HEATING SYSTEMS OF DETACHED HOUSES IN FINLAND- A REVIEW TO HOUSE OWNERS' PLANS, ATTITUDES AND VALUES

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ABSTRACT

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Abstract

Most of temperature rising greenhouse gas emissions are originated from energy and an important part of tackling climate change is a transition from fossil energy sources to renewable energy. Beside European Union, Finland has ambitious targets to decrease the GHG-emissions and improving buildings energy efficiency has important role in reaching the goals. There are more than one million residential detached or semi-detached houses in Finland, and small house living has been traditionally very popular mode of living in Finland. Due to long and cold winters, the heating of buildings is consuming a large share of a buildings' total energy demand. Heating of houses have also become more an economical issue due to increased energy costs. Historically high electricity prices hit the market in the late 2022's, causing an unexperienced energy crisis in Finland.

The aim of the study was to investigate house owners plans to change or update their heating system, to find out does the heating system effect on house value from house owner's perspective, to examine attitudes towards tightening energy efficiency requirements and the statutory energy performance certificate EPC, that provides information about the energy efficiency of the house, and to find out how much the environmental friendliness of the heating system weights in relation to the costs. Quantitative research was carried out by using a web-based questionnaire to collect the data. The results of the study showed that a significant part of house owners did consider changing or updating the heating system of their house to more energy efficient system. For the most house owners, the costs were the most important driver and the environmental aspects played less important role. Even there were many negative tones towards EPC amongst the house owners, it was widely agreed that the type of heating system does have strong effect on house value. As a conclusion, speeding up the change to update the heating systems to more energy efficient and environmentally friendly systems, it could be emphasized more as a value adding long-term investment, instead of a plain direct cost, to activate the house owners to change or update the heating systems of their houses.

Key words
Detached house, heating system, energy efficiency, house value

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Tiivistelmä

Suurin osa ilmastoa lämmittävistä kasvihuonekaasupäästöistä on lähtöisin energiasta ja tärkeä osa ilmastonmuutoksen torjuntaa on siirtyminen perinteisistä fossiilisista energialähteistä uusiutuvaan energiaan. Osana Euroopan Unionia Suomella on tavoitteita vähentää kasvihuonekaasupäästöjä ja rakennusten energiatehokkuuden parantamisella on tärkeä rooli tavoitteiden saavuttamiseksi. Suomessa on yli miljoona vakituisessa asumiskäytössä olevaa omakoti- tai paritaloa, ja pientaloasuminen on ollut perinteisesti suosittu asumismuoto Suomessa. Pitkien ja kylmien talvien takia omakotitalojen lämmittäminen kuluttaa suurimman osan talojen energian kokonaiskulutuksesta. Talojen lämmittämisestä on tullut myös enenevissä määrin taloudellinen kysymys kohonneiden energian hintojen takia. Vuoden 2022 loppupuolella sähkön hinta nousi erittäin korkeaksi aiheuttaen Suomessa energiakriisin.
Tutkimuksen tavoitteena oli kartoittaa omakotitalon omistajien suunnitelmia lämmitysjärjestelmän vaihtamiseen, näkemyksiä lämmitysjärjestelmän vaikutuksesta talon arvoon ja selvittää miten talonomistajat asennoituvat kiristyviin energiatehokkuusvaatimuksiin, talon energiatehokkuudesta kertovaan lakisääteiseen energiatodistukseen ja selvittää kuinka paljon lämmitysjärjestelmän ympäristöystävällisyys merkitsee suhteessa kustannuksiin. Tutkimuksessa käytettiin internet- pohjaista kyselyä vastauksien keräämiseen. Tutkimuksen tulokset osoittivat, että merkittävällä osalla talonomistajista oli suunnitelmia vaihtaa tai päivittää talonsa lämmitysjärjestelmää energiatehokkaampaan järjestelmään. Kustannukset olivat tärkein ajuri muutokselle, kun taas lämmitysmuodon ympäristöystävällisyyttä ei pidetty yhtä tärkeänä. Vaikka energiatodistusta kohtaan ilmeni paljon negatiivista asennetta talonomistajien keskuudessa, laaja yksimielisyys oli siitä, että lämmitysjärjestelmällä on suuri vaikutus talon arvoon. Lopuksi voidaan todeta, että lämmitysjärjestelmän vaihtamista energiatehokkaampaan ja ympäristöystävällisempään järjestelmään olisi hyvä korostaa arvoa lisäävänä pitkän ajan investointina, eikä suorana kuluna, jotta talon omistajia saataisiin aktivoitua lämmitysjärjestelmänsä uusimiseen energiatehokkaampaan järjestelmään.

Asiasanat
Omakotitalo, lämmitysjärjestelmä, energiatehokkuus, talon arvo

Säilytyspaikka
Jyväskylän Yliopiston kirjasto

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1 INTRODUCTION

Living in a "omakotitalo" has been a traditionally popular way of living in Finland. Heating houses during long and cold winters is causing remarkable costs to the house owners and producing environmental impacts, due to high energy consumption of heating. Tackling the climate change is one of the major issues of our time that needs to be solved. Due to rapid economic growth starting from the late 1700's, burning fossil fuels has increased carbon dioxide (CO^2) emissions into the atmosphere and it has led to global warming. To cut the greenhouse gas emissions, it is important to invest on technological energy transition from fossil fuels to renewable energy sources. (Sachs, 2020, p. 184 &187). Two- thirds of temperature rising greenhouse gas emissions originates from energy, so the climate change is largely a global energy challenge. To achieve the goal of net- zero level within the next few decades, the new technological innovations are needed to improve energy efficiency to avoid the harm it causes in the atmosphere. (IPCC, 2020). The European Union is strongly committed to fight against climate change and has set ambitious targets, that all the EU countries must follow. The Council of the European Union has set a green deal strategy that aims EU to reach climate neutrality by 2050. Energy efficiency of buildings is an important part of the plan to reach that goal of climate neutrality. The use of renewable energy helps to decrease CO^2 - emissions and speed up detaching from harmful fossil energy. (European Council, 2023).

There are more than a million detached or semi-detached houses in Finland (Statistics Finland, 2022). Due to cold and long winters in Finland, heating the buildings, including heating the using water, is consuming remarkable amount of energy. Approximately 75% of the total energy consumption of detached houses is due to heating and heating the water, dividing into heating 50% and heating the water 20%. (Vattenfall, 2023). Switching to more energy efficient heating systems is highly essential, to improve the energy efficiency and energy economy, and to minimize the environmental impacts. Traditionally, the houses in Finland have been heated with direct electricity, oil, and wood. Nowadays, the renewable energy sources are taking over the field and becoming more common in the heating of detached houses. The ground source heat pumps have become the most popular heating system in new construction, and air heat pumps have become more popular, mostly used as an additive heating system in cold climate country. The change actualizes through new construction and repair construction. (Rouhiainen, 2018).

The basic aim of this Master's Thesis was to investigate detached house owners plans, attitudes and values regarding detached house's heating systems. The purpose of the study is to produce information that can be possibly utilized for further examination or for encouraging house owners to change their house's heating system to more environmentally friendly and energy efficientsystem, and to get benefit in the form of reduced heating costs or possibly in the value of the house.

The previous research has made findings that energy efficient heating systems have often positive impact on housing prices, as well as some studies have found out that good energy performance certificate rating has an upward effect on price. There are also contradictory results from studies depending on country and context of the study. Studies conducted in different countries cannot be directly compared to each other because the climate conditions vary and depending on that, a different amount of energy can be used either for heating or cooling, which in turn directly affects the costs.

The study carried by Qiu, Wang & Wang (2017) in United States Arizona 2014, revealed that installed solar panels with electricity generating solar systems had a positive impact on housing prices offering a price premium of 17 %. Another study from United States examined housing price change after an air source heat pump (ASHP) adoption across 23 states. It was found out that ASHP adoption offered a price premium of 4,3- 7,1% on average and the price premiums were bigger than installation costs. (Xingchi, Liu, Lucy, Patwardhan & Parth, 2021). The study in Belgium 2016-2021 found out that energy efficient properties create price premium and the higher the energy performance certificate rating was, the higher was price premium. (Gerassimenko, Defau & De Moor, 2023). The research carried out in Spain investigated the impact of energy certification on the asking price of housing in Alicante real estate market. Homes with the best energy ratings (A and B) were not sold at higher prices than homes with lower ratings. The results of study were contradictory to results found in Belgium. (Cespedes-Lopez, Mora-Garcia, Perez-Sanchez & Marti-Ciriquian, 2020). Taruttis & Weber (2022) studied the impact of energy efficiency on detached houses' housing prices in Germany collecting data from 2014 to 2018. The study found out that energy efficient houses were sold at a price premium and the asking prices of energy efficient houses were also higher.

A methodological literature review of European peer-reviewed studies concerning buildings energy efficiency and green attributes effect on housing prices published in 2016- 2021, concludes that the energy efficiency may influence on housing prices but the impact of energy performance certificate and green attributes on housing prices are varying, and the results are sometimes contradictory. (Fregonara & Rubino, 2021). In Finland, the latest research has discovered that ground source heat pumps increased the housing price of detached houses approximately 5,3% compared to houses with some other heating system, which is a statistically significant result. The data for the research was collected in Finland from years 1999- 2018. The study also found out that the housing prices increased more in the Helsinki metropolitan area, where the houses are more expensive. (Vimpari, 2023).

The data for this research was collected by an e-mail survey, using the Webropol survey platform. The research is defined as quantitative research with few open-ended qualitative questions that offered an opportunity to express thoughts in own words. The survey was sent to 163 private detached house owners living in Finland, using the real estate company's existing customer register. Most of the house owners lived in the Uusimaa area. The survey was active from

8th of June 2023 to 15th of June 2023. Total 96 answers were received and participating to research was active, 59 % of recipients replied to the survey. The questionnaire consisted of six compulsory background questions and 15 actual survey questions, of which 11 were compulsory to answer.

The study aims to find answers to the following research questions:

1. Has the rising energy prices and energy crisis in late 2022s effected on house owners' plans to change or update the heating system of their own house? How much do the environmental values weigh in heating system selection from the house owners' perspective?

2. What kind of attitudes the detached house owners have towards the Energy Performance Certificate (EPC), a statutory tool for measuring buildings energy efficiency?

3. Does the heating system effect on the house value from the house owners' perspective? What kind of future visions the house owners have?

4. What kind of attitudes the house owners have towards tightening energy efficiency requirements?

The thesis starts from the chapter 2 "*From fossils to renewable energy*" providing a general review to energy and electricity production and consumption and its environmental impacts and giving an overview what is the current stage of the global energy transition, starting with the global perspective and comparing it to situation in Finland. Thereafter the EU's targets to improve buildings energy efficiency, as a part of larger scale Green Deal- policy to tackle climate change challenge, are presented as well as the special tool for evaluating and comparing the building's energy efficiency, Energy Performance Certificate, is introduced. The chapter ends with summarizing the development of energy and electricity prices in Finland during the last decades.

The chapter 3, "*Heating systems of detached houses*" presents the existing detached housing stock in Finland and explains the ongoing transition from traditional heating systems based on fossil fuels to new technology heating systems, including different types of heat pumps and solar heating.

The fourth chapter "*Energy efficiency and its effects on house value*" provides an overview to the previous research and literature related to topic, aiming to investigate does the energy efficiency, heating systems and energy performance certificate rating have effect on house value according to previous findings. Under review were peer-reviewed studies from different countries all over the world and studies that have been made particularly in Finland.

The *Research methodology* is explained in the chapter 5, including describing the aims of the research, research method selection, research participant selection, data collection method, sampling, questionnaire, survey questions and methods of analysing the data.

The *Results of the research* are presented in the chapter 6, followed by the *Analysis and discussion* in the chapter 7, answering to the research questions, and discussing about the possible future research related to the topic. The results in chapter 6 and analysis and discussion in chapter 7 are presented in the same order. The thesis ends with summarizing the results of the study in *conclusions.*

2 FROM FOSSILS TO RENEWABLE ENERGY

The chapter 2 provides a theoretical framework to the topic. Starting from a paragraph *2.1, "Energy and electricity- from global to Finland",* with general introduction to global energy and electricity production and consumption. Alongside the global view, the situation in Finland will be presented in comparison. The paragraph *2.2, "EU and Finland- improving buildings energy efficiency",* provides a view to the existing residential building stock in Europe, explains the environmental effects of residential buildings and outlines the European Union's ambitious targets to tackle the climate change and decreasing greenhouse gas emissions. The paragraph *2.3, "Energy Performance Certificate EPC",* introduces the tool for measuring building's energy efficiency, the Energy Performance Certificate EPC. The last paragraph *2.4, "Rising energy prices",* explains the development of energy and electricity prices in Finland.

2.1 Energy and electricity- from global to Finland

Climate change is one of the major environmental and societal issues of our time. It is one of the emerging global risks, causing environmental crisis which is originally caused by last two hundred years of rapid economic growth. Carbon dioxide (CO^2) emissions by burning fossil fuels has led to global warming, emitting heat-absorbing greenhouse gases into the atmosphere. New technological innovations offer a possibility to shift from using of fossil fuels to renewable energy, for example wind, solar, hydro, and geothermal, to lower the human impact and produce less green-house gas emissions. Another opportunity to reduce the energy demand, for heating and cooling, is an improving building design, that can help to cut emissions also. (Sachs, 2020, p, 184, 187, 188).

The continuous population growth leads to higher demand of residential dwellings and commercial floor space worldwide. It has been forecasted that the building construction sector will grow 85 % worldwide by 2030, of which China, USA and India would account for 57 %. The building sector consumes approximately 40 % of total global energy production. The energy consumption in buildings is predicted to grow in the future, due to demand for building infrastructure. As the building sector is one of the most energy consuming sectors, it is also one of the sectors emitting most harmful greenhouse gases. The building sector has enormous opportunities for energy conservation, and to make the building sector sustainable it is essential to support the development of energy-efficient buildings and green building rating systems. (Singh & Kishore, 2020, p. 3-7, 26).

Environmental scientist Bjorn Lomborg brings forth a dilemma between globally growing GDP (gross domestic product) and increasing carbon dioxide emissions. The global GDP at current prices has grown from 12 554 billion US

dollars (1985) to estimated 105 000 billion dollars in 2023 (Statista, 2024). It is supposed that the GDP will grow around the world in the coming decades. Better economic circumstances cause lots of positive impacts, and growing incomes lead to better environmental conditions, as people start to give more value on environmental issues. But, in addition to that, growing GDP is also increasing carbon dioxide emissions and create more warming. Finding a right balance between these two sectors is essential for well-being in the future. (Lomborg, 2021, p, 45, 46).

Carbon dioxide emissions, caused by using coal and gas, have increased remarkably, almost tripled in the last half century. Total amount of carbon dioxide in the atmosphere has increased 40% since 1750. (Lomborg, 2021, p. 39). Climate change is largely a global energy challenge, because two-thirds of temperature rising greenhouse gas emissions originates from energy. To reach the net-zero level required by IPCC analysis within the next few decades, technological innovations are needed to improve energy efficiency to switch heating buildings using low-carbon electricity sources, powering vehicles, using the potential of clean hydrogen, increasing the use of sustainable bioenergy, and utilizing carbon dioxide, before it causes harm in the atmosphere. (IPCC, 2020).

The largest amount of world energy comes from fossil fuels; oil, coal, and gas, still account over 80% of global energy consumption (Figure 1). In 2022, approximately 16 % of world energy, consisting of electricity, transport, and heating was from low-carbon sources, including renewable sources and nuclear energy. The share of renewable energy was around 11 %. (Ritchie, H, Roser, M & Rosado, P, 2022).

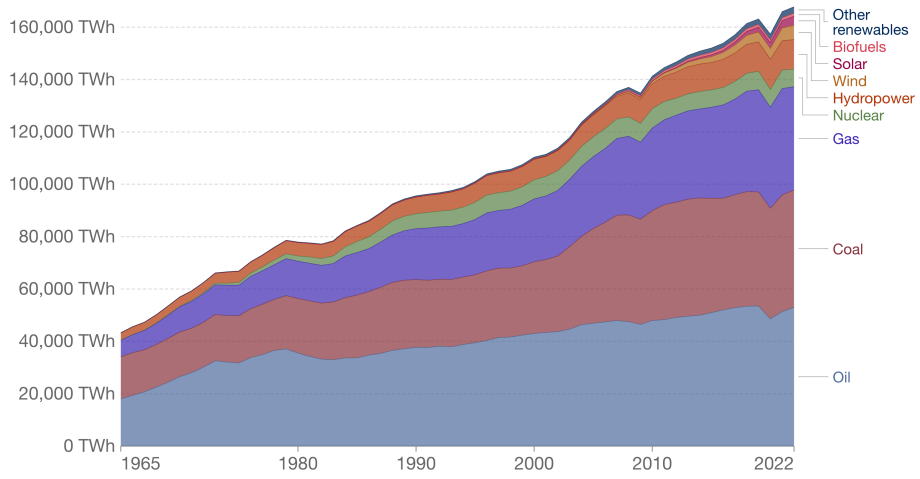

FIGURE 1. Global energy consumption by source 2022. (Energy Institute - Statistical Review of World Energy, 2023).

