Regeringen

Ministry of Infrastructure

Sweden's Third National Strategy for Energy Efficient Renovation

Report pursuant to Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings.

Contents

1. Introduction

Sweden reported strategies for energy efficient renovation to the European Commission in 2014 and 2017 pursuant to the then applicable requirements of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.
The purpose of this report is to fulfil Article 2a of Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, which following amendments stipulates that each Member State must establish a long-term renovation strategy to support the renovation of the national stock of housing and buildings which are not intended for residential use, including both public and private buildings, to create a building stock with a high degree of energy efficiency where fossil fuels are phased out by no later than 2050, and to facilitate the cost-effective conversion of existing buildings to near-zero energy buildings.

The third strategy for energy efficient renovation forms part of Sweden's integrated national energy and climate plan pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council and Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council.

Sweden's third strategy for energy efficient renovation represents a further development of the two previous strategies. The implementation of previous strategies is described in *Annex 1*. In November 2018, the Swedish

Government instructed the Swedish National Board of Housing, Building and Planning (*Boverket*) and the Swedish Energy Agency (*Energimyndigheten*) to prepare a basis for the third strategy for energy efficient renovation[1]. The remit required the authorities to consult with relevant stakeholders regarding the content of the strategy. The consultation procedure is described in *Annex 2*. The final report on the assignment

was submitted to the Government Offices of Sweden (Ministry of Infrastructure) in December 2019.

1.1 Definitions and terms

A_{temp}: The area of all floors, attic floors and basement floors with temperature-controlled areas which are intended to be heated to over 10°C and that are bounded by the inside of the building envelope. The area occupied by interior walls or openings for stairs, shafts and similar is included. However, area in garages, in the building in a residential building or in non-residential premises other than a garage is not included (Swedish National Board of Housing, Building and Planning building regulations BFS 2011:6 – regulations and general advice).

Asymmetric information: Information that, in a perfect market economy, is assumed to be available to everyone is instead unevenly distributed between the parties that are to enter into an agreement or a financial transaction. One party has an information advantage and therefore knows more than the other.

The building's energy consumption: The energy that, for normal use during a normal year, needs to be supplied to a building (often referred to as 'purchased energy') for heating, comfort cooling, hot tap water and the building's property energy.

Property energy: The part of the property electricity that is related to the building's needs. This includes fixed lighting in public and technical areas.

Specific energy consumption: The building's energy consumption spread over A_{temp} expressed in kWh/m² and years. Household energy or business energy consumed in addition to the building's basic requirements for heating and hot water. Until June 2017 inclusive, specific energy consumption was used as an expression of the energy performance of a building.

[1] M2018/02768/Ee.

Energy performance: Since 1 July 2017, the energy performance of a building has been expressed as the primary energy demand, i.e. the various types of energy included in the building's energy consumption in accordance with the above are weighted and distributed over A_{temp}.

External effects: Effects that arise when one party in a market acts in a way that affects others without the party taking this into consideration in its decisions.

Household energy: The electricity or other energy consumed for household purposes. Examples of this include electricity consumption for dishwashers, washing machines, drying machines (including in communal laundry facilities), cookers, refrigerators, freezers and other household appliances as well as lighting, computers, TVs and other consumer electronics; see the Swedish National Board of Housing, Building and Planning building regulations BFS 2011:6) - regulations and general advice.

Profitability´: A measure is considered to be profitable if the expected saving exceeds the cost. In profitability calculations, the expected lifespan of the measure should be taken into consideration.

Market failure: Situations that lead to operators systematically making decisions that mean that society's resources are not being optimally used.

Trigger: 'Trigger' means a suitable point in a building's life cycle for carrying out energy efficient renovation. Examples of triggers include a sale, change of tenant/landlord, renovation or damage.

2. The national building stock

According to data from the real property register of the Swedish mapping, cadastral and land registration authority (*Lantmäteriet*)[2], there are just over 8 million buildings in Sweden, of which 37% are residential buildings. The most common type of building is what are small 'complementary buildings', e.g. free-standing outbuildings, garages and storage buildings. Complementary buildings account for 58% of the building stock. The remaining 5% comprise various types of non-residential buildings.

Table 1. Number of buildings in Sweden broken down according to their main purpose, 2018.

Purpose	Number of buildings
Housing	3,016,677
Industry	81,733
Social function	126,081

[2] The real property register is Sweden's official register of the division and ownership of land in Sweden. The register is regulated by Act (2000:224) on a real property register and Ordinance (2000:308) on a real property register.

Business	60,670
Agricultural buildings	34,721
Complementary buildings	4,696,479
Other buildings	141,042
Total	**8,157,403**

Source: Swedish Real Property Register.

2.1 The building stock's energy consumption and greenhouse gas emissions

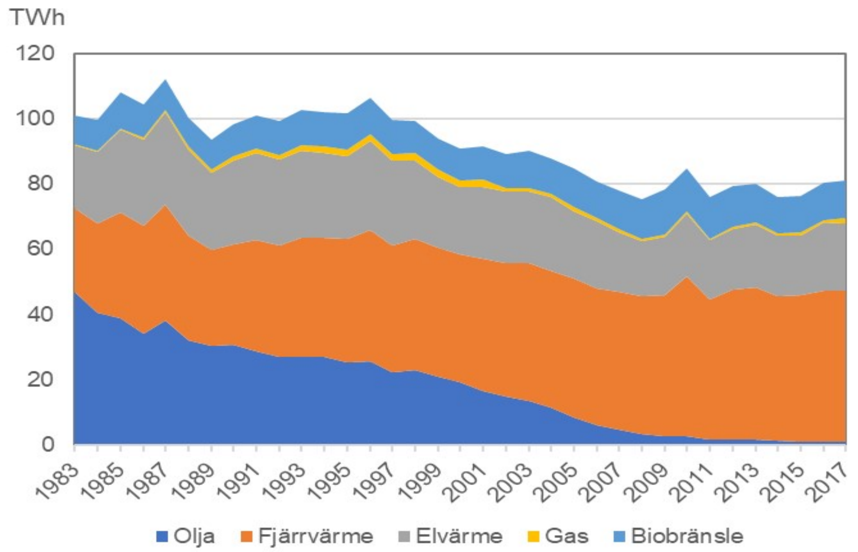
In 2017, the housing and services sector accounted for 39% of end-use energy consumption in Sweden[3]. The sector encompasses houses, apartment buildings and non-residential premises, including agricultural and forestry premises. Total end-use energy covers all energy that is consumed in buildings, i.e. household energy, business energy, property energy and energy for heating and hot water. Housing and non-residential buildings accounted for approximately 90% of total end-use energy in the sector, just over 132 TWh in 2017.

2.1.1 Energy consumption for heating and hot water

Heating and hot water normally account for approximately 60% of end-use energy consumption in the housing and non-residential premises sector. During 2017, 81 TWh were consumed for heating and hot water in the sector. Figure 1 shows the distribution per energy carrier over time for houses, apartment buildings and non-residential premises. The statistics for energy consumption for heating and hot water do not include 'property energy'.

Figure 1. Energy consumption for heating and hot water in houses, apartment buildings and non-residential premises, broken down by energy carrier.

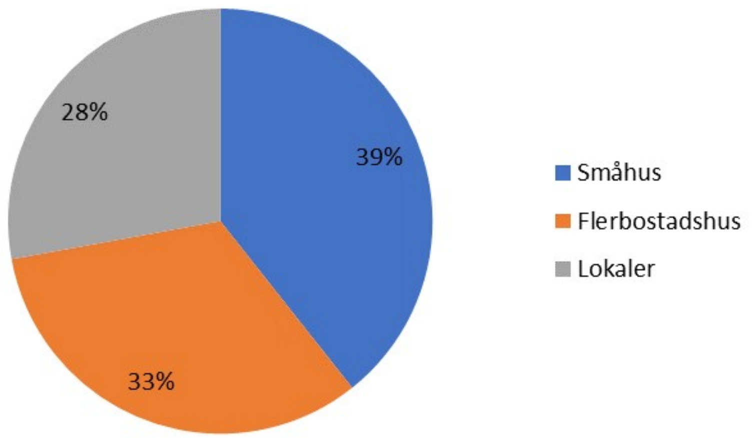
[3] *Energimyndigheten (2019), Energiläget i siffror 2019* [Swedish Energy Agency (2019), The energy situation in figures, 2019].



Source: Swedish Energy Agency.

The total of 81 TWh consumed for heating and hot water in 2017 was relatively evenly split between apartment buildings and non-residential premises. Houses account for a slightly higher proportion, as illustrated in Figure 2.

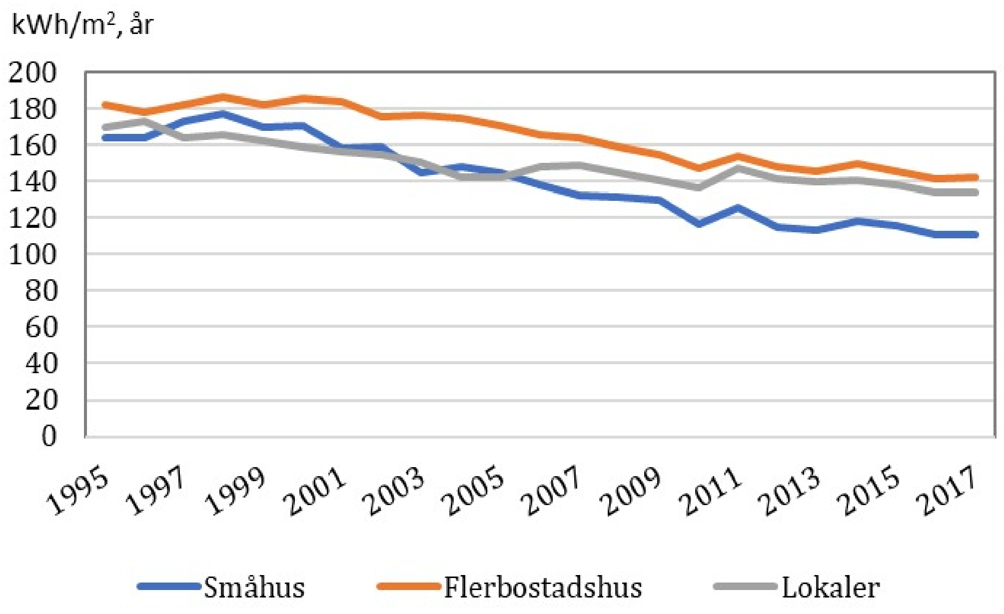
Figure 2. Distribution of energy consumption for heating and hot water in the housing and services sector by building type, 2017.



Source: Swedish Energy Agency.

The temperature-corrected mean energy consumption for heating and domestic hot water in housing and non-residential premises has a downward trend, as illustrated in Figure 3. During the period 1995-2017, temperature-corrected energy consumption decreased most in the ‘houses’ building category. Compared with 1995, energy consumption for heating and hot water fell by 33, 22 and 21% for houses, apartment buildings and non-residential premises respectively.

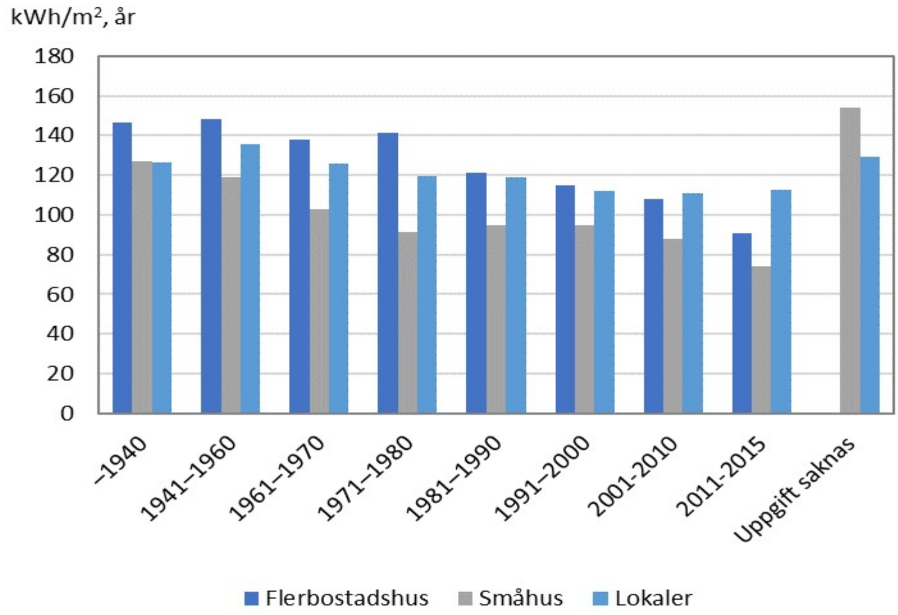
Figure 3. Temperature-corrected mean energy consumption for heating and hot water per unit area and building type.



Source: Swedish Energy Agency.

The energy required for heating and hot water in a building depends to a large extent on the construction of the house and its shape, insulation, windows, ventilation, technical solutions, etc. The mean energy consumption per square metre for heating and hot water therefore often varies depending on the year of construction. Figure 4 shows how the mean energy consumption for heating and hot water per square metre decreases significantly with the year of construction for apartment buildings and houses. A decrease can also be seen for non-residential premises, but this is less clear.

Figure 4. Mean energy consumption per m² for heating and hot water in 2016, by year of construction and building category.



Source: Swedish Energy Agency.

2.1.2 The building stock's greenhouse gas emissions

Greenhouse gas emissions for heating and hot water in buildings include both direct emissions from the combustion of fuels in the buildings, and emissions linked to the production of district heating and the generation of electricity for heating purposes.

As the main sources of energy for heating and hot water in buildings are district heating and electric heating (including heat pumps), direct greenhouse gas emissions from the combustion of fuels in buildings are low. In 1990, total greenhouse gas emissions from buildings amounted to just over 9.30 million tonnes of carbon dioxide equivalents and have since declined markedly to just under 0.89 million tonnes of carbon dioxide equivalents in 2018[4].

Relatively little fossil fuels are used in Sweden's electricity and district heating production. The proportion of energy supplied for electricity generation of fossil origin has been low since the 1980s, as electricity generation has been dominated since then by

[4] Swedish Environmental Protection Agency's emission statistics, www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaserterritoriella-utslapp-och-upptag/.

hydroelectric and nuclear power. In 2017, the proportion of fossil energy supplied for electricity generation amounted to approximately 2%[5].

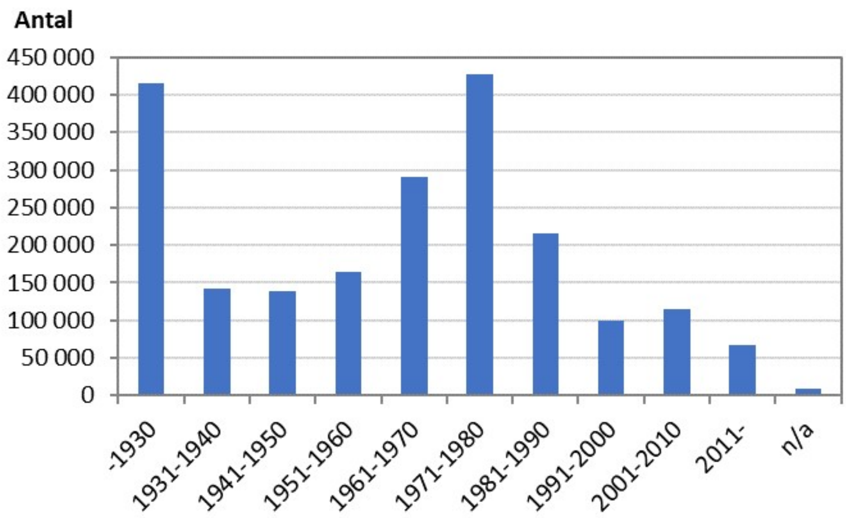
For district heating production, the fossil fuels coal, natural gas, oil and peat accounted for 6% of energy supplied in 2017. If other fossil fuels from waste heat and waste (where plastic is the largest source of fossil fuel) are included, the proportion of fossil fuels amounted to 22% in the same year[6].

Total greenhouse gas emissions from the production of electricity and district heating in Sweden amounted to almost 4.9 million tonnes of carbon dioxide equivalents in 2018 .[7].

2.2 Houses

In Sweden, 93% of residential buildings consist of houses. According to the Swedish apartment register, which excludes holiday homes, 20% of apartments in houses were constructed before 1930 and 45% were constructed during the period 1961 to 1990. The years of construction are shown in Figure 5.

Figure 5. Number of apartments in houses by year of construction.



Source: Statistics Sweden (SCB).

In total, houses in Sweden consumed just under 32 TWh of energy for heating and hot water in 2017. Electric heating (including heat pumps) represented the largest share and accounted for almost half of the energy consumption, while biofuels accounted for

[5] *Energimyndigheten (2019), Energiindikatorer 2019 – Uppföljning av Sveriges energipolitiska mål, ER:2019:11* [Swedish Energy Agency (2019), Energy indicators 2019 - Follow-up of Sweden's energy policy goals, ER:2019:11].

[6] *Energimyndigheten (2019), Energiindikatorer 2019 – Uppföljning av Sveriges energipolitiska mål, ER:2019:11* [Swedish Energy Agency (2019), Energy indicators 2019 - Follow-up of Sweden's energy policy goals, ER:2019:11].

[7] Swedish Environmental Protection Agency's emission statistics, www.naturvardsverket.se/Sa-mar-miljon/Statistik-A-O/Vaxthusgaserterritoriella-utslapp-och-upptag/.

