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PROSUMERS ROLE IN FUTURE ENERGY INFRASTRUCTURE: THE ROAD TO SUSTAINABLE HOMES IN FINLAND

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List of abbreviations

CenSeS	Centre for Sustainable Energy Studies
CIA	Central Intelligence Agency
EEA	European Environment Agency
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gasses
IPCC	Intergovernmental Panel on Climate Change
MWh	Megawatt-hour
OECD	Organisation for Economic Cooperation and Development
PV	Photovoltaics
P2P	Peer-to-Peer
R&D	Research and Development
SDP	Social Democratic Party
SNG	Social Development Goals
TWh	Terawatt-hour

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ABSTRACT:

The research investigates the opportunities of introduction prosumers scenario on the Finnish energy market and their role in the changes in the energy industry in Finland. The study concentrates on limiting CO_2 emissions in the future through decentralization of the power industry. The intention of this research is to find answers to the four research questions: 1) What is the current situation of energy infrastructure in Finland? 2) What opportunities there are for development of sustainable and self-sufficient homes? 3) Who are prosumers and what kind of role do they have in the future? 4) How do operations of energy companies influence prosumers and how the cooperation between them could look like in the future?

Henceforth, detailed interviews are being completed with two energy companies, including medium-size operator and clean energy association, operating on the Finnish market to understand a view of the current situation of infrastructure, upcoming developments and possible possibilities in the area.

From obtained data, it is confirmed that existing energy infrastructure is suitable to implement the scenario of prosumers and the researched concept was considered by energy companies. It is also proved that prosumers have an essential role in changes towards sustainable energy production in the future. It is possible to implement the idea of prosumers in Finland, with adjustments to existing infrastructure and energy operators as a transition towards carbon neutral Finland in upcoming future.

Moreover, the research revealed the benefits of implemented scenario in economic, social and environmental perspectives. The advantages are seen on an individual, regional and national scale. Implemented scenario brings advantages to all parties involved, including one on the governmental level.

KEYWORDS: PROSUMERS, ENERGY INFRASTRUCTURE, SUSTAINABLE HOMES, FINLAND

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1. Introduction

1.1 Background of the study

We are on the stage of the evolution of civilization where we need an incredible amount of energy to maintain our basic needs. As humans, we require an unbelievable quantity of power. Households and industries are enormous energy consumers. Some people even feel lost and uncertain when the power outage appears. Over time, we will need even greater amounts of energy to sustain our development and growing population. Nowadays, as studies shows, over 80% of produced energy comes from fossil fuels (Shell, 2017). The source which is completely not sustainable and non-renewable.

The energy production, both the quantity and source of it, has changed multiple time in long-term observations. We could notice that almost all the world's energy was produced from traditional biomass – mostly burning wood and other organic matter, starting from the 1800s. Coal was not used in a significant amount as only 2% globally, with the highest amount burned in the United Kingdom area. The oil consumption did not begin until the 1870s. This step was developed further and followed two decades later by natural gas and hydroelectricity usage. By the beginning of the XX century, the whole coal consumption had increased significantly to over 50% of usage and the other half was reserved for biomass, while oil, gas, and hydroelectricity remained not so popular yet (Ritchie, 2019).

Following human development, we can observe that by the 1950s, the energy mix had to vary notably. As we entered the new half-century coal left behind the traditional biofuels and oil increase up to around 20 per cent. Nuclear electricity production started to gain its supporters in the 1960s and a significant amount of nuclear power plants were built around the world. Finally, as we entered 1980-90s the idea of renewables like solar, wind and modern biofuels were introduced. Other renewable sources, such as geothermal and marine technologies, have been developed later in the beginning of the

XXI century (Shell, 2017). The whole perspective of energy sources through out the centuries can be seen below in **Figure 1**.

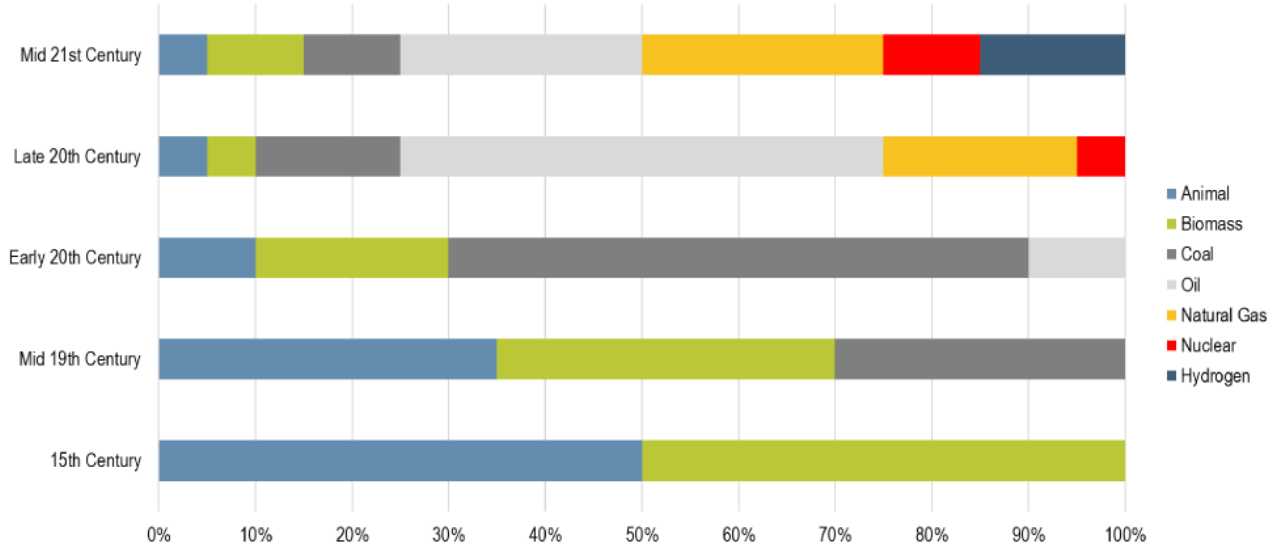

Figure 1. Evolution of energy sources (transportgeography.org, 2020).

As the world is trying to become more sustainable, the energy sources are also shifting towards greener energy. In this term, greener energy means the energy produced sustainably, without harm to the environment and with the smallest or no existing emission of CO_2 to the atmosphere. Unfortunately, some people may think that renewables account for a larger share of global energy consumption than coal, while in fact, their total contribution remains small globally. In that situation, the question arises what is the current situation of energy infrastructure in Finland? What opportunities there are for the creation of sustainable and self-sufficient households? Who are prosumers and what role do they have in the future? How do operations of energy companies influence prosumers and how the cooperation between them could look like in the future? This thesis brings attention to the questions which will help to develop a greener way of producing the energy and focus on the sustainability of our development. Is using fossil fuel necessary? There are several sources of green power

production: hydropower, geothermal energy, biofuels, biomass, waste, solar photovoltaic, wind, tidal and waves power. All of them are more or less environmentally friendly, sustainable but unfortunately still expensive in construction or maintaining.

1.2 Research gap, question and objectives

The energy industry is one of the major sectors which needs a change to support increasing energy demand. Transforming a way of energy production may reduce the emission of CO_2 and lower the use of non-renewable fuels. This brings a question, what role can prosumers represent in the future energy infrastructure, to create more sustainable homes in Finland? Additionally, is the current infrastructure suitable for implementation of the concept of self-sufficient units? Plus, what part do the energy companies have in that process? The answer to those questions will be explored in this research.

Nowadays, electrical systems are more centralized and use either coal or uranium. One of the most powerful visions in the future electrical systems is that it would be much more decentralized and distributed than today. Local communities will be able to produce their own renewable energy and share the surpluses through the existing network. Additionally, they will own local small-scale energy storage facilities, and consist of energy-sufficient buildings inhabited by smart 'prosumers' (mix of consumers and producers). What is more, the houses itself are energy-sufficient, containing energy-efficient appliances which require less energy to work. The vision of sustainable, self-sufficient homes does not end here. Produced energy will work in the closed-loop for the home itself. That means that the amount of energy produced will be large enough to sustain the whole household. In case of the surplus, the energy could be stored in the smart storage facility added to the house or it might be transferred via existing infrastructure to companies, public buildings, etc., who require a higher amount of energy than a household. This solution would minimize the demand

for energy in the energy industry which would lead to a lower cost of energy production. Plus, it would help to supply the whole network, especially in pick times. The role of a hundred thousand households would be significant. From energy consumers which they are today, they would change into producers in the future.

The scenario described above is not yet analysed or studied. This is a gap in the academic area on which this thesis will put a focus. In this thesis we are trying to answer following research questions:

1) What is a current situation of energy infrastructure in Finland?

2) What opportunities there are for creation of sustainable and self-sufficient homes?

3) Who are prosumers and what kind of role do they have in the future?

4) How does operations of energy companies influence prosumers and how the cooperation between them could look like in the future?

This research will give the answers to the research questions displayed above.

1.3 Definitions and limitations

The studied area of this research is extensive and as such, there is a need for limitation. This research will focus on industrial and business possibilities and management of proposed solutions. This chapter clarifies the main terms included in the research, as well as, the one recognized as the most crucial in understanding the background of the study.

1.3.1 Prosumers

Prosumers are people who have changed the way they live to a more sustainable one, using the energy from clean and renewable sources. They are not only the consumers of the energy which they purchase from energy companies. Installation of solar photovoltaics, wind turbines at their homes made them producers of the energy. What is underlined in Oberst study, is that prosumers are partially self-consumers of energy they produced. The homes of the prosumers can generate the energy by utilisation of many sustainable solutions, including solar PV, wind turbines and biomass (Oberst, 2019). Anyone can become a prosumer by making the necessary changes to create a sustainable household they live in. In the same study, Oberst stated that prosumers' households differ from regular consumer homes, in terms of the housing situation and socio-economic aspects.

Also, with growing environmental awareness, more people are likely to take actions in terms of modifying their houses. European Union law encourages this sort of transformation and recognises various opportunities in prosumers scenario (Campos, 2019).

1.3.2 Energy infrastructure

The infrastructure system is a necessary network providing the electricity to every household in Finland and anywhere else in the world. The energy traverses a long journey to get to the homes of thousands of Finns. The electricity flows through the so-called connection to the electricity grid. This connection can be transmitted out in two ways: by air or by underground. The connectors come across each other at the end of the line. The main fuses are located in this place as well. Behind every connector, we can find an electricity meter, which is tremendously important, as it is a piece of equipment which can calculate the cost of electricity consumption. All these elements are safeguarded with unique seals and the electricity consumers do not have

access to them regularly. In the most probable scenario, the connector is installed outside the building, either on the wall of the house or near the fence, sometimes in the basements of the apartment's buildings, in an appropriate box (Gabriel, 2008). Thanks to this solution, the connectors do not affect everyday operation. What is important to underline, they are not a threat to the health and life of electricity consumers. This whole infrastructure provides the electricity to consumers' homes and can be used in the future to transfer the surpluses created by prosumers. In the study of Guelpa, we can acknowledge that differentiate energy infrastructure brings many benefits. Variety of energy sources, whether it is solar PV, biomass energy, heat pumps, present improved management of the energy sources, decreases consumption and waste, plus that transformation allows a higher share of renewables which comes with lower environmental impact and drop in costs. (Guelpa, 2019).

