ElectriCITY – Hammarby Sjöstad 2.0. Tamarinden is an innovative project that aims to establish an energy community within a new residential area. The goal is for this community to be capable of producing, storing, and sharing energy (Tamarinden - Bygg Örebro, 2023). ElectriCITY – Hammarby Sjöstad 2.0 is an innovation platform led by citizens, which is striving to establish an energy community in the Hammarby Sjöstad district of Stockholm. SIMRIS was an initiative carried out in the southern region of Sweden, with the objective of demonstrating that a village can be entirely self-sufficient on energy obtained from renewable sources.

The Tamarinden project is focused on the creation of a new energy-efficient residential area in Örebro, a city in Sweden. Initiated in the fall of 2022, the project involves the construction of ten residential buildings, providing a total of 800 apartments. The project is a collaborative effort led by the municipality of Örebro, in partnership with construction companies and building operators such as ÖBO, Friendly Building, Magnolia, Serneke, and Tornet. The aim is to establish a community capable of reducing, producing, storing, and sharing energy within a local energy system. The ultimate goal is to promote the production of local renewable energy, reduce power peaks, alleviate the strain on the national grid, enhance flexibility, and achieve significant energy savings (Tamarinden - Bygg Örebro, 2023).

Launched in 2022, ElectriCITY - Hammarby Sjöstad 2.0 is a project that unites various stakeholders to form a local energy community. This community is structured to produce solar energy and administer a microgrid furnished with load-balancing capabilities and batteries to boost the local power supply. ElectriCITY also has the objective of assisting housing associations in the area by introducing energy conservation methods to decrease their energy consumption. The objective is to foster a sustainable energy cycle, transforming the district's inhabitants into prosumers who both produce and consume energy. (Hammarby Sjöstad 2.0, 2021).

5.8 Norway

There are not so many energy communities in Norway, but there are lots of energy community initiatives. Of those initiatives only five have been implemented. Most energy community initiatives have been spearheaded by property developers and real estate firms who are constructing energy-efficient residential structures that generate and store renewable energy. In Norway, numerous energy community initiatives are led by a diverse group of actors, including citizen cooperatives, municipalities, private investment firms, and others. The primary motivations for these actors are economic and environmental benefits, as well as the desire to secure a more reliable energy supply for rural communities. These actors invest in renewable energy production on residential buildings for internal use. A typical example of these initiatives is when property developers mount solar panels on the rooftops of residential complexes to generate energy for the building. (Bergren, et al., 2023).

Another common type of energy community initiative was led by DSO companies. The objective of these DSO companies is to create various microgrid models in specified regions to alleviate the burden on the primary grid and consequently reduce future expenses associated with maintenance. (Bergren, et al., 2023)

Finally, another instance of current energy community initiatives in Norway is the establishment of microgrids in isolated regions that are capable of producing, storing, and distributing energy. The development of supplementary microgrids capable of efficiently storing and sharing energy could reduce some of the load on the main grid, particularly during peak demand periods, potentially extending its lifespan. (Bergren, et al., 2023)

Two real-life examples of energy community initiatives in Norway are Smart-Senja and Lohøgda. Smart Senja is an innovative project that aims to create a local energy system on the isolated island of Senja, with the goal of satisfying the increasing electricity demand of the expanding fishing industry (SmartSenja, 2020). Lohøgda is a residential cooperative that functions as an energy community by investigating and distributing local renewable energy production (Aarsbog, 2022). Each of these examples represents a unique approach to developing and implementing energy communities.

Lohøgda example could be used in Finland, because it is a big housing association with 777 apartments. The energy community is sharing production and storage of renewable energy. They have common water heating system and solar panels, currently they are planning to have energy storage hydrogen. After this project started 2016 energy community members have minimized their energy costs by over 50 % (Aarsbog, 2022).

5.9 Other countries

In Croatia they have developed a software platform for energy communities called *MARS*. This platform assists ECs in gathering, calculating, and analysing data related to energy generation and usage both on individual household and community level. MARS is used by ECs, energy managers, city administrations and renewable power plant operators. (EU, 2023a)

Som Mobilitat is a Spanish mobility cooperative that provides solutions for e-mobility, like rental service of EVs, bikes or motorbikes. Vehicles are owned by the cooperative or individual members of

EC. The cooperative is non-profit, and its main focus is to network with local investors and public bodies. Same kind of cooperative is in France *Mobicoob*, it has 20 000 members, and it is also sharing public transportation service using EVs. One share cost 100 EUR and member have to commit for five years, after five years period share can be sold back to EC. (Reis & al., Antunes, 2021)

In Spain they have developed a common online platform called *Som Comunitats*, that is offering different internal management services for energy communities. Visual structure of this platform is presented in figure 11. This platform enables ECs to manage their operations from a single location with a range of services available. This platform includes tools for project management, data visualisation for each user, member administration with other EC related administrative tasks. All these tools can be customized for energy communities' own needs and can be integrated to their own website. (EU, 2023a)

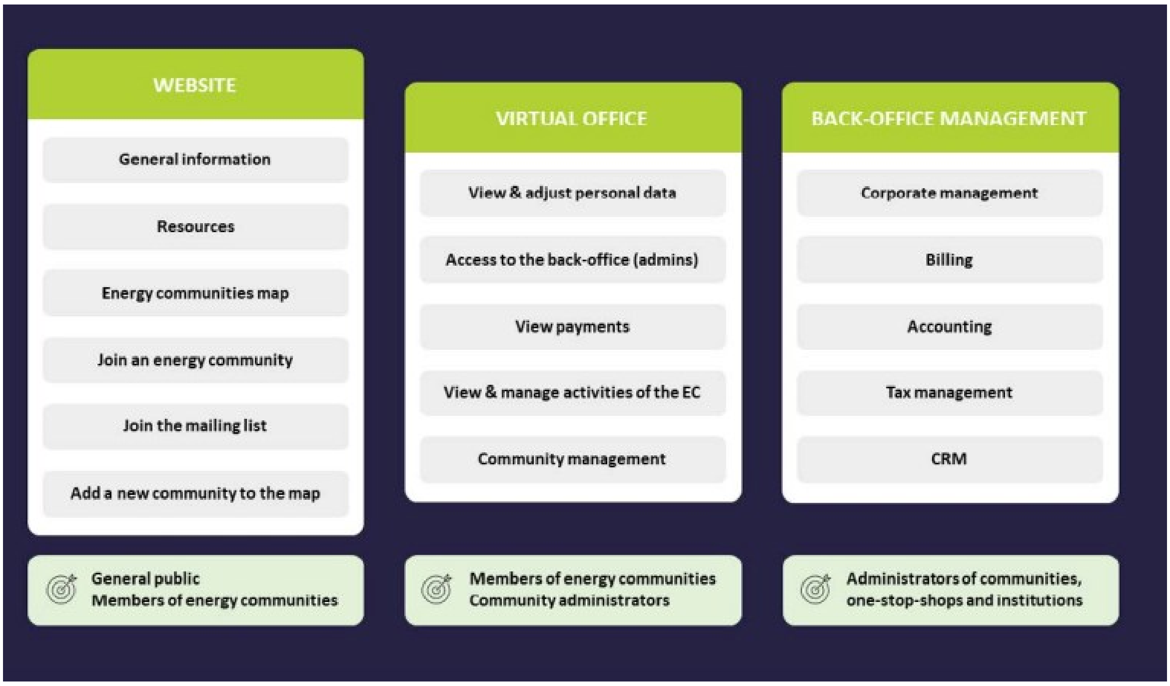

Figure 11. Visual structure of the *Som Comunitats* platform (EU, 2023a)

This type of platform would also fit well in Finland, as it would simplify the administrative work associated with energy communities.