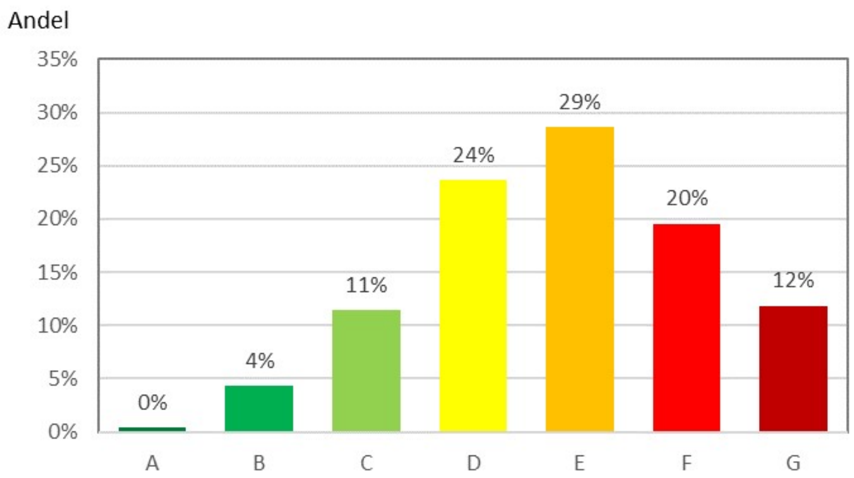
a third and district heating for 17%. Oil and gas collectively accounted for just over 2%[8].

In 2016, the heated area in houses amounted to a total of 302 million m^2 of gross living space and the mean energy consumption for heating and hot water was 106 kWh/m^2 (excluding property energy)[9].

Energy declarations had been issued for approximately 22% of houses, equivalent to 486,609 houses, in July 2019[10]. Existing houses do not need an energy declaration until they are sold, which explains the low proportion of buildings with an energy declaration.

The houses covered by energy declarations have a mean specific energy consumption of 100 kWh/m^2 A_{temp} and year, and a mean primary energy demand of 144 kWh/m^2 A_{temp} and year. The breakdown of houses for which energy declarations are available by class is shown in Figure 6.

Figure 6. Distribution of energy classes for energy-declared houses as of 1 July 2019.



Source: Energy Declaration Register.

Approximately 15% of houses covered by an energy declaration fulfil the requirement for near-zero energy buildings in Sweden, i.e. energy classes A-C. Energy classes D-E account for 3% of energy-declared houses and energy classes F-G 32%[11].

[8] *Energimyndigheten (2019), Energiläget i siffror 2019* [Swedish Energy Agency (2019), The energy situation in figures, 2019].

[9] *Energimyndigheten (2019), Energiläget i siffror 2019* [Swedish Energy Agency (2019), The energy situation in figures, 2019].

[10] Energy Declaration Register, 1 July 2019.

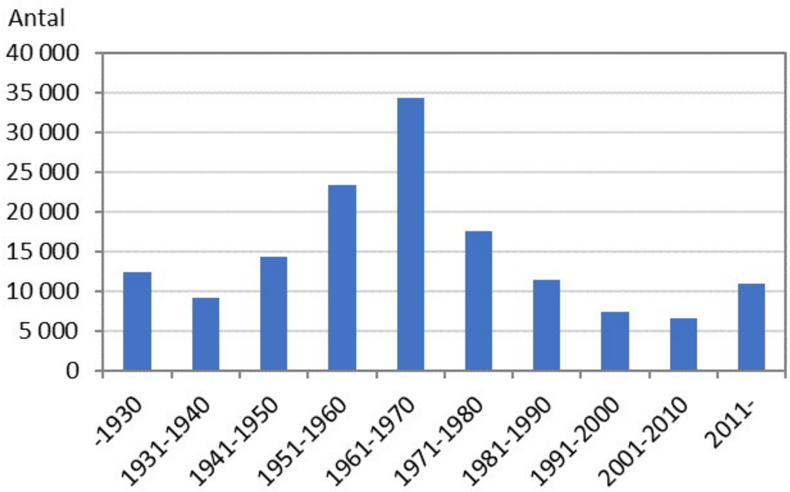
[11] Energy Declaration Register, 1 July 2019.

Of the energy-declared houses, 20,077, or 4%, use oil or gas for heating and hot water to some extent. Some of these buildings can use renewable gas or oil, but at national level these energy carriers mainly consist of fossil fuels. The information makes no reference to the extent to which these energy carriers are used, but all houses that have declared a consumption of at least 1 kWh of oil or gas are included.

2.3 Apartment buildings

Apartment buildings account for 5% of all residential buildings in Sweden. According to the apartment register, 61% of apartments in apartment buildings were built during the period 1941 to 1980; see Figure 7.

Figure 7. Estimated number of apartment buildings by year of construction, 2018.



Source: Statistics Sweden (SCB).

NB: Estimated number of apartment blocks based on the assumption of an average of 17 apartments per apartment building.

Of the apartments in apartment buildings, 27% are owned by the public housing sector, i.e. municipal housing companies, 41% by housing associations and the remaining 32% are under other private ownership[12].

In total, apartment buildings in Sweden consumed just under 27 TWh of energy for heating and hot water in 2017. In the case of apartment blocks, district heating is the overwhelmingly dominant energy carrier and accounted for 90% of hot water heating in 2017[13]. Electric heating, including heat pumps, accounted for 8%,

[12] *SCB, Statistikdatabasen* [Statistics Sweden, Statistical Database], table Number of apartments by region, building type, owner category and year (including specialist dwellings). Number of apartment blocks estimated based on the assumption of an average of 17 apartments per apartment building.

[13] *Energimyndigheten (2019), Energiläget i siffror 2019* [Swedish Energy Agency (2019), The energy situation in figures, 2019].

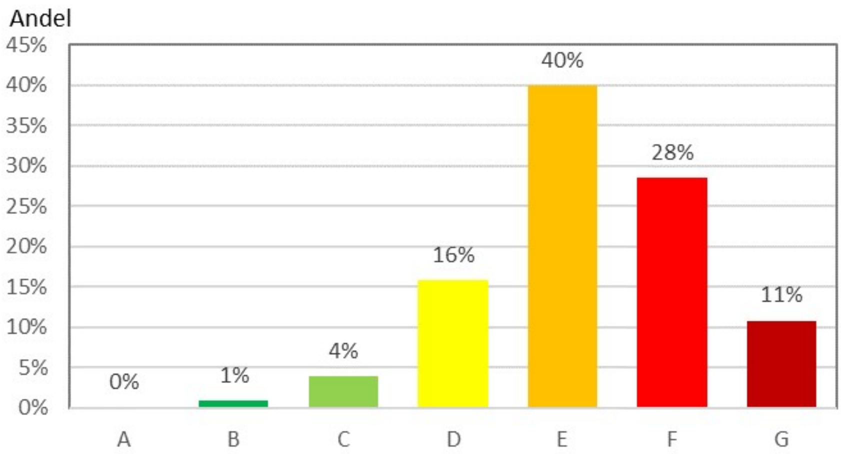
biofuels accounted for 2%, while oil and gas collectively accounted for just over 1%.

In 2016, the heated area in apartment buildings amounted to a total of 196 million m^2 of gross living space and the mean energy consumption for heating and hot water was 136 kWh/m^2 (excluding property energy)[14].

Approximately 63% of apartment blocks, equivalent to 104,453 houses, had an energy declaration in July 2019[15][16]. The majority of apartment blocks in Sweden have to have an energy declaration, but some property owners have not declared their property even though they are obliged to[16].

Declared apartment buildings have a mean specific energy consumption of 131 kWh/m^2 A_{temp} and year and a mean primary energy demand of 149 kWh/m^2 A_{temp} and year. The breakdown of declared apartment buildings by class is shown in Figure 8.

Figure 8. Breakdown by class for energy-declared apartment buildings, 1 July 2019.



Source: Energy Declaration Register.

In July 2019, approximately 5% of declared apartment buildings fulfilled the requirement for near-zero energy buildings in Sweden, i.e. energy classes A-C. The majority, equivalent to 79%, fulfilled energy classes E-G. The majority of apartment buildings in energy classes E-G were constructed during the period 1950 to 1979. These buildings make up 34% of the number of declared

[14] *Energimyndigheten (2019), Energiläget i siffror 2019* [Swedish Energy Agency (2019), The energy situation in figures, 2019].

[15] Energy Declaration Register, 1 July 2019.

[16] Section 6 of Act (2006:985) on energy declaration of buildings, Obligation to energy-declare buildings.

apartment buildings, but account for half of the total energy consumption by apartment buildings[17].

Of the energy-declared apartment buildings 5%, equivalent to 5,086 buildings, use oil or gas for heating and hot water to some extent. Some of these buildings can use renewable gas or oil, but at national level these energy carriers mainly consist of fossil fuels. The information makes no reference to the extent to which these energy carriers are used, but all apartment buildings that have declared a consumption of at least 1 kWh of oil or gas are included in this figure.

2.4 Non-residential premises

Non-residential premises include industrial buildings, buildings with a social function, buildings with commercial activity such as hotels, offices, commerce, restaurants or multi-storey car parks and agricultural buildings.

In this context, an agricultural building is defined as a building which consists of more than 50% non-residential premises. Non-residential premises can also form part of an apartment building or a house. According to the real property valuation register, there were approximately 3,500 houses and 52,150 apartment buildings containing both residential properties and non-residential premises in 2018.

The housing and services sector does not include industrial buildings, which are not required to have a declaration either. However, the sector does include non-residential premises, including agricultural and forestry premises. In total, these premises in Sweden consumed just under 23 TWh of energy for heating and hot water in 2017.

Amongst apartment buildings, district heating is the dominant energy carrier for non-residential premises. In 2017, district heating accounted for 74% of energy consumed for heating and hot water. Electric heating, including heat pumps, accounted for 16%, biofuels 3% and oil and gas collectively for just under 7%.

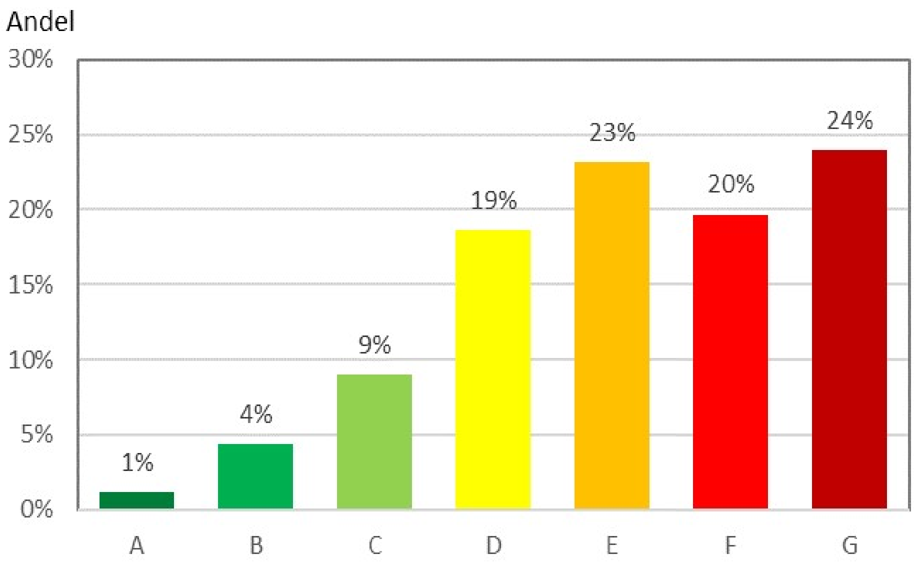
The heated area in non-residential premises in 2016 amounted to 176 million m^2 of gross living space, while the mean energy consumption for heating and hot water was 124 kWh/m^2 (excluding property energy).

[17] Energy Declaration Register, 1 July 2019.

In July 2019, there were 55,675 non-residential premises with energy declarations. The mean specific energy consumption for these buildings was 128 kWh/m² A_{temp} and year,

and the mean primary energy demand was 186 kWh/ m² A_{temp} and year[18]. The breakdown of declared non-residential buildings by class is shown in Figure 9.

Figure 9. Breakdown by class of declared non-residential buildings



Source: Energy Declaration Register.

Approximately 14% of declared non-residential buildings currently fulfil the requirement for near-zero energy buildings, i.e. energy classes A-C. The breakdown between energy classes D, E, F and G is relatively evenly split, with 19-24% of non-residential buildings in each class.

Offices and schools are the most numerous of the declared non-residential buildings and also consume the most energy. The most energy is consumed in offices in buildings constructed during the period 1960 to 1989 in energy classes E-G and in schools constructed during the period 1950 to 1989, again in energy classes E-G.

Of the declared non-residential buildings, 4,915 buildings, equivalent to 9%, use oil or gas for heating and hot water to some extent. Some of these buildings can use renewable gas or oil, but at national level these energy carriers consist almost exclusively of fossil fuels. The information makes no reference to the extent to which these energy carriers are used, but all

[18] Energy Declaration Register, 1 July 2019.

apartment buildings that have declared a consumption of at least 1 kWh of oil or gas are included in this figure.

2.5 Estimated proportion of renovated buildings and renovation rate

2.5.1 Renovation needs concerning apartment buildings

A study conducted by the Rise Research Institutes of Sweden AB (RISE)[19] shows that there is a 'renovation deficit' amongst Swedish apartment buildings. Many apartment buildings were constructed more than 50 years ago and many of them have been inadequately maintained and seen little renovation. As a result, their value year has not changed and remains their year of construction. The value year is an expression of the likely remaining life of the building, taking into account the year of construction, and any year of conversion and the scope of the conversion. The value year is equal to the year of construction if no conversion has taken place. The study assumed that renovation will be required if the value year exceeds 50 years. This is based on the Swedish Tax Agency's guideline value for the securing of value. For this reason, the value year of many of the buildings will exceed 50 years over the coming years, indicating that these buildings are in considerable need of renovation. The generally poor condition of the buildings means not only that substantial investments will be needed to protect their value and improve their standard, but also that there is considerable potential for energy savings to be made amongst the buildings.

The renovation rate for apartment blocks has increased over the past ten years compared with the previous decades, but the number of renovated buildings still does not match the number of buildings reaching a value age of 50 years. This means that the renovation deficit of the building stock is increasing and that the value of the building stock is not being protected. More renovations are being carried out today than during the 1990s, but while total renovations were common during the 1990s, less extensive renovations are usually carried out today. This means that the value year of the buildings will be adjusted to a lesser extent. However, buildings in which minor investments have been made on an ongoing basis may have a value year that is not fully in line with the actual standard of the building. This is because a new value year will only be assigned once the property owner has

[19] *RISE (2019), Forskningsrapport 2: Renoverings- och energieffektiviseringsscenarier* [RISE (2019), Research report 2: Renovation and energy efficiency improvement scenarios].

registered the renovation. This may result in the renovation deficit being overestimated.

2.5.2 Estimated proportion of renovated area

The proportion of the total area of apartment buildings, schools and offices that have already been renovated was estimated with the aid of the real property register (as of 2014) according to the following criteria:

- all buildings renovated at an investment cost corresponding to 70% of the new-build price;
- 75% of buildings renovated at an investment cost corresponding to 20-69% of the new-build price; and
- 25% of buildings renovated at an investment cost corresponding to 1-19% of the new-build price.

The values were then adjusted to 2016 with a renovation rate of 2.3% from 2014 to 2016[20]. The data concerns apartment buildings, but is assumed to also apply to schools and offices. A value cycle of 40 years was assumed. The proportion of the area assumed to be renovated and the proportion of the area in need of renovation are presented in Table 2.

Table 2. Estimated proportion already renovated in apartment buildings, schools and premises and proportion of area in need of renovation.

Year of construction	Proportion already renovated area	Proportion of area in need of renovation
Before 1940	13%	87%
1941-1960	13%	87%
1961-1970	18%	82%
1971-1980	12%	88%

Note: Only existing buildings in need of renovation are considered here. Buildings erected after 1980 are therefore excluded.

2.5.3 Renovation rate for apartment buildings, public offices and schools

The following assumptions were used concerning the renovation rate from 2016 for apartment buildings, private offices and schools:

- it is assumed that buildings from the 1950s will be renovated over the next 20-year period;

20 RISE (2019), *Forskningsrapport 1: Det senaste decenniets utveckling av energiprestanda, energiklass och renovering [Research report 1: Developments in energy performance, energy class and renovation during the past decade]*.

- it is assumed that buildings from the Million Programme (1961-1975) will be renovated over the next 10 year-period; and

- it is assumed that other buildings have a renovation cycle of 40 years.

This means that it is assumed that buildings constructed in or after 1981 will not start to be renovated until after 2020. The proportion of the total area that is renovated annually is presented in Table 3.

Based on information obtained from[20] interview-based studies conducted in 2019, a lower renovation rate was assumed for the period 2016 to 2019. However, it is assumed that the renovations that were not carried out will be carried out during the periods referred to above. Based on information obtained from the interviews, it was also assumed that public offices are renovated at the same rate as apartment buildings and schools.

Table 3. Estimated proportion of the total area of apartment buildings, public offices and schools that are renovated each year.

Year of construction	Estimated proportion of renovated area, 2016-2019	Estimated proportion of renovated area after 2019*
Before 1940	2.5%	2.5%
1941-1960	3.8%	3.8%
1961-1970	5%	10%
1971-1980	3.7%	7.4%
1981-1990	-	2.5%
1991-2000	-	2.5%
2001-2010	-	2.5%
After 2011	-	2.5%

* Annual proportion renovated until the entire area has been renovated. Start year for the renovation of houses built after 1980, commenced after 40 years.

[20] CIT, Wahlström and Glader (2019), *Nuläge och framtidsscenarier av renovering av byggnadsbeståndet – en analys i HEFTIG* [CIT, Wahlström and Glader (2019), Present situation and future scenarios of renovation of the building stock - an analysis using HEFTIG].

2.5.4 Renovation rate for privately owned offices and university premises

The following assumptions were used concerning the renovation rate from 2016 onwards for privately owned offices and university premises:

- older office premises (year of construction before 1961) are assumed to be renovated in the same way as apartment buildings from the same time period;

- for offices built during the period 1961 to 1980, it is assumed that 10% of the area will be renovated annually;

- for offices built during the period 1981 to 1990, the proportion renovated is assumed to be declining slightly compared with previous years; and

- it is assumed that more recent offices will not be renovated until they reach 20 years of age and thereafter at an annual refurbishment rate of 5%.