For comparison to global situation the figure 2 describes how the total energy consumption was divided by source in Finland 2022. The share of renewable energy sources of total consumption was 42 %, and it remained the same as previous year. The total energy consumption was 1,3 million terajoules. (Statistics Finland, 2023a).

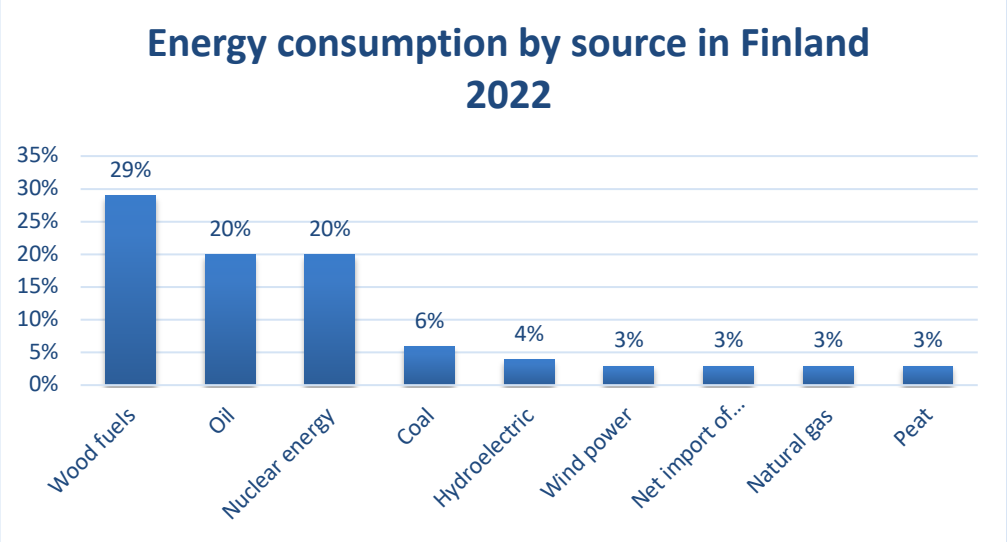

FIGURE 2. Energy consumption by source in Finland 2022. (Statistics Finland, 2023a).

According to IRENA's (International Renewable Energy Agency) statistics, the total amount of generated electricity from renewable sources was 7 858 TWh, that was a 27,8 % share of total electricity generation. The renewable electricity sources were divided to hydro, 55 %, wind energy 23 %, solar energy 13 %, bioenergy 8 % and geothermal energy 1 % (Figure 3). Bioenergy included solid biofuels (70 %), biogas (15 %), renewable municipal waste (14 %) and liquid biofuels (1 %). Between 2020 to 2021, the share of renewable electricity generation increased 5,4 %. Wind and solar energy generation dominate the growth of renewable energy sources. 80 % of renewable growth accounts for wind and solar energy.

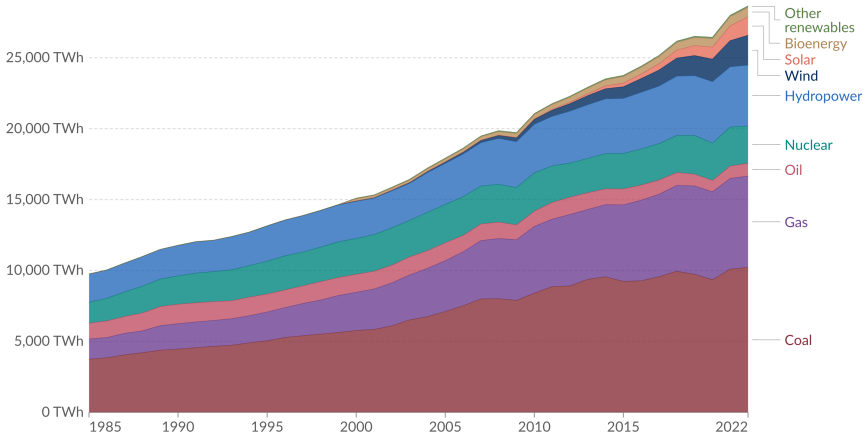

FIGURE 3. Global electricity production by source. (Ember, 2024)

In 2022, the world's energy demand was recovering after COVID-19 pandemic, but the war in Ukraine was affecting to energy sector. In total energy consumption there was 1% increase, about 3% of the level of 2019, before the pandemic. Fossil fuel consumption remained in the same level at 82%, and the renewable

energy consumption reached a level of 7,5%, increasing 1% from the previous year 2021. Total global electricity generation had grown 2,3%in 2022. The dominant fuel for power generation was still coal (35,4% share) but the share of renewable sources, including wind and solar, reached a record high, 12% of total share of power generation. Solar energy recorded a 25% and wind energy 13,5% growth in output. (Energy Institute, 2023). Referring to International Energy Agency IEA (2024) statistics from year 2023, various renewable energy sources in electricity production has increased remarkably in 2023. The production capacity of renewable energy sources increased by 50 % compared to previous year, which means 510 gigawatts increase. Especially, the amount of solar power energy increased, 75 % of the growth in the renewable energy production took place with the contribution of solar energy. The renewable energy production capacity increased most in China.

Figure 4 shows how the electricity consumption divided by source in Finland 2022. The largest share of total electricity consumption came from nuclear power. The share of nuclear production increased due to Olkiluoto 3 power station, which was connected to the national grid in March 2022. Wind power also increased the share of total consumption, there was a 41 % growth from 2022 and wind power covered 14 % of total consumption. (Motiva 2023, Statistics Finland, 2023).

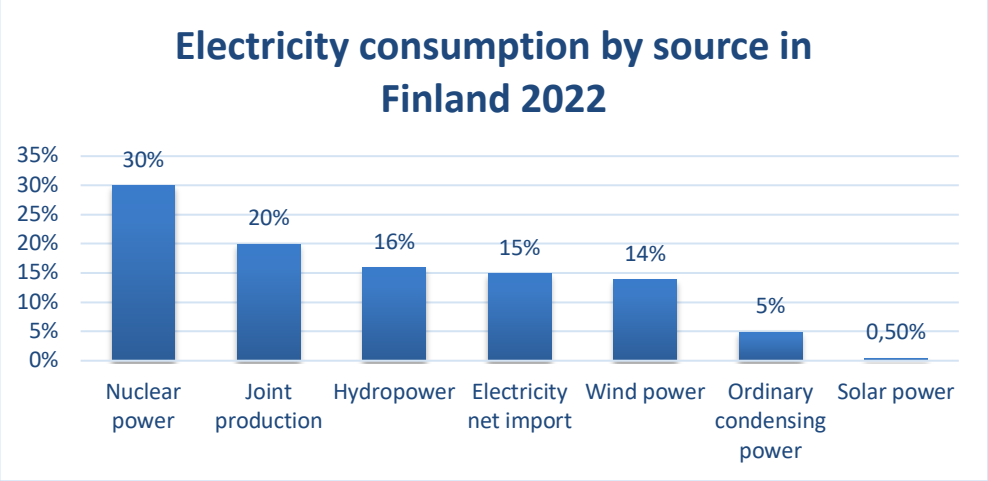

FIGURE 4. Electricity consumption by source in Finland 2022. (Statistics Finland 2023a)

According to Finnish Energy (2024) estimation there has been a significant decrease in the carbon dioxide emissions of electricity production in Finland from 2022 to 2023. (Figure 5). There has been a 38 % decrease from the previous year 2022, 65 % decrease in the last five years, and 87 % decrease since 2010.

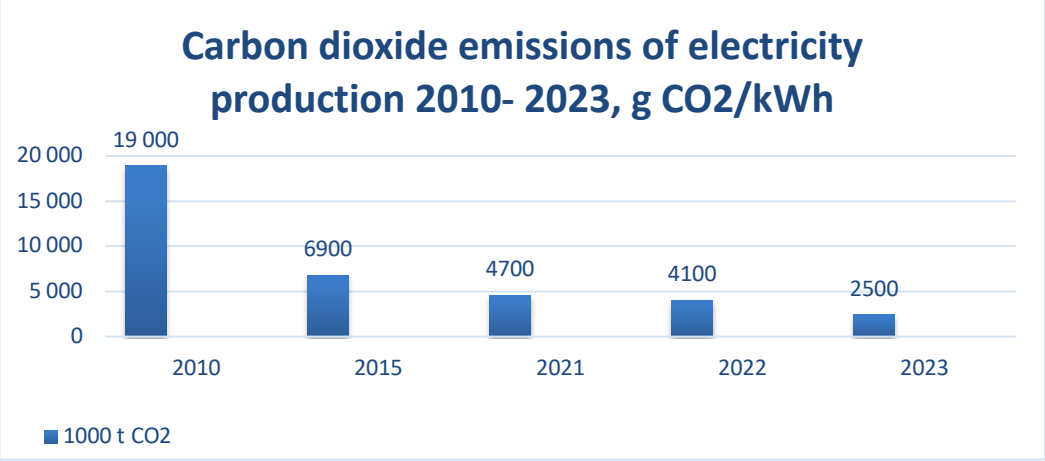

FIGURE 5. Carbon dioxide emissions of electricity production in Finland 2010- 2023 (Finnish Energy, 2024)

The Finnish Innovation Fund, SITRA (2021) has estimated in the report "enabling cost-efficient electrification in Finland" that the widespread electrification of the Finnish economy will increase the need for electricity by more than 20 % of the current level by 2035. And, on the long run, by 2050, the annual electricity consumption in Finland would double from the current level to approximately 170 TWh (terawatt hours). Finland's electricity production capacity should more than triple from the current approximately 20 gigawatts to more than 70 gigawatts by 2050, to respond the growth in consumption.

2.2 EU and Finland- improving buildings' energy efficiency

The existing building stock in Europe is relatively old and slightly renovated. Over 40 % of residential buildings in Europe has been built before the 1960s, when the energy related building regulations were minimal. The oldest building concentration in Europe are in United Kingdom, Sweden, France, Denmark, and Czech Republic. Buildings constructed between 1945 and 1980 have the highest energy consumption. Besides designing and building new energy efficient buildings, it is also important to focus on the high energy consumption of existing older buildings, considering that the average age of buildings in Europe is about 55 years, some being in use already for hundreds of years. (D´Agostino, 2020, p. 193- 194).

According to statistics from 2021, the residential buildings (households) in Europe are estimated to be responsible for approximately 27,9 % of total energy consumption, while the industry accounts for 25,6 %, services 13,8 % and transport 29,2 %. (Eurostat, 2021). The residential building sector accounts for more than a quarter of total consumption and two-thirds of buildings consumption. Space heating is most remarkable building's energy consumer in Europe,

and it accounts for about 70 % building's total consumption. Since 2000, the energy efficiency of residential buildings has improved 1,7 % yearly, mostly due to energy efficiency improvements in space heating. The share of space heating in total consumption of households is constantly decreasing. Since 2008, the household's electricity consumption has been decreasing in most countries due to new technology and diffusion of energy efficient devices. Energy labelling and ecodesign directives have accelerated the energy efficiency of household appliances. Also lightning consumption has been diminishing in half in Europe since 2000, thanks to the diffusion of Compact Fluorescent Lights (CFLs) and Light Emitting Diode (LEDs). (D´Agostino, 2020, p. 181- 185).

The European Union has set an ambitious target to be the first climate-neutral continent and the European Green Deal- policy has been set up to tackle the climate change challenge. (European Commission 2024a). Beside Green Deal, the European Union launched REPowerEU Plan in May 2022, to maintain EU to save energy, accelerate the clean energy transition and to diversify the energy supplies. (European Commission, 2024b). For contributing directly to European Union's energy and climate goals and achieving a decarbonized building stock by 2050 and for improving the energy efficiency of buildings, the EU has established a legislation including The Energy Performance of Buildings Directive EU/2010/31 and the Energy Efficiency Directive EU/2023/1791. As the building sector is the single largest energy consumer in Europe, it has an important role achieving the EU's climate and energy goals. The large majority, around 85 % of buildings in the EU area has been constructed before 2000, and 75 % of those buildings have weak energy performance. The directives are aiming to achieve a highly energy efficient building stock by 2050 and providing consumers and businesses knowledge to save energy and money by making energy efficient choices. (European Commission, 2024c).

In March 2023, the European Parliament approved its position, which aims to reduce energy consumption and GHG- emissions of buildings and increase basic renovations and knowledge about energy efficiency. The directive was amended on a way that energy consumption of building sector would be reduced remarkably by 2030 and the climate neutrality would be achieved by 2050. For residential buildings, the energy efficiency class E should be achieved by 2030 and class D by 2033. To achieve these goals, the member states must prepare their national improvement plans. (European Parliament, 2023). The tripartite negotiations were finished in December 2023, and the new directive will still be approved by the Commission and Parliament in the beginning of 2024. The Energy Efficiency of Buildings Directive is setting targets for the minimum energy efficiency of residential and non-residential buildings and obligates member states to support building owners in financial issues considering energy renovations. Other issues to be considered are setting technical requirements for energy efficiency renovations, setting installation obligations for solar panels, and introducing the life cycle carbon footprint and indoor air of buildings. The member states are required to prepare a national plan, which shows a detailed plan for achieving the set goals. The goal of new directive is to gradually increase the number of buildings to be renovated. The total energy consumption of residential

buildings must be reduced by 16 % by 2030 and 20- 22 % by 2035 from the 2022 level. Continuing from this, energy consumption must be reduced by a specifically defined percentage until carbon neutrality is achieved. There is an option for member states to apply for exemptions for certain types of buildings. (FIGBC, 2023).

In Finland, the new Construction Act, that will replace the previous Land use and Construction Act, will enter into force 1.1.2025. The operating environment of construction has changed strongly during the years and the new Act aims to prevent climate change and support sustainable development in construction sector. EU legislation impacts significantly on the guidance of constructing terms of energy efficiency requirements. (Martinkauppi, K, 2024, p. 1-12). For the new buildings, the new Construction Act is targeting close to zero- energy buildings, referring to a building with very high energy efficiency, and the small amount of needed energy could be produced with renewable energy sources. When starting a new construction project or large-scale renovation project must be ensured that at least 38 % of calculated purchase energy will be originated from renewable energy sources, if it is feasible technically, functionally, and economically. A large- scale renovation refers to technical renovation whose total costs are more than 25 % of the value of the building, excluding the value of the land. According to new Act, starting a new construction project also requires a compulsory technical, economic, and environmental evaluation of the heating system if the planned system of the new building is a building- specific heating system that is based on fossil fuels. Evaluation is not needed if the heating system is not based on fossil fuels or if the building does not have any heating system. (Martinkauppi, 2024, p. 92- 99). The energy efficiency requirements according to new Construction Act are not applied with certain exceptions, including for example very small buildings with floor area less than 50 m2, buildings that are used for leisure purpose, temporary buildings, industrial buildings, and protected buildings. Most detached houses in Finland are covered by the new law. Detached houses are using 27 % of building's energy demand and 10 % of the entire country's annual energy consumption. Improving the energy efficiency of detached houses is important for Finland to achieve its energy saving goals. (Martinkauppi, 2024, p. 182- 185).

The house owners have been able to apply financial support for energy renovations in Finland. The Centre for Economic Development, Transport and Environment, ELY, has been allocating financial assistance for detached and semi-detached house owners for remoting the oil heating or gas heating system and replacing it with other forms of heating, excluding heating systems using fossil fuels. Financial support is targeted for residential houses which are used all year round. If oil heating or gas heating is replaced with district heating, ground source heat pump or water source heat pump, the amount of support is 4000 euros, and 2500 euros for other non- fossil heating systems. (ELY, 2024). The Housing Finance and Development Center of Finland, ARA, has been providing financial support for renovation projects that improve the energy efficiency of residential buildings in the years 2020- 2023. The amount of support was based on approved costs of renovation, depending on energy efficiency improvement

which appears in the updated energy performance certificate. (ARA, 2023). In addition to straight financial support of ELY and ARA, the Income Tax Act offers a possibility for household deduction that can be used also for energy renovations, on the condition that no other subsidies have been used. (TVL § 127 a, 2023).

