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CARBON DIOXIDE NEUTRAL ENERGY PRODUCTION IN SOUTH SAVO IN 2050

Master's thesis 2019

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ABSTRACT

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The purpose of this qualitative research is to study the energy system transition towards low-carbon energy solutions and carbon neutrality on a regional level. The research surveys the phenomenon from the perspective of local actors operating in the province of South Savo in Finland. The focus of the study is on finding out the plans of these actors for emission reduction and their strategies for implementing renewable energy. Moreover, the research aims to find out the current state of energy production on the EU level, the governmental level in Finland, and finally on the regional level in South Savo. By studying the phenomenon on different levels, also the perceived drivers and barriers for the energy system transition are identified.

The empirical evidence for this research was gathered by primary and secondary data collection and analysis. Publications about the topic were collected from the local actors and used as a secondary data source. The primary data was gathered by conducting semi-structured interviews for informants within the local actors.

The results indicate that the energy transition to emission free energy production is possible at least in terms of electricity production of the province. The results also show that local actors are positive that the energy production can become carbon neutral.

TIIVISTELMÄ

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Tämän laadullisen tutkimuksen tarkoitus on tutkia alueellisella tasolla energiajärjestelmän siirtymistä vähähiilisiin ratkaisuihin ja kohti hiilineutraalisuutta. Tutkimus tarkastelee ilmiötä Etelä-Savon maakunnassa toimivien paikallisten toimijoiden näkökulmasta. Tutkimuksessa keskitytään selvittämään näiden toimijoiden suunnitelmia päästöjen vähentämiseksi ja strategioita uusiutuvan energian käyttöönotossa. Lisäksi tutkimuksen tavoitteena on selvittää energiantuotannon nykytila EU:n tasolla, valtiollisella tasolla Suomessa ja lopuksi alueellisella tasolla Etelä-Savossa. Kun ilmiötä tutkitaan eri tasoilla, samalla voidaan myös tunnistaa energiajärjestelmän siirtymisessä havaittavia edistäviä tekijöitä ja esteitä.

Tutkimuksen empiirinen aineisto koostettiin primääri- ja sekundääridataa keräämällä ja analysoimalla. Aiheeseen liittyviä julkaisuja paikallisilta toimijoilta kerättiin ja käytettiin sekundäärisenä tietolähteenä. Primääridata kerättiin toteuttamalla puolistrukturoituja haastatteluja alueen toimijoiden edustajille.

Tulokset osoittavat, että siirtymä päästöttömään energiantuotantoon on mahdollista ainakin maakunnan sähköntuotannon osalta. Tulokset osoittavat myös sen, että paikalliset toimijat ovat myönteisiä siitä että energiantuotannosta voi tulla hiilineutraali.

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LIST OF ABBREVIATIONS

CCS	carbon capture and storage
CHP	combined heat and power
CO_2	carbon dioxide
COP21	the Paris Conference of Parties
ESS	energy storage solutions
EU-ETS	the EU Emissions Trading Scheme
GHGs	greenhouse gasses
GWh	gigawatt hours
HP	heat pump
INDC	the Intended Nationally Determined Contribution
kWp	kilowatt peak (solar energy)
LULUCF	the EU's Land Use, Land Use Change and Forestry
MW	megawatt (windpower)
mWp	megawatt peak (solar energy)
PEC	primary energy consumption
PV	solar photovoltaic
QCA	qualitative content analysis
QDA	qualitative data analysis
RED II	the Renewable Energy Directive
RE	renewable energy
RES	renewable energy sources
RET	renewable energy technologies
SE	sustainable energy
TWh	terawatt hours
UNFCCC	the UN's Framework Convention on Climate Change

1 INTRODUCTION

1.1 Background

Energy production is a part of the system, which represents a remarkable share of the connection between the environment and society. Thus, environmental impacts have traditionally been caused by energy production, while societal processes dictate the rules of the game. (Peura et al. 2011, 927) Global energy production has been dependable on fossil fuels for a long time (Karytsas et al. 2014, 480). In total, fossil fuel resources account for about 80% of primary energy and two thirds of final energy (Heard et al. 2017, 1124). This dependency on the limited fossil fuel resources contributes to local and global emission levels, which are causing climate change (Karytsas et al. 2014, 480).

Climate change mitigation is one of the defining challenges present generations are facing. While this challenge is global, the human activities that are causing climate change are undoubtedly local. The greenhouse gasses (GHGs) gathered in the atmosphere are a consequence of the use of fossil fuels, and emissions from agriculture, forestry, industry and waste taking place on a local level. In mitigating the problem, the attention should be focused on reducing these emissions, in which local governments may play a vital role. (Damsø et al. 2017, 406)

Oil and coal-based fossil fuel energy generation is expected to decrease remarkably in the coming years, in order to battle against climate change and to reach overall energy goals both globally and locally (Child & Breyer 2016b, 519). Climate change and global economic pressures are powerful drivers for energy system transitions towards climate-neutrality, low-carbon economy and better resource and energy efficiencies. The response to these pressures, such as increased use of renewable energy sources (RES), creates many new challenges related to energy policy's supply-demand balance and the planning of electricity systems. (Panula-Ontto et al. 2018, 504) Furthermore, demand must be met in a responsible manner that does not put excessive burdens on society in terms of how disruptive or costly solutions are implemented (Child & Breyer 2016a, 25-26).

The energy transition is dependent on political outcomes and stability (Sovacool 2017, 578). This energy transition is not only technological, but also a combination of economic, political, institutional and socio-cultural changes. Therefore, the transition should be led by the principle of sustainability and ethics, and a perspective of resilience. With the ongoing global energy transition, the world leaders will need to provide plans for the future, as well as solid policy options. (Child et al. 2018, 321-322) The decarbonization pathways are supported by strong policies and policy commitment at not only the national and regional levels, but within municipalities and local communities. In addition, subnational actors will need to continue adopting climate and energy goals that are even more aggressive than national targets (Sovacool 2017, 578).

1.2 Research gap and research questions

Studies show that emissions occurring on a local scale are a significant contributor to global climate change, and that energy production is the main cause of carbon dioxide (CO_2) emissions. Thus, it is necessary to study the energy transition phenomenon on a regional level, where decisions regarding energy solutions are being made. The goals of cities and municipalities to become carbon neutral in terms of energy improve their energy efficiency and self-sufficiency, and help fighting global climate change.

In the case of this thesis, the focus of the study is in the province of South Savo in Finland. The thesis presents the actions and implementation alternatives in energy production, for achieving carbon neutrality and zero-emission energy production in South Savo. Previous studies have investigated energy transition and renewable energy production on a global level, on the EU level and on a governmental level, including Finland (Child et al. 2018; Child et al. 2017; Pilpola & Lund 2018; Vass 2017). Also regional studies of the topic can be found, but not many concidering the region of South Savo (Damsø et al. 2017; Viholainen et al. 2016). In addition, the theory lacks qualitative studies where the focus is put on the energy production plans of municipalities and companies, to find out whether a carbon neutral state can be achieved through the actions of the actors within the region. This study aims to answer to this research gap, by the means of examining the plans of municipalities and the energy companies operating within the region of South Savo and interviewing these local actors. Therefore, the study aims to answer to the following research question:

RQ: How does local actors' engagement contribute to pursuing carbon neutrality on a regional level?

In order to help answering this question by the means of reviewing existing literature about the topic, by analyzing documents from the local actors and by gathering empirical evidence, the following sub-questions were formulated:

SQ1: What are the perceived driving forces and challenges for low-carbon energy transition?

SQ2: What are the preconditions of renewable energy on a regional level in South Savo?

SQ3: How are the local actors planning to further reduce their emissions?

The objective of the main research question is to explore the level of engagement of the local actors and how it contributes to reaching carbon neutrality. The first sub-question aims to finding out what are the drivers and barriers for the transition, and will be answered in the literature review section of this study and with the help of the semi-structured interviews. The goal of the second sub-question is to find out the current state of energy production and consumption within the region. The aim of the third sub-question is to identify what are the efforts being made in implementing low-carbon energy solutions in South Savo. The following Table 1 shows which parts of the thesis aim to answer to each research question.

Table 1. Research questions

Research questions	Literature review	Secondary data: publications	Primary data: interviews

RQ: How does local actors' engagement contribute to pursuing carbon neutrality on a regional level?		x	x
SQ1: What are the perceived driving forces and existing challenges for low-carbon energy transition?	x		x
SQ2: What are the preconditions of renewable energy on a regional level in South Savo?	x	x	x
SQ3: How are the local actors planning to further reduce their emissions?		x	x

1.3 Scope and delimitations

The thesis studied the contribution of local actors such as municipalities and energy companies in the energy transition towards low-carbon solutions, in the South Savo province in Finland. The main goal of the qualitative case study was to find out how these local actors' engagement can affect in attaining carbon neutrality within the region. In addition, the goals of the case study also included finding and defining the most important driving forces and possible barriers for the energy transition. Moreover, by analyzing the secondary data and executing semi-structured interviews, the goal was to clarify the current state and preconditions of energy production within the province, and what are the plans and strategies to further reduce emissions. Thus, the scope of the case study was focused on forming a general picture of energy transition in South Savo province, through a wider analysis of available secondary data, and through a more detailed analysis by interviewing a few experts from the operators within the region.

The thesis does not cover all aspects related to low-carbon energy transition. One major delimitation that was set for the thesis was leaving out the transportation sector as emitter and only focusing on the energy production and its role in energy transition towards low-carbon solutions and reduced emissions. This was done due to time limitations as well as in order to delimit the topic in a more manageable frame.

1.4 Structure of the study

The structure of this study is described in Figure 1 below. The thesis constructs of six main chapters, which can be divided in two different parts: theoretical part and empirical part.

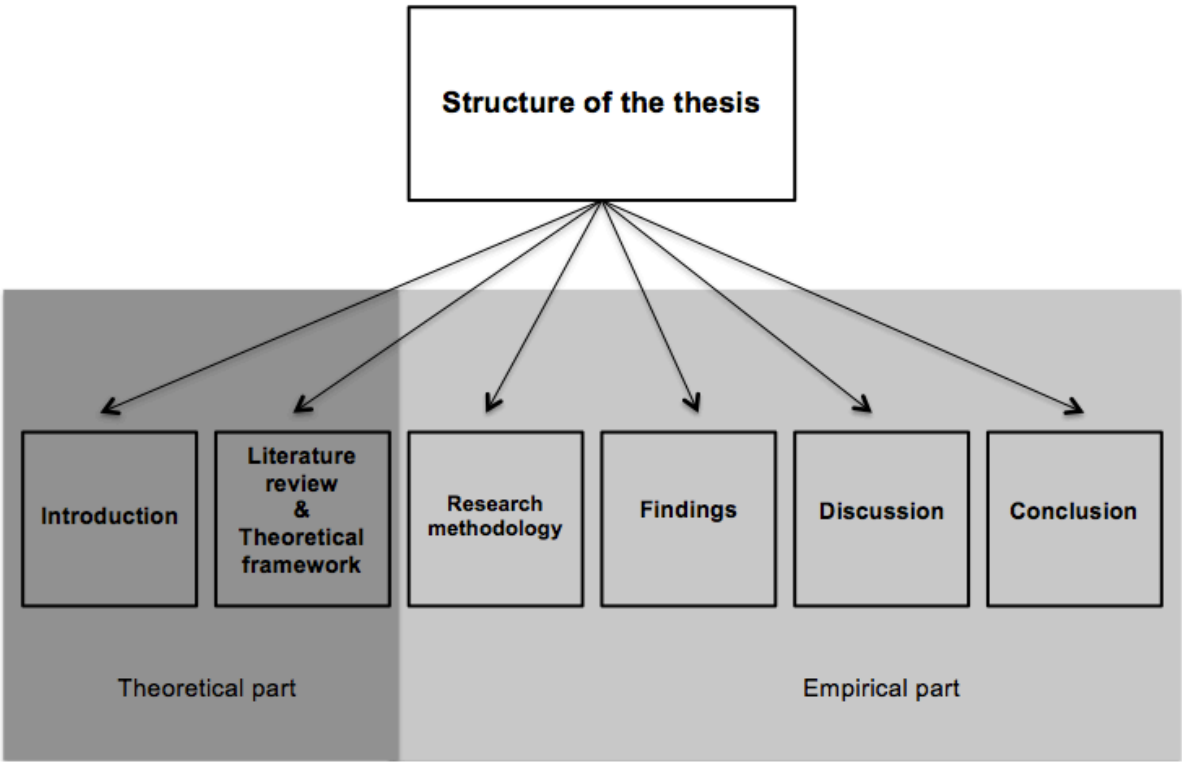

Figure 1. Thesis structure

The theoretical part consists of introduction, literature review, and the theoretical framework for the study. The first step of this research was conducting a literature review, in order to identify the most important aspects and issues within the topic. The literature review's purpose is to prove that in most cases, municipalities and cities on a regional level are in a key position in cutting the emission and making the required changes in the transition towards carbon neutral future. Then from the basis of the literature review, the theoretical framework for the research is represented.

The empirical part consists of research methodology, findings of the study, discussion and finally, conclusions. In addition, also limitations regarding the research are reviewed, as well as possible future studies of the topic. The empirical part starts with research methodology in chapter 3, in which study design, approach and strategy are presented.

1.5 Definitions

Bioeconomy

"Bioeconomy" is an economy that relies on renewable natural resources to produce food, energy, products and services. It is based on the idea that an economy should use RES instead of fossil resources, in order to be truly sustainable. In the face of environmental pollution, climate change and biodiversity loss, the concept of bioeconomy has gained increasing attention globally. Developing biotechnologies presents potential economic opportunities, because bioeconomy will reduce the dependence on natural fossil resources, prevent biodiversity loss and create wealth and new jobs, which are in line with the principles of sustainable development. (Bosman & Rotmans 2016, 1-2)

Carbon neutrality and zero carbon

Due to increasing concern with the impacts of anthropogenic carbon emissions, terms such as ''carbon neutral'' and ''zero carbon'' have become more popular, driven by the efforts to reduce carbon emissions. However, these terms remain very loosely defined (Kennedy & Sgouridis 2011, 5264).

There are many contradictory definitions of carbon neutrality, most of which mainly focusing on carbon off-setting, which implies to reducing the negative impacts of human activities on atmosphere by means of replacing fossil fuels with RE or planting trees. Carbon neutrality can also be described as a situation where the net emissions associated with an organisation's operations or a product, are equal to zero through carbon offsets that meet the criteria. (Zuo et al. 2012, 279) While some institutions may already be carbon neutral, some are only starting a GHG emissions inventory and setting targets for emission reduction (Rauch & Newman 2009, 108). Zero carbon, on the other hand, can be defined as a situation where there are zero CO_2 net emissions from all energy use (Kennedy & Sgouridis 2011, 5260).

Carbon sinks

Forests act as carbon sinks, when the carbon stored in the soil and vegetation increases from one year to the next. Thus, the size of the carbon sink is the same as the change in carbon stock showing a net increase in CO_2 in a forest in a given year. All harvests affect the amount of carbon stored in the forests, since they decrease the growing stock of wood. When logging residues are not collected but left on site, the amount of carbon in the forest soil increases. However, the residues will gradually decay and cause emissions later on. When logging residues and stumps are collected, they decrease the amount of carbon in the soil, at least in short term. (Kallio et al. 2016, 55)

Energy efficiency

Energy efficiency is described by the European Commission as the most effective way to reduce CO_2 emissions, improve energy supply security, increase competitiveness and stimulate the development of new energy-efficient technologies. Improving energy efficiency is regarded by the Commission as a key element in its energy policy. (Tuominen et al. 2012, 48)

Green innovations

Green innovations do not only address to environmental problems such as reducing emissions and waste but are also expected to result in economic advantages for the innovator, such as competitive advantage and operational efficiencies through saving resources. A company's success in bringing green innovations to market depends its stakeholder management. How the company deals with the impact of new technology on its primary and secondary stakeholders is an essential success factor in managing innovation projects. (Fliaster & Kolloch, 2017, 2)

Renewable energy sources (RES)

There are several definitions of RES in the literature. RES are practically inexhaustible sources of energy obtained from the continuing or repetitive currents of energy occurring in the natural environment. RES include technologies such as wind power, solar energy, hydropower, tide and waves, geothermal heat and bioenergy. (Peura et al. 2018, 88; Peura et al. 2011, 930) Bioenergy covers all forms of biomass including biological waste and liquid biofuels. The contribution of RE from heat pumps (HPs) is also covered for the EU Member States. (Eurostat 2018) RES have a much smaller impact on the environment when compared to fossil fuels. RES contribute to energy security and independence from external factors such as energy imports. They are more flexible compared to traditional sources of energy, and help creating jobs for the local population. (Karytsas et al. 2014, 480)

Sustainable development

Sustainable development has more than three hundred definitions within the context of environmental management (Peura et al. 2018, 85). The most common definition must be the often-quoted Brundtland report, which defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Sauvé et al. 2016, 51). Sustainable development consists of economic and social aspects, in addition to environmental protection. Sustainable development becomes a more concrete phenomenon when studying it on local level in a specific context, e.g. energy production on regional level. (Väisänen et al. 2016)

Sustainable energy (SE)

The concept of sustainable energy (SE) directly follows from the concept of sustainable development. SE has become one of the key concepts in reforming the energy sector both globally and in the EU. (Peura et al. 2018, 85)

2 LITERATURE REVIEW

In order to gain an insight to the phenomenon, its current aspects and issues, a literature review of relevant researches and journal articles was conducted. The literature review observes the topic on three different levels; firstly on the European Union (EU) level, secondly on a governmental level with its focus on Finland, and lastly on a regional level. In addition, the literature review seeks to identify the existing driving forces and possible barriers for the energy system transition.

First part of the literature review studies the premises and prerequisites of energy production and RE. The second part is focused on previous literature about energy transitions towards more sustainable solutions, its main focus on the Finnish energy sector. In addition, also the role of energy consumers and households in the transition is studied briefly. The third and final part of the literature review aims to find out all the most important driving forces for the change to happen, and equally the possible barriers that might affect the energy transition are listed.

2.1 Premises and prerequisites

Next, the current state of affairs regarding energy policies, energy production and RES are described at different levels and perspectives. First, the focus is brought on the regulations at EU level, which then affect to the national level, and so forth the national targets affect the regional level. At the national level, the main focus is put on the state of energy production in Finland.

2.1.1 EU regulations

All over the EU, efforts are being made to obtain GHG emission reduction targets that have been set for 2020 (Child & Breyer 2016b, 518). The EU has adopted a precise target for the share of RE in the provision of gross final energy consumption, which was agreed upon in the context of the "EU climate and energy package". This energy package has also been called the 20-20-20 package. The package includes a 20% reduction in GHG emissions compared to 1990, increasing the share of RE in the EU's final energy consumption to 20%, and a 20% improvement in the energy efficiency of the EU. (Knopf et al. 2015, 50) These objectives were first set by EU leaders in 2007 and adopted in the legislation in 2009. In addition, they also are the main objectives of the Europe 2020 strategy for smart, sustainable and inclusive growth. (Calanter 2018, 130)

The EU is acting in many areas to reach its 2020 objectives (Calanter 2018, 139). The EU-wide emissions reduction objective is meant to be reached by the means of national reduction targets in each of the 28 Member States, and with the use of the EU Emissions Trading Scheme (EU-ETS) (Fragkos et al. 2017, 218). The aforementioned EU-ETS is a good example of the emission reduction objectives. The EU-ETS is the EU's main tool for decreasing GHG emissions from large combustion plants in the energy sector, industrial sector and in the aviation sector. The ETS covers about 45% of the EU's GHG emissions. By 2020 the target for these sectors within the ETS system is, that the emissions will be 21% lower compared to year 2005. (Calanter, 2018, 130)

There are also national targets for emission reduction. These objectives are related to sectors which are non-EU-ETS and account for approximately 55% of total EU emissions. This covers sectors such as housing, agriculture, waste and transport. The targets set for 2020 to reduce emissions are binding in these sectors. The objectives, however, differ depending on the level of development of a country. The range varies from a 20% decrease for the most developed countries, up to a maximum of 20% increase for the least developed countries, when the latter also need to make sustained efforts for reducing their emissions. The progress in the reductions is monitored by the European Commission yearly, with every country being obliged to report its emissions. (Calanter 2018, 130) Moreover, as Knopf et al. (2015) state, the EU Council’s conclusions have defined an “at least” 27% RE target, which implies that a higher than 20% target might be possible if individual Member States set their own national goals higher.

