Long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private

FINLAND

Notification pursuant to Article 4 of the Energy Efficiency Directive (2012/27/EU) to the European Commission in April 2017

Name of the report Long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private – update 2017	
Contact person and contact details Ministry of the Environment Jyrki Kauppinen P.O. Box 35 FI-00023 Government	Reference YM28/612/2016

Foreword

Article 4 of the EED is designed for identifying ways of mobilising investment in the energy efficiency of public and private residential and commercial buildings, and implementing these in a systematic and timely manner in connection with renovations.

In connection with the transposition of the Energy Performance of Buildings Directive (EPBD) in Finland, comprehensive requirements were set for renovating the building stock with regard to energy performance. Cost-optimal levels of minimum energy performance requirements for renovations entered into force in 2013. The objectives of the Renewable Energy Sources (RES) Directive are also promoted by a range of means with regard to buildings undergoing thorough renovation.

This updated version of the strategy was drawn up in collaboration with the Ministry of the Environment, local authorities, property owners, service providers specialising in energy performance renovations, research organisations, educational and training institutions, financial institutions and other stakeholders. Technical updating was carried out by research scientists from Tampere University of Applied Sciences (TAMK) and VTT Technical Research Centre of Finland.

11 April 2017

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1. Article 4 of the Energy Efficiency Directive

Article 4 of the Energy Efficiency Directive (EU, 2012), which was adopted in 2012, urges Member States to take measures to encourage investment in the deep renovation of both public and private residential and commercial buildings. This report has been structured as follows on the basis of the requirements laid down for such a strategy:

Member States shall establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. This strategy shall encompass:

(a) an overview of the national building stock based, as appropriate, on statistical sampling;

Chapter 2. Overview of Finland's building stock.

(b) identification of cost-effective approaches to renovations relevant to the building type and climatic zone;

Chapter 3. Cost-effective, deep renovations suitable for Finland's climate, and their financing.

(c) policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations;

Chapter 4. Policies and measures that promote deep renovations.

(d) a forward-looking perspective to guide investment decisions of individuals, the construction industry and financial institutions; (e) an evidence-based estimate of expected energy savings and wider benefits

Chapter 5. Scenarios and impacts and Chapter 3.

2. Overview of Finland’s building stock

2.1. Gross floor area of the building stock, as well as its owners and their tenure status

Gross floor area

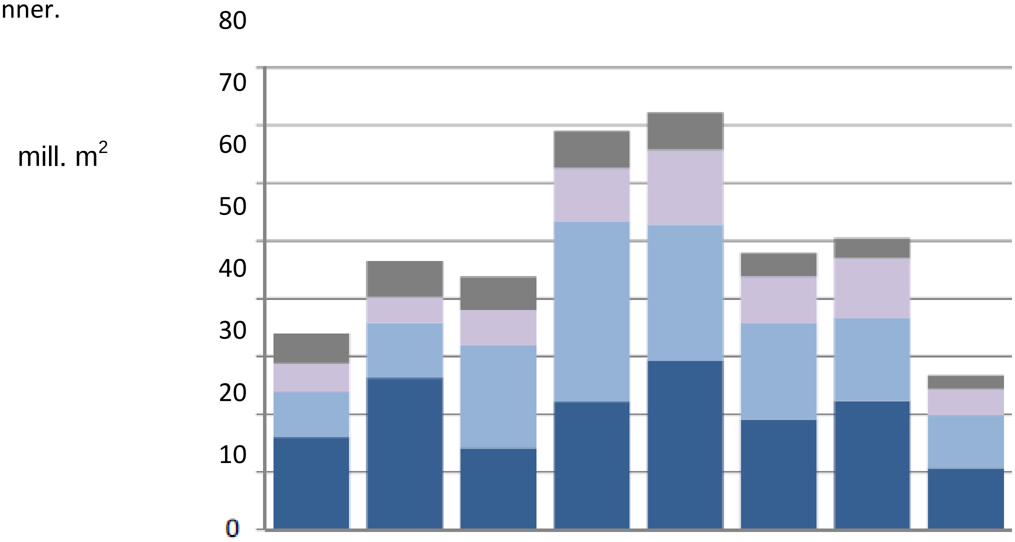
The total gross floor area of residential, commercial and public buildings in Finland is 390 million square metres (Figure 1). One-dwelling buildings account for 41 percent of the total gross floor area, multiple-dwelling buildings for 33 percent, commercial buildings for 16 percent and public buildings for 10 percent.

Ownership

Private households own 65 percent of all buildings, either directly or through the housing company system. They have the highest share of ownership in one-dwelling buildings (91%) and through the housing company system in multiple-dwelling buildings (71%). Enterprises own 20 percent of all buildings. Their share of ownership is highest in the case of commercial buildings, either directly or through the joint-stock property company system. Municipalities and the State own less than 10 percent and approximately one percent of all buildings, respectively (Table 1).

Tenure status

Of one-dwelling buildings, 85 percent are occupied by the owner, while just 3 percent are rented and 10 percent are not permanently occupied. Of the dwellings in buildings with multiple dwellings, 42 percent are occupied by the owner, 21 percent are rented from non-profit organisations (subsidised housing production) and 22 percent are rented on the open market, either from private households or enterprises. Some dwellings are not permanently occupied (Table 2). The tenure of commercial buildings is divided, half-and-half, between owners and tenants (KTI & RAKLI, 2014). The buildings of municipalities are usually managed by their facilities administration and rented internally to their education services, social services and other departments. The Finnish State’s building stock is managed by Senate Properties, which rents out the buildings or premises to State organisations in a similar manner.



	-1939	1940-59	1960-69	1970-79	1980-89	1990-99	2000-09	2010–
Public buildings	5	6	6	6	6	4	3	2
Commercial buildings	5	5	6	9	13	8	10	5
Multiple-dwelling buildings	8	9	18	31	24	17	14	9
One-dwelling buildings	16	26	14	22	29	19	22	11

Figure 1. The gross floor area of Finland's building stock totals 390 million square metres. Half of the building stock (gross floor area) has been built since 1980. Source: Statistics Finland, Buildings and free-time residences, 2016.

Table 1. Owners of the building stock in Finland. Source: Population Register Centre, Building and Dwelling Register, 2016.

	Proportion of one-dwelling buildings, %	Proportion of multiple-dwelling buildings, %	Proportion of commercial buildings, %	Proportion of public buildings, %
Private households	91%	2%	12%	1%
Housing companies	6%	71%	4%	1%
Joint-stock property companies	0%	12%	37%	10%
Businesses	1%	8%	38%	14%
Municipalities	1%	2%	5%	57%
State	0%	0%	2%	4%
Others (parishes, non-governmental organisations, etc.)	0%	4%	3%	12%
Total	100%	100%	100%	100%
	mill. m^2	mill. m^2	mill. m^2	mill. m^2
Gross floor area	160	130	60	40

One-dwelling buildings: detached houses

Multiple-dwelling buildings: terraced houses and apartment blocks

Commercial buildings: commercial buildings, office buildings, transport and communications buildings

Public buildings: health care and social services buildings, educational buildings and assembly buildings

Housing company: a company established to own and administer a residential building (or buildings)

Joint-stock property company: a company established to own and administer a building or the facilities of a building with no limitation on the purpose of use Tenement buildings are joint-stock property companies regardless of the fact that they are used for housing.

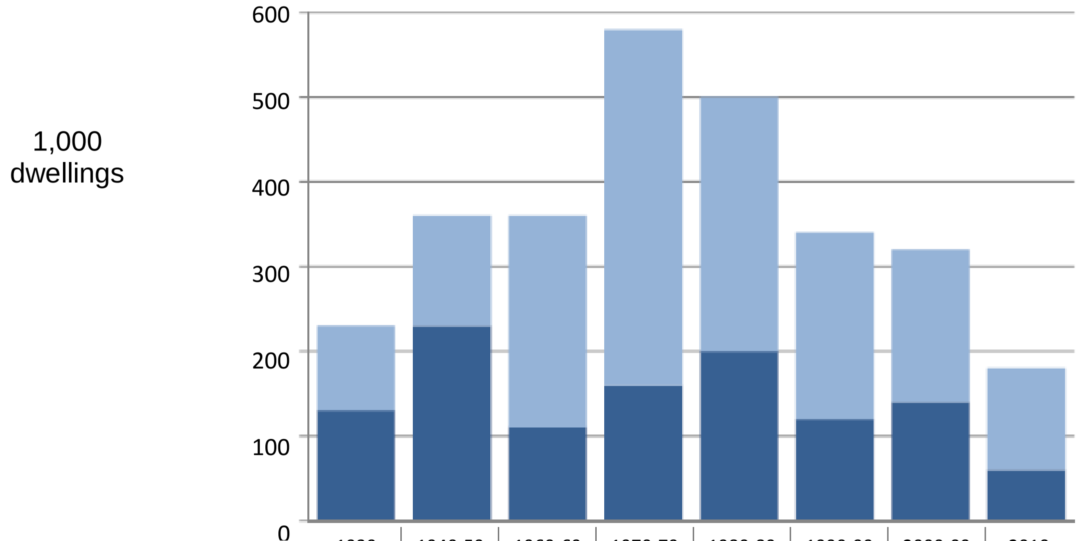
Residential buildings

The total number of dwellings is 2.85 million, of which 1.15 million are in one-dwelling buildings and 1.7 million are in multiple-dwelling buildings (Figure 2). The housing construction of the 1970s and 1980s is the result of strong rural-urban migration. Migration has accelerated again since 2010. Due to long-standing migration, approximately 15 percent of dwellings constructed before 1970 and 8 percent of dwellings constructed after 1970 have been left empty. Of the housing stock, 10 percent is not permanently occupied. Projections indicate that the population will decrease in many locations and that the number of empty dwellings will grow further in the coming years (Figure 3).