1.3.3 Green energy and its sources

The term of green energy indicates that the power was generated without harm to the environment and with the small or no emission of CO_2 to the atmosphere. Bhowmik states in his research that green energy comes from clean sources of which have a lower environmental influence in contrast to usual energy technology (Bhowik, 2017). Solar photovoltaics, wind turbines and biomass are renewables and will be used as examples in this research. Sustainability is used fairly with connection to green energy and as a term might have a wide meaning. According to the Cambridge dictionary, it is "the quality of causing little or no damage to the environment" (Cambridge, 2020). Furthermore, sustainability in the economic aspect, declares that commodities and services should be produced without the use of the resources that cannot be replaced, and without damage to the environment (Cambridge, 2020). It is worth to underline that sustainability, in terms of this research, will concentrate on different dimensions: economic, environmental and social.

Solar energy is one of the most popular renewable sources of energy around the world. The sun offers 10,000 times more energy than needed to satisfy the whole world's energy needs every day (Redy, 2012). Solar energy is not going to end anytime soon in contrast to fossil fuels. It is single, the biggest alternative power source available presently.

The power of wind is also a well-known and popular renewable. Wind power does not pollute the air, soil or water and does not drain water supplies. This presents it as a clean and safe energy source. An advantage is that the wind is a free and endless power source material (Bratley, 2017). The cost of wind energy is comparable to fossil fuel-based energy. Including the greenhouse gas emissions into account, the cost stands around 80 EUR per MWh (Jain, 2011). The energy obtained from wind is emissions-free which marks it as a green source of energy.

Biomass is a renewable energy source which is received from organic material of plants and animals. The plants absorb the sun's energy which is then stored in the biomass in the process of photosynthesis. If the biomass is subjected to the burning process, the chemical energy in the matter is released as heat. Biomass, as a source of energy, can be used in many ways. It can be burned directly or transformed into liquid biofuels or biogas, which might be used as fuels (EIA, 2018).

Besides specified above green energy sources, there are several more renewables which could be introduced for the mass power production like hydrogen, hydropower, tidal and biofuel energy although this work concentrates on the future 'prosumers', small scale green energy producers and consumers.

1.3.4 Sustainable home

A sustainable home is a self-sufficient house, powered by green energy, environmentally healthy, neutral for the natural environment, comfortable to live in for family and equipped with energy-efficient appliances. That kind of units can have built-in power

storage which will collect surplus energy, to use when the production is not sufficient to power a whole house (Henderson, 2016). As proven by previous studies, including Henderson's the biggest obstacle of introduction sustainable households is cost and legislature. Although, the solution to that issue is to research economic factors and market assessments (Hagbert, 2016). The great example of a sustainable or green home is an area Kvillebäcken in Göteborg, Sweden, on which Hagbert based his study. The district of the city is called a smart city and it is the first urban area in Göteborg which was constructed under the new, environmental requirements. Both, residential and commercial buildings must fit the specifications on energy balance, indoor conditions, healthy construction materials, noise and moisture protection, green backyards, and exterior water control. To add to that the area is intended to eliminate the dependency on transportation by car. The definition of a sustainable home can vary, depending on each research and, as Hagbert emphasised, it is due to different market insights on housing standards, lifestyles and household designs that are being applied.

1.4 Structure of the study

This thesis is divided into five, separate main chapters, which will, in the end, form a clear and logical basis for the research.

Chapter one is an opening chapter, containing a background overview of the energy situation and history around the world. It also holds a description of the key terms and limitations. Chapter one as well encloses thesis question and objectives.

Chapter two concentrates on the introduction of Finland and existing energy infrastructure in the country. Energy sources are extensively analysed in that section. Chapter two also answers questions on a current situation of energy infrastructure in Finland. And what opportunities there are for creation of sustainable and self-

sufficient homes. This part includes a summary and profile of the energy consumers in Finland.

Chapter three consists of an overview of literature on prosumers, their role and sustainable homes. Possible solutions, which can be adapted by prosumers to create sustainable households in the future, will be included in the chapter. What is more, it answers the question on how operations of energy companies influence prosumers and how the cooperation between them could look like in the future. Chapter establishes the theoretical basis for the subject under research.

Chapter four presents an outcome of the interviews conducted on the energy companies in Finland who were the target group of the study. Interviews were conducted with medium-size energy company and clean energy association, operating on the Finnish energy market. The research aim was to check the readiness of Finnish power suppliers for change and their possible adaptability to decentralized market. The outcomes of the study will also present how keen energy companies are in drive for possible changes.

Chapter five, the last chapter, connects the entire study and delivers conclusions for the research question.

2. Case country background

This chapter will consist of background information about Finland. The part includes an overview of the energy system in the country. A summary of the population structure and energy prosumers will be enclosed as well.

2.1 History and political outlook of Finland

Finland is a European country located in a northern part of the continent. It shares its borders on the north with Norway, on the northwest with Sweden and the east with Russia. The western and southern border is bordering mostly with the Baltic Sea. Additionally, there are the Åland Islands, which are an autonomous region. The country is associated with being part of the Nordics.

The first information mentioning Finland appeared in the XII century when the Catholic church started to gain believers in the south-western part of the country (Haggren, 2016). Due to ongoing Swedish colonisation and Northern Crusades, most of the lands of modern Finland became part of the Swedish Kingdom and the realm of the Catholic church from the XIII century for more than few hundred years (Haggren, 2016). Russia won a large part of Finnish lands when the Finnish War ended between the Kingdom of Sweden and the Russian Empire in 1809 (Our Finland, 2017). Following, the Grand Duchy of Finland was established. The Lutheran Church was dominating in the area at this time. The following century was about the growth of nationalism and thriving Finnish culture and traditions after which Finland gained its independence from Russia on 6th December 1917 (Our Finland, 2017). Independence caused a civil war in the country. The power was gained by the White Gourd, which was opposing communism. While everything stabilized, the mainly agrarian economy grew

moderately fast. Finland worked on building relations with the West, although tensions remained with the Soviet Union. Finland fought twice against the Soviet Union during World War II.

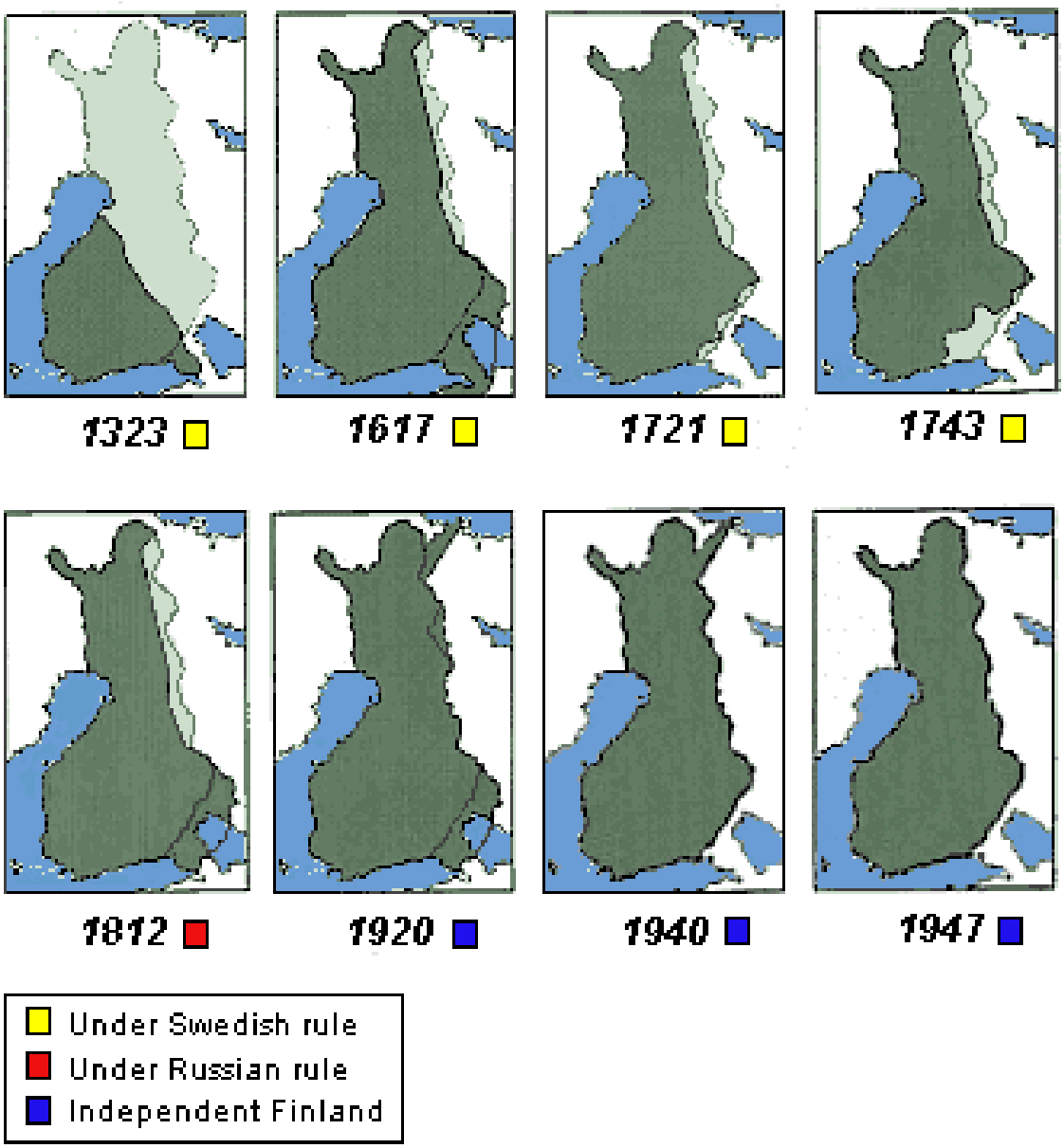

Figure 2. Finland's eastern border 1323 – 1947 (finland.fi, 2020).

The country was defending its independence in the Winter War which was then followed by the invasion of the Soviet Union in the Continuation War. Signed peace settlement left Finland without a large part of Karelia and some other areas to the advantage of the Soviet Union. Finland remained an independent democracy in Northern Europe after World War II (Our Finland, 2017). The change of Finnish borders may be seen above in **Figure 2**.

The economic boom in the 1970s made Finland's GDP per capita one of the world's highest. In the next twenty years, the welfare state was introduced and expanded in Finland. That increased the number of public sector employees, spending and originated high tax rates for its citizens. At the beginning of the 90s, the market has seen an overheating of the economy, followed with noticeable down of Western, Russian and the local market (Our Finland, 2017). In 1995, Finland joined the European Union, which followed with a change of its national currency markka to Euro in 2002. Joining the EU is seen as the biggest achievement of Centrist-Conservative government at that time (Our Finland, 2017).