In November 2016, the European Commission adopted a legislative proposal for a recast of the Renewable Energy Directive (RED II). The European Parliament and the EU Council proposed changes, and a final compromise deal was agreed on 14th of June 2018. In RED

II, the overall EU target for RES consumption by 2030 was raised to 32% from the originally proposed 27%. (ICCT 2018, 1-2)

As Pilpola and Lund (2018) discuss in their research, the national energy systems are under constantly increasing political pressure to meet the stricter climate mitigation targets. In December 2015, in the Paris Conference of Parties (COP21), the Paris Agreement was reached by 195 member nations. The Paris Agreement's purpose is to combat climate change through actions and investments towards a low-carbon, sustainable future. (Fragkos et. al, 2017, 216) The Agreement and the outcomes of the COP21 cover really important areas such as rapid emission reduction, and limiting global warming (Fragkos et al. 2017, 216; Pilpola & Lund 2018, 323) Within the EU, the Intended Nationally Determined Contribution (INDC) is based on long-term climate policy vision. This long-term perspective is crucial because it makes longer time frame assessment possible, especially when taking into consideration the consistency with the temperature objective of the United Nation's (UN) Paris Agreement (Fragkos et. al. 2017, 218). The Agreement includes the target of limiting global warming to only 1.5°C above pre-industrial levels (Seneviratne et al. 2018, 41).

The European Commission is examining economically efficient methods to transform the European economy into a "clean" economy, which consumes less energy (Calanter 2018, 131). The EU is committed to increasing the use of RES, and various policy goals have been set (Varho et al. 2016; 130, Sutherland & Holstead 2014, 102) Besides the 2020 targets, the EU is committed to decreasing its GHG emissions by 80–95% from the 1990 level by 2050, as suggested in the low-carbon economy roadmap, called Energy roadmap 2050 (Calanter 2018, 131; Claudelin et al. 2017, 2). For reaching this target, the intermediate points are emission reduction by 40% by 2030, and 60% by 2040 (Calanter 2018, 131). Moreover, besides further reducing GHG emissions, the EU's aim is to raise its energy security (Sutherland & Holstead 2014, 102).

As the EU plans to cut its GHG emissions by 80–95% by 2050, there are several decarbonization options for reaching this target. These options include RE, nuclear power, and energy efficiency. (Pilpola & Lund 2018, 323) RES are carbon-free, and thereby have huge potential to contribute to CO_2 emissions reductions as replacements for fossil fuels. They also help to decrease EU's dependence on imported energy sources. (Vass 2017, 164) According to Vass (2017) RES still are comparatively costly. In 2016, the share of energy from RES in gross final consumption of energy reached 17% in the EU. This is double the share of 8.5% back in 2004, which is first year for available data. Among the 28 EU Member States, 11 had reached their national target levels for 2020 already in 2016. These countries are Sweden, Bulgaria, the Czech Republic, Denmark, Estonia, Croatia, Italy, Lithuania, Hungary, Romania and Finland. (Eurostat 2018)

In the future, the cost of renewables is expected to drop due to development of technology, which is driven particularly by government policy to reduce emissions. Particularly the costs of solar PV are reducing continuously, as a result of falling manufacturing costs and competition in the market. For example, in the UK solar PV costs fell by 40% during year 2016. European countries are also promoting renewables by supporting them with different schemes such as feed-in tariffs and green certificate schemes. (Vass 2017, 169) The EU also has different investment support systems for RE and helps by financing innovations. The EU supports the development of low-carbon technologies, for example by its NER300 program meant for renewable energy technologies (RET) and carbon capture and storage (CCS). Another example is EU's funding of the Horizon 2020 programme, meant for research and innovation. (Calanter 2018, 130) These support systems also differ between EU's Member States (Varho et al. 2016, 31).

Several studies have investigated the role of bioenergy within EU's energy policy. As forests act as a significant storage for carbon, they are also a source of carbon. (Pilpola & Lund 2018, 324) The European Commission's renewed RED II provides a framework for the sustainability of biomass. The RED II introduces new sustainability criteria for biofuels and bioenergy for raw materials obtained from forests. The Directive orders that harvesting takes place with legal permits, that the harvesting levels do not exceed the growth rate of the forest, and that forest regeneration takes place. (ICCT 2018, 5) As the Paris Agreement focuses on NDCs and reaching carbon neutrality by 2050, it pushes particularly forests into a key role in meeting these climate targets. This is because forests serve as potential sinks in many countries, and emission reductions could also be made from decreased deforestation. (Krug 2018, 7)

The EU Commission is pledged in ensuring that the biomass used in bioenergy production continues to be sustainable and that it provides significant GHG emission reductions. When compared with fossil fuels, the bioenergy has to be produced so that does not cause deforestation or loss of biodiversity. Moreover, the biomass needs to be transformed into energy with cogeneration technologies, combined electricity and heat. RED II promotes efficient use of resources and strengthens EU's criteria on bioenergy sustainability. For the post-2020 period, the directive includes four new specific requirements. These requirements include:

- Advanced biofuels will emit at least 70% less GHG emissions compared to fossil fuels
- A new sustainability criterion on forestry biomass used in the field of energy to reduce the risk of overheating
- A requirement to reduce GHG emissions by 80% for heat and electricity produced by biomass and biogas
- A requirement that electricity from biomass should be produced using combined technologies for the production of high-efficiency electric and thermal energy. (Calanter 2018, 133)

The results of the study by Fragkos et al. (2017) indicate, that the EU energy sector will have transformation challenges ahead of it. This is mostly due to ageing infrastructure, e.g. old power plants and low energy efficiency in buildings, as well as energy supply security. The implementation of the energy transition will have effects on the EU INDC achievements and to the ambitious long-term decarbonisation targets. Therefore, the EU policy design has to figure out the right balance between investments in the energy system update and investments related to other climate-policies. In addition, it has to ensure the support of research and development (R&D), as well as the technological development. This needs to be done in order to guarantee cost reduction for clean energy technologies and the cost-effective implementation of the EU INDC. (Fragkos et al. 2017, 225)

When it comes to biofuels and bioenergy, the resources acquired from forest must comply with requirements and principles included in the EU's Land Use, Land Use Change and Forestry (LULUCF). Especially, the country where the biomass feedstock comes from must have signed the Paris Agreement and submitted a NDC to the UN's Framework Convention on Climate Change (UNFCCC). In addition, the country must be covering emissions and removals from LULUCF sector and show that emissions do not surpass forest cuttings. Countries also need to have a national system for accounting emissions and removals from LULUCF sector, and this accounting system must follow the requirements in the Paris Agreement. The EU Commission will define specific implementation guidelines by 31 January 2021. (ICCT 2018) As Krug (2018) states, it is solely up to the Member States to create incentives within their own NDCs. This creates additional responsibility on the international community, since the integrity of the NDCs needs to be monitored and guaranteed. (Krug 2018, 11)

2.1.2 Energy production and goals in Finland

Simultaneously, as what is happening on the EU level, various nations are looking beyond the year 2020 and exploring the roles of many RET within their own energy systems (Child & Breyer 2016b, 518). Within the EU countries, Finland tops the use of RES together with Sweden, Latvia and Austria (Haukkala 2015, 53). It is one of the most successful Member States in reaching the 2020's energy targets, with over 30% RES in final energy consumption already in 2012 (Zakeri et al. 2015, 244). In 2016 the primary energy consumption (PEC) in Finland reached to 381 TWh, which was 2% less than 2011, and the use of RES increased by 5%. Carbon emissions totalled 46.6 Mt, which was the lowest since 1990. (Zakeri et al. 2015, 244, 248)

As Finland is located in the Northern part of the EU, it is characterized by its cold Nordic climate, where the demand for energy services is high due to the needs of an industrious society (Child & Breyer 2016, 518, Pilpola & Lund 2018, 324). Finland has a very energy-intensive industry not only due to the coldness, but also because it is a thinly populated country with a fragmented regional structure, and therefore the energy consumption per capita has been one of the highest among industrial countries (Haukkala 2015, 53; Pilpola & Lund 2018, 324) Fuel combustion for energy is the main source of GHG emissions in

Finland. In 2010, 81% of total emissions consisted of it. (Kallio et al. 2016, 54) The shares of different energy sources in total energy consumption are represented in Figure 2.

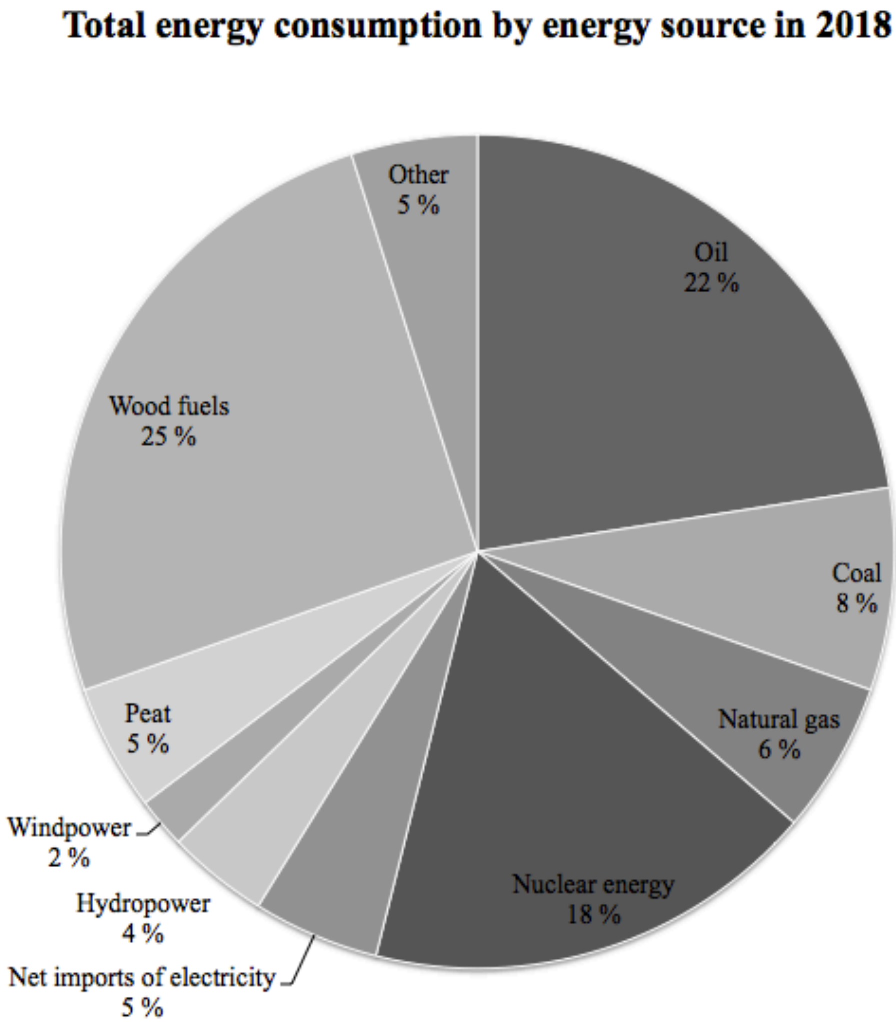

Figure 2. The total energy consumption by different energy sources. Adapted from Tilastokeskus (2018)

In the Nordic countries, biomass, hydropower and wind power are envisioned as key pillars for CO_2 mitigation (Pilpola & Lund 2018, 323). At the moment, wood-based biomass is the main source of RE in Finland, as Finland has long traditions of using bioenergy in combined heat and power (CHP) and heat production (Haukkala 2015, 53; Holma et al. 2018, 1433; Pilpola & Lund 2018 324). The reason for this is explained by the huge and still increasing forestry resource, since Finland actually is the most forested country in the whole Europe (Pilpola & Lund 2018, 324; Child & Breyer 2016b, 519).

Biomass is primarily produced in the pulp and paper industry, and further used for industrial heat production for example (Haukkala 2015, 53). Simultaneously, bioenergy made from agricultural residues has large, nearly untapped potential (Child & Breyer 2016b, 519). However, as Holma et al. (2018) claim, in the future the use of other RES such as wind power, liquid biofuels and HPs, will grow.

Finland's Energy and Environmental Policy has underlined fossil fuel consumption and energy imports as events that need to be mitigated with new decarbonized energy production. (Zakeri et al. 2015, 244) While the EU has set the RES target for 38% by 2020 for Finland, the share of energy from RES in gross final energy consumption was already 38.7% in 2016 (Holma et al. 2018, 1433; Eurostat 2018) Though the target has already been reached, further increase in the share of RES beyond the target has attracted a broad attention in common energy debate (Zakeri et al. 2015, 244). Furthermore, Finland follows the EU goals to decrease the GHG emissions by 80–95% by 2050, compared to 1990 levels (Pilpola & Lund 2018, 324).

Since November 2016, the Finnish government policy on climate and energy has set very ambitious goals by 2030:

• Share of renewable energy in final consumption to be increased to 50%;
• Self-sufficiency of final consumption to be increased to 55%;
• Share of renewable transport fuels to be raised to 40%;
• Coal will no longer be used in energy production;
• Use of imported oil for the domestic needs will be cut by half.

(Pilpola & Lund 2018, 324)

Finland hasn't set any obligations or binding recommendations for power companies to promote energy production from RES. In environmental law, incentives are often divided into tax-based, economic, volunteer-based, or eco-labeling. Finland has primarily used tax incentives to promote wind energy and other RES until 2010. (Jung et al. 2016, 214) Finland also has feed-in-tariff system of 83.5 €/MWh, meant for energy production from RES such as wind, biogas, and wood fuel. However, solar energy is currently excluded in the Finnish feed-in-tariff system. (Dahal et al. 2017, 8) Additionally, small-scale RE investments can be supported by a state grant in Finland, but they are only accessible for companies, municipalities, associations etcetera, and not individuals (Varho et al. 2016, 31).

2.1.3 Regional level

Even though the energy system transition is a global challenge, energy policies, tools and instruments supporting the change have been widely studied on a regional level. Multiple researches have shown, that justified methods for improving regional sustainability are frequently related to both efficient energy use and exploitable local energy resources, the key element being renewable resources in the energy system transition. Therefore, actions taken for increasing the share of RE in the energy supply and improving both production and end-use energy efficiency, are often built into the regional sustainability targets. (Viholainen et al. 2016, 295-296)

According to Viholainen et al. (2016), many regional operators are going through a phase, where their former roles either as energy producers, distributors or consumers have started to mix together and become more complicated. An example of development like that is the growing number of private companies and individual households that can also act as energy producers themselves. Viholainen et al. (2016) claim, that even though this might create additional challenges for energy planning, it can also open new business possibilities in energy services and remarkably affect to the energy efficiency on a regional level and is a step towards sustainable development. (Viholainen et al. 2016, 296)

For villages and small regions, implementing RES usually generates positive impacts, because it means mobilization of unused, available resources, and a decrease in money flowing outwards of the region from importing fossil fuels (Okkonen & Lehtonen 2017, 103). The most powerful driver for sustainable energy (SE), in addition to the potential regional economic impacts, is the impact it can have on employment (Peura et al. 2018, 85). Peura et al. (2018) state in their work that it has been repeatedly claimed that RES generates more jobs than conventional energy production. The presumption is, that by creating regional self-sufficiency, all the money could be kept within the region and its

RES-based value chains (Peura et al. 2018, 94). In Finland this could be most easily achieved by promoting the use of bioenergy, since wind power for example is commonly produced by big, international enterprises that export the profits outside the regions. Therefore, the total impact RES generates always depends on the scale, because normally big scale capital-intensive wind power creates more employment abroad within big manufacturing organizations, rather than providing jobs inside the region. (Peura et al. 2018, 95)

The most significant role for increasing RES will be by forest biomass, which is mostly utilised in communities' CHP plants and the forest industry (Laihanen et al. 2016, 89). In general, local energy production can create important socioeconomic benefits for small industrial towns and rural communities, which are struggling with economic challenges such as retaining population (Okkonen & Lehtonen 2017, 103). The positive impacts, which were clearly seen in the results of the research by Peura et al. (2018), also included more efficient use of existing machinery in forestry and agriculture, particularly when utilizing bioenergy (Peura et al. 2018, 95).

The results of a study by Peura et al. (2011) refer that a majority of rural areas in Finland have the potential of becoming self-sufficient in energy production through bioenergy, but also other RES like solar power, will have a bigger role in the future. This stands particularly for areas right outside the largest population centres and most energy intensive industries, but in outer regions the RE potential exceeds the energy demand greatly, which means that in outer areas the spatial coverage of energy self-sufficiency is vast. (Peura et al. 2011, 927) In addition, as Damsø et al. (2017) state, municipalities need to ensure that their system development is sustainable in long-term, while aiming to meet their targets. This will require a high degree of coordination and cooperation between various local actors and transboundary issues such as biomass utilization (Damsø et al. 2017, 412).

Also within individual cities, climate change and urban development have received spreading attention, spurring a wide range of low-carbon initiatives during the past decade (Kramers et al. 2013, 1276). According to a research by Dahal et al. (2017), cities are responsible for generating 60–70% of the global GHG emissions currently. Due to national and international political agreements like the Paris Agreement, cities around the globe are bound to reducing their GHG emissions. (Dahal et al. 2017, 2) For instance in Sweden, the city of Stockholm has declared an aim to be free from fossil fuels by 2050, while in Denmark Copenhagen has set an ambitious target of being carbon-neutral by 2025 (Kramers et al. 2013, 1276). In many other countries too, cities are recognizing the means of cleaner production and sustainable consumption of their local energy resources, in order to tackle the climate change and ensuring energy security of their regions (Dahal et al. 2017, 1).

2.1.4 Energy balance of South Savo

Energy wood consumption in Finland has increased a lot since the early 2000s (Mynttinen et al. 2014, 41). When comparing energy balances of different regions in Finland, the different features and industrial structures of the regions must be taken into account, because these factors define the energy usage (Karttunen et al. 2017, 11-12). In terms of wood resources, the region of South Savo is one of the richest in Finland, and it is actively increasing its energy wood production and use. (Mynttinen et al. 2014, 41) The remarkable forest supplies give many opportunities to exploit bioenergy in the energy production for communities (Karttunen et al. 2017, 11-12).

In a report about Finnish forest industry in South Savo region, Karttunen et al. (2017) review the findings of their project and the future visions for 2020. With regional energy balances, the current situation of energy usage of primary energy sources can be reviewed. By knowing the current situation, it is possible to estimate the exploitation and sufficiency of local resources, and to evaluate the possibility of replacing fossil fuels with RES. By increasing the use of local RES, the energy self-sufficiency of South Savo can be improved and new regional sources of livelihood created. The big power plants of South Savo mainly use domestic wood fuels, and also the smaller heating plants of the local communities have decreased their dependency of oil by replacing it with wood fuels. (Karttunen et al. 2017, 11-12) The following Table 2 demonstrates the energy consumption among some of the cities and municipalities within the province.