According to Energy Communities Digital Tools for energy Communities report Italy has developed a digital tool *Magliano Alpi*, for energy forecasting. Tool is taking account the aggregated energy needs and generated electricity volumes and potential energy production. Tool will also handle seasonal trends, meteorological factors, number and typer of prosumers and customer and the geographical location. The Energy Community consortium have planned this tool to be open source, so it will be available in EU for every energy community. (EU, 2023a)

5.10 Energy community projects

Reis, et al. have collected interesting energy community projects that are presented in table 5 (Reis, et al., 2021).

First project *wind kraft SimonsFeld* is nowadays a stock company with more than 1600 shareholders and 69 wind power stations with a total power of 136 MW in Austria and 2 in Bulgaria. Second project is *Ecopower* in Belgium, it has 50 000 members and 40 000 customers. A single share costs 250 euro and shareholders cay buy max. 50 shares. Third project is *Hvide Sande community* in Denmark, community owns 3 wind turbines, and it has 400 shareholders. Revenue is invested back to modernize the local harbour. Fourth project is *Enercoop* in France, it has 70 000 members. It operates 100 hydro power plants, 25 windfarms, 3 biomass generators and 104 solar projects. Profits are reinvested in new initiatives and financing is done through bank loans, partnership, and citizen financing.

Fifth project is called *Som Energia* from Spain. It has 68 000 members and generates totally 10 GWh energy from PV, wind, biogas, and biomass sources. One share cost 100 EUR. Sixth project is *Svalin community* in Denmark, it consists of solar panels, geothermal heat pumps and EVs. Community is producing more energy than using, so it is called energy positive. Seventh project is called *Solar community energy project in Recklinghausen Germany*. It consists of citizens in Recklinghausen, and it is using public roof surfaces for solar panels. EC is producing yearly 195 000 kWh of electricity. Project was fully financed with own capital resources, each member invested 3300 EUR. (Reis, et al., 2021)

Strategies and tOOls for Incentivization and management of flexibility in Energy Communities with distributed Resoucers (RESCHOOL) is a new EU co-funded project, which unites 16 partners from 7 European countries. This project will develop two tools that will boost the involvement of citizens in energy communities and the active role of communities in energy markets. It will also improve the energy markets knowledge including communication with stakeholders. Four pilots across Europe will test and verify these tools. Pilots are Girona in Spain, Athens & Rafina in Greece, Amsterdam in the Netherlands, and Hammarby Sjöstad 2.0 in Sweden. (Reschool, 2023a)

Table 5. Summary of energy community projects (Reis, et al., 2021; Reschool, 2023a)

Energy community projects				
Project	**Country**	**Members**	**Energy from**	**Power**
Windkraft Simonsfeld	Austria	1600 shareholders	Wind power	Total power of 136 MW
Ecopower	Belgium	50 000 members	Wind, hydro, PV	Production 51 million kWh/year
Hvide Sande community	Denmark	400 shareholders	Wind	
Enercoop	France	70 000 members	Hydro, wind, PV, biomass	
Som Energia	Spain	68 000 members	PV, wind, biogas, biomass	10 GWh/year
Svalin community	Denmark	20 households	PV, geothermal heat pumps, EVs	Energy positive
Solar community energy project in Recklinghausen	Germany	60 households	PV	195 000 kWh/year
Rescool – Girona	Spain	4 villages, 90 households, 30 public facilities, 2 local businesses	PV	N/A
Rescool – Athens & Rafina	Greece	40 citizen participants, 6 schools, 2 SMEs	PV	99.7 kWp EV
Rescool – Amsterdam	Netherlands	540 house holds	Solar panels, EV charging stations	
Reschool – Hammarby Sjöstad 2.0	Sweden	900 apartments, 9 housing associations	EV chargers	280 kWp

6 BUSINESS MODELS WITH ENERGY COMMUNITIES

The competitive landscape has changed, and it is not easy to recognize who the competitors are. Instead, in energy communities, different actors work together to create value for customers. Due to the diversity and complexity of energy communities, there are various business models for different actors, functions, and types of communities. (ProCemPlus, 2021)

Business Model Canvas is a tool that can display the business models of energy communities. Energy actors must decide which energy market they will enter before they participate. The following chapters present the results for the research question "What are the possible business models in Finland for energy communities".

6.1 Actors on energy market

Energy communities are creating an innovative ecosystem, where more and more different actors are involved as the number of electric cars, battery storage, heat pumps, and smart home features grows. The energy community changes the usual structure of supply and demand side actors since both energy and flexibility services are consumed and produced at the customer end. Like in an ecosystem, the roles of different actors can shift as the actors identify the gaps in the ecosystem. Also the significance of different roles varies and aligns with the company’s strategy. For example, a hardware supplier can become an operator or analyst, and an end user can become an energy or flexibility service provider (ProCemPlus, 2021).

ProCemPlus has identified the following actors on energy markets: service providers, operators, aggregators, energy producers, hardware suppliers, software suppliers, community members and enablers.

The importance of various service providers, such as operators and aggregators, is becoming increasingly evident as they enable the implementation of new technologies and business models. These service providers act as mediator between other energy system actors and customers, making technology more user-friendly. For housing companies, the increasing number of electric cars has led to an increased demand for operators, who are responsible for optimizing, measuring, and billing electric car charging. (ProCemPlus, 2021)

According to Mengelcamp et al., the operator’s field of tasks is very wide. Firstly, it consists of integration of traditional building energy management and automation systems, including energy consumption optimization; management, operation, and maintenance of building energy resources; and optimization of conditions according to customer wishes. Secondly it defines what is the aggregation towards reserve markets. Thirdly operators task requires a platform for handling community transactions for local markets and flexibility. Operators should deal with commercial and contractual handling processes, between the community and service providers. A broker-style operator could operate, whose tasks could include measuring the financial viability of the energy community, offering alternatives to active customers or the entire community, handling needs assessments and tenders, assisting with system integration, and billing. Finally, the operator should handle financing solutions. The community may not necessarily own all resources, but the community can acquire the system through a leasing agreement or rent them. Building the right pricing, for example with a fixed service fee, helps to avoid large capital costs. (Mengelcamp, et al., 2019)

Energy producers, including prosumers, operate in a similar manner to traditional energy markets, but on a smaller scale. They are also responsible for maintaining network balance and providing backup power. Hardware suppliers play a crucial role in the production and supply of equipment such as electricity meters, chargers, batteries, and solar panels. These suppliers may include White Label actors, who manufacture equipment for various resellers. These resellers then sell the equipment to communities or operators, ensuring that the necessary hardware is available to support their operations. (ProCemPlus, 2021)

Software providers and data analytics companies offer software, such as platforms for different technologies or peer-to-peer markets, to operators, equipment providers, or both. They also apply methods such as machine learning to create visualizations, analyses, and predictions, which can help enhance the operations of communities and operators. The data collected can be used to give feedback to customers and devices and can even be merged with other data to generate new opportunities outside the energy sector. For instance, real-time electricity usage and its variations can be used to assist in elderly care. Data management also allows participation in various ecosystems while considering data ownership, customer privacy, and data security. (ProCemPlus, 2021)

Community members as active customers play an important role in the community's operations and success. Enablers may include municipalities and other public actors, electricity sellers, DSO, Transmission System Operators (TSO), construction companies, builders, landowners, property owners, research institutes, financiers, and advocacy organizations. These entities work together to create an environment that enables energy communities to thrive and succeed.