Based on information obtained from interview-based studies conducted in 2019[21], a lower renovation rate was assumed for the period 2016 to 2019. However, it is assumed that the renovations that were not carried out will be carried out during the periods referred to above.
It is assumed that university premises are renovated at the same rate as office premises. The proportion of the area that is estimated as being renovated per year is shown in Table 4.

Table 4. Proportion of the total area of private offices and university premises which are renovated each year.

Year of construction	**Estimated proportion of renovated area, 2016-2050**
Before 1940	2.5%
1941-1960	3.8%
1961-1970	10%
1971-1980	10%
1981-1990	5.2%
1991-2000	5%
2001-2010	5%

[21] *CIT, Wahlström and Glader (2019), Nuläge och framtidsscenarier av renovering av byggnadsbeståndet – en analys i HEFTIG* [CIT, Wahlström and Glader (2019), Present situation and future scenarios of renovation of the building stock - an analysis using HEFTIG].

After 2011	-

Note: Annual proportion renovated until the entire area has been renovated. In the case of buildings constructed after 1980, renovation is expected to commence after 40 years.

2.5.5 Renovation of houses

The most recent nationwide survey of the Swedish building stock, which covers houses, was conducted by the Swedish National Board of Housing, Building and Planning (*Boverket*) on behalf of the Swedish Government in 2008-2009. During the survey, known as *Byggnaders energianvändning, BETSI* (Energy consumption, technical status and indoor environment of buildings), 826 houses were inspected. The sample was selected with the aid of Statistics Sweden (SCB) because the survey was to cover buildings which represented the entire national housing stock.

The survey estimated that about 70% of all houses in the country had experienced some type of damage. Approximately 45% of the damage which was discovered consisted of damp-related damage, which could affect the indoor environment, but most damage and defects which were recorded were not serious in nature. Approximately 30% of all buildings had mould, mould odour or high moisture levels which could impact on the indoor environment. This corresponds to approximately 45% of all detected damage and defects.

Another important conclusion reached by BETSI was that a high proportion of the Swedish house stock is under-ventilated, i.e. ventilation flows in many Swedish houses do not comply with applicable standards. According to the study, in 2008, 75 TWh/year of heat had to be supplied to Swedish houses in order to compensate for the heat losses which occur as a result of the ventilation and the air turnover which was measured during the survey. According to BETSI, the mean air turnover in the house stock was just 0.23 l/s, m^2 and $A_{temp.}$ The Swedish National Board of Housing, Building and Planning building regulations (2011:6) - regulations and general recommendations (BBR) require a ventilation flow rate of 0.35 l/s, m^2 and A_{temp}. If the house stock were to comply with the ventilation flows required by the regulations, a further 5.4 TWh/year would have to be supplied to houses.

The renovation needs identified in BETSI probably still exist today, as the renovation rate in the 'house' category is generally low[22]. More data is needed concerning the rate of renovation of houses today, as no statistics are

[22] Study within the Swedish Energy Agency's client network for energy efficient improvements in houses, June 2019.

available concerning completed renovations. The category of house owners is a large, heterogeneous group with widely varying circumstances and priorities, which further complicates any estimation of the renovation rate.

2.5.6 Estimated proportion of renovated area 2020

Table 5 shows the estimated renovations carried out between 2016 and 2020. As stated previously, the rate is considered to be somewhat lower during this period than had been predicted in 2016.

Table 5. Expected proportion of renovated buildings (apartment buildings, offices and schools) in 2020.

Year of construction	Proportion of area already renovated, 2019	Expected proportion of renovated area, 2020
Before 1940	14.9%	15.4%
1941-1960	14.9%	15.7%
1961-1970	22.4%	25.2%
1971-1980	14.6%	16.0%
1981-1990	1.9%	2.0%
1991-2000	1.9%	1.9%
2001-2010	1.9%	1.9%
After 2011	1.9%	1.9%

3. Instruments and measures

Sweden has a number of instruments which offer incentives to improve energy efficiency in conjunction with renovation. Many instruments are complementary and aimed at correcting for various market failures linked to energy efficiency improvements and renovation, e.g. split incentives or lack of access to information. Instruments may also be aimed at accelerating a trend, so that adopted goals are attained at the lowest possible cost to society.

A general description of Sweden's existing instruments for energy efficiency improvements and reductions in greenhouse gas emissions can be found in Sweden's integrated national energy and climate plan; see section 3[23].

[23] https://www.regeringen.se/48edd1/globalassets/regeringen/dokument/sveriges-integrerade-nationellaenergi-och-klimatplan-enligt-forordning-eu-2018-1999.pdf.

3.1 Measures to promote energy efficiency improvements in conjunction with the renovation of apartment buildings

There is currently no consensus regarding which technical energy-efficient measures can be carried out profitably in conjunction with renovations. The primary reasons for this are that property companies have varying requirements regarding rate of return and profitability criteria, different financial circumstances and operate in different strong markets. These determine the thresholds at which investments are considered to be profitable.

This section describes an example of a systematic approach to identifying renovation needs and measures to improve the energy efficiency of apartment buildings. The *Rekorderlig Renovering* (Reliable Renovation) method is based on the principle of 'measure-for-measure' and takes into account the financial circumstances of the property owner when determining cost-effective measures. Property owners can use the method to determine which

individual energy efficiency measures are profitable and which offer benefits when included in the package.

As regards apartment buildings, major renovations in particular represent a suitable time (trigger) for carrying out energy efficiency improvements. Apartment buildings are estimated to have a renovation cycle of 40-50 years. Provided that apartment buildings follow their renovation cycle, this means that, from the 1950s onwards, apartment buildings will be in need of further major renovation within 20-30 years and apartment buildings erected during the period 1961-1975 within 10-20 years.

Other suitable times in the life cycle of apartment buildings for carrying out renovation which improve energy efficiency are in connection with a change of owner or tenant.

3.1.1 *Halvera Mera* and the *Rekorderlig Renovering* method

The *Halvera Mera* initiative has been carried out in three stages with the aim of disseminating information and raising awareness of the *Rekorderlig Renovering* method. This method was developed by members of the Swedish Energy Authority's client network for energy-efficient apartment buildings (BeBo).

The aim of the initiative was to identify cost-effective measures with a view to halving the energy consumption of buildings. The improvement in energy efficiency varies between the buildings concerned, but calculations indicated that energy consumption halved in 70% of the buildings[24].

The aim of *Rekorderlig Renovering* is to increase the degree of energy efficiency in conjunction with renovation and provide property owners with a systematic overview of the needs of individual buildings as regards renovation and energy efficiency improvements. It provides property owners with a basis for decisions regarding measures to improve energy efficiency in conjunction with renovation, with a focus on indoor environment, energy consumption and knowledge-building. *Rekorderlig Renovering* is carried out in three stages, as described below.

Preparation	**Implementation**	**Conclusion**
• Description of objectives	• Detailed design	• Commissioning (cont.)
• Preliminary study — present situation	• Physical conversion	• Monitoring of goal attainment and evaluation
• Preliminary study — measures	• Commissioning	• Experience feedback
• Finance	• Final inspection	
• Procurement		

Preparation **Implementation** **Conclusion**

During the first stage — Preparation — needs and circumstances are analysed and potential energy efficiency measures are then chosen and planned. A package of proposals for energy efficiency measures aimed at halving energy consumption is put together during the preliminary study, where the package as a whole is cost-effective as regards property economics. During the second stage – Implementation – all or some of the measures in the package are carried out. During the third and final stage – Conclusion – the results are followed up and cross-checked against calculated values.

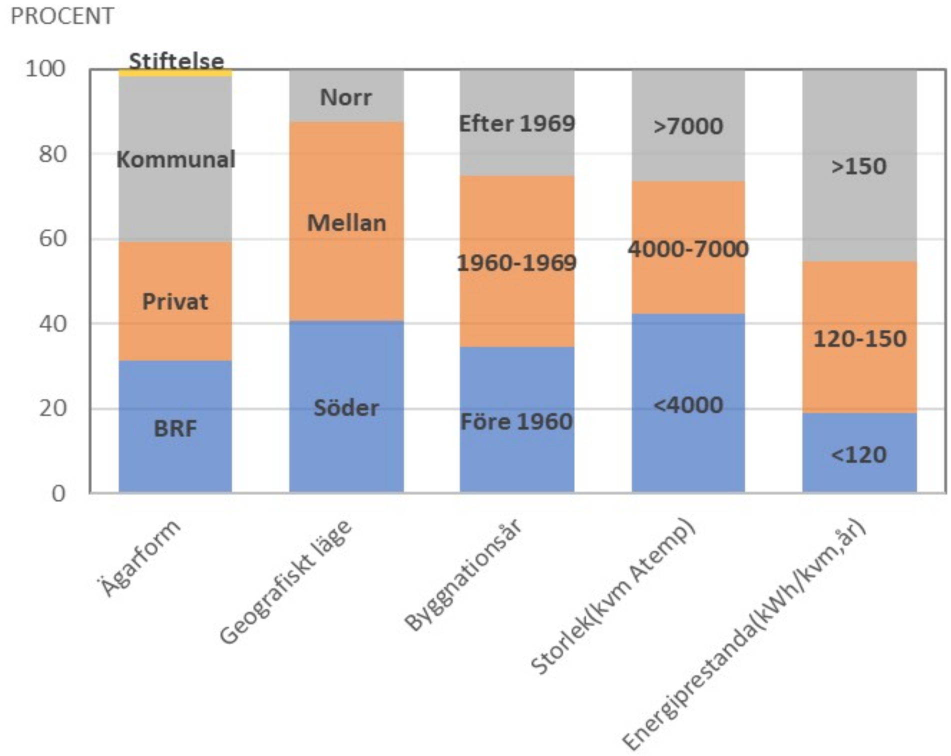
Through the *Halvera Mera* campaign, more than 60 projects have been carried out according to the first phase of the *Rekorderlig Renovering* method. Some projects have gone further and completed all three stages. For example, one housing association has cut its energy consumption by 67%, from 157 kWh/m² and year to 52 kWh/m² and year, after completing all three stages of *Rekorderlig Renovering.* Property owners who have taken part in *Halvera Mera* are relatively widely dispersed across the country. Participants come from northern, central and southern Sweden. The breakdown is

[24] *Westerbjörk (2019), Halvera Mera 1+2+3 – Analys*

[Westerbjörk (2019), Halve More 1+2+3 - Analysis].

shown in Figure 10. Property owners include municipal, private and housing associations. Most of the buildings studied during the first stage were erected before 1969, cover less than 7,000 square metres (A_{temp}) and have a relatively high energy consumption, equivalent to more than 120 kWh/m² per year.

Figure 10. Breakdown of buildings and property owners in *Halvera Mera* (1 + 2 + 3) by ownership, geographical location, age, size and energy performance.

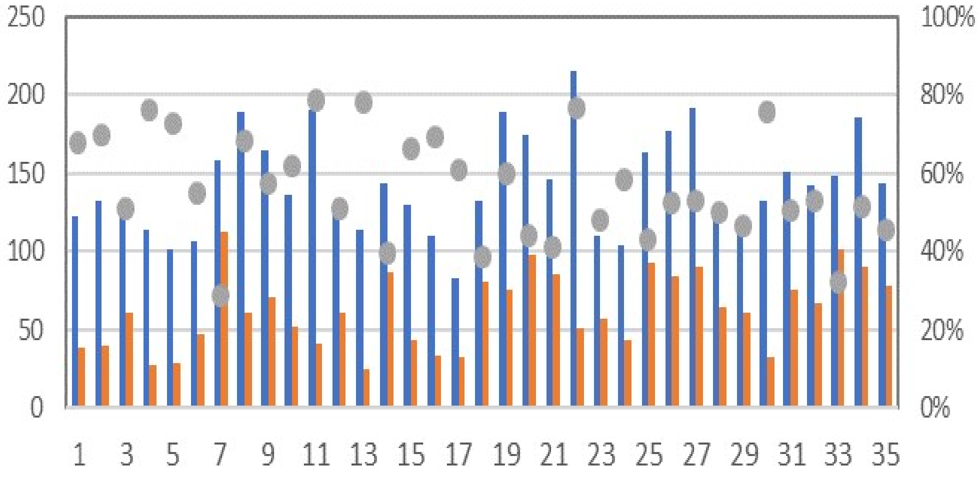


Source: BeBo.

The results for the buildings that were studied are shown in Figures 11 and 12. The figures show actual energy performance (present situation) and estimated potential energy performance if identified measures are implemented. The figures also show the percentage improvement in energy efficiency before and after the implementation of planned measures.

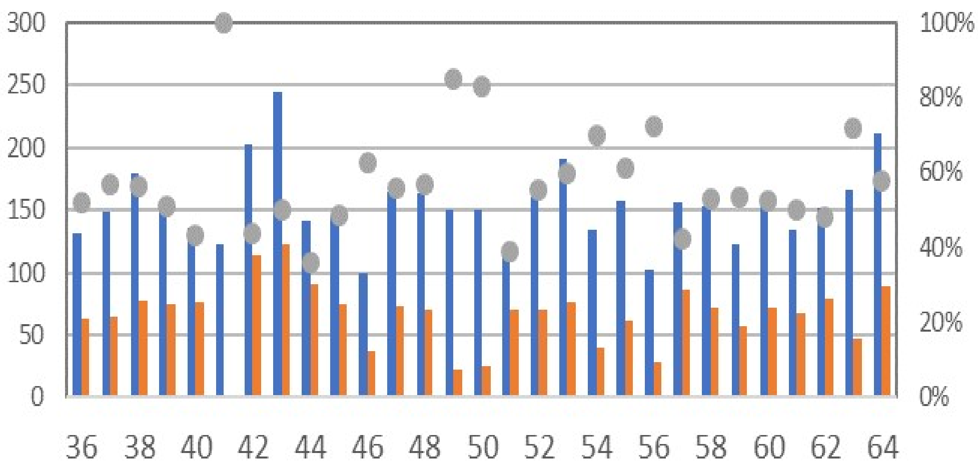
The degree of improvement in energy efficiency varies between the buildings studied, from 29% to 85%. On average, the studies showed a reduction in energy consumption of 61%, equivalent to a reduction of approximately 80 kWh/m² and year.

Figure 11. Improvement in energy performance for the respective projects (1-35). The bars show the energy performance before and after the calculated measures in kWh/m² and year. The dots show the percentage improvement for each project.



Source: BeBo.

Figure 12. Improvement in energy performance for the respective projects (36-64). The bars show the energy performance before and after the calculated measures in kWh/m² and year. The dots show the percentage improvement for each project.

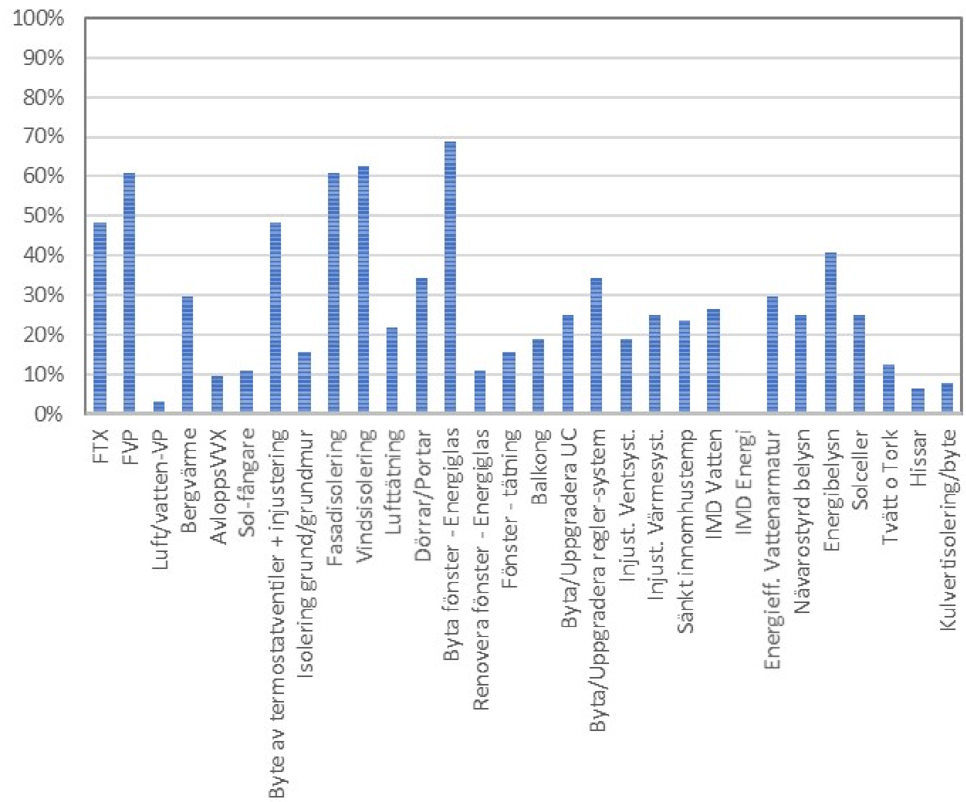


Source: BeBo.

The cost-effective energy efficiency measures in the packages calculated for the buildings in the study are shown in Figure 13. The most numerous measures are technical measures such as the installation of an exhaust heat pump (FVP) or ventilation with heat recovery (FTX), measures aimed at the building envelope, adjustment and replacement of thermostatic valves, and measures relating to control and regulation systems.

None of the preliminary studies included the measure involving the installation of individual metering and charging for heating (IMD Energy) as a cost-efficient energy efficiency improvement measure. For some buildings, the measure involving the installation of individual metering and charging for water (IMD Water) was considered to be a profitable measure. An analysis of the studies shows that properties with a high annual energy consumption per square meter are more likely to be able to identify cost-effective measures relating to the building envelope, such as the replacement of windows or the additional insulation of attics and façades. In the preliminary studies where energy consumption was already relatively low compared with other buildings in the study, measures involving operational adjustments such as adjustments to systems and presence control were more common.

Figure 13. Incidence of investigated measures in completed preliminary studies under *Halvera Mera*.