Table 2. Biggest and smallest energy consumers in South Savo. Adapted from Karttunen et al. (2017, 43)

		Energy consumption in 2015
Biggest energy consumers	Mikkeli	2560 GWh
	Savonlinna	1610 GWh
	Pieksämäki	690 GWh
Smallest energy users	Sulkava	120 GWh
	Enonkoski	50 GWh
	Total energy consumption of primary energy in South Savo	7035 GWh

From the used RES in 2015, the most significant ones were solid by-products of the forest industry with 1176 GWh, firewood with 840 GWh and wood chips with 827 GWh. Every municipality in South Savo currently has some sort of district heating network, and wood fuels are widely exploited in heat production and CHP production. (Karttunen et al. 2017, 41, 43) In 2012 within South Savo's heat and power plants, about 47% of their total energy consumption constituted of wood-based energy sources (Mynttinen et al. 2014, 43). As a result to their study, Mynttinen et al. (2014) found out that there is a growing need for wood energy and considerable potential in the region of South Savo in Finland, and it should be possible to remarkably increase the production and the use of energy wood in the region in the future, either for local consumption or as a national reserve of energy wood. In Figure 3, the different shares of RES in South Savo are visualized.

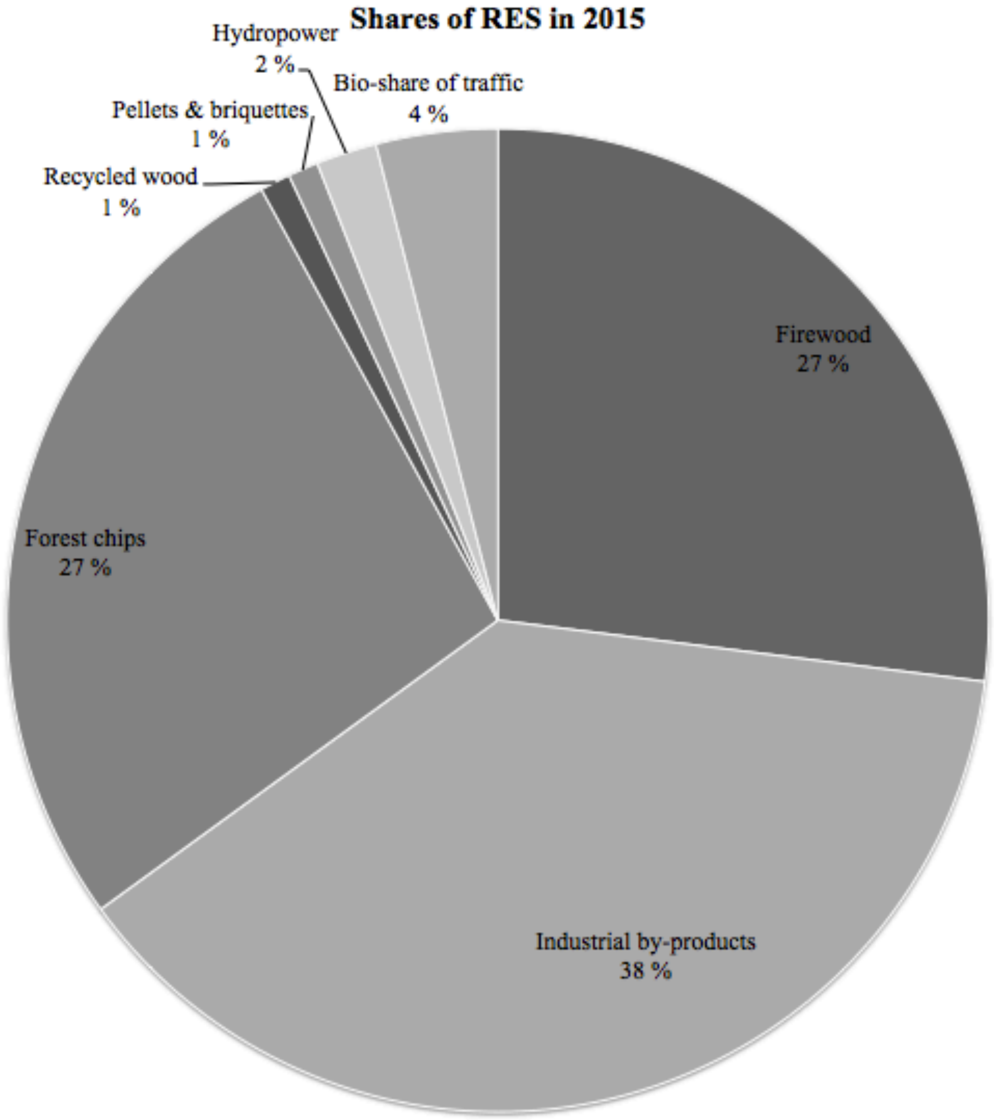

Figure 3. The share of different RES in South Savo in 2015. Adapted from Karttunen et al. (2017)

2.2 Low-carbon energy transition

Next, the energy system transition phenomenon is reviewed. The ongoing transition in Finland is viewed from the perspective of different forms of RE, and what is their role in the Finnish energy balance now and in the future. Moreover, the role of energy consumers and households is reviewed, since house-builders and owners can contribute to energy transition by the means of what decisions they make regarding energy options, including electricity and heating.

2.2.1 Energy system transition

Large technical systems, such as energy systems, are so intertwined with many aspects of social life, where change cannot happen in one sphere without the other. Thus, energy systems can be quite resistant to change, due to e.g. existing norms and ideologies. (Child & Breyer 2017, 18) As Bosman and Rotmans (2016) describe, a transition is a fundamental change in structure, culture and practices of a societal system or a subsystem. Transition is the result of a co-evolution of economic, technological, institutional, cultural and ecological developments at different scales. Transitions are long-term and can take up to 25–50 years, and they are extremely complex, including a range of different domains and stakeholders. Present-day transitions are often related to sustainability targets, their goal to solve pressings issues the modern societies are facing. Usually, fundamental change processes such as transitions might be highly challenging, involving a variety of actors across different domains. (Bosman & Rotmans 2016, 3) Thus, as Bosman and Rotmans (2016) state, with transitions it will most likely take decades to reach a new dynamically stable equilibrium.

The establishment of RE production has been a subject of notable academic interest in the past years. The attention has mainly been focused on industry-level energy transitions, public perceptions, governance and the potential for community involvement. (Sutherland & Holstead 2014, 103) The implementation of RES-based energy management systems on a bigger scale will require practical changes, and in most cases, an overall transition from fossil fuels to new raw materials and technical solutions. The emergence of new systems will be a long-term process, since they will most likely differ a lot from the prevailing centralized systems. (Peura et al. 2011, 940) From a fossil fuel-based energy system transition to a RES-based system, increasing the volume of RE will produce different demands for integration of the system and increased decentralization (Damsø et al. 2017, 412). For the implementation of RE, also the technological progress is an important point (Horschig & Thrän, 2017, 11). Moreover, the suitable transition of the present energy systems is often considered from sustainability perspective (Viholainen et al. 2016, 295). As Viholainen et al. (2016) state, a sustainable system has to be able to ensure that the required economic, social and ecological resources are available also for future generations.

Energy transition to low-carbon or reaching carbon neutrality requires energy production to shift towards cleaner energy sources. (Dahal et al. 2017, 2; Knopf et al. 2014, 12). Depending on which target is adopted, e.g zero carbon or carbon neutral, it affects the strategy for emission management. If the target is zero carbon, emissions will have to be cut completely, which in turn can inspire significant innovation in technology. (Damsø et al. 2017, 412) Conversely, a carbon neutrality target allows for offsetting or balancing emissions, which according to Damsø et al. (2017) naturally reduces the requirements for system changes. In addition, energy transition is also dependent on the geographic circumstances that cause the niche to evolve, and to be incorporated into the systems and landscape variations. (Dahal et al. 2017, 2)

Such transformative changes require both radical and incremental innovation, and the changes usually take decades. In incremental innovations the focus is on doing things more efficiently, but radical innovations are about doing things totally differently. Radical innovations are about system innovations, thereby transitions. Nonetheless, as transitions are highly contested societal processes, they often involve challenging the status quo and therefore can encounter severe resistance from different stakeholders with vested interests. (Bosman & Rotmans, 2016, 2) As Peura et al. (2011) state, in the process of the acceptance and diffusion of any new innovation, several thresholds and obstacles need to be overcome first (Peura et al. 2011, 940).

2.2.2 Energy sector in Finland

The Finnish energy system is currently at a crossroads in consequence of an aging power generation system, differing opinions about low-carbon energy production, responsibilities concerning climate change mitigation, changing energy prices and targets concerning national energy security (Child et al. 2017, 1). In Finland, almost 70% of the primary energy is imported, due to an absence of domestic fossil fuel resources. This, however, poses a risk for Finland’s energy security. Therefore, a key pillar in the energy policy is domestic forest-based bioenergy. (Pilpola & Lund 2018, 324) According to Pilpola and

Lund (2018), Finland's decision to support such traditional low-carbon energy can be characterized as a conservative energy transition. They claim, that as this decision may provide one option for climate change mitigation, it’s still in short-term and not completely risk-free. (Pilpola & Lund 2018, 324) Moreover, in Finland the goal is both to maintain a competitive industrial sector, as well as to meet the needs of future generations (Child et al. 2017, 1).

There are regional differences in the exploitability of different RES in Finland. The geography represents a challenge to high levels of solar PV and wind power due to the seasonal variations, especially with solar power, which has most potential in Southern Finland (Child & Breyer 2016a, 26; Peura et al. 2011, 937). Moreover, while there are high amounts of solar irradiation during the summer months, it is the complete opposite during winter months. Furthermore, there is also clear variation for both onshore and offshore wind power, with more energy produced during winter. (Child & Breyer 2016a, 26) Naturally, during long and dark Finnish winters the need for heat and electricity is higher on the demand side. It has always been a significant task to find the required flexibility in the Finnish energy system. (Child & Breyer 2016a, 26) As Child and Breyer state (2016a), also the need for energy storage solutions (ESS) seems obvious in a future energy system, which is based on high shares of RE. According to them, the extreme situation of Finland could then serve as a model for other countries at high latitudes, on how RE generation can play a role in a highly developed and industrious society (Child & Breyer 2016a, 26).

Finland also differs from most of the EU countries by having a much lower natural gas share. In year 2014, nuclear power dominated by a 27% share in electricity, which was followed by a 26% share of CHP, and hydropower with 16% share. Imported electricity had a 22% share within primary energy sources. On the energy consumption side within the same year, 45% of energy went to industry, over half of which went to forest industry alone, 26% to space heating, and 17% to transport. (Pilpola & Lund 2018, 324) In Finland, heat production is more distributed than electricity production. In residential buildings, the small-scale use of wood accounts for one fourth of the heating. Especially HPs have quickly gained popularity, with over 60 000 units sold annually. According to Varho et al. (2016) in 2010-2012 HPs accounted for approximately 4% of all space heating, and the capacity of HPs is much higher than the capacity of solar panels or solar heat collectors. (Varho et. al, 2016, 31, 36)

The research of Child & Breyer (2016b) studies and analyzes future re-carbonized energy system scenarios in Finland, based on RE. As a re-carbonized energy system, they defined one, which seeks to replace fossil-based carbon completely. The results of the study showed that out of all of their scenarios, one scenario called the Basic 100% RE, had the lowest overall cost at 24.1 b€/a. (Child & Breyer 2016b) Based on the assumptions made in their analysis, Child and Breyer (2016b) suggest that an energy system based on 100% RE is possible for Finland to achieve by 2050. It also is a cost-competitive option, compared to their other scenarios featuring variable shares of nuclear power. Moreover, with a 100% RE energy system a high level of energy self-sufficiency could be reached. The results of the study also suggested that re-carbonized energy scenarios should essentially lead in zero GHG emissions in the future (Child & Breyer, 2016b).

Bioenergy

Finland is a country with a highly variable climate, which causes geographical differences in forest productivity and structure (Hynynen et al. 2015, 417). 60% of the country is covered by forest, and the availability of bio-based resources plays a key role in Finland. The large supply of biomass is an obvious strength and has led to the strong presence of forestry and other related industries. (Bosman & Rotmans 2016, 1,7) Thus, Finland is one of the leading countries in using biomass for energy production and increasing the use of wood energy also plays an important role in the low-carbon pathways for Finland (Kallio et. al, 2016, 46; Zakeri et al. 2015, 248).

In 2012, 25% of total energy consumption consisted of bioenergy, with an amount of 92 TWh (Zakeri et al. 2015, 248). In the second quarter of 2018, bioenergy still accounted for 25% (Tilastokeskus 2018). The role of domestic wood as raw material is very remarkable, since over the past decade the total annual consumption of wood and biomass has been about 70 million m3, which is equivalent to 85–90% of the total annual consumption (Hynynen et al. 2015, 416). There are strong links between the forestry and energy industry, since forest industry is accountable of almost 70% of RE produced in Finland, although it often is in the form of traditional biomass. Moreover, four out of the top ten Finnish export products are related to forestry. (Bosman & Rotmans 2016, 7)

Assessing the potential of and alternatives for biomass production has become of the uttermost importance (Hynynen et al. 2015, 416). Zakeri et al. (2015) state in their study, that the future of bioenergy is strongly correlated to forest-based industries' status and the use of forest-based biomass, since 80% of wood-based bioenergy is produced and consumed within forest industry itself. For increasing the use of bioenergy in the future, the most potential resources will be forest chips, biogas from biowaste and energy crops, and second-generation biofuels refined from woody biomass. The realization of the 2020's targets depends on many different aspects, including carbon and fossil fuel prices, stumpage and chip prices, and subsidies for the use of forest chips in small-scale CHP plants (Zakeri et al. 2015, 248-249). In addition, as Hynynen et al. (2015) state, even though domestic wood and biomass resources are currently plentiful, the challenge still is to improve raw material availability and the cost-efficiency of wood biomass supply.

Demands for forest-based energy and biodiversity protection are often considered to be conflicting, and meeting both targets is a challenge (den Herder et al. 2017, 54). Burning forest chips or roundwood as fuels causes immediate GHG emissions, and this is also observed as a reduction in forest carbon stocks. However, such reductions stay temporary when the forests are managed in a sustainable manner. There are various dynamic mechanisms used in determining the extent, and when the same amount of carbon will be recaptured in forests. In general, the concept of carbon debt refers to the time between when the biomass is harvested until the amount of the harvested biomass has regrown. (Kallio et al. 2013, 403) In terms of carbon neutrality, boreal forests have relatively long rotation periods, typically varying between 60 to 100 years, meaning that after the final felling it still takes decades for temporal carbon neutrality to be achieved. (Pilpola & Lund 2018, 325)

In Finland, the forests work as a rather important carbon sink. However, due to the variations in the annual wood harvests, the size of the forest sinks has varied notably. On a study by Kallio et al. (2016), they based their analysis on six different Low Carbon Finland 2050 (LCF) scenarios. In their LCF scenarios, wood was considered as a completely carbon neutral fuel, so using it for energy production was a practical and economical way to change the Finnish society and energy system to be less carbon intensive. The results of Kallio et al. (2016) suggest, that despite considerably increasing the use of wood for bioenergy, Finland's carbon balance in full carbon accounting might become negative already before 2040, thanks to the forest sinks which are still increasing as well.

Hydropower

Hydropower has an important role in Finland, since up to 20% of end-user electricity consumption can be supplied by hydropower (Child et al. 2017, 19). There are approximately 200 hydropower plants in Finland, including run-of-the-river plants with limited reserve capacity. Hydropower capacity is currently fully exploited in Finland, since potential sites for new plants are under environmental protection. The level of water resources is one of the key factors in Nordic electricity market prices, which vary remarkably year-to-year in Finland. According to Zakeri et al. (2015), while there is no estimation for significant changes in hydropower capacity in the future in Finland, small hydro plants could still be promoted with less strict environmental laws. The realized techno-economic potential for hydropower is approximately 940 MW. Still, it must be noted that 460 MW of this estimation stays in protected areas. For future installations and upgrades in the existing equipment, Zakeri et al. (2015) assume an extra hydropower potential to be from 500 up to 600 MW.

In addition, there is also a seasonal element to hydropower in Finland. The system is dominated by run-of-river hydropower with limited reservoir capacity, which is comparable to approximately 6.5% of Finnish electricity demand. As most energy inflow occurs within the spring runoff in May, hydropower can mainly be used as seasonal energy storage in Finland. The reservoirs are kept comparatively full until energy is needed over the winter months, from December to April. (Child & Breyer 2016a, 26) According to Child and Breyer (2016a) Finland is currently lacking a full accounting of the potential to utilize hydro storage, and their study either does not fully explore the full available potential of hydro storage.

Solar energy

As solar power is clean energy, it remarkably reduces GHG emissions, which help to achieve RE production targets and meet carbon neutrality goals (Dahal et al. 2017, 11). Together with other RES, solar PV is the leading economically and environmentally viable option to fill increasing energy needs, as long as no other low-emission technological breakthroughs occur, such as CCS (Child et al. 2017, 17). On a larger scale production, solar energy can also be integrated with other RES systems such as geothermal, bio-energy or HPs (Dahal et al. 2017, 11). As the use of solar PV grows, also financial CO_2 emission reduction profits can be observed, as a result of the rapidly increasing competitiveness of PV. Solar PV also provides energy security, and more diverse energy production. (Child et al. 2017, 17)

Solar energy has not been harnessed in a large scale in Finland (Zakeri et al. 2015, 250). In many ways, Finland represents a challenge to high levels of solar PV in an energy system, due to high fluctuations in solar irradiation throughout the year. Whilst the country gets high amounts of sunlight during the summer months, it's quite the opposite during the winter solstice and the long, dark winter months. These variations create a challenge for the energy system to find alternate resources at the dark time of the year (Child et al. 2017, 2; Child & Breyer 2016b, 518). Nonetheless, the average annual potential of solar energy in Finland is almost the same as in Germany, and over the summer months the irradiation is even higher (Haukkala 2015, 50). As Haukkala (2015) states, this raises the question of why Finland hasn't taken more advantage of solar power and taken solar PV into broader use in order to grow the share of RES in its energy mix.

In the case of solar thermal, as opposed to general perceptions, the annual potential of it in Finland is only 20% lower when compared to North Italy for example. However, since the production occurs mainly in summer months, when the demand for heating is very low, solar thermal cannot contribute the heating network without long-term heat storage systems. (Zakeri et al. 2015, 250) The need for storage technologies seems obvious, on a daily and seasonal basis to better match supply with demand (Child et al. 2017, 2, Child &

Breyer, 2016b, 518). However, according to Child and Breyer (2017), the precise mix of optimal production and storage technologies for Finland has not been examined for a fully integrated energy system.

Compared to other RES, the use of solar power in the Nordic countries has been relatively scarce, and in Finland the position of solar technology has been especially weak. In 2015, the share of solar energy in Finland was only 0.01 percent. (Haukkala, 2015, 50) There are only five solar PV plants operating in Finland, which are greater than 500 kWp, and their total installed capacity is nearly 20 MWp. Two of the largest installations in Finland are found in the city of Turku on the rooftops of supermarkets. Additionally, there are several utility-scale projects under planning for different parts of the country. In terms of small-scale ownership, no comprehensive statistics are available. (Child et al. 2017, 2) However, according to Child et al. (2017), it is estimated that a majority of solar PV panels in Finland are roof-mounted, and that only a small part of the installed capacity is grid-connected.

The most common reason for the small use of solar energy in Northern countries seems to be the almost non-existent financial support, and the common belief that Northern Europe has no use for solar power (Haukkala 2015, 53). In general, subsidy systems play an important role in promoting the solar energy production. There are various types of subsidy systems that can be implemented, such as feed-in-tariffs, RE subsidies, tax exemption for solar energy production and investment cost subsidies. One quite common subsidy system used in EU member countries are feed-in-tariff systems for RE production. Finland is one of the only EU countries that barely use any direct subsidies for solar energy. The investment support Finland has available for solar energy production is only available for the public sector and companies. (Dahal et al. 2017, 8)

As Haukkala (2015) states, it is a fact that the amount of solar power is unlikely to successfully increase in Finland unless there is a political decision for its active support. Solar PV still suffers from higher initial cost compared with other energy sources, such as fossil fuels, and from higher installation prices (Haukkala 2015, 56). As there is no feed-in tariff for solar electricity in Finland, it lowers its economy (Laihanen et al. 2016, 93). Also with heat production from solar, the price is higher in comparison to fossil fuel heat production, which shows that without subsidies, solar heat and power production can be expensive. In the case of small-sector, as households do not get investment subsidies for solar energy production, solar electricity prices are much higher compared to more traditional energy sources. Small-scale solar electricity production price is approximately 11 c/kWh, with as long payback time as 20 years. (Dahal et al. 2017, 6) However, the interest towards solar energy has increased, due to technology and applications becoming more affordable for individual consumers, and more easily available equipment and services (Laihanen et al. 2016, 93).

