Not even close to the goals - A “snapshot” of Swedish property owners’ energy renovation plans

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Abstract. A pre-requisite to reach the EU 2030 and beyond targets is a significantly increased ambition among property owners regarding energy-efficient refurbishments. The Swedish Energy Agency and the National Board of Housing, Building and Planning are on the Swedish government assignment developing a strategy with policy instruments to increase energy-efficiency oriented renovation. In order to design the right policy instruments, deeper knowledge is needed on the potential for energy efficiency and property owners’ present actions. To gain more insight into these questions an interview study with 20 building owners, covering more than 15% of the Swedish property area of multi-family buildings, schools and offices were performed in 2016. The interviews aimed to identify how building owners reason on different energy saving levels, what level of energy efficiency they currently are realizing and what obstacles and possibilities they expect if they take further steps in energy renovation. The interviews were based on four different common packages of energy-efficiency measures defined as renovations levels: 4, 15, 30, and 50 percent respectively. In 2019 the strategy was updated based on follow up interviews with mainly the same building owners. The interview results were used, together with assumptions of future renovation rates, in a calculation tool called HEFTIG. This tool enables long term calculation and visualization of energy-efficiency measures. The present situation was compared with scenarios made in 2016 and new scenarios were developed for 2030, 2040 and 2050 for the Swedish building stock. The result is a “snapshot” that the property owners’ current actions are far from the cost-efficient potential and that the potential is larger for heating than for electricity. The results also show that the energy renovation rate has to increase in the near future if the EU targets should be reached.

1. Introduction
A pre-requisite to reach the EU 2030 and beyond targets is a significantly increased ambition among property owners regarding energy-efficient refurbishments. The building stock accounts for a significant part of energy use, and if Sweden is to meet its long-term sustainability goals our existing buildings need to be energy-efficient [1]. In order to accelerate the transition to energy-efficient buildings, additional instruments may be needed. To design the right policy instruments, good knowledge is needed both of how development is taking place today, with the instruments and other influencing factors that already exist in society, and of the economically reasonable technical potential for energy efficiency.

Knowledge is needed of how property owners currently act when it comes to energy-efficient renovation, and how they are likely to act when it comes to energy efficiency over the next few years. This work provides a basis for the Swedish Energy Agency's and the Swedish National Board of
Housing, Building and Planning’s task to develop a national strategy for energy-efficient renovation of existing buildings.

2. Methodology

2.1. Data Collection
There is limited information on how property owners handle renovations and energy-efficient renovation on a larger scale available in Sweden. In order to get a picture of it an interview study with 20 building owners was performed in 2016. The interviews aimed to identify how property owners act when it comes to energy-efficient renovation. The interviews included both private and public property owners of different sizes and were covering more than 15 percent of the Swedish property area of multi-family buildings, schools and offices. In 2019 the work was updated based on follow up interviews with mainly the same building owners [2].

To get a representative picture of how much of the building stock in Sweden that is being renovated, mainly large companies were selected since they represent a large proportion of the total area. But some smaller companies were also included since the smaller companies together represent a large area and they might act differently compared to the large ones. The companies were also selected to give a good geographical spread within Sweden. The interviews aimed to identify how building owners reason on different energy saving levels, what degree of energy efficiency they currently are realizing and what obstacles and possibilities they expect if they take further steps in energy renovation.

In addition to the interviews, a literature study was conducted and especially result from two other studies was used [3]. The data collection also included reviewing the work from a previously study generating packages of renovation measures [4]. This work included a larger literature review of common renovation measures and the corresponding potential of reducing energy use and implementation costs. Other important sources of information are the property taxation register and official building statistics form the Swedish Energy Agency.

2.2. Generation of scenarios for simulations
Four different levels of renovation corresponding to different degrees of energy efficiency were defined from previous performed renovation investigations [4], there each level consisted of a number of common measures which together gave an energy reduction. These levels were used in the interviews to facilitate for the property owners to describe to which extent of energy efficiency they normally are implementing at renovation. The four levels are defined as follows:

- **Daily maintenance**: which accounts for daily operation and maintenance and provides up to 4 percent energy efficiency.
- **Level 1**: which corresponds to maintenance/light renovation with about 15 percent energy efficiency.
- **Level 2**: which stands for standard improvement with about 30 percent energy efficiency.
- **Level 3**: representing a deep renovation with an energy efficiency of about 50 percent for apartment buildings and schools and 40 percent for offices.

