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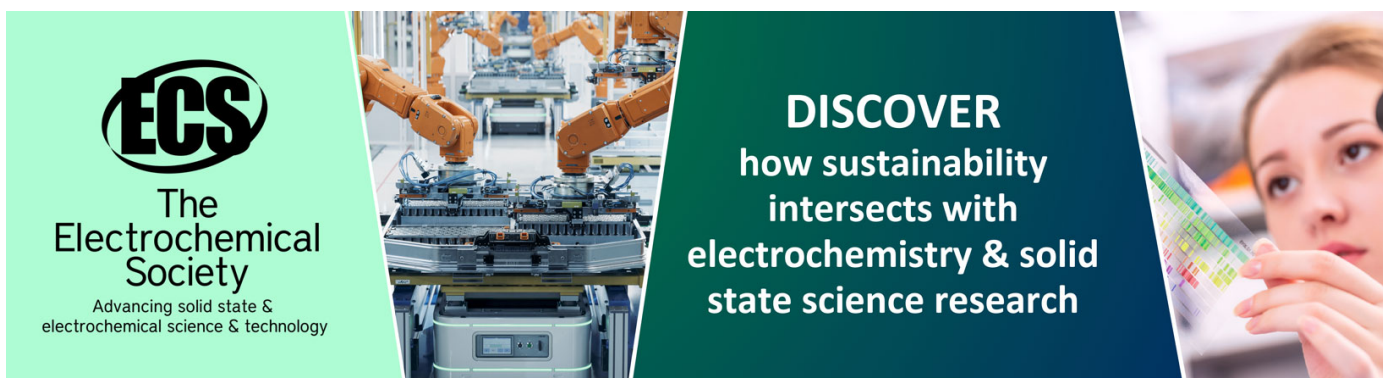
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Energy use patterns and renovations of Swedish second homes

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Abstract. During and post pandemic more people spent time in their second homes, which is expected to have led to higher energy use for heating. The knowledge of energy performance, heating systems, energy renovation and use patterns of second homes is still poor. The aim of the research is therefore to compile available information from building registers but also to empirically investigate user patterns, heating source and the renovation and energy efficiency measures carried out in second homes. A first step is to synthesize existing knowledge and develop a method for a broad mapping in a next step. The methods used are analysing statistics from national building registers and collecting information from owners/users through a pre-survey that is developed and tested. In this paper statistics on Swedish second homes and results from a pre-survey responded by 92 second homes owners/users are reported. From statistics, the energy performance and the main heating source for second homes with an EPC are identified. Despite the limited sample, the results from the pre-survey give an indication of user patterns, energy renovation measures carried out, and also whether the owners care about cultural values. Based on the experience from the pre-survey, a national survey has been initiated in Sweden.

1. Introduction

We are facing major challenges to transform society's energy system to reduce climate impact. The aim is that by 2050 buildings in the EU hardly use any energy and from 1 January 2021 all new buildings in the EU should use little or no nonrenewable energy for heating, cooling, and hot water. EU countries will also have to prepare national long-term strategies to support the renovation of buildings. The EU regulations have enforced compulsory energy performance certificates (EPC) for buildings to enable owners or tenants to compare and assess the energy performance. For single family houses an EPC is required when the house is sold, but second homes are excluded from the requirement. Moreover, the Swedish building regulation imposes requirements on maximal energy demands for new construction of single-family homes but not on second homes, which nevertheless have a non-negligible impact on the total energy and power use. However, some second homes have an energy declaration, probably made in connection with sales or a major renovation [1].

Second homes are rather common in the Nordic countries, Norway, Sweden, Finland, Denmark but also in the United Kingdom, France, Germany, the Czech Republic, South Africa, Canada, the United States, and Australia, [2, 3]. During the 1960s, 1970s and the early 1980s, second home construction boomed and added cottages to locations on the urban outskirts all over the Nordic countries [4, 5, 3, 6, 7]. The majority of second homes in Sweden, Norway, and Finland, between 80 and 90 per cent, were purpose-built. However, the second home stock is complemented by converted second homes that previously served as primary residences but had become obsolete or abandoned due to increased demands on comfortable modern housing, or outmigration as a result of urbanization [4, 8, 9]. Hence, converted second homes are common in rural areas in the Nordic countries. About 50% of all Nordic



households have access to a second home, [5]. In Norway 26% of the population own a second home, but 40% use second homes [10], and in Sweden about 54% of the population owns or has access to a second home through relatives and friends [11, 12]. In Finland 62% of the population has regular access to one or more second homes, [13], and in Denmark 14% owns a second home but most certainly more people have access to one [14]. When it comes to how frequently second homes are used, the three countries generally display the same pattern. In Finland the second homes are used on an average of 75 days per year, in Sweden 71 days and in Norway 26-51 days per year (national mean: 47 days per year). However, there are major regional differences in the frequency of use due to location and standard [8].