Wind energy

Wind energy is one of the key pillars for reaching future RES targets in Finland (Zakeri et al. 2015). For wind power, the largest potential is available offshore, in coastal areas and fells in the North, in Lapland. Wind as an energy source is practically inexhaustible and makes an important addition to the RES potential all over Finland (Peura et al. 2011, 937). In 2012, Finland had 260 MW installed wind capacity (Zakeri et. al, 2015). At the end of 2017, the wind capacity was already 2044 MW (Suomen tuulivoimayhdistys 2018). The planned production for wind power by 2025 is 6 TWh/a, and 9 TWh/a by 2030. In order to evaluate the maximum potential of wind energy, different criterias from land use requirement to wind availability should be taken into account. (Zakeri et. al, 2015) According to Zakeri et al. (2015), the maximum potential of wind power in Finland is not yet systematically determined. Comparing Finland to Denmark and Germany for example, the relatively lower integration potential for wind power can be associated with limited interconnection capacity. (Zakeri et al. 2015)

2.2.3 Energy consumers and households

Consumers can be seen as the engines of the energy transition (Calanter 2018, 133). Consumers play a key role in reducing GHG emissions, and help mitigating climate change, as both individuals and companies are searching for more climate-friendly energy sources (Claudelin et al. 2017, 10; Dahal et al. 2017, 11). The energy consumers can be divided into three categories, which are: private enterprise, public sector and private household. Nowadays, traditional consumers, like the private enterprises, can simultaneously be energy users and as well as producers. (Viholainen et al. 2016, 297)

Energy consumers can become active players on the energy market, thanks to new technologies, such as smart homes and grids, competitive solar panels and battery storage solutions. The RED II allows consumers to use the energy they produced from RES, without excessive limitations. The directive also ensures that the consumers are compensated for the energy they place on the power network. The benefits of this revised directive are big reductions in costs that enable consumers to increasingly produce their own RE. For example, the costs for exploiting solar and wind energy have decreased respectively by 30-40% between 2009 and 2015. Consumers have increased rights to produce their own electricity and return any surplus to the network and to generate, consume, store and sell any energy produced from RES. (Calanter 2018, 133)

Globally, residential buildings account for 24% of total final energy consumption and are responsible for 14% of global GHG emissions. Therefore, reducing energy consumption in the housing sector plays a vital role in mitigating climate change. In Finland, detached houses account for 27% of the energy consumption of Finland's total building stock. Thus, homeowners of detached houses form a major group that needs to be taken into consideration when thinking of ways to reduce GHG emissions. The owners could reduce their emissions by updating their heating systems, or by implementing RE production technology, and by adjusting their daily power consumption habits. (Claudelin et al. 2017) The share of RES can be increased by, for example, using individual HPs as a replacement for electric heating. The use of HPs at household level depends on economic attractiveness and incentives, possibility for installation and other available heating options (Zakeri et al. 2015, 253). According to Zakeri et al. (2015), by optimally utilizing HPs, Finland's energy consumption could be cut by 11%, which would reduce condensing thermal power by 66% and energy imports by 32%, respectively.

2.3 Drivers and barriers for change towards carbon neutrality

Here the most crucial driving forces in the low-carbon energy transition are recognized, as well as possible barriers and obstacles that might delay or challenge the transition. Based on the findings, a table of the found drivers and barriers was formed.

2.3.1 Drivers

Global energy systems constantly evolve in response to a countless number of drivers. According to a study by Child and Breyer (2017), there are certain key drivers for energy system transition. These key drivers include climate change mitigation, strengthening energy security, securing economic competitiveness, providing social justice, lessening energy poverty, and stimulating technological innovation. With such strong forces of change, it is obvious that future energy systems may differ significantly from current systems. (Child & Breyer 2017, 11) It also needs to be taken into account, that economic profit is not the only driver for implementing RE, as other drivers such as climate protection, and exhaustion of fossil fuel resources, will force this transition to happen. Together all these drivers will result in a complete transformation of the entire energy sector. (Peura et al. 2018, 86) In addition, the chance of yet unexpected disruptive technological progresses or other game changers needs to be taken into account. (Child & Breyer 2017, 11)

Societal acceptance is an important concern in energy policy and in the marketing of new innovative solutions. Societal acceptance is a dynamic process, and it can range from active support to resistance. (Jung et. al 2016, 814) In the case of energy system transition, a broader environmental behavior and education can stimulate public awareness on RES, as people with better environmental behavior are more likely to get interested on information about RES. Increasing the number of individuals that are more educated and more environmentally-friendly can have a positive effect on RES awareness, and raise the acceptance. (Karytsas et al. 2014, 484)

For example, as Jung et al. (2016) state, many studies have indicated that most of the public in Finland is aware of solar and wind technologies, when comparing knowledge levels of different RET. For wind and solar power, the level of subsidies is the most important driver, followed by the level of electricity consumption. Generally, the subsidy systems are a key driver for RE implementation. (Panula-Ontto et al. 2018, 510-511) However, as recent development has enabled lower prices for PVs, it has made a positive impact on the popularity of solar power in Finland and increased its acceptability. In addition, also ground source HPs are common and energy efficient techniques in Finland, which may increase the acceptance towards them. (Jung et al. 2016, 821)

As Wustenhagen and Menichetti (2012) state, policy is also one of the important drivers, but markets cannot be driven by policy alone. Policy can be seen as the central driver for investing in RE, but especially in the investment community, the role of private capital seeking for investment opportunities with or without policies, is emphasized. For investment decisions, risk and return are important drivers. Thus, policy makers aiming at increasing the share of RE should do their best to reduce risk and provide sufficient profits. In addition, it is also important that the policy makers are helping the market to value the positive externalities of renewables. (Wustenhagen & Menichetti 2012, 6)

Driving factors are the strongest for policies aiming at implementing RE on a regional level (Peura et al. 2018, 95). For instance, as Brown et al. (2014) state in their study, onshore wind production's public acceptance can be increased if stakeholders, such as local communities, are engaged in the planning process early on, and if their concerns are addressed and they benefit from the project outcome (Brown et al. 2018, 841). It is also important to improve knowledge and understanding concerning the possible regional economic and employment impacts of SE, because these impacts are one of the main drivers for RE implementation. (Peura et al. 2018, 86) For example, in the case of bioenergy, the socioeconomic and rural development aspects are among the main drivers for biofuel project implementation. The socioeconomic effect is created by the employment the project offers, and by running the plant, and the money created is circulated in the local economy instead of paying to supply companies that import fossil fuels. (Okkonen & Lehtonen 2017, 103)

2.3.2 Barriers

As opposed to the drivers in the previous chapter, also barriers related to energy system transition can be found. The process of the acceptance and diffusion of any new innovation always needs to overcome several thresholds or obstacles (Peura et al. 2011, 940). Transition must begin with sustainable development pathways, which are faced predominantly with social and political challenges. The barriers to global technological transition are also mainly social and political. (Panula-Ontto et al. 2018, 511) However, according to Pilpola and Lund (2018), new and disruptive technologies carry by definition a larger economic and technological risk compared to current technologies. The established technologies are supported by major corporate and economic interests, rules and regulations. These factors can become a barrier for establishing new technologies. For this reason, changes to the prevailing system are typically not transforming but small, non-radical and incremental. In order to change an energy system, new technologies are required, in addition to new supporting infrastructure. (Haukkala 2015, 52)

In Finland, one of the biggest barriers is the tendency towards business-as-usual. Forestry has played a central role in Finnish history and present-day economy, which naturally creates a path dependency towards incremental innovations such as bulk biomass production. Thus, the transition game in Finland is ruled by traditional players instead of new players, while the most radical innovations are born from niches. (Bosman & Rotmans 2016, 9) In addition, also the excessive usage of forest biomass can be seen as a barrier, because it lessens the forests' CO_2 sequestration (Pilpola & Lund 2018, 332).

In general, most people object to change, and in some areas the objections may come from different stakeholders such as investors or managers, or even from concerned employees (Haukkala, 2015, 51). Fliaster and Kolloch (2017) argue, that green innovations are likely to be affected by interaction with both primary and secondary stakeholders. Thus, new innovations must gain the social acceptance nationally, as well as locally. In addition, they must be structured so that laws, and regulations do not oppose them but can support them. Lastly, new innovations have to evolve technologically and offer more efficient solutions. (Peura et al. 2011, 940)

Both wind power and solar power may face social acceptance barriers (Pilpola & Lund 2018, 332). In the case of solar power, a range of technical, economic, institutional, political and behavioral barriers exists that may prevent increasing the solar PV capacity (Child et al. 2017, 20). On their case study of the implementation of an offshore wind farm in Germany, Fliaster and Kolloch (2017), found out that the secondary stakeholders, such as special interest groups, can cause serious damage to a company, even though they are not directly involved in economic transactions and value creation process. The study of Fliaster and Kolloch (2017) showed that the stakeholders can a critically influence green innovation because they can affect both on its content, e.g. offshore vs onshore wind power station, and on the implementation process itself (Fliaster & Kolloch 2017, 9). High installed capacities of wind turbines both onshore and offshore, as well as solar PV may cause resistance. This might be due to aesthetic impacts the installations have on landscapes. (Child & Breyer 2016b, 530) As Child and Breyer (2016b) argue, such highly visible and widespread installations could affect tourism and property values.

Building owners and residents represent the most critical stakeholders in defining the share of energy efficiency and RET potential, as renovations to existing buildings are mainly made at their cost. There are several barriers which may prevent individuals from seeking a more environmentally friendly home. These barriers include cost-effectiveness of the investment, shortage of attractive products and services, limited knowledge and prioritizing comfort. (Jung et al. 2016, 814) In their study of transition towards low-carbon living, Claudelin et al. (2017) found out in their survey results that about 80% of the respondents were willing to save energy for environmental reasons. Almost 90% of the respondents were also interested in saving energy to gain financial savings, but still half of the respondents thought that they would not be able to save enough energy to obtain real savings in money. In addition, nearly three-quarters of the surveyed people answered not being willing to lower their standard of living in order to save energy. (Claudelin et al. 2017, 5)

In terms of energy efficient buildings, Tuominen et al. (2012) found multiple barriers in their study for building them. The most common barrier they found seems to be inadequate or too loose regulation, since nearly every country taking part to the survey reported some barriers related to government regulation or its execution. In addition, governments often face difficulties in communicating energy efficiency policies to the actors in the market. Problems related with financing can also occur, since one common barrier was the lack of financing for energy efficiency improvements. Another commonly perceived barrier is that energy efficiency improvements do not raise the value of the property. Energy consumption and energy efficiency are generally not at the top of priorities of house buyers. Thus, as a result, there is only limited correlation between efficiency level and price. (Tuominen et al. 2012, 54)

Often times, the difficulty governments face in trying to change the policy, are the conflicting wishes of society. This multitude of overlapping and contradictory stakes can result in vested interests. These vested interests can be seen mainly as political but also as economic barriers. (Haukkala, 2015, 51)

2.3.3 Energy system's change factors

Based on the drivers and barriers found from previous literature, the most important ones were collected and put in the following Table 3. The table displays drivers and barriers divided in five different perspectives, which are: political, social, environmental, economic and technological.

Table 3. Drivers & barriers

	Drivers	**Barriers**
Political	• Laws and regulations ➢ e.g. Paris Agreement, INDCs • Climate change mitigation • Subsidy systems • Reducing risks related to RE	• Supporting current technologies as opposed to new ones • Too loose national regulations or poor execution ➢ e.g. energy-efficient buildings • Poor communication between governments and the markets

Social	• Societal acceptance and awareness • Social justice • Education and environmental behavior	• Objections towards change • Stakeholders' resistance
Environmental	• Climate protection • Exhaustion of resources • Biodiversity loss	• Excessive usage of forest biomass
Economic	• Profit • Economic competitiveness • Energy security • Socioeconomic effect ➢ regional economic and employment impacts	• Lack of financing for energy-efficiency improvements • Cost-effectiveness ➢ investments in RES might not be profitable • Not being willing to lower the standard of living in order to save energy
Technological	• New innovations • Radical innovations born from niches • Disruptive new technologies	• Risks related to new and disruptive technologies • Business-as-usual ➢ no demand for new innovations

As it can be noted from the table, there are many driving factors supporting the energy system transition, but also many possible obstacles and challenges which might cause delays on the path towards carbon neutrality and low-carbon technologies. However, it is possible to overcome these barriers with new policy, regulations and raising awareness (Child et al. 2017, 20).

2.4 Research framework

On the basis of the literature review, it can be noted that even though energy transition towards low-carbon energy solutions is a global phenomenon, the decisions to invest in these solutions still happen on a governmental or even on a regional level. However, what guides these decisions being made are in most cases powerful external forces that can either act as drivers or barriers for these changes to take place. An example of such forces are laws and regulations, which can be seen as driving forces since compliance to act accordingly to these policies is required from governments, cities, municipalities and companies operating within local communities.

Based on all of what was found out in the literature review, a research framework for this study was formed. As the study itself is focused on a regional level perspective, the purpose of the literature review and this research framework is to prove that it indeed is necessary to study the energy transition phenomenon on this particular level, where the actual changes take place. The framework is presented in Figure 4.

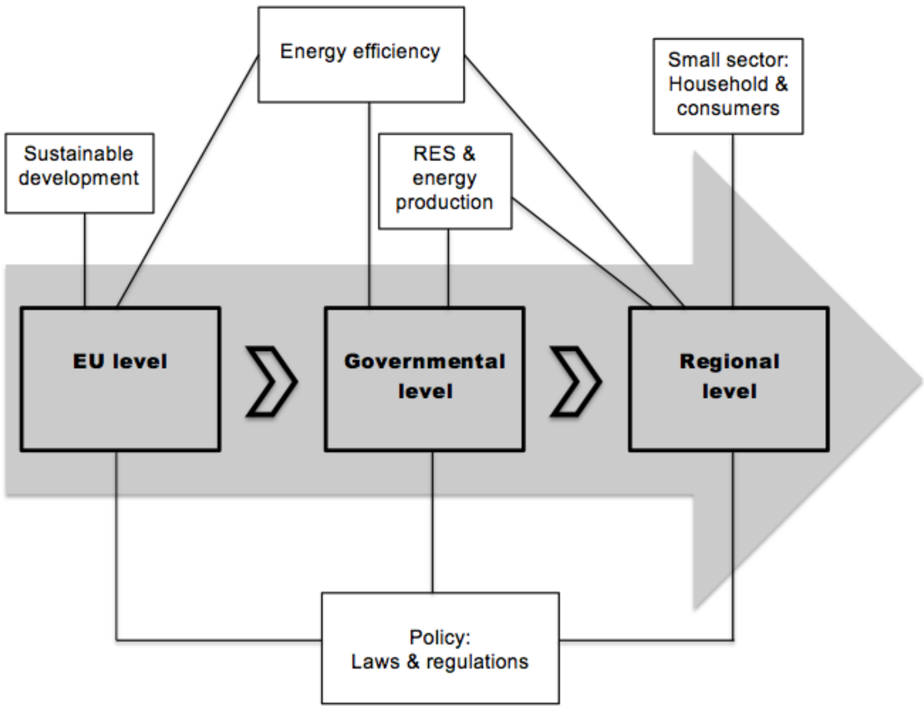

Figure 4. Research framework

The framework presented above visualizes the process of low carbon energy transition on three different levels, surrounded with driving forces and other factors that can have effects on the transition. In addition, what happens on a bigger scale in terms of EU policies then affects to each member country's laws and regulations, and these governmental decisions in turn affect the decisions to implement RES on a regional level. Thus, the framework is presented as an ongoing process from bigger scale to a smaller level.

3 RESEARCH METHODOLOGY AND DESIGN

The purpose of this chapter is to present and explain the chosen methodology for this thesis. The chosen research design, the data collection and analysis methods are introduced, in order to justify why these particular methods were chosen for this case study. In addition, the reliability and validity of the research are evaluated.

3.1 Study approach and design

To describe the chosen research methodology, the approach and design used in the study, a research framework designed by Saunders et al. (2016) is used. Figure 5 visualizes the research approach and design, which this thesis follows.

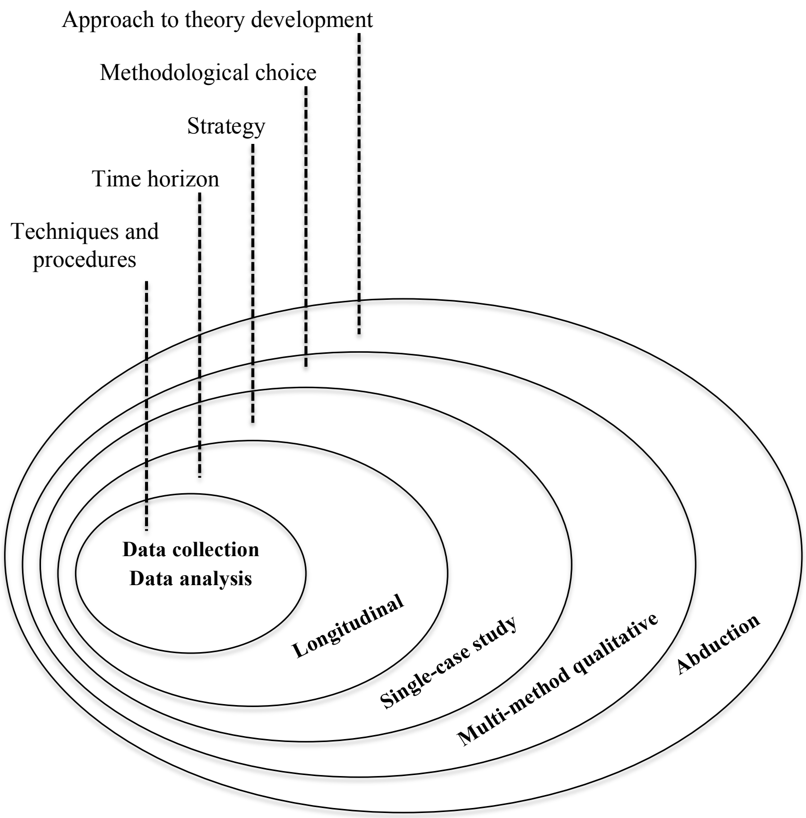

Figure 5. Research approach & design. Adapted from Saunders et al. (2016)

Approach to theory development

For the theoretical part of this thesis, an abductive research approach was conducted. Abduction is the middle ground between induction and deduction, which gives researchers the tools to describe and explain scientific innovation and creativeness (Patokorpi & Ahvenainen 2009, 126). Traditionally, deduction is moving from theory to data, and induction from data to theory. Instead of this, an abductive approach moves back and forth between theory and data, combining both deductive and inductive approaches. (Saunders et al. 2016, 148) This back and forth movement enables the researcher to develop new theories or modify existing ones (Awuzie & McDermott 2017, 357). In this study, the literature review was written first using a deductive approach, after which the secondary data of the cases was collected and analyzed. Then, the interview questionnaire was formed based on the result of the secondary data, which refers more to an inductive approach. Thus, this thesis uses the combination of these two approaches, and is therefore abductive.