In figure 12 are presented different actors in business models.

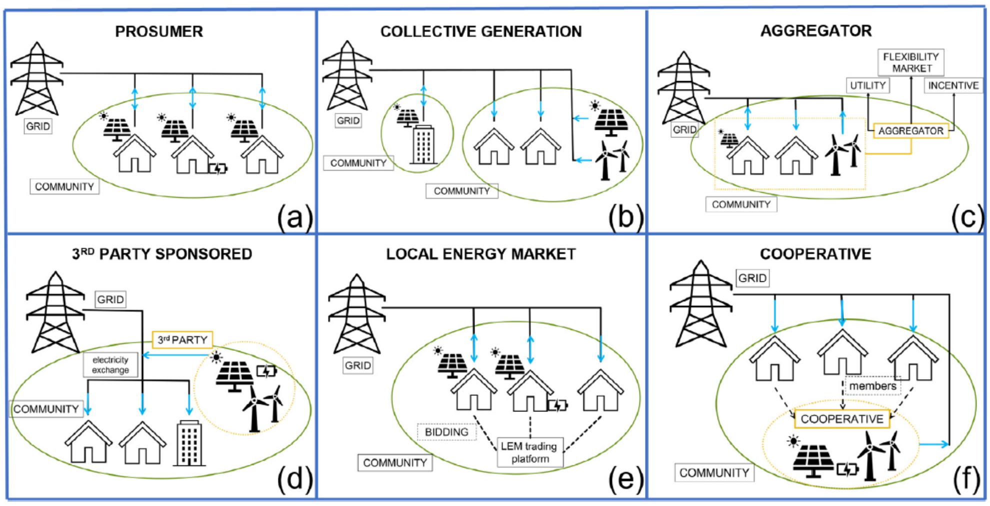

Figure 12. Different actors in business models (Reis et al., 2021)

6.2 Business Model Canvas

A Business Model Canvas (BCM) is a strategic management tool that provides high-level view of the key strategic factors of a business. It provides a way to show the key elements of any business model on a single sheet of paper. Business model consists of nine elements. These elements include key partners, key activities, key resources, cost structure, value proposition, customer relationships, channels, customer segments and revenue streams (Business Model Canvas, 4.6.2022).

Reis et al. (2021) have implemented a BCM for energy communities that is presented in figure 13.

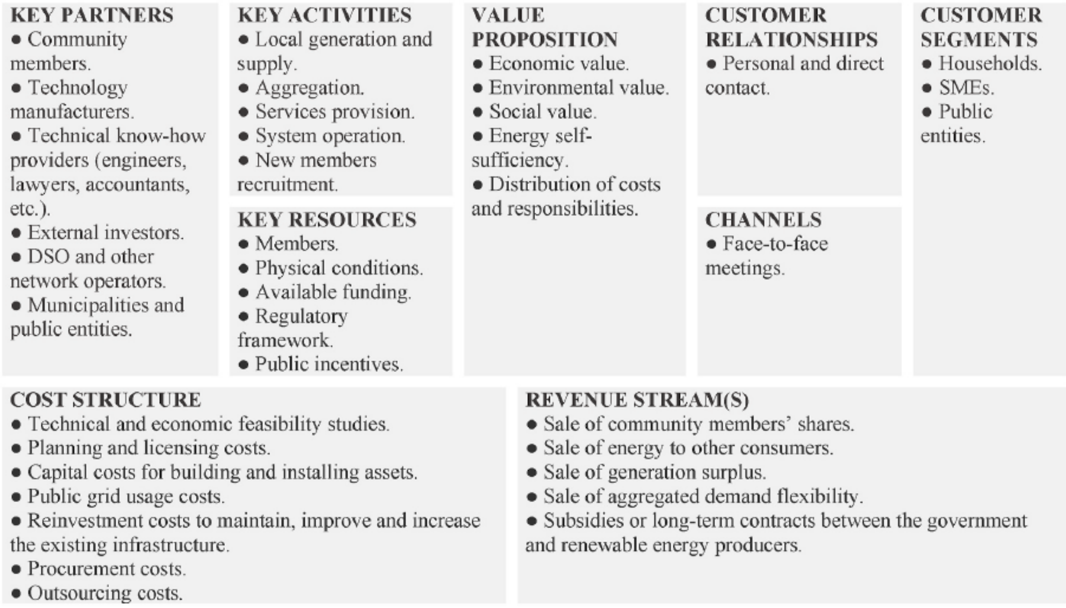

Figure 13. Energy community BCM (Reist et al., 2021)

Fina and Monshberger research shows two different business model for energy suppliers and aggregators. Energy suppliers could provide services like helping to establish an energy community, buying of surplus energy and providing billing service. Aggregators can trade electricity on flexibility market since they have larger volumes of capacity (0.1 – 1 MW). Aggregator can offer energy communities the service to aggregate with certain devices and find the best balance between energy consumption and market participation with required capacity. These business models are presented in figures 14 and 15 and both BCM model are also applicable in Finland. (Fina & Monshberger, 2023)

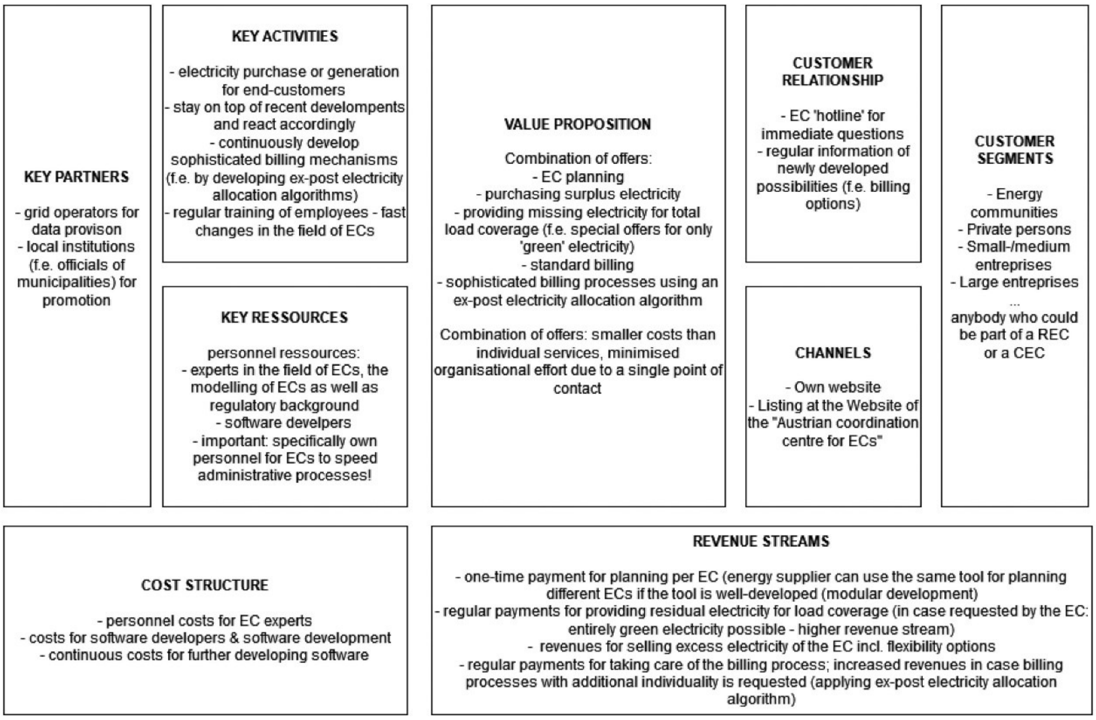

Figure 14. Potential business model for energy suppliers (Fina & Monshberger, 2023)