The interest in buying and using second homes has increased in recent years as an effect of both flight shame which has meant more vacations close to home and within the country instead of traveling abroad and the pandemic with increased opportunities to work remotely, which will most certainly remain. Second homes have different uses, summer residences, winter residences and variants in between, and the operation is managed in different ways. Moreover, second homes may well become permanent residences or vice versa. However, it is not known what effects increased use of second homes and possible renovations and energy efficiency improvements will have on the energy system, flows of building materials, and cultural values among the second homes.

The fact that second homes have an environmental and climate impact has attracted attention since the 1970s [15]. Studies from different parts of Europe show that simpler second homes are renovated for greater comfort. An increase in the standard of second homes in Norway has led to increased energy use and climate impact [16]. An increase in energy use, larger building space and increased pressure on land use from holiday homes have been seen in France [17]. A Danish study shows that second homes used for rental have higher standards and a higher energy use and, unlike the rest of the Danish building stock, electricity is almost exclusively used for heating second homes [18]. A questionnaire survey among Norwegian second homeowners studying their motives for ownership, with the aim to increase understanding the Norwegian second home phenomena in relation to sustainability (environmental, social and economic), have shown that there is a low interest for energy use. They note an increase in use both by owners and by people other than the owners during the pandemic, but also that the line between second homes and permanent homes is blurring. They also report that on average there has been an increase in the living space per second home, material use, energy use and standard [19]. In Finland, there is a national survey of second home owners called the Second Homes Barometer [20], which contains information about where the second homes are located, what facilities are available and what plans the owners have for the house. Supplementary local surveys of second home owners in Finland have been used to study travel habits and related climate impact of holiday homes [21]. Also, outside Europe, increased pressure on second homes and related climate impacts has been noted [22].

Electricity consumption in second homes has increased steadily over the years as second homes are switched to year-round living for retired people and second homes are increasingly used as family holiday homes. The more intensive use, it should be noted all year round, has increased electricity consumption in second homes, regardless of whether the purpose may be space heating or the production of hot water. The history of the increasing electricity consumption also includes the fact that most second homes were and are built exclusively for use in the summer, which is why they are usually poorly insulated. Andersson, et al have simulated the energy use in Danish second homes combining top-down estimations based on time series of total electricity consumption and number of second homes, combined with bottom-up analyses of estimated use based on measured electricity consumption for specific second homes, and the number of second homes of different types, considering heat losses and electricity used for appliances combined with four user patterns [23]. Based on knowledge gathered from a survey including 700 second homeowners from selected areas in Denmark, and interviews with representatives of typical groups of second homeowners as well as actors in rental, construction, electricity supply, regulatory processing and supply of renewable energy plants, a "catalogue" of recommendations for energy savings, aimed at each of the mentioned actors including the second home owners themselves. The conclusion from this study is that the potential for energy savings in holiday homes is great and that the solutions are just waiting to be exploited. However, there is a lack of knowledge about these solutions, but also a belief that there is something to be gained by investing in energy savings in the second homes, [24]. In Norway, the use of electricity has increased by 97% from 1973 to 2005 [25].

Electricity use in Sweden has been around 3 TWh with a trend downwards, from 3,5 TWh in 2011 to 2,83 TWh per year in 2020 [1, 12]. The latest survey on energy use in second homes in Sweden was made in 2011. From a basis of 589 525 second homes a stratified random sample of 4,500 items were drawn for a combined web and postal survey. A total of 2,534 responses were received, corresponding to a response rate of 63 percent. According to the survey electricity in combination with biofuel was the most common heating method (57%) followed by direct electricity (19%). Approximately 19% of the second homes had installed a heat pump and the most common solution was air to air at 57% and 35% used ground source heating. The average electricity consumption per second home, was about 6.0 MWh during the period 1 September 2010 to 31 August 2011 [12].