Table 2. *Housing tenure status. Source: Dwellings and housing conditions, 2016.*

	Owner-occupied housing	Rented dwelling subsidised by the State/with an interest support loan	Other rented dwelling	Right of occupancy dwelling; other tenure status	Not permanently occupied	Total
One-dwelling buildings	85%	0%	3%	2%	10%	100%

Multiple-dwelling buildings	42%	21%	22%	5%	10%	100%
Arava dwellings (later ARA dwellings) social housing dwellings produced through government Arava loans in the period 1949–2005, with restrictions on use and transfer. Arava loans were used for the construction of both owner-occupied and rented dwellings. Social housing built with Arava loans was replaced by a system of interest subsidy loans in 2006. Interest subsidy is available for both new development and renovations. Right of occupancy dwelling is an intermediate stage between owner-occupied dwelling and rented dwelling.						



	-1939	1940-59	1960-69	1970-79	1980-89	1990-99	2000-09	2010–
Multiple-dwelling buildings	100	130	250	420	300	220	180	120
One-dwelling buildings	130	230	110	160	200	120	140	60

Figure 2. Age structure of the housing stock. One-dwelling buildings include a total of 1.15 million dwellings and multiple-dwelling buildings 1.7 million dwellings. The total number of dwellings is 2.85 million, of which 0.29 million are not permanently occupied. Source: Statistics Finland, Dwellings and housing conditions, 2016.

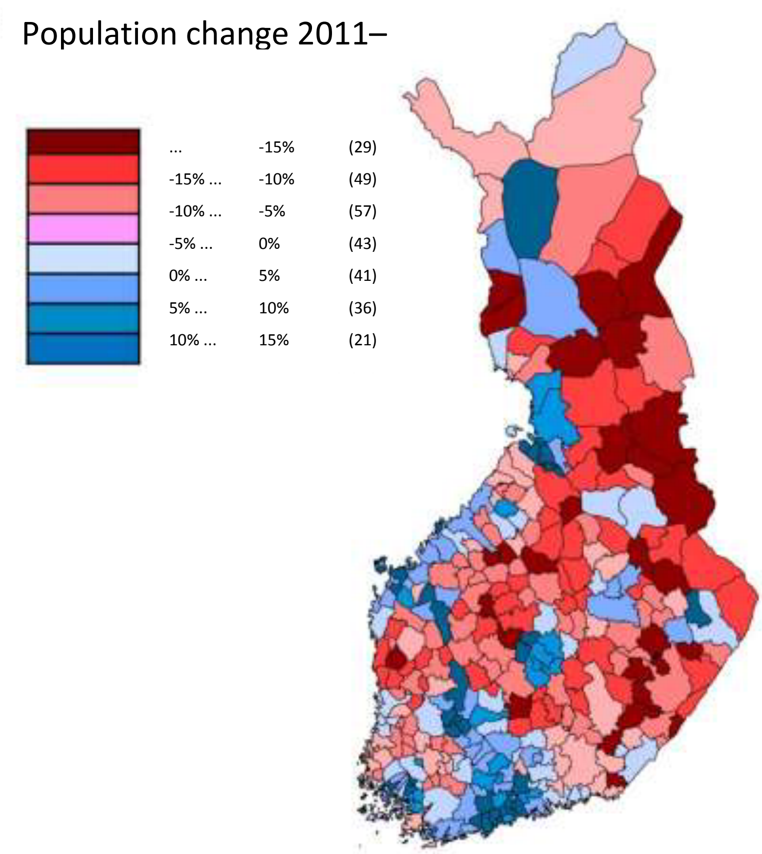
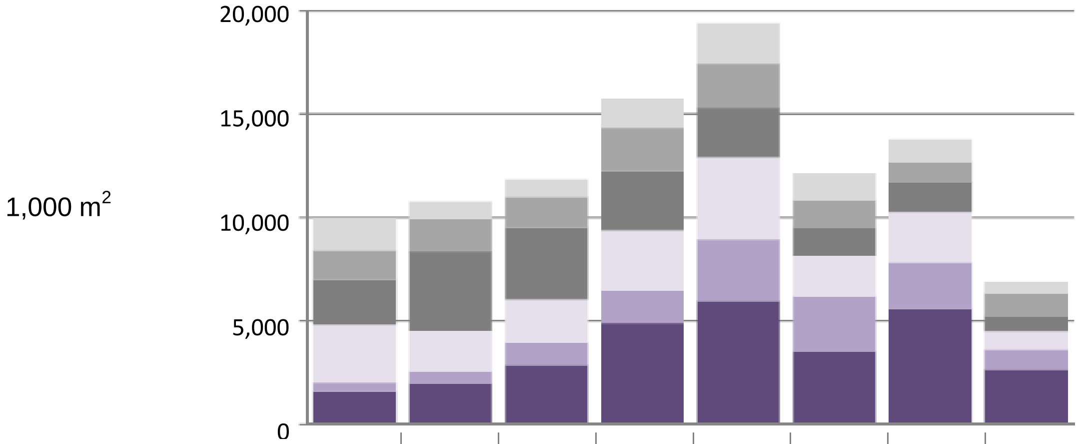


Figure 3. Increase of population proportionate to the population of each municipality. Population will decrease in 60 percent of all municipalities (red rasters in the figure). In these municipalities, some residential, commercial and public buildings will become under-occupied or will be left empty. Source: Statistics Finland, Population projection, 2015.

Commercial buildings and public buildings

Commercial buildings include commercial buildings, office buildings, transport and communications buildings. The occupancy rate of commercial buildings is relatively high, as the owners manage their real estate properties actively, whereas there is a high oversupply of office buildings. Economic restructuring and technological development have changed the needs of businesses to such an extent that out-of-date office premises are unsuitable for businesses. The proportion of empty office premises varies across regions, ranging from 10 to 20 percent. It is very high in the Helsinki metropolitan area (KTI, 2016). New uses are being sought for empty premises, for example by converting them into flats.

Public buildings include educational buildings, health care and social services buildings and assembly buildings. Due to migration, the population – and thereby the need for such premises – is decreasing in many municipalities. Premises will also be left empty as a result of the currently ongoing regional administration reform. According to an expert on municipal premises, municipalities have an excess of 30 percent of premises to manage (Ympäristölehti, 2015).



	-1939	1940-59	1960-69	1970-79	1980-89	1990-99	2000-09	2010–
Assembly buildings	1,560	840	850	1,410	1,930	1,300	1,080	550
Health care and social services buildings	1,430	1,560	1,500	2,100	2,150	1,340	930	1,140
Educational buildings	2,170	3,820	3,450	2,860	2,370	1,340	1,470	680
Office properties	2,800	1,980	2,110	2,900	3,990	1,970	2,450	900
Transport and communications buildings	410	600	1,060	1,570	2,970	2,670	2,240	960
Business properties	1,610	1,960	2,880	4,900	5,970	3,510	5,590	2,660

Figure 4. The gross floor area and age structure of commercial and public buildings in Finland. The gross floor area of commercial buildings is 60 million square metres and that of public buildings is 40 million square metres. Source: Statistics Finland, Buildings and free-time residences, 2016.

2.2. Energy performance of residential, commercial and public buildings

The turn of the 1970s and 1980s was the first milestone with regard to the energy performance of residential, commercial and public buildings. The first U-value requirements for new buildings were set in 1976 (Finnish Ministry of the Environment, 2012). Half of Finland’s building stock (gross floor area) was built after the U-value requirements entered into force (Figure 1). The requirements have been tightened on several occasions.

The 1970s energy crises triggered efforts to improve the energy performance of existing buildings. With buildings being renovated after 30–40 years of use, almost all buildings built before the energy crises had been renovated at least once by 2017.

Another milestone for the energy performance of buildings was the year 2010, when thermal insulation regulations were significantly tightened for all buildings (Table 3). The impact of this tightening is shown by energy certificates: buildings constructed before 2010 are placed in a clearly poorer energy class than buildings constructed after 2010 (Figure 5, Figure 6 and Figure 7). In renovations, windows and technical systems have been renovated to correspond to the standards of new construction at the time, while adding insulation to external walls is relatively rare.