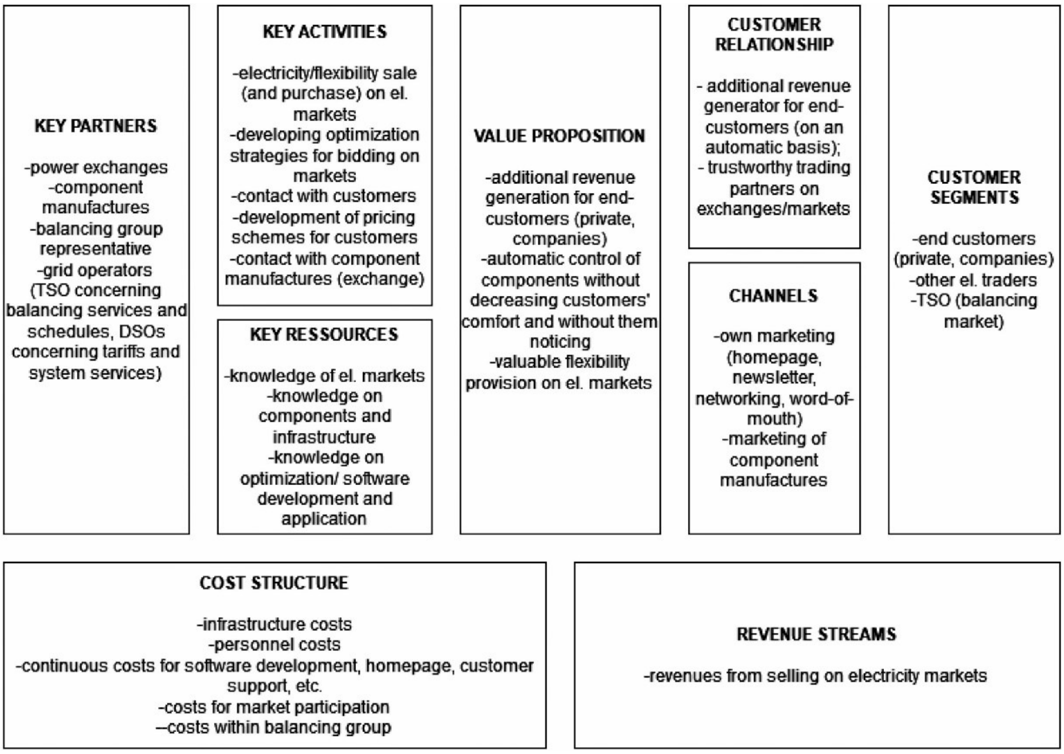

Figure 15. Possible business model approach for aggregators (Fina & Monshberger, 2023)

6.3 Value distribution models

Energy communities have the potential to generate economic value for their members through a variety of functions. The business model of an energy community may focus on energy production, flexibility, or both.

Value distribution models are designed to allocate the value generated among the members of the energy community. Selecting the appropriate value distribution model is critical, as it influences the decision of potential members to join the energy community during its formation. The value distribution model also has a significant impact on the behavior of members within the energy community. A fair, stable, understandable, computationally feasible value distribution model that encourages members to act in the best interest of the entire energy community is essential. The criteria for a value distribution model may seem conflicting and the best model will depend on the specific situation of each case. (ProCemPlus, 2021)

According to Iazzolino et al. (2022) main purpose of value distribution model is increasing energy communities' self-consumption or collective consumption, it will also mean avoided costs and energy self-sufficiency.

Value distribution models are methods that help decide how much each member gets based on their contribution to the energy community. According to ProCemPlus program following value distribution models have been applied to ECs: equal sharing, sharing based on energy production capacity, sharing by consumption, credit-based calculation, and Shapley method. Equal sharing means that every member of the energy community gets the same share, despite how much they have invested on EC. Sharing based on energy production capacity means that those who produces the energy takes all the benefits. Sharing by consumption means that they get benefits based on their consumption. Credit-based calculation means equal sharing for EC members. Shapley method is counted as the fairest one, because the benefits and costs are distributed fairly among EC members by their contribution to EC. (ProCemPlus, 2021)

6.4 Energy community functions

Energy community can participate in energy market as passive or active actors. Active model is more beneficial for the whole energy system. As electric cars, heat pumps, and other resources become more common, along with self-consumption of own production, there are new possibilities for flexibility and extra income from flexibility markets. (ProCemPlus, 2021)

Figure 16 shows the different functions of energy communities. A passive energy community is the simplest and does not require changes to production or consumption patterns. If a passive energy community has controllable resources, it can try to increase economic benefits by changing the time of consumption and/or joining flexibility markets. The arrows in the figure symbolize the shifts in the energy community's operations from a passive to a more active alternative, which increases the complexity of the operations. Technical solutions enable the growth of energy communities. (ProCemPlus, 2021)

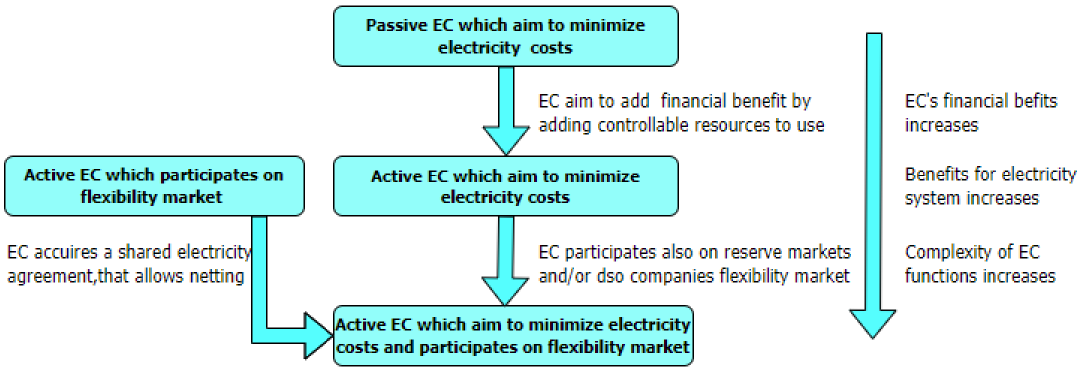

Figure 16. Different functions of energy communities, modified from (ProCemPlus, 2021)

6.5 Business revenues

Currently the business models for energy communities are dynamic and they could change in technology and by legislation. Legislation is still evolving all the time and new business models will be created after legislation has been approved.