In 1995 the right-wing party lost the election to Social Democratic Party. The SDP government included Greens, the Left-Wing Alliance and the Swedish People's Party which was unique for Finnish standards. In 2000, Tarja Halonen was the first woman who became a Finnish President. President Tarja Halonen, from the left side, won a right-wing candidate Sauli Niinistö, from the conservative National Coalition Party, by less than four percentage points in next election in 2006 as well. She was 11th Finnish President and served her country until 2012 (Our Finlnad, 2017). The job of President of Finland since then belongs to her previous opponent Sauli Niinistö (finland.fi, 2019). Institutionally, Finland is a parliamentary republic consisting of 311 municipalities.

2.2 Socio-economic outlook of Finland

Many things changed after the war. Before, the forest and farm industries were the principal budget suppliers over the years. Finland progressed through an extraordinary shift from a farm and forest economy to a diversified, modern and industrial economy in the last half-century. Finnish income per capita is now among the highest in Western Europe and oscillates around 50,152.34 USD (World Bank, 2018). That is equivalent to around 385 per cent of the world's average. The land stands on a highly industrialized free-market economy. Finland extremely depends on the export of its goods which accounts for over 33% of GDP in the last years (PWC, 2019). Finnish market profits on its competitiveness in manufacturing, mainly the wood, metals, engineering, telecommunications and electronics industries. Raw materials, energy, and some components for manufactured goods are regularly imported to the country as the import is an essential part of the Finnish economy. Agricultural growth is restricted to production based on self-sufficiency in basic products as for the cold climate in which Finland is placed.

The population was estimated at 5.52 million inhabitants with the majority of over 1.4 million of whom live in the central Greater Helsinki area in 2019 (Statistics Finland, 2019). Currently, Finland is the eighth-largest country in Europe and the most sparsely populated nation in the EU. In the last decade we can see a significant growth of the population. This is illustrated in **Figure 3** below.

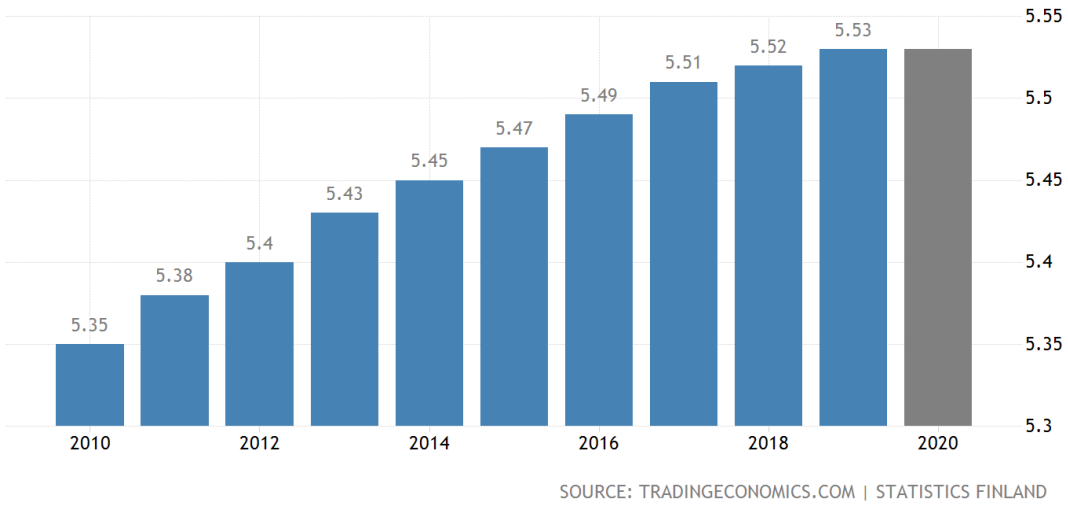

Figure 3. Population of Finland in recent years (tradingeconomics.com, 2020).

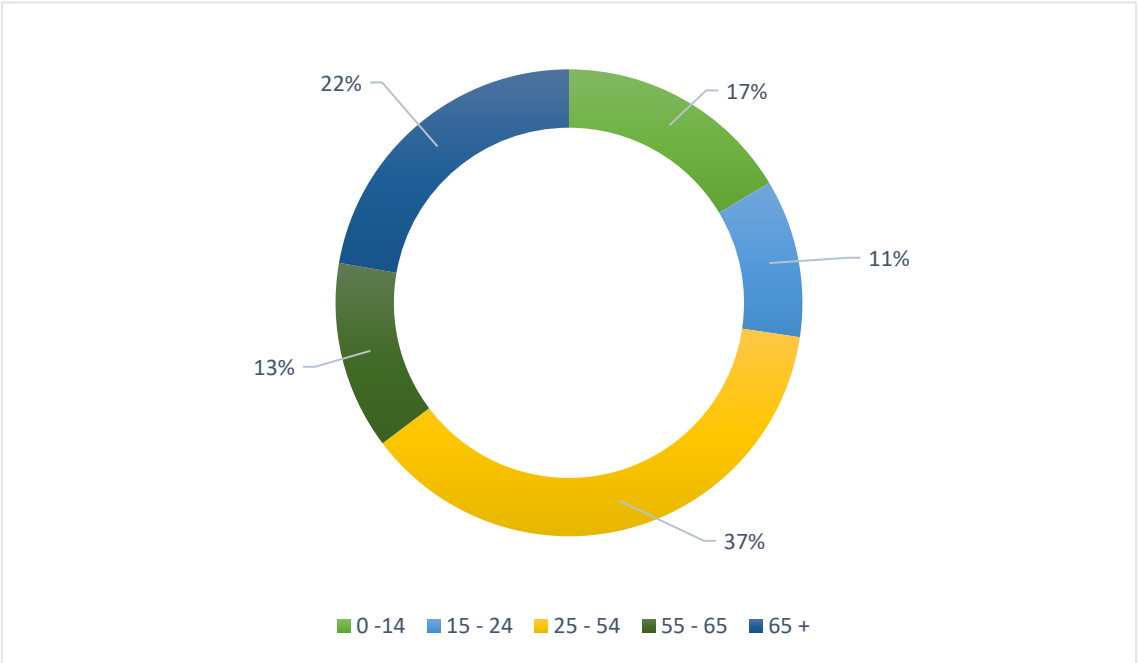

Figure 4. Age structure in Finland (CIA, 2020).

Looking at the age structure displayed in **Figure 4**, the most numerous groups are people within 25-54 years old which creates 37.64% of the population. Following, the second

most numerous groups consists of elderly people, 65+ years old with 21.51%. Next, 16.44% are children up to age 14 and people aged 55-64 with 13.19%. The group with the smallest quantity of people is youth, aged 15-24 with 11.21% (CIA, 2018).

According to the statistics, the average number of family members in Finland is 2.8 person (Statistics Finland, 2017). The distribution of persons who belong to a family has been diminishing continuously. The most common family structure consists of a married couple without children with a rate of 36% of the families. A married couple with children of some age living at home was a common family structure only up to 2004. As for 2017, the number of families descended to 1,472,000 in Finland. The number indicates that 74 per cent of the Finnish residents belong to a family. The rate is decreasing since the 1990s. The peak with 87 per cent of the population belonging to the family was reached in the 1960s with the falling rates later on. An overview of a family structure above can put a light on how average household looks like in Finland.

2.3 Energy systems, capacity and consumption in Finland

Finland is a part of Nordic electricity market area which is considered to be the most progressive one in the EU. Unfortunately, Finland is one of the main emitters of CO_2 in that region. The energy consumption per capita is also one of the highest in comparison to the members of the International Energy Agency (Daneshpour, 2017). It is as well second among Nordics and OECD members, right after Iceland. This might be due to industries with high energy consumption (pulp and paper industries), high standards of living, the cold climate and long winters which are normal for that location and long distances in the country. Additionally, Finland takes the last spot in eco-efficiency ranking among its Nordic neighbours.

Finnish electricity production relies on nuclear and coal-fired plants. Hydropower is the next important source of electricity production (Daneshpour, 2017). The power production mix contains biomass and renewables as well. In total 65 TWh was produced in 2017. Nuclear plants delivered 21.5 TWh, hydropower plants produced 14.6 TWh, coal and gas-fired plants created around 8.7 TWh. Net import of 20.4 TWh was also needed. In the end, the total electricity consumption summed up to 85.5 TWh as displayed in **Figure 5** (Statistics Finland, 2018). Finland has shortages of domestic sources of fossil energy. Considerable quantities of petroleum, natural gas, and other energy resources, including uranium for nuclear power must be imported. The electricity network in Finland spreads to a total of 400,000 kilometres. In addition, the district heating system accounts for a little under 15,000 kilometres, while the natural gas pipeline extends to about 1,800 kilometres (Finnish Energy, 2019).

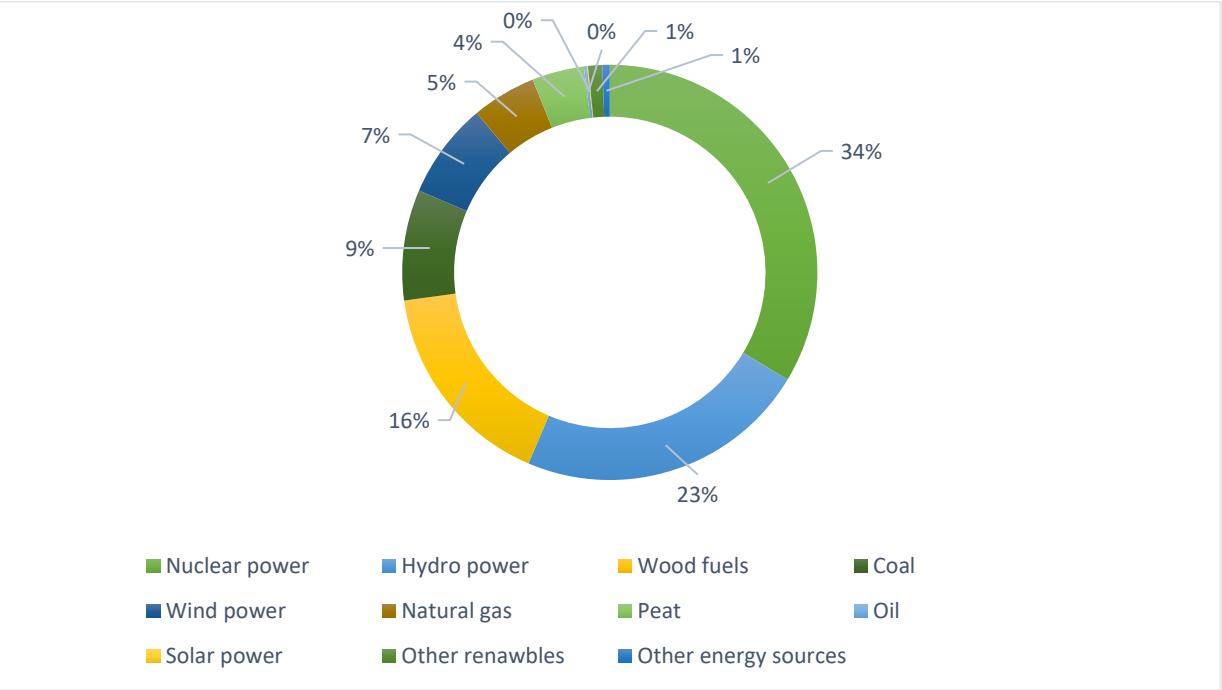

Figure 5. Electricity supply by source in 2018 (Statistics Finland, 2019).