Table 3. *Properties of building components affecting the energy performance of residential, commercial and public buildings in buildings of different ages. Source: EKOREM, 2005; Finnish Ministry of the Environment(2012, National Building Code of Finland C3).*

U-values, W/(K·m²)	-1975	1976-2003	2003-2010	2010–

External walls	0.30..0.60	0.28..0.40	0.24..0.25	..0.17
Roofs	0.20..0.45	0.22..0.35	0.15..0.16	..0.09
Floors	0.40..0.50	0.36..0.40	0.24..0.25	..0.09/0.17
Window(s)	1.00..2.50	1.00..2.10	1.00..1.40	..1.00

Properties of technical systems

- All buildings have separate ventilation (no window ventilation during the heating season)
- Ventilation with heat recovery has been required since 2003, systems with heat recovery have been installed voluntarily since the 1980s. In connection with renovations, even old buildings have been equipped with heat recovery.
- Water circulation radiators are equipped with thermostat valves.
- All electricity meters are read remotely, and customers can monitor their electricity consumption via an online service.
- Remote reading is in use in almost all houses connected to district heating networks, and customers can monitor their district heating consumption via an online service.
- All new and the majority of old buildings have water saving taps and sanitary ware.

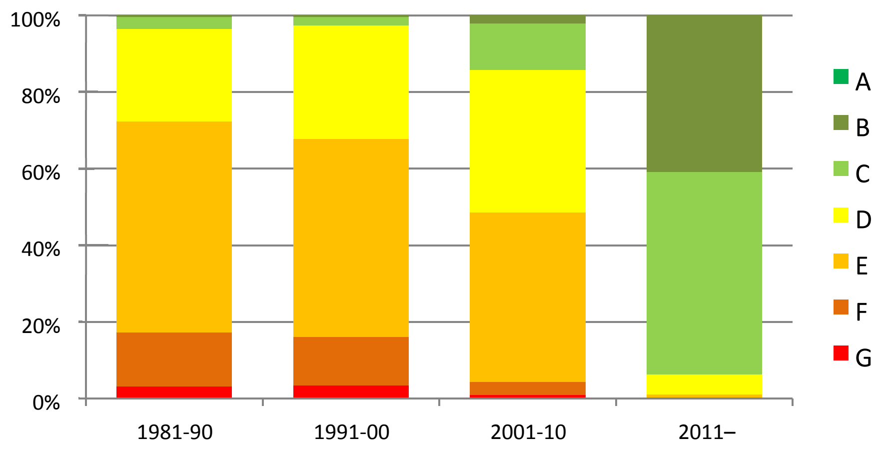


Figure 5. Energy class distributions of one-dwelling buildings of different ages. Source: ARA, Energiatodistukset, 2016.

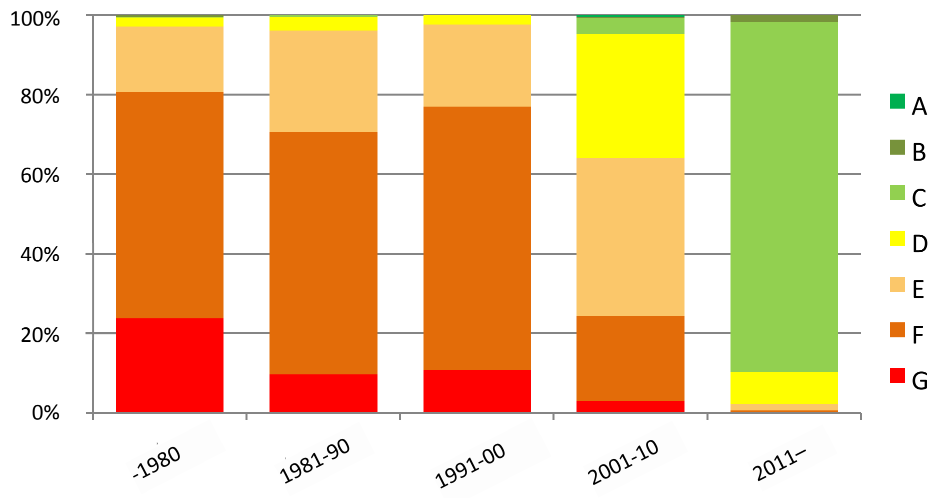


Figure 6. Energy class distributions of multiple-dwelling buildings of different ages. Source: ARA, Energiatodistukset, 2016.

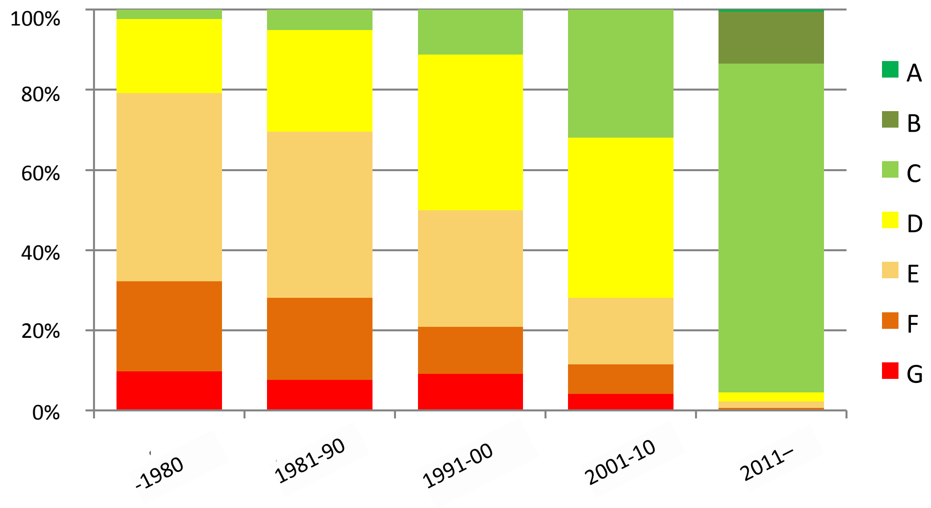


Figure 7. Energy class distributions of commercial and public buildings of different ages Source: ARA, Energiatodistukset, 2016.

2.3. Energy consumption

Energy end-use and primary energy consumption

Residential, commercial and public buildings consume a total of 73,300 GWh of energy annually (Table *4*). Residential buildings account for 75 percent of total energy consumption. District heating is used for the heating of 90 percent of multiple-dwelling buildings and 75 percent of commercial and public buildings. One-dwelling buildings are heated with property-specific heating plants (55%) or electricity (45%).

The use of fossil fuels and electricity for heating increases the proportion of one-dwelling buildings of the total primary energy consumption (Table 5), while district heating in multiple-dwelling buildings, commercial buildings and public buildings decreases their proportion of total primary energy consumption. A significant proportion (32%) of district heating is produced by means of renewable energy sources (Finnish Energy, 2017). In addition, 70 percent of district heating is produced by CHP plants. To avoid peak periods in electricity consumption, it is inadvisable to replace district heating with property-specific renewable energy systems (Finnish Climate Change Panel, 2013).

Table 4. *Heating of the spaces and hot water of residential, commercial and public buildings, including standard electricity consumption for lighting, technical systems and household electricity consumption (final energy). Source: Finnish Environment Institute, 2016.*

	One-dwelling buildings	Multiple-dwelling buildings	Commercial buildings and public buildings	Total	Rates
Electricity	10,400	4,200	1,800	16,400	22%
District heating	2,400	17,000	12,000	31,400	43%
Heat pumps	3,800	300	300	4,400	6%
Biofuels	13,100	200	800	14,100	19%
fossil fuel	2,900	1,100	3,000	7,000	10%
Total, GWh/year	**32,600**	**22,800**	**17,900**	**73,300**	100%

Rates of energy consumption	44%	31%	25%	100%	
Proportions of gross floor area	41%	33%	26%	100%	

Table 5. *Primary energy consumption of residential, commercial and public buildings. Source: Finnish Environment Institute, 2016.*

(energy form coefficients 2012)*	One-dwelling buildings	Multiple-dwelling buildings	Commercial buildings and public buildings	Total	Rates
Electricity (1.7)	17,700	7,100	3,100	27,900	39%
District heating (0.7)	1,700	11,900	8,400	22,000	31%
Heat pumps (1.7)	6,500	500	500	7,500	10%
Biofuels (0.5)	6,600	100	400	7,100	10%
Fossil fuels (1)	2,900	1,100	3,000	7,000	10%
Total, GWh/year	**35,400**	**20,700**	**15,400**	**71,500**	100%
*energy form coefficients will be revised in 2018					

District heating and heat pumps

In connection with the renovation of one-dwelling buildings, biofuel (wood) and oil have been replaced with electricity in heating (Figure 8). In recent years, the efficiency of electricity use has been improved with air-source heat pumps, air-water heat pumps and geothermal heat pumps (Figure 9). Most of the 60,000 heat pumps installed each year are installed in one-dwelling buildings. Compared to direct electric heating, heat pumps decrease primary energy consumption significantly, but not peak power demand during the coldest periods in winter.