According to Fina & Monshberger research three different business models are used in Italy for REC's. The first model involves the REC itself taking the capital expenditure for the technologies. In the second model, a separate company acts as a technology partner that splits revenues with the REC. In the third model, the community, and the developer share both costs and revenues. (Fina & Monshberger, 2023)

In figure 17 is presented energy community and different stakeholders in Austria including their exchanges, like money, data, and energy flows. This figure is appropriate also in other EU countries because Austria is a forerunner in energy community related issues. As can be seen in figure 17 Participants/Members makes contracts with EC and DSO and they also agree about the pricing. DSO are responsible for smart meter installation and metering data. Energy suppliers offer a balancing group for customers in EC and are responsible for surplus generation. EC works with aggregators and electricity traders, who market EC's electricity and coordinate with them about their assets. Energy service providers and Contractors provides third-party services like planning, invoicing, operation and contracting for ECs. Financing institutes loans money for investments related to ECs. If there are any issues with the organisation, coordinator centres offer in-depth information and assistance. ECs are regulated by ministries and authorities that set the legal guidelines. Local actors support the EC concept and act as a role model function. Third parties like industries and large businesses participates in CECs and contribute by large investments. (Fina & Monshberger, 2023)

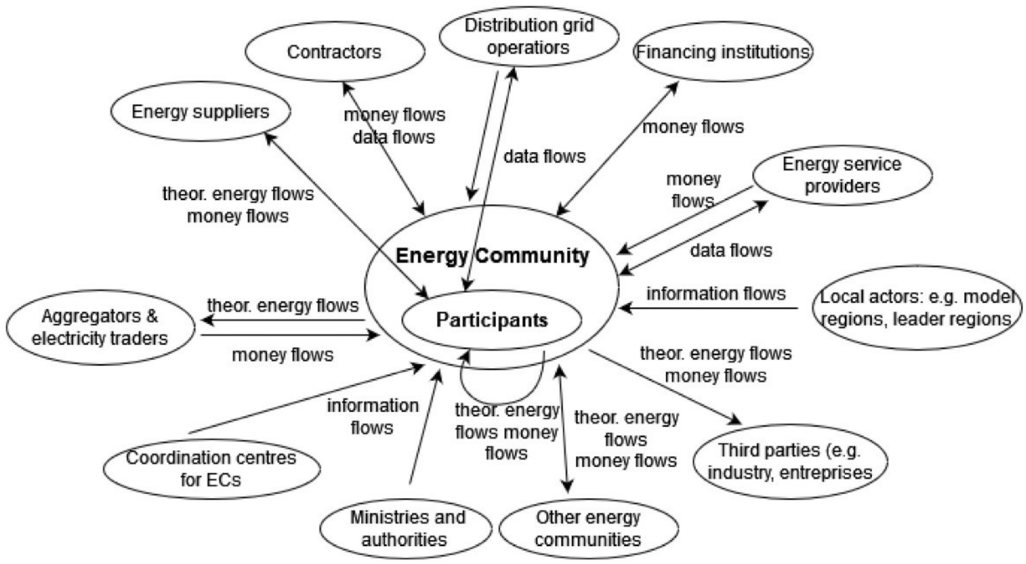

Figure 17. Energy communities and different stakeholders in Austria (Fina & Monshberger, 2023)

6.6 How energy communities can generate revenue

It is important for energy communities to develop sustainable business models and explore different kinds of revenue streams to ensure long-term financial success and viability. Energy communities in EU countries can generate revenue through various ways. The next chapters provide some examples.

Embracing the Role of Energy Prosumers: An increasing number of citizens are becoming ‘energy prosumers’, who both consume and produce energy. This can be on an individual level, such as households installing solar panels on their roofs, or on a collective level, like energy communities that unite citizens to jointly produce local, clean energy. (European Commission, 2022)

Involvement in Energy Production, Distribution, and Supply: Energy communities, as legal entities, enable citizens, small businesses, and local authorities to produce, manage, and consume their own energy. They can be involved in various aspects of the energy value chain, including production, distribution, supply, consumption, and aggregation. EC could offer energy-related service to community members, such as energy audit, energy efficiency consultancy and installation of renewable energy systems. In these cases, revenue stream will come from service fees. (European Commission, 2022)

Boosting Energy Efficiency: Energy communities provide citizens with access to low-cost renewable energy by allowing them to their own production installations and providing information on how to improve energy efficiency in their homes. This can help them lower their energy costs while making individual investments reasonable.

Employment Opportunities: These communities create jobs locally and improve social harmony through yearly meetings and activities in the area (European Commission, 2022).

Attracting Private Investments: Energy communities help increase public support of renewable energy projects, which lower the barriers for private investor to contribute to the shifts to clean energy transition (EU, 2023a).

Energy sales: Energy communities can sell excess energy generated from renewable source back to grid, earning income through feed-in tariffs or power purchase agreements with energy companies (European Commission, 2022).

These strategies not only generate income for the energy communities but also contribute to a more sustainable and resilient energy system.

Reis et al. (2021) stated that energy communities can generate revenue from various sources, such as selling community members' share, selling energy to other customers, selling excess generation, selling aggregated demand flexibility, and receiving subsidies or long-term contracts from the government and renewable energy producers.

According to Fina and Monshberger (2023), energy suppliers revenue streams can be generated from different sources, such as a single payment for planning per EC, regular payments for supplying backup electricity for load coverage, for trading surplus electricity of EC with flexibility options, and regular payments for handling the billing process. Aggregators could generate revenue by trading electricity on markets and offering flexibility or reserve services.

7 RESULTS

As been seen in research papers energy communities can have various forms, like cooperatives, limited liability companies, private corporations, foundations, owner associations, capital companies, community institutes, SMEs, nation-wide energy communities, local energy communities, joint or communal energy communities, a non-profit organization, eco-villages, wind park cooperatives, solar park communities, heating cooperatives and small-scale heating systems (Erikson Bergren, et al., 2023; ProCemPlus, 2021).

Members of energy community could be private users, banks, farmers, municipalities, public institutions, and churches.

This chapter is presenting the findings for following research questions: "*What is the status of energy communities in Finland?*", followed by *"How energy communities have been used in other countries?"* and *"What kind of business models could be possible when using energy communities in Finland?"*

7.1 Status of energy communities in Finland

Current legislation does not recognize distributed energy communities. This kind of distributed energy community can be established within an existing national policy framework. Under the current legislation, distributed energy communities are not able to distribute energy between communities regionally or nationwide in such a way that electricity extracted from the grid and self-produced electricity would be netted directly within the balance sheet period. (TEM, 2023a)

Netting is possible for energy communities withing buildings. The directive states the netting electricity during the balance period can only happen if it does not affect how network charges, tariffs and other fees related to electricity are collected. (TEM, 2023a)

As TEM stated in their final report that specific actions are needed in Finland to enable distributed energy communities to be more active in the electricity market. They have also proposed that energy from distributed energy communities should be shared by local energy communities and active customers all over Finland. TEM also agrees that tax laws for energy communities should be investigated more. TEM's working group also explored the different policies for CEC. Unfortunately, the concept of different policies is not possible because of the current legislation. (TEM, 2023a)

TEM is stating that we need to investigate how to use transmission and distribution network to deliver electricity within in Finland's borders, in order to make distributed energy communities possible in Finland. Technical solutions are different when we are discussing local distributed energy communities compared to nationwide energy communities. Solutions for how metering, data exchange and invoicing should be done should be investigated. It should be possible to balance self-produced and bought electricity within the balance sheet period, so that the measured amount of energy is different from the amount of energy that billing is based on. Intra-balance sheet netting does not affect taxes or network service fees. TEM's proposal to change the electricity market model requires that active customers can also share electricity throughout Finland. (TEM, 2023a)