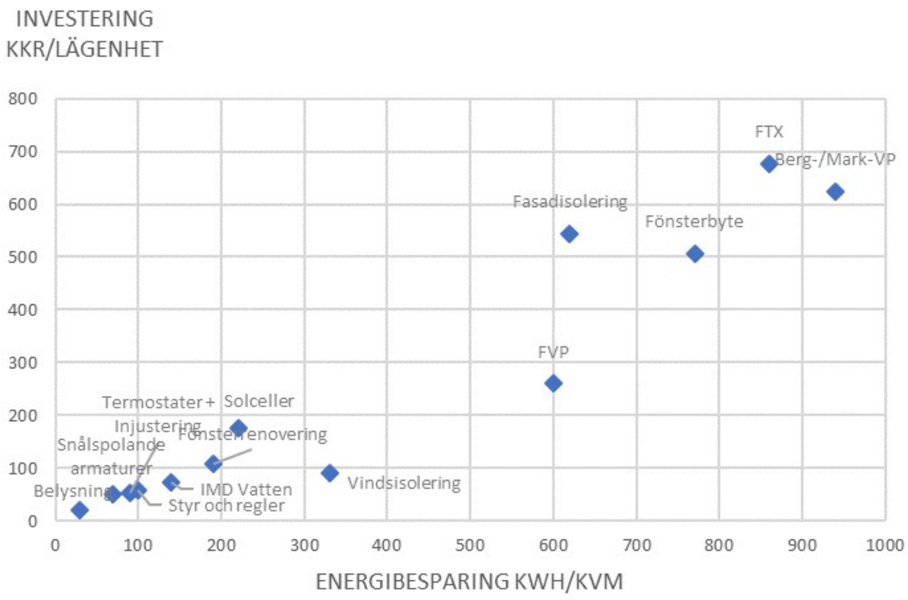
Source: BeBo.

The average investment cost and potential energy savings for the most common measures in the preliminary studies are shown in Figure 14. The Y axis indicates the total investment cost in thousand Swedish kronor per apartment, while the X axis indicates the total energy saving for various measures in kWh per square meter over the lifetime of the measure[25]. This gives a picture of the profitability of the proposed measures. The installation of FTX and ground heat pumps are the measures which offer the most potential as regards energy efficiency improvements. However, these measures are also linked to the highest investment cost. The insulation of

[25] According to BeBo, the lifespan is assumed to be 15 years for technical installations and 40 years for structural measures.

attics has a relatively low investment cost compared with the improvement in energy efficiency that the measure offers. The preliminary studies under *Halvera Mera* include an average of about eight measures, with a range of between two and sixteen.

Figure 14. Mean reduction in energy consumption over the lifetime of the measure and the cost per measure.



Source: BeBo.

3.1.2 National building-specific information

The national building-specific information (NBI) project carried out by RISE studied trends in energy performance, energy efficiency class and the renovation of apartment buildings over the past decade. The analysis was based on apartment buildings for which a second energy declaration was prepared in 2018 and for which a comparison with the first energy declaration issued in 2008 was possible. Data was based on the apartment buildings for which two energy declarations were issued in January 2019. In terms

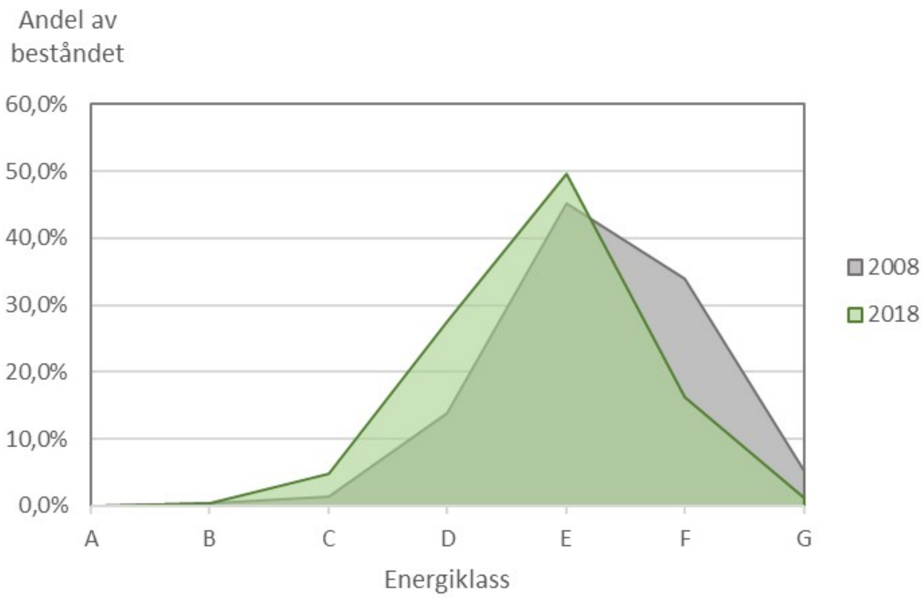
of area (A_{temp}), the apartment buildings studied accounted for just under 15% of the total area of energy-declared apartment buildings[26].

The study shows a marked improvement during the ten-year period. The

[26] RISE (2019), *Forskningsrapport 1: Det senaste decenniets utveckling av energiprestanda, energiklass och renovering [Research report 1: Developments in energy performance, energy class and renovation during the past decade].*

mean specific energy consumption decreased from 135 kWh/m² to 121 kWh/m². The distribution between energy classes in the energy declaration system showed a decrease in the proportion of buildings in the worst energy classes (F-G). The breakdown of buildings between the energy classes in 2008 and 2018 is shown in Figure 15.

Figure 15. Breakdown of energy classes in 2008 and 2018 respectively for buildings with two registered energy declarations in January 2019.



Source: RISE.

The comparison shows that buildings from energy classes D and E in particular have been recategorised to energy classes A-C following energy efficiency measures, i.e.
corresponding to the requirements for near-zero energy buildings. Buildings which have been recategorised from energy classes F and G have predominantly been reassigned to energy class E. Thus, the recategorisations which have taken place have primarily been minor. Recategorisation from energy classes F and G to energy classes A-C is unusual. However, the buildings that have been recategorised from energy classes F and G include a significantly higher heated area than those recategorised to A-C, as shown in Table 6.

Table 6. Recategorisation from energy classes D-G to energy classes A-C (near-zero energy standard) and from the lowest energy classes F and G to energy classes A-E between 2008 and 2018.

	A	B	C	D	E	F	G	TOTAL ATEMP ($10^3 m^2$)
To A–C				43.4%	40.0%	15.2%	1.4%	1,520

From F-G	-	0.3%	2.9%	18.1%	78.8%			7,950

Source: RISE.

An analysis of the scope of the renovations carried out on the studied buildings shows that more of the buildings recategorised to energy classes A-C and those recategorised from energy classes F and G following the completion of energy efficiency measures had undergone moderate or total renovation compared with other declared apartment buildings, as Table 7 shows. No renovation was carried out on more than half of the buildings recategorised to energy classes A-C which could be deduced from the energy declaration register. Amongst the buildings recategorised from energy classes F and G, almost 70% had not undergone any apparent renovation. This does not mean that these buildings had not undergone renovation, but that any renovation which had been carried out was not apparent from the register.

Table 7. Incidence of renovations over the past decade amongst the buildings recategorised to energy classes A-C from energy classes F and G, and amongst all buildings with two energy declarations in January 2019 and amongst the stock of apartment buildings.

	No renovation	**Light renovation**	**Intermediate renovation**	**Total renovation**	**Total A_{temp} (10^3 m^2)**
Recategorised to A–C	66.6%	15.8%	12.6%	1.38%	1,520
Recategorised from F and G	69.1%	16.7%	10.3%	1.44%	7,950
Reference: Apartment buildings with two declarations	73.2%	16.1%	7.95%	0.73%	32,600
All declared apartment buildings	79.8%	8.69%	7.83%	0.52%	224,000

Source: RISE.

The energy efficiency declaration register does not record exactly which energy efficiency measures have been carried out. However, it is possible to deduce from the energy declaration whether any changes have been made to the energy source used for heating purposes in the building or to the ventilation system, or whether solar cells have been installed. Just over 28% of the buildings which were recategorised to energy classes A-C have had exhaust ventilation with heat recovery installed, and just under 19% have had heat pumps installed. The proportion of buildings which have undergone these measures is higher in the group of buildings recategorised to energy classes A-C than in the other buildings studied. This indicates that these measures have been driving the recategorisation to energy classes A-C[27]. Table 8 shows how common the various measures are.

Table 8. Incidence of energy efficiency measures amongst the buildings recategorised to energy classes A-C from energy classes F and G, and amongst all buildings with two energy declarations in January 2019.

	Heat pump installed	**Solar cells installed**	**Exhaust ventilation with heat recovery installed**	**Installed FTX**	**Total A_{temp} (10^3 m^2)**
Recategorised to A–C	18.8%	5.33%	28.4%	9.83%	1,520
Recategorised from F and G	4.05%	2.10%	9.00%	10.0%	7,950
Apartment buildings with two declarations	2.45%	1.51%	6.22%	7.84%	32,600
All declared apartment buildings	-	-	-	-	224,000

Source: RISE.

Amongst the buildings recategorised from energy classes F and G, the proportion of buildings that have had exhaust ventilation with heat recovery and/or heat pumps installed is only slightly higher than in the other buildings studied. It is therefore likely that measures that cannot be deduced from the energy declaration, such as adjustments and other minor measures, were the driving force behind the recategorisation of these buildings from energy classes F and G[28].

The NBI project also facilitates an analysis of the results according to form of ownership, the building envelope, the scope of the renovation and the income of residents. This analysis shows that, although there has been an improvement in all segments of the stock studied over the ten-year period, the change was greatest amongst the buildings which initially had the poorest energy performance. The greatest change occurred amongst buildings erected during the period 1960 to 1975 and amongst buildings which had undergone total renovation. The analysis also shows a clear correlation between energy performance and income of residents, with residents'

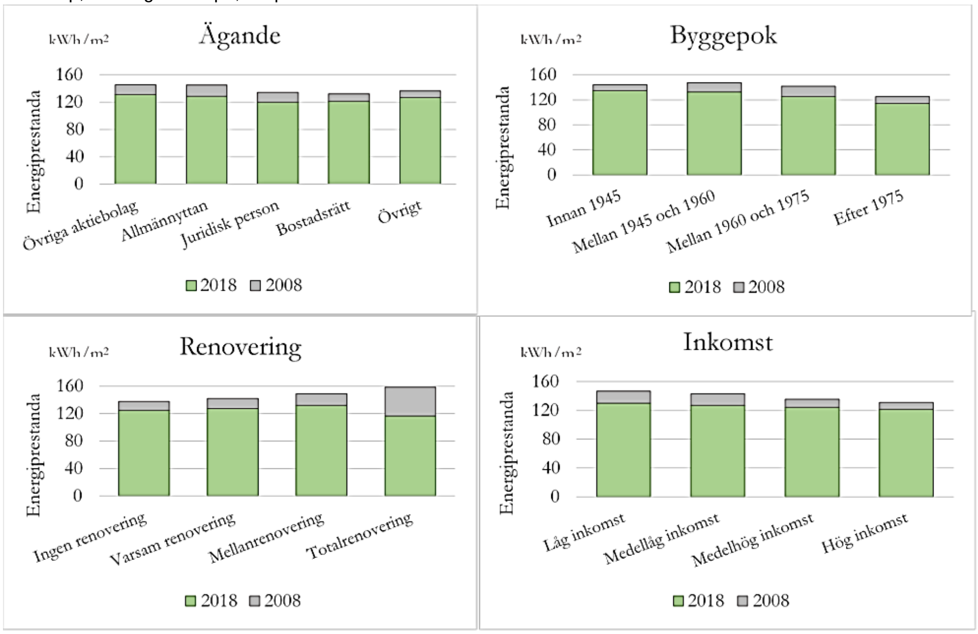
[27] RISE (2019), *Forskningsrapport 1: Det senaste decenniets utveckling av energiprestanda, energiklass och renovering [Research report 1: Developments in energy performance, energy class and renovation during the past decade].*

[28] *RISE (2019), Forskningsrapport 1: Det senaste decenniets utveckling av energiprestanda, energiklass och renovering [Research report 1: Developments in energy performance, energy class and renovation during the past decade].*

income being generally lower in the case of buildings with low energy performance, as

illustrated in Figure 16. The analysis of the other characteristics of the specific buildings shows that the buildings that have been recategorised to energy classes A-C generally consist of younger buildings erected since 1975 which to a large extent comprise tenant-owned apartments with relatively high income owners. As mentioned previously, heat pump solutions have been the principal driving force behind the recategorisation to energy classes A-C.

Figure 16. Studied buildings with two registered energy declarations in January 2019, broken down by form of ownership, building envelope, scope of renovation and residents' income.



Source: RISE.

The buildings recategorised from energy classes F and G generally consist of older public housing erected during the period 1945 to 1975. The incomes of residents occupying these buildings tend to be relatively low, and minor measures are the main driving force behind improvements in energy performance[29].

3.2 Energy efficiency measures in conjunction with the renovation of non-residential premises

There is also currently no consensus for non-residential premises regarding which technical energy efficiency measures can be carried out profitably in conjunction with renovations. The primary reasons for this are that property

[29] *RISE, Forskningsrapport 1: Det senaste decenniets utveckling av energiprestanda, energiklass och renovering* [Research report 1: Developments in energy performance, energy class and renovation during the past decade].

companies have varying requirements regarding rate of return and profitability criteria and different financial circumstances

and operate in different strong markets. These determine the thresholds at which investments are considered to be profitable.

Major renovation also represents a suitable time (trigger) to carry out energy efficiency measures for non-residential premises. In the event of a change in tenant, non-residential buildings can be adapted to meet the needs of the new owners, and renovation measures aimed at improving the energy efficiency of the building can also be carried out at the same time which would be difficult to carry out when the premises are in use. Another suitable time for carrying out energy efficiency renovation measures is when there is a need to improve the indoor environment. For example, when a building's ventilation system is to be improved, the energy efficiency of the building can also be improved at the same time by installing ventilation with heat recovery, which both reduces the energy demand of the building and improves the ventilation of the premises.

The way in which non-residential buildings are used determines how renovations are carried out. Schools and offices are assumed to have a renovation cycle of 40 years. It is therefore considered that schools dating from the 1980s will be in need of major renovation from 2020 onwards. Offices dating from the period 1981-1990 are considered to be in need of major renovation within 15 years and offices dating from 1960 to 1990 within 20 years.

3.3 Energy efficiency measures in conjunction with the renovation of houses

As regards houses, it is unusual to systematically plan and carry out major renovations where energy efficiency measures could be carried out at the same time. Most house owners are private individuals who form a diverse target group with widely varying priorities and circumstances.

Profitable measures to improve energy efficiency in conjunction with renovation are available[30], but most of the renovation measures which are realised in the house sector are in practice normally carried out immediately

[30] Study within the Swedish Energy Agency's client network for energy efficient improvements in houses, June 2019.

after a change of owner or in conjunction with changes in family situations and do not stem from a planned renovation need or a systematic approach.

A number of energy efficiency measures are relevant and can be considered to be cost-effective in conjunction with the renovation of houses in the right circumstances. Table

9 shows a number of measures which may be cost-effective and present an opportunity to improve energy efficiency.

Table 9. Energy efficiency measures for houses which may be profitable in conjunction with renovation.

Category	Measure
Control and regulation measures	Installation of control systems for direct resistive electric heating Installation of control systems for heating boilers Installation and adjustment of thermostatic valves
Hot water measures	Replacement of hot water heaters Installation of low-flush fittings
Window-related measures	Replacement of windows with windows with a U-value of 1.2 or better Addition of energy-efficient glass
Attic-related measures	Attic insulation
Door-related measures	Replacement of doors with doors with a requirement for U value = 1.0 or better

The installation of solar cells and the installation or replacement of heat pumps may also be included in possible energy-efficiency measures as regards houses, as these measures can improve energy performance in accordance with the energy management rules of the Swedish building regulations. However, like some other listed measures, they do depend on a building being in need of renovation.

3.4 Strategies and measures aimed at the segment ‘buildings with the worst energy performance’

Many of the existing instruments are relevant for buildings with the worst energy performance, but there are currently no instruments in place which are specifically targeted at this particular group.

On 1 December 2019, an amendment was made to Ordinance (2014:348) on the measurement of energy in buildings, which involved the establishment of certain requirements regarding the installation of a system for individual metering and charging (IMD) for heating and hot water. The IMD requirement may lead to apartment buildings with the worst energy performance being renovated and upgraded in terms of their energy efficiency. The requirements regarding the installation of IMD enter into force on 1 July 2021.

3.5 Strategies and measures aimed at problems caused by split incentives

'Split incentives' refer to an informative market failure, which stems from asymmetric information between the parties and can lead to energy efficiency investments not being carried out as a result of one party being responsible for investment costs while the other party benefits from the resultant energy savings.

Together with the Swedish Energy Agency, the Swedish National Board of Housing, Building and Planning has analysed the problem of split incentives amongst the existing building stock[31]. The study covered problems arising from split incentives in the existing stock of apartment buildings and non-residential premises, and in conjunction with new-build. The overall conclusion was that split incentives constitute a relatively minor obstacle to energy efficiency improvements, compared for example with profitability issues and knowledge-related obstacles. An important reason for this is that leases based on rent which include heating[32] dominate in Sweden, particularly in the apartment building sector.

If they are not formulated satisfactorily, both types of rent (i.e. with and without heating) can create problems as a result of split incentives, albeit of different types. Rents without heating give the user (tenant) an incentive to manage their energy consumption carefully, but the disadvantage that they reduce the property owner's incentive to make the building more energy efficient. This may result in energy performance-enhancing investments not being carried out, even though they would be profitable in terms of the overall economics of the property, i.e. at building level. In the case of rents which include heating, it is the users' incentive which is reduced instead. The study claims that leases which include heating have the major advantage that the incentive to improve the energy efficiency of a building rests with the party that is normally responsible for energy efficiency investments, i.e. the property owner. The property owner is also normally the party which is best

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[31] *Boverket (2013), Analys av delade incitament för energieffektivisering, rapport 2013:32* [Swedish National Board of Housing, Building and Planning (2013), Analysis of split incentives for energy efficiency improvements, report 2013:32].