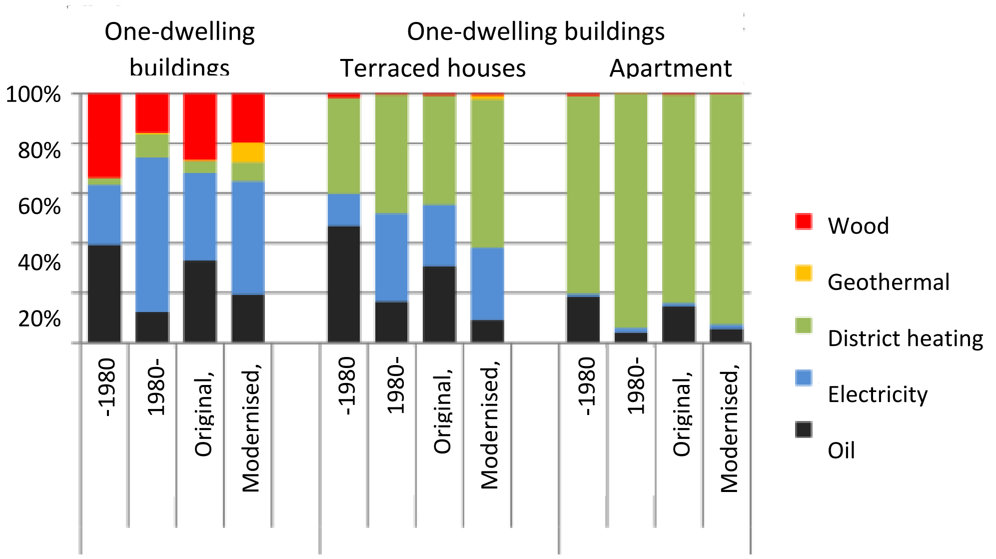


Figure 8. Original and modernised energy sources in residential buildings. Statistics Finland, Energy Statistics, 2013.

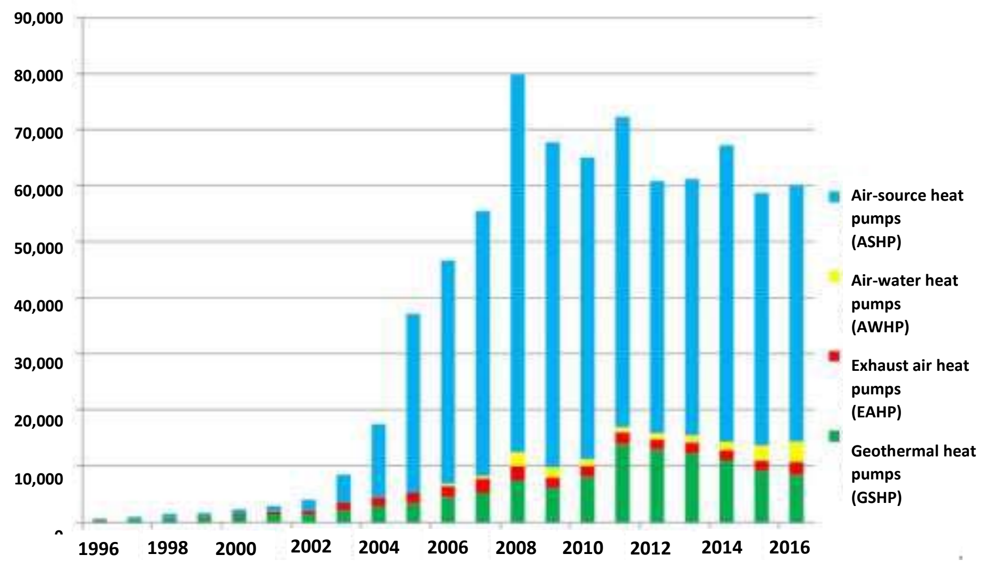


Figure 9. Number of introduced heat pumps. Source: Finnish Heat Pump Association (Sulpu), 2017.

In multiple-dwelling buildings, district heating is by far the most common energy source for heating. As Figure 10 demonstrates, some buildings were connected to the district heating network during the construction phase, while others were converted from property-specific heat production to district heating at a later stage.

The majority (75%) of commercial and public buildings are heated by means of district heating. Even in this case, some buildings were connected to the district heating network during the construction phase, while others were converted from property-specific heat production to district heating at a later stage (Figure 11).

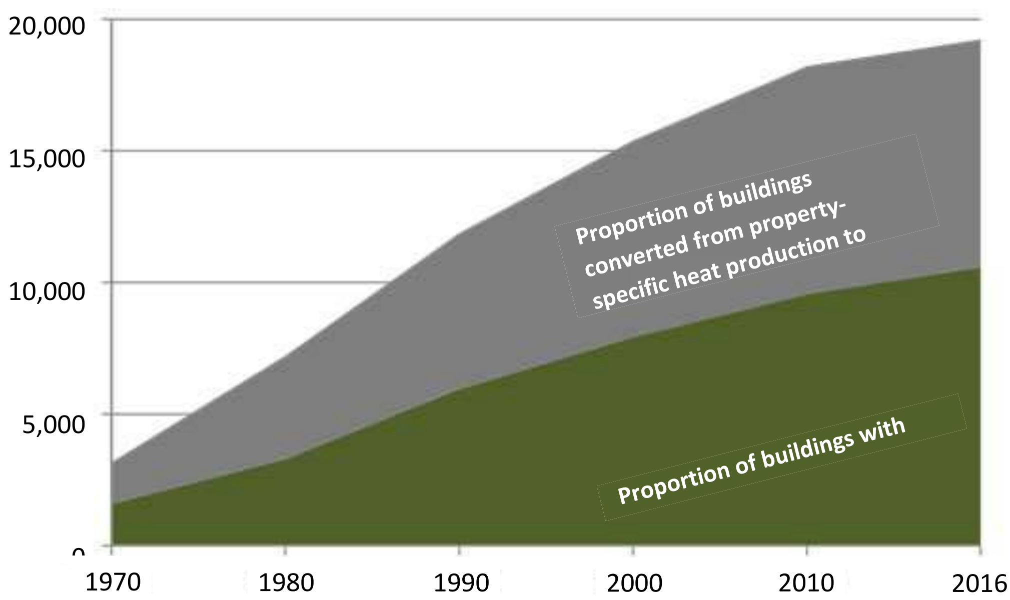


Figure 10. District heating supplied to multiple-dwelling buildings. Source: Statistics Finland, Energy Statistics, 2016 & Finnish Energy, Kaukolämpö, 2017.

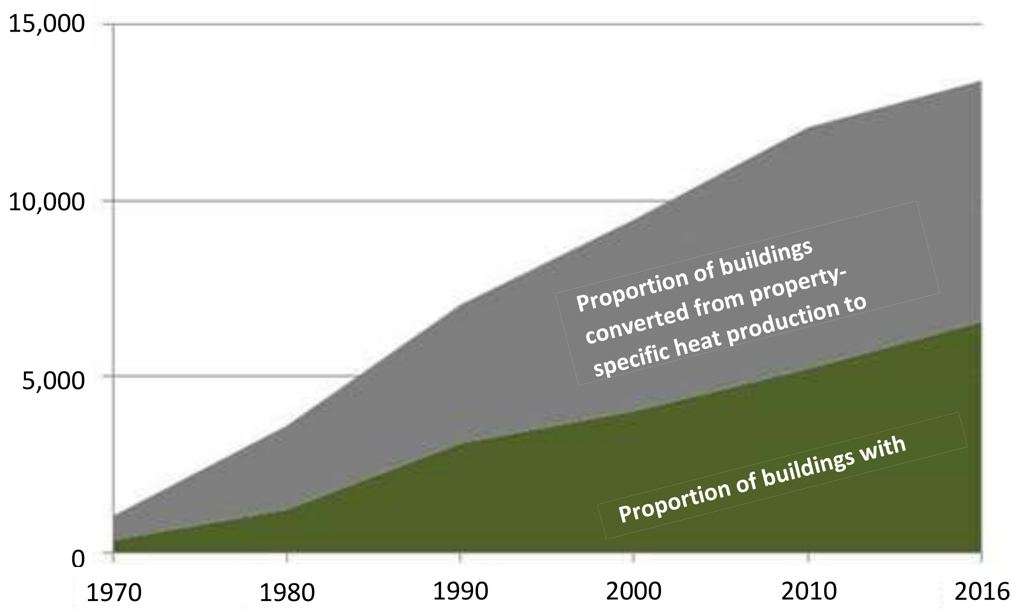


Figure 11. District heating supplied to commercial and public buildings. Source: Statistics Finland, Energy Statistics, 2016 & Finnish Energy, Kaukolämpö, 2017.

2.4. Finland's climate

Finland's climate is a so-called intermediate climate, combining the characteristics of both a maritime and a continental climate. The weather in Finland very much depends on the direction of the prevailing wind and the movement of weather disturbances, i.e. low and high pressure areas. Finland's mean temperatures are largely determined by its location in the middle latitudes, mainly between 60° and 70° North. The annual mean temperature varies from more than +5 degrees in southwestern Finland to a couple of degrees below zero in Northern Lapland (Finland's Climate Guide).