TEM is also stating that in the future legislation drafting it is important to consider how different sectors work together, especially when the electricity system is linked with heat and gas sectors, local electricity production, transport electricity solutions and hydrogen are connected to the electricity. This will increase the advantages of sector integration and promotes the operating conditions of energy communities and other operators. (TEM, 2023a)

7.1.1 Number of energy communities in Finland

In May 2023 Finland had 97 energy communities in Datahub. The biggest energy community had 226 delivery sites and the smallest energy community had only 3 delivery sites, medium for delivery sites are 18. In figure 18 are shown the increase for energy communities in Datahub starting from 1.1.2023. (Fingrid, 2023a)

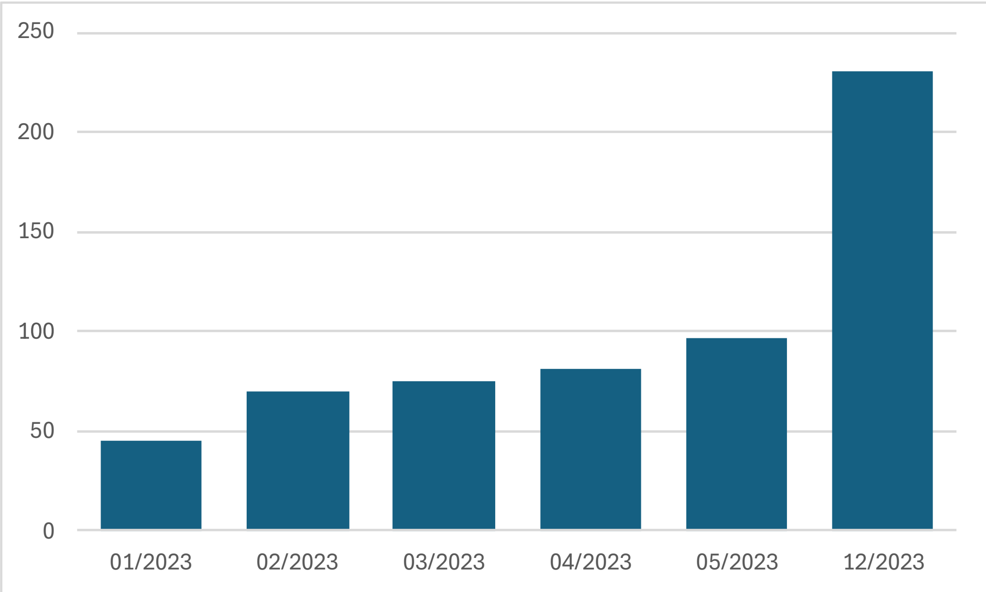

Figure 18. Number of energy communities in Finland starting from 1.1.2023, modified from (Fingrid, 2023a; Fingrid, 2023b)

According the Fingrid Datahub Oy's Datahub-newsletter there are now 231 energy communities in Finland with total 5400 individual delivery sites. 83 % of energy communities are using surplus method SMA and 17 % are using surplus method SMB. Surplus methods define how surplus (extra) energy is distributed by EC member. SMA means that surplus energy will be distributed for one production delivery site and SMB means that surplus energy will be distributed equally to all consumption delivery sites according to agreed share. (Fingrid, 2023b)

In Finland we have a total 3 891 918 consumption delivery sites and only 5400 of those are involved in energy community, that is only 0,0014 % of delivery sites (Fingrid, 2023a). It is obvious that there are lots of improvements needed for increasing the number of energy communities.

7.1.2 Examples of energy communities in Finland

Earlier only companies and detached houses could have their own electricity production, but nowadays housing cooperatives and commercial buildings can also have it by forming energy communities. The first example of the newest energy communities from 2023 are housing cooperatives that have solar panels on the roof and members are usually private users. For example, in Kuopio a terraced house with 8 apartments added 100 solar panels on their roofs and formed an energy community. (Yle, 2023)

One of the most well-known examples is the Lempäälä Energy Community or LEMENE project. The initiative was a key project of Finland's Ministry of Economic Affairs and Employment. Lempäälä is a self-sufficient energy system that was completed in 2019. It utilizes renewable energy sources and operates independently. Members of this energy community are companies in the Marjamäki industrial area. Its most famous building is the Ideapark Lempäälä shopping mall. The industrial area consists of six substations which form a ring network. The system consists of 13 000 solar panels, six gas engines, electricity and district heating energy storage and fuel cells (see figure 19). Lempäälä can operate as a stand-alone power grid without a power outage.

Figure 19. Lemene energy system (Lempäälän Energia, 2023)

The third example is an innovative ecovillage in Kempele. Building av ecovillage started in 2011 and the goal was to be fully independent by heat and electricity. Ecovillage consists of 10 houses. The ecovillage-maintained self-sufficiency with its own small power plant, which uses wood chips. The powerplant makes wood gas from the wood chips, which is then used to generate electricity. The heat from the generator goes to heating water, which keeps the houses warm. Unfortunately, this “wood chips to wood gas” method seemed to be too expensive in Finland and this ecovillage needed to be connected to national power grid after 5,5 years. (Mainio, 2021)

7.2 How energy communities have been used in other countries

Fina and Monshberger (2023) identifies in their study that there are four types of strategies to enhance the growth and more integration of energy communities (ECs): The first one is improving cooperation or collaboration with existing stakeholders such as energy suppliers, DSOs, and energy service providers. Second is assuming new roles, for instance, managing distribution grids. Third category is expanding trading opportunities, which could be with other communities, third parties like industries and large enterprises, or directly on the market and finally receiving extra support from local actors. These steps can help ECs become more integrated and widespread.

In following chapter is presented an overview of the potential of energy communities in Finland's future. It presents the findings in terms of financial, energy system modelling, energy communities knowledge sharing, acting with new roles and geographical locations sections. This chapter responds to the research question "How energy communities have been used in other countries".

7.2.1 Financial

In Finland we could use same kind of subsidy that they have in In Netherland. In Netherland ECs get their own subsidy scheme that guarantees energy prices will stay within a certain range. If the energy prices will fall, it does not affect the business model of ECs. This kind of scheme has encouraged banks to invest in ECs, because the business case will be more stable. (European Commission, 2023)

ECs in Netherland foster collaboration with neighbours and the benefits from ECs are used for the local area instead of the energy company. In Finland benefits from ECs are used for individual members, it would be beneficial to return benefits to local area. Social aspect could be increase by cooperation with EC members and the profits should be invested in neighbourhood so that it benefits all. (European Commission, 2023)

In Austria at present, any surplus energy produced is sold back to the network operator. However, if these communities had integrated additional energy storage systems, they could potentially have the capacity to store and strategically sell energy to interested parties in the future. As it stands, an individual producer can sell up to 12,500 kWh without incurring any tax. This would be an interesting option in Finland. (Bergren, et al., 2023).

In Austria, associations that form energy communities do not own their own facilities. They either rent them or use the ones that belong to their members. On the other hand, big cooperatives that operate energy communities often have their own facilities. In Finland we could also use this renting and leasing model.

A family or a small group usually runs most CECs in Austria. CECs have the benefit of wider participation than RECs, as they can span multiple substations and limited liability companies can join them. CECs could play a more important role in the energy transition in the future, especially if bigger corporations choose to invest and get involved. Energy communities help to lower energy poverty by providing members with cheaper energy. They also allow members to take part in the energy transition without having to pay for the required infrastructure, such as PV panels (Energy

Communities, 2023). If ECs in Finland did not need to pay for required infrastructure, that could increase number of ECs in Finland. It could also be interesting to see energy communities with only family members.