2.3 Energy Performance Certificate EPC

The law for building's Energy Performance Certificate (EPC) has been set in Finland 18.1.2013 (50/2013) and updated in 30.11.2017 (788/2017). The law is aiming at improving the energy efficiency of buildings and increasing the use of renewable energy. The purpose of the law is setting about the building's energy certificate, producing, purchasing, and using the certificate, and the supervision of use and consequences of breaking the regulation. The updated law from 2013 replaced the old law from 2007 (487/2007), which was concerning only buildings which had been built after 1980. The law is based on the Energy Performance of Buildings Directive (EU/2010/31) (European Commission, 2024). The policy is aiming to offer transparency and information to the consumers, and to help in decision- making according to property purchase or rental purposes. The energy performance certificate is a practical tool to compare the energy efficiency of buildings. The owner of property is responsible for supplying the EPC and the EPC must be included in the documentation given to purchasers or renters. The law requires that the certificate must be prepared for new buildings when applying for building permission and for all existing buildings when selling or renting. The EPC is mandatory for all residential buildings, which are over 50 m² of size. For seasonal holiday houses and cottages, it is not required to supply the certificate. The Energy Performance Certificate EPC (Figure 6) will show the energy rating of building, which are classified from class A (best) to class G (worst) and the year as a subscript, the energy efficiency rating is presented with the codes A2018- G2018. The year shows the legislation according to which the certificate was made. (Motiva, 2018, 2022a).

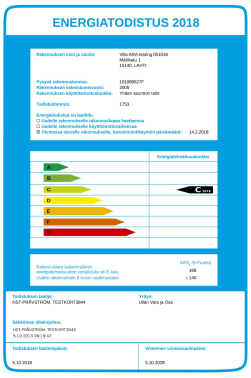

FIGURE 6. The Energy Performance Certificate EPC model. (Energy Certificate Register, 2023a)

As the law for buildings' energy performance certificate was updated in 2017 (Degree of the Goverment 788/2017), and the new regulation entered into force at the beginning of 2018. The numerical values of the coefficients of energy forms used in buildings were updated and the energy certificates before 2018 and from 2018 onwards differ in terms of the calculation bases of the energy categories. When the certificates are renewed with the new regulations 2018 onwards, the energy class of the building may change, even there has not been made any changes to the building. The numerical values of the coefficients of energy forms are 1.2 for direct electricity heating, 0.5 for district heating, 0.28 for district cooling, 1.0 for fossil fuels and 0.5 for renewable fuels used in the building. (Ministry of Environment, 2018). The building's energy efficiency classification is based on certain E-number, which measures the annual purchased energy consumption (electricity, district heating, oil, pellets, etc.) per heated net area (kWh/m²/year) based on the standard use of the building. The coefficients of the energy forms affect the determination of the E-number, so the heating method is an important factor. The rating scale for energy efficiency classes are from A to G, A being the best energy rating and G is the worst (Figure 7). E-number is a calculated benchmark based on technical features of building; mostly of the heating system of house, and other constructional qualities of house that have effect on energy efficiency, including insulation of outer walls and attic floor, windows, and doors (size and tightness), ventilation system, measuring of using water, use of plumbing fixtures and energy efficiency of lightning system and electrical devices. (Motiva 2018, 2022a).

A= > 90
B= 91- 155
C= 156 - 192
D= 193- 272
E= 273- 402
F= 403- 472
G= < 473

FIGURE 7. Rating scale for energy efficiency classes for small buildings. (Energy Certificate Register, 2023a)

Despite the E-number is based on calculated value, the EPC also gives information about the actual purchased energy consumption of the building, if that information is available. Realized energy consumption shows the amount of energy used under prevailing conditions affected by the using habits and activities of the building's users. The EPC also offers recommendations on actions that can be made to improve the building's energy efficiency. The validity time for EPC is ten years. (Motiva 2018, 2022a, 2023c).

2.4 Rising energy prices

The electricity prices reached a new record in Finland, in the last quarter of 2022, and the households paid more for energy than ever before. (Statistics Finland, 2023b). By the end of 2023, an electricity self-sufficiency was reached in Finland, and it means that Finland is producing so much electricity itself that it covers annual consumption. (YLE, 2023). Despite of price statistics on annual bases, new price records were reached again during 2023, and in the beginning of January 2024, the price of stock exchange hit a new record and the cost of electricity was at the highest 2,35 €/kWh and 1,1€ /kWh on average during the day. (YLE, 2024, Keravan Energia, 2024).

The total electricity price consists of three parts; the price of electricity, the price of transmission costs and network service, and the electricity- and value added (VAT) taxes. Electricity transmission costs are 29 % of total price, taxes 31 % and electricity energy 40 %, for household consumers whose annual consumption is from 5000kWh to 15 000kWh, according to statistics in September 2023. The electricity price itself can be tendered out, but the price for transmission is defined by electricity companies. The transmission and network service fee covers the services related to the electricity company's electricity network operations. (Finnish Energy, 2024a&b). For example, in a case of detached house with direct heating, consuming electricity 18 000 kWh/h per year, the total electricity price has increased from 0,09 € kWh/h to 0,15 € kWh/h, from 2008 to 2020. (Statistics Finland, 2020a). The tax-free transfer price of electricity was 5,2 cents/kWh in 2021. Compared to other European countries, the transfer price is less than the average price of all European countries (6,58 cents/kWh). The transfer price was cheapest in North Macedonia (1,98 cents/kWh) and the most expensive in Belgium (10,5 cents/kWh). (Finnish Energy, 2022)

Electricity price statistics from the year 2023, published by Finnish Energy 4.1.2024, reveal that Finland had the second cheapest electricity in Europe in 2023, the electricity was cheaper only in Sweden. As an average of the year, the price for electricity in Finland was 56,5 €/MWh, therefore 0,0565 €/kWh. Ireland had the most expensive electricity, 130€/MWh, and in 11 other countries the price was more than 100€/MWh. In Finland, the electricity price decreased 64 % from the previous year 2022, when it was 164 €/MWh/h (0,164 €/kWh. (Figure 8). Years 2021 (82 €/MWh/h) and 2022 have been the most expensive years, in 2010 the price was 74 MWh/h, related to the consumer price index. From 2011 to 2020, the price was between 33 to 62 MWh/h. (Finnish Energy 2023b&c).

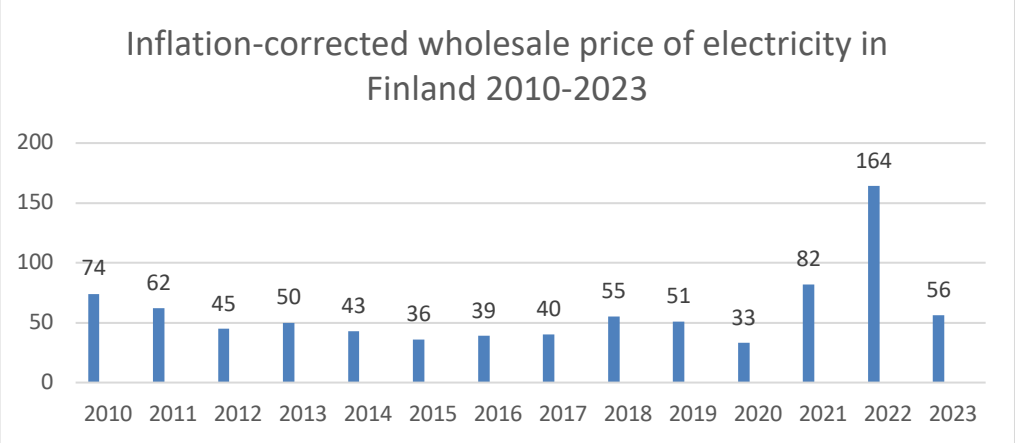

FIGURE 8. Inflation-corrected wholesale price of electricity in Finland 2010- 2023 (Finnish Energy, 2023b)

Own electricity production in Finland has increased and it has helped to separate from the price development of Central Europe. The price of electricity is formed by electricity production, its demand, and international transmission connections. Much- needed basic power was brought by Olkiluoto 3 nuclear power station and there has been a remarkable increase in the supply of wind power that has brought power to production, but also unprecedented effects in the price of electricity. Due to high supply of wind power, it has saturated the market so that the price of electricity has gone negative; there was 467 negative prices during the hours in 2023 (Figure 9). Negative price hours have increased significantly; in 2022, there was 27 and 2021, 5 negative price hours. (Finnish Energy, 2024b&c).

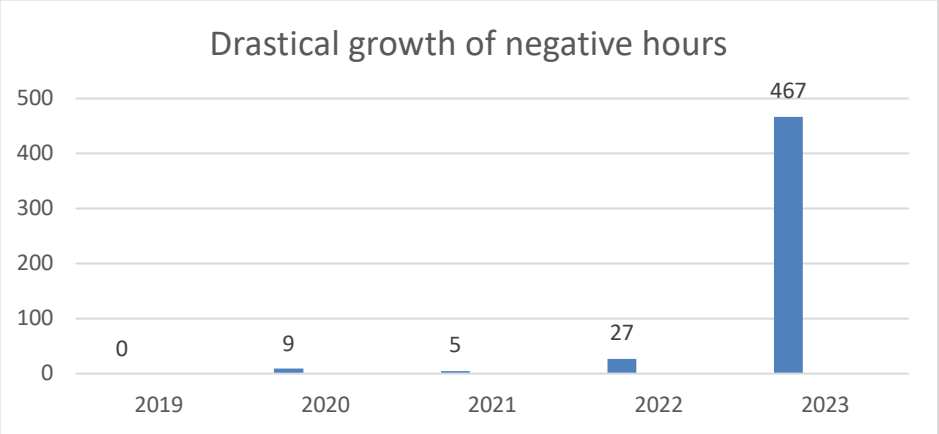

FIGURE 9. Drastical growth of negative electricity price hours (Finnish Energy, 2023b).

Finland belongs to Nord Pool electricity exchange, and the price of electricity is defined and set according to Nord Pool's spot prices. Nord pool is an electricity exchange, which has been operating since 1990s in 16 European countries and it is owned by the Nordic and Baltic grid companies. The purpose of the Nord Pool electricity exchange is to buy and sell electricity across borders and to increase

competition and equalize demand peaks in different countries and areas. (Nordpool, 2024). There are several factors which effect on the price of electricity: supply, demand, and cross-border impacts. Supply related effects are changing expenses of factories, the situation of water reservoirs, sun ja wind conditions and usability of power plants. Demand related effects are weather conditions, time of day or week, activity of industry and quantity of demand elasticities. Border crossing effects are demand and supply in neighboring countries, availability of transmission connections and possible maintenance or failure situations of transmission connections (Finnish Energy, 2023b).

The price of *district heating* consists of three parts: joining fees, power charge and energy fees. The price of electricity depends on the energy company and the energy production method and that is why the price may vary widely. (Motiva, 2022c). The average price for district heating in Finland 2022 was 91,32 €/MWh, including all taxes, power and energy charges, and other annual district heating charges, excluding joining fees. The district heating prices varied from 45 €/MWh to 125 €/MWh between the district heating suppliers. Approximately 75 % of district heating companies provided energy to their customers in the price range 75- 100 €/MWh. Since 1987, the price for district heating has increased steadily, after 2010, the growth has been faster. 1987 the average price for district heating was around 20 €/MWh, reaching 55 €/MWh in 2010. (Finnish Energy, 2023). The market price for *light fuel oil*, which is used for oil-heated houses, has also increased over the time. In 2001, the average consumer price of light fuel oil was around 40 cents/l and in 2023 it was 145 cents/l. The increase from 2003 to 2023 was 105 cents/l, the price has rose by around 263 % in twenty years period. Beside electricity, the price of light fuel oil also hit a new record in 2022, and the price went up to 170 cents/ l. (Statistics Finland, 2023c).

Rising energy prices have created energy poverty, but even the poor people are the most vulnerable to high prices, it also effects on people in the western world; it has been estimated that around two hundred million people suffer from energy poverty, meaning that energy costs are 10% or more of their incomes. (Lomborg, 2021, p, 11, 143, 144). International Energy Agency is estimating that in the United States, 9% of people, 29 million habitants, are energy poor. (IEA, 2017). European Commission estimated in 2019, that approximately 54 million people, 11% of habitants in the EU area may suffer from energy poverty. (European Commission, 2019). Energy efficiency has a straight connection to climate-warming carbon dioxide emissions. Increasing the use of renewable energy sources and reducing energy consumption result to reduction of CO-emissions. Besides that, energy efficient buildings are good for climate, the energy efficient buildings are also good for people. Energy efficiency of buildings reduces the operation costs of buildings and curbs the growth in costs if the price of energy rises, and often improve living comfort. (Ministry of Environment, 2024).

3 HEATING SYSTEMS OF DETACHED HOUSES

The chapter 3 introduces to the existing detached housing stock in Finland and presents the most common heating systems of Finnish detached houses. These heating systems include traditional heating systems, direct electricity, oil, gas, pellets, and wood to modern technology heating systems, including different type of heat pumps and solar heating. The chapter provides a review to development and transition in progress from traditional heating systems to new technology heating systems and summarises the current situation.

The chapter begins from *paragraph 3.1, "Detached houses in Finland"*, with overview to existing detached housing stock in Finland. The paragraph *3.2, "From traditional heating systems to new technology"*, presents the development and the current situation of transition from traditional heating systems to new technology systems. The paragraph *3.3, "Heat pumps"*, continues introducing to different types of heat pumps, including *ground source heat pump (GSHP), water source heat pump (WSHP), exhausted air heat pump (EAHP),* and *air source heat pump (ASHP).* The paragraph *3.4, "Supportive heating systems- wood and solar"*, presents heating systems that are mostly used as supportive heating system, including wood and solar heating.

3.1 Detached houses in Finland

There are over a million detached and semi- detached houses in Finland. Figure 10 shows the existing housing stock in Finland including all age permanently used residential detached and semi-detached houses in Finland. The total amount of houses is divided by a year of construction. (Statistics Finland, 2022). The Finnish housing stock is getting relatively old, only 23 % of houses are built after 2000. The most active times for construction in Finland's history has been after the second world war during the years 1940–1959 and secondly, during the time of economic upturn in years 1980–1989. After the World War II, there was an urgent need for new houses in Finland. A special finnish type of wooden detached house model is called "rintamamiestalo" that was created after the war, to build residents for more than 400 000 Karelian evacuees, for the families of soldiers, and to rebuild the destroyed areas. The "rintamamiestalo" had a certain simple floorplan and it was possible to build by one's own. It was one of the most popular house types and the technical factors made the fast reconstruction possible. In the 1980's during the rapid economic upturn, a record amount, over 200 000 houses were built. The prefabs become more common and that fastened remarkably construction possibilities. The energy efficiency issues were brought to construction in the 1980's. (Löyttyniemi, 2012 & Mölsä, 2016 & Raksystems, 2019).

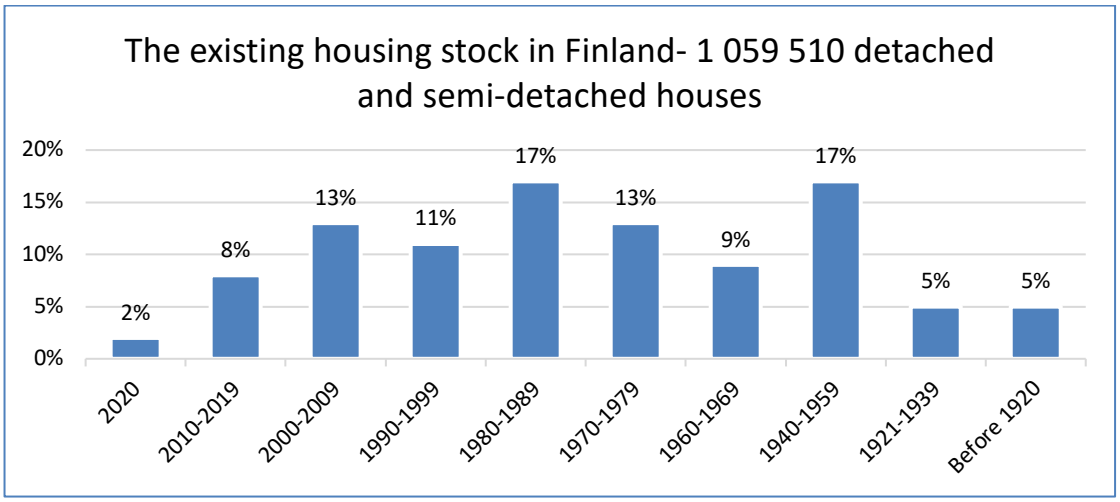

FIGURE 10. Detached and semi-detached houses in Finland, divided by the year of construction. (Statistics Finland, 2022a).

Living is causing around one third (39 %) of Finns greenhouse gas emissions, the food 16 % and transport 19 % and goods and services 26 % (Sitra, 2018). As it can be seen in the figure 11, space heating covers most of the energy consumption of housing, around 64 % of total consumption. Heating of water consumes the second most energy by 17 % share. Electrical devises, heating of saunas, lightning and cooking are sharing the rest 19 % of total consumption, a new led-technology and energy efficient household appliances have decreased the energy consumption during the last years. (Statistics Finland, 2020b).