Second homes have varying degrees of renovation needs and varying potential for energy efficiency measures. Second homes represent great economic and cultural but also social values that must not be neglected or distorted. It must be ensured that the energy efficient measures do not cause moisture damage or devastate cultural and cultural historical values. At the same time, second homes must also provide a good indoor environment regarding both thermal climate and air quality, which becomes especially important if the users' time spent in the second homes increases. A Swedish study has also drawn attention to problems with dampness and mold and related health problems if second houses are not insulated and renovated correctly [26]. Moreover, the influence of constant output heating for energy saving purposes while avoiding moisture damage in the cottages through measurements was studied in seven non-insulated massive log walled cottages in Tampere region, Finland [27].

Even though there are a few former studies on energy use, and some studies on energy efficiency, the information of the current energy use, heating sources and user pattern in second homes is still poor. In addition, there is very limited research on renovation and its impact on the cultural values of second homes. The overarching aim of the study is to compile and systemize information on energy use and energy renovation measures to analyze the energy efficiency potential in Swedish second homes with focus on those with cultural values. This was done by collecting data from several sources, both registers and surveys. Since energy declarations are not mandatory for second homes, not even when sold, the property register does not contain much data on energy use or energy performance. However, almost 11 000 second homes have an EPC with information about energy class and energy performance, and even though there is very low percentage of the houses with a declaration, this gives an indication of the energy use in the second homes building stock. The information has been collected and is presented in the paper. To be able to evaluate the energy performance and energy efficiency potential of the second home stock, register data have been supplemented with deeper information obtained from a pre-survey on user patterns and implemented energy efficiency measures and renovations, as well as how the cultural values are considered. Despite the limited sample, the results give some interesting indications which are presented in the paper.

2. Methods

2.1 *Extracting information from national statistics*

The national statistics information has been retrieved from EPCs of Swedish single-family houses with the latest extracts made in 2022-08-11 and table 430 VESHB YGG (Single family houses) [1] and from the cadastral register dated 2022-06-21. Data matching of the register and the standardization of the input data were done using methods developed by Eriksson and Johansson (2022) [28].

2.2 *Pre-survey*

The pre-survey was carried out preparing a questionnaire with several multi choice questions about ownership, user pattern, type of house, heating system, heating temperature while the house is not used, renovations and energy efficient measures carried out the last 10 years, and if the decisions of measures have been influenced by the cultural values of the building. The questionnaire was distributed both as a paper version but also as a digital version accessed online at <https://survey.mailing.lu.se/Survey/44972>, among the authors' friends, neighbors and colleagues but also through social networks in order to reach a decent number of second home owners.

3. Results

3.1 Results from national statistics of housing and energy performance certificates

In Sweden, on 1 January 2022, there were 610,372 second homes with the highest number in the municipalities of Norrtälje (26 538), Värmdö (14 328), Gotland (12 453), Härjedalen (9 397) and Borgholm (8 798) and the lowest (26) in Sundbyberg [Statistics Sweden, 2022]. Second homes are here defined as valuation units that do not have registered residents and are taxed as; agricultural unit with building(s), single-family house unit with building(s), single-family house unit, single-family house on freehold land or single-family house unit with building value below SEK 50,000.

In August 2022 there were 10 767 second homes with an energy performance certificate (EPC), which represents 1,8% of the total number of second homes. The number of second homes holding an EPC is distributed among the municipalities, with the highest number in Värmdö (595) and Norrtälje (409). The EPC generally includes one building. However, it can also include several buildings if they are of similar characteristics, which means that the specific energy use can be an average of several buildings expressed in kilowatt-hours (kWh) per square meter heated living space and year. In figure 3, the specific energy use is plotted as a function of original construction year reported by the owner. The clusters of buildings with construction year of 1700, 1800, 1850 could be caused by an estimate by the building owner due to lack of detailed information and the cluster on year 1929 is due to the fact that buildings with unknown construction year were registered as 1929.