[32] 'Rent which includes heating' means that energy costs are determined on the basis of a standard calculation and included in the rent, while 'rent which does not include heating' means that the charge is based on the actual consumption by the tenant.

informed regarding the building's technical solutions and the energy efficiency investments that would be profitable.

According to the study, split incentives are considered to be a bigger problem in the non-residential premises than in the housing stock. One reason for this is that leases which do not include heating are more common amongst non-residential premises.

The impending requirements concerning the installation of IMD relating to heating and hot water for certain apartment buildings[33] may impact on the issue of split incentives. From an incentive perspective, IMD for heating will lead to more similarity with leases which do not include heating, although IMD only covers the variable component of the energy costs and therefore cannot be compared with leases which do not include heating. The effects arising from the introduction of IMD will also depend on which IMD conditions the parties in the rental market agree on at local level.

A number of informative and administrative instruments are in place which address the associated market failure of asymmetric information and which are also considered to have a positive impact on split incentives. These include the Energy Labelling Regulation[34] and the Ecodesign Directive[35]. The main national strategies and measures being used to combat split incentives concern various state-funded project initiatives aimed at promoting the use of ‘green leases’. For more information about green leases see section 3.5.1 below.

3.5.1 Green leases

The fundamental elements of ‘green leases’ can be very broadly defined as cooperation between the parties, e.g. the property owner and tenant, the continuous exchange of information and monitoring to identify measures which would be profitable to carry out on a property, and the allocation of the incomes and costs that the investment measures will result in which are appropriate from an incentive perspective (proportionate). However, green leases need not only include cooperation concerning energy efficiency

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[33] See Section 3 of Ordinance (2014:348) on energy metering in buildings.

[34] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU.

[35] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.

measures, but may also include, for example, indoor environment, material selection and waste management.

Green leases are not in themselves state instruments. However, there are various state-funded project initiatives aimed at disseminating knowledge and promoting the use of green leases. The Swedish Energy Agency has for example previously granted aid to a project to develop standards for green leases relating to non-residential premises. The Swedish Energy Agency has also

recently developed an online course[36] and an information brochure[37] concerning green leases.

The Swedish Energy Agency's client group for energy efficient premises (BeLok) has carried out a survey of collaboration models, including green leases, which are available on the market and the way in which they are structured[38]. The study provides answers regarding, inter alia, the practical use of incentive agreements, as well as the needs and opportunities that exist regarding the development of the leases.

3.6 Strategies and measures aimed at problems caused by market failure other than split incentives

The potential market failures that Sweden is addressing through measures are, in addition to split incentives, negative externalities, asymmetric information and lack of information. Table 10 shows the existing instruments and potential market failures addressed by the instrument.

Table 10. Instruments, obstacles and market failures.

Instrument	Potential market failure
Economic instruments	
Energy and carbon dioxide taxes	Negative external effects
Tax deductions for ROT (Repairs, Conversions and Extensions)	Asymmetric information
The EU emissions trading system (EU ETS)	Negative external effects
Administrative instruments	

[36] https://www.energimyndigheten.se/nyhetsarkiv/2018/ny-webbutbildning-lar-dig-mer-om-grona-hyresavtal/.

[37] *Energimyndigheten (2017), Gröna hyresavtal, ET 2017:31* [Swedish Energy Agency (2017), Green leases, ET 2017:31].

[38] *Lundborg et al (2019), Kartläggning – Befintliga samverkansformer mellan fastighetsägare och hyresgäster* [Lundborg et al (2019), Mapping - Existing collaboration forms between property owners and tenants].

The Swedish National Board of Housing, Building and Planning building regulations (BBR)	Asymmetric information
The rent setting system	No market pricing (regulatory failure)
Ecodesign Directive	Asymmetric information
The Environmental Code's management provisions	Asymmetric information
Requirements regarding energy surveys by major companies	Lack of information (does not need to stem from any market failure)
Informative instruments	
National Renovation Centre (NRC)	Lack of information
The information site 'Renoveringsinfo.se'	Lack of information
Information Centre for Sustainable Construction (ICHB)	Lack of information

Instrument	**Potential market failure**
Energy declarations	Asymmetric information
The *Energilyftet* online course and other courses on low-energy construction under *Kunskapshöjande insatser* (Knowledge-enhancing initiatives)	Lack of information
The Framework Energy Labelling Regulation	Asymmetric information
Municipal energy and climate advice	Lack of information
The Swedish National Board of Housing, Building and Planning's guidance concerning the occupation of properties in conjunction with alterations and conversions	Asymmetric information Lack of information
Research and innovation	
Innovation networks	Asymmetric information Lack of information
Research	Lack of information

3.7 Measures which combat energy poverty

Sweden makes no distinction between energy poverty and general poverty, and therefore does not use the concept of energy poverty. The issue is managed within the context of social policy and there are no instruments in place which are specifically aimed at this issue.

3.8 Strategies and measures aimed at public buildings

Both the Energy Efficiency Directive[39] and the Energy Performance of Buildings Directive[40] require public authorities to lead by example through the early implementation of energy efficiency improvements.

In 2019, the Swedish public sector comprised a total of 340 public authorities[41], 290 municipalities and 21 regions. In Sweden, the requirement in Article 5 of the Energy Efficiency Directive covers buildings which are owned by central government administrative authorities, as well as the courts of law. Sweden opted to transpose Article 5 by imposing an energy-saving obligation on such buildings for the period 2014-2020. Two authorities, the National Property Board Sweden and the Swedish Fortifications Agency, own the vast majority of the buildings and are also responsible for most energy consumption. In order to promote cost-effective measures and low administrative costs,

the energy requirement, which is calculated for all public authority buildings, must be fulfilled by these two dominant property owners. A new energy-saving requirement will be established for 2030.

3.8.1 Environmental management systems in central government

Since 2009, Ordinance (2009:907) on environmental management of public authorities has laid down requirements regarding the establishment and development of environmental management systems and regarding the annual monitoring and reporting of the results of the work. In 2019, 187 government authorities were covered by the ordinance. The main steps in the process are the performance of an environmental goals study, the establishment of an environmental policy with environmental goals for the organisation, and the development of an action plan for attainment of the goals. An annual audit must be carried out to monitor the effectiveness of the environmental management system and the level of compliance with the environmental regulations and other governing documents regarding the authority's environmental management and work. The results of the environmental management work are reported annually to the Swedish Environmental Protection Agency, which collates the results in a report to the Government. According to the ordinance, the environmental management system must include a requirement for the authority to use energy-efficient IT to ensure that its activities are environmentally friendly.

[39] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

[40] DIRECTIVE 2010/31/EU of the European Parliament and the of the Council of 19 May 2010 on the energy performance of buildings.

[41] http://www.statskontoret.se/var-verksamhet/forvaltningspolitikens-utveckling/arliga-uppfoljningar/, downloaded 29.10.2019.

This could include an IT system for controlling and regulating lighting, heating, ventilation and energy efficiency improvements to equipment.

3.8.2 Purchases of energy-efficient products, services and buildings by authorities

Ordinance (2014:480) on the purchase by public authorities of energy-efficient goods, services and buildings requires public authorities to procure energy-efficient goods, services and buildings above threshold values, subject to certain conditions. The work is reported to the Swedish Environmental Protection Agency, which in turn reports to the Government Offices of Sweden.

3.8.3 The Energy Efficiency Council

The Energy Efficiency Council, which was set up in 2010 in accordance with a proposal in the Government Bill (prop. 2008/09:163) *En sammanhållen klimat- och energipolitik - Energi* [An integrated climate and energy policy - Energy], is tasked with strengthening inter-agency cooperation and facilitating coordination of the implementation and follow-up of measures and instruments in order to achieve the energy efficiency goals adopted by the Swedish Parliament. The Council is appointed by the Swedish Energy Agency and acts as an arena where strategically important issues are raised to strengthen inter-agency cooperation and increase transparency within the area of energy efficiency, including with regard to procurement by central government authorities and measures to improve energy efficiency.

The Energy Efficiency Council is an advisory body and meets four times a year.

3.8.4 The Offentliga fastigheter Collaboration Fund

Offentliga fastigheter (Public Properties) is a collaboration fund between the Swedish Association of Local Authorities and Regions and three state property managers, which has been in existence since 1994. Offentliga fastigheter acts as a forum for the exchange of experience and the development of shared issues within the field of property management. At present (2019), there are a number of energy-related focus areas, such as lighting in public premises, renovation involving energy efficiency measures, energy-efficient schools, and low-energy construction in the state, municipality and county council sectors.

3.8.5 Municipal energy planning

According to Act (1977:439) on municipal energy planning, every municipality must establish an up-to-date plan for the supply, distribution and use of energy. This plan must include, inter alia, the municipality's assessment of developments within the energy sector and the measures that the municipality intends to implement which will impact on energy consumption and energy supply. Since 2018, there has been an additional requirement for a strategic environmental assessment to be carried out if a plan which is established in accordance with this law can be expected to have a significant impact on the environment.

3.9 Overview of national initiatives to promote smart technology and the connection of buildings

One of the two secondary goals of the digitalisation policy is that Sweden must have world-class broadband. All households and businesses should be well-placed to make use of electronic public services and broadband services[42]. The Government has developed a broadband strategy for a fully connected Sweden in 2025[43]. Since 2009, rapid developments have been taking place in both broadband roll-out and broadband use. In 2018, 81% of all households and businesses had access to broadband with a speed of at least 100 Mbit/s[44]. In the same year, approximately 77% of households had access to a fibre network, which represented an increase of almost five percentage points compared with the previous year.

3.9.1 National research programmes and projects to promote to promote smart technology in buildings

Viable Cities

Viable Cities, the strategic innovation programme for smart and sustainable cities, is the largest programme ever carried out in Sweden within research and innovation concerning smart and sustainable cities. Viable Cities is led by KTH Royal Institute of Technology and brings together around 50 stakeholders from a wide range of research fields, industry, public services and civil society. The programme extends over a 12-year period from 2018-2029 and has a total programme budget of SEK 1 billion.

[42] Prop. 2009/10:193, bet. 2009/10:TU18, rskr. 2009/10:297

[43] https://www.regeringen.se/informationsmaterial/2016/12/sverige-helt-uppkopplat-2025---enbredbandsstrategi/.

[44] *Post- och telestyrelsen (2019), PTS mobiltäcknings- och bredbandskartläggning 2018, PTS-ER-2019:5* [Swedish Post and Telecom Authority (2019), Swedish Post and Telecom Authority mobile coverage and broadband survey 2018, PTS-ER-2019:5].

Smart Built Environment

Smart Built Environment is part of a joint initiative concerning strategic innovation programmes being run by Formas (a Swedish research council for sustainable development), Vinnova (Sweden's innovation agency) and the Swedish Energy Agency. The aim of this initiative is to establish the right conditions for international competitiveness and sustainable solutions to global societal challenges. The programme was launched in 2016 and will run for 12 years.

Smart City Sweden

In 2018, a number of steps were taken to bring together and establish Smart City Sweden as the national demonstration platform for smart solutions in sustainable cities. A framework agreement was signed with a supplier which will be responsible for operating and developing the platform. The work of Smart City Sweden has been developed and, in addition to energy and environmental issues, the platform will address issues such as planning and construction, digitalisation, social sustainability, mobility and other issues of relevance to sustainable urban development. The new initiative also includes the linking together of regional initiatives in Sweden.
The outreach work will be reinforced during 2019 with six regional nodes. From its launch in May 2017 through to mid-2019, Smart City Sweden received a total of more than 3,600 visitors, more than half of whom were international visitors. Initiatives will take place between 2018-2021 and have a budget of SEK 100 million.

Research to promote integrated and sustainable societal development

In 2017, the Government instructed Formas to develop a ten-year national research programme concerning sustainable societal development in collaboration with other research finance institutions. The programme covers approximately SEK 100 million per year for the period 2019-2026.

4. Aid to promote the mobilisation of investments

In Sweden, it is the property owner that bears the main responsibility for maintenance and for investments and reinvestments in their building. An unusual feature amongst Swedish rental properties, particularly on the housing side, including tenant-owned dwellings in the apartment building stock, is that rents include heating and hot water costs. This gives the property owner an incentive to carry out energy efficiency improvements on the building, and the incentive structure for renovations which include energy efficiency improvements differs from that in the case of rents which do not include heating, i.e. if the tenant had paid for heating and hot water separately instead[45]. Another unusual feature is the Swedish rent-setting system for housing (the so-called ‘utility value system’), which makes a clear distinction between maintenance measures and measures which improve the standard of the building. Only measures in the latter category give entitlement to increase rents, which means that energy efficiency measures in themselves must be profitable for the property owner. As a result, property owners have slightly less incentive to carry out measures which are not considered to improve the standard of a building.

A further unusual feature is that, unlike individual apartments, entire properties generally consist of rental apartments. In these circumstances, it is often in the interest of the landlord that the property as a whole is energy-efficient.

According to Article 17 of the Energy Efficiency Directive[46], ‘Member States shall encourage the provision of information to banks and other financial institutions on possibilities of participating, including through the creation of public/private partnerships, in the financing of energy efficiency improvement measures’. The Swedish National Board of Housing, Building and Planning has created opportunities for banks and financial institutions to obtain information on the energy declarations of buildings so that they can issue ‘green loans’ or ‘green

mortgages’. This enables borrowers with energy-efficient residential properties to obtain preferential interest rates. These types of loans have arisen in response to demand and vary somewhat between the banks.

A relatively new financing instrument which has attracted increasing interest in recent years amongst various stakeholders, including property owners, is ‘green bonds’. ‘Green bonds’ are bonds where the capital is earmarked for projects and activities which help to improve the environment and sustainability in different ways. For example, banks and other credit institutions issue green bonds to finance the green loans that are offered to customers; see above. However, it has also become more common for municipalities and property companies, for example, to issue their own green bonds, which may be a financially more attractive alternative to traditional

[45] Rents which do not include heating are most common in the rest of Europe, with clear exceptions for Sweden and Finland. Both rents which include heating and those which do not give rise to ‘split incentives’ between property owners and tenants, albeit of different kinds. The term ‘split incentives’ refers to an informative market failure, which stems from asymmetric information between the parties and which could lead to energy efficiency investments not being carried out as a result of one party being responsible for investment costs while the other party benefits from the resultant energy savings. The problem ultimately stems from deficiencies in the wording of the tenancy agreement. ‘Green leases’ (incentive agreements) have been developed, particularly on the non-residential premises side, which are partly aimed at sharing costs and incomes in a way which incentivises both parties to carry out profitable measures which reduce the energy consumption of the building concerned. See Swedish National Board of Housing, Building and Energy Agency report 2013:32 for more on split incentives.

[46] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

bank loans. What sets green bonds apart, as compared with conventional bonds, is that the capital can only be used for green projects which meet the requirements of a specific framework and associated criteria established by the company. For example, one criterion for a property company may be that investments in renovation measures must also lead to a certain specified minimum improvement in the energy performance of the building.

Pension and insurance companies, including the state national pension funds, have shown increasing interest in investing in green products. For example, the Second Swedish National Pension Fund sets aside one percent of the total strategic portfolio for investments in green bonds[47].

A recent preliminary study carried out by BeBo presents an overview of the funding opportunities that are currently available for energy efficiency measures which are open to property owners in the Swedish market[48].

4.1 Aid to promote market introduction, technological development and innovation clusters

The procurement of technology is an instrument which is designed to initiate a market transition and disseminate new, more efficient technologies and methods, such as new products, systems and processes. Network-based procurement for technological development is a methodology which encompasses the entire decision-making process, from preliminary study and the buyers' group, to the specification of requirements

and dissemination, as well as the further development of more energy efficient technologies. This is for example used within areas such as heating and control, ventilation and lighting. The Swedish Energy Agency coordinates innovation clusters for housing (BeBo), commercial and public premises (BeLok), house-builders (BeSmå), the public sector which rents non-residential premises (HyLok) and food distribution (BeLivs). LÅGAN is a collaboration between the Swedish Construction Federation, the Swedish Energy Agency, the Swedish National Board of Housing, Formas, building contractors, construction clients and consultants which supports regional networks with regard to the construction of low-energy buildings.

The aim of these client groups and networks is to create a meeting place and a platform where government agencies, industry and academia can work together to develop energy-efficient methods, create good examples and give demonstrations,

[47] https://www.ap2.se/sv/hallbarhet-agarstyrning/integrering/grona-obligationer/.

[48] *Ekelin et al (2019), Kartläggning av möjligheter för grön finansiering av energieffektiviseringsåtgärder – Förstudie* [Ekelin et al (2019), Review of opportunities for green financing of energy efficiency improvement measures – Preliminary study].

etc. The network is working to test, introduce and evaluate new technologies, models and products, and to bridge knowledge barriers in the market. The network also acts as a meeting platform and brings together industry stakeholders, authorities and academia to create cooperation and engagement.

4.2 Risk mitigation measures for investors

The Swedish National Board of Housing, Building and Planning currently offers credit guarantees[49], which can be used to finance both the construction and conversion of residential properties. Credit guarantees can be provided both during construction and/or for end financing. Irrespective of when a credit guarantee is provided, it cannot amount to more than 90% of the Swedish National Board of Housing, Building and Planning's estimated market value. In the case of housing which is let under a cooperative tenancy right, up to 95% of the market value may be guaranteed. As credit guarantees can also be issued for loans for conversions, this instrument is considered to have some impact on the scope of energy efficiency improvement renovations, particularly as regards private and publicly owned apartment buildings.