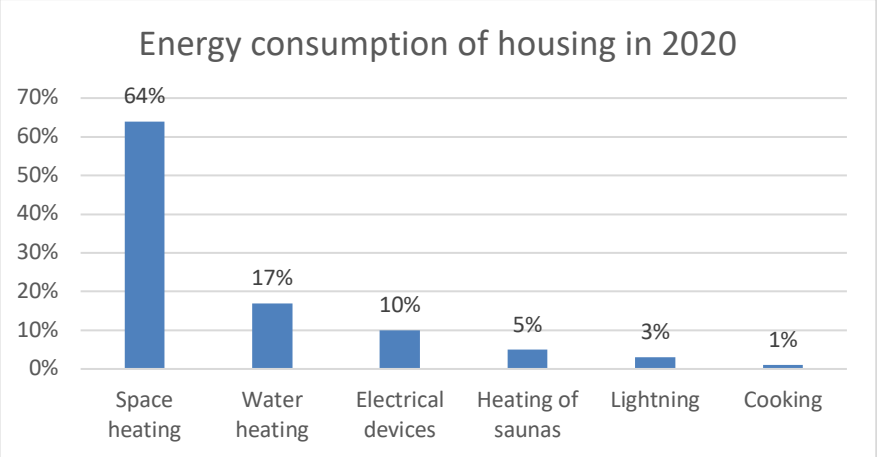

FIGURE 11. Energy consumption of housing in Finland 2020. (Statistics Finland, 2020b).

According to the Finnish Association for Manufacturers of Prefabricated Houses, at today's minimum level built new detached houses are very energy efficient. A new house requires 25 % less heating energy than a house that has been built 20 years ago. Compared to houses built in the 1980s, the need of heating energy has been halved. Energy efficiency requirements for new houses are strict, it is more

difficult for detached houses to get the best energy performance rating of A, compared to bigger dwellings. (PTT, 2023a). The energy performance rating of detached and semi-detached houses built in the years 2020- 2021, 22 % of houses receives the rating A and 76 % receives the rating B. Only 2 % of new houses are placed in the rating C. (Energy Certificate Register, 2023b). The new building, which is meeting the regulations for almost zero-energy construction, will primarily be placed in the category B. The rating and energy class can be improved for example improving thermal insulation, recovering ventilation heat, using renewable energy and in addition, by increasing own energy production with the help of solar panels. (Motiva, 2023c).

3.2 From traditional heating systems to new technology

The most popular traditional heating systems used in detached houses in Finland have been direct electricity heating, district heating and oil heating. Natural gas and pellets have had a minor share. It is notable, that the district heating network is available only on certain population centre areas. As Finland is a sparsely populated country, district heating network does not reach most of the house owners.

According to Statistics Finland (2022) numbers, the transition from using traditional heating systems has become faster during the last decade, the development has fastened especially during the years 2016- 2022. (Figure 12). Especially use of direct electricity and oil have been decreasing. In 2022, 36 % of detached houses were heated with electricity and 10 % with oil. District heating is much more common for heating apartment houses, for detached houses, 7 % were using district heating. Both, *ground source heat pumps (GSHP)* and *air source heat pumps (ASHP)* have become more common as the main heating systems, 15 % of detached houses are using GSHP and 12 % ASHP.

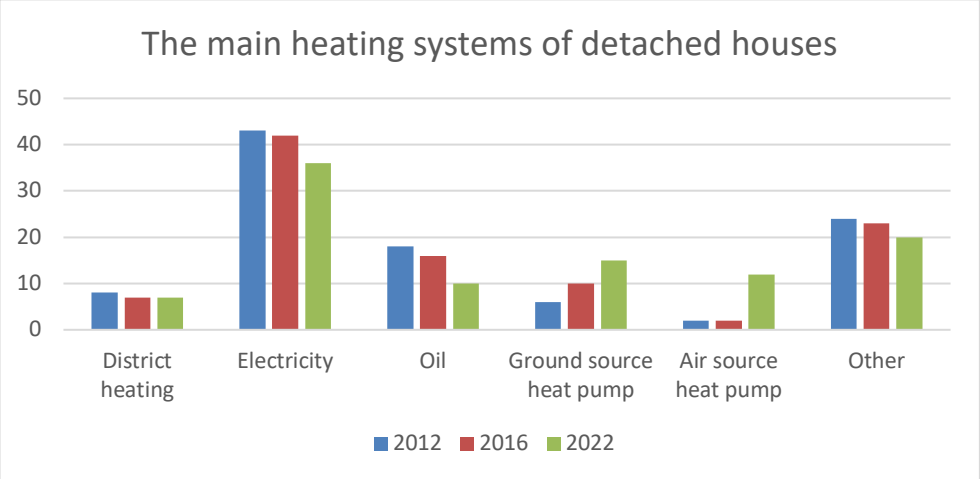

FIGURE 12. The main heating systems of detached houses in Finland from 2012 to 2022. (Statistics Finland, 2022b).

In the houses built in the 1960s and 1970s oil was the most common source of heat, but for the new houses, it is no longer the choice. In the houses of 1980s and 1990s direct electrify heating became the most popular heating method. In the 21st century, different types of heat pumps, especially the ground source heat pumps, have grown the popularity enormously; the GSHP is chosen for every other new detached house. (PTT, 2023b). In the year 2020, over 80 % of new detached houses are heated with some type of heat pump. (Figure 13). Beside the main heating system, the supportive systems are popular in new houses; almost every new house acquires a fireplace and air source heat pumps are popular especially with the electric heating. (PTT, 2023b).

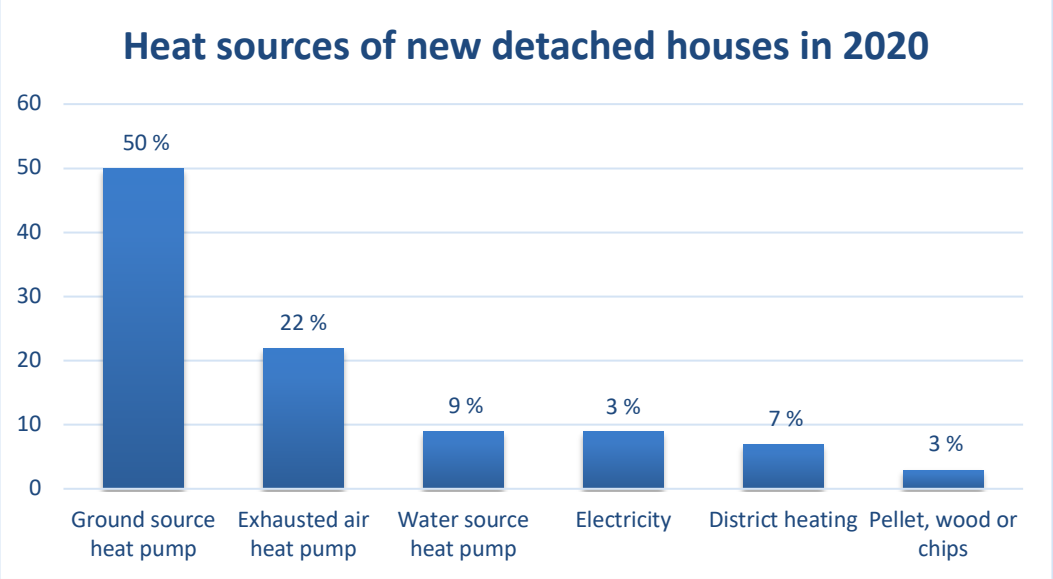

FIGURE 13. Heat sources of new detached houses in 2020. (PTT, 2023b)

3.3 Heat pumps

Heat pump technology is an environmentally friendly and renewable energy technology that helps to improve energy efficiency and to decrease the carbon emissions of buildings. According to European Heat Pump Association, France, Italy, and Spain have a 50% share of sold heat pump units in the European market. Finland, Norway, and Estonia are top seller countries per capita basis. (Valancius, R, Singh, R, Jurelionis, A & Vaiciunas, J, 2019, 51, 52). According to Finnish Heat Pump Association, SULPU, there were over one million heat pumps in Finalnd in 2020, and in 2022, almost 200 000 new heat pumps were sold, that means 50 % growth in sales. There was 60 % growth in sales of air source heat pumps, 60 % growth in water source heat pumps and 20% growth in ground source heat pumps, only the exhausted air heat pumps sales were declining by 20 %. (SULPU, 2023a).

The heat pumps are classified according to its original energy source; the pumps are exploiting renewable heat energy either from the ground, water, or air for the building. There are four types of heat pumps: *the ground source heat pumps (GSHP), water source heat pumps (WSHP), air source heat pumps (ASHP) and exhausted air heat pump (EAHP).* (SULPU, 2023a). The Coefficient of Performance (COP) value describes the amount of transferred heat that electrically- powered heat pump produces compared to the electrical power consumed. The COP value indicates the efficiency of system. The electrically powered heat pumps COP value can be from three to four. (Valancius et all, 2019, 51-55).

The ground source heat pump (GSHP) is a renewable energy system, that is utilizing solar energy stored in the ground. The system needs electricity to deliver heat energy into the water and for circulating hot water in the building system, including heating pipelines and using water. (Janhunen, Vimpari, & Junnila, 2022). GSHP system has higher installation costs due to drilling, but the cost is compensated by a higher performance. Temperature differences between inside and outside does not usually affect very much on GSHP operation, that makes it suitable and effective for cold climate circumstances. The COP value of GSHP can be up to four. (Valancius et all, 2019, 54). The GSHP is suitable for all size of houses, but it is more profitable in the larger houses with larger area to be heated. Installation of GSHP requires a procedure permit, which must be applied from the municipality. GSHP systems may not be installed in the groundwater area. (Motiva, 2023a).

The water source heat pump (WSHP) is using water as a heat source that is brought to the unit. The advantage of WSHP is low installation costs, compared to the GSHPs. On average, the COP value of WSHPs is like GSHPs, at best close to four. (Valancius et all, 2019, 55). When an outside temperature gets down to –15 to -30 degrees Celcius, the heat coefficient and output power will clearly reduce. For backing up the heating system, the electric resistances of the indoor unit of the WSHP are often used. (Motiva, 2023b).

The exhausted air heat pump (EAHP) is collecting heat energy from an exhaust air of the house and transfers the heat to the supply air, reusing energy of waste air. EAHP has lower installation costs than GSHPs and WSHPs and it is most suitable for smaller houses with lower energy need. EAHP system requires another energy source during the cold temperature periods. (SULPU, 2023b). The amount of purchased electrical energy can be reduced by burning wood during the frost periods. A house with a EAHP system does not need a separate ventilation machine or heat recovery device. (Motiva, 2023e).

The air source heat pump (ASHP) is utilising an air as a source for a heat. The COP value of ASHPs is 2.3- 3.5. When the outside temperature gets lower than –10 degrees, the ASHPs are not so efficient than other heat pumps, and it requires some other optional energy source to be used beside the ASHP. That is why ASHPs are mainly used as a supportive heating system in cold climate countries. (Valancius et all, 2019, 54). The first ASHP systems were installed already in 1990s and since then there has been an accelerating growth in installations, with ASHP's heating costs can be reduced by almost half with a relatively small investment. (SULPU, 2023c).

3.4 Supportive heating systems- wood and solar

Supportive heating system means some additional energy source that is used for providing energy beside the major heating system of a house. The most used supportive types of heating in Finland are wood, air source heat pump (ASHP) and solar panels. The air source heat pump was presented above in the paragraph 3.3, beside the other heat pumps.

The small- scale wood burning, using the wood in slices and claps, is the second largest form of use of wood after the industrial use of wood. Wood is used for heating detached houses, large properties, fireplaces, and boilers. Firewood covered 38 per cent of heating of small houses and nearly 40 % of used firewood is birch. The importance and popularity of wood burning has changed over the time, for example in the 1960s when the district heating started to produce energy in large power plants, and in the 1980s when the electric heating began to spread, decreased the small-scale wood burning. In the 21st century, emerging climate change and need to replace fossil fuels with renewable energy, has grown the popularity of wood burning again. (Motiva, 2023d).

According to Natural Resources Institute Finland LUKEs statistics, a total of 6,9 million cubic meters of firewood were used in small houses during the heating season of 2016/2017. The amount of used wood had increased 3 % compared to previous statistical period 2007/2008. 28 % of total wood was burned in the stoves and ovens, 27 % in various clapboard and chip boilers, 19 % in sauna and 14 % in baking ovens. (LUKE, 2023). Referring to Finnish Hearth and Chimney Association, TSY, in Finland, there are more than two million fireplaces in heating use and around 40 % of the heating energy of a small house is achieved from firewood. Approximately 15 terawatt hours (TWh) of energy is produced by this way, that corresponds to the annual production of two nuclear reactors in Olkiluoto. Having a spare fireplace in a small house, up to half of the heating energy can be produced. (TSY, 2023).

The Finnish Environment Institute, SYKE, is bringing up, that even the cheap price of wood and security of supply are the major advantages of wood heating, but it has also ecological disadvantages. Burning fossil and bio-based fuels are generating air pollution emissions and greenhouse gasses, and small-scale burning of wood produces accentuated particle emissions that contain big amounts of black carbon. While the particulate emissions from traffic and industry have decreased due to legislation, small-scale wood burning has become the greatest source of particle emissions and black carbon. (SYKE, 2020).

Use of *solar panels* has increased in Finland enormously during a short period of time since 2015, and solar panels have become more popular supportive heating system for detached houses and leisure cottages. (Energy Authority, 2022). According to Finnish Solar Energy Association, SARY, the largest user of solar energy in Europe is Germany, where almost half of the electricity consumption of the country can be covered by solar electricity. Southern Finland receives sunshine around 1,000 kilowatt hours per square meter per year, that is almost as much as Germany does. In Finland, solar energy should be used in the summer;

water can be heated, and household electricity consumption covered with solar energy. The solar power plant offers the best output in May- June, followed by July- August same amount obtained energy. In March and September, the output is approximately half of the best months yield. (SARY, 2023). Produced solar energy in a detached house can be also connected into the grid and sold out to the electricity company. Only alternating current can be fed into the grid, and the system includes an inverter also. (Motiva, 2022b).

The rapid growth of small-scale solar energy production had led to doubling the capacity in two years. At the end of 2021, approximately 395 megawatts of solar energy production were connected to the electricity grid, there was almost 100 megawatts increase per year. (Figure 14). In 2021, solar energy production was around 0,4 % of Finland's total electricity production. There are approximately 22 megawatts of solar electricity capacity that has not been connected to grid, that has been installed in 55 000 detached houses, and particularly leisure cottages. (Energy Authority, 2022). Roughly 80-90% of solar systems are installed either to detached or semi- detached houses. (PTT, 2023b).

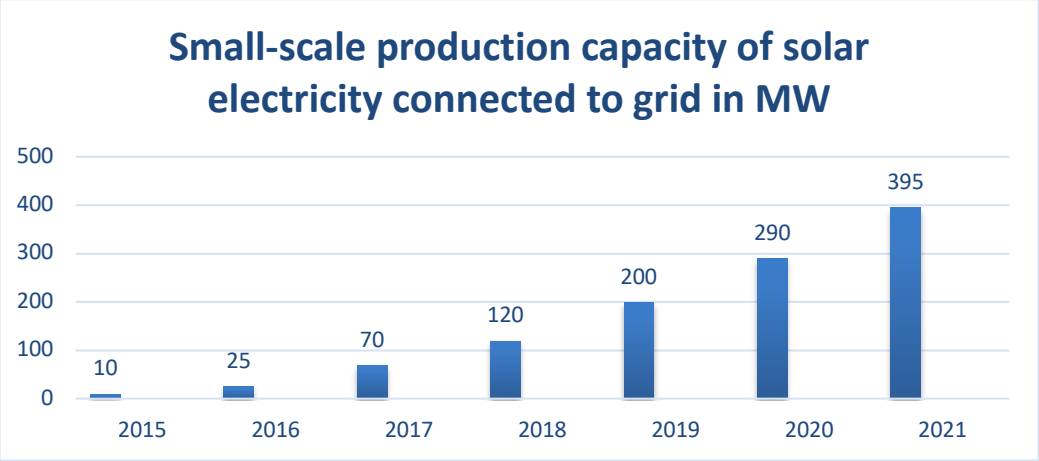

FIGURE 14. Grid- connected small-scale production capacity of solar electricity (Energy Authority, 2022)

4 ENERGY EFFICIENCY AND ITS EFFECTS ON HOUSE VALUE

The chapter 4 provides a review to previous peer-reviewed research related to the topic; examining does the heating system and energy efficiency of residential buildings have effect on housing prices and house value. The literature review is limited to energy efficiency ratings (Energy Performance Certificate and other energy labelling) and heating systems, to find out if these different variables offer any price premium to actualized selling prices. The focus is to review studies from latest few years, as the field is constantly changing, and new energy efficient technology is under fast development. The paragraph *4.1, "Global view"*, provides a review to international studies selected from countries all over the world and the paragraph *4.2, "Finland"*, presents the latest topical findings from Finland.