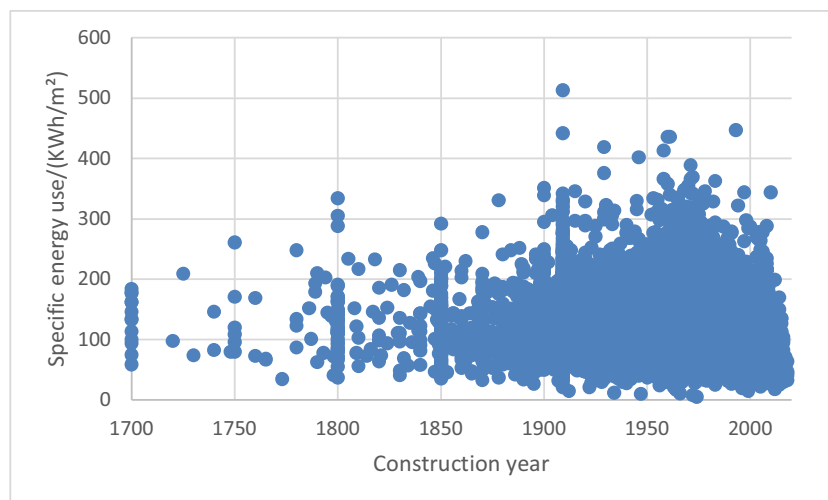


Figure 1. Specific energy use for 10 767 second homes with an EPC.

Each EPC with associated buildings is assigned an energy class based on the primary energy number as a measure of the energy performance of the buildings. The main form of heating is reported in the energy declaration and presented for each energy class in figure 2. Most second homes are in energy classes E, F and G. The majority have direct electricity as their main heating system. Some have installed an air-to-air heat pump, presumably to reduce electricity consumption. Ground source heat pump is more common in second homes with higher energy classes (A-D), probably since it is a significantly larger investment than installing an air-to-air heat pump. Quite a few of the houses are heated by burning wood. In the EPC there is also information if the building has special value or if it is a protected building, since this will influence the energy efficiency measures proposed.

From the 10 767 EPSs with buildings, the energy experts registered 48 buildings as buildings with special value and 15 as protected buildings. Most EPCs with buildings (7500) were assessed as “no” and more than 3000 had no assessment (N/A).

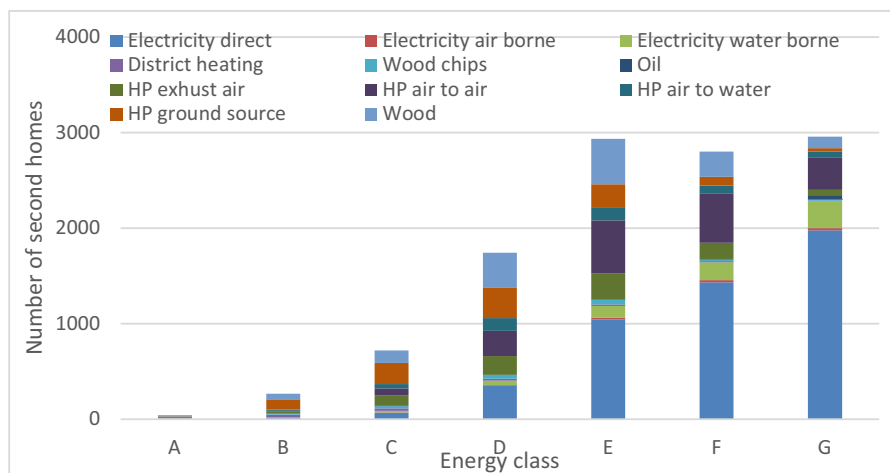


Figure 2. Main heating system for each energy class A-G.

3.2 Results from the pre-survey

During the period from June to September 2022, there were 92 respondents in total with the majority from the West coast and South of Sweden but also other places. The respondents represented different types of housing (summer cottages, colonist's cottage, croft, villa, farm) with a wide range of construction years, ownerships, user patterns, and interest for renovation, energy efficiency and cultural values. The type of ownership was distributed in three groups "own ownership", "shared ownership" and "access to second home", as shown in figure 3. The self-reported use of the second home during different seasons and main heating system in figure 4 and 5.