With an average of 2.8 people in the house, the power consumption is as **Figure 6** implies in 2017. The majority of the energy is consumed by space heating, with 67% of the total share. Heating of water uses up to 15% of energy. Use of electrical appliances, lighting, cooking etc. utilize 13% of the energy of the house. Sauna's heating consumes 5% of the household's energy. This situation is not usual for the rest of Europe, as the sauna is definitively a Nordic practice. The majority of the homes own or share a sauna in the apartment building they live in since it is a tradition in Finland. To sum up, there are over 2.3 million saunas in the country (Statistics Finland, 2018).

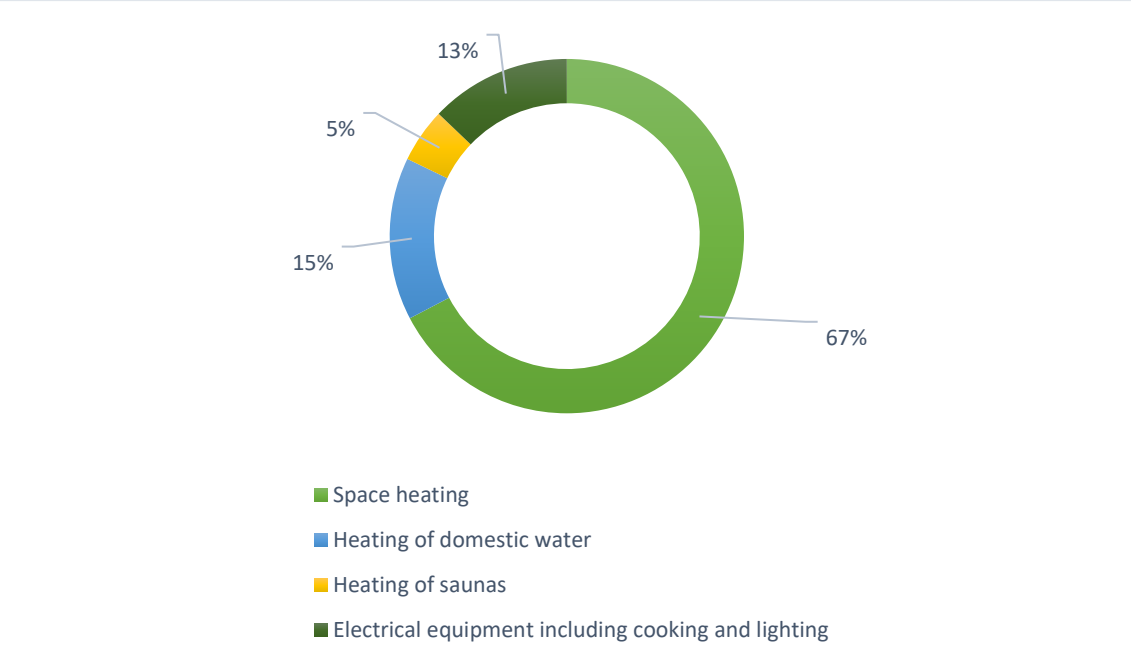

Figure 6. Energy consumption by household in 2017 (Finland Statistics, 2019).

A recently conducted survey among the Nordics shows that the majority of energy consumers are aware that they can change the electricity supplier. The same study implies that most of them are passive when it comes to change. It is mostly due to the small savings which would occur due to a change (Nordic Energy Regulators, 2018). The findings prove that active electricity customers, who signed a contract in the last year consist of 26 per cent of people. Furthermore, 16 per cent have looked

at the electricity offers in the last year but remain with their former supplier, and therefore they are seen as aware consumers. Among the participants of the survey, 58 per cent have neither changed nor compared contracts in the last several years, which is why they are defined inactive or passive customers.

The same research stated that the Finnish customers are the most active one among Nordics and are therefore flexible to choose another offer if it is more suitable. Additionally, Finland and Norway have the highest percentage of aware consumers. The last spot, with the share of the most inactive customers, belongs to Denmark.

2.4 Energy infrastructure and its administration in Finland

There are over 3 million energy users in Finland, according to the statistics (Finnish Energy, 2019). They can choose the offers from several major producers of the energy like Fortum, Pohjolan Voima, Teollisuuden Voima and Helsingin Energia. As for the transmission of the electricity, Fingrid Oyj is a national electricity transmission grid operator granted by the Finnish Energy Authority. **Figure 7** displays the Finnish electricity transmission system, which indicated that all main areas in the country are connected to the energy net.

Finnish state owns the majority of the company's shares. Fingrid declares that they consider the environmental impact of their operations and good governance while suppling the electricity for Finns. What is also interesting for a company who operates in an energy market, is that Fingrid promotes the UN's global Sustainable Development Goals (SNGs) related to climate action, energy and infrastructure.

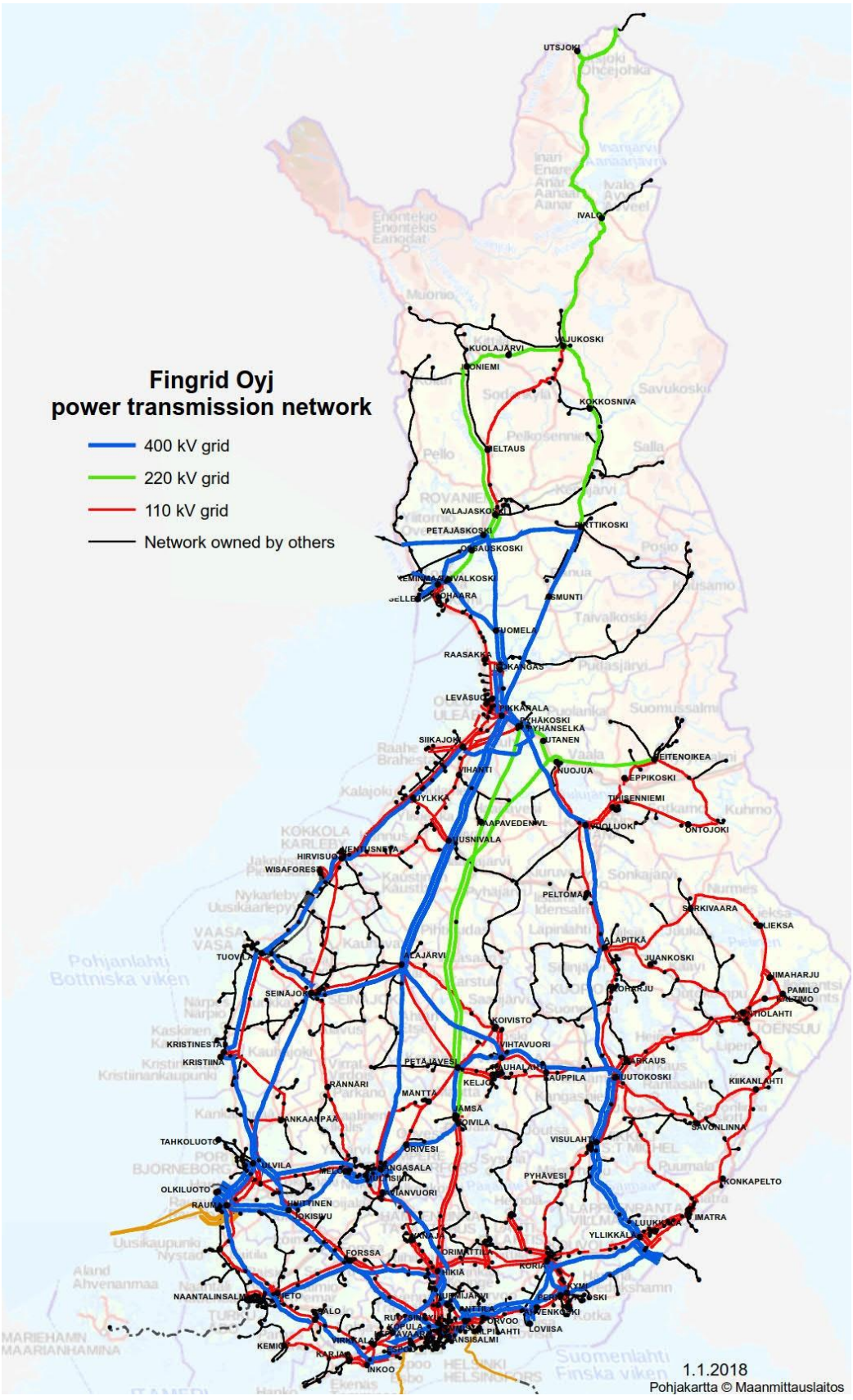

Figure 7. Finngrid Oyj's power transmission network (Fingrid Oyj, 2018).

2.4.1 Energy generation and current administration

Most electricity is generated in the nuclear and coal-fired plants, as introduced shortly above. Finland differs from other countries with a variety of energy sources. The 67.5 TWh of electricity was produced in 2018 (Statistics Finland, 2020). Sadly, the amount of electricity generated with the use of fossil fuels and peat increased by 14 per cent in 2018 (Statistics Finland, 2020). The share of renewable energy declined to 46.2 per cent in 2018, from 47.2 per cent in 2017 (Statistics Finland, 2020). Overall, the energy produced from renewable sources reached 31.2 TWh, with 42 per cent produced by hydropower (13.1 TWh), 19 per cent by wind and nearly all the rest with wood-based fuels. Nuclear power plants generated 32 per cent of the Finnish power, 16 per cent was produced with fossil fuels and five per cent with peat. In the end, the total electricity consumption summed up to 87.5 TWh (Statistics Finland, 2018). That is 2 TWh more than a year before. The remaining energy deficit was imported mostly from Russia and Estonia.

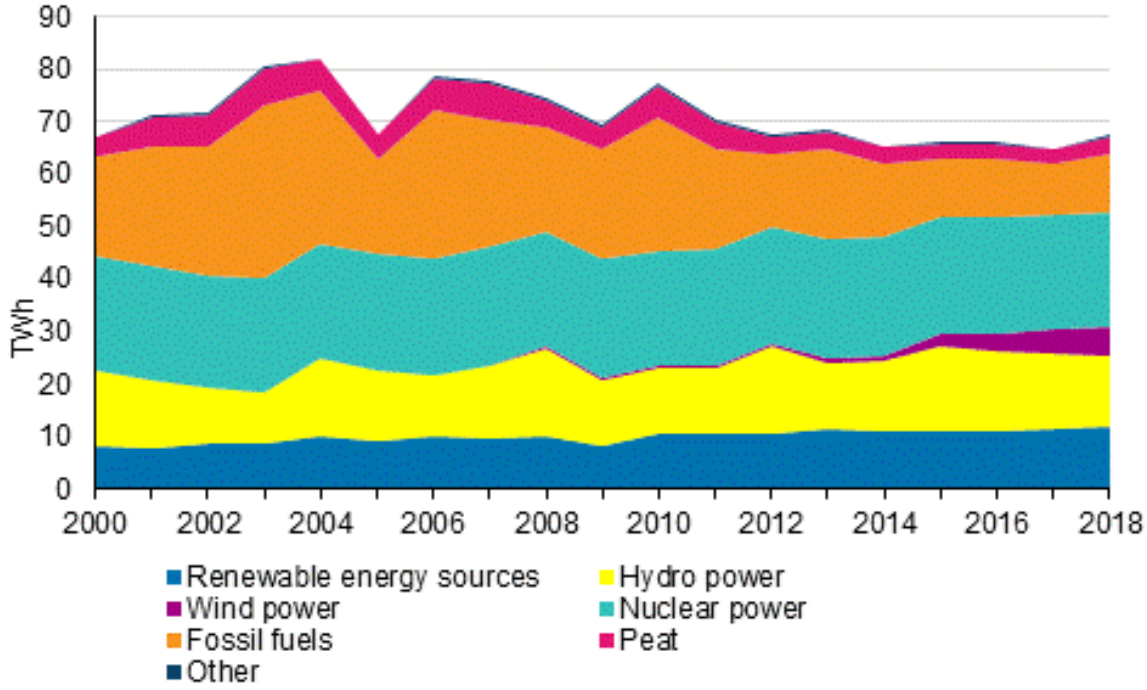

Figure 8. Electricity generation by energy source 2000-2018 (Statistics Finland, 2019).

Figure 8 reveals an overview of the energy sources throughout the years formulated by Tilastokeskus. It is the only Finnish public authority established for the creation of statistics. Consolidated data by the authorities enable us to notice a massive decline in fossil fuels and an increase in renewable energy, especially wind power. Nuclear power is seen stable as the years pass by.

To reach the European Union climate and energy targets, modifications must be implemented in the energy sector. Finland set a goal of reducing domestic greenhouse gasses (GHG) emissions by 80%, by 2050 from the 1990 level. Furthermore, Finland is planning to go coal-free by 2030 (EEA, 2020). Therefore, considerable investments are placed in renewable energy and biofuels. That means that enormous changes must be performed to accomplish the set targets of emission. Creating sustainable households could be an answer to emerging environmental problems.

2.4.2 Energy distribution and management process

Fingrid Oy is a national transmission operator whose network was introduced earlier as **Figure 7** The system operated by the company ranges to a total of 400,000 kilometres (Finnish Energy, 2019). The entire network consists of 3 different grids: 400 kV, 220 kV and 110 kV. There are some other networks in Finland, although they are smaller and used for distribution on a local scale. Most of the distribution occurs in the southern part of Finland, as 25% of Finnish citizens are living in and around Helsinki Metropolitan area and another 25% populate southern part up to Tampere. The least populated is the central and north of Finland.

Fingrid has tremendous plans prepared for the future. The transformation of the network is already ongoing. Fingrid is planning on increasing energy distribution from wind farms and other renewable sources. The energy market is trying to reach its environmental targets on CO_2 emissions and resignation of fossil fuel energy.

Figure 9 presents the future of Finnish energy which looks greener than it is nowadays. Together with human development, demand for energy will increase which will cause new challenges in the energy sector.

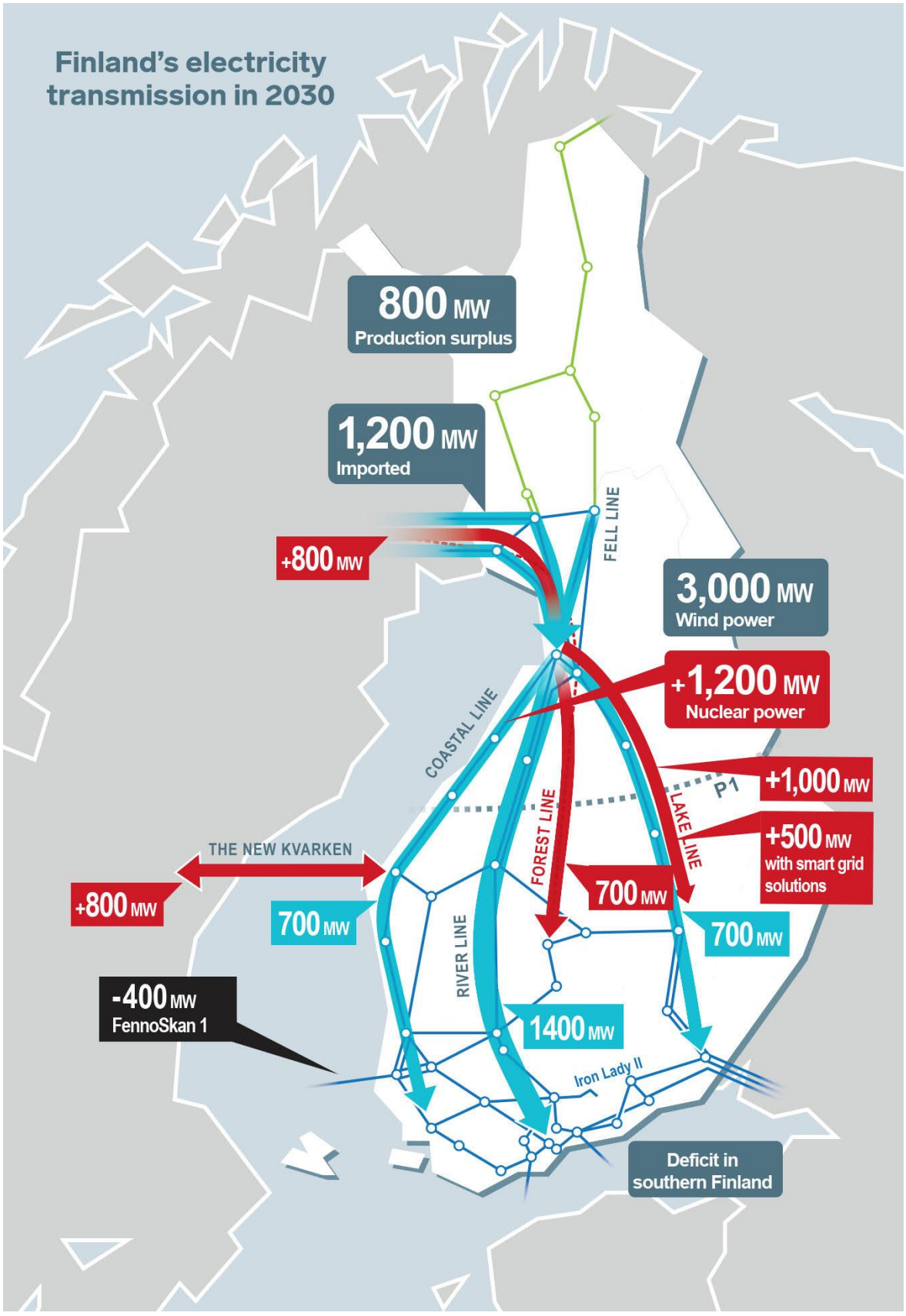

Figure 9. Finland electricity transmission in 2030 (Fingrid Oyi, 2019).

This is an enormous opportunity to develop new, green technological solutions to support that development. The rise in weather-dependent electricity production has shown a shift to a greater demand for flexibility on the market. Fingrid is working on allowing electricity consumers to engage in demand-side management. An increase in demand-side management will help consumers switch to a green electricity system cost-effectively and on market terms. Fingrid is also considering implementing the small-scale production of energy by the consumer as its demand-side management. This is the possibility for prosumers and sustainable housing to be a part of the future energy infrastructure. Nowadays only a few operators allow to choose their consumers the electricity generated only from renewable sources.

National grid operator holds great responsibility. Its principal task is to maintain the safety of the system. The network must be used at all times to keep security levels. What is more, the production and consumption of energy must be balanced. Fingrid must take care of any disturbance which may occur around the network. Further, Fingrid needs to allow international electricity trade with the highest transmission volume available and secured on the electricity markets (Fingrid Oy, 2019).

3. Literature Review

This chapter will contain a comprehensive background information about the proposal of an ideal sustainable home. An overview of the possible solutions to use by prosumers will be also enclose in this part. Also, the prosumers and its role will be described. The literature review is made so, that it is focused on latest research and key sources of information.

3.1 Prosumers

Prosumers are residents of sustainable households in future communities. Their houses are equipped with modern, technological solutions for energy generation. The technology is based on renewable sources of the energy, including solar, wind power and biomass. The electricity produced by the solutions is clean, does not create pollution and is more than enough to support the lifestyle of the residents of the house. Sometimes an additional power surplus may be generated. Being prosumer does not indicate a complete cut from energy corporations as emphasised by Oberst and Campos. There might be circumstances when the production of electricity will be impossible or insufficient, which is normal in weather depended power generation. Prosumer may import energy from centralized energy market when his/her generation does not satisfy the needs of the household (Gautier, 2018). Being a resident of the self-sufficient unit can be attractive for numerous reasons. From an economic point of view, the generation of own energy can lower the costs of electricity in the times of rising costs of power (Hernandez, 2019). What is more, it gives prosumers independence in case of deficit of electricity from the network caused by power outbreak. Looking at social reasons, the environmental impact is lower opposed to conventional electricity production. Emissions of CO_2 from renewable energy sources are non-existing or minimal which presents prosumers as environmentally conscious and socially responsible. Plus,

Peer-to-Peer (P2P) exchange of energy may optimize the share of renewables on the market (Hahnel, 2019). What Hahnel also proved is that approximately 77% of prosumers are willing to share the energy with others. This delivers a positive outlook on prosumers enterprise (Hahnel, 2019). Furthermore, prosumers' efforts, in energy generation, make it more accessible for governments to achieve their environmental targets. The transformation from fossil fuel-based power to green energy can carry health impacts as well, meaning that the costs of healthcare may decline.

3.1.1 Role of prosumers in future energy infrastructure

The prosumers have an essential role to play in the transformation of the modern energy market. The European Union actions are pushing the initiative of self-sufficient households since the Kyoto Protocol implemented in 2005 and followed by the Paris Agreement in 2016 (CenSeS, 2018). An executed idea of prosumers in any country, not only in Finland, would have a tremendous impact on lowering the CO_2 emission and reducing the greenhouse gases emissions into the atmosphere (Gautier, 2018). This state promotes the goals of the EU. Creating self-sufficient households would be an excellent way to eliminate fossil-based fuels from energy production and could be a starting point towards sustainable energy production.

Having every household transformed into a self-sufficient unit is a powerful vision of the future, which changes the electricity market. That solution implemented on a broad scale turns the energy companies from being a supplier of an enormous amount of power to a business partner of prosumers (Hahnel, 2019). If homes produce enough energy to meet their own needs, the market can shift from being committed to producing more power due to the growing demand for being a supervisor (Zajączkowska, 2016). Households could sell the surpluses of the electricity they produced to their neighbours or companies via existing infrastructure. It is a win-win situation for all the parties (Hahnel, 2019). Prosumers profit by selling the surplus

energy, electricity market may end uncertainty of supplying the growing demand for power and relocate huge investments needed into new, sustainable and fossil-free infrastructure (Rehmar, 2018; Vergados, 2016). What is more, governments meet their environmental goals, plus the society lives in a healthy environment with minimal or non-existing CO_2 emissions, which are needed by the year 2050 (IPCC, 2019). To add to this, the positive economic aspects for governments, healthcare systems, energy market and prosumers itself (Monasterolo, 2019).

3.2 Ideal sustainable home

As climate change is affecting many areas and industries, the energy market is one of them as it is one of the largest pollutants and environmentally damaging sector. Therefore, it is crucial to make significant changes in many areas. These actions can help to minimize human's carbon footprint and ease our planet to recover (Monasterolo, 2019). Transforming the way we live can be challenging and for many a radical, and impossible step to do. As humans, some of us are more flexible to make changes than others. Therefore, changing the way where we live can be a significant move on a way to a greener future. An idea of a sustainable home is simple and subjected to modification depending on the house location.

3.2.1 Criteria for a sustainable home

Sustainable home represents a house which is self-sufficient. Demand and supply of energy are balanced as the house is powered with energy generated by renewables, including solar photovoltaics, wind turbines or biomass powered generators (Rehmar, 2018). These renewables might be installed for a single house or entire neighbourhood

and connected by existing energy infrastructure (Rehmar, 2018). A sustainable home is healthy for its residents, neutral for the natural environment, comfortable to live in for family and equipped with energy-efficient appliances. A smart solution for build-in power storage would be accommodated in the house. This is important as energy is supplied from weather-influenced sources. That storage will collect surplus energy to use when the production is not sufficient to power a whole house.

Secondly, an indication of a sustainable house is its size. **Figure 6** pointed out that over 67% of energy is used for space heating in Finnish households. Energy usage drops drastically in a smaller space. Worth highlighting is that less space does not equal a lower standard of life, as most of the people might be concerned. A sustainable home is designed thoughtfully to ensure comfort, but at the same time, it gives its residents a view on more sustainable living. Sustainability, in any aspect, is enormously needed in the world we live in, especially, in the spotlight of climate emergency and over-consumerism (Rehmar, 2018). Although, over-consumerism is not the subject of this research and will not be analysed.

3.2.2 Role of institutions in sustainable home

Governments around the world have an enormous task to do, to ensure a safe and healthy habitat for its citizens, now and in the future. It is an urgent matter especially now with growing importance of climate change issue and its consequences on human lives. It is without a doubt one of the priorities for most governments around the world to be implemented. Climate change already have an enormous impact on people, in terms of water shortage, unprecedented weather events, drought, floods, power out brakes, weather anomalies in terms of heatwaves etc. Most of the countries signed the Paris Agreement Act on Climate, which obligates them to fight dangerous climate change by limiting global warming to considerably below 2°C and continuing efforts to limit it to 1.5°C (IPCC, 2019). This means that every country must reduce its

CO_2 emissions to the atmosphere, focus on green energy and implement sustainable solutions in many areas to protect the environment (European Commission, 2019). It is the first document legally binding global climate change agreement.

European Union has its targets in a fight against climate change. By 2030 the EU wants to achieve:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels);
- At least 32% share for renewable energy;
- At least 32.5% improvement in energy efficiency; (European Commission, 2020).

Meanwhile in Finland, the National Climate Change Adaptation Plan for 2022 was introduced and it intends to control the risks related to climate change and adapt to the changing climate for Finnish society (EEA, 2020). In 2019, the Finnish government committed to carbon neutrality by 2035, which means that there are less than 15 years to accomplish the plan and remove fossil fuel-based energy sources from power production. Undertaken actions will influence Finnish taxes, as the Finnish state collects substantial taxes from fossil fuel traffic. As for 2018, state vehicle taxes were in total €8,100 million (Autoalan Tiedotuskeskus, 2019). In this case, the government should support prosumers in its actions for making their home sustainable units. These actions could be in the form of grants, tax reductions or other compensations. Turning Finnish homes into sustainable units not only impact the environment positively but also the whole society. This action creates a connection of people to its community and a sense of responsibility for lowering the emissions. With the help of the government and with the cooperation of companies from the energy market, the goals set by the government are more than likely to be achieved.

As nowadays technology and science exist to achieve self-sufficient households' idea, the need for social research is required to understand society and its will to transformation, change in its purchase choices and shopping behaviour. As prosumers are the residents of households based on the production of its power, it is crucial to see how society is open for that opportunity today. What Hahnel proved in his study

is that approximately 77% of prosumers are willing to share the energy with others. This gives a positive outlook on prosumers initiative (Hahnel, 2019). Based on the previous studies, society is relatively open to the inhabitation of self-sufficient units. How well the infrastructure is prepared and energy companies itself for the concept of prosumers will be explored in following chapters.

4. Methodology

This part describes techniques used to collect and analyse empirical data which are a base of this study. The chapter is consisting of several sections, including research design, data collection, online questionnaire, analysis, reliability and validity of the research.

According to Webster dictionary, research is "an investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws" (Merriam-Webster dictionary, 2020) In this study the research process is displayed on **Figure 10**.

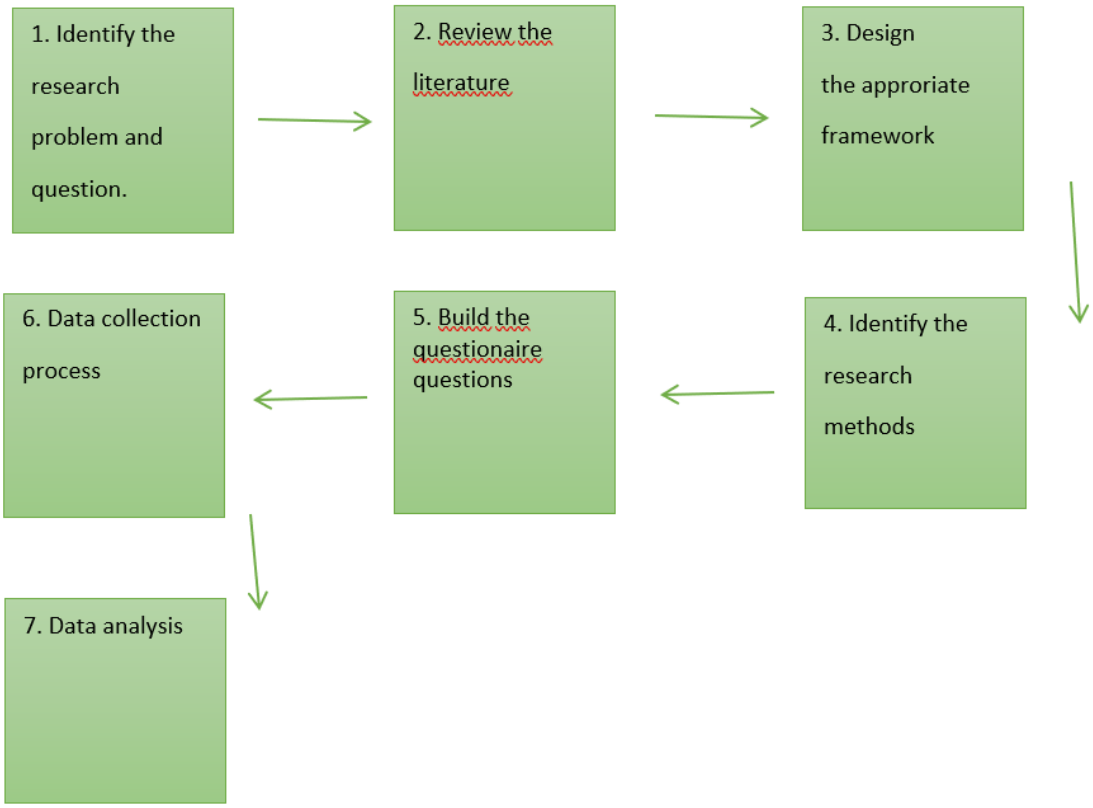

Figure 10. Research process.

The goal of the study is finding a greater understanding of the topic and knowledge for successive research this is why displayed research process on **Figure 10** was created based on University of Southern California study on research design (University of Southern California, 2018). The main research methods used in this study were empirical and descriptive, consisting of questionnaires and interviews.

4.1 Research design and data collection

An exploratory study is utilised in this research due to the recentness of the study. This research has an exploratory character as well as it is adaptable to support a variety of questions. The conducted study design is a useful technique for obtaining assumptions on a particular matter. Additionally, the exploratory analysis provides the answers for nurturing questions and issues. Plus, it helps to recognize research problems (Creswell, 2014).

To display the benefits of the implementation of prosumers scenario, it is necessary to understand if Finnish energy companies analysed the issue and how ready is the infrastructure in Finland. Also, it is important to know the view on the future by Finnish energy companies. For efficient data collection, primary and secondary data gathering methods were used in this exploratory research study.

Primary data are consisting of self-generated speculative studies, case investigations, surveys, focus groups and observations, according to BYU (2018). Secondary data are data from studies that have already been done, which includes books, studies conducted by other institutions or organizations. In this study, the primary data were used to conducted surveys with energy companies operating on the Finnish market. Two companies were interviewed, including medium-sized energy company and a clean energy association operating on Finnish energy market. The answers received from the interviews were medium length consisting of the most important information concerning the topic. The responses were straightforward, clear and on the subject.

Secondary data was applied to estimate and examine the current energy circumstances in Finland. That includes the energy infrastructure condition as well as the socio-economic background of the country. This consists of annual reports, data available on energy companies' websites and statistics included on Tilastokeskus. This type of data was also used to identify prosumers, types of green energy and sustainable housing. The survey was mailed to various energy companies and organizations operating on the Finnish market. The data obtained were investigated and the result is presented in chapter 5.

The preparation of the study supported the basic objectives of good research. Including competence, openness, privacy protection, validity, reliability and objectivity. Following chapters will examine the validity and reliability of this investigation.

The objectives of this research were as follow:

1. to establish who are prosumers and what is their role in the future energy

2. to give background on the current situation of energy infrastructure in Finland

3. to analyse the opportunities there are for the creation of sustainable and self-sufficient homes

4. to investigate the influence of operations of energy companies on prosumers and their possible cooperation between the in the future

Chapter 1 and 3 answered the objective 1. Chapter 2 profoundly analysed objective 2, which was also strengthened during an online questionnaire and will be discussed in chapter 5, as well. In chapter 3, objective 3 were analysed and answered. More insights to that objective will be investigated in chapter 5. The most comprehensive analysis of objective 5 will be displayed in the following part, chapter 5.

The competency, openness and privacy protection of the study can be explicated in the way the data were gathered and studied. Furthermore, interviewed companies were notified on reasons of essentiality of the data to this study.

4.1.1 Online questionnaire

In the following part of the research, the answers will be discovered to the questions on possibilities of introduction of self-sufficient households in Finland, the readiness of infrastructure and potential future solutions in the matter. The section is based on interviews with two companies operating on the Finnish energy market conducted in spring 2020. The online survey was sent out to most of the leading energy companies on the Finnish energy market. Two of the companies gave answers, including where one of the companies filled out a survey online and second company decided to answer the questions during a Zoom call. Due to high competition on the market, the names of the companies will not be made public. Qualitative methods were used in this analysis, using a prepared questionnaire, containing 9 questions, which can be seen in **attachment 1**.

4.2 Analysis

The primary step, after data collection, is data analysis. That investigation aims to see relationships, patterns between them, to examine new possibilities. Nowadays, the world is filled with data on various topics and it is up to the researchers to find a valid source of the information. This data also needs to be understandable, so the analysis is necessary (Berthold et al. 2010).

Qualitative data represents to non-numeric evidence, including interviews, questionnaires answers, notes, different types of recordings, images and text documents (Research methodology, 2019). This study was using quantitative methods to its analysis. Google form was used to create a survey for this research.

The aim of this qualitative research is not only to identify the existing analysis but the essential thing to underline is the importance of the study, analysis, and derivation of

the collected information. The online survey method was chosen due to the high approachability, flexibility, and inexpensiveness. Additionally, the online questionnaire was sent to the representatives of the Finnish energy companies via email.

The companies which were chosen, have an established position on the market and significant share when it comes to the deliverability of energy. There was no difference between the region the companies operate. Due to high competition on the market, the names of the companies will not be mentioned. Due to similar views on the study, the answers will be generalized.

4.3 Reliability and validity

The assessment of the reliability of research outcomes challenges researchers to evaluate the 'accuracy' of the research, possibly in terms of the applicability and the significance to existing studies. Qualitative research is frequently reviewed for missing the accuracy of the research. Often seen with the insufficient support of the research objectives, perhaps due to used technique or neglecting to present clarity in the analysis (Noble & Smith, 2015).

The online survey was conducted with highly professional individuals who understand the fields of prosumers and energy market in Finland, and therefore, their judgment and feedback are reliable.

Various methodological approaches were used during this examination to ensure the honesty of the research outcomes. At first, the researcher's personal preference was removed in order to guarantee fair and dependable results. There were no private associations, stereotypes, and cultural settings included in the process of creating, interviewing nor evaluating the online survey. All matters were precise and accurate in the whole structure of data collection and analysis. Moreover, the researcher saved documents, showing the exact results and supporting the interpretation of data, as they

are consistent and reasonable. Thirdly, most energy companies in Finland prepare their analysis on the matter from which some are uploaded to the public.

5. Findings

This chapter includes views on prosumers and sustainable future of Finnish energy market by Finnish energy companies.

As mentioned above, the principal source of data collection for this study was an online questionnaire, which was sent to a dozen energy companies in Finland. The questionnaire, as the main approach to information gathering, helps to deliver three objectives. Primarily, the questionnaire can obtain valuable data from energy companies on their views on the subject. Secondary, due to the growing interest in the topic of future energy systems, it is important to know companies' opinion about the changes from their perspective. Lastly, the energy companies may help to answer the research questions: "What is prosumers role in the future energy infrastructure? What opportunities there are for the creation of sustainable and self-sufficient households? And how do operations of energy companies influence prosumers and how the cooperation between them could look like in the future?" The results of the survey may be generalized for the whole industry as the respondents have significant market share, as medium size energy company. Although, due to high competition in the energy industry, the names will not be published.

5.1. Results

The aim of this research is to give an answer to the question who prosumers are and what is their role in the changes of the energy infrastructure in the future in Finland. The objective's goal is to promote the prosumers scenario to create a more sustainable future in Finland by reducing the dependency on fossil fuel.

As we observe changes of views on sustainability in many areas of development and businesses, energy companies do not differ from the rest. Interviewed companies agree that actions must be taken towards a reduction in global CO_2 emissions. It is without a doubt the main driver for change and investment in the sector. Minimalization of GHG emissions is required to achieve environmental goals set up by the Finnish government as well as a binding goal due to signed Paris Agreement. It is comprehensively analysed within the sector on how to proceed in upcoming years. The long-term goals await new technology to be developed within energy production and transmission. Yet, the focus on short term goals should rise, as from these actions depends, if the 2030 environmental goals will be achieved. Energy companies are looking for solutions which would be executed in upcoming years as a transition before a new technological advancement. This situation gives many possibilities to the adaptation of the prosumer scenario and many other smaller, sustainable initiatives. Any changes towards increasing the share of renewable energy and minimizing or removing fossil fuel as a source of power is a positive difference and a change in the good direction.

When the question was asked, ‘do you, as a company, agree that actions must be taken to minimize CO2 emissions worldwide?’ the interviewers admitted that steps need be taken to do so. It is in everyone’s best interest to shift towards more sustainable living, addressing the concerns of CO2 emissions. The look into the future reveals that the investigation of the subject is crucial.

For the question, ‘do you think that fossil fuel-based energy production should be banned or restricted?’ companies responded for restriction on production with fossil-fuel based energy. Fossil fuel-based energy is not viewed as attractive anymore as it was in the previous century. It is, without a doubt, an end of an era of oil and coal. Transitioning to renewable-based energy generation is required more than ever. Furthermore, energy corporations believe that fossil fuel-based production should be somehow restricted or limited. Establishing a limitation on the source of the energy generation could advance the process of the transformation to a more sustainable and emission neutral future. To make it possible the Finnish government would have to exert

an initiative. For an even bigger change in the energy industry, an adequate law would have to be introduced by the European Union. Global cooperation and responsibility would be necessary as well to limit the extraction of oil and coal. That is an extreme situation as some countries whole or significant parts of their economies are based on the production of oil and coal, for example, Venezuela, Saudi Arabia or Kuwait (World Economic Forum, 2016).

For the question, 'do you know who are prosumers and what kind of role do they have in the future?' companies answered undoubtedly. Prosumers are producers and consumers of power, residing self-sufficient homes, as stated earlier in this study. Research shows that Finnish power companies are familiar with the concept and did analyse the opportunities suitable for their industry. That gives a positive outlook on the future when potential scenarios are investigated, taking under attention environmental impacts even more than in the past

To the question, 'does the current situation of energy infrastructure in Finland allows to introduce the scenario of self-sufficient units / decentralized energy supply?' the responses were positive. Modern infrastructure is more than satisfactory to introduce prosumers scenario. The theory of prosumers is likely to be implemented, due to Finnish infrastructure being satisfactory to support the idea, as examined by energy companies. What is seen as an advantage, is that this would allow the companies to minimize their investments in the process of implementation. Worth to mention is that the companies believe, that new technology which would revolutionize energy market is yet to come in the next 10 - 20 years or so and that prosumers plan would be a great transition in between.

When the question was asked, 'what opportunities there are for the creation of sustainable and self-efficient homes?' the companies believed there are plenty. Good to mention is a positive view on opportunities of self-sufficient housing creation. It is due to the availability of all necessary components, such as different kind of energy production methods, storage facilities and intelligent management systems. What is worth to underline, is that consumers have comparable views on the idea as proved

in previous chapters. That formulates a positive position on the market for energy companies, as their plans align with the views of consumers for the upcoming future. As consumer are more environmentally aware and want to live sustainably, they are keen to cooperate with power distributors in the presented scenario.

For the question, ‘do you think that if there would be a financial aid from the Finnish government (tax return, grant, etc.) to turn a household into the self-sufficient unit would it be more appealing to customers?’ the companies agreed. Nowadays, modifying houses to produce their energy, either by use of solar photovoltaics, wind turbines or biomass to energy transformers is expensive. Available products for renewable energy generation vary with a price depending on the producer. Yet, it is usually a substantial investment for a family, sometimes not even possible to implement. According to Finnish energy companies, customers would be likely to invest in this solution if financial help would be available. The financial support could be in any form, for example as a tax deduction or tax return, grant, 0% loan from the central or local government, etc. Monetary assistance for implementing the idea could increase the share of renewable energy in power generation nationwide. That would also help low-income families to be able to afford solar PV installation, lower their energy bill and possibly bring additional income from selling generated excess energy.

To the question, ‘how do operations of energy companies influence prosumers and how the cooperation between them could look like in the future?’ companies agreed that closer cooperation and discussion is needed for the subject. As currently the focus of the companies is somewhere else. Also observed is that some companies concentrate on grid-related costs and increase the prices of electricity as a future strategy. This is not the favourable situation, as the focus on off-grid and sustainable solutions, like prosumers scenario, is shifted. Off-grid ideas and related infrastructure are an essential part of a sustainable future and should be examined further on the market. Some firms already concentrate their efforts on investigating sustainable scenarios and create incentives for their customers, which is highly required to reach environmental goals. In general, sustainable solutions for power markets are currently trending in Finland and around the globe.

Worth emphasising is that energy companies should develop suitable business models which would contain their plans towards sustainable advancement, meeting environmental goals and possible scenarios, including complete abandonment of fossil fuel-based energy. Owning a clear, detailed plan with a scope could be key to a sustainable future. Carbon-neutral future is perceived as something distant in time, with 2030 or 2050 in mind. Though, the actions and change must be developed much faster to halt global warming and the increase of the temperature by 1.5 degree Celsius, as described by the IPCC. The prosumers scenario is ideal to implement in that matter.

As there are many driving forces and in one research we cannot examine everything it is reasonable to suppose that prosumers will have important role in the development and transformation of the energy market in upcoming years. That is up to prosumers and electricity companies to determine how great the transformation will be. The implementation of self-sufficient households will positively change the entire energy market and shift it from monopolized one, as it is today, to decentralized market.

5.2 Synthesis of the findings and possible solutions

In the next part, a synthesis of the findings of this study is presented in **table 1** below. Essentially, a discussion on the possible solutions to challenges connected to cooperation between prosumers and energy companies is discussed.

Table 1. Synthesis of findings.

Number	Research questions	Results of the study
1.	What is a current situation of energy infrastructure in Finland?	Current state of energy infrastructure in Finland is sufficient to sustain the implementation of prosumers scenario. No investments are necessary in terms of energy companies contribution for the scenario to be adapted. Currently, on the energy market, there is a deficit of the energy which need to be imported. Therefore, the prosumers solution helps to decrease the dependency on that issue.
2.	What opportunities there are for creation of sustainable and self-sufficient homes?	There are plenty opportunities existing to adapt the self-sufficient households plans. That includes existing elements like different kind of sustainable energy production methods (solar photovoltaics, wind turbines, biomass etc.), storage and intelligent management systems. Further research may help to improve those and create more cost-efficient sustainable energy sources.
3.	Who are prosumers and what kind of role do they have in the future?	Prosumers are producers and consumers of power, residing self-sufficient homes which have balanced energy usage in terms production - consumption. The homes of the prosumers can generate the energy by utilisation of many sustainable solutions which are mentioned in point 2 of this table. The households are also equipped

		with energy efficient appliances and modern technology helping to reduce energy usage. That households are neutral for the environment, usually constructed with sustainable materials, using best-in-class, sustainable construction technology.
4.	How does operations of energy companies influence prosumers and how the cooperation between them could look like in the future?	Operations of energy companies influence prosumers in many aspects. Both sides, prosumers and energy companies utilize current energy infrastructure. Yet, the companies are the one who has management authority on the matter. Currently, energy companies focus on the existing grid and cost-related operations instead of investigating possibilities beneficial for both parties. Future relations may be open on closer cooperation/partnerships. Not only of prosumers and energy companies but as well as governments, research facilities, universities and producers of sustainable technology. The partnership will influence on the development of more adequate and sustainable technology for minimizing environmental impact during energy production. The relations between parties can be also on terms producer/transistor of energy where prosumers are the one producing energy and selling their surplus back to the network.

Shift on the market is noticeable, yet still needs to be driven forward on a national scale. The genuine initiative would be to encourage local and national brands, which operate within the renewable energy market to work together. It is, for example, producers of new technology, like solar PVs, biomass to energy transformers etc. Supporting researches and universities is another way to advance the development of technologies and create future experts in the area of energy and sustainable developments. Therefore, an increase in spending on Research & Development (R&D) is vital. Closer cooperation of energy firms and research facilities is crucial to building a sustainable future for the next generations. Furthermore, local or nationwide cooperation could be an opportunity for energy companies to promote their plans for smart self-sufficient households. The cooperation could be in terms of:

- energy company & energy company/companies
- energy company/companies & producer/producers of renewable technology solutions
- energy company/companies & producer/producers of renewable technology solutions & universities & research laboratories
- governmental organizations & producer/producers of renewable technology solutions & energy company/companies
- all of the above: energy companies, government, producers of renewable technology, universities, researchers, government, etc.

Creating mentioned cooperation can impact on the relations with consumers. It may appear problematic for a regular consumer to turn his/her home into a self-sufficient unit.

If an energy company could offer an advice service, legal guidance or offer an entire ready-to-go household adjustment, this could begin a unique relationship with the consumer. Starting a connection with a customer with this offer could lead to

a long-term relationship, which is needed in the proposed prosumer scenario. Especially in terms of surplus exchange and usage of existing infrastructure. That area has an enormous potential which needs to be examined further.

The cooperation between participants and financial assistance is one of the recommendations to introduce the scenario. Another beneficial aspect to implement is a nationwide educational campaign demonstrating the advantages of the solution.

If power companies have detailed strategies for the future, the plans should be implemented, to encourage people to join the transformation. Shift to self-sufficient households has numerous benefits, as described comprehensively in this research. It is substantial for government and energy companies to engage people in that transformation. The data presented above are based on gathered information from conducted questionnaires and interviews.

6. Conclusions

This part of the research contains a summary of the whole study. That includes relevant findings, conclusions, meeting objectives, suggestions and possibilities for future research.

6.1 Findings of the study

This study started by studying the state of the current energy situation in Finland and key decisions makers, related to the energy market were analysed. Furthermore, the idea of prosumers was analysed and the possibilities of introducing it in Finland taking under consideration energy companies' engagement, infrastructure, future sustainability plans of the Finnish government. Attention was directed on the role of consumers in the future energy market and how they could lead the way of transformation of the energy market in Finland. As for this research we tried to answer following questions:

1) What is a current situation of energy infrastructure in Finland?

2) What opportunities there are for creation of sustainable and self-sufficient homes?

3) Who are prosumers and what kind of role do they have in the future?

4) How does operations of energy companies influence prosumers and how the cooperation between them could look like in the future?

Environmental issues are rising in their urgency worldwide and the attention to climate change is growing. In Finland, the topic is also high on the agenda. One of the sectors which need extraordinary attention is the energy sector. After centuries of not sustainable development based on coal and oil, a change appeared in renewable energy production. That change was and still is developing for the last few decades. The beginning of the XXI century began even more significant advancement in

renewable technology. The renewables, as a source for power generation, is rising around the globe, but a restriction of fossil fuel-based energy is needed, to fast-forward the change towards a sustainable future.

Chapter 2 presents the answers to the first question of the study. In that part, we will find there a historical, political and socio-economical look at Finland, including the state of current energy infrastructure, capacity, the share of modern energy sources used in 2017, as well as, consumption and administration of the infrastructure. As explained in previous chapters, the share of coal and nuclear-based energy is still significant in Finland. Noteworthy to notice is the fact that a deficit of energy in Finland exists, therefore, imports from the neighbouring countries are currently required. Worth to mention, are the results of the earlier studies pointing out that Finnish energy users are active on the market, and open for changes if they see, for example, cost benefits.

Chapter 3 resolved the questions on who are prosumers and possible opportunities of creation of self-sufficient housing in Finland. The prosumers idea inhabiting self-sufficient households seems to be an answer to the transformation of the energy industry for more environmentally friendly. It is without a doubt, a solution fitting for an introduction in Finland. The existing energy infrastructure would be able to sustain the implementation of prosumers scenario, where households would generate electricity with the adjustment to their homes. And as investigated in the interviews with energy companies, this sustainable plan was analysed and is viewed positively.

As for last question, we can find the answers in chapter 3 and 4. We can agree that implementation of prosumers scenario brings positive aspect to all participants. The decentralization of the market, due to the implementation of the scenario, would bring numerous benefits for all parties involved. For the customers, generation of the energy sustains their needs, lower electricity bills and fulfil the environmental responsibility towards their families, local communities or country. The power firms increase their share of renewable energy sources, possibly create partnerships with their customers, to manage their energy production and allocate surpluses where needed. What is more, the scenario does not require a vast amount of investments to

the network. Furthermore, the demand for energy is easier to predict and control. The pressure, of the growing demand for power, is shifted to prosumers, who most likely will fulfil their energy needs. Benefits for local or national governments include meeting their environmental targets. Emission neutral future may bring positives to many aspects, including the governmental budget. It is widely known that air pollution influence of quality of life, the health of the society and economy of the country.

6.2 Recommendations

Prosumers are producers and consumers of the energy their produce due to adjustment to their households. The homes are constructed or adjusted to be self-sufficient units, where production and consumption of the energy are balanced. The possible surpluses may be stored in accommodated to the household's storage solutions or shared via existing energy infrastructure to other residential or commercial buildings. That actions will be managed by existing energy companies. The relationship between these two parties might be based on close cooperation. Prosumers will have a vital role to play in the transformation of the current energy system established in Finland. The goal of this study was to establish the role of prosumers in the shift of energy infrastructure towards more sustainable future in Finland. The results of the study might be view as suggestions. Existing energy companies have investigated the scenario discussed in this research and it is the decision of mentioned companies existing on the energy market and the government of Finland to implement the presented idea.

Worth to underline is that society is becoming more environmentally conscious and do not see the changes as something unnecessary or hard to implement. Growing responsibility among people is a good indication for energy companies to start the market conversion. The good initiative would be to introduce financial support for the consumers to help them in adjusting their houses. The aid could be implemented

in many ways, for example, tax deductions, grants or favourable loans. Having any kind of support, monetary or legal advisory could increase the number of consumers accepting for the change.

Prosumers idea is viewed by energy companies as a short-term solution before new technological advancement which will appear in upcoming future. Yet, the results of implementation are not known and could be surprising. If prosumers concept would be implemented on a nationwide scale the outcomes could be even more surprising and exceed the expectations.

6.3 Future research suggestions

This research gives a primary suggestion for the future study, in terms of prosumers and accommodating the scenario on a greater, global scale. The prosumers scenario is flexible enough to be implemented in different regions around the world with or without additional adjustments.

Moreover, sustainable energy generation technology requires additional improvement to address its cost-effectiveness, as well as new concepts of sustainable energy production. This can be in terms of new ideas of solar photovoltaics, wind turbines, biomass energy systems or new technology generating green energy with no emissions of CO_2.

The idea of green housing consisting of self-sufficient households could be investigated further. That can be in terms of new, green developments of households, construction gap or urban planning. The area of green building or sustainable construction has an enormous potential to be further researched.

Another important research gap to study are concepts of new technologies which could revolutionize energy market and change it into fossil-fuel free and carbon neutral

market in upcoming years. A study is needed to prepare the infrastructure, investment and environmental plans for upcoming change.

Additionally, it will be reasonable to investigate more thoroughly the market and strategic opportunities for energy companies in Finland. Especially, the effects of the prosumers' scenario in different areas of companies' operations. To add to that, it is necessary for other business areas, such other industries like paper and pulp industry in Finland which are energy-intensive industries.

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APPENDIX

Attachment 1

Questionare for Master Thesis Research

Prosumers role in a shift in the energy industry in Finland

A survey is made for Master thesis research purposes. Its aim is to find out how society and energy companies are open for the opportunity to live in self-sufficient units - households who produce their own energy. In those units, demand and supply of energy are balanced as the house is powered with energy generated by renewables, including solar photovoltaics, wind turbines or biomass powered generators. A sustainable home is healthy for its residents, neutral for the natural environment, comfortable to live in for family and equipped with energy-efficient appliances.

Your participation in this online interview is completely voluntary and you may opt-out of any question in the questionnaire. All of your responses will be kept confidential. They will only be used for research purposes. The completion of the questionnaire should not take more than 20 minutes of your time.

The possible introduction of prosumers (producers and consumes) into Finnish energy market could help achieve governmental goals on environment. What is a possibility of decentralization of the market? Please answer below.

1. Do you, as a company, agree that actions must be taken to minimize CO_2 emissions worldwide?
2. Do you think that fossil fuel-based energy production should be banned or restricted?
3. Do you know who are prosumers and what kind of role do they have in the future?

4. Does the current situation of energy infrastructure in Finland allow to introduce the scenario of self-sufficient units / decentralized energy supply?
5. What opportunities there are for the creation of sustainable and self-efficient homes?
6. Was that scenario analyzed or discussed by your company?
7. Do you think that if there would be a financial aid from the Finnish government (tax return, grant, etc.) to turn a household into the self-sufficient unit would it be more appealing to customers?
8. How do operations of energy companies influence prosumers and how the cooperation between them could look like in the future?
9. Any additional comments, suggestions?

To participate, please click on the following link:

https://forms.gle/zLnJyGdUKKTbsKsf7