4.1 Global view

Gerassimenko, Defau & De Moor (2023) examined the impact of energy performance certificates on sales and rental prices, the study was carried out in Belgium Flanders. The data was collected from the years 2016 to 2021. The findings of the research were that energy efficient properties create a price premium, but the premium is much bigger in the sales market than in the rental market. The key finding of the study was that A, B and F- labelled dwellings had a remarkable impact on price, in the sales and rental market both. The higher the EPC label was, the higher was price premium. C and E- labelled dwellings had a relatively small impact on price in both markets. Label D was used as a default category, the labels above D increasing price premium were found, and below label D, increasing price discount was found.

Similar type of research was carried out in Spain few years earlier, with contradictory results than it was found in Belgium. Cespedes-Lopez, Mora-Garcia, Perez-Sanchez & Marti-Ciriquian (2020) investigated the impact of energy certification on the asking price of housing in Spain Alicante real estate market. The study found out that the homes with best energy ratings (A and B) were not sold at higher prices compared to homes with lower ratings (less than B). Several reasons explained the results: the homes without energy qualifications are offered in the market for the same price than homes having high qualifications, there are no sanctions for not publishing the energy qualifications, the owners are not interested in improving energy qualifications, it is not encouraged to improve the energy efficiency of the homes and the general perception of EPC is pretty much negative.

A case study from Sweden analyzed how energy performance certificate presentation and energy consumption (kWh/m2) affected on housing prices, under examination were detached houses in Sweden, in the years 2012- 2018. The result of the study shows that expected energy consumption (kWh/m2) is more informative on predicting the price of property than energy class rating. The finding is suggesting that the buyers and sellers in the housing market are paying more attention and giving value to estimated energy consumption than energy rating itself. The study also revealed that energy consumption affected on housing prices as a primary factor, but for the oldest buildings expected energy consumption played less important role. (Wilhelmsson, 2023).

Zhang, Liu & Wu (2017) made research about China's green labelled housing and investigated if green- labelling had any impact on price premium. Chinese Green Building Label was introduced in 2008, and China was one of the first developing countries that had an official rating system for buildings' sustainability. The data was collected around the country in 2013. The empirical analysis concluded that the green labelled housing attracted a price premium of 6,9 %, compared to non- labelled housing.

The impact of energy efficiency on single-family homes' housing prices was studied also in Germany using a data from 2014 to 2018. The findings of the study confirmed that energy efficient houses were sold at a price premium. Also, a positive relationship was found between the asking prices of houses and energy efficiency; if there was on 100 kWh/m² increase in energy efficiency, the asking prices were 6,9 % higher on average. The impact on housing prices had increased from 2014 to 2018, that were under examination. The study also noticed that the connection between these variables was weaker in the cities and metropolitan areas and stronger in rural areas, which could be possible offset by growing housing scarcity. (Taruttis & Weber, 2022).

Research carried out in Belfast Ireland by McCord M, Davis, McCord, J, Haran & Davison (2020) examined energy performance certificates and the possible connection to housing prices by examining transaction prices. Findings of the study were that housing prices rose significantly only in the top quantile of the price distribution in higher rated properties. Also, a "brown discount" was found for properties with lower EPC ratings within F- and G- rated at the higher quantile of the pricing distribution. The findings of the study highlight that it is difficult to draw generalizations between energy performance and actualized housing prices. The impact of EPC rating to pricing may not be convincing because several studies have failed to establish price premiums connected to EPC ratings. The researchers also point out that early studies have tended to show positive connection and capitalization impacts. Later, it has been observed with improved data and more accurate techniques, that there are several factors, for example nation, region, market, household, and individual behavior that must be considered.

The study performed by Qiu, Wang & Wang (2017) investigated does solar photovoltaics installation have impact on residential property value and housing prices. The data was collected in Arizona Unites States in 2014, limiting the research to single family houses. Arizona has been one of the leading states in terms

of total installed solar energy capacity. The results of the study show that solar panels have positive impact on housing prices and property values; a price premium for transaction prices was 28 000 dollars that makes 17 % of medium sales price. A statistically significant premium was found for homes with electricity generating solar systems, for plain solar water heaters no significant premium was found.

Xingchi, Liu, Lucy, Patwardhan & Parth (2021) have examined housing price change in residential properties after an air source heat pump (ASHP) adoption across 23 states of the Unites States. The data for sales prices consisted of transaction records from 2000 to 2018. The study revealed three findings; the properties with an ASHP enjoyed a price premium of 4,3%- 7,1% on average. Secondly, it was found out that the environmentally conscious, middle-class residents living in mild climate regions, are eager to pay larger price premium. Third, the price premiums were bigger than installation costs of heat pumps and the estimated social benefits of changing to heat pumps.

"Homeowner's perceptions of renewable energy and market value of sustainable buildings" was studied in Cyprus by Vardopoulos, Vannas, Xydis & Vassiliades (2023). The study investigated homeowner's interest level to invest on renewable energy solutions, energy efficiency measuring for their homes and how the homeowners appreciated the market value of sustainable buildings. The results revealed that 64 % of homeowners had positive attitude towards investing in renewable energy solutions, 72 % showed interest to energy efficiency measures and 58 % estimated that investing in renewable energy solutions improved the market value of sustainable buildings. It was also found out that the homeowners with higher education and better income levels scored higher percentages in all three questions.

Hahn, Hirsch & Bienert (2018) have examined residential properties, both apartments and houses, to find out how the selected heating systems impacts on housing price. The study was carried out by observing properties in Germany in 2015. The study recognized significant importance of heating system's impact on purchasing price. It was also found out that there was a difference if the energy efficient "green" technologies were implemented or whether "brown" systems with old technology were used. Properties low energy consumption connects with a price premium, but on the market that "green premium" maybe turned into "brown discounts".

Fregonara & Rubino (2021) have published a methodological review of European peer-reviewed studies concerning residential buildings energy efficiency, green attributes and its effect on housing prices that has been published in the last five years (2016- 2021). The literature review does support that buildings energy efficiency may influence on housing prices, but the impact of green attributes and Energy Performance Certificate on property value is still varying in different contexts. The study found out that the research questions and research methods have gradually refined during the examined period, and latent variables and green attributes that impact on real estate pricing should be considered.

4.2 Finland

The latest research in Finland, published in January 2023 by Aalto University researcher Jussi Vimpari, has been discovered that using of ground source heat pumps as a heating system has increased the value of detached houses approximately 5,3%, compared to housing prices with some other alternative heating system. This sales premium can be classified a statistically significant. The study was carried out by collecting data of actualized housing prices in Finland during the years 1999- 2018. It must be considered that the study was completed before the energy crisis broke out 2022 in Europe and Finland. The study shows that the ground source heat pump heating does increase the actualized housing prices, even the study also reveals that the value will increase more in Helsinki metropolitan area, where the houses are more expensive. Transforming the price premium 5,33 % into monetary values, the average selling prices for old, detached houses in the Helsinki metropolitan area were 609 789 euros and the rest of Finland 214 071 euros, and these selling prices indicated a price premium of 32 484 euros in the Helsinki metropolitan area and 11 404 euros in the rest of Finland. Remarkably higher selling prices in Helsinki metropolitan area indicates that the investment cost of GSHP heating system can be captured in the selling price, while in the other parts of Finland five years of energy savings after installing a system is required to get the same benefit. (Vimpari, 2023). Housing prices, rents and incomes are varying depending on locations while the investment costs remain the same in all locations, and that is why areas with lower housing prices and uncertain expectations of housing price development have less motivation to invest on new heat pump technology. (Vimpari, 2021).

Another case study from 2020, was researching opinions and perspectives of property valuation professionals in the Finnish real estate market, concerning on commercial properties. The study focuses on examining building- specific renewable energy investments in the Helsinki metropolitan area. It was found out that beside the benefits of decreasing energy costs, the improved public image and better sale ability were mentioned. Also, this study discovered that energy investments are more profitable in city areas, where the markets are functioning better. (Leskinen, N, Vimpari, J, & Junnila, S, 2020)

In addition to previous study, Leskinen, Vimpari & Junnila (2019) investigated earlier a profitability of building- specific on-site energy solutions, such as heat pumps (HP) and rooftop photovoltaics (PVs). The study indicates that property yields reflect the risks of building specific energy investments and applying it to profitability analysis of on-site energy investments suggests that building specific energy investments are more profitable in the appealing central locations rather than in remoter areas. Investments in building specific energy production is increasing value of properties in locations where property yields are lower than on-site energy yields, and that makes it profitable for rational investors to consider investing on building specific energy production.

Fuerst, Oikarinen & Harjunen (2016) have examined apartment transactions in Helsinki to find out does residential properties energy efficiency ratings

provide more benefits than saving money through energy savings. The study found out that 3,3 % price premium observed in apartments that belonged to the best three best energy efficiency categories. It was also found out that a favorable energy efficient rating did not fasten the selling process in the analyzed market.

Kontu, Vimpari, Penttinen & Junnila (2020) are also bringing up the changes in the developing heating sector concerning district heating. The district heating is available on certain densely populated areas, and the district heating companies in Finland have been traditionally owned by municipalities. Traditionally, the DH companies have had a role of providing reasonable priced heat energy for people. Also, district heating is facing new challenges on the markets on demand to improve energy efficiency and cut the emissions. Technological development of other heating systems, especially heat pumps is increasing the competition on the market and the district heating's role as a cheapest heating system has changed.

5 RESEARCH METHODOLOGY

5.1 Aims of the research

As there are over a million detached or semi-detached residential houses in Finland, the continuously tightening energy efficiency requirements and rising energy prices are affecting on large group of house owners. Due to the large share of space heating in total energy consumption, European Union regulation for improving buildings energy efficiency is setting a challenge specially to house owners of cold climate countries like Finland. The wealth of Finns is largely tied to owner-occupied housing and preserving the property's value in the future is important.

The basic aim of this research was to investigate house owners plans to change the heating system of their house, to find out whether the heating system effect on house value from the house owners' perspective, how useful tool the homeowners are rating the energy performance certificate, which provides information about the building's energy efficiency, what kind of attitudes the house owners have towards tightening energy efficiency requirements and how much the environmental values weight in house owners decisions.

The collected data by the research provides an overview to house owners plans, opinions and attitudes, and the collected data may offer useful information for different stakeholder groups, for example political decision makers, officials, and real estate professionals. Collected information may offer help for the politicians or officials for the progress of encouraging house owners to update their house's heating systems to more environmentally friendly or for the real estate professionals the information may be used for advising house owners and buyers, and especially in marketing and sales process, possibly bringing positive effect on sales process.

5.2 Quantitative research

In the simplest and generalized way, the *quantitative* and *qualitative* research methods can be defined as contrast to each other; quantitative research is collecting data that is expressible as numbers and qualitative research data is expressible as words. (Williams, M, Wiggins, R & Vogt, P, 2021, p. 2-3). Quantitative research aims to give answers to questions how much, how many, or how often, and surveys and experiments are used for measuring that. Typical for quantitative research is that there is big amount of data collected, to be able to make perceptions, draw conclusions and present the data with numbers and statistics. (Vilkka, 2007, p. 13-17). Quantitative research may possibly also predict future. (Williams et al, 2021, p. 2-3). Hakala (2018, p. 35- 36) points out that quantitative

research aims to be objective, opposite to qualitative research that allows a researcher a subjective role. Using a quantitative method, the researcher aims to give all the research subjects neutral value, when the qualitative research may emphasize some subjects. Typical for quantitative research is that the research problems and research methods are decided before starting the actual research. Qualitative research is usually more flexible and adaptive, and the research task setting, and form of the report may change during the research process.

Quantitative and qualitative research methods should not be seen as mutually exclusive and competitive methods, both methods have usually some elements from another method. Different methods can provide different information and methods can be used side by side. (Saaranen- Kauppinen & Puusniekka, 2006, p. 5-6). Referring to the definitions explained above, this thesis can be classified as quantitative research. The amount of collected data using a survey method was big and the results are presented mostly on numerical way using figures and tables. Even the questionnaire included two open- ended questions, that can be categorized as qualitative data, the study overall fills the requirements of quantitative research.

5.3 Research participants

The real estate company's existing customer register was used to find research participants that were in a selected target group; owners of permanently used detached houses. Under investigation were all age and all size of private owned residential detached houses in Finland. Participating to research was relatively active, 96 house owners completed the questionnaire and the response rate was therefore 59 per cent.

65 % of answerers lived in the Uusimaa- area and the rest in other places around Finland. The location was not a compulsory question to answer, and the study did not observe regional differences. The survey questions included compulsory background questions including age, gender, and the size of household. From all 96 research participants, 58 were female, that are 60 %, and 38 were male, which are 40 %. In addition to that, 40 % of all participants were in the age group of 41- 50 years old, counting 38 participants. There were participants from all age groups, except the youngest group, from 20 to 30 years old. 24% (n= 23) were in the group of 51- 60 years, 21 % (n=20) in a group of 31-40 years, 10 % (n=9) in a group of 61- 70 years and 5% of participants were older than 70 years. 65 % of all participants were in an age group of 31- 60 years old.

A majority of participants had a household of two persons. 47 % of participants (n=45) had two person's household. 18 % (n=17) had family of four family members and 16 % (n=15) had three family members. Only 4 % of participants had five family members and 2 % had six family members or more. 13 % were single households. A large majority, 81% of participants, had a household of 2-4 persons.

5.4 Survey

Survey is not straight forward equal to quantitative research, but survey is very often used for collecting data in quantitative study. (Vilkka, 2007, p. 17). Survey is a way to collect data when the forming of questions is standardized; all the participants will answer to same questions that are asked in same order and same way. Survey is suitable especially when there are big number of participants, and they are located apart from each other. (Vilkka, 2007, p. 27-28). According to Franklin (2012, p. 171- 172) surveys are usable when the aim of the research is to capture attitudes, opinions or to get information how people behave and to collect this information from a relatively large group of people. Secondly, the surveys are suitable when gathering detailed information and describing a particular population.

Resources and the type of data are most important things that are defining what type of data collection will be used. Collecting data using surveys, can be divided into self-completion, and using interviewers, or a hybrid of these two methods. Self- completion is the most common way of surveying, having an advantage on scale, speed, and possibility to ask sensitive and personal questions. (Williams et al, 2021, p. 80- 87). Surveys can provide three types of information, descriptive, exploratory, or explanatory. The *descriptive research* aims to get an explicit profile of persons, events, or situations, while the *exploratory research* focuses on asking open questions to find out what is happening to gain insights about the research topic. Along with the previous, the *explanatory research* presents causal relationships or correlation between variables. (Saunders, Lewis & Thornhill, 2012, p. 170- 172).

For the research in question, the self- completion was used for survey data collection, due to its speed, costs, and the object of getting neutral answers. The target of the research was to discover attitudes and intentions of house owners considering the heating systems of their detached houses, and to find out how much the house owners consider that the selection of heating system has effect on house value. The selected research method was a combination of these three methods, emphasizing on descriptive method; the research aimed to discover and *describe* house owners' attitudes and intentions, to *explore* insights with few open questions and to explain whether there was some causality or correlation between the variables.

5.5 Sampling

Need for sampling in research data collection is very often caused, and even forced, due to limited resources, time, expenses, and accessibility to the data. Collecting and analyzing all the possible potential data and examining the entire population is often impossible. (Saunders et al, 2012, p. 258). Sampling means selecting certain observation units from the population, using a particular chosen

sampling method. The selected sample should represent the whole population as well as possible, and to show the general view of population. (Vilkka, 2007, p. 51-57). According to Williams et al (2021, 54) quantitative research produces generalizations that are statistical, and the aim of the research is to maximize the reliability, that must be considered when selecting the sample and designing the research.

In the case of this research, the population means all detached house owners in Finland. Contacting and reaching all the house owners individually would not be possible, instead of that a small chosen subset of the entire population was selected to carry out the survey. The selected approach chosen to get contact with the house owners and to create an appropriate sample was *purposive sampling*. When using *purposive sampling* the researcher must evaluate and select the observation units that are able to answer research questions (Saunders et all, 2012, p. 287). Being an owner of detached house in Finland was the essential requirement for being able to reply to questionnaire.

To reach a desirable size group of house owners in a moderate time frame and access to real estate company's customer database led to a decision to use an existing customer database to catch up with the special target group. The selected sample, the participants chosen to take part in a survey, consisted of detached house owners in Finland, without any other limitations. The sample and the participants chosen from customer database were selected using the latest customer relationships, to minimize the possibility that the person had already moved out from a detached house. It was considered and predicted beforehand that there would be some inappropriate participants who would not be able to reply to questionnaire, because they did not own a house any longer.