In future in Austria EC members can be members in multiple ECs at the same time, this could also be applicable in Finland and EC members could get more benefits.

According to Campos, et al. research, energy communities in Netherland can be established geographically in same post code area. These EC members get benefits from tax deductions for self-produced consumption for 0.1333 Euro/kWh up to 10 000 kWh/year for 15 years' time. In Switzerland benefits consists of network tariffs and taxes deductions, energy communities with less than 50 000 kWh/year, pays only 30 % of maximum power tariff. All this could also be applicable in Finland if the legislation would allow this. (Campos, et al., 2020)

Energy communities in Finland should have their own tariff and it should be set at a level that benefits both DSO and EC. It is much more reasonable to use the public grid than to construct their own one. Government support in the form of financial aid or subsidies could limit the financial obstacles in Finland. For instance, in Austria, the Coordination Office for Energy Communities establishes funding programs for the creation of energy communities.

According to ProCemPlus program research (ProCemPlus, 2021) energy community members do not have to pay transfer fees at all for the production they have generated. In Austria EC members that use public network, will get tax benefits. This kind of tax benefits could also be applicable in Finland. In many countries own network tariffs have been implemented for ECs. In France they have implemented local network tariff that, that means EC members will get more benefits during summertime and less benefits during wintertime, based on different time. Similar benefit exists also in Italy, but EC members will get extra 100 euro per produced energy afterwards, and this incentive in Italy is valid for 20 years.

Trading opportunities could be expanded in Finland between other communities, third parties like industries and large enterprises, or directly on the market.

7.2.2 Energy system modelling

In Germany, energy communities produce electricity from PV and wind sources and heat from biomass. In Finland, we should boost our wind and biomass heat sources in our energy communities.

Other things that we could use in Finland is adding heat sources to energy communities. In Netherland and Denmark, they have integrated both electricity and heat sources to energy communities, but in Finland we have only PVs for housing cooperatives.

In Denmark they have ECs that has combined heat pumps and PV, this could be applied to Finland also. There are also cases where entire villages and recently formed neighborhoods are structured as energy communities. These communities are often situated in locations that allow them to utilize nearby areas for heat production or wind turbine installation. For these larger communities, the distribution of electricity via the shared grid emerges as the most suitable model for power sharing. In Finland when we should also take ECs in account when we build new neighborhood areas.

In Sweden they have existing models that share similar characteristics with CECs. These include wind power cooperatives, solar power communities, eco-villages, and small-scale heating cooperatives, which are currently the most prevalent forms of energy communities in Sweden. In Finland we could increase the number of wind power cooperative and small-scale heating cooperatives. (Bergren, et al., 2023). We could have projects like Tamarinden in Finland, where the project is a collaborative with construction companies and several building operators. The aim is to establish a community capable of reducing, producing, storing, and sharing energy within a local energy system. Another good example of project in Sweden is Hammarby Sjöstad that also could be replicated in Finland. (Hammarby Sjöstad 2.0, 2021; Tamarinden, 2023)

Norway's Lohøgda example could be used in Finland, because it is a big housing association with 777 apartments. The energy community is sharing production and storage of renewable energy. They have a common water heating system and solar panels, currently they are planning to have energy storage using hydrogen. After this project started 2016 energy community members have minimized their energy costs by over 50 % (Aarsbog, 2022).

7.2.3 Increasing energy community knowledge

In Netherland they have own organisation called Energy Together that represents energy communities in Netherland. This kind of organisation would be suitable for Finland also if that would only be promoting energy community issues. (European Commission, 2023)

Another example is the Coordination Office for Energy Communities in Austria. This organization serves as a bridge between energy communities and Austria's federal stater, the relevant ministry, and other key actors, providing support and education to both energy communities and policymakers. (Bergren, et al., 2023)

One possibility in Finland is to teach children in school about energy communities. When they understand the fundamentals, they can share their knowledge with adults, and this will increase the knowledge and the number of energy communities in the future.

TEM have also stated in their final report that information about energy communities should be increased. TEM suggested that Motiva should take this task. Motiva should advise citizens on every kind of energy community questions, such as different kind of energy communities, how to set up an energy community and how they work, how to operate in energy community, what kind of contract types are possible, how to join or leave energy community, what legal types are possible. (TEM, 2023a)

7.2.4 Software or systems

Alliander a Dutch network company has developed a tool called ENTRNCE Trader, that allows electricity providers and customers to trade directly. Tool can be used with other energy communities and third parties. It provides full transparency to all EC members of energy production and consumption (EU, 2023a). This kind of tool would be needed also in Finland.

Som Mobilitat is a cooperative in Spain that offers e-mobility options, such as renting EVs, bikes or motorbikes. The vehicles belong to the cooperative or to individual members of EC. The cooperative is non-profit, and its focus is to network with local investors and public bodies. Same kind of cooperative is in France *Mobicoob*, it has 20 000 members, and it is also sharing public transportation service using EVs. One share cost 100 EUR, and member have to commit for five years, after five years period share can be sold back to EC. (Reis, et al, 2021). Both this EC activities could be suitable in Finland.

In Finland we could have use for this shared online platform called "Som Comunitats" that has been created in Spain, it provides various internal management services for energy communities. ECs can use this platform to handle their operations from one place with different services at their disposal. This platform has features for project management, data display for each user, member administration and other EC related administrative tasks. All these features can be adapted to energy communities' own requirements and can be linked to their own website. (EU, 2023a)

MARS is a software platform for energy communities in Croatia. It helps ECs collect, compute, and examine data about how much energy they produce and use at the household and community level. MARS is useful for ECs, energy managers, city administrations and renewable power plant operators. (EU, 2023a). This tool could be used in Finland also.

Italy has developed a digital tool *Magliano Alp*i, for energy forecasting. Tool is taking account the aggregated energy needs and generated electricity volumes and potential energy production. Tool will also handle seasonal trends, meteorological factors, number and typer of prosumers and customer and the geographical location (EU, 2023a). This tool could also be used in Finland.

7.2.5 Act with new roles

Some of the ECs in Germany are not only involved in energy distribution, but also work as a grid operator. This might be something that could be tried or applied in Finland as well.

Energy community initiatives in Norway are mainly driven by property developers and real estate firms who build energy-efficient homes that produce and store clean energy. In Norway, actors such as citizen cooperatives, municipalities, private investment firms, and others also lead various energy community initiatives. (Bergren, et al., 2023). In Finland property developers and real estate developers should be more proactive in EC initiatives.

In Norway, the prevalent form of energy community initiative was led by DSO companies. The objective of these DSO companies is to create various microgrid models in specified regions to alleviate the burden on the primary grid and consequently reduce future expenses associated with maintenance (Bergren, et al., 2023). In Finland DSO companies could be more proactive and create new EC initiatives.

7.2.6 Geographical location

In Austria they have nationwide energy communities that are not restricted by geographical boundaries, but members are required to obtain their energy from the same network operator. This model is favored by families spread across the country who wish to share their electricity, as well as individuals living in grid areas where no REC exists yet. This nationwide family favored models could also be suitable in Finland, the only problem is that in Finland we have many network operators, and residents need to live in same area. Of course, this kind of EC will also need changes in current legislation. In the European context, a nationwide energy community would be classified as a CEC. (Bergren, et al., 2023)

As stated by Campos, et al. (2020), energy communities in Netherland can be based on the same postal code area geographically. This could raise the number of energy communities if it were possible in Finland.