The warmest time of the year is towards the end of July (Figure 12). In continental Finland, the highest summer temperatures outside the long-term averages reach between 32 and 35 degrees. The highest temperature ever recorded in Finland dates back to July 2010: 37.2 °C at Joensuu airport in Liperi. The coldest time of year is around the end of January/beginning of February. The lowest winter temperatures in Lapland and Eastern Finland are between -45 and -50 degrees, in other parts of the country they are usually between -35 and -45 degrees. The lowest temperature recorded at Finland's meteorological observing stations in the 20th century was -51.5 °C in January 1999 (Pokka, Kittilä, 28 January 1999).

The map below shows the geographical distribution of Finland's building stock and the regional heating degree days (Figure 13).

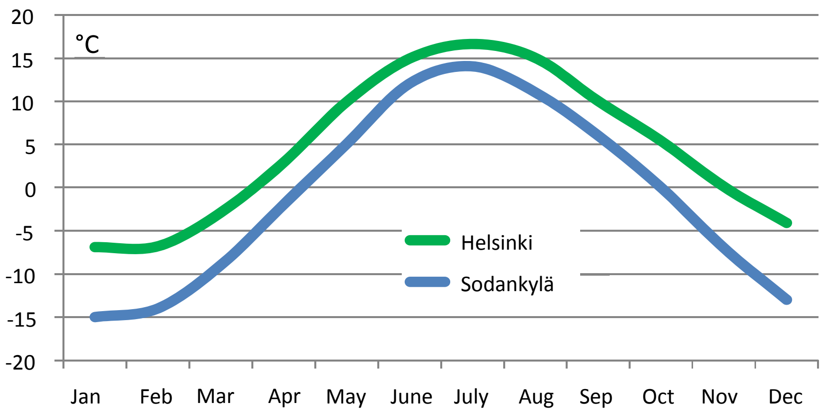
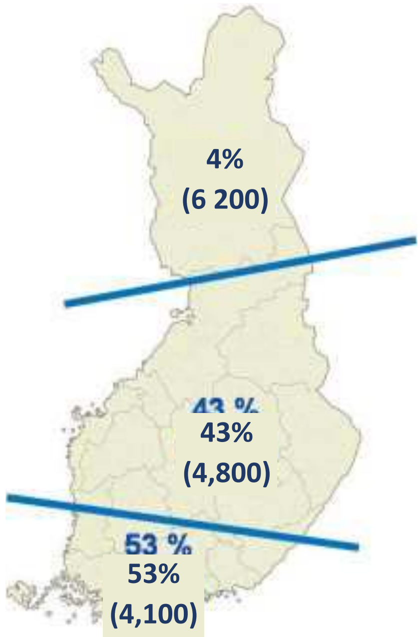


Figure 12. Long-term mean temperatures (1981–2010) in Helsinki (Southern Finland) and in Sodankylä (Northern Finland). Source: Finnish Meteorological Institute, monthly statistics.

Figure 13. Geographical distribution of residential, commercial and public buildings (percentages) and regional heating degree days (°C day).
Source: Statistics Finland, Buildings and free-time residences & Finnish Meteorological Institute, heating degree days



3. Cost-effective deep renovations suitable for Finland's climate and their financing.

3.1. Deep renovation

A renovation is extensive if the total costs of repairs relating to the external walls and roofs or technical systems of a building based on reconstruction costs exceed 25 percent of the value of the building, excluding the value of the building land. In connection with an extensive renovation, anyone undertaking repairs must demonstrate that the measures selected are at a cost-optimal level.

Energy performance can be improved by:

- *modernising building components and systems in stages (staged deep renovation; the most common way);*
- *renovating entire buildings (deep renovation); or*
- *demolishing entire buildings or parts of buildings if no suitable use can be found due to the building's location or condition, or for other reasons.*

The numerical values of the requirements are presented in sections 3.5.1, 3.5.2 and 3.5.3.

3.2. One-dwelling buildings

Methods and sources

The structure of energy consumption in old one-dwelling buildings is presented in the figure (Figure 14). The recommended renovation measures (Table 6) are based on a study by Tampere University of Technology (TUT) on the energy savings potential in the building stock in connection with renovations (Heljo & Vihola, 2012) and reports drawn up for the implementation of the EPBD (Airaksinen & Vainio, 2012; Kauppinen, 2013).

The most cost-optimal measures are based on a joint research project of Aalto University, TUT and VTT Technical Research Centre of Finland, which assessed the cost-optimal levels of minimum energy performance requirements for renovations (Finnish Ministry of the Environment, 2013b). It used the systematics of energy economical choices in refurbishment projects developed at TUT (Heljo & Kurvinen, 2012). In addition, energy advice material targeted at consumers (www.eneuvonta.fi) and coordinated by the Finnish Energy Authority was used.

The cost-optimal levels of measures to improve the energy performance of one-dwelling buildings have been assessed in accordance with Commission Delegated Regulation (EU) No 244/2012, on the basis of life cycle costs for a calculation period of 30 years, taking account of initial investment costs as well as energy costs, maintenance costs, replacement investments, the residual value of investments, the discount rate and the projected increase in the energy price. The selection systematics by TUT are based on additional costs arising from measures taken to improve energy performance and the energy savings achieved by taking the measures (Abel, 2010).

Measures to reduce energy consumption

One-dwelling buildings differ from large buildings due to the fact that 55 percent of one-dwelling houses have property-specific heat production. In one-dwelling buildings, it is possible to make large savings on primary energy and reduce emissions, by targeting measures at either heat production or energy consumption (Table 6).

Such measures can be implemented at the same time (deep renovation), but this is rare due to the differing service lives of structures and systems. All measures can also be taken individually as independent measures (staged deep renovation), but in certain cases care must be taken to ensure interaction between the measures. If heat loss through windows, external walls and roofs is reduced, the heating system should be adapted to correspond to changed consumption. Adding heat recovery from exhaust air to a building affects its original heating system.

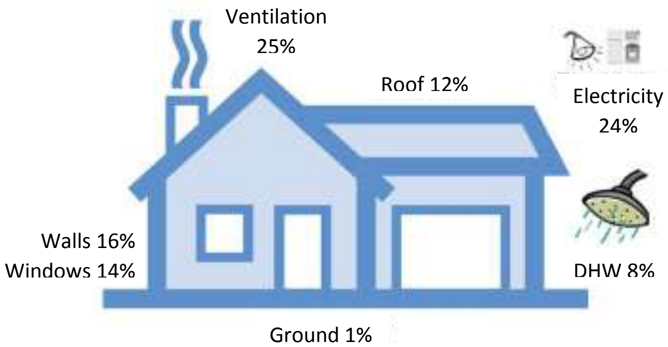


Figure 14. In an old one-dwelling building, heat loss through external walls and roofs accounts for 66 percent of total energy consumption, hot water for 8 percent and lighting, household appliances and other electrical equipment for 24 percent. Source: EKOREM, 2005.

Table 6. *Measures to improve the energy performance of one-dwelling buildings.*

Building component/system	Remedies	Can be implemented as an independent measure	Measures interact
Electricity	After the end of their technical service lives, replacing household appliances with new appliances that are as energy-efficient as possible Replacing light bulbs with energy saving lamps Acquiring photovoltaic panels	X	
ventilation	After the end of their technical service lives, replacing old heat recovery units with energy efficient units	X	
Domestic hot water	Replacing taps and sanitary ware with water saving ones	X	
Window(s)	Replacing windows in poor condition with new, better windows	X	X
External walls	Sealing of feedthroughs Additional insulation, when external cladding needs to be replaced	X	X
Roofs	Additional insulation if there is room Buildings with a flat roof: additional insulation during the renovation of a roof	X	

Floors	Socle: improving ground frost insulation	X	
Heating system	Direct electric heating: adding an air source heat pump Electric storage heaters: adding an air-water heat pump Oil heating: replacing with geothermal heating Fireplaces: replacing with energy efficient ones, for example, replacing an open fireplace with a heat-storing fireplace	X	X

The most cost-effective measures

The most cost-optimal measures **to reduce heat loss** include adding the thickest possible additional thermal roof insulation and replacing the original windows. When the cladding of external walls is replaced, it pays to add thermal insulation as well.

From the perspective of **heat production**, one-dwelling buildings include two relevant groups requiring measures: houses with oil heating and houses with electric heating. **District heating** is seldom available for one-dwelling houses.

Adopting the use of renewable energy sources in houses with oil heating: Oil heating is used to heat almost 20 percent of one-dwelling buildings. Finland's energy and climate strategy (TEM, 2016) sets the target of switching away from oil heating by 2050 in the case of residential buildings. After the end of their technical service lives, property-specific systems should be replaced by systems based on a heat pump (geothermal heat pump; air-water heat pump) or biofuel, as appropriate depending on which is the most sensible option given the geographical location of the building. The system can be switched even earlier if a functioning oil heating system is used as a supporting heating form, in order to level out the heating peak. **Switching from oil heating to geothermal heating is the most cost-optimal** way of meeting the requirements set for renovations (Finnish Ministry of the Environment, 2013a). The idea of replacing oil heating with less expensive heating systems is also supported by a report by the Finnish Ministry of the Environment on fuel poverty in Finland, which identified households with limited means in oil-heated dwellings as a risk group (Finnish Ministry of the Environment, 2013c).