5.6 Questionnaire

Questionnaire is a certain data collection method in which every respondent is requested to answer the same set of questions in a predetermined order. Questionnaire provides an effective way to collect information from a large sample prior to quantitative analysis. (Saunders et all, 2012, 503-504). Digital self-administered surveys with ready-made questionnaires are fast and cost-effective way of collecting data. To carry out the questionnaire successfully and ensuring good response rates, it is essential to make sure that the questions are well- designed, all the contingencies are covered and to verify that all the asked questions are understood correctly by respondents. In addition to that, it is important to proceed a test drive on yourself and some other people, before launching the actual survey. (Franklin, 2012, 175-179).

The questionnaire can be designed using different types of questions, and the results will follow the chosen question formats. The questionnaire questions can be classified *closed- ended* or *open- ended* questions. The closed-ended questions are predetermined questions with pre-specified alternative responses

to select from. The closed-ended questions produce reliable data for quantitative and straightforward analysis. (Franklin, 2012, 178). Saunders et all (2012, 520-521) points out that this type of category closed- ended questions are particularly useful when collecting data concerning people's behavior or attributes.
The open-ended questions give the respondents freedom to reply in their own words without pre-given alternatives. The open-ended questions may help to reflect the respondents' thoughts better by encouraging to express opinions freely. Open-ended questions can be useful for example to find out what is uppermost in the respondent's mind, if there are too many possible alternatives to list or if the detailed answer is required. (Franklin, 2012, 178).

The survey was organized and implemented with a digital self-administered questionnaire, and it was open to a selected group of individuals, that were the private detached house owners. Real estate company's customer register was used to get contact information for these house owners. Each chosen house owner was contacted personally by an e-mail, that included an invitation to the survey, a brief introduction to the topic of survey and the link to the questionnaire (Figure 15). The questionnaire was designed using twelve closed-ended questions and two complementary open-ended questions. The aim was to get numerical data for quantitative analysis about house owners' behavior, intentions, and values. The complementary open-ended questions were set to reflect closer house owners' attitudes and thoughts in more detail and to let the participants express themselves freely and give possibility to explain their views. It was optional to answer to the open-ended questions, to achieve voluntarily given honest positions. The questionnaire was performed with web-based Webropol- survey platform, the access to survey platform was provided by the University of Jyväskylä. Before launching the questionnaire, the pilot test was run with six persons to make sure that the questionnaire was functioning well, the questions were understood appropriately, and the question layout was working as planned. The questionnaire was sent out to 163 house owners on 8th of June 2023, and it was open until 15th of June 2023. The goal was to receive approximately 100 answers. The data collection was completed in 8 days. One reminder e-mail was sent after 6 days, 13th of June.

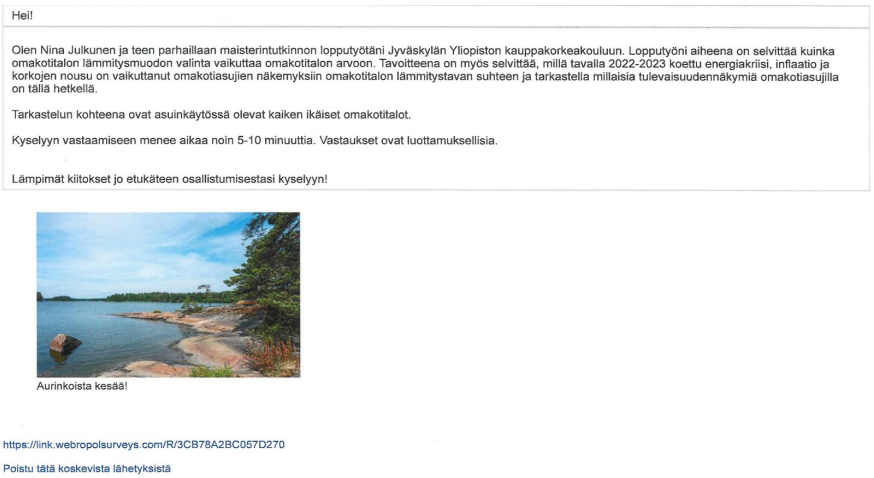

FIGURE 15. Link to the questionnaire sent personally by e-mail.

5.7 Survey questions

The survey consisted of 15 questions, divided into four major question groups, with sub- questions. 11 of survey questions were compulsory to answer. The data collection and analysing method was mostly quantitative, with compulsory multiple-choice questions. To investigate house owners' opinions, attitudes and values in more detail about the energy performance certificate and tightening energy efficiency requirements the word was free, and the collected data is qualitative for those questions. Each open-ended question had a short introduction, to give participants a basic knowledge about the asked question and a topic.

The survey questions were:

1. Have you planned to change the heating system of your house in the near future? If you have planned to change to system, which system you have and to which you are planning to change it? (Questions 2-3)

   Have you planned to update your heating system in the near future with air- source heat pump, solar panels, or fireplace? If you have planned to update, which one(s) you have planned to get? Are you aware that the detached house owners have been able to get financial support from ARA (Housing fund of Finland) for energy renovations? (Questions 4-6)

   During the years 2022- 2023, an energy crisis caused by rising energy prices, rising interest rates and inflation have been experienced in Finland. Have these societal changes effected on your plans to change or complement the heating system of your house? (Question 7)

   How much the following factors effect on your heating system selection; expenses, environmental friendliness, effect on selling price, effect on selling time and self-sufficiency? (Question 8)

2. How useful you find the statutory energy performance certificate, EPC?

   How much the energy class effects on your buying decisions, if you were buying a new house at the moment?

   How useful do you find the energy performance certificate in a role of seller? What kind of thoughts the EPC is rising? (Questions 9-12)

3. How much do you estimate that the heating system effects on house value currently? After 5 years? After 20 years? (Questions 13-15)

4. What kind of thoughts does the EU's new regulation on the energy efficiency of building's is raising? (Question 16)

5.8 Methods of analyzing the data

The research data was collected by using web-based Webropol- Survey platform and the analysis was prepared with the same program. The results of quantitative closed-ended questions are presented in percentages and averages. For closed-ended questions the scale for answers in every question, was from number 1 to number 7, of which 1 indicating that something is not useful or has no effect, and number 7 indicating that something is very useful or has a plenty of effect. The figures and table were created with Excel program. The results of qualitative open- ended questions have been written and analyzed verbally.

6 RESULTS OF THE RESEARCH

In this chapter the results of the questionnaire are presented. *The paragraph 6.1* starts summing up the background information of research participants, consisting of size of participant's houses, the construction year of the house and the current heating system of the house. *The paragraphs 6.1.1- 6.1.4*, present the results to the questionnaire. The following chapter 7, provides an analysis and discussion to received data, proceeding in the same order than the results are presented in this chapter.

6.1 Participants' background information

The survey questions included also three compulsory introductory background questions to help to analyse the results with more details. The introductory background questions were the surface area of house, the construction year of house and the current heating system of a house. First, the surface area of house where the participants of the research were owning and living at the time of the survey was asked. 43 % of survey participants had a house sized of 100 -150 m², 20 % had a house of 150 -200 m², and 19 % had a house of 50- 100 m², and 19% were over 200 m² houses. 63 % of participants had a house of 100- 200 m².

Secondly, the construction year of a house was asked. 32 % of participants were living in a house that had been built after 2000, 16 % had a house that had been built between 2000 -2009 and 16 % of participants had a relatively new house that had been constructed after 2010. Quite a big share, 31 % of participants' houses had been built before 1960, that was also the earliest option. Between the newish and old houses, there were evenly houses representing all decades, from 1960 to 1990. 10 % of houses had been built in the 1960's, 8 % in the 1970's, 13 % in the 1980's and 6 % in the 1990's. (Figure 16).

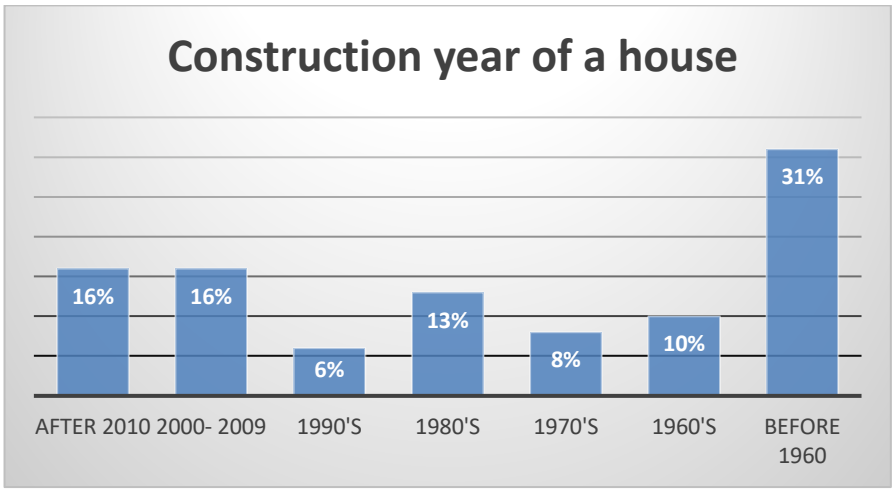

FIGURE 16. Construction year of a house

Third, the current heating system of participants' house was investigated. 34 % of survey participants were living in a house with direct electricity heating, followed by oil heating (19 %), ground source heat pump (GSHP) with 15 % of share, water source heat pump (WSHP) (15 %), central heating (8%), exhausted air heat pump (EAHP) (7 %) and last gas and pellet with 1% share each. (Figure 17). In addition to main heating systems above, 46 % of participants had an air source heat pump (ASHP) in their house, 70 % had a fireplace and 4 % had solar panels, used as a supportive heating system.

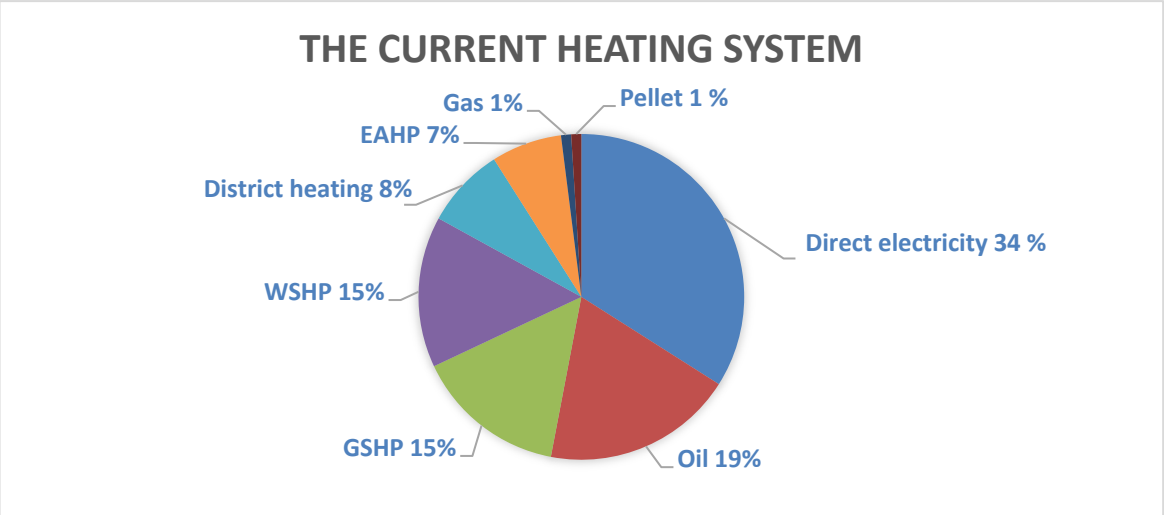

FIGURE 17. The current heating system of a house

6.1.1 Plans to change the heating system – effect of energy crisis

The first group of questions, numbered 2- 5, were about to find out whether the house owners had plans to change or update the heating system of their house in the near future, and if they did, to which system they were planning to change or update the old system. First, 9 % (n=9) of the participants replied that they did have plans to change the heating system of their house, and 14 % (n=13) of participants were considering it. A total of 22 % had plans or it was under consideration to change the heating system. 77 % replied that they have no plans to change the system.

The house owners who had plans or who were considering changing the heating systems were asked a follow-up question, to find out in more detail what kind of plans they actually had, and what kind of new heating system they were planning to use to replace the old system. 22 % of house owners had plans or the system change was under consideration. 82 % of those who had plans to change the system either to ground source heat pump (GSHP) or water source heat pump (WSHP); 41 % considered air-water heat pump, 27 % ground source heat pump and 14 % were comparing these two systems and going to select either air- water heat pump or ground source heat pump. (Figure 18). 4 % planned to change to

exhausted air heat pump (EAHP) and 14 % were going to make changes amongst the traditional heating systems (direct electricity, oil, district heating or gas).

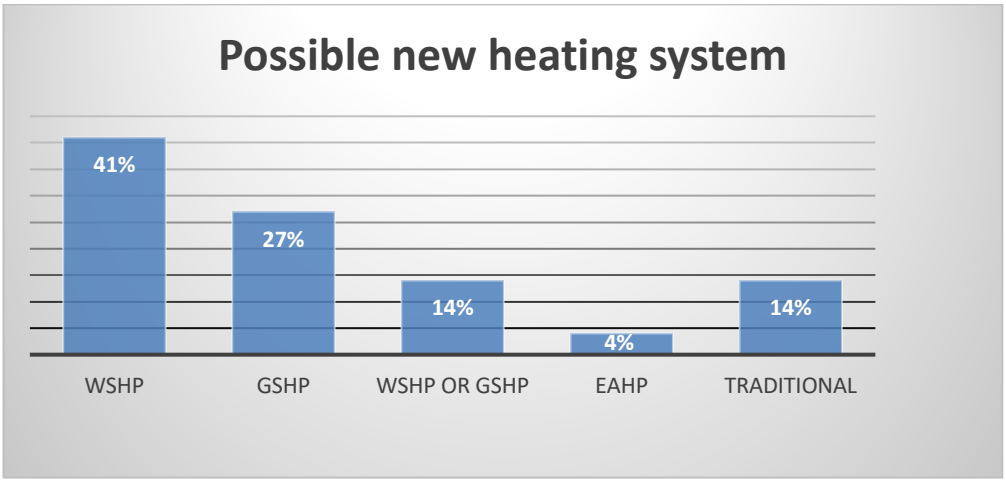

FIGURE 18. Possible new heating system to replace the old heating method.

The follow- up question was to find out whether the house owners had plans to update their house's heating system with some of supportive heating systems, air- source heat pump (ASHP), solar panels, or fireplace. 34 % of participants did have plans to update the heating system and 23 % were considering it. The minority, 43 % did not have plans or consider updating the heating system with supportive heating systems. The most popular planned supportive heating system was solar panels, with 53 % share. 47 % were planning air- source heat pump and 24 % fireplace. The question number six was to find out if the house owners were aware that private house owners were able apply for financial support from ARA (Housing fund of Finland) for energy renovations to improve the energy efficiency of their house. 56 % of house owners were aware of possibility to get some financial support from ARA, and 44 % replied that they did not know about it.

The questions seven and eight focused to investigate the possible impact of 2022- 2023 experienced rising energy prices causing an energy crisis, inflation and increasing interest rates. First, it was asked if the energy crisis, rising energy prices and other societal changes (inflation and higher interest rates) have affected on house owners plans regarding changing or updating the heating system of their house. The scale was between 1 to 7, 1 meaning that there has been no impact, and 7 meaning that there has been plenty of impact. (Figure 19). The majority, 31 % of house owners answered that the energy crisis and other societal changes have not had any impact on their plans regarding changing or updating the heating system and 13 % replied that there has been hardly any effect. On the other hand, 26 % replied that the changes have had plenty of impact to their plans, selecting 6 or 7 on the scale. 30 % of participants estimated that the impact has been moderate, choosing 3- 5 in the scale. The average of answers was 3.6.