7.3 Ways that energy communities can generate revenue in Finland currently or later on

In chapter *Business models with energy communities* were presented theory for business models. Based on how energy communities can generate revenue, this chapter responds to the research question "What kind of business models could be possible when using energy communities in Finland.

Selling Energy Back to the Grid: Energy communities often generate their own renewable energy, for example through solar panels or wind turbines. When they generate more energy than they consume, they can sell this excess energy back to the grid. This not only provides a source of income but also contributes to the overall supply of renewable energy in the grid.

Energy Efficiency Measures: Energy communities can implement energy efficiency measures to reduce their energy consumption. This can lead to significant savings on energy bills, which effectively acts as a form of income.

Government Incentives and Subsidies: In Finland, the government could provide financial incentives or subsidies to promote the generation of renewable energy. Energy communities can benefit from these incentives, which can be a significant source of revenue.

Participation in Energy Markets: Energy communities can participate in energy markets, providing flexibility services to the grid. For example, they can adjust their energy demand in response to price signals, which can generate revenue.

Providing Energy Services: Energy communities can also provide various energy services to their members, such as energy audits, installation of energy-efficient equipment, or energy management services. These services can be a source of revenue.

Investments: Energy communities can attract investments from members or external investors. These investments can be used to finance the installation of renewable energy systems or energy efficiency measures, which can generate returns over time.

8 FINDINGS AND CONCLUSIONS

8.1 Objectives and implementation

In conclusion, this thesis aimed to investigate how to utilize energy communities in future in Finland. The study examined different definitions for energy communities, what kind of different energy community types exists, what are the benefits and challenges and how to mitigate challenges. The study also analysed what is current state of energy communities in Finland and what is the current state of energy communities in selected countries. At the same time business models for energy communities were analysed and a proposal how energy communities can create more revenue was suggested. The work relied on several public studies done in the EU and Finland, reports by working groups and legislation. The sources included material from TEM, VTT, Fingrid, ProCemPlus, Eurostat and Nordic Energy Research group. Besides that, material was also gathered from EU websites.

Results for what is the status of energy communities in Finland, was presented by legislation, examples of energy communities and the number of energy communities. Results for how to utilize energy communities in Finland in the future was presented based on the overview of energy communities' status in selected top six EU countries. Study suggested some models that could be applicable also in Finland. Results for new business models were presented based on how revenue could be generated with energy communities.

However, there are still many regulatory issues that prevents most of these suggestions to be realized in Finland, but for example, increasing the knowledge of energy communities do not need any regulatory changes and that could be implemented fast.

The number of energy communities could increase if we ensure clear and simplified legislation and enable electricity sharing. In addition, we should create incentives for energy communities and create supportive networks. In the future when we are constructing new buildings, we should take account needs for possible energy communities already in the planning phase.

It is obvious that there is a need for one clear and simplified definition for energy communities. Implementation of REDII and IMDII varies in different countries. In EU we should define one clear definition for energy communities.

Breuker et al. (2020) is stating that in the future EU electricity Market, individuals as communities have access to all electricity markets, all customers will have right to dynamic electricity prices, energy sharing withing community will be allowed, new roles for aggregators will be created, individuals and communities will be allowed to participate in demand response and as maybe ECs are allowed to own and operate a distribution network.

According to (Fina & Monshberger, 2023), the analysis of their study reveals that strategies to promote the spread and further integration of energy communities can be grouped into four categories: First one is enhancing cooperation or collaboration with established stakeholders such as energy suppliers, DSOs, and energy service providers. Second one is assuming new roles, for instance, managing distribution grids. Third category is expanding trading opportunities, which could be with other communities, third parties like industries and large enterprises, or directly on the market. Finally, the fourth category is receiving additional support from local actors. These measures can help ECs become more integrated and widespread. Their categories are similar to categories that are presented in this thesis.

According to Eurostat (2022) latest static from 2022 share of energy from renewable sources are high in Norway, Finland, and Sweden. For example, in Norway there are only 3 energy communities but the share of energy from renewable sources are 76 %. In Germany they have very high number of energy communities but the share of energy from renewable sources are only 21 % (Gjergii, 2023). It would be interesting to see what the result would be if we add a column of energy community members in numbers in this static.

8.2 Future usage of energy communities in Finland

Currently in Finland we have energy communities in housing cooperatives with solar panels. In the future we could have other renewables also, like wind turbines, district heating or biomass facilities. We could also enhance Smart Grid Integration within the energy community, this could also include demand response systems and energy storage solutions. We could also invest in energy storage systems like batteries and provide energy storage services to the grid or local business. Energy communities could participate in demand response programs during peak periods in exchange for financial incentives from grid operators, energy companies or TSO. Energy communities could engage in peer-to-peer energy training where members could buy and sell energy directly within the community.

Smart grids enable better management of energy resources and enhance grid stability. We could have energy trading platforms for EC members, so that they can directly sell and buy surplus energy within the community. We should collaborate with ECs to implement energy efficient initiatives, like energy audits, energy saving projects and energy management systems for optimizing energy usage. We could also establish and enable EV charging infra structure in ECs. We could share the knowledge and information about the EC benefits and possibilities with an awareness campaign and educational program.

Fina and Monshberger (2023) have identified four strategies that would increase the number of energy communities. Strategies are improving cooperation or collaboration, acting in new roles, expanding trading opportunities and receiving extra support from local actors. All these strategies could also be implemented in Finland.

Finland should also follow what is happening in reschool program *Strategies and tOOls for Incentivization and management of flexibility in Energy Communities with distributed Resources*, because the results will also benefit Finland. The reschool program is a new EU co-funded project that started in March 2023, and it unites 16 partners from 7 European countries. This program will develop two tools that will boost the involvement of citizens in energy communities and the active role of communities in energy markets. It will also improve the energy markets knowledge including communication with stakeholders(Reschool, 2023b)

8.3 Reflection

When I started to work with this thesis the main goal was to focus only on distributed energy communities. But soon I discovered that distributed energy communities are not allowed in Finland and there is not so much research about the topic. So, I changed the topic to normal energy communities and started to research it.

Energy communities are a popular topic of research and there are many sources available. I only focused on the most recent sources from 2022-2023. A big challenge was to determine when I had enough sources, because it seemed to me that every day, I discovered a new great source that I wanted to use in my thesis.

I should have used Zotero or similar tool for all the sources I have collected during this writing process, and I had saved lots of time. Now I started to use Zotero it the middle of this writing process.

It was a surprise for me that Finland is not at the forefront of energy community's issues. Overall, this thesis has enhanced my understanding of the complexity with energy communities. Nowadays it seems that I see articles and news about energy communities every day and everywhere and that is not a bad thing.

8.4 Further research topics

There are lots of possible research topics that could be investigated related to energy communities. One research topic in the future could be how to consider energy communities when constructing new buildings. Another research topic could be based on energy community usage, whether it is industrial, commercial, or household. Third research topic could be a summary of all energy communities that exists currently in Finland. Fourth research topic could be focusing only on REC.

The scope of this thesis has been limited to some EU countries, but future research could apply a similar approach to other countries outside EU.

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APPENDIX 1: A MIND MAP OF ENERGY COMMUNITY TERMS