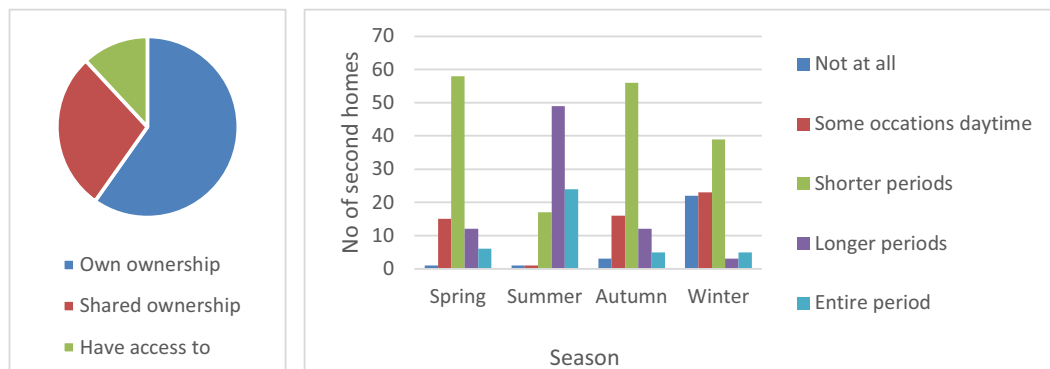


Figure 3. Type of ownership. **Figure 4.** Estimated use patterns during different seasons.

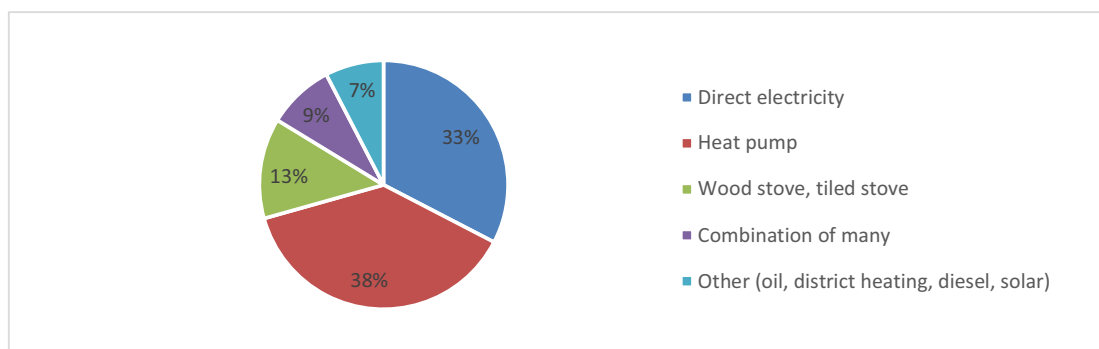


Figure 5. Main heating source reported by the respondents in the pre-study.

The original year of construction, and the years when extensive reconstructions or extensions of the building have been carried out, were reported by 74 respondents, and presented in figure 6.

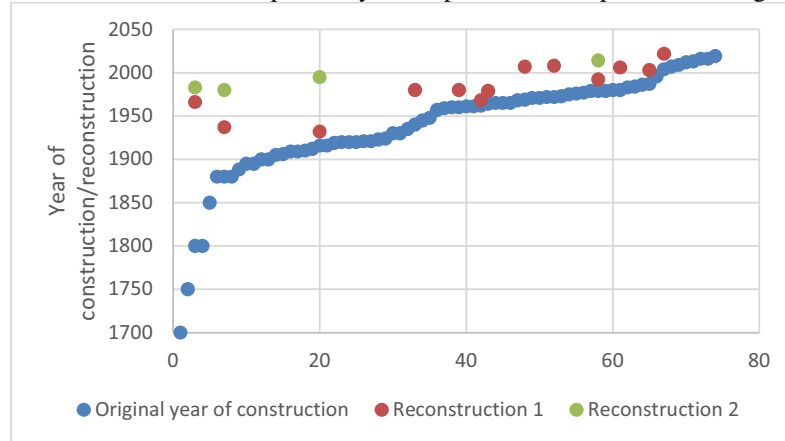


Figure 6. Original year of construction and reconstructions reported by 74 out of 92 users.

The housing owners/users have reported if any and in that case what kind of measures to improve the energy performance of the building, and also if, and in that case what kind of other renovation measures have been carried out during the last 10 years, see figures 7 and 8.

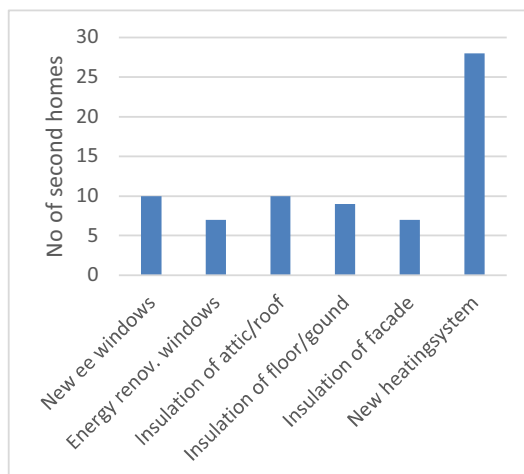


Figure 7. Energy efficient renovation measures carried out the last 10.