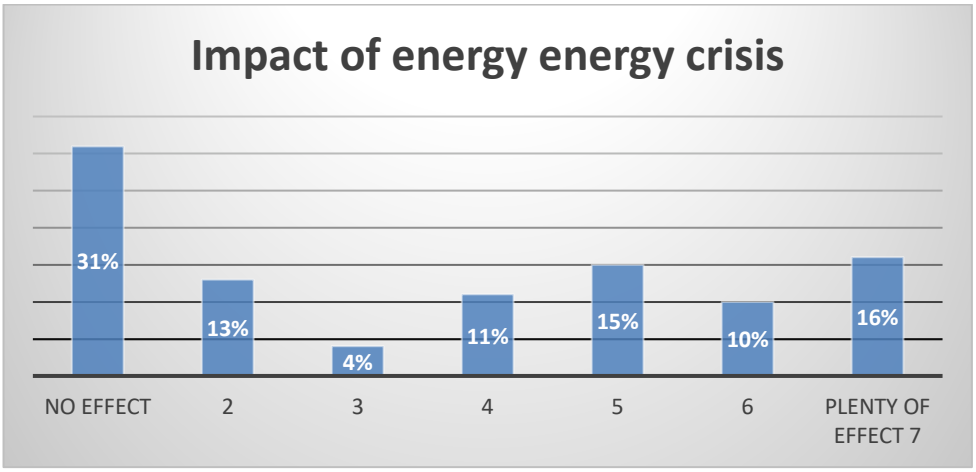

FIGURE 19. The impact of the energy crisis on plans to change the heating system

The follow- up question was to investigate closer which factors have most effect on selecting the heating system to house. There were five different factors that were under examination: expenses, environmental friendliness, effect on housing price when selling, effect on selling time and self-sufficiency (for example during the electricity blackout) (Table 1). The scale was from 1 to 7, 1 meaning that there is no effect and 7 meaning that there is a plenty of effect. The expenses were estimated as most important factor by far, the average of answers was six. 79 % of participants estimated the effect of expenses was 6-7 in scale, 30% valued 6 and 49 % valued 7. The second most important factor was effect on house's selling price, with the average of answers 5,1. The effect on house's selling time was estimated on average 4,4 and the self- sufficiency 4,8. Environmentally friendliness was estimated least important factor, with the average of 4,3, that had effect on heating system selection.

The effect of different factors on the selection of heating system The scale from 1 (no effect) to 7 (plenty of effect)								
	1	2	3	4	5	6	7	**Average score**
Expenses	4%	1%	1%	7%	8%	30%	49%	**6,0**
Environmental friendliness	9%	9%	13%	19%	17%	26%	7%	**4,3**
Effect on housing price when selling	8%	3%	6%	13%	20%	23%	27%	**5,1**
Effect on selling time	9%	13%	5%	17%	22%	17%	17%	**4,4**
Self-sufficiency (power cut etc.)	5%	13%	9%	8%	21%	19%	25%	**4,8**

TABLE 1. The effect of different factors on the selection of heating system

6.1.2 Energy Performance Certificate EPC

Energy performance certificate EPC is statutory for all the residential houses that are sized over 50 m². The house owner is responsible for purchasing the certificate. The energy performance certificate is a tool to compare the energy efficiency between the buildings. The energy efficiency class is a calculated value, and it does not consider real energy consumption. The energy efficiency classes are classified between A and G, starting from the most energy efficient class A.

The survey questions 9- 12 focused to examine how useful the house owners found the energy performance certificate. The questions 9-11 were compulsory to answer and the question 12 was optional open-ended question, that provided house owners a change to leave comments and use free word about the EPC. First it was measured how useful tool the house owners estimated the energy performance certificate as it is at the moment. (Figure 20). The scale for answers was from 1 to 7, number one implicating useless and number seven implicating very useful. 40 % of participants estimated that EPC is quite useless, selecting 1 or 2 in the scale. 50 % estimated that the certificate is moderately useful by selecting 3, 4 or 5 in the scale. Only 10 % considered that the certificate was clearly useful, picking 6 or 7 on the scale. The average of answers was 3.3.

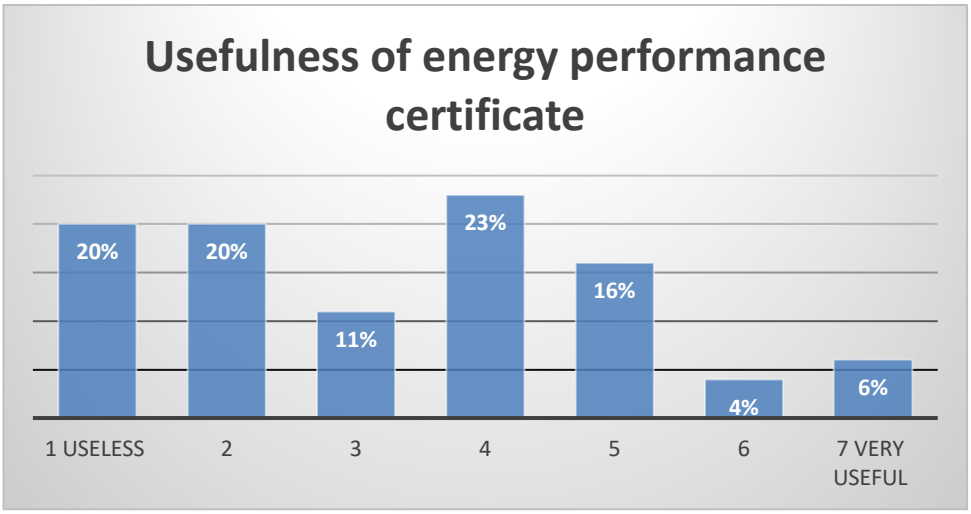

FIGURE 20. Usefulness of energy performance certificate

The next question was to answer from a role of buyer, and to estimate how much effect the energy efficiency class of EPC has to a buying decision, if purchasing a new house. (Figure 21). The average of answers was 4.1 and there was quite a lot of dispersion on answers. Some people found that the energy efficiency class has no effect on buying decision (13 %) and on the opposite, 8% found that the energy efficiency class has plenty of effect on decision when buying. A majority of participants replied that the effect on buying decision is moderate, 53 %, picking 3, 4 or 5 on the scale.

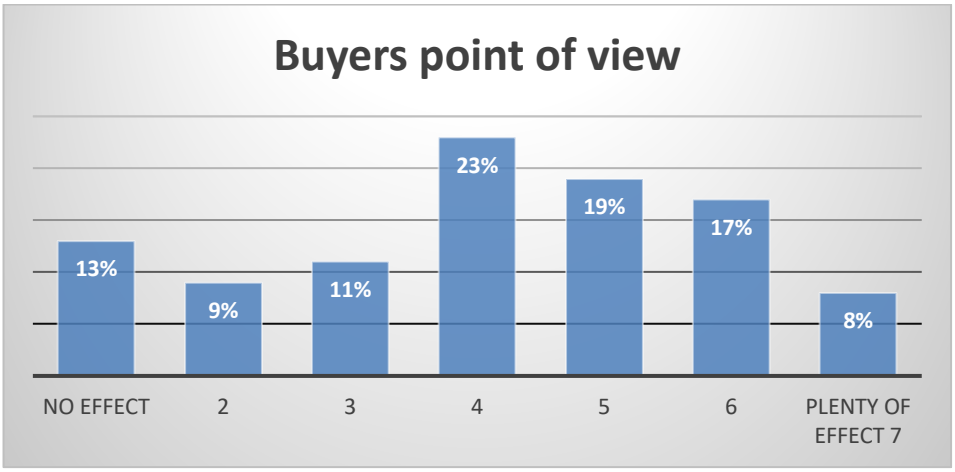

FIGURE 21. The effect of the energy efficiency class on buying decision, if buying a new house now.

The following question was viewing the same issue from house seller's perspective, figuring out how useful the energy performance certificate was found in a seller's role, if selling a house. (Figure 22). The average of answers was 4.4 and 57 % of participants found the EPC moderately useful tool, picking 3, 4 or 5 on the scale and 19 % replied that EPC is very useful tool, choosing 6 or 7 on the scale.

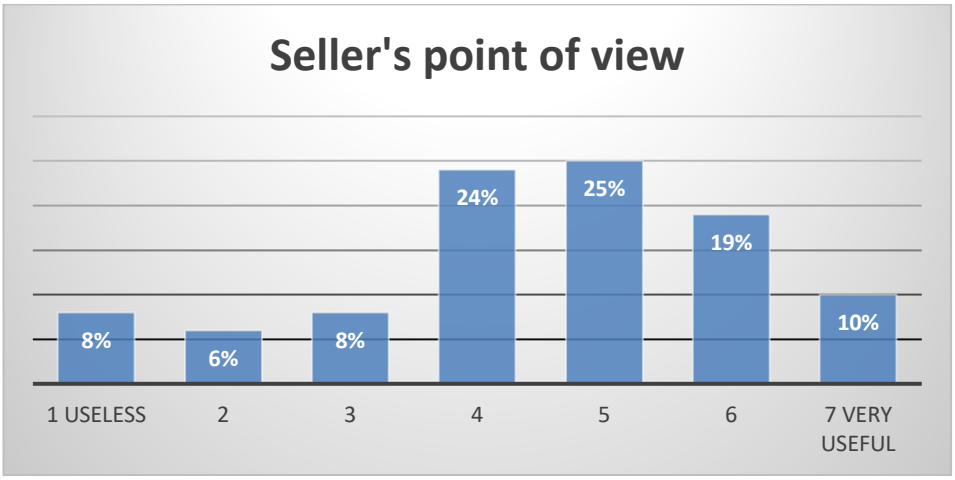

FIGURE 22. Usefulness of the energy performance certificate from the seller's point of view.

The last question (12) considering the energy performance certificate was an open-ended question that was not compulsory to answer. 43 % of 96 participants replied and left some comments. The comments had a plenty of variation from quite negative aspects to very positive ones. 85 % of comments could be classified negative or at least critical, and a minority of participants, 15 %, left positive comments and agreed that the energy certificate is useful, and it does have a certain function.

" Incredible thought in a two-hundred-year-old house"

" Energy performance certificate is politics"

" Misleading, useless"

" Mostly about collecting money. Energy efficiency should be able to prove on other ways"

" Tells nothing about house or expenses, misleading certificate, it depends a lot on living habits"

" Useless in its current form. Nobody understands energy efficiency figures. Actual operation costs are understood instead"

" A much-criticized statutory document"

" Many houses on the market do not have an energy certificate"

"I understand the need for an energy certificate in new houses, but not in the old ones"

"I doubt the reality of the method of making the certificate"

"An old historical house, I would not like to purchase an energy certificate"

" In my opinion, it is good that those things are being measured"

" I guess it gives an indication of what can be expected in terms of electricity costs"

" Helps with comparison"

" I have already purchased an energy performance certificate, because I'm planning to sell my house in the near future"

" Useful in new houses"

6.1.3 The effect of the heating system on the value of the house

The research questions 13- 15 focused to investigate how much the detached house's heating system does effect on house value from the house owner's perspective. At first, under examination was the house value at the current moment of replying to the survey. Secondly, the perspective was the house value in five years. And the last, the house value in twenty years' time span. The scale for answers was from 1 to 7, number one implicating that there is no effect on house

value and number seven implicating that there is plenty of effect on value. The distribution of answers on the scale looks very similar in all time perspectives; a strong majority of house owners does think that the heating system of detached house has moderately or plenty of effect on house value. (Figure 23). On average, from current situation to a situation after 20 years' time, 96 % of answerers estimated that the heating system's effect on house value is moderate or large, by picking an option 4- 7 on the scale. The average now was 5,7, in 5 years' time span 5,8 and in twenty years' time span 5,6. Only a small minority, a few participants in total, were thinking that the heating system's effect on house value would be slight or non- existing, picking 1-3 on the scale.

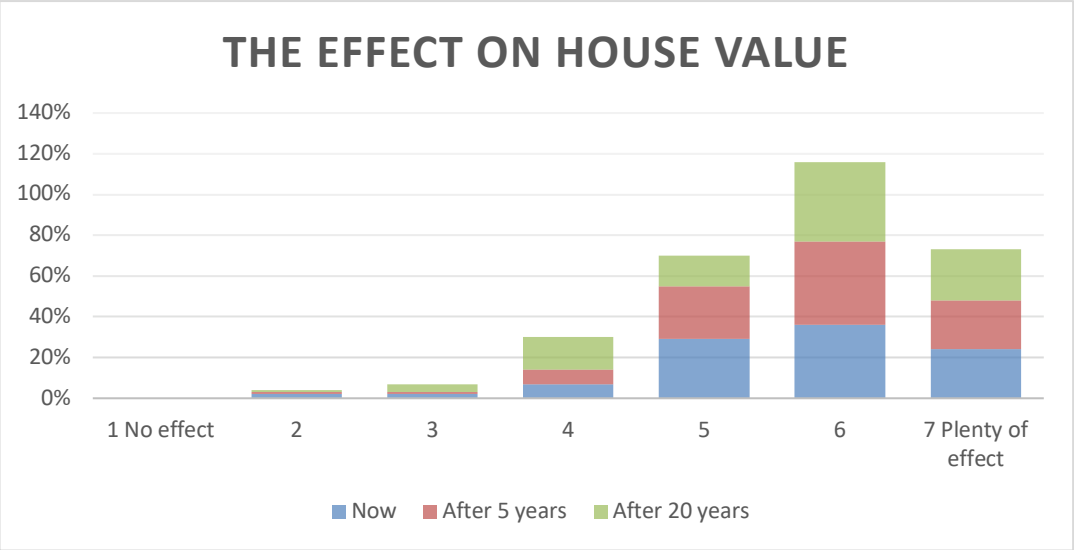

FIGURE 23. The effect of the heating system on the value of the house, now, after 5 years and after 20 years

6.1.4 Tightening energy efficiency requirements for buildings

The last question (16) was about the latest EU energy efficiency regulation that has been accepted in March 2023. The European Parliament have approved the proposal for improving the energy efficiency of buildings in 14.03.2023. According to targets of Parliament, the residential buildings should achieve at least the energy class E by 2030 and energy class D by the year 2033. The last question focused to investigate what kind of thoughts the new EU regulation has risen from the house owners' point of view. The question was open-ended, and the word was free for opinions. The question was not compulsory to answer. The participation was still active, and total 58 house owners, 60 % of all participants, gave some comments. 86 % of comments were either critical, concerned, or negative. 14 % gave approbative or positive comments.

" As the owner of an old house, it sounds like an unreasonable demand"

" Too strict law and it brings too many expenses to house owners"

" This cannot be generalized in the EU area"

" An unreasonable demand considering Finland's construction stock. There are for example old houses owned by elderly people, and the owners may not have financial possibility to improve energy class of their house"

"There will be too many expenses for old houses, and it will be difficult to sell them in the future"

" Not very realistic in Finland"

" Mission impossible"

" I'm worried how I will manage this in my own house"

" It's great if there is a payer for everything. As inequality increases. Houses in the countryside and growth centers have a different value, but renovation costs are the same"

" In sparsely populated areas, the value of the houses will collapse"

" A cost- benefit- analysis is missing. When renovating an old house, it is good to be patient, especially in declining areas"

" The direction is good and necessary. But the requirements are still too modest"

" A very good requirement, could be even stricter. The energy is mostly consumed from the common climate wallet"

"I support the effort to improve energy efficiency"

" Positive from the buyer's side"

" When maintaining the house, the is no harm"

" Good thing. Raises some thoughts how the financing of the changes would be successful"
" I'm not very familiar with the topic, but in principle, energy efficiency is a good thing, as long as you do not create air quality problems at the same time"

7 DISCUSSION

The chapter 7 discusses how the study managed to find answers to the research questions and finalizing to possible future research suggestions, that came out as a result of the current research. The basic four research questions for this study were to investigate whether the detached house owners had plans to change or update the heating system of their house and if the rising costs and energy crisis have affected on their plans and how much the environmental values weight in their decisions. Secondly, house owners' attitudes towards energy performance certificate were under examination. Third, the heating system's effect on house value was investigated and last it was examined how the house owners considered tightening energy efficiency requirements and new EU regulation. In the following four sub-chapters answers to these research questions will be discussed and analyzed.

7.1 Answers to the research questions

7.1.1 Plans to change the heating system – effect of energy crisis

The first research question was aiming to find out whether the house owners had plans to change or update the heating system of their house, and continuing from that, to examine has the experienced energy crisis in the late 2022 and rising energy prices effected on these plans. A total of 22 %participants replied that they had plans or they were considering changing the heating system. The older the house is, the more likely the traditional heating methods are used in heating, including direct electricity, oil, gas, pellets, and central heating. In the 21st century heat pump technology began to become more common. The survey participants owned relatively old houses, 68 % of houses had been constructed before 2000 and 64 % of houses were heated with traditional heating systems. Therefore, it is understandable that relatively high percent of house owners were considering changing the system. The most popular heating systems to replace the old one, were water circulation systems, ground source heat pump (GSHP) and water source heat pump (WSHP). 82 % of house owners were considering GSHP or WSHP or comparing these systems with each other. Against the fact that 19 % of houses were heated with oil, the alternatives considered are understandable-changing a water circulated system to another water circulated system, it is cheaper and easier to carry out the renovation. A majority, 57 % of house owners were planning or considering updating the heating system of their house with some supportive systems, divided to air source heat pump (ASHP) 47 %, solar panels 53 % or fireplace 24 %. ASHP was already in 46 % of houses and 70 % had a fireplace. Solar panels were installed only in 4 % of houses. The house owners' interest towards solar panels is remarkable and the answers strongly support the

latest statistics that are telling about a rapid growth of solar heating. Awareness of ARA's support to energy renovations were known by 56 % of participants, that could be interpreted that informing has not reached all the house owners who might be affected.