The gathered information was then used to construct likely setups representing how the entire sector is acting, and this was used to simulate and illustrate different scenarios, in a timespan from 2020 to 2050, in the program HEFTIG. Three different scenarios were performed:

- **Reference scenario**, a so-called snapshot of how far it is likely that energy efficiency will be done with the conditions and the view of renovation prevailing among the property owners today. Corresponding to a mix of all levels.
- **Energy-efficient renovation**, a case that shows the technical potential, based on economically reasonable grounds, if all property owners would realize extensive energy renovation at every renovation event. Corresponding to level 2.
Deep renovation, a scenario where complete renovation is carried out at each renovation event, which entails an increased technical potential for energy efficiency, based on economically reasonable grounds. Corresponding to level 3.

In order to further create the scenarios general information of the Swedish building stock is needed. First already renovated buildings for each building category and decade of construction were estimated with help of the property taxation register. These buildings were assumed to have no further energy efficiency within the scenarios time span.

Assumptions of future renovation rates for each building category allocated to different decade of construction were estimated with the present renovation rate and that buildings from the 1950s are assumed to be renovated over the next 20 years, buildings from the 1960s over the next 10-year period and other buildings to have a 40-year renovation cycle.

Finally, from the interviews results were distinguished between public and commercial building owners as well as co-operative apartment owners and their share of renovation within the four energy efficiency levels were estimated. A detailed presentation of the used values can be found in the two main reports [2].

2.3. Simulations

The combined result from the interviews and literature was analysed using a computer program called HEFTIG. HEFTIG is developed by the Swedish Energy Agency and enables long term simulations and visualization of energy efficiency measures for the Swedish building stock.

HEFTIG is a software with statistic data of energy use for the Swedish building stock and forecast of future energy use from the Swedish Energy Agency's. With HEFTIG it is possible to simulate and illustrate the influence of different energy measures on the total energy use of Swedish buildings. By entering information on energy measures e.g. changes in energy use for heat, hot water, operation and domestic electricity in kWh/m², the effect on the change in future energy consumption can be estimated.

The calculation can be done by keeping the Swedish Energy Agency's forecast on future energy demand or by making new scenarios starting from the level of a given year. HEFTIG was updated in May 2019 with new statistics on area and energy use in the building stock and the new forecast of future energy use from the Swedish Energy Agency's. The most recent statistical year is 2016.

For the calculations the energy measures impact on different categories of buildings must be defined. The impacts are specified as the measure being applied to a specified percentage of the building stock grouped by different building categories and decade of construction.

In this work new scenarios were estimated for the present situation (2020) and for future development to 2030, 2040 and 2050 instead of using the Swedish Energy Agency’s forecast.

3. Results

The results of the interviews show that energy efficiency in itself is not a driving force for renovation. They also show that the opportunities that exist for energy efficiency in connection with renovations are used to a very low degree in the current situation and that the energy efficiency that occurs is far from the technical potential. The energy efficiency that is being carried out mainly concerns measures that reduce the need for energy for heating, and it is difficult to streamline the use of electricity.

Renovation of housing is mainly due to maintenance needs and high maintenance costs. Schools and offices are mainly renovated due to the changing needs of the users’ activities and the need to improve the indoor environment (mainly ventilation). Planning of housing renovation largely depends on the possibility of evacuation, for schools it is the needs of the users’ activities and opportunity for evacuation and for offices renovation is done mainly in connection with tenant adaptation. Environmental certification has become a strong driver for new production of energy efficient building and is now starting to become interesting also for renovation.

The interviewees have some form of energy goals that most will achieve. Several of the real estate companies will set new goals within the next few years. The goals are expressed more and more in the form of climate impact and are more and more affected by local or regional sustainability goals. A
tendency that emerges in the 2019 interviews is that more and more focus is being placed on power efficiency as well.

3.1. Current situation 2020
First, the current situation, 2020, is estimated based on a renovation rate and efficiency levels identified by the two interview occasions from the statistic year 2016. Table 1, presents estimated energy savings from 2016 to 2020, for different building categories. The value in the 2016 column is from the statistics inserted in HEFTIG and the values in the 2020 column is the predicted current situation.