4.3 Use of public funds to stimulate the private sector

On 1 October 2016, an aid scheme was introduced which was aimed at stimulating renovation and energy efficiency improvements to rental housing in areas facing socio-economic challenges[50]. The aid comprised two components - one concerning renovation and one concerning energy efficiency improvements. The renovation aid amounted to 20% of the cost of the renovation. This component of the aid went directly to the tenants through a rent discount over a seven-year period. The aid for energy efficiency improvements was calculated on the basis of the energy savings that would be achieved after the renovation. This component of the aid went to the property owner. In order to receive this component of the aid, the renovation had to result in an improvement in energy performance of at least 20%. It was not possible to apply for aid for renovation only or for energy efficiency improvements only, as this would not fulfil the purpose of the aid[51].

[49] Ordinance (2004:105) on state credit guarantee for loans for residential development, etc.

[50] Ordinance (2016:837) on aid for renovation and energy efficiency improvements in certain residential areas.

[51] *Boverket – Informationsbroschyr om stöd till renovering och energieffektivisering i vissa bostadsområden* [Swedish National Board of Housing, Building and Planning - Information brochure on aid for renovation and energy efficiency improvements in certain residential areas]
(November 2016), https://www.boverket.se/contentassets/ccd44b6e3e81436986c55391cf93570f/informationsbroschyr-om-stodtill-renovering-och-energieffektivisering-i-vissa-bostadsomraden_nov2017.pdf.

This aid was abolished following the Swedish Parliament's decision concerning the National Budget for 2019[52]. In order to fulfil existing commitments, SEK 165 million was earmarked for the funding for 2020[53].

Green bonds

The Government has instructed the Swedish National Debt Office (*Riksgäldskontoret*) to carry out, within the framework of the guidelines on public debt management and by 2020, an issue of green bonds, i.e. bonds which finance expenditure items in the budget relating to sustainable investments and projects. According to the remit, the choice of appropriate green expenditure should be based on the climate policy framework and the Government's climate and environment policy, which is followed up through the work relating to the national environmental goal and is reported to the Parliament.

Tax deductions for ROT (Repairs, Conversions and Extensions)

Tax deductions for ROT are a reduction in tax for the cost of labour relating to repairs, maintenance and alterations and extensions to residential properties. The deduction was introduced in 2008 with the aim of simulating the availability of labour and reducing undeclared work[54]. Some of the measures covered also contribute to more efficient energy use[55]. A natural effect of the ROT deduction is that it creates an incentive for property owners to carry out more renovations. On 1 July 2016, the tax reduction was reduced from 50% to 30% of the cost of labour.
The maximum aid is still SEK 50,000 per person and year. The aid is available to owners of houses, apartments and holiday homes, as well as tenant owners.

4.4 Guiding investments towards energy-efficient public buildings

Kommuninvest i Sverige AB

Kommuninvest i Sverige AB (Kommuninvest) is a credit institution owned by Swedish municipalities and regions, which offers financing solutions to municipalities and regions in the form of loans and advice. Kommuninvest

[52] Bet. 2018/19:CU1, rskr. 2018/19:83.

[53] Prop. 2019/20:1, bet. 2019/20:CU1, rskr 2019/20:96.

[54] Prop. 2006/07:94, bet. 2006/07:SkU15, rskr 2006/07:181 and prop. 2008/09:97, bet. 2008/09:FiU18, rskr. 2008/09:183.

[55] For house owners, the right to a tax deduction is for example granted for the drilling and installation of geothermal systems, along with the replacement of windows, doors and taps, additional insulation and the installation and replacement of ventilation systems. For individual tenants, only work relating to repairs, conversions and extensions that is carried out in the apartment gives entitlement to a tax deduction.

finances, inter alia, municipal housing companies, schools and hospitals. The credit institution is non-profit-making.

Kommuninvest offers special 'green loans', which cover energy efficiency improvements in the building stock, amongst other things. Loans may be granted to projects in apartment buildings which will result in a reduction in energy consumption per square metre of at least 15% compared with what is determined by the Swedish National Board of Housing, Building and Planning's building regulations (2011:6) — regulations and general recommendations. For non-commercial premises, the figure is a 20% reduction in energy consumption. In addition, Kommuninvest can grant credit for major renovations to existing buildings, provided that the reduction is at least 30% per square metre per year. Credit can also be granted with corresponding requirements for the renovation of partial systems in existing buildings[56].

State aid for the refurbishment of school premises

During the period 2015-2018, it was possible to apply for a state grant for the refurbishment of school premises in order to improve the learning and working environment and reduce the impact on the environment[57]. The contribution amounted to a maximum of 25% of the total cost of the eligible measures.

The Offentliga fastigheter Collaboration Fund

Offentliga fastigheter (Public Properties) is a collaboration fund between the Swedish Association of Local Authorities and Regions and three state property managers. Offentliga fastigheter acts as a forum for the exchange of experience and the development of shared issues within the field of property management. Within the framework of

the collaboration fund's operation, a number of reports and information products have been produced concerning the energy consumption of buildings[58].

4.5 Accessible and transparent advisory tools

Information Centre for Sustainable Construction

[56] https://kommuninvest.se/for-kunder/vara-produkter/grona-lan/berattigade-projekt-och-hallbarhetskriterier/, downloaded 31 October 2019.

[57] Ordinance (2015:552) on state aid for refurbishment of school premises and of outdoor environments around schools, preschools and holiday homes.

[58] http://offentligafastigheter.se/publikationer/energi.297.html.

Informationscentrum för hållbart byggande (Information Centre for Sustainable Construction, ICHB) was established on 1 January 2018 and is run by Svensk Byggtjänst AB on behalf of the Swedish National Board of Housing, Building and Planning[59]. On behalf of the Government, the Swedish National Board of Housing, Building and Planning regularly monitors the work and results of ICHB. The Swedish National Board of Housing, Building and Planning's remit on behalf of the Government will remain in force until 2021, and the agreement will be extended for only year at a time only following an evaluation. ICHB's remit is to 'promote increased energy efficiency in renovation and an energy-efficient construction with the use of sustainable materials and a low carbon footprint from a life-cycle perspective'. The remit involves the collection, customisation and dissemination of information on sustainable construction. The centre's website provides information on research, results and experiences. ICHB is aimed at all target groups: professional builders, house owners, board members of housing associations, property owners and others involved in the construction process in any other way[60].

Municipal energy and climate advice

Energy and climate advice has been provided in various forms for almost 40 years. A review was conducted in 2015 and new guidelines were adopted by the Government in the form of Ordinance (2016:385) on contributions to municipal energy and climate advice. The aim of this advice is to provide an impartial, free, technology-neutral and commercially independent service to households, businesses, housing associations and organisations. Advice can be provided by telephone or e-mail or through a personal visit.

All municipalities can now provide basic energy and climate advice. For municipalities in sparsely populated areas, additional support is available for coordination and travel in order to provide the advice. In addition to basic advice, municipalities can provide expanded energy and climate advice with additional financial support from the Swedish Energy Agency. The increased support should enable more

advice to be provided and will be run as a partnership between municipalities or projects focusing on a locally prioritised target group.

National Renovation Centre

[59] Svensk Byggtjänst AB collaborates with IVL Svenska Miljöinstitutet, Rise Research Institutes of Sweden AB, Energikontoren Sverige, the National Renovation Centre at the Faculty of Engineering, Lund University (NRC) and Sustainable Innovation (SUST).

[60] https://ichb.se/.

Nationellt Renoveringscentrum (National Renovation Centre, NRC) is organisationally and administratively attached to the Faculty of Engineering at Lund University and, by creating knowledge and disseminating information, aims to support various stakeholders in the construction sector in their efforts to carry out an efficient renovation process to ensure that existing buildings are energy-efficient and that their functions are maintained or improved in order to meet the changing demands of users and authorities. The aim is to make existing buildings more environmentally, economically and socially sustainable from a life-cycle perspective, with improved or maintained functioning to meet the demands of users and public authorities[61].

The website renoverings.se is a joint initiative by NRC and Svensk Byggtjänst AB. The aim of renoverings.se is to help stakeholders in the industry carry out efficient renovation processes through knowledge-buildings and information dissemination. This website collates debate articles, news, information on renovation projects, research information and information collated for specific renovation measures. The news section is behind a pay wall, while the rest is freely available.

5. Taxation of expected and potential energy savings and its effects in a broader sense

Estimates of expected energy savings have been prepared by Chalmers Industriteknik (CIT) through reference scenarios created using the 'HEFTIG' simulation program, which is a tool for calculating energy efficiency potential in the built environment[62]. The reference scenarios show how energy consumption in the built environment can be developed, provided that existing or equivalent instruments remain in place and provided that property owners continue to work in the same way as at present as regards energy efficiency improvements and renovation in their buildings.

5.1 Reference scenarios for energy efficiency as a result of renovation

The reference scenarios show the trend until 2050, assuming that existing or equivalent instruments remain in place and that property owners continue to work in the same way as at present as regards energy efficiency

[61] http://www.renoveringscentrum.lth.se/.

[62] HEFTIG was developed by Profu, WSP and CIT 2012 on behalf of the Swedish Energy Agency.

improvements and renovation of their buildings. Reference scenarios have been developed for apartment buildings, schools and offices. The process was based on an interview-based survey conducted amongst property owners in order to identify the current level of energy efficiency renovation and the intentions of the owners as regards energy efficiency improvements in the coming years[63]. The study was updated with interviews in 2019. The methodology used for the reference scenarios is described in more detail in *Annex 3*.

There is no reference scenario for houses. The underlying data is too diverse and no studies have been carried out for this category of buildings. By studying the national statistics, some improvement in energy performance is apparent amongst houses, but it is likely that this is due to changes in purchased energy (i.e. installation of heat pumps) and better new buildings rather than measures aimed at improving energy efficiency in conjunction with renovation.

The interviews which have been conducted show that although renovations and energy efficiency improvements are being carried out, the scope of the renovations and the degree of energy efficiency improvements varies. To calculate and visualise this, four levels of renovation and energy efficiency improvement are used:

- Level 0: Daily operation and maintenance with a 4% improvement in energy efficiency.

- Level 1: Maintenance/light renovation with a 10% improvement in energy efficiency.

- Level 2: Standard improvement with a 30% improvement in energy efficiency.

- Level 3: Total renovation with a 50% improvement in energy efficiency (40% for offices).

Each level is based on a blend of measures, which collectively constitute a package of measures which result in an improvement in energy efficiency at

[63] *CIT, Wahlström och Glader (2019), Nuläge och framtidsscenarier av renovering av byggnadsbeståndet – en analys i HEFTIG, underlag till Boverket och Energimyndigheten* [CIT, Wahlström och Glader (2019), Present situation and future scenarios of renovation of the building stock - an analysis in HEFTIG, basis for the Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency].

the level concerned. The measure packages were developed on a basis[64] which was created for the previous reporting of the strategy for energy efficient renovations, with measures for apartment buildings being based on 'Rekorderliga Renovering' projects[65] and measures in schools and offices being based on projects carried out in accordance with the 'total methodology'[66].

Examples of the measures included in the packages are described for apartment buildings in Table 11. The measure packages for schools and offices are similar, but differ slightly. This is shown in *Annex 3*.

Table 11. Measures for various energy efficiency improvement levels in conjunction with the renovation of apartment buildings.

	Ongoing maintenance	**Level 1**	**Level 2**	**Level 3**
Painting + sealing of windows/doors	Yes	Yes	Yes	-
Window replacement, U<1	-	-	-	Yes
Attic insulation, 300 mm loose wool	-	-	Yes	Yes
Façade insulation, 100 mm	-	-	-	Yes
New entrance/basement doors	-	-	Yes	Yes
Switch to low-energy bulbs	Yes	Yes	-	-
Presence-controlled LED	-	-	Yes	Yes
New fans	Yes	Yes	-	-
Replace thermostats/valves	-	Yes	Yes	Yes
Adjust heating	Yes	Yes	Yes	Yes
FVP 3.0	-	-	Yes	-
FTX η85 %	-	-	-	Yes
Adjust ventilation system	Yes	Yes	Yes	Yes
Low-flush fittings	-	Yes	Yes	Yes
Energy-efficient laundry rooms	-	Yes	Yes	Yes
IMD Heating and Hot water	-	-	-	Yes
Waste-HVAC	-	-	-	Yes
Total energy saving:	**4%**	**10%**	**30%**	**50%**

Source: CIT.

[64] CIT, Wahlström et al (2016), *"Fallstudier till HEFTIG", rapport till Energimyndigheten* [Case studies for HEFTIG, report to the Swedish Energy Agency].

[65] www.bebostad.se.

[66] www.belok.se.

The extent to which renovation and energy efficiency improvements are assumed to take place broken down between the four levels differs. The breakdown in each building category is shown in Table 12.

Table 12. Breakdown of estimated renovation level carried out by property owners amongst the existing building stock according to the reference scenario.

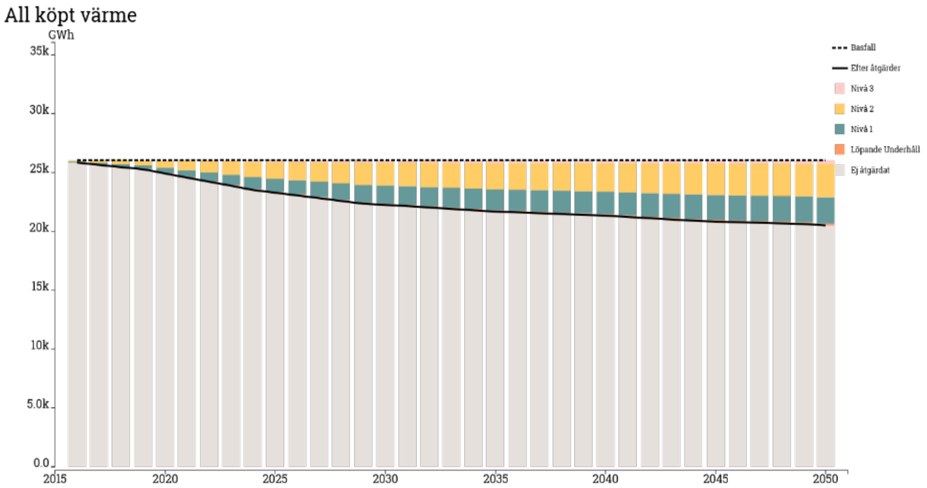
Proportion of apartment buildings (%)	**Private**	**Public**	**Tenant owner apartments**	**Total**
Level 0	10	15	25	18
Level 1	50	60	54	55
Level 2	35	24	20	26
Level 3	5	1	1	2
Proportion of schools (%)	**Private**	**Universities**		
Level 0	10	10		
Level 1	55	55		
Level 2	30	30		
Level 3	5	5		
Proportion of offices (%)	**Private**	**Public**		
Level 0	10	10		
Level 1	70	60		
Level 2	18	25		
Level 3	2	5		

Source: CIT.

The reference scenarios for apartment buildings, schools and offices show that in apartment buildings the baseline scenario gives a reduction of energy consumption due to renovation measures of around 15% by 2050 compared with 2015. For schools, the reduction is over 13%, while for offices, it is closer to 10%.

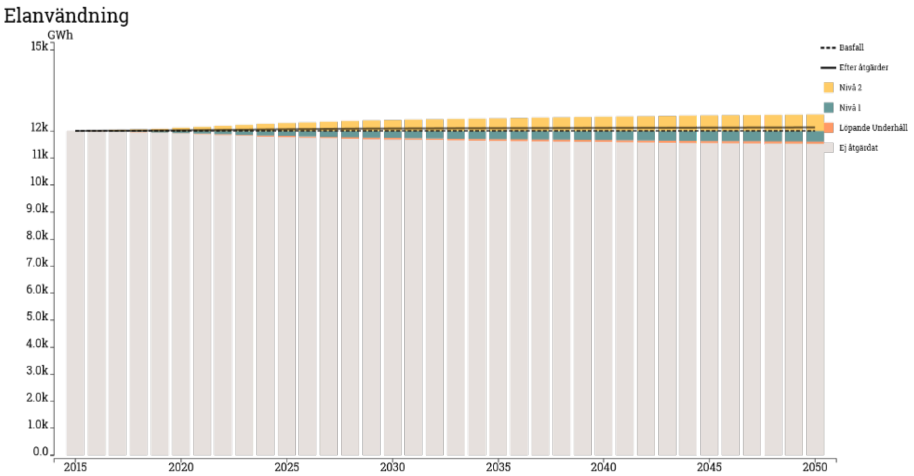
For apartment buildings, the reference scenario in Figure 17 shows that heat purchased for heating purposes and hot water decreases by over 17% through to 2050. However, Figure 18 shows that electricity consumption increases by approximately 1%, which is due to an increase in the use of electricity when energy efficiency improvements are carried out which involve the installation of ventilation with heat recovery where there was previously no mechanical ventilation. The electricity consumption includes electricity which is used for both commercial purposes and property purposes. Energy consumption for activities was not included in the scenarios, and cannot be separated from the statistics.

Figure .
17 Change in purchased heat in apartment buildings according to the reference scenario.



Source: CIT.

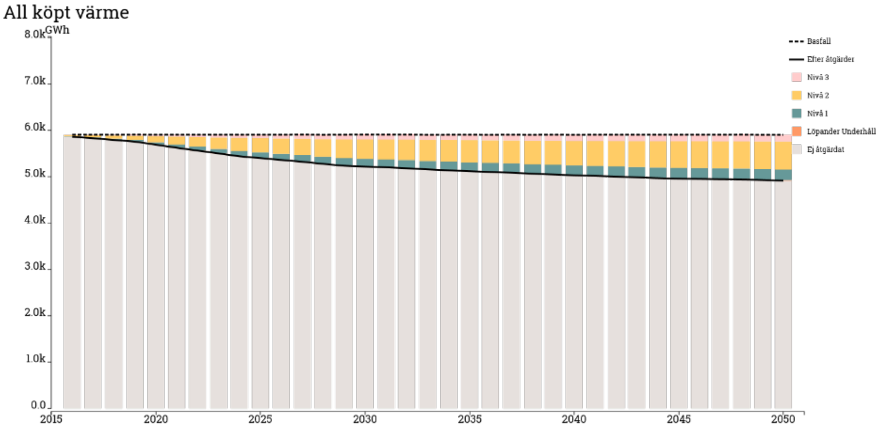
Figure 18. Change in purchased electricity in apartment buildings according to the reference scenario.