Improving the energy performance of houses with electric heating: The share of houses with electric heating is 45% of all one-dwelling buildings (Figure 8). Many houses with electric heating were built

in the 1980s, and do not yet require renovation. However, there is a significant need to improve energy efficiency if the heating system is direct electric heating. The recommended renovation measure involves the installation of a heat pump (Table 7).

High-consumption buildings

The location of a building is an important factor when planning measures for a high-consumption building. In areas suffering from depopulation, property owners should consider the future of their dwelling, as there is risk that it will be left empty after their occupancy. If a short future occupancy period is foreseen for the building, a deep renovation is unlikely to be a profitable investment. If demand is expected, even in the long term, renovation measures should be prioritised on the basis of the condition of structures or systems. In terms of financing such renovations, it is a good idea to begin making energy cost savings by using free energy (such as geothermal energy). In growing urban areas, demolishing the building may be an option if an energy-efficient, new building with a significantly higher gross floor area can be built on the plot.

Steering of decision-making relating to renovation investments

Householders who own their homes make all decisions concerning their one-dwelling buildings and often carry out any necessary repairs themselves. A change of ownership provides a window of opportunity for deep renovations. Potential new owners are given information on the condition of a building and any renovation needs in the results of property inspections. **Property inspections** are voluntary, but are performed for most sales, particularly in the case of old buildings. The purpose of an inspection is to ensure that an excessive price is not paid for a building in poor condition, but that the condition is reflected in the price and resources are left over to enable the buyer to carry out renovations. The inspector is an external expert with a construction qualification. A technical education can be supplemented with a property inspector's professional degree.

In addition, the **energy performance certificate** required by the EPBD must be presented during a property sale. Individuals who issue energy certificates must have a suitable technical degree or corresponding work experience, and pass a test to demonstrate their familiarity with the drawing up of energy performance certificates and the related legislation. Individuals who issue energy certificates must present cost-effective measures for improving energy efficiency as part of the certificate. Guidance on identifying such measures and assessing their impacts is provided in training material produced by the Finnish Ministry of the Environment.

The joint Elvari project, carried out by the Finnish Energy Authority (energy advice for consumers) and Finnish Energy to improve the efficiency of electric heating, has led to the production of guidelines on reducing energy consumption for users of electric heating under the title ”these guidelines will save you money” (Table 7). By following the guidelines, consumers can save 50% in heating costs. **An air source heat pump is a cost-effective technology for reducing the energy consumption of direct electric heating**. The guidelines also recommend the use of fireplaces in cold winter weather. This is important for both the household and the electricity system, as wood heating helps to cut electricity consumption peaks. Wood used for heating must be dry and clean so as to minimise particulate matter emissions.

The Finnish Home Owners' Association (http://www.omakotiliitto.fi/en), which is a lobbying and service organisation for single family house occupants, provides its members with energy saving tips. Its services also include a maintenance manual that provides property owners with guidance on the systematic management and maintenance of their properties.

Table 7. *Guidelines for owners of one-dwelling buildings. Source: www.eneuvonta.fi*

1. **Monitor and examine your electricity consumption.** Make use of the hourly monitoring service offered by your energy company. Determine whether your consumption is at a normal level. Rapidly address any deviations in consumption.
2. **Monitor and control indoor temperatures for each room separately**. Utilise automatic systems according to your needs or adjust room-specific heaters accurately. Seldom used rooms and storage spaces or garages should not be heated to a comfortable room temperature of 21–22 degrees.
3. **Adjust the ventilation system and use it correctly.** Adjust forced general ventilation according to need, override heat recovery during the summer period and restore it immediately after the warmest summer period. In cases of natural ventilation, set the valve of the air inlet window in the winter position and reduce the gap of the bathroom disc valve during winter.
4. **Check the temperature setting of the hot-water heater.** The recommended temperature is 55–60 degrees. Increase the temperature, if there is insufficient hot water for normal use. Also pay attention to your water use habits.
5. **Use your fireplaces if you have any.** One stacked cubic meter of dry firewood equates to approximately 1,000 kWh of delivered energy. Wood burning is of greatest benefit in mid-winter and in cold winter weather.
6. **Investing in an air source heat pump as a form of supplementary heating is almost always profitable.** Always adjust the basic heating system to a level that is 3–4 degrees lower than the pump. Learn to use the pump in an energy-efficient manner.
7. **Rationalise the consumption of household electricity.** Small changes in electricity consumption habits can bring considerable savings. Pay attention to your use of your sauna, lighting and standby modes of devices. Purchase energy-efficient equipment.

Financing of renovation investments

The state only grants regular renovation subsidies to special-needs groups. The form of assistance for normal households is **a tax credit for domestic expenses**, which can be claimed for work carried out by a business enterprise that has a valid registration for tax prepayment. In 2017, the proportion of the tax credit is 50 percent of the value of the work done, including VAT. However, tax payers must pay EUR 100 of the costs themselves, and the maximum tax credit is EUR 2,400 (Finnish Tax Administration, 2017). The tax credit for domestic expenses is personal and tied to residence, which means that all residents can claim a tax credit if they have contributed to the renovation costs.

Owners of one-dwelling buildings finance most renovations themselves **with savings or market-based loans**. Access to market-based loans is affected by collateral. For example, in areas with low property prices, the need for a loan may be too high compared to the market value of the residential property.

Other financial instrument options include financing from the sale of real estate property (e.g. the parcelling out of land) and financing arranged by product suppliers.

Barriers to renovations of one-dwelling buildings

The condition and energy performance of buildings are assessed when the owner or tenant changes. If no such changes are foreseen, assessing the state of a building is dependent on the initiative and activity of the owner. A renovation may also be prompted by service providers. In both cases, there is a risk that the renovations are haphazard measures rather than based on assessing the improvements required by the building as a whole, and taking account of all possible energy saving methods. It would be worth studying the German example of an “Individual Renovation Roadmap” for promoting renovations of one-dwelling buildings.

Figure 3 illustrates the change occurring in Finland's regional structure, which is leaving residential buildings without permanent residents. In areas suffering from depopulation, some one-dwelling buildings will not be renovated, as their useful life is expected to be short.

Practices in other EU Member States
The Individual Renovation Roadmap (the German approach) is a compact, intuitive and standardised tool, which takes account of customers' needs and is long term and future oriented. The key idea underlying standardised methods is the preparation of renovation roadmaps by energy consultants, who translate the building-specific consulting service into a format that the building owner can understand and handle as a description of the effects of individual measures on energy efficiency, while the economic efficiency of such measures strengthens the owner's willingness to invest.

http://www.buildup.eu/sites/default/files/content/build_up_webinar_08_2017-0202_building_passports_3_mpehnt.pdf

3.3. Multiple-dwelling buildings

Methods and sources

Old apartment blocks consume energy as described in the figure (Figure 15). **Almost all multiple-dwelling buildings are connected to the district heating network**. District heating began to become more popular in the 1970s. Access to district heating was ensured for new residential areas as part of preconstruction, and old buildings with property-specific heating systems switched to district heating (Figure 10).

Measures to improve the energy performance of multiple-dwelling buildings can be targeted at their technical systems or structures. The recommended renovation measures (Table 8) are based on a study by Tampere University of Technology (TUT) on the energy savings potential in the building stock in connection with renovations (Heljo & Vihola, 2012) and reports drawn up for the implementation of the EPBD (Airaksinen & Vainio, 2012; Kauppinen, 2013).

The most cost-optimal measures are based on a joint research project by Aalto University, TUT and VTT Technical Research Centre of Finland, which assessed the cost-optimal levels of minimum energy performance requirements for renovations (Finnish Ministry of the Environment, 2013b). It used the systematics of energy economical choices in refurbishment projects developed at TUT (Heljo & Kurvinen, 2012). Monitoring data from demonstration buildings monitored by VTT was also used.

The cost-optimal levels of measures to improve the energy performance of multiple-dwelling buildings have been assessed in accordance with Commission Delegated Regulation (EU) No 244/2012 on the basis of life cycle costs for a calculation period of 30 years, while taking account of initial investment costs and maintenance costs, replacement investments, the residual value of investments, the discount rate and the projected increase in the energy price. The selection systematics by TUT are based on additional costs arising from measures taken to improve energy performance and on the energy savings achieved by the measures (Abel, 2010).