Methodological choice

The methodological choice for this study follows a qualitative research design. Qualitative data collection technique uses non-numerical data, such as interviews. A qualitative research design may use a single data collection technique or use more than one qualitative data collection technique. Using more than one technique is known as a multi-method qualitative study. (Saunders et al. 2016, 164, 168) Thus, the methodological choice for this study is multi-method qualitative, as it uses collected qualitative data such as in-depth interviews and documents in text form, analysing the collected data through qualitative methods.

Using more than one method in a research can have significant advantages, although it almost inevitably is more time consuming. The main advantage is that it permits triangulation. Multi-method approach can also be used to address different but complementary research questions within a research. (Robson & McCartan 2016, 384)

Research strategy

The chosen research strategy for this study is a case study. A case study usually examines a present-day phenomenon, a case, within its real-world context and in depth. Same study can contain only one case which is then single-case design, or more than one case, which is called a multiple-case design. (Yin 2014 80, 187) This thesis follows a single-case study design, since it only contains one single case, which is the province of South Savo. Single-case design requires careful investigation of the potential case, to minimize the chances of misrepresentation and to maximize the access needed to collect the evidence for the case. Moreover, case studies' have a unique strength because with a case study design it is possible to deal with a variety of different evidence, such as documents and interviews. (Yin 2014 80, 181)

This study follows an exploratory purpose. An exploratory study is a useful way to ask open questions to detect current events and gain insights about the chosen topic (Saunders et al. 2016, 174). Exploratory research questions are likely to begin with "How" or "What", with which the formulated research question and the sub-questions for this study all begin with. (Saunders et al. 2016, 43) An exploratory study is especially helpful when wishing to clarify the understanding of an issue or phenomenon, as is the case with this study. (Saunders et al. 2016, 174-175)

Time horizon

The time horizon of a research can be either cross-sectional or longitudinal. Longitudinal study means that the data is obtained over a longer period of time. One way of obtaining time-series data is to use a series of company documents, as a source from which longitudinal secondary data set is created. (Saunders et al. 2016, 326) The main strength of longitudinal researches is their capacity to study change and development (Saunders et al. 2016, 200). Since the phenomenon studied in this thesis is taking place over a longer time period, as such changes in energy systems don't happen in a moment, the time horizon for this study is longitudinal.

3.2 Techniques and procedures

In the core of the structure of the thesis, as visualized in the Figure 5 above, are techniques and procedures, which include data collection and data analysis methods. The used techniques for data collection in this thesis are in-depth semi-structured interviews and secondary data. For data analysis, coding of the collected publications and coding of the transcribed interviews were conducted. The collected secondary data and the data of the interview were then triangulated in order to get more valid results.

3.2.1 Data collection methods

This thesis studied a combination of both primary and secondary data. In order to gain more insight to the local actors within the region, secondary data such as annual reports and publications on the municipalities' and the energy companies' websites were collected and analyzed before conducting the interviews. In total 15 different publications were collected for further analysis. As primary data, semi-structured interviews were conducted for a few local actors, and the cases were chosen to best present the representativeness of the region.

Document secondary data, in this case the publications, is often used in studies that also collect primary data. On many occasions it can be useful to compare collected data with secondary data, because by doing so it is possible to place the findings within a more general context or, alternatively, triangulate them. Triangulation involves using more than one source of data and method, in this case multi-method qualitative (Saunders et al. 2016, 319). Triangulation can help to counter the threats to validity and confirm the validity. (Robson & McCartan 2016, 374) The purpose of using several independent sources of data collection and methods within one research is to ensure that the data actually is telling what the researcher thinks it's telling (Saunders et al. 2016, 319). In other words, the triangulation obtained by the use of two or more methods helps to reduce the concerns about the trustworthiness of data so that it is analyzed and interpreted correctly (Robson & McCartan 2016, 374).

As for primary data collection, the semi-structured interviews were conducted by telephone where the calls were recorded for later transcription and analysis. Conducting interviews by telephone can offer advantages associated with access, speed and lower cost. The researcher may especially be able to interview participants whom would otherwise be difficult to interview due to the distance, costs, and time required. (Saunders et al. 2016, 421) The main reason for not conducting face-to-face interviews with the informants was due to long distance and time restrictions. Thus, to save time and resources, it was settled to organize the interviews over phone conversations, with the interviewees consent for the audio-recording of the calls. Three different local actors were chosen for the interviews, with one representative for each actor, so the data sample was relatively small. The interviews lasted approximately 30 to 45 min.

3.2.2 Data analysis methods

Document analysis is a form of qualitative research in which documents are interpreted by the researcher to provide a firm understanding about the research topic. In addition, document analysis incorporates coding content into themes. (Dahal et al. 2017, 4) Qualitative content analysis (QCA) can be distinguished in three different approaches, which are: summary, explication and structuring. Each of these approaches can be carried out either independently or by combining them, depending on the particular research questions. Of the three options, summary especially refers to reducing the used material to more essential content in order to make it easier to manage for the analyst. Among the different analysis types, summary is the closest one the software-assisted approach to QCA, as conducted in this thesis. (Kaefer et al. 2015, 4)

For the software-assisted analysis, NVivo (Version 13) software was selected as a tool for data management and analysis. In qualitative research, the processes of organizing, coding and analyzing data are basically invisible to the reader (Kaefer et al. 2015). Thus, in order to keep the analysis process as transparent as possible and to add the trustworthiness of the secondary data analysis results, the following coding approach is presented below in Figure 6.

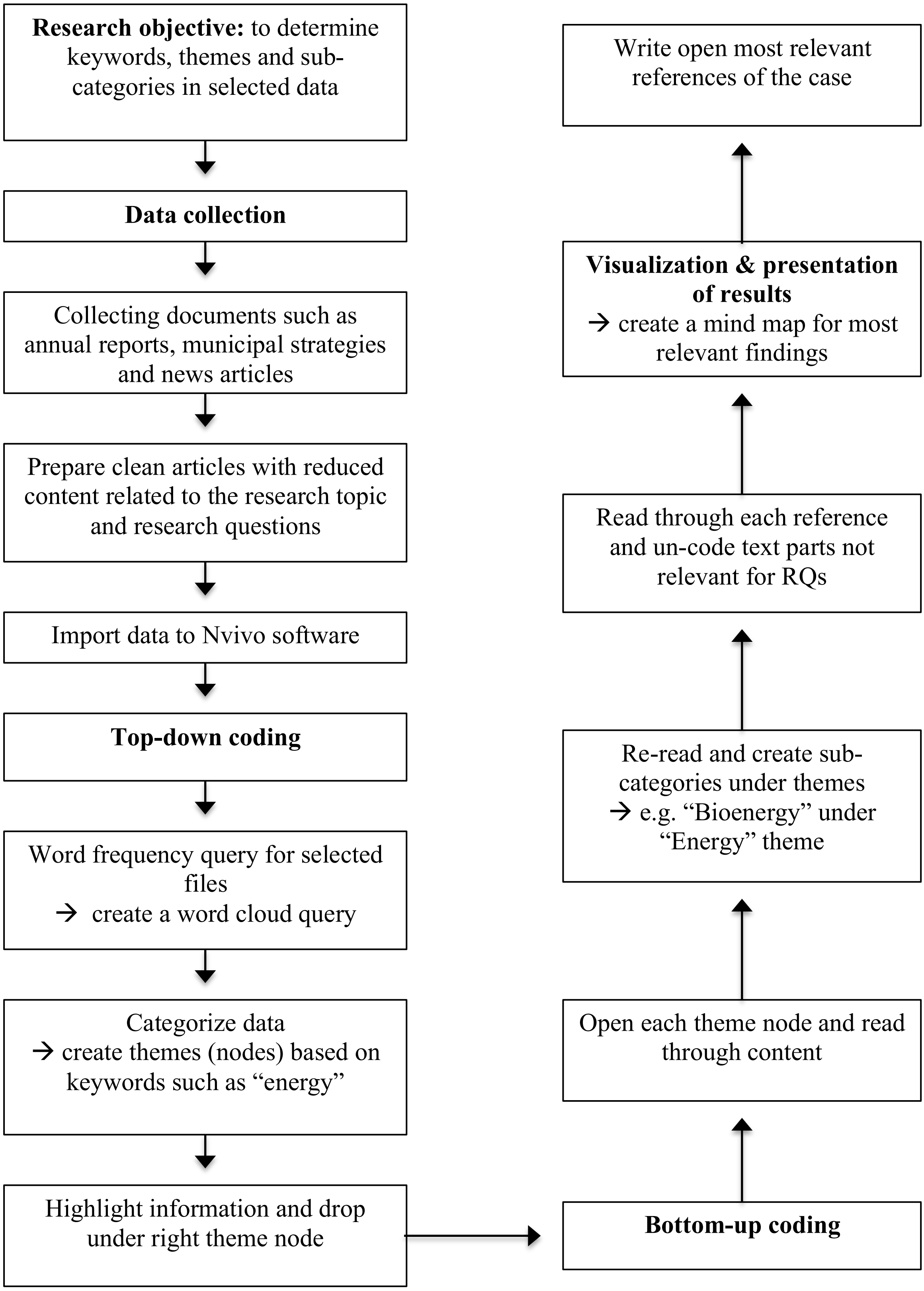

Figure 6. QDAS-assisted coding approach to qualitative content analysis. Adapted from Kaefer et al. (2015)

When using NVivo, coding means assigning segments of text to nodes, which can be best described as containers. Nodes can contain references about a specific theme for example, as in this analysis. Depending on the chosen methodology, either inductive or deductive approach can be used. For example, inductive coding starts with a detailed analysis of used sources and generating concepts and ideas as themes emerge. On the other hand, deductive coding means to start with a specific set of themes or keywords, and then exploring whether they can be found in the sources (Kaefer et al. 2015, 10). For this analysis, an inductive coding approach was used, as different themes (nodes) were generated based on the keywords and concepts found in the data queries.

The used analysis approach for the content analysis in this thesis is called thematic analysis. Most approaches to content analysis often begin with predefined categories, but thematic analysis allows categories to emerge from the data (Saldaña 2013, 177). The key purpose of this approach is to search for themes that occur across a data set. Thematic analysis involves a researcher coding qualitative data to identify themes or patterns for further analysis, related to the set research questions. (Saunders et al. 2016, 579)

As illustrated above in Figure 6, the first step in the coding process was to reduce the documents to parts which were relevant for the research questions. Next, NVivo's word frequency query function was used to generate a list of the most frequent words within the data, to help find certain keywords. After this, main themes were selected among the keywords and nodes for them created. The data files were then coded by dropping relevant text sections under each theme, and after re-reading the content within each theme necessary sub-categories were created under each theme. The visualization and presentation of the findings of the analysis are presented in the following chapter.

As for the semi-structured interviews, the data analysis was conducted much similarly to the analysis of secondary data. NVivo software was again used analyzing the data. The interviews were first transcribed and then entered to the software for further analysis. To help the analysis, the interview questions had been divided under four different themes which each answer to one of the four research questions. This way the coding process of the data was easier to conduct as the answers were already under the right theme. The selected themes were based on the results of the secondary data's content analysis. So the main difference between the two separate data analyses was that with the secondary data the themes emerged from the collected data, and in the interviews' case the themes were predefined.

3.3 Reliability and validity

Reliability of a research means being able to demonstrate that the research procedures of a study, such as the data collection methods, can be repeated with the same results. The target of reliability is to minimize the mistakes and biases in a research. (Yin 2014 162, 169). However, in qualitative research the results may not necessarily be intended to be repeated since they reflect the socially constructed interpretations of participants in a special setting at the particular time it is conducted, as in the case of this thesis. Still, strict description of the research design and methods may help other researchers to replicate similar studies. (Saunders et al. 2016, 205) Validity, on the other hand, is about the appropriateness of the used methods, precision of the analysis and generalisability of the findings (Saunders et al. 2016, 202).

The purpose of this study was to present the actions and implementation alternatives in energy production, for achieving carbon neutrality and possibly zero-emission energy production in South Savo. The study aimed to answer to a research gap concerning the local actors' perceptions about the energy system transition phenomenon, by examining the strategies and plans of municipalities and energy companies operating within the region, and by interviewing these local actors. Particularly with a case study research such as this thesis, using multiple sources of evidence for triangulation can help increase the validity and reliability of the evidence (Yin 2014, 331-332). When evaluating the reliability of a qualitative case study such as this study, the literature review and secondary data collection and analysis methods probably are replicable. However, it must be noted that if the interviews were conducted again later, the results might differ as new updated and more ambitious strategies and targets may have already come into effect.

As for the generalisability of the results, it must be taken into account that the scope for the interviews was relatively small, as it only included three representatives from local actors. Nonetheless, these experts for the interviews were chosen to best present the representativeness of the province, as the interviews included a representative from one city, a representative from an energy company, and a representative from one other company that is an important actor within the region. However, the results of the interviews as well as the secondary data analysis of the publications, can only be generalized in the province of South Savo as that is the only geographical area the evidence concerns. The results would be different concerning some other province in Finland, as South Savo is distinctive of its nature with its vast forests, vital forestry and bioenergy sector. Thus, the results cannot be applied to other parts of Finland where the geography and sources of livelihood are different.

4 RESULTS

This chapter presents the empirical findings of the study. First, case South Savo is introduced in order get more insight to the province's energy production, strategies for the future and possible targets for emission reduction. An overview of the secondary data's results is presented, which indicates the current state of energy affairs of the province, and the direction it is going towards. Next, the experts representing local actors who were interviewed are introduced, and the interview's results presented. Lastly, the two separate results and analyses are triangulated by creating an energy transition roadmap for South Savo.

4.1 Case South Savo

In order to gain more insight to the local actors within the region, secondary data such as annual reports and publications from South Savo's municipalities' and the energy companies' websites were analyzed, before conducting the semi-structured interviews. The results are based on the findings of the QDA.

4.1.1 Case characteristics

The analysis was made by addressing to set the research questions. The set research questions were:

RQ: How does local actors' engagement contribute to pursuing carbon neutrality on a regional level?

SQ1: What are the perceived driving forces and challenges for low-carbon energy transition?

SQ2: What are the preconditions of renewable energy on a regional level in South Savo?

SQ3: How are the local actors planning to further reduce their emissions?

However, the secondary data analysis' purpose was not trying to find full and ready answers to the research questions but act more as a guiding line to help forming the interview questions guide for the semi-structured interviews, which go even deeper to the topic. Thus, the secondary data analysis works more as an introduction to the South Savo case and gives valuable knowledge of the actors within the region, about their current state of energy production and their plans and strategies for the future.

4.1.2 Case overview

The province of South Savo is located in the heart of Lake-Finland and constitutes of 14 municipalities in total. (Etelä-Savon maakuntaliitto 2019) The used data for the QDA were selected from available publications on the websites of the regional council, municipalities, and energy companies operating within the region. The used data sources for this analysis are presented below:

1. Etelä-Savon Energia (ESE) annual report 2017
2. South Savo's provincial strategy 2030
3. South and North Savo's climate program 2025
4. Regional economic impacts of ESE's fuel choices
5. ESE's environmental report 2017
6. Suur-Savon Sähkö (SSS) annual report 2016
7. Municipalities' climate targets and measures - a research by Deloitte
8. Savon Voima (SV) annual report 2017
9. City of Savonlinna's strategy 2018-2021
10. City of Mikkeli's climate and energy strategy's monitoring report 2015
11. South Savo's provincial program 2018-2021
12. Joroinen's municipal strategy 2018-2022
13. South Savo exports forest expertise to the world - a release by Miksei Ltd
14. Energy production - a webpage of SV
15. City of Mikkeli's climate strategy - an article by Länsi-Savo magazine

The created themes and sub-categories formed under these themes are presented in the following Table 4. The table also informs how many of the data file sources contained references related to each theme, and how many references were coded under each theme in total. In addition, evidence found for each theme is presented.

Table 4. Created themes for QDA

Theme	Sub-categories	Number of files (out of 15)	Number of references	Evidence
Energy	• Bioenergy • Current energy production • Wind, solar & hydro	13	103	• Majority of electricity and heat are produced with forest fuels, which reduces the need and use of fossil fuels • The use of wind energy, solar power, hydropower and geothermal heat are promoted
Environment	• Carbon neutral • Climate change • Emissions • Environmental impacts • Environmental management systems (EMS)	12	103	• The provinces' intent is to reduce GHG emissions and mitigate to the challenges set by climate change → carbon neutral progression of the society
Innovations	• Cleantech • New technologies • Smart specialization	8	47	• Cleantech cluster in development
Strategy	• Bioenergy program • Climate program • Energy production objectives • Provincial strategy	13	97	• The climate targets are the same as on a national level → emission reduction by 80% by 2050

4.1.3 Secondary data's main results

How the results are presented to audience can impact the credibility of the results. To ensure credibility, a researcher should present each theme with its respective meaning and evidence from the data. Adding a visual representation of the themes, their relationships, and related ideas helps the audience to better understand the findings. (Adu 2016) Thus, the following mind map was formed to visualize the key findings of the QDA, based on selected themes and their sub-categories. Each theme and evidence from the data are first visually presented in Figure 7 below, and after that described in more detail. Parts of the results are explained in writing for in-depth analysis, in purpose to give more insight to the findings.

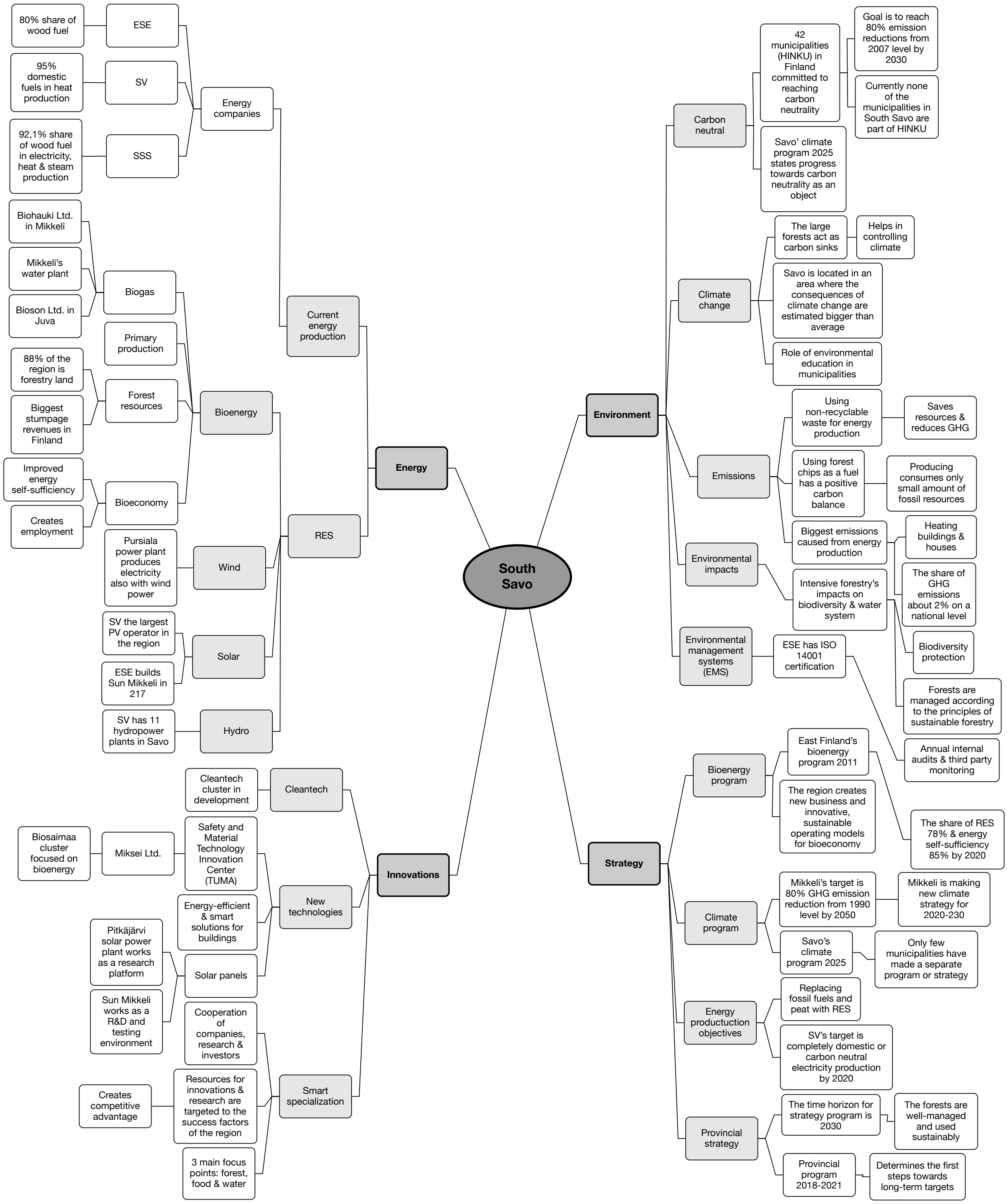

Figure 7. Mind map of QDA's key findings

In 2014 the primary energy consumption was about 2% from the nationwide consumption in South Savo. Out of that amount 49% was produced with RES and the provincial energy self-sufficiency was 42%. The climate targets in South Savo are the same as on a national level, so reducing CO_2 emissions by 40% from 1990 level by 2030 and by 80% by 2050. Thus, the national target for the amount of renewable energy by 2020 has already been exceeded in South Savo but the self-sufficiency in electricity was weaker. (Etelä-Savon maakuntaliitto 2017)

South and North Savo's climate program 2025, which was published in 2013, is a target program, which brings together provincial programs' and strategies' climate and energy targets and actions. In 2013, only a small proportion of Savo's municipalities had formed a separate climate program or strategy. (Mörsky et al. 2013) However, the provinces' mutual intent is to reduce GHG emissions and mitigate to the challenges set by climate change. The purpose of the actions taken is the wellbeing of the citizens and a carbon neutral progression of the society (Mikkelin seudun ympäristöpalvelut 2015). The climate strategy states that the share of RE will continue to increase to at least 60% of final energy consumption by 2050 (Mörsky et al. 2013). The Provincial Program 2018-2021 is the provincial strategy's essential tool. The four-year program defines the first steps towards long-term goals. (Etelä-Savon maakuntaliitto 2017) Savo is located in an area where the global warming is estimated to be stronger than the average on the globe (Mörsky et al. 2013). In South Savo, the biggest emissions are generated in energy production to heat buildings, in traffic and in agriculture (Etelä-Savon maakuntaliitto 2017).