Source: CIT.

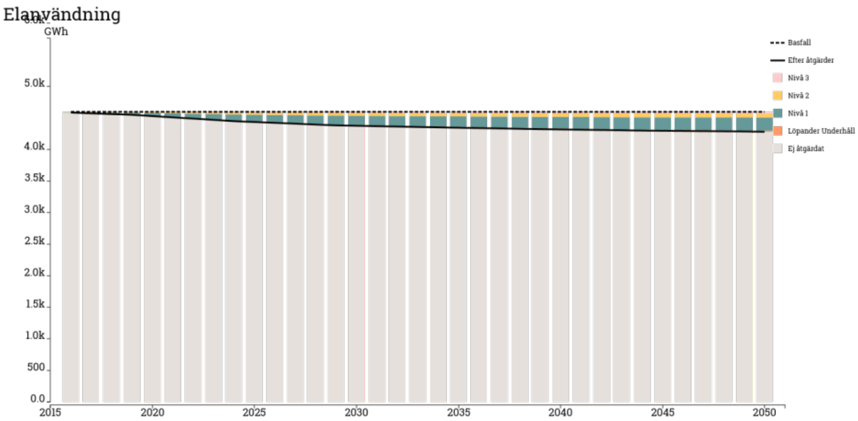
For schools in the reference scenario, Figure 19 shows that heat purchased for heating and hot water decreases by over 13% through to 2050 as a result of renovation measures. Figure 20 shows that electricity consumption declines by over 5%.

Figure .
19 Change in purchased heat in schools according to the reference scenario.



Source: CIT.

Figure 20. Change in purchased electricity in schools according to the reference scenario.

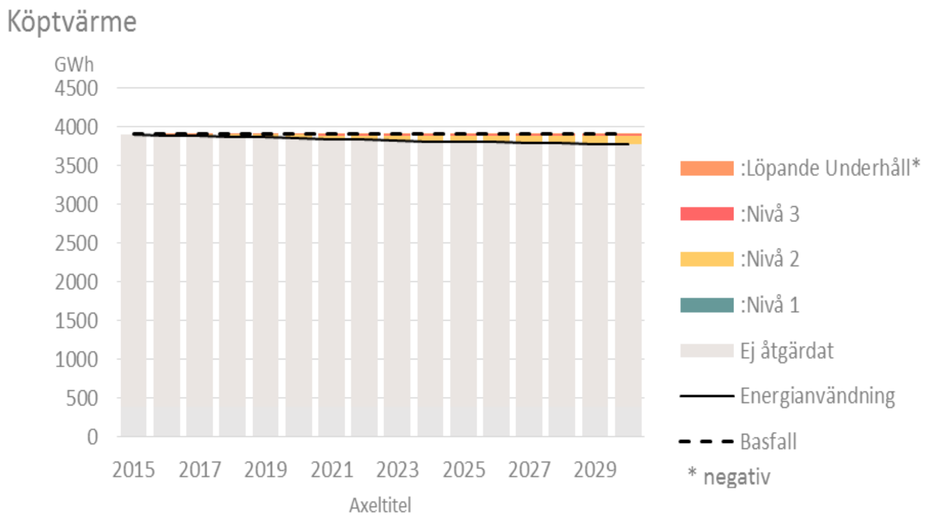


Source: CIT.

For offices, the reference scenario shows that purchased heat for heating and hot water is expected to decrease by over 3% by 2050, as shown in Figure 21. In the reference scenario, electricity consumption for offices is expected to decrease by almost 13%, as shown in Figure 22.

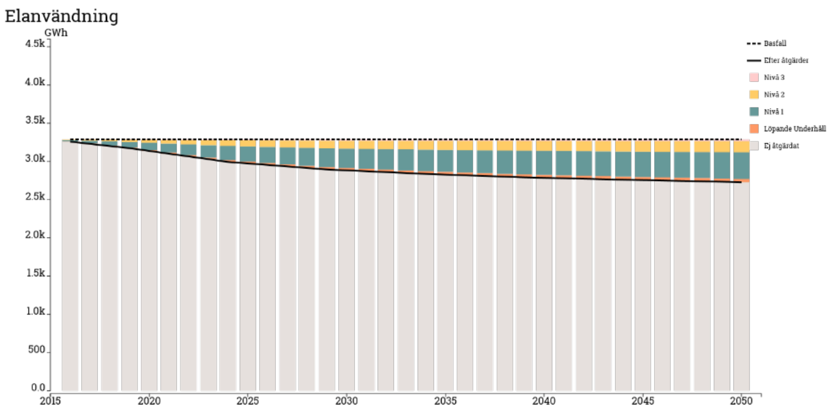
21 Change in purchased heating in office buildings according to the reference scenario.

Figure .



Source: CIT.

Figure 22. Change in purchased electricity in office buildings according to the reference scenario.



Source: CIT.

Table 13 shows the results of the reference scenario modelling. The expected reduction in energy consumption as a result of renovation measures is shown

Figure .
for the years 2030, 2040 and 2050 for each building category: apartment buildings, schools and offices.

Table 13 Expected energy consumption in GWh for the years 2030, 2040, 2050 for the building categories apartment buildings, schools, offices and houses according to the reference scenario.

Building category	**Heating/electricity**	**2020**	**2030**	**2040**	**2050**	**Total saving 2020–2050**	**Change from 2020 to 2050 (%)**
Apartment buildings	Purchased heat	24,917	22,249	21,343	20,509	4,408	- 17.7%
	Purchased electricity	10,039	10,093	10,115	10,130	+ 91	+ 0.9%
Schools	Purchased heat	5,690	5,216	5,032	4,915	775	- 13.6%
	Purchased electricity	2,910	2,812	2,775	2,750	160	- 5.5%
Offices	Purchased heat	3,854	3,775	3,743	3,723	131	- 3.4%
	Purchased electricity	3,138	2,884	2,786	2,728	410	- 13.1%

Source: CIT.

5.2 Effects of energy efficiency improvements in a broader sense

Increasing attention is being paid to the fact that more ambitious energy efficiency improvement measures can have various types of side effects (both positive and negative) over and above the more direct effect in the form of reductions in energy consumption and increases in net operating income. These side effects are normally divided into economic, social and environmental effects; see below. However, all these effects are translatable in terms of socio-economic added value or added costs.

Positive side effects (added value) which benefit residents, but which they do not have to pay for, e.g. an increase in the attractiveness of areas which is not reflected in the rent, results in an increased consumer surplus for residents. There may also be side effects in terms of external effects, i.e. impacts which are not priced or internalised in current market prices, and which represent an increased benefit or cost for third parties, in this case society at large. Examples include improved health, reductions in social problems and reductions in crime in the areas concerned. As these effects result in a reduction in public spending, they benefit society as a whole.

As there are side effects which fall outside the basis used to calculate the cost-effectiveness of property measures (e.g. those referred to above), the profitability of renovations involving energy efficiency improvements differs from, and probably underestimates, the socio-economic benefits associated with them. In turn, this means that energy efficiency improvements are likely to be carried out to an extent that is less than optimal for society, e.g. through fiscal taxes and monopoly pricing. The optimal level is that at which further energy efficiency will no longer deliver benefits that exceed the cost from a socio-economic perspective.

However, the quantification and valuation of these effects is associated with difficulties. Nevertheless, some studies have been conducted on an international basis in recent years, e.g. at European level and in some EU Member States, which have quantified and valued these effects. A summary of these studies and their findings is presented in Anthesis Enveco's report *Omvärldsbevakning – mervärden av energieffektivisering* [External monitoring - added value of energy efficiency improvements] from 2017[67].

6. Roadmap for energy efficiency in the building stock

Sweden's energy policy is based on the same three pillars as energy cooperation within the EU. The policy is aimed at combining environmental sustainability, competitiveness and security of supply. The energy policy will therefore create the right conditions for efficient and sustainable energy use and a cost-effective Swedish energy supply system with low negative impacts on health, environment and climate, and facilitate the transition to an ecologically sustainable society. The Swedish Parliament has adopted the following energy policy goals[68]:

- The target for 2040 is 100% renewable electricity production. This is a goal, rather than an end date which prohibits nuclear energy, nor does it imply the closure of nuclear power through political decisions.
- By 2030, Sweden's energy consumption will be 50% more energy efficient compared with 2005. The goal is expressed in terms of energy supplied relative to gross domestic product (GDP).

Sweden aims to take the lead within the field of climate and environment and become the first fossil-free welfare country in the world. By 2045,

[67] *Anthesis Enveco AB (2017), Omvärldsbevakning – mervärden av energieffektivisering, Rapport 2017:10* [Anthesis Enveco AB (2017), External monitoring - added value of energy efficiency improvements, Report 2017:10].

[68] Prop. 2017/18:228, bet. 2017/18:NU22, rskr. 2017/18:411.

Sweden shall not have any net greenhouse gas emissions into the atmosphere, and emissions from enterprises in Swedish territory shall be at least 85% lower than those in 1990. In June 2017, the Swedish Parliament adopted a climate policy framework for Sweden[69]. This framework was adopted by a large majority and consists of national climate goals, a Climate Act (2017:720) and a Climate Policy Council. The climate policy framework creates order and stability in the climate policy and sets out

long-term conditions for business and society. The framework is a key component of Sweden's efforts to deliver on the Paris Agreement.

In addition to the climate and energy policy goals, the national building stock also meets targets regarding spatial planning, housing and construction. Sweden's overarching objective for spatial planning, housing market, construction and surveying means that, from a social perspective, everyone throughout the country will have a healthy living environment which promotes the long-term appropriate management of natural resources and energy and facilitates the construction of housing and economic development[70].

6.1 Sector strategies for energy efficiency improvements

On 6 July 2017, the Government instructed the Swedish Energy Agency to draw up sectoral strategies for energy efficiency, in cooperation with various sectors and in consultation with the relevant authorities. This task runs until 2030. The task will be carried out in the form of a dialogue concerning suitable indicative targets and measures for the contributions of the sectors to the goal of a 50% improvement in energy efficiency by 2030, taking into account other goals set out in energy and climate policies. The Swedish Energy Agency has identified five sectors and, together with stakeholders, five strategic areas have been developed:

- Fossil-free transport
- World-class production
- Flexible and robust energy system
- Trade and consumption of the future
- Resource-efficient development

[69] Prop. 2016/17:146, bet. 2016/17:MJU24, rskr. 2016/17:320.
[70] Prop. 2011/12:1, bet. 2011/12:CU1, rskr. 2011/12:89.

In its further work, the Swedish Energy Agency intends to focus on collaboration and the work will be carried out in the form of an iterative process, where strategic areas may be added or abolished along the way. The sectoral strategies must safeguard the driving force and ambitions of Swedish stakeholders. The key factor will be the stakeholders' commitments and activities which will lead to more resource efficient energy use in concrete terms.

The sector with the strongest connection to the roadmap and the work relating to renovation and energy efficiency amongst the building stock is Resource-efficient development. The work relating to the sectoral strategies will focus on the following directional choices and priorities in a

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dialogue with industry and other stakeholders to achieve a high degree of energy efficiency amongst both new and existing developments, cost-effectiveness and collaboration. For example, it could create the right conditions for bringing about resource-efficient energy use in the construction process at an early stage, through stakeholder interaction, innovative solutions through the development of proactive regulations and the involvement of stakeholders who lay down challenges and take the lead in the development of new solutions. New solutions will be tested and matured for implementation, promoting the conversion of the existing building stock through the systematic optimisation of operations and far-reaching renovation.

The sectors 'Resource-efficient development' and 'Flexible and robust energy system' collaborate regarding crucial issues which are linked to the integration of the building sector into the energy system and which could lead to

- the properties switching from being end users to becoming a pivotal player in terms of production, management and use of energy;

- the property also becoming a place where different systems for heating/cooling and electricity networks meet;

- the rapid development of digital services in buildings, including outside the area of energy; and

- with electric car charging, the property becoming a service provider for the transport sector.

6.2 Indicative milestones and progress indicators

The indicative milestones of the roadmap aim to show what change should have occurred by a certain point in time. The milestones are forward-looking and were chosen to be relevant and consistent with Sweden's energy and climate policy, and to contribute to attainment of the European Union's goal of an improvement in energy efficiency of at least 32.5% by 2030 in accordance with the Energy Efficiency Directive[71].

The indicative milestones are linked to an appropriate number of progress indicators, which provide a measure of the change that has taken place.
Progress indicators are used not only to monitor the milestones, but also to show particularly important statistics which can and should be followed up in order to monitor progress.

For the indicative milestones, an argument is put forward concerning the potential for energy efficiency improvements on a national basis, described as scenarios.

6.2.1 More efficient energy consumption in the national building stock

The building stock accounts for a high proportion of Sweden's energy consumption. A significant proportion of the buildings are old and can be considered as being in need of renovation to varying degrees. More energy efficiency improvements must be carried out if the national building stock is to use energy more efficiently than it does at present. Although the overall trend indicates that a reduction in energy consumption amongst the building stock is already taking place, there is potential for further improvements.

Existing instruments for energy efficiency, such as taxes, information and research, are contributing to attainment of the cross-sectoral long-term goal. Through the Swedish Energy Agency's assignment for the Swedish Government concerning sectoral energy efficiency strategies, overarching

[71] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC.

strategic work relating to energy efficiency is being carried out with relevant industry stakeholders. Of particular importance in the effort to bring about energy efficiency improvements in the building stock is the continuing strategic work in the sector 'Resource-efficient development'.

To ensure that the overall trend of a reduction in energy consumption amongst the national building stock continues, indicative milestones concerning a gradual reduction in energy consumption per unit area and year are presented in Table 14. This indicative measure has been chosen because the more specific parameter of energy consumption for heating is difficult to separate from the national statistics.

Table 14. Indicative milestones for energy efficiency amongst the Swedish building stock.

Indicative milestone for 2030	Lower energy consumption per m^2 and building type than in 2020
Indicative milestone for 2040	Lower energy consumption per m^2 and building type than in 2030
Indicative milestone for 2050	Lower energy consumption per m^2 and building type than in 2040

The indicative milestone for 2030 concerning a lower energy consumption per m^2 and building type than in 2020 contributes to the European Union's common energy efficiency target for 2030 by reducing energy consumption per m^2 and building type as a result of more efficient energy consumption.

To measure progress towards improving the energy efficiency of existing buildings, the progress indicators set out in Table 15 are used.

Table 15. Progress indicators for energy efficiency amongst the Swedish building stock.

Progress indicator	**Monitoring method**
Temperature-corrected energy consumption (kWh) per m^2, year, for heating and hot water in houses, apartment buildings and non-residential premises.	National energy statistics
Specific energy consumption (kWh/m^2, year) for houses, apartment buildings and non-residential premises.	Energy Declaration Register
Proportion of buildings with direct resistive electric heating.	Energy Declaration Register
Energy consumption for heating and hot water in houses, apartment buildings and non-residential premises, TWh.	National energy statistics

6.2.2 Improved distribution of the building stock's energy classification

and increase in proportion of near-zero energy buildings

Most buildings that have been energy-declared are categorised under energy classes E- G, and few buildings meet the Swedish requirements for near-zero energy buildings, i.e. energy classes A-C. The link between the energy performance of a building and its energy class means that all measures which are aimed at improving the energy performance of buildings can also be considered to contribute to an increase in the proportion of buildings in the better classes. The indicative milestones shown in Table 16 are intended to help ensure that a higher proportion of buildings meet the requirements for energy classes A-C, thus increasing the proportion of near-zero energy buildings.

Table 16. Indicative milestones for improving the distribution of the energy classification of the building stock and increasing the proportion of near-zero energy buildings.

Indicative milestone for 2030	Higher proportion of buildings in A-C and lower proportion of buildings in E-G than in 2020; see the classification for 2020.
Indicative milestone for 2040	Higher proportion of buildings in A-C and lower proportion of buildings in E-G than in 2030; see the classification for 2020.
Indicative milestone for 2050	Higher proportion of buildings in A-C and lower proportion of buildings in E-G than in 2040; see the classification for 2020.

Progress towards improving the distribution of energy classes amongst the building stock and increasing the proportion of near-zero energy buildings is monitored through the progress indicators set out in Table 17.

Table 17. Progress indicators for improving the distribution of the energy classification of the building stock and increasing the proportion of near-zero energy buildings.

Progress indicator	Monitoring method
Class breakdown within the building stock for houses, apartment buildings and non-residential premises, compared with the base year 2020.	Energy Declaration Register
Proportion of buildings in energy classes E-G for houses, apartment buildings and non-residential premises in percent; see the base year 2020.	Energy Declaration Register
Proportion of buildings in energy classes A-C for houses, apartment buildings and non-residential premises in percent; see the base year 2020.	Energy Declaration Register

6.2.3 Phasing out of the direct use of fossil fuels amongst the building stock

Fossil energy consumption within the building stock which can primarily be influenced by the renovation of buildings is that which is used directly in buildings, i.e. the use of fossil oil and gas for heating and hot water. Indirectly, fossil fuels are also used by the building sector through the production of district heating and electricity, which is then supplied to the building sector. The direct use of fossil energy carriers within the building stock has decreased considerably in scope since the 1980s[72]. To ensure that this trend continues, indicative milestones have been adopted, as shown in Table 18.

Table 18. Indicative indicators for phasing out of the direct use of fossil fuels amongst the building stock.

Milestone year	Fossil share of end energy use amongst the building stock
2030	1%
2040	0%
2050	0%

To measure progress towards the phasing out of the direct use of fossil fuels amongst the building stock, the progress indicators set out in Table 19 are used.

Table 19. Progress indicators for phasing out of the direct use of fossil fuels amongst the building stock.

Progress indicator	**Monitoring method**
Distribution of energy carriers for energy use for heating and hot water in houses, apartment buildings and non-residential premises, TWh.	National energy statistics
Proportion of buildings directly using fossil-based gas or oil for heating and hot water.	Energy Declaration Register
Greenhouse gas emissions from own combustion of fuels for heating and hot water amongst housing and non-residential premises in tonnes of CO_2e.	National emission statistics

[72] Energimyndigheten (2019), *Energiindikatorer, ER 2019:11* [Swedish Energy Agency, Energy indicators, ER 2019:11].