Table 1: Changes in purchased energy 2016-2020.

| Building category | Purchased energy for | 2016 (GWh) | 2020 (GWh) | Energy saving (%) |
|-------------------|----------------------|------------|------------|------------------|
| school buildings  | Heating              | 5 906      | 5 690      | 3.7              |
|                   | operation electricity| 2 954      | 2 910      | 1.5              |
| multi-family buildings | Heating          | 26 044     | 24 917     | 4.3              |
|                   | operation electricity| 10 018     | 10 039     | +0.2             |
| office buildings  | Heating              | 3 900      | 3 854      | 1.2              |
|                   | operation electricity| 3 289      | 3 138      | 4.6              |

The energy savings gained from the renovations between 2016 and 2020 is slightly lower than the ones estimated in 2016. Thus, the belief among the interviewees is that this delay will be recovered in the coming years.

3.2. Estimation of purchased energy from 2016 until 2050

3.2.1. School buildings. The estimated change in purchased energy for heating in school buildings is presented in Table 2 and for purchased operation electricity in Table 3. The values are the predicted current situation and future change in energy use when the different scenarios are applied.

Table 2: Purchased energy (GWh) for heating in school buildings for different scenarios.

| Reference scenario | 2020 | 2030 | 2040 | 2050 | Energy saving (%) |
|--------------------|------|------|------|------|-------------------|
| Energy-efficient renovation | 5 468 | 4 510 | 4 138 | 3 902 | 28.6              |
| Deep renovation    | 5 260 | 3 845 | 3 296 | 2 947 | 44.0              |

As can be seen, the potential, maximum energy savings, for deep renovation in purchased energy for heating, is three times greater than the predicted energy savings with the renovation at the current rate, i.e. the reference scenario. If an increase in ambition based on economically reasonable grounds is reached, energy-efficient renovation, energy savings for purchased heat can be doubled.

Table 3: Purchased operation electricity (GWh) in school buildings for different scenarios.

| Reference scenario | 2020 | 2030 | 2040 | 2050 | Energy saving (%) |
|--------------------|------|------|------|------|-------------------|
| Energy-efficient renovation | 2 924 | 2 857 | 2 831 | 2 815 | 3.7              |
| Deep renovation    | 2 879 | 2 711 | 2 648 | 2 606 | 9.5              |

The purchased operation electricity is expected to decrease according to the reference scenario. In energy-efficient renovation, electricity savings are expected to be lower than in the reference scenario due to the installation of more ventilation measures which allows for the increased recovery of heat.
The total predicted energy savings for renovations of the Swedish school building stock from 2016 to 2050 is 1 195 GWh or 13.5 percent.

### 3.2.2. Multi-family buildings.

The estimated change in purchased energy for heating in multi-family buildings is presented in Table 4 and for purchased operation electricity in Table 5. The values are the predicted current situation and future change in energy use when the different scenarios are applied.

**Table 4: Purchased energy for heating (GWh) in multi-family buildings for different scenarios.**

| Year   | Reference scenario | Energy-efficient renovation | Deep renovation |
|--------|--------------------|----------------------------|-----------------|
| 2020   | 24 917             | 23 780                     | 23 223          |
| 2030   | 22 249             | 18 425                     | 16 550          |
| 2040   | 21 343             | 16 603                     | 14 279          |
| 2050   | 20 509             | 14 625                     | 12 187          |

The potential, maximum energy saving for deep renovation in purchased energy for heating is 2.5 times greater than the predicted energy savings with the renovation at the current rate, i.e. the reference scenario. The reference scenario is a snapshot based on the assessments today. If an increase in ambition level based on economically reasonable grounds is reached, energy-efficient renovation, energy savings for purchased heat can be doubled.

**Table 6: Purchased operation electricity (GWh) in office buildings for different scenarios.**

| Year   | Reference scenario | Energy-efficient renovation | Deep renovation |
|--------|--------------------|----------------------------|-----------------|
| 2020   | 10 039             | 10 398                     | 10 018          |
| 2030   | 10 093             | 11 338                     | 10 018          |
| 2040   | 10 115             | 11 729                     | 10 018          |
| 2050   | 10 130             | 12 010                     | 10 018          |

The purchased operation electricity is expected to increase somewhat according to the reference scenario and be unchanged in the deep renovation scenario. For the energy-efficient renovation scenario, electricity consumption is expected to increase with 15 percent. This is due to the installation of improved ventilation and exhaust air heat pumps. The total predicted energy savings for renovations of the Swedish multi-family building stock from 2016 to 2050 is 5 423 GWh or 15 percent.