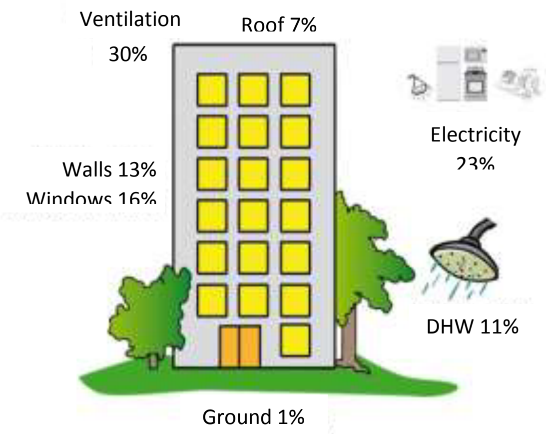


Figure 15. In an old multi-dwelling building, heat loss through the building envelope and ventilation accounts for approximately 66 percent of total energy consumption and hot water for 11 percent. The remaining 23 percent is accounted for by lighting, household appliances and other electrical equipment. Source: EKOREM, 2005.

Measures to reduce energy consumption

These measures can be implemented at the same time (deep renovation), but this is rare due to the differing service lives of structures and systems. All measures can also be taken individually as independent measures (staged deep renovation), but interaction between measures must be ensured in certain cases. If heat loss through windows and the building envelope is reduced, the heating system should be adjusted to correspond to the new situation. Adding heat recovery from exhaust air or waste water to a building affects its original heating system.

The most cost-effective renovation measures

The most cost-optimal measures relate to cutting the energy consumption for ventilation. Forced general ventilation should be equipped with **heat recovery from exhaust air** and the transfer of heat to either central heating or hot water heating. At the end of their service lives, **windows should be replaced** with new ones that have U-values similar to those used in new development. The supply of fresh air can be ensured with supply air valves for windows. An efficient way of saving on water consumption is to **reduce pressure**. Energy can be recovered from waste water centrally. Adding insulation to the building envelope is only financially viable if the surfaces of the envelope need to be replaced for other reasons.

Old buildings must be equipped with unit-specific water consumption measurement during replumbing, whereas unit-specific metering of heat consumption and the related billing would only increase costs (VTT, 2013). A more profitable measure would be to ensure **the settings and functioning of heating and ventilation systems centrally**.

Table 8. *Measures to improve the energy performance of multiple-dwelling buildings.*

Building component/system	Remedies	Can be implemented as an independent measure	Measures interact	
ventilation	Replacing old units with more energy efficient units after the end of their technical service lives Mechanical exhaust air system: adding an exhaust air heat pump	X		X

Electricity	LED lighting with occupancy sensors in common spaces	X		
Domestic hot water	Adjusting the water pressure Replacing taps and sanitary ware with water saving ones Heat recovery from waste water	X		X
Window(s)	Replacing windows in poor condition	X	X	
External walls	Additional insulation, when external cladding needs to be replaced Sealing of feedthroughs	X	X	
Roofs	Additional insulation if there is room Buildings with a flat roof: additional insulation in connection with the renovation of the roof	X		
Floors	Socle: adding insulation boards Isolating the ceiling of the basement in storage spaces	X		
Heating system	Balancing the heating system Replacing the automation system with a dynamic control system	X	X	X

High-consumption buildings

If a multiple-dwelling building requires expensive renovations in addition to measures taken to improve energy efficiency, demolishing the building may be an option worth considering. In areas with low demand, there are often several buildings in the same situation, and buildings in poor condition have low potential to succeed in the mutual competition for tenants or owner-occupants. Rental properties can apply for a demolition subsidy from the Housing Finance and Development Centre of Finland (ARA). In growing urban areas, it is possible to apply for rezoning for the plot so as to be able to construct a larger, energy-efficient, new building on the plot.

Steering of decision-making relating to renovation investments

Joint-stock property companies (rental properties) are governed by the Finnish Limited Liability Companies Act (624/2006) and separately issued statutes, such as statutes on the joint management and restrictions on the use and assignment of state-subsidised (Arava) Rental Buildings and on residential leases. Limited liability joint-stock property companies and housing companies that own residential properties are governed by the Finnish Limited Liability Housing Companies Act (1599/2009). The original Limited Liability Housing Companies Act was issued in 1926. Its most recent reform entered into force in 2010 (Finnish Limited Liability Housing Companies Act, 2009). The Limited Liability Housing Companies Act obligates the Board of Directors to draw up **a report regarding the need for any maintenance on buildings** during the five years following the General Meeting at which such a report must be presented. In addition, it is recommended that housing companies draw up a strategy for 10–20 years. In the case of staged deep renovation, this would be particularly useful to ensuring that account can be taken of interactions between the measures. When selling shares in a housing company, the vendor must present a certificate issued by the building manager, which includes technical details and the company's financial statements as well as the report on the need for maintenance on the property and the related **energy performance certificate.**

The Finnish Real Estate Federation (http://www.kiinteistoliitto.fi/en/) introduced a counselling service for its members in 2016. In addition, it has produced tools for property management and maintenance, which help companies to provide and prepare for future renovations and perform renovation projects in a controlled manner. These include a **condition estimate and a long-term**

maintenance plan based on the estimate. Construction, HVAC and electricity experts who issue condition estimates determine the methods, estimated costs and recommended schedule for the necessary renovation measures. Based on these, preparations for a future renovation can be started in good time, for example by commissioning a project plan and the necessary renovation plans and other contract documents from a qualified designer, applying for the necessary permits from authorities, and making the financial arrangements required by the renovation project.

In multiple-dwelling houses (limited liability housing companies), proposals on renovations and measures to improve energy efficiency are prepared by the Board of Directors, which consists of lay members. A guide has been prepared for this target group. It provides information on the energy consumption of buildings and its reduction, as well as on the management of renovation projects (Figure 15). The same group is also the target group of the **energy expert** training programme

(https://www.motiva.fi/en/home_and_household/housing_companies/energy_expert_activities). An energy expert is an occupant who monitors the energy consumption of the building, passes on information and helps other occupants to take account of energy efficiency. Exchanging and comparing energy consumption data is an important part of energy expert activities. Partly in relation to energy expert activities, case studies of energy efficiency investments, savings achieved and other impacts have been published (www.ekokumppanit.fi/tarmo/onnistumisia/).

*Figure 16. **Taloyhtiön energiakirja** (Energy management book for housing companies) provides guidance on the life cycle management of buildings and renovation project management. The book includes examples of **the impacts of renovation measures on heat and electricity consumption and life cycle costs**. Life cycle costs are compared to a situation where no renovation measures are implemented. Source: Virta & Pylsy, 2011.*

Financing of renovation investments

Renovation and energy subsidies for residential buildings were granted in the period 2003–2013. In addition, countercyclical energy subsidies and start-up assistance for renovation work have been granted (including for measures to improve energy efficiency). Subsidies have been granted for renovations aimed at improving energy efficiency, the replacement of heating systems and adoption of heating systems based on renewable forms of energy and as means-tested energy subsidies for detached houses and in support of the systematic maintenance of buildings.

As a general rule, shareholders in a housing company decide on renovations of the buildings and basic utility systems and jointly pay for them using either their own resources (savings, internal financing, reserves, funding) or market-based loans or, in exceptional cases, the interest subsidy granted by the Housing Finance and Development Centre of Finland (ARA). However, financing granted by ARA tends to be available for non-profit institutions only.

Market-based loan financing for housing companies is more easily available if the maintenance charges confirm that the company is able to manage its finances. A separate bank account is opened for paying renovation invoices. After a renovation has been completed and the invoices have been paid, the account is converted into a loan that will be repaid based on charges for common capital expenditure. According to the renovation barometer of the Finnish Real Estate Federation, the loan maturity period is less than 10 years for half of all housing companies that have taken out a loan (Finnish Real Estate Federation, 2013). In the case of rental properties and rented premises, renovation costs are passed onto either the rents of the property in question or those of the owner's entire building stock.

The amount of loan to be taken out can be reduced by pre-funding. A housing company can collect money for renovations into a renovation fund (balance sheet) for five years in advance. Another option is to make a residential building provision, which can be used to level out the financial result of the housing company over a maximum period of ten years (minimum EUR 3,500/year or maximum EUR 68/m^2/year).

Housing companies can apply for the right to construct additional spaces in a building (rooms in the attic; additional storeys) or on the plot and finance the renovation of the old building with the proceeds from their sales. This is also in the interests of municipalities in growing urban areas. It can save on the costs of building infrastructure and providing services, compared to new development undertaken in a new area (Nykänen, 2013).

In addition, financing arranged/offered by product suppliers is available for multiple-dwelling buildings.

Finnish housing companies are small. By combining projects, housing companies can create a larger renovation project that interests a larger number of contractors, thereby achieving a genuine tendering process. This approach can create benefits in the form of cost savings or a higher-quality outcome in terms of energy efficiency improvements. The Finnish Ministry of the Environment has developed, tested and implemented this approach together with the private sector (http://www.taloyhtio.net/ryhmakorjaus/). Cooperation has also been promoted through projects (www.ekokumppanit.fi/tarmo/).

Barriers to renovations of multi-dwelling buildings

Responsibility for the activities of a housing company lies with the Board of Directors, which usually consists of lay members who may lack the knowledge, skills and time to participate actively in the preparation and commissioning of renovation projects.