In recent years many municipalities have committed to pursuing carbon neutrality with their emissions in Finland (Deloitte 2018). Many of the municipalities with such targets are a part of a carbon neutral municipality project called HINKU. In the project the municipalities, companies, citizens and experts together implement solutions to control emissions. The HINKU municipalities are committed to 80% reductions in GHG emissions from 2007 level by 2030 and compensating for the remaining 20%. There are currently 42 municipalities in the HINKU project, but yet none of the municipalities are from South Savo. (Saari 2018)

However, some of South Savo's cities and municipalities mention bioeconomy, climate issues and carbon neutrality in their municipal strategies. The city of Savonlinna states in its strategy, that its long-term future target is a carbon neutral city (Weander 2018). The municipality of Joroinen's strategy is to promote bioeconomy and circular economy within its region (Joroisten kunta 2018). South Savo's biggest city, Mikkeli, states in its energy and climate strategy that its main goal is to have the lowest emissions per citizen and the highest share of renewables in energy production compared to other cities the same size in Finland (Mikkelin seudun ympäristöpalvelut 2015). Mikkeli has been able to reduce its GHG emissions 28% during six years. In 2010 Mikkeli had yet not set a climate neutrality target and is now planning a new climate strategy for 2020-2030 with more ambitious goals. (Saari 2018)

Forests are the most important natural resource in Savo (Mörsky et al. 2013). South Savo is the most forested area of all provinces in Finland with 88% of its land area being forestry land, and it is the number one in terms of stumpage revenues in Finland (Etelä-Savon maakuntaliitto 2016; Miktech Oy 2013; Etelä-Savon maakuntaliitto 2017). Almost tenth of the annual forest growth takes place in South Savo (Etelä-Savon maakuntaliitto 2017). Forestry is intensive in South Savo. About 4% of the area is nature reserve and there are only few old forests. The provincial program of South Savo is committed to cherishing the distinctive natural values of the region (Etelä-Savon maakuntaliitto 2017). Thus, the forests are managed by the principles of sustainable forestry (Etelä-Savon maakuntaliitto 2016). The provincial program states creating new business and sustainable innovative business models for bioeconomy as its main goal. The core of bioeconomy is based on the whole value chain of forest sector in the province (Etelä-Savon maakuntaliitto 2016).

Bioeconomy is a growing possibility in the region and it supports the sustainable future of Savo. The economic structure of Savo is the most focused in primary production in whole Finland. (Mörsky et al. 2013) Bioproducts and wood-based energy have the biggest growing possibility in bioeconomy. In addition, harvesting wood and bioenergy production creates local employment, promotes the competitiveness of the region and improves self-sufficiency. (Etelä-Savon maakuntaliitto 2017; Mörsky et al. 2013) Today, the vast majority of electricity and heat are produced with forest fuels, which reduces the need and use of fossil fuels and peat (Miktech Oy 2013; Mörsky et al. 2013). Also the use of wind energy, solar power and geothermal heat are promoted in Savo (Mörsky et al. 2013; Etelä-Savon maakuntaliitto 2017). The energy self-sufficiency level and employment within the industry are supported by decentralized energy production. (Mörsky et al. 2013)

In terms of new innovations, Savo's climate program states that the goal is to build a cleantech cluster there. The funding is directed to promote clean energy technologies and development of and resource-efficient processes. In the city of Mikkeli operates a safety and material technology's innovation center TUMA. TUMA brings together different cleantech operators that benefit from cooperation with each other. (Mörsky et al. 2013) The province's forest expertise is internationally on the top in fibre and process technology within the industry (Etelä-Savon maakuntaliitto 2016). Companies in South Savo have been among the first ones to develop new procedures and devices to use forest energy more efficiently, which have been put to use around the world (Miktech Oy 2013). Savo's climate program describes the province's way to operate as Smart specialisation. In South Savo the focus points of smart specialisation are forest, water and food, which are described as the natural strengths of the area. (Mörsky et al. 2013)

There are a few energy companies operating in South Savo, which produce heat and electricity mostly from renewable sources for the cities and municipalities within the province. For instance, Savon Voima Ltd. (SV) has executed a bioenergy program since 2001, which aimed for lifting the share of domestic fuels to 90% in district heating production and electricity production related to it. (Savon Voima Oyj 2019) In 2015, the utilization of domestic fuels was already 95% (Savon Voima Oyj 2019; Savon Voima Oyj 2018). Moreover, using raw materials that are produced locally creates positive effects to the regional economy (Savon Voima Oyj 2018). SV also seeks growth in its electricity production by investing in emission-free hydro, wind and solar power (Savon Voima Oyj 2019). SV is on its way to carbon neutral energy production with eleven water plants and being the biggest PV operator within the region (Savon Voima Oyj 2019; Savon Voima Oyj 2018). SV's goal is to have a fully domestic or carbon neutral electricity production by 2020 (Savon Voima Oyj 2018).

Another energy company, Etelä-Savon Energia Ltd. (ESE) operates in the city of Mikkeli and produces electricity and district heat in their Pursiala's CHP plant. ESE utilizes almost entirely domestic fuel and is one of the leading bioenergy users in Finland. ESE exploits forest energy wood and forestry by-products in its energy production. (Vanhanen et al. 2015) In 2014, ESE's fuel consumption was 900.6 GWh in total. Out of this amount, wood fuels accounted for 730.3 GWh (81.1%), peat 163.8 GWh (18,2%) and oil 6.5 GWh (0.7%). (Mikkelin seudun ympäristöpalvelut 2015) ESE also produces power with solar energy in their Sun Mikkeli plant. Ristiina's district heat plant levels its power peaks with solar heat that is stored in a reservoir on sunny days (Etelä-Savon Energia Oy 2018b; Etelä-Savon Energia Oy 2018a). Sun Mikkeli also works as learning and testing environment for products related to solar power (Etelä-Savon Energia Oy 2018b). The future development of ESE is steered by a certified ISO 14001 EMS, which obliges the organization to improve its operations continuously (Mikkelin seudun ympäristöpalvelut 2015).

A third energy company, Suur-Savo Sähkö Ltd's (SSS) share of domestic fuels in electricity, district heat and steam production was 97.5% in total in 2016. Out of this, wood accounted for 92.1%, peat 5.4% and heavy fuel oil 2.5%. SSS produces local energy, and cooperates with local companies, organizations and forest owners. (Suur-Savon Sähkö 2017)

There are also biogas producers in South Savo. BioHauki Ltd's biorefinery started its operation in 2017. The refinery produces biogas from manure and vegetable scraps. (Etelä-Savon Energia Oy 2018b) Another biogas plant operates at Mikkeli's water plant, which produced 1148 MWh of biogas for heating in 2014 (Mikkelin seudun ympäristöpalvelut 2015). In Juva, operates Bioson Ltd. which is a biogas plant shared by multiple farms, which started its production in 2011. (Mörsky et al. 2013)

4.2 Local actors' strategies and actions

Next, the representatives from chosen local actors are introduced and the main results of the conducted semi-structured interviews are presented. In order to protect the identities of the informants and the local actors they represent, the informants are referred to as "Expert A" and so forth.

4.2.1 Interview informants' descriptions

Expert A works as an environmental inspector in one city in South Savo, with work tasks related to municipal environmental protection. The work role of the informant also includes climate and energy issues and monitoring and promoting these aspects. The city the informant works for owns 100% of an energy company located in there.

Expert B works for a city-owned non-profit development company. The informant is in charge of the development of bioeconomy and cleantech industries. As a public company, its purpose is to promote the creation of new jobs in the urban area, to promote the growth and internationalization of companies in the region and marketing the city as a new location for businesses. In addition, the company promotes tourism affairs. What the company does is in line with the strategy and targets of the city that owns it, and the city's plans are in line with the provincial strategy. The company has its own projects to support the targets of the company, and they cooperate with companies within the region and industry, in collaboration with research institutions.

Expert C works for an energy company, which distributes electricity to the province of South Savo. The informant runs the production business, which includes heat production and distribution, and the informant is in charge of the power plants. The company has district-heating operations on ten different localities and it also has a subsidiary that sells electricity. The company also has two small water plants, and it also owns shares of power plants through other energy companies, so that way they also have Norwegian and Swedish hydropower. In addition, they currently use a small amount of nuclear power. The case company also has a small amount of coal condensing outside the South Savo region, but these coal-fired power plant units have been mostly disposed of, and some of them have also been closed.

4.2.2 Main results of the interviews

Here, the key findings of the semi-structured interviews are presented and visualized. First, the following Table 5 summarizes together the research questions and the interview themes. Also the meanings of the themes are explained, and evidence that was found related to the research questions. In order to keep the analysis process of the gathered data from the interviews as simple and clear as possible, the interview themes were divided under each research question they aim to find the answer to. The themes are named "Theme 1" and so forth based on the order they were brought up in the interviews. The interview questions and the themes can be found in their entity in Appendix 1 and 2.

Table 5. Summary table of the interview results

Research questions	Interview themes	Meaning	Evidence
RQ: How does local actors' engagement contribute to pursuing carbon neutrality on a regional level?	Theme 3: Implementation options	The data reviews the implementation of RET and the role of carbon sinks	• Energy companies investing in RET, e.g. solar energy and using hydropower • The role of bioenergy is remarkable and complicates the question of carbon sinks
SQ1: What are the perceived driving forces and challenges for low-carbon energy transition?	Theme 4: Drivers and possible barriers	Drivers and barriers for emission free energy production, challenges the EU sets, people's consumer choices and other possible challenges	• Energy policy tools are strong drivers • The cost and viability of the transition is a challenge • Climate consciousness can guide actions on some level
SQ2: What are the preconditions of renewable energy on a regional level in South Savo?	Theme 1: Introductory questions for estimating the level of commitment of the local actor	Strategies and actions for emission reductions	• Strategies in line with the climate strategy of North and South Savo • Reduced shares of peat and oil

SQ3: How are the local actors planning to further reduce their emissions?	Theme 2: Target state	Targets for emission free energy production and carbon neutrality	• Carbon neutrality possible to achieve in energy production • No set targets for completely emission free energy production

The informants were interviewed as representatives of their workplaces, but it must be noted that these conducted interviews also left room for the informants to express their personal opinions on the issues at hand. The following concept map presents the main results of the interviews in a visual form. To give more insight to the content of the interviews, the most relevant parts of the given answers follow after the Figure 8.

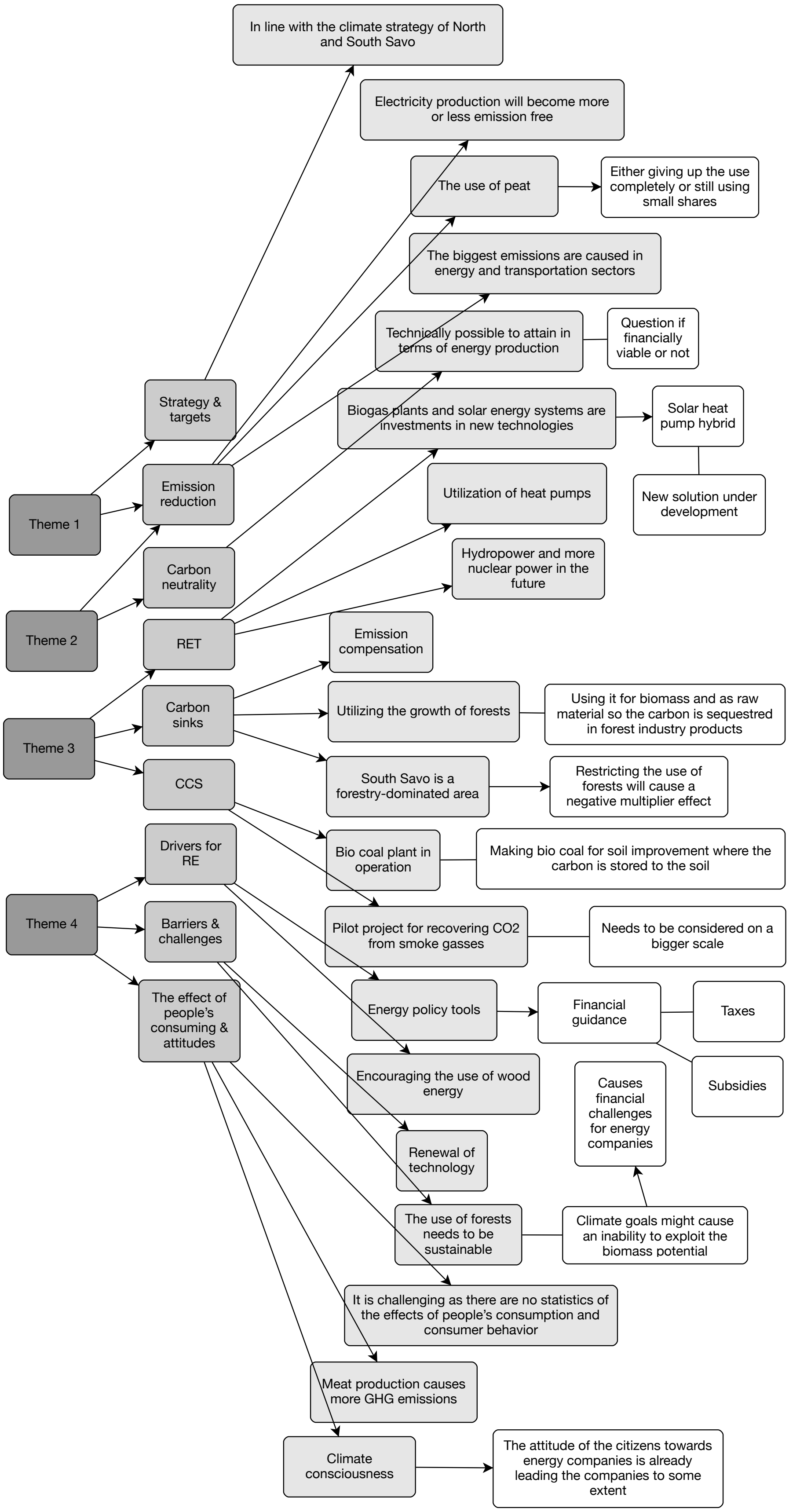

Figure 8. Primary data's main results

In terms of *strategy and targets*, Expert A told that the city has had its current climate and energy strategy from the year 2010. The goal is to reduce GHG emissions with at least 30% compared to the 1990 levels by 2020, and 80% by 2050. Since the 2020 target has already been reached, the city has planned to make a more ambitious goal for the next ten-year-period. The biggest emissions are caused in energy and transport sectors and as the informant said it can be stated that transport will be the biggest challenge for the city, as it is for the whole country.

Since the company Expert B works for does not have its own separate *targets* and the city it operates in is in line with the provincial targets, Expert B referred to the climate strategy of North and South Savo. In the climate strategy it is stated that in energy production, the use of fossil fuels and peat is phased out in products where CO_2 is not captured. The share of RE will continue to increase to at least 60% of final energy consumption by 2050. (Mörsky et al. 2013) This information is also mentioned in the earlier chapter 4.1.3 in the secondary data's main findings. The informant observed that when the current strategy expires, it then should be considered what the national strategy is, as there are 2030 and 2050 targets in Finland. On a provincial level it needs to be made certain that the target are in line with the national ones. The informant believes that the province can do activation work and information work, and direct provincial EU funding for development work that contributes to increasing the use of RE.

Expert C told that the energy company has no set target year for completely emission free energy production, although the informant stated that the electricity production will become more or less emission free. Otherwise the company is not pursuing a completely emission free state, since when considering CO_2 emissions the company does not believe it is wise to attain becoming completely independent of oil. This is mainly due to the fact that the company still needs the peak plant and spare plant units, which use oil, in case the main boilers malfunction. As these spare units get so few drive hours or be even driven yearly, it would be economically quite heavy to acquire wood chips or pellet boilers there. With regard to the very low oil usage the informant said that the company sees that it is sensible to have a certain amount of these oil boilers to be preserved and used, as their use rates are comparatively low.

There is also the question of burning peat in South Savo. Expert A said that the city is aiming to reach its emission reduction targets by giving up the use of peat completely and by saving energy. The city will stop using peat between 2030 and 2040, and the production is set to stop 2035, as decided by the only energy operator in the city. However, as the informant stated it cannot be said that the production will be completely emission free since using wood fuel still causes the CO_2 to be freed to the atmosphere, but the production can still become *carbon neutral*. Emissions are monitored on an annual basis, as the city is involved in a CO_2 report system, which calculates the caused CO_2 emission yearly. The city's energy efficiency agreement aims to reduce energy use in the city's own operations.

According to Expert A, in the city's own energy production the share of wood has continually been increased and the share of peat decreased since the 1990s. Currently the use of wood-based energy is around 80% and the use of peat already under 20%, with oil playing a minor role as a supporting fuel with 1% share. In terms of fuel oil, the share of smaller units such as fired boilers still using it is really small compared to the main CHP unit. Of the city's two production units, the newer one can already operate completely on wood chips. The older unit also operates mostly on wood chips, but it still uses a small share of peat, which can be reduced by slight changes and then given up completely when unit comes to the end of its life cycle in 20 years. There is one biogas plant in operation, and another biogas production unit under production. In terms of circular economy, there is a 100 hectares circular economy park under construction in connection to the existing waste management center. In there, they are building a new sewage treatment plant, which will create synergy benefits. As the informant explained, this will create a circular economy and organization cluster to the area, which will give a significant contribution to climate work. The idea of the circular economy park is that in there public and private companies alike can develop environmental technologies together and waste will be increasingly used as raw material.