### 3.2.3. Office buildings.

The estimated change in purchased energy for heating in office buildings is presented in table 6 and for purchased operation electricity in table 7. The values are the predicted current situation and future change in energy use when the different scenarios are applied.

**Table 7: Purchased operation electricity (GWh) in office buildings for different scenarios.**

| Year   | Reference scenario | Energy-efficient renovation | Deep renovation |
|--------|--------------------|----------------------------|-----------------|
| 2020   | 3 854              | 3 680                      | 3 591           |
| 2030   | 3 775              | 3 325                      | 3 092           |
| 2040   | 3 743              | 3 184                      | 2 894           |
| 2050   | 3 723              | 3 104                      | 2 781           |

The potential, maximum energy savings for deep renovations in purchased energy for heating is six times greater than the predicted energy savings with the renovation at the current rate, i.e. the reference scenario. If an increase in ambition based on economically reasonable grounds is reached, energy-efficient renovation, energy savings for purchased heat can be four times higher.
The purchased operation electricity is expected to decrease for all three scenarios. The maximum savings from deep renovations is 1.5 times greater than the savings achieved in the reference scenario. The total predicted energy savings for renovations of the Swedish office building stock from 2016 to 2050 are 738 GWh or 10 percent.

3.2.4. Summary. Table 8 shows mean values for specific energy use (including household electricity and business electricity) in 2016 and 2050 together with the share of energy saving for the three scenarios and building categories.

Table 8: Mean value of total specific energy use (kWh/m²) for each building category year 2016 and for the three scenarios in 2050. The value in brackets shows share of energy savings.

|                                | Multi-family buildings | Offices | Schools |
|--------------------------------|------------------------|---------|---------|
| Actual use, 2016              | 162                    | 225     | 216     |
| Reference scenario, 2050       | 137 (15%)              | 202 (10%)| 187 (13%)|
| Energy-efficient renovation, 2050 | 119 (26%)              | 177 (21%)| 164 (24%)|
| Deep renovation, 2050         | 100 (38%)              | 163 (24%)| 135 (37%)|

3.3. Visualisation of the results

The results from the simulations in HEFTIG can also be presented using graphs, generated by the program. In Figures 1 to 6 the results for school buildings corresponding to the results in Tables 1, 2 and 3 are visualized. The dotted lines show how the current situation as a base line while the filled line show how much energy that need to be purchased each year for the scenario. The different colors in the graphs correspond to the levels of energy savings i.e. 4, 15, 30, and 50 percent respectively and each contribution to energy savings.

Figure 1: The change in purchased energy for heating, top, and the change in purchased operation electricity, bottom, according to the reference scenario.
4. Discussion

The building sector accounts for 21 percent of Sweden’s greenhouse gas emissions and the existing building stock accounts for 60 percent of that [1]. In order to reach the Swedish goal of a climate neutrality in 2045 [5] for the existing building stock large efforts must be done both to decrease the overall energy use as well as improving the energy production towards resources with less greenhouse gases.
With today’s degree of renovations, we will only reach between 10 and 15 percent of energy savings to 2050 with the base year 2016. Today we are not even close to reaching the technical potential of energy savings.

In order to reach a larger portion of energy savings, different measures can be used. The most feasible one is to increase the energy efficiency achieved in the already ongoing and planned renovation, i.e. moving from the presented reference scenario to the efficient renovation scenario or even to the deep renovation scenario. Another possibility is to implement policy instruments that increase the renovation rate i.e. the frequency in which renovations are done. However, before implementing such instruments, renovation of building envelope and services before reaching the technical or economical lifespan should be considered in comparison with emissions of using new materials and energy during the renovation.

The results of the interviews indicate, that some policy instruments are needed to increase the ambition of the building owners, if an extensively increase in energy savings should be reached.

The three scenarios show that the potential for energy efficiency in the course of renovation is significant, but that the opportunities available for energy efficiency in connection with renovation are used to a relatively low degree. The buildings that have already undergone renovation will not do so again in the near future and hence all future renovations need to take place according to the higher energy efficiency levels if the full energy efficiency potential is to be realized.

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