Annex 1 Implementation of the previous strategy for energy efficient renovation

During the work on previous strategies for energy efficient renovation, a need was identified for more knowledge in order to overcome barriers to energy efficiency renovation. In the 2017 letter of allocation, the Government instructed the Swedish National Board of Housing, Building and Planning to commission an operator to establish an information centre for sustainable construction. In partnership with other stakeholders, the Swedish Energy Agency has implemented numerous skills-enhancing measures within the field of low-energy and energy efficiency aimed at vocational teachers in upper secondary schools, tradesmen and fitters, clients, property owners and managers.

In addition to informational measures, a number of other instruments have been introduced, concluded and/or revised since the previous energy efficiency renovation strategy was reported; see Table 20.

Table 20. Overview of instruments and measures introduced since the previous strategy for energy efficient renovation.

Instrument/measure	Description	Status
Aid for renovation and energy efficiency improvements in certain residential areas	On 1 October 2016, a financial aid scheme was introduced which was aimed at stimulating renovation and energy efficiency improvements amongst rental housing in areas facing socio-economic challenges. This aid was available until the end of 2019 and was evaluated during 2019.	Ended.
Energy saving loans	The study concerning energy saving loans was reported in 2017.	Dormant.
Energilyftet	A web-based initiative concerning free training relating to low-energy buildings which was launched in 2016. During the period May 2016 to December 2017, seminars were also arranged on an ongoing basis to inform people and generate interest in energy efficiency improvements, low-energy construction and training.	Ongoing.
Nya glasögon (New glasses)	Training initiative within sustainable construction and energy efficiency improvements aimed at vocational teachers at upper secondary level within construction, electricity and HVAC. A total of 573 vocational teachers were trained through the initiative.	The project was concluded in 2018.

Energibyggare (Energy builder)	Energibyggare is the result of BUILD UP Skills and is a training course aimed at tradesmen and fitters. Approximately 500 people were trained as mentors in order to continue the training of staff directly at workplaces around Sweden.	Ended.
Aid for the refurbishment of school premises	During the period from November 2015 to 31 December 2018, aid was available for the refurbishment of school premises and outdoor facilities at schools. The aims of the aid were to improve the learning and working environment of the pupils and reduce the environmental impact of the premises, and to provide students with an improved and secure learning environment which promotes physical activity.	Dormant.
Energy mapping in small and medium enterprises	Small and medium enterprises apply to the Swedish Energy Agency for a financial contribution in order to carry out energy surveys to analyse the distribution of energy in different parts of an undertaking's activities, costs relating to energy consumption and proposals for energy efficiency improvements to processes and equipment.	Ended during 2019.
Investment aid for energy efficiency measures	Until 15 October 2019, small and medium enterprises which carried out an energy survey were able to apply for investment aid for measures aimed at improving energy efficiency.	Ended during 2019.
Information Centre for Sustainable Construction (ICHB)	ICHB's remit is to 'promote increased energy efficiency in renovation and an energy-efficient construction with the use of sustainable materials and a low carbon footprint from a life-cycle perspective'. The remit involves the collection, customisation and dissemination of information on sustainable construction. The centre's website provides information on research, results and experiences. ICHB is aimed at all target groups: professional builders, owners of houses, board members of housing associations, property owners and others who are involved in the construction process in any other way.	Ongoing.

Annex 2. Consultation on the third strategy for energy efficient renovation

During the work on the third strategy for energy efficient renovation, consultations with stakeholders have taken place through meetings with an external reference group and through an open public hearing with the industry. The consultation was carried out by the Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency.

External reference group

The Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency set up an external reference group to provide input to the third strategy for energy efficient renovation. The purpose of the reference group was to establish a dialogue with selected representatives in order to get different perspectives and experiences regarding various key issues.

The participants in the reference group were chosen to represent different operators such as property owners, the construction industry and researchers; see Table 21.

Table 21. Invited and participating stakeholders in the external reference group.

Name of organisation	Comments
Byggherrarna Sverige AB	
Byggmaterialindustrierna Bysam Service AB	
Energieffektiviseringsföretagen, EEF	
Fastighetsägarna Sverige AB	
HSB	
Swedish Union of Tenants	
Installatörsföretagen Service i Sverige AB	
KTH Royal Institute of Technology	*Invited, but unable to participate*
Linnaeus University	
Riksbyggen	
Swedish Association of Local Authorities and Regions	*Invited, but did not respond*
Sveriges allmännytta (formerly SABO)	
Sveriges Byggindustrier	
Villaägarna	*Invited, but unable to participate*
Uppsala University, Gotland Campus	

Meetings were held with the external reference group during the period June to September 2019. Issues discussed with the reference group were:

- Barriers to renovation.
- Whether the underlying conditions for the various measures have changed since 2016.
- Instruments.
- Added value of energy efficient renovations.
- Resource efficiency in conjunction with renovation.
- Milestones and progress indicators.

An important view put forward by the reference group was that it was the drivers for energy efficiency improvements in particular which were lacking, even though funding is often available. The outcome of the calculation as to whether or not an investment is likely to be profitable often depends on what is included in the calculation and the assumptions that are made.

As regards the state of knowledge, the participants in the reference group agreed that a lot of knowledge and information is available. However, there was a desire for a knowledge platform to be established that will be the first port of call for those who are looking for information. The reference group also stated that, although there are many different informative instruments, more stringent instruments would be needed to ensure that things actually happen. It should be 'easy to do the right thing'.

The participants in the reference group agreed that, although the renovation strategy should have a broader perspective as regards resource efficiency, it is difficult to know where to set the limits. It was noted that although the research community is very aware of this issue, the knowledge has not yet reached the industry.

Hearing for input from industry

In October 2019, the Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency arranged an open hearing concerning the basis for the third strategy for energy efficient renovation with representatives of property owners, trade associations, industry, the public sector and other enterprises. A total of 57 people took part. During the hearing, Sweden's energy efficiency policy, the status of the building stock and the roadmap's milestones and progress indicators were presented.

The following questions were put to the participants:

− What potential for energy efficiency improvements do you see? − How can renovation/energy efficiency improvements contribute? − What barriers must be overcome?

− What is needed in order for more to happen?

− How can you or your organisation contribute to the objectives of the roadmap? − What windows (triggers) for energy efficiency improvements exist?

The responses from the participants were not consistent, but were collected via an integration tool and used as a basis in the further work.

Sector dialogues for sector strategies for energy efficiency improvements

An important measure for energy efficiency improvements amongst the existing building stock is the Swedish Energy Agency's task of developing sectoral strategies for energy efficiency improvements. This task will continue until 2030 and will help Sweden to achieve the goal of 50% more efficient energy consumption by 2030. The aim of these sectoral strategies is to establish, at an early stage, a dialogue between the Swedish Energy Agency, various industries and relevant authorities concerning appropriate indicative targets and measures in each sector, in order to make a cost-effective contribute to attainment of the national energy and climate goals. Of particular importance in the effort to bring about energy efficiency improvements amongst the building stock is the strategic work in the sector 'Resource-efficient development'.

Annex 3. Methodology for scenarios for energy efficiency improvements as a result of renovation measures

Scenarios have been developed by Chalmers Industriteknik (CIT) on behalf of the Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency to provide an overview of the anticipated degree of energy efficiency improvements through to 2050, based on the scope of renovation which is currently taking place, with existing instruments based on how property owners are currently acting and likely to act over the coming years.

A comprehensive survey was conducted in 2016[73], during which both private and public sector property owners of apartment buildings, schools and offices were interviewed. In 2019, these property owners were interviewed again in a follow-up survey[74]. The number of interviews has been limited and particular attention was therefore given to selecting the right companies to interview in order to ensure both the widest possible representation of the proportion of areas within each building category and the broadest possible geographical coverage.

Implementation

The aim of the project was to update the underlying data which had been produced in 2016. To obtain an updated snapshot of the current situation in 2019, further interviews were carried out, mainly with the same local property owners as in the 2016 survey. As regards apartment buildings, information was collected through interviews of local property owners who also have residential properties and from recently published studies relating to apartment buildings. The work was carried out over a total of four months, from July 2019 to October 2019, and involved the following stages:

- Updating and supplementation of the question database and low-cost renovation packages for the interviews.
- Updating of contact details for follow-up interviews and the addition of new companies.
- Conducting of new interviews.
- Collation of information from other studies relating to apartment buildings.

[73] *CIT Energy Management, WSP och Profu, (2017), Energieffektivisering vid renovering av flerbostadshus, skolor och kontor – En intervjustudie och analys i HEFTIG* [CIT Energy Management, WSP and Profu, (2017), Energy efficiency improvements in conjunction with the renovation of apartment buildings, schools and offices – An interview study and analysis in HEFTIG].

[74] *CIT, Wahlström and Glader (2019), Nuläge och framtidsscenarier av renovering av byggnadsbeståndet – en analys i HEFTIG* [CIT, Wahlström and Glader (2019), Present situation and future scenarios of renovation of the building stock - an analysis using HEFTIG, basis for the Swedish National Board of Housing, Building and Planning and the Swedish Energy Agency].

- Determination of the renovation rate and the proportion of renovated buildings.

- Analysis of interviews and determination of the proportion of the various renovation packages which will be carried out relative to the overall renovation rate.

- Analysis in HEFTIG of three scenarios; reference scenario, energy efficient renovation and major renovation.

- Presentation of results and discussion.

- Throughout the work, the results of the interview survey conducted in 2016 formed a basis for further analysis.

Prior to the interviews, four levels of renovation were defined. These were used to enable the owners to answer the question regarding the extent to which energy efficiency improvements are carried out in conjunction with renovation. For each level, various representative energy efficiency measures were packaged together in order to match the respective level of energy efficiency. The four levels which were defined were:

- Ongoing maintenance, which accounts for daily operation and maintenance and provides a 4% improvement in energy efficiency.
- Level 1, which corresponds to maintenance/light renovation with a 15% improvement in energy efficiency.
- Level 2, which accounts for a standard improvement with a 30% improvement in energy efficiency.
- Level 3, which represents total renovation with an improvement in energy efficiency of at least 50% for apartment buildings and schools, and 40% for offices.

The results of the interviews were used to describe a probable scenario regarding the way in which the entire sector is acting. This was then used to simulate and illustrate various renovation scenarios in the analysis program HEFTIG. Three scenarios from 2020 to 2050 were developed with the aid of HEFTIG:

- Reference scenario, a 'snapshot' of the likely scope of energy efficiency improvements given the currently prevailing circumstances and views of renovation.

- Energy efficient renovation, a case which demonstrates the technical potential, on a cost-effective basis, if all property owners were to carry out major energy efficient renovation every time renovation was carried out.

- Major renovation, a scenario where total renovation is carried out every time renovation is carried out, thereby increasing the technical potential for energy efficiency improvements on a cost-effective basis.

Results

The results of the interviews show that energy efficiency improvements are not in themselves a driver for renovation to be carried out. They also show that the opportunities that are available to improve energy efficiency in conjunction with renovation are currently being utilised to a much lesser extent and that the energy efficiency improvements that are being carried out are a long way away from the technical potential. The energy efficiency improvements that are being carried out primarily concern measures which reduce the amount of energy needed for heating purposes and it is difficult to make electricity consumption more efficient.

Virtually all those interviewed are planning to erect new buildings over the next few years. Irrespective of the building category, most respondents interviewed during 2019 do not believe that this competes with renovation, as they are different budget items. The interviews conducted in 2016 indicated that new-build took up all the available resources, which may mean that less renovation will be carried out.

Residential properties are primarily renovated as a result of a need for maintenance and high maintenance costs. Schools and offices are mainly being renovated because of the fluctuating needs of the users and the need to improve the indoor environment, particularly ventilation. The planning of residential property renovations is largely the result of a need to provide for evacuation. For schools, it is the needs of the users and the need to provide for evacuation. In the case of offices, renovations are primarily carried out in conjunction with alterations to meet the needs of tenants. Environmental certification has been a powerful driver for new-build, but it is now starting to also become of interest in conjunction with renovation.

All respondents had some form of energy goals of their own, most of which are likely to be achieved. Many of the property companies will develop new goals over the next few years. The goals are increasingly being expressed in the form of climate impact and are more and more being influenced by local or regional sustainability goals. One trend which emerged during the 2019 interviews is that an ever-stronger focus is being placed on improvements in power efficiency alongside improvements in energy efficiency.

During the 2016 interviews, both public and private sector office owners stated that there was a shortage of skilled labour in the market. During the interviews conducted in 2019, the private property companies stated that there was no shortage of building resources, while public sector companies still believed that the shortage of resources was a cost-driving factor.

The three scenarios show that although there is considerable potential for energy efficiency improvements in conjunction with renovations, relatively little use is being made of the opportunities for energy efficiency improvements in conjunction with renovation. Buildings that have already undergone renovation will not be renovated again in the near future and hence all future renovations will have to be carried out according to the higher energy efficiency levels if the full potential for energy efficiency improvements is to be realised. The estimated energy efficiency improvement for each building type and scenario is shown in Table 22.

Table 22. Total energy consumption of various building categories in 2016 and 2050 and share of energy savings for the three scenarios.

		Reference scenario	**Energy-efficient renovation**	**Major renovation**
	Total energy consumption 2016 (kWh/m²)	*Total energy consumption 2050 (kWh/m²)*	*Total energy consumption 2050 (kWh/m²)*	*Total energy consumption 2050 (kWh/m²)*
Apartment buildings	162	137 (15%)	119 (26%)	100 (38%)
Offices	225	202 (10%)	177 (21%)	163 (27%)

Schools	216	187 (13%)	164 (24%)	135 (37%)

Energy efficiency measures in conjunction with renovation with different levels of energy efficiency improvement

In connection with the interviews and the HEFTIG simulations, four levels of renovation were defined.

− Ongoing maintenance, which accounts for daily operation and maintenance and gives a 4% improvement in energy efficiency.

− Level 1, which corresponds to maintenance/light renovation with a 15% improvement in energy efficiency.
− Level 2, which accounts for a standard improvement with a 30% improvement in energy efficiency.
− Level 3, which represents total renovation with an improvement in energy efficiency of at least 50% for apartment buildings and schools and 40% for offices.

Each level of renovation represents a different package of energy efficiency measures. The presented measure packages are based on information produced during a previous HEFTIG study[75], where measures for apartment buildings were based on a literature study and completed 'Rekorderlig renovering' projects[76], while measures concerning schools and offices were based on previously completed projects carried out using the 'total methodology'[77].

Tables 23, 24 and 25 show the measure packages for apartment buildings, schools and offices respectively. The renovation packages also contained measures without any energy-related impact, which are not presented here.

Table 23. Measures for various energy efficiency improvement levels in conjunction with the renovation of apartment buildings.

	Ongoing maintenance	Level 1	Level 2	Level 3
Painting + sealing of windows/doors	Yes	Yes	Yes	-

[75] CIT, Wahlström et al (2016), '*Fallstudier till HEFTIG', rapport till Energimyndigheten* [CIT, Wahlström et al (2016), Case studies for HEFTIG, report to the Swedish Energy Agency].

[76] www.bebostad.se.

[77] www.belok.se.

Window replacement, U<1	-	-	-	Yes
Attic insulation, 300 mm loose wool	-	-	Yes	Yes
Façade insulation, 100 mm	-	-	-	Yes
New entrance/basement doors	-	-	Yes	Yes
Switch to low-energy bulbs	Yes	Yes	-	-
Presence-controlled LED	-	-	Yes	Yes
New fans	Yes	Yes	-	-
Replace thermostats/valves	-	Yes	Yes	Yes
Adjust heating	Yes	Yes	Yes	Yes
FVP 3.0	-	-	Yes	-
FTX η85 %	-	-	-	Yes
Adjust ventilation system	Yes	Yes	Yes	Yes

	Ongoing maintenance	**Level 1**	**Level 2**	**Level 3**
Low-flush fittings	-	Yes	Yes	Yes
Energy-efficient laundry rooms	-	Yes	Yes	Yes
IMD Heating and Hot water	-	-	-	Yes
Waste-HVAC	-	-	-	Yes
Total energy saving:	**4%**	**10%**	**30%**	**50%**

Table 24. Measures for various energy efficiency improvement levels in conjunction with the renovation of schools.

	Ongoing maintenance	**Level 1**	**Level 2**	**Level 3**
Replacement of FT with FTX	-	-	Yes	Yes
Replacement of F with FTX	-	-	Yes	Yes
Replacement of FTX	-	-	-	Yes
Demand-controlled ventilation	-	Partially	Partially	Yes
Replacement with more energy-efficient windows	-	-	-	Yes
Additional insulation, roof/attic	-	Yes	Yes	Yes
Modern lighting in classrooms/group rooms/corridors, etc.	Yes	Yes	Yes	Yes
Replacement of thermostats and adjustment of heating systems	Yes	Yes	Yes	Yes
Installation of the radiation collectors	Yes	Yes	Yes	Yes
Modern outdoor lighting	-	Yes	Yes	Yes

Total energy saving:	**4%**	**10%**	**30%**	**50%**

Table 25. Measures for various energy efficiency improvement levels in conjunction with the renovation of offices.

	Ongoing maintenance	Level 1	Level 2	Level 3
Upgrading of ventilation systems	-	-	Yes	Yes
Demand-based and control of ventilation	-	Partially	Yes	Yes
Replacement with more energy-efficient windows	-	-	Yes	Yes
Operational optimisation of cooling	-	-	Yes	Yes
Upgrading of lighting in public areas	Yes	Yes	Yes	Yes
Upgrading of lighting in office areas	Yes	Yes	Yes	Yes
Additional attic/roof insulation	-	-	-	Yes
Measures around entrances	-	-	-	Yes
Shading	-	-	-	Yes
Domestic hot water measures	-	-	-	Yes
Total energy saving:	4%	10%	30%	40%