Rising energy prices culminating to energy crisis in late 2022 and other societal changes, including inflation and rising interest rates brought more expenses to house owners. Although 31 % participants replied that these changes have not affected at all on their plans changing the heating system, 52 % estimated that these changes have had a moderate or strong effect on their plans. The answers were very divided on the scale, and it can be supposed that the type of heating system the house owners had in their house effected strongly on their answers. The heating costs of less energy efficient houses increased more and may have had stronger effect on house owners' plans to cut heating expenses. On closer inspection of values and effecting factors on heating system selection it was found out that the overwhelmingly most important driver was expenses. 79 % of house owners replied that expenses had a plenty of effect (6 & 7 on scale) on heating system selection, while only few participants disagreed (1 & 2 on scale). The effect on housing price when selling was the second most important factor, scoring 5.1 on average. The effect on selling time was not considered as important than housing price, scoring 4,4 on average. Environmental friendliness was estimated least important factor effecting on heating system selection scoring 4,3 on average. The answers considering the environmental friendliness were evenly distributed on the scale, but only 18 % (1 & 2 on scale) responded that environmental friendliness does not have any effect on heating system selection. Self-sufficiency, for example in situations like a power cut, was scored 4,8 on average and 44 % replied that it effects strongly (6 & 7). Unstable circumstances and war in Ukraine may have affected on house owners' opinions on this question why self-sufficiency was considered so important. From the houseowners perspective it can be summarized that money talks and people are most interested in that what they must pay or how much they get financial benefit.

7.1.2 Energy Performance Certificate EPC

The second research question was aiming to investigate house owner's attitudes towards the energy performance certificate EPC, a tool for measuring energy efficiency of buildings. The house owners estimated that energy performance certificate is not very useful tool at the moment. Even 40 % of participants replied that EPC can be described as useless (1 & 2 on the scale) and only 10 % valuated EPC as a very useful tool (6 & 7 on the scale). The remaining half of the respondents classified EPC on scale 3-5, moderately useful. An open-ended question offered a possibility describe and justify thoughts in more detail and almost half of the participants left some comments. Accordingly, compared to previous question about the usefulness of EPC, there were lots of variation in comments, 85 % were negative or critical and 15 % were positive with encouraging feedback. The criticism was for most part about the cost of certificate, a concern how reliable

the tool really is for old houses, about the reliability of the tool, a hesitation whether the EPC consider the real energy consumption and a suspicion if the EPC gives misleading information. It was also pointed out that the certificate is missing very often in sale advertisements, even it is compulsory. The positive comments pointed out that the energy performance certificate may help to predict the living costs of house better, especially when buying a new house, and EPC helps to compare different houses and help the selling progress. It is noteworthy that close to 50 % of participants replied to open-ended question and used their word to explain their thoughts closer. Almost the same number of participants replied in earlier question that EPC is either useless or very useful. It can be expected that people with stronger opinions are eager to leave free comments. People with neutral attitude may not have so strong arguments and need to leave any comments.

The house owners' attitudes towards EPC were also examined from the perspective of buyer and a seller. From the buyer's perspective it was asked if the energy efficiency class of EPC has effect on buying decision. The answers were evenly distributed on the scale, an average score 4.1. It was surprising that even 22 % replied that energy efficiency class does not effect on buying decision at all, picking 1 or 2 on the scale. The EPC rating offers valid information about the energy efficiency of a house and energy efficiency walks hand in hand with energy consumption and costs. The question layout might have been misleading and that would explain the great dispersion of answers and relatively high amount of "no effect" answers. Buying "a new" house might have been understood in two ways; a new home (that can be also an old house) or newly constructed house. From the seller's perspective it was asked how useful EPC was considered in a role of seller of the house. The EPC was found more useful tool from the seller's perspective scoring an average of 4.4. 14 % of participants found EPC as a useless tool from the seller's perspective.

When comparing the results from buyer's perspective and seller's perspective, the answers were divided quite similarly, share of moderate (3-5) answers was clearly the highest. In comparison to the EPC question about the usefulness of EPC in general, there was a big difference how the answers have divided on the scale. A great share, 40 % of participants, replied that EPC is a useless tool, and the average of answers was only 3.3, while the usefulness of EPC was estimated much higher, when evaluating from the buyers or sellers' perspective, with an average of 4.1 and 4.4. The question about the general usefulness of EPC was the first question about the EPC, and it could be analyzed that the participants replied according to their first thoughts and feelings that the question raised in their mind. The following questions about the seller's or buyer's role, may have raised different thoughts, or may have encouraged to think more and to guide to look at the matter from a new perspective, and then the EPC was not found any longer that useless than in the first EPC question and the attitudes changed clearly to more positive direction.

7.1.3 The effect of the heating system on the value of the house

The third research question aimed to find out whether the heating system of house does effect on house value from the house owner's perspective and how the development in the future was seen, comparing the present moment with a time span of 5 years and 20 years in the future. Amongst the house owners it was very strongly agreed that the heating system does effect on house value now and in the future. On average, including all time perspectives, the answers were 5,7/7 on the scale. At present, 85 % of participants replied that heating system has strong effect on house value, in 5 years' time span, 87 % replied that the effect is strong and in 20 years' time span 76 % answered that the effect was strong, choosing 5, 6 or 7 on the scale. Only few participants total replied that heating system would have no effect on house value. After 20 years the technology has been developing and if the transition to more energy efficient heating systems will continue, it can be predicted that bigger share of the houses has energy efficient heating systems and the differences between houses are not so big as they are at the present. The lower percentage after 20 years could be explained with this assumed development.

7.1.4 Tightening energy efficiency requirements for buildings

The last fourth research question aimed to investigate house owner's attitudes and thoughts towards the tightening energy efficiency requirements, that had been approved by EU parliament 14.3.2023. A large majority, 86 %, of house owners were relatively critical about the new EU regulation and hesitating the effects of decision and wondering how the new requirements could be adapted and implemented in practice in Finland's circumstances. The house owners were worried about the increasing expenses, especially for the owners of older houses and older people who are already retired and may have weaker economic situation. Many house owners also mentioned regional differences and were worried about the older houses in sparsely populated areas. It was perceived unfair to require same renovations for houses whose value is many times less than in metropolitan areas and growth centers. Even the comments were for the most part hesitating or negative, 14 % of participants who gave comments mentioned positive factors or gave constructive feedback. These people considered that it is necessary to tighten energy efficiency requirements and few participants even replied that new requirements could be tighter. When analyzing the comments and statements of house owners considering the energy efficiency requirements it is essential to keep in mind the background information of survey participants. 31 % of participants had a house that had been constructed before 1960 and 68 % had a house that had been built before 2000. In addition to that, 55 % of participants'

houses were heated with direct electricity, oil, or gas. In relation to this background information, it makes is understandable why there appeared so much worry and criticism towards the tightening requirements. The owners of older house that have less energy efficient heating system, are the ones that are most affected by the changes and new regulations.

7.2 Possible future research related to the topic

This study has presented a review to detached house owner's plans, attitudes and values considering the heating systems of detached houses, energy performance certificates and tightening energy efficiency requirements. The findings of the research supported mostly the findings of the previous research and some open questions and ideas for further research can be defined.

The results of the study showed that the heating system does effect strongly on house value from house owners' perspective. There are several types of heat pump systems available on the market, and the house owners have more alternatives to choose from than few decades ago. It could be examined in more detail how a particular heating system effects on housing value and further on, to compare if there are some differences between the systems how they effect on value. Installation costs of air and water source heat pumps are much lower than ground source heat pumps, it would be interesting to examine actualized housing prices and find out whether these systems offer a same price premium than ground source heat pump has been offering according to previous study has shown in Finland. Research material and actualized transactions should be available to extend the study to other heat pumps also.

As the study carried out in Finland earlier has revealed in 2023, there are relatively big regional differences in Finland, and the housing prices and value of houses is much bigger in the Helsinki metropolitan area and few other bigger cities than in sparsely populated areas. Also, the climate conditions vary quite a lot within the country and the heating season is longer in Northern Finland. Regional differences were pointed out also by the house owners on several occasions and even this research did not make a regional distinction, it would be informative to study that in more detail to get better understanding of regional differences that exists in a country like Finland.

The research found out that house owners had relatively negative or contradictory attitudes towards the energy performance certificate as well as tightening energy efficiency requirements. Primarily most of the house owners considered the EPC and energy efficiency requirements directly as extra costs, it can be concluded that money talks to the house owners. Further on it could be investigated in Finland does the energy performance rating and energy efficiency effect on housing prices, house value and selling time. There are such studies from other countries, but it would be informative to get data from cold climate country like Finland for comparison.

8 CONCLUSION

The aim of this Master's Thesis was to investigate detached house owner's plans for changing or updating the heating system of their house, to find out whether the experienced energy crisis and rising energy and electricity costs have effected on house owners plans to change the heating system, to review house owner's views on the statutory energy performance certificate that is a tool for measuring the energy efficiency of buildings, to find out whether the house owners think the heating system have effect on housing price, find out the importance of environmental values, and to investigate house owners' attitudes towards tightening energy efficiency requirements.

This study found that remarkable amount of house owners had been considering changing or updating the heating system of their house. Overwhelmingly most popular new heating systems planned were water circulation heating systems, water source heat pumps (WSHP) and ground source heat pump (GSHP). According to results, the energy crisis in the late 2022's and rising energy and electricity prices were not a significant driver or source of motivation for changing the system. The house owners' views on the statutory Energy Performance Certificate EPC, were for the most part negative in tone, but on the other hand, the house owners fully agreed that the heating system does have effect on house value. The results of questionnaire showed that saving costs was more important driver than environmental values when changing the heating system. The attitudes of house owners towards the tightening energy efficiency requirements led by the EU were doubtful, incredulous, and negative in tone.

The previous research over the last few years around the world has found out that type of heating system does have a positive impact on house value, but energy efficiency labelling, classification and energy performance certificates do not affect the house value as strongly, or the results of previous studies have been contradictory. The findings of this study were relatively similar; the house owners did agree that the heating system does effect on house value, but at the same time the energy performance certificate is not considered a very useful and valuable tool and there is contradiction on opinions.

In Finland, winters are long and cold and the need for heating energy is high compared to many other warmer climate countries, and the heating costs take a larger share of house owner's incomes. To speed up the transition towards more energy efficient and cost-saving environmentally friendly heating systems, it is essential to investigate further and, in more detail, how much the type of heating system and energy performance certificate rating effect on actualised housing prices in Finland. To tackle house owner's negative attitudes towards tightening energy efficiency requirements and change, it would be useful to produce and share more information to house owners about the benefits of changing the heating system; in addition to saving money, an environmentally friendly heating system reduces the need to use fossil fuels.

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APPENDICES

Hei!

Olen Nina Julkunen ja teen parhaillaan maisterintutkinnon lopputyötäni Jyväskylän Yliopiston kauppakorkeakouluun. Lopputyöni aiheena on selvittää millä tavalla 2022–2023 koettu energiakriisi, inflaatio ja korkojen nousu ovat vaikuttaneet omakotiasujien (talon omistajien) näkemyksiin omakotitalon lämmitysmuodoista ja sen vaikutuksesta omakotitalon arvoon. Tavoitteena on myös tarkastella omakotiasujien näkemyksiä lakisääteisestä energiatodistuksesta, ja siitä millaisia tulevaisuudennäkymiä omakotiasujilla on tällä hetkellä. Tarkastelun kohteena ovat asuinkäytössä olevat kaiken ikäiset ja kaiken kokoiset omakotitalot.

Kyselyyn vastaamiseen menee aikaa noin 5–10 minuuttia. Vastaukset ovat luottamuksellisia. Pakolliset kysymykset on merkitty tähdellä (*).

Lämpimät kiitokset jo etukäteen osallistumisestasi kyselyyn.

TUTKIMUSKYSYMYKSET

1. Mikä lämmitysmuoto on käytössä nykyisessä omakotitalossasi? Mahdollisuus valita myös useampi vaihtoehto. *

Suora sähkölämmitys
Kaukolämpö
Öljylämmitys
Maakaasu
Pelletti
Maalämpö
Vesi- ilmalämpöpumppu (VILP)
Poistoilmalämpöpumppu (PILP)
Takka tai kamiina
Ilmalämpöpumppu
Aurinkopaneelit

2. Oletko suunnitellut lämmitysmuodon vaihtamista lähitulevaisuudessa? *

Kyllä
Ei
Harkinnassa

3. Jos olet suunnitellut lämmitysjärjestelmän vaihtoa, niin mistä ja mihin? Avoin vastaustila.

4. Oletko suunnitellut nykyisen lämmitysjärjestelmäsi täydentämistä ilmalämpöpumpulla, aurinkopaneeleilla tai tulisijalla? *

Kyllä
Ei
Harkinnassa

5. Mitä seuraavista täydentävistä lämmitysmuodoista olet suunnitellut hankkivasi? Voi valita useamman vaihtoehdon.

Ilmalämpöpumppu
Aurinkopaneelit
Takka/ tulisija

6. Oletko tietoinen, että omakotitalon energiaremontteihin on mahdollista hakea tukea ARA:lta (Asumisen rahoittamis- ja kehittämiskeskus)? *

Kyllä
Ei

7. 2022–2023 aikana on koettu energiakriisi, inflaatio ja korkojen nousu. Kuinka paljon arvioisit asteikolla 1–7 näiden vaikuttaneen omiin suunnitelmiisi koskien omakotitalosi lämmitysmuodon vaihtamista tai päivittämistä? *

8. Kuinka paljon seuraavat syyt vaikuttavat mielestäsi omakotitalon lämmitystavan valintaan? (Asteikko 1–7)

Kustannukset *

Ympäristöystävällisyys *

Vaikutus talon arvoon myytäessä *

Vaikutus talon myyntiaikaan *

Omavaraisuus (esim. sähkökatkon aikana) *

9. Energiatodistus on Suomessa pakollinen kaikissa asuinkäytössä olevissa yli 50 m² omakotitaloissa. Energiatodistuksen hankkiminen on kiinteistön omistajan vastuulla. Energiatodistus on työkalu rakennusten energiatehokkuuden vertailuun. Laskennallisen vertailun avulla on mahdollista vertailla rakennuksien energiatehokkuutta vertailuluvun (E-luku) avulla. Energialuokat energiatodistuksessa ovat A:sta G:n. Kuinka hyödylliseksi koet omakotitalojen lakisääteisen energiatodistuksen nykyisellään? *

(Asteikko 1–7)

10. Kuinka paljon energiatodistuksen energialuokka vaikuttaa ostopäätökseesi, jos olisit tällä hetkellä hankkimassa uutta omakotitaloa? *

(Asteikko 1–7)

11. Kuinka hyödyllisenä koet energiatodistuksen, kun olet myyjän roolissa myymässä omaa taloasi? *

(Asteikko 1–7)

12. Mitä ajatuksia energiatodistus herättää? Avoin vastaustila.

13. Omakotitalon lämmitysjärjestelmän vaikutus omakotitalon arvoon nyt ja tulevaisuudessa. Kuinka paljon omakotitalon lämmitysjärjestelmällä on mielestäsi vaikutusta omakotitalon arvoon tällä hetkellä? *

(Asteikko 1–7)

14. Kuinka paljon arvioisit, että omakotitalon lämmitysjärjestelmällä on vaikutusta omakotitalon arvoon 5 vuoden päästä? *

(Asteikko 1–7)

15. Kuinka paljon arvioisit, että omakotitalon lämmitysjärjestelmällä on vaikutusta omakotitalon arvoon 20 vuoden päästä? *

(Asteikko 1–7)

16. EU:n parlamentti hyväksyi 14.3.2023 ehdotuksen rakennusten energiatehokkuuden parantamisesta. Parlamentin tavoitteiden mukaan asuinrakennusten olisi saavutettava vähintään energiatehokkuusluokka E vuoteen 2030 mennessä ja luokka D vuoteen 2033 mennessä. Millaisia ajatuksia herättää EU:n uusi asetus rakennusten energiatehokkuudesta? Sana vapaa.

17. TAUSTAKYSYMYKSET

Minä vuonna omakotitalosi on rakennettu? *

2010 jälkeen
2000–2009
1990-luvulla
1980-luvulla
1970-luvulla
1960-luvulla
ennen 1960

18. Omakotitalosi asuinpinta-ala? *

50–100 m²
100–150 m²

150–200 m²
yli 200 m²

19. Vastaajan ikä? *

20–30 v
31–40 v
41–50 v
51–60 v
61–70 v
yli 70 v

20. Vastaajan sukupuoli *

Nainen
Mies
Muu

21. Montako henkilöä taloudessasi asuu? *

1
2
3
4
5
6 henkeä tai enemmän

22. Millä paikkakunnalla asut? Avoin vastaustila.