Related to emission reduction, Expert B noted that it is strongly binded to the fact that the use of RE increases if it is economically viable for end users. This is related to energy policy and its directing methods, and the informant stated that as the only energy policy instruments are at national level, there are no provincial or sub-regional or city-specific directing methods. On provincial level there might be R&D fundings that come from provincial EU fundings, which can be granted for the regions, but the provinces themselves cannot set any energy subsidies or tax subsidies.

Expert C told that the energy company's electricity production is going to be emission free after a little time, when the last of their coal condensing contracts end. Then the company will only be producing electricity with hydropower, nuclear power and a small share of wind energy, the amount of which they are possibly going to increase by building more. In terms of heat production, the company has had a pretty good situation for a longer period of time already, since over 90% of existing fuels are wood-based. Depending on the year in question, the company has had a share of about 6 to 8% of peat and a couple of percent of light fuel oil in the peak plant and spare plant units. The district heating production's oil share has been partially replaced with pellet burners, in the peak plant and spare plant units. In practice this means that the oil burners were replaced with ones that can burn pellets instead of oil. Through such actions the company has been able to reduce their use of oil.

Expert C explained that the company still uses a small amount of peat for burning, as peat is in fact a fuel that keeps the boiler somewhat cleaner when burning forest chips. Thus, the boilers are better able to operate safely through the winter period too without any unplanned shutdowns. So, the company still uses a little peat for the burning process but if it was decided that peat needs to be given up completely, then, as the informant noted, it is technically possible already. The informant also reminded that as would be a small thing for their company as the area is rich with forest, for other companies it would be a bigger issue and could result in overheating of wood-fuel markets. The informant stated, that energy companies may have a chance to pay a little extra for fuels, but not in terms of the competitiveness of the forest industry. Thus, the informant thinks that forbidding peat is contrary to the overall interest of Finland as it would hit the forest industry hard, and this mechanism should to be understood before making the decision of giving up peat.

In terms of *carbon neutrality*, according to Expert A the city's new strategy for carbon neutrality target will probably be 2030 or 2035. The informant stated that it is an issue that needs to be aimed for ambitiously and believes that the targets for other areas in South Savo will not likely be any less ambitious on the provincial level. The informant said that municipalities of South Savo have done a lot in terms of tree felling and the goal is to start a carbon neutral South Savo project at the end of 2019. In addition, the informant noted that when making the climate strategy program for the city, also other partner municipalities will be taken into account since they do not have their own programs and would likely participate if a program was drawn for them. Also because of the government's national solutions, the progress will be rapid and because of that the informant believes that the province itself will be carbon neutral already way before 2050 or no later at least.

Expert B also believed that achieving carbon neutrality is possible, if heavy enough energy policy directing methods are brought into use. Although, as the informant stated, it is at least technically possible but it is another question how expensive it will be. The informant also stated that in terms of energy production it is possible to attain, but the question remains if it is sensible because it could become surprisingly costly for the Finnish economy, so it may have quite heavy economic impacts.

When it comes to using *RE and implementing RET*, Expert A explained that the city has two biogas plants and solar energy systems, which are investments in new technologies. There is no wind energy production in the city, but there are some units built for the utilization of solar energy. Expert B referred to the Energy Balance of South Savo publication by Karttunen et al. (2017), which is also referred on this thesis' literature review in chapter 2.1.4. The informant stated that the use of RE has evolved and RE has been invested in, in the province, but these investments are more individual investments made businesses such as energy companies, not by the development company itself. These investments have been made into building solar energy systems and also HPs have been utilized.

Expert C stated that the company does not have its own solar electricity production, but its subsidiary sells solar panels to small producers. The company currently has hydropower and will have more nuclear power in the future, and in heat production oil burners have been replaced with ones that burn pellets. As an example of an investment to new technology, the informant told that the company currently has a permit in progress for an aid from Business Finland. They are applying for the aid for their new solution in district heating, which is a sort of solar heat pump hybrid. The informant explained, that as the wood chip boilers have the issue of running a small load, it is difficult to run the small summer load with them and the efficiency of it is low. Thus, the idea is to produce the summer load with solar collectors and the main boiler could then be put out for the summer. Then, the solar collectors would heat up the heat accumulator and by boosting with a HP when needed, it would then produce district heat by moving the heat from air to water. However, there is yet no decision of implementation for this project but this sort of hybrid technology would be groundbreaking in Finland and is under discussion in the company.

When considering *carbon sinks* and forests of the area, Expert A thought that their meaning is significant since the province is located in so-called forest Finland where trees grow the best. The meaning is significant especially in terms of compensation, because carbon sinks would likely be the easiest way to compensate for the emissions. Nevertheless, the informant acknowledged that there is a lot of talk about the role of forests and bioenergy, which makes things more difficult. However, as the informant stated, if the forest resources do not matter in the most forested part of Finland, then it can be asked that where do they matter. In addition, it is already required of the city to record its current carbon sinks. The city currently owns 3% of the forests within the region, and for the new strategy the goal is that the forest growth needs to exceed felling, even though the sink is small and can only capture a small amount of the caused emissions in the area. The informant reckoned, that the aspect of forest sinks will most likely be taken into account from a bigger scale than only to consider the city's own emissions. The informant also added that the scientific facts needed for raising the share of carbon sinks come from projects with partner organizations such as LUT University and Lukes, since these parties produce credible results.

The other informants had a somewhat differing opinion about carbon sinks compared to Expert A. Expert B believed that it would be short sighted to start limiting the use of forest biomass, especially as long as it stays in a sustainable harvest. The informant thought that it is more important is to utilize the growth of the forests, keep the growth of the forests at a good pace, and use it for biomass and as a raw material for the forest industry, so that the carbon is removed from the carbon cycle for a longer period by sequestering it in forest industry products. Then, the forest by-products are efficiently used for energy production with the assumption that a significant part of it will replace the use of fossil energy sources.

The way Expert C saw it, is that forestry should be practiced in the forests of South Savo, so the wood would be harvested and the forest industry would get its own, and the logging residues will be used for burning. The informant did not see it as a good thing that the forests would be considered as carbon stocks in the area, because even if the forests are not hacked down then eventually the trees will die naturally, and that will release CO_2 into the atmosphere, in other words the normal carbon cycle. According to the informant, if this carbon release is slowed down in forest areas by 50-80 years, when it still is forestry-dominated area, then it will create a much more negative multiplier effect. From the energy company's perspective that fuel still needs to be transported from somewhere else if they do not get from the nearby forests, and that would not really make sense, since the transportation also requires energy.

In terms of *CCS*, Expert A said that the city has not particularly thought about solutions for it yet, but there is a bio coal plant operating in one municipality, and the goal there is to start making bio coal for soil improvement where the carbon is stored to the soil and not released to the atmosphere so it works as a place for capture. The plant also produces barbecue charcoal, but the main focus is on bio coal production. The interviewee estimates that there probably needs to be more than one of such plants operating in the future, but currently there is this one plant operating. Expert B said that options for CCS have been considered but the informant could not tell more about them. Expert C told that the company had a pilot container in cooperation with another firm, where CO_2 was recovered from smoke gasses and the informant recalled that the pilot succeeded reasonably well. But on a company level there are no such options that would have been considered seriously. The informant reminded that even though CO_2 has its certain market, there still is the problem like with the pilot that the experiment did not result in the collected CO_2 ending up in food industry or elsewhere. And the question remains whether there could be even bigger scale solutions for the company regarding CCS.

The topic of *drivers and barriers* for the use of RE and the transition to low-emission energy production was also discussed with the informants. Expert A mentioned financial guidance, like taxes and subsidies as examples of drivers. The informant also thought that providing information and fact knowledge is important, so that the use of RES will become the new norm. As the informant noted, this might cause some extra costs, and some people will be more willing to pay the price than others, so it is also about a change in people's attitudes. However, the use of RE also needs to be economically profitable so the informant believed that the government should provide the means to the implementation of RE. Expert B also mentioned energy policy tools as a driver, as they are a way to influence fuel price ratios and profitability.

Expert C said that an important driver is that the use of wood energy is encouraged, by not to limiting the use of forests, so that there will be no taxes, sanctions or emission counting factors. The informant stated that it is important that the forest industry is doing well. On the other hand the informant thought that there should not be any subsidies that will distort the market, so there should be as little as possible additional guidance and the market should be let to handle things itself. This, according to the informant, is due to the fact that the market for emission allowances has begun to work in Finland, and that there is a set price for emission allowances. The price of the allowance is currently at a healthy level, and it is the price that controls the market, so the emissions issue has begun to work as intended.

As for barriers for the change to take place, and possible challenges, Expert A stated that the questions of biofuels, renewal of technology and the use of electric cars still remain and need to be solved on a bigger scale. These issues are a challenge as is the question of carbon sinks, and these questions need to be taken into consideration. The informant also believed that new knowledge is needed in how to use soil in carbon capture and how to guide agriculture to the direction where the emissions could be reduced also in that sector.

The informant suggested that this probably is an area where there is constantly coming new information and new measures. As for the city's part, agriculture was not considered in the previous climate strategy but will probably be taken into account in the new strategy, as it is a challenge for all municipalities, units and operators alike. Hence, they should all work together in the direction of emission reductions. As other possible challenges the informant recognized a question about forest wood material and waste raw material. The challenge will be if there is enough of this material for energy production, since the use of forests needs to be sustainable and biodiversity and other values still need to be protected. The informant believed that material scarcity could become a problem if recycling is performed so well that there will be nothing extra to use or spend as the material is circling so efficiently. But on the other hand, as the informant remarked, this could also be the target in this matter.

Expert B noted that it is a challenge if the climate goals are causing an inability to exploit the excellent biomass potential and biomass production that the province has. The second challenge, which the informant thought is a positive one, is that when the prospect of using RE is also growing elsewhere, it gives a huge opportunity for the development of RET, commercialization of technology exports and know-how. This way local businesses are involved and can develop products that are in demand and gain market shares with them, so it has a very good potential for growth. This reflects what the development company is aiming for, creating new jobs to the area. So, as the informant explained it, taking advantage of the biomass resources will run a certain amount of business, but the opportunity to increase business through exporting technology is multiple. As other possible challenges the informant recognized the question of what the transition to RE will cost, since in Finland the transition to emission free energy production can happen relatively quickly. The informant estimated that it might even happen within a decade, since it is technically possible but the price of it is another question. The interviewee reminded that with emission free energy production, when considering RES, the emission free state cannot be reached by only using wood energy or solar power or biofuels. It requires the use of all the different forms of RE is, as well as energy savings.

Expert C stated that if the use of forests becomes more difficult, or if some forest products will get an emission factor, then there would be the need to review emission rights, which then would cause economic challenges for the company. In terms of challenges related to the transition to emission free energy production, the informant believed that if coal and peat are completely given up, as the company produces a lot of energy by burning, then it will result in not being able to produce enough energy by burning process in Finland. It would eventually lead into increased use of wind power, where the problem of storing energy still exists, and this problem will be reasonably big. The informant reckoned, that all sorts of price elasticities and adjustable production will become very valuable in the future, and these storage and elasticity issues are barriers for wind power. The informant reminded, that even though the sun produces a lot of energy during summer, it still will not be able to satisfy the energy needs of the Finnish winter, so the solution for the energy problem is not found in solar power alone. The informant believed that small nuclear power plants and nuclear reaction-based heat production will be developed within coming decades and it will certainly help in the transition to this emission-free energy production. The informant stated that mostly wood-based fuels will be used South Savo in the medium term, due to the forest resources of the area. It will also be the most sustainable solution, since long transition distances do not make sense.

Lastly, *the effect of people's consuming and attitudes* was discussed with the informants. Expert A believed that they affect a lot, but it is challenging as there necessary are no statistics of the effects of people's consumption and consumer behavior. The informant noted that wealth brings increased emissions in terms of increased travelling and different consumer behavior. However, the informant thought that it might not only be a question of wealth but dependent on how people live, eat and travel in general, since every consumer choice people make have consequences and may cause big effects. The informant stated that the meaning of this aspect should be highlighted and calculated somehow if possible, but at least on the idea level it has a big meaning.

Also Expert B believed that the attitudes and consuming do have a meaning, for example in the case of food, meat production causes more GHG emissions. The informant said that when it comes to the use of forest and wood biomass, the consumer values can affect if some issue becomes a really important one for people, or if they start opposing the use of forests and biomass. Expert C stated that people's climate consciousness has grown really fast in South Savo. Because of this, for example, in electrical products the company has already given product descriptions, ie what kind of emissions the products cause. So, as the informant put it, the attitudes of the citizens are already leading energy companies to some extent, which is a good thing and needs to be taken into account.

4.3 Roadmap for energy system transition

Next, the results of previous chapters are used to draft a roadmap for the energy system transition. In the following Table 6, the key findings of the QDA of publications and the main results of the interviews are combined and presented. As the thesis is qualitative of its nature, it must be kept in mind that these results are guiding, only showing the direction where the province of South Savo is headed with its actions so far, and current strategies for emission reduction and energy system transition towards RES and decarbonization. Thus, only assumptions for the roadmap of the transition can be drafted. However, as one of the interview informants stated, the transition to emission free energy production can happen relatively quickly, even within a decade, since it is technically possible but the price of it is another question.

Table 6 below gathers the main evidence from the analyzed data, both primary and secondary. One-page visual displays help immensely to visualize the phenomenon, but they can only contain so many words. Thus, a simple text chart was chosen to outline the findings and their connections, and to provide an executive summary. (Saldaña 2013, 254)

Table 6. Evidence from secondary and primary data

Key Findings

Emission reduction targets	• Reducing CO_2 emissions by 40% from 1990 levels by 2030 and by 80% by 2050 • The province's climate strategy → in energy production the use of fossil fuels and peat is phased out in products where CO_2 is not captured • The city of Mikkeli's goal is to reduce GHG emissions with at least 30% compared to the 1990 levels by 2020, and 80% by 2050% • On a provincial level the targets are in line with the national ones
RES	• In 2014, 49% of primary energy consumption amount was produced with RES and the provincial energy self-sufficiency was 42%. • The climate strategy of the province states that the share of RE will continue to increase to at least 60% of final energy consumption by 2050 • Cleantech cluster under development • Investments in new technologies and CCS
Electricity production	• The vast majority of electricity and heat are produced with forest fuels, which reduces the need and use of fossil fuels and peat • Some local actors have certain targets, e.g. Savon Voima's goal is to have a fully domestic carbon neutral electricity production by 2020 • One interview's informant noted that their company's electricity production will become more or less emission free
Heat production	• Small shares of peat and oil still used • The use of peat is contradictory, some operators are phasing it out and others think that forbidding peat is contrary to the overall interest of forest industry and the whole country • In district heating production some operators have replaced oil burners with ones that can burn pellets • Some operators' CHP production units can operate completely or mostly on wood chips and the small shares of peat can be reduced by slight changes and eventually phased completely within 20 years
Carbon neutrality	• No set target for carbon neutrality in the province's strategies yet • The goal is to start a carbon neutral South Savo project at the end of 2019. • All interviewed informants believe attaining carbon neutrality in energy production is possible by 2050 the latest
Drivers	• Energy policy tools • Providing sufficient information about the importance of RE • The use of wood energy is encouraged by not to limiting the use of forests • The use of RE needs to be economically profitable • Climate consciousness can guide operators' actions on some level
Barriers & possible challenges	• Economic impacts of carbon neutrality target and energy system transition • Renewal of technology • Question of the role of carbon sinks • Material scarcity if the use of wood energy is restricted in any way

Based on these key findings, the following roadmap scenario for energy transition in South Savo was drafted. This roadmap is presented in Figure 9 below. The contents of the roadmap are estimations of what targets will be met and when, and whether carbon neutrality will be reached on a provincial level. The roadmap also visualizes the drivers and barriers recognized by the interviewees. It must be noted that this roadmap is based on the perspectives of the interviewees, both on their personal views to the topic and the position their employer represents. Thus, this roadmap is a combination of what was learned from the publications and the interviewees' views on the same energy transition's aspects and issues.

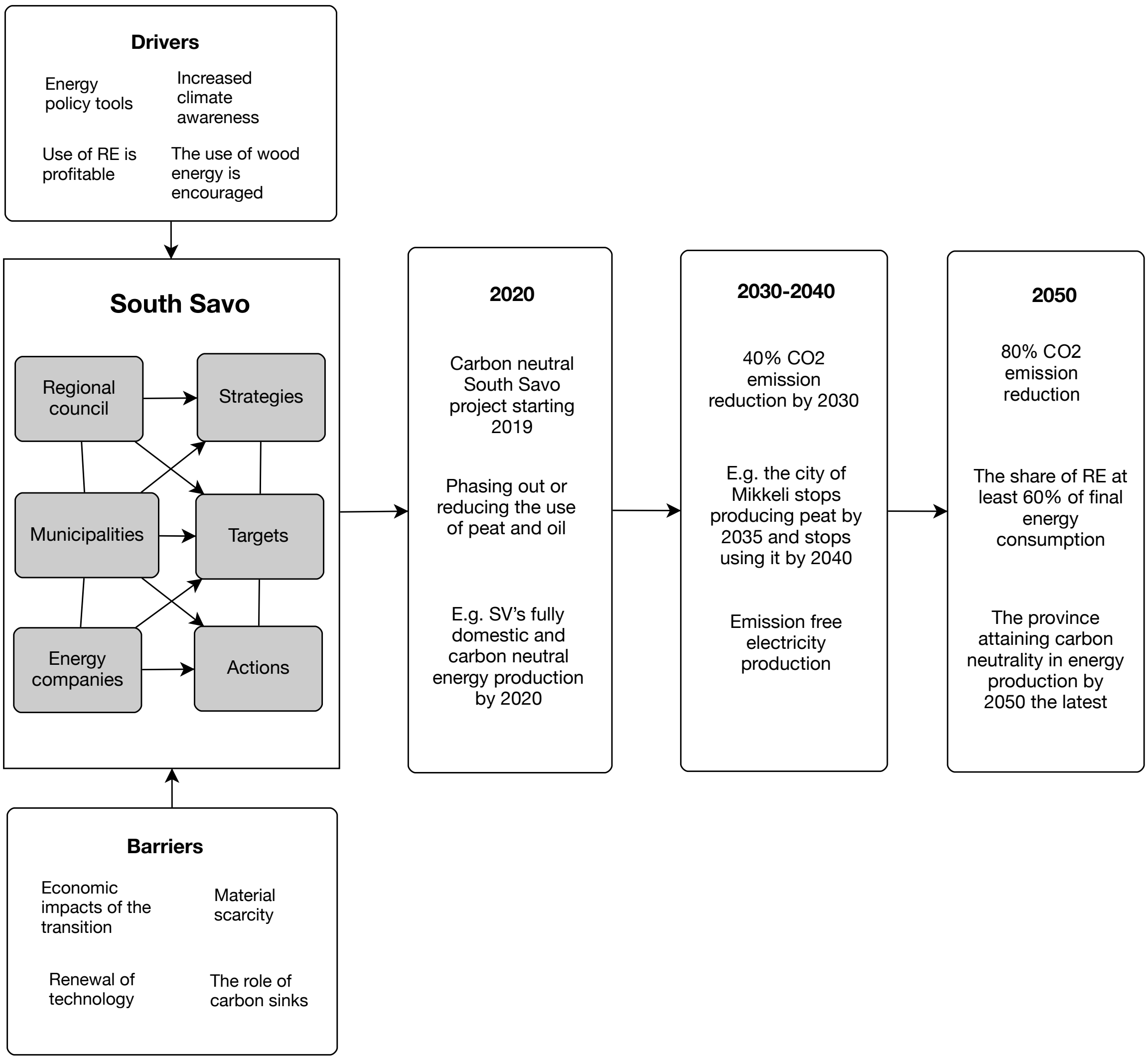

Figure 9. Energy transition scenario for South Savo

5 DISCUSSION

In this chapter the research results are reviewed and reflected to the background literature and to the research framework that was drawn based on the literature review. The chapter also aims to evaluate the meaning of the found results.