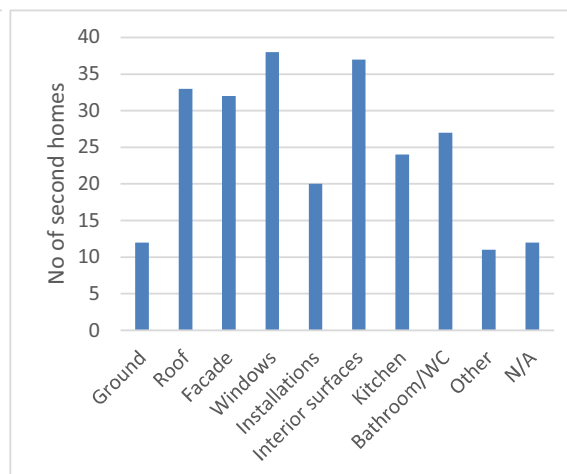


Figure 8. Other renovation measures carried out during the last 10 years.

The respondents also indicated if their decisions regarding renovation and/or energy efficiency measures have been influenced by their care of cultural values of the second home, and 37% answered yes, because we value the cultural values of the building, 55% answered no, 7 had not done any renovation and 1% gave no answer.

4. Discussion

The number of second homes has increased with approximately 4% in Sweden during the last 10 years. In contrary to Norway that has experienced a doubling of electricity use [25], the total electricity consumption for heating second homes in Sweden has decreased from 3,5 TWh to 2,83 TWh which means approximately 20% during the last 10 years. A comparison between the survey in 2011 and information from energy certificates from 2021 indicates a shift from direct electricity (19%) and direct electricity in combination with biofuel (57%) in 2011 towards direct electricity (43%) and heat pumps

(35%) as main heating source in 2021 [1, 12]. The use of heat pumps has almost doubled the last 10 years, with a majority of air-to air (43%) and ground source heat pumps (25%) [1].

Most second homes have quite a poor energy performance which can be illustrated by the 11 463 second homes with an EPC of which a majority have energy class E-G. The poor energy performance can be explained by the fact that 80-90 % were purpose built intended mainly for use during summer.

According to the pre-study, people spend a lot of time in their second home, not only for the summer season, a pattern confirmed also by foreign studies. Increased use is likely to lead to a higher standard and increase the requirements for interior and exterior expression, which leads to more renovations being carried out. Similar to what has been seen in other countries, most second homeowners have made exterior but also interior renovation of their houses during the last 10 years, according to the pre-study. Some of them have also installed a new heating system to decrease the energy use, mainly by installing a heat pump. Energy efficiency measures have been developed and presented in a Danish study [24] but is rarely implemented, which is also the case in Sweden. Increase awareness of energy efficiency measures tailored for different types of second homes also considering the cultural values are needed.

When comparing the energy experts' reporting of buildings with special values (48) and protected buildings (15) out of 10767 value units, it is much lower than when the owners themselves have responded in the pre-survey that their decision on renovation and energy efficient measures were influenced by the buildings' cultural values (34 out of 92). Most likely, energy experts miss a lot of buildings that are not legally protected buildings, but most certainly have cultural values worth preserving.

5. Conclusions

The main conclusions from the compilation of information from national statistics on second homes are:

- The number of second homes are distributed throughout the country, but most are located along the coasts with very high numbers in a few municipalities.
- The specific energy use varies a lot among the second homes, and there is no clear correlation between specific energy use and year of construction.
- The most common main heating system among the second homes with EPCs are direct electricity followed by heat pumps, especially in buildings with energy class D-G, which corresponds well with the answers from the 92 respondents in the pre-study where 38% reported they have heat pump and 33% have direct electricity as their main heating system.
- Results from the pre-study is that renovation measures are done in many of the buildings such as renovation of windows, interior, roofs, facades followed by bathroom and kitchen.
- The group "shared ownership" and "access to" is almost as big as "own ownership" which means that many will use the second homes while it is mostly the owners who have an interest in and make decisions to carry out energy renovation.
- The most common energy efficient measure is installing a new heating system.
- Only 1,8% of the buildings with an EPC have been registered as buildings with special value or as protected whereas among the respondents to the pre-study 34 out of 92 answered that the decision on renovation measures were influenced by the cultural values of the building.

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