The shareholder base of housing companies is highly diverse. Renovations can be prevented by the limited means of shareholders or non-acceptance of renovation costs by owners of buy-to-let dwellings.

Figure 3 illustrates the change taking place in Finland's regional structure, which leaves residential buildings without permanent residents. In areas suffering from depopulation, some buildings will not be renovated as their useful life is expected to be short.

Public sector example: Energy triathlon

In Tampere, the city has organised energy triathlons in which housing companies can compete in three categories: savings in heating energy, electricity and water consumption.

Results of the 2016 Energy Triathlon

Heating	-22%
Electricity	-59%
Water	-10%

3.4. Commercial buildings and public buildings

Methods and sources

The distribution of energy consumption in old commercial and public buildings is shown in the figure (Figure 17). Most commercial and public buildings are connected to the district heating network, and thus measures to improve the energy performance of the buildings mainly relate to their technical systems and structures. The recommended renovation measures (Table 9) are based on a study by Tampere University of Technology (TUT) on the energy savings potential of the building stock in connection with renovations (Heljo & Vihola, 2012) and reports drawn up for the implementation of the EPBD (Airaksinen & Vainio, 2012; Kauppinen, 2013).

The most cost-optimal measures are based on a joint research project by Aalto University, TUT and VTT Technical Research Centre of Finland, which assessed the cost-optimal levels of minimum energy performance requirements for renovations (Finnish Ministry of the Environment, 2013b).

The cost-optimal levels of measures to improve the energy performance of multiple-dwelling buildings have been assessed in accordance with Commission Delegated Regulation (EU) No 244/2012 on the basis of life cycle costs for a calculation period of 30 years, taking account of the initial investment costs as well as maintenance costs, replacement investments, the residual value of investments, the discount rate and the projected increase in the energy price.

Measures to reduce energy consumption

All measures can be taken individually as independent measures (staged deep renovation) or in various combinations. Due to the differing service lives of structures and systems, it is rare for all of the measures to be implemented at the same time (deep renovation). The interoperability of measures must be ensured if they are implemented individually. For example, if heat loss through windows and the building envelope is reduced, the heating system should be adapted to correspond to the change in consumption.

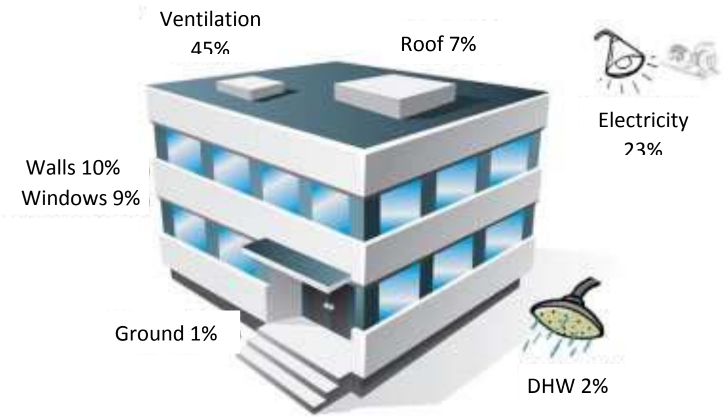


Figure 17. In old commercial and public buildings, heat loss through the building envelope and ventilation accounts for approximately 70 percent of total energy consumption, hot water for 2 percent and lighting and electrical equipment for 27 percent. Source: EKOREM, 2005.

Table 9. *Measures to improve the energy performance of commercial and public buildings.*

Building component/system	Remedies	Can be implemented as an independent measure	Measures interact	
ventilation	Installing heat recovery if not yet installed. Replacing the ventilation control system (ventilation according to need). After the end of their technical service lives, replacing old units with more energy efficient units. Paying special attention to the efficiency of heat recovery. (District cooling; geothermal cooling)	X		X
Electricity	Replacing fluorescent lighting with LED lighting Lighting systems with occupancy sensors Solar panels, if used around the year and not closed for the summer	X		
Heating system	Replacing the automation system with a dynamic control system Balancing the heating system Property-specific oil heating system: replacing with geothermal heating	X		X
external walls	Additional insulation, when external cladding needs to be replaced Sealing of feedthroughs	X	X	
Roofs	Additional insulation, if there is room Buildings with a flat roof: additional insulation in connection with renovating the roof	X	X	
Window(s)	Replacing windows in poor condition	X	X	

Floors	Socle: adding insulation boards Isolating the ceiling of the basement in storage spaces	X		
Domestic hot water	Adjusting the water pressure Replacing taps and sanitary ware with water-saving ones Heat recovery from waste water, if high volumes of water are used	X		X

The most cost-effective renovation measures

In commercial and public buildings, the most cost-effective measures relate to **ventilation** (efficient ventilation units, heat recovery, ventilation according to need, and district cooling, if appropriate) and **lighting** (LED lighting; control by occupancy sensors).

Even if commercial and public buildings have a water circulating central heating system, most heating and cooling is distributed to the premises by forced air through ventilation. That is why the amount of heat distributed through water circulating radiators is low, and metering and billing on such a basis would only increase costs. Ensuring that **heating and ventilation systems are well-functioning** is more profitable.

A renovation project tends to involve the identification of the building elements to be renovated and replaced and the building services to be replaced. Instead of old procurement practices, it is recommended that building services be purchased on the basis of requirements set for their **energy efficiency properties and technical performance**, so as to ensure the interoperability of system components.

Due to changes taking place in the regional and sectoral structure, the expected useful life of buildings may be too short for renovations to be profitable. In such cases, an alternative solution is to **increase space efficiency**. The aim is to reduce maintenance costs, while ensuring that the premises remain in good condition with respect to health and safety. Premises are used in a controlled way until they are no longer satisfactory and then the **building is demolished**.

High-consumption buildings

In the case of high-consumption buildings, consideration should be given to demolishing the building, as many such buildings also require renovation measures other than those taken to improve energy efficiency. In growing urban areas, it is worth investigating whether it is possible to apply for rezoning for the plot, so as to be able to construct a larger, energy-efficient new building there. In areas with low demand, several buildings are often in the same situation and buildings in poor condition have low potential to succeed in the competition for tenants.

Steering of decision-making relating to renovation investments

The buildings are either used by their owners or let out, either to external parties or, in the case of municipalities, internally. Decision-making regarding renovations is affected by the functional requirements set for the use of the building. Businesses and organisations that operate in their own premises pay little attention to property management costs. Properties that are let out, on the other hand, can provide a bigger return on the landlord’s investment if energy costs are lower.

Property owners are encouraged to **increase the energy performance of their buildings by means of an agreement scheme** (Motiva, 2017), which is designed to help Finland meet its international obligations in mitigating climate change. Voluntary energy efficiency agreements have been signed with the property and building sector, the service sector and the municipal sector.

Businesses and non-governmental organisations that have signed an energy efficiency agreement set their own targets for increasing energy efficiency, carry out measures and report annually on their progress and other initiatives aimed at improving energy efficiency. One of the key goals of the agreement scheme is to promote **the adoption of new, energy-efficient technologies and services** and the exchange of information on successful measures to improve energy efficiency.

Financing of renovation investments

The state supports businesses and non-governmental organisations participating in an energy efficiency agreement in the performance of energy audits and analyses and, in some cases, can contribute towards energy efficiency investments and the costs of adopting new, energy-efficient technologies.

The Finnish Association of Building Owners and Construction Clients (www.rakli.fi) has developed a number of operating models and tools that are designed to improve eco-efficiency in contracts between landlords and tenants (RAKLI, 2011). Green lease and Light green lease agreements can be used to jointly agree on energy efficiency targets, forms of energy, metering and the sharing of costs arising from such measures.

Other financing options:

- Self-financing or other financing acquired by the business or organisation (a bank loan or other financial instrument)
- Financing by service providers (loan, leasing, transfer of accounts receivable to a third party, financing tied to the balance sheet of the service provider)
- ESCO projects: investment aid granted by ELY centres (requires a guarantee for energy savings).

Barriers to renovations of commercial buildings

In commercial buildings, the focus is on the activities carried out on the premises. Property management costs, including energy costs, are a minor cost item compared to other costs arising from the operations, and little attention is therefore paid to them.

Energy conservation and the use of renewable energy sources could remove barriers in terms of image.

Many commercial buildings are rented properties, where renovations are typically carried out when the tenants change. Such timing is not always optimal for carrying out energy efficiency improvements.

Some commercial buildings suffer from under-utilisation as clients (potential tenants) prefer modern premises.

Barriers to renovations of public buildings

Due to the 1970 energy crises, some measures were implemented in public buildings that were not interoperable with the old structures. For this reason, energy efficiency improvements still have a bad reputation as a cause of indoor air-quality problems.

If ventilation rates are increased to a level meeting current requirements or the level of air quality is raised, energy consumption increases instead of savings.

Finland’s dependency ratio, low employment rate, industrial restructuring and trade deficit have led to budgetary problems. This is directly reflected in opportunities to invest in the renovations of public buildings.