5.1 Interpretations of the energy system transition

As it was found in the literature review, the existing energy systems are quite resistant to change (Child & Breyer 2017, 18). The transitions are long-term and it can even take up to 50 years to reach a new dynamically stable equilibrium (Bosman & Rotmans 2016, 3). Energy transition to low-carbon or reaching carbon neutrality requires energy production to shift towards RES-based energy and giving up the use of fossil fuels (Dahal et al. 2017, 2; Knopf et al. 2014, 12). In Finland, the energy system is at crossroads due to an aging power generation system and differing opinions about low-carbon energy production and climate change mitigation (Child et al. 2017, 1). Next, the different aspects of the energy transition are discussed from the perspective of what was found in the literature review, and the results of the two separate analyses.

The energy system transition was reviewed on three different levels in the thesis; the EU level, on governmental level and lastly on the regional level. The regional level was focused on the province of South Savo, which was the focus region of the research. However, the results of the secondary and primary data analyses can also be compared to the EU level and the governmental levels, as it is the energy policies from these higher authorities that guide the transition on a regional level.

In terms of *strategy and targets* and *emission reduction* on the EU level, in RED II, the overall EU target for RES consumption by 2030 is 32% (ICCT 2018, 1-2). The Member States, including Finland, have committed to decreasing their GHG emissions by 80–95% from the 1990 level by 2050, and the intermediate points are 40% by 2030, and 60% by 2040 (Calanter 2018, 131; Pilpola & Lund 2018, 324). The results of the QDA showed that the climate targets in South Savo are on the national target level, 40% reduction by 2030 and 80% reduction by 2050. Still, the 2050 target could be even more ambitious in South Savo as the EU and national level targets aim up to 95% reduction maximum. From the interview results regarding strategies, the interviewees believed that the provincial targets should be in line with the national ones, which they currently are.

In 2010, 81% of total GHG emissions consisted of fuel combustion for energy in Finland, which is the main cause of emissions in the nation (Kallio et al. 2016, 54). For the energy companies operating within the region, there might not be a set target year for completely emission free energy production, but the electricity production will become more or less emission free. Heat production in the region still uses small amounts of peat. However, the results of the QDA and the interviews showed that the province is gradually giving up peat at least in a case if its use is completely forbidden in the future. It is already technically possible to stop using peat, but forbidding it completely might be contrary to the overall interest of Finland and could result in overheating of wood-fuel markets. Thus, giving up peat can be contradictory.

The Paris Agreement is focused on reaching *carbon neutrality* by 2050. Hence, especially forests play a vital role in meeting the climate targets, since they serve as potential sinks in many countries. (Krug 2018, 7) Targets can vary from zero carbon to carbon neutral, and strategies for emission reduction depend on which target is adopted. The target being zero carbon means cutting the emissions completely, when a carbon neutrality target allows for offsetting emissions. (Damsø et al. 2017, 412) In North and South Savo, the provinces' goals are climate change mitigation and reducing GHG emissions, in order to ensure the wellbeing of the citizens and a carbon neutral progression of the society. South Savo is the most forested province in Finland, and its provincial program is committed to sustainable forestry and preserving its natural values. The goal is to start a carbon neutral South Savo project by the end of 2019. All of the interview informants were positive that the province can reach a carbon neutral state in terms of energy production by 2050 the latest. However, it must be noted that there also were raised concerns about the economic impacts that pursuing carbon neutrality can cause, which might be quite heavy. Thus, it can be said that South Savo is making carbon neutrality a target, but when it will be reached and how expensive it will be is to be seen in the coming decades.

When it comes to *RE and implementing RET*, the EU's energy sector will have transition challenges ahead of it due to ageing infrastructure (Fragkos et al. 2017). In Finland the share for RE in energy is already at a relatively good level. While the EU had set the RES target for 38% by 2020 for Finland, the share of RES in gross final energy consumption was 38.7% already in 2016 (Holma et al. 2018; Eurostat 2018). There is an undeniable link between the forestry and energy industry in Finland, as forest industry is accountable of almost 70% of RE produced (Bosman & Rotmans 2016, 7). The role of bioenergy is especially crucial in a forested province such as South Savo, where 47% of the province's heat and power plants' total energy consumption constituted of wood-based energy sources back in 2012 (Mynttinen et al. 2014, 43). The forest resources help improve the self-sufficiency within the region, and in addition implementing RES can help in creating positive socio-economic impacts, such as increased employment.

Previous studies suggested that an energy system based on 100% RE is not only possible but also a cost-competitive option for Finland to achieve by 2050 (Child & Breyer 2016b). On a regional level, the official RES target for 2050 in North and South Savo's climate program is 60% share of RE of final energy consumption. With upcoming new strategies however, this target is likely to change. The cleantech cluster that is currently under development will help creating circular economy and new technologies to South Savo. Investments to RET have been made which include utilization of HPs, solar energy systems and hydropower. Additionally, the share of RET has increased also because of replacing oil and peat with pellet burners and boilers that can operate completely on wood chips. These implementations are actions of local actors, such as cities and energy companies, that help reaching the targets for RE and emission reduction on a provincial level.

When considering the role of forests as *carbon sinks*, it must be remarked that they serve as a significant storage for carbon but they are also a source of carbon. Burning forest fuels causes immediate GHG emissions, and is also a reduction in forest carbon stocks. Nevertheless, these reductions stay temporary provided that the forests are managed in a sustainable manner. (Pilpola & Lund 2018, 324, 325) The RED II sets the sustainability framework for the use of biomass. Harvesting needs to be performed with legal permits and the harvesting levels cannot exceed the growth rate of the forest. (ICCT 2018, 5) In addition, the production of bioenergy should not cause deforestation or loss of biodiversity.

In terms of the interview results, the meaning of carbon sinks was seen as controversial since forests play such a huge role in the energy production in South Savo. However, as one of the informants stated, that if the forest resources do not matter in the most forested part of Finland, then where do they matter. Two out of three interviewees believed that as long as the harvesting of the biomass stays sustainable there should be no limitations to the production. Restricting forestry would likely cause negative effects to the industry. In addition, it can be agreed that importing fuel elsewhere is not sustainable either due to transportation costs and caused emissions, in a case where the use of local forests is restricted. Thus, it can be argued that as long as the harvesting stays sustainable, then the carbon sequestration of the forests is bigger than the reduction in forests' carbon stocks.

When discussing *CCS*, in the literature review of the thesis there were only two mentions in earlier researches about it. So far RES and RET are needed in filling the increasing energy needs, as long as no new low-emission technological breakthroughs such as CCS occur (Child et al. 2017, 17). In the QDA of the publications, no references towards CCS solutions were found. However, the subject of CCS was included under one theme in the interviews, in order to find out whether there already are some existing solutions for CCS within the region that the interviewees were aware of. In terms of CCS, there have been some experiments among the local actors and one bio coal plant where CO2 is captured in the soil. Otherwise no permanent solutions for CCS exist yet, but the interviewees agreed that in the future the meaning of such solutions will most likely take a bigger role in emission reduction.

The role of small producers and *the effect of people's consuming and attitudes* were also regarded. Consumers play a key role in reducing GHG emissions and help mitigating climate change (Claudelin et al. 2017, 10, Dahal et al. 2017, 11). Today, energy consumers contribute to the energy transition as a growing number of private companies and individual households are becoming energy producers themselves (Viholainen et al. 2016). In Finland, particularly HPs have quickly gained popularity (Varho et. al, 2016, 31). The use of such installations can be encouraged by making them more attractive for consumers by using incentives (Zakeri et al. 2015, 253). All the interviewees agreed that consumers can in fact contribute to climate change and the energy system transition, either in a good way or a bad way depending on their consuming choices and attitudes towards these issues. Bad consumerism choices like excessive travelling and dieterial habits contribute to climate change, but on the other hand the raised awareness about global warming and climate change can also guide companies if consumers start demanding cleaner energy solutions.

5.2 Perceived drivers and barriers

Next, the driving forces for the energy transition and its possible barriers are discussed based on the findings of the literature review, and the evidence from the analyses.

Energy systems evolve in response to many different *drivers* (Child and Breyer 2017). For the use and implementation of RE, one of the most important drivers found in the previous studies and based on the interview results, was that it also needs to be economically profitable. Policy and energy policy tools were found as one of the central drivers for investing in RE. Based on the literature review, subsidy systems are a key driver for the implementation RE, especially in the case of wind and solar (Panula-Ontto et al. 2018, 510-511). One of the interviewees believed that financial guidance such as subsidies is an important driver, but another interviewee saw that in terms of forestry, subsidies could even distort the market and that there should be as little additional guidance as possible. Thus, the effect of subsidies as a driver cannot be denied but they might not always work in favor for all the actors in the market. Lastly, the socioeconomic effect of RE implementation is an important driver, since it can increase employment and create positive economic impacts (Okkonen & Lehtonen 2017, 103). As one interviewee saw it, the growing rates of RE elsewhere gives South Savo a huge opportunity for the development of RET and exporting these technologies and local know-how. This gives local actors new business opportunities in developing products that are in demand also outside the region, nationally and even internationally.

In terms of *barriers* for energy system transition, transitions are often faced with political and social challenges (Panula-Ontto et al. 2018, 511). In the literature review it was found that the tendency towards business-as-usual can be seen as a barrier, especially related to forestry which has played a key role throughout history to the present day in Finland (Bosman & Rotmans 2016). However, as the evidence from the QDA and the interviews indicate, in South Savo the province's forest expertise is internationally on the top in fibre and process technology. Local companies have been among the first ones to develop new procedures and devices to use forest energy more efficiently, which have been used even globally. Thereby South Savo can be seen as a forerunner in the industry, so forestry should not be seen as a barrier within the region but more as an asset. However, energy policies related to restricting the use of biomass due to climate goals could turn out to be a big barrier in a forested province such as South Savo. Protecting the biodiversity and demands for bioenergy are often considered to be conflicting, and being able to meet both of these target is a challenge (den Herder et al. 2017, 54). Nonetheless, restricting the use of the most important natural resource of the region could lead into material scarcity and to the need of transporting fuel from elsewhere, which would affect self-sufficiency negatively and cause transportation emissions.

6 CONCLUSIONS

The purpose of this thesis was to present the strategies and actions for attaining carbon neutrality and possibly emission free energy production in South Savo in Finland. This case study was focused on the regional level where the implementation decisions and alternatives of RE take place. The study aimed to answer to a research gap concerning the energy system transition phenomenon in the province of South Savo, by interviewing local actors about their perceptions to the topic, and by evaluating the existing strategies of municipalities and energy companies operating within the region. This chapter will first summarise the findings of the study by providing answers to the research question and the following sub-questions. Next, the theoretical contribution and practical implications this thesis provides are suggested. Lastly, limitations regarding the study are gone through and possible future researches to the topic are proposed.

6.1 Summary of the results

RQ: How does local actors' engagement contribute to pursuing carbon neutrality on a regional level?

The main evidence from the primary and secondary data analyses suggested that energy is mainly produced with forest fuels in the province, which has reduced the need for oil and peat. The role of bioenergy is remarkable, as South Savo is the most forested province in Finland. The province is committed to the sustainable use of these forest resources. In addition, the use of wind energy, solar power, hydropower and geothermal heat are promoted in the province, and energy companies within the region have invested in these RES. For example, investments have been made in the implementation of solar energy systems. There have also been investments in new technologies such as a solar heat pump hybrid, and there is a bio coal factory in operation that contributes to carbon sequestration by storing carbon in the ground. Moreover, there is a cleantech cluster under development in the region, which will create circular economy to the area and give a significant contribution to climate work.

SQ1: What are the perceived driving forces and challenges for low-carbon energy transition?

As it was found in the literature review of this thesis, drivers and barriers related to energy system transitions can be divided in five different perspectives. These include political, social, environmental, economic and technological perspectives. Energy policy tools such as subsidies were found as a strong driver for the implementation of RE. One other important driver suggested was that the use of RE needs to be economically profitable. As for the role of consumers, increased climate consciousness can act as a driver and guide energy operators', such as energy companies', actions on some level. When it comes to barriers and other possible challenges, the cost and viability of the energy system transition is a challenge. If the use of RE is more expensive than fossil fuel alternatives, then big economic impacts of the energy system transition and attaining carbon neutrality could become a barrier for the change to take place. For the region of South Savo, possible challenges are caused if climate targets restrict the use of wood energy in any way, as the area is heavily dependable on its forestry. Restricting the use of the most important natural resource of the region could possibly lead into material scarcity.

SQ2: What are the preconditions of renewable energy on a regional level in South Savo?

In 2014, 49% of primary energy consumption was produced with RES in South Savo. The targets of municipalities and energy companies are in line with the climate strategy of North and South Savo, which states that the share of RE will continue to increase to at least 60% of final energy consumption by 2050. In heat production, small shares of peat and oil are still used. However, their use has been reduced by replacing old units and burners with ones that can operate completely on wood chips or pellets. In terms of electricity production, it is likely to become more or less emission free and carbon neutral. There is also utilization of HPs, solar energy systems and hydropower within the region. In addition, there are currently a few biogas plants in operation and one under construction.

SQ3: How are the local actors planning to further reduce their emissions?

The province is committed to reducing CO_2 emissions by 40% by 2030 and by 80% by 2050, compared to the 1990 levels. Thus, the emission reduction goals are in line with the national ones. There currently are no existing targets for completely emission free energy production, but the climate strategy of North and South Savo states that in energy production the use of fossil fuels and peat is phased out in products where CO_2 is not captured. The municipalities and energy companies are further reducing their emissions by reducing the share of peat, or possibly giving it up completely. In terms of carbon neutrality, the goal is to start a carbon neutral South Savo project by the end of year 2019. All of the interviewees were positive that it is possible to attain a carbon neutral state in energy production by 2050 the latest.

6.2 Theoretical contribution and practical implications

The thesis contributes to the debate about ongoing changes in energy system by focusing on the energy transition phenomenon on a regional level. The theoretical research framework created in this thesis indicates the process of the low-carbon energy system transition from the EU level to a national level and onwards to a regional level, where the implementation decisions of RE take place. The study gives insight to the current state of energy and climate affairs in the case region, and enlightens the perceptions of the local actors towards the transition phenomenon and how they can contribute in reaching the set targets.

Moreover, the research contributes to finding out the driving forces and possible barriers for the energy system transition. This was reviewed both from a theoretical perspective by studying previous researches about the topic, and from an empirical perspective by examining what these perceived drivers and barriers are for the local actors within the region.

As for practical implications, the thesis brought together the climate and energy strategies and actions from the municipalities and energy companies in South Savo, in order to draw a roadmap of the direction the province is currently going with its energy transition. This gives practical knowledge to the regional council and other local actors, as the evidence from the QDA and the interviews was used to form this roadmap and show the development of the region as a whole for coming decades.

6.3 Limitations and future researches

As for limitations, the biggest one was related to logistics and location, as the writer of this thesis lived elsewhere than the subject region of the study. Hence, due to long distances and limited time frame and budget, it was necessary to conduct the semi-structured interviews via telephone instead of face-to-face encounters with the interviewees. In terms of the chosen experts for the interview, the author was given a choice to pick a few representatives out of a list of experts who worked for different actors within the region. The interviewees were chosen so that the representativeness of the whole region would be presented in a best possible way with a respectively small sample size.

The small sample size was a limitation for the study, as in only a limited number of interviews could be conducted. Therefore, future studies regarding the same topic and the same region could be executed by providing a larger sample of interviews, in order to get more insight to the results. The thesis did not aim to affirm whether the plans for emission reductions and implementing renewable energy will be realized, since they are part of longer term strategies that will take time to be executed. Thus, future studies could therefore take into account the results of this research and study whether the plans were executed and set targets met.

This thesis also included the perspective of driving forces and barriers for the low-carbon energy transition. The most important drivers and barriers concerning the phenomenon were identified both in the literature review and by the interviewees, but the study could not include ways to overcome these barriers and possible future challenges. Hence, future studies to the topic could include the aspect of overcoming these barriers and challenges ahead.

As for possible bias, it must be noted that the publications used for secondary data analysis were mostly made and published by the local actors themselves. As the case study relies upon this collected secondary data of the case area and the interview results, it is possible that some bias has occurred in them. However, it must be noted that in this qualitative case study aimed to examine the local actors' perceptions about the energy transition phenomenon. Thus, the evidence includes individual perspectives of the experts that were interviewed, which gave valuable knowledge about the prevailing opinions towards the phenomenon.

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APPENDICES

APPENDIX 1: Semi-structured interview guide in Finnish

Teema 1: Johdantokysymykset alueen toimijan sitoutuneisuuden arviointiin

- Kertoisitteko lyhyesti työnkuvastanne?
- Voitteko kuvailla kuntanne/yrityksenne strategiaa kasvihuonekaasupäästöjen vähentämiseen liittyen?
- Voitteko kuvailla toimenpiteitä, joilla olette pyrkineet vähentämään päästöjä?

Teema 2: Tavoitetila

- Onko teillä jonkin tietyn ajankohdan tavoite saavuttaa täysin päästötön energiantuotanto? (esim. 2030, 2040 tai 2050)
- Mitä teidän tulee vielä tehdä päästäksenne haluttuun tavoitteeseen?
- Onko mielestänne mahdollista saavuttaa hiilineutraalius maakuntatasolla Etelä-Savossa viimeistään vuoteen 2050 mennessä?

Teema 3: Toteutusvaihtoehdot

- Oletteko investoineet uusiutuvaan energiaan, jolla korvata fossiilisten polttoaineiden käyttöä?
- Oletteko investoineet uusiin teknologioihin?
- Oletteko harkinneet muita keinoja, kuten hiilen talteenottoa ja varastointia?
- Mikä merkitys Etelä-Savon metsien hiilivarastoilla eli hiilinieluilla on?

Teema 4: Edistävät tekijät ja mahdolliset esteet

- Mitkä ovat mielestäsi tärkeimpiä uusiutuvan energian käyttöä edistäviä tekijöitä? (esim. lainsäädäntö)
- Kuvailkaa mahdollisia haasteita, joita EU:n ja valtion ilmastotavoitteet asettavat yrityksellenne/kunnalle?

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- Mikä rooli ihmisten kulutustottumuksilla, arvoilla ja asenteilla mielestänne on tavoitteiden toteutumisen kannalta?
- Mitä haasteita tai esteitä täysin päästöttömään energiatuotantoon siirtyminen mahdollisesti tuo esille?

APPENDIX 2: Semi-structured interview guide in English

Theme 1: Introductory questions for estimating the level of commitment of the local actor

- Could you shortly tell about your job description?
- Could you describe your company's/municipality's strategy for GHG emission reduction?
- Could you describe the actions taken in order to reduce emissions?

Theme 2: Target state

- Do you have a certain time frame for attaining completely emission free energy production? (e.g. 2030, 2040 tai 2050)
- What still needs to be done in order to reach the target?
- Do you believe it is possible to achieve carbon neutrality at provincial level in South Savo by 2050 the latest?

Theme 3: Implementation options

- Have you invested in renewable energy that can replace the use of fossil fuels?
- Have you invested in new technologies?
- Have you considered other options such as carbon capture and storage?
- What is the meaning of the forest carbon storages in South Savo, also known as carbon sinks?

Theme 4: Drivers and possible barriers

- What do you consider as the most important drivers for the use of renewable energy? (e.g. legislation)
- Describe possible challenges that the EU's and the government's climate targets set for your company/municipality?
- What is the meaning of people's consumer habits, values and attitudes in terms of the realization of set targets?
- What other challenges might come up in the transition to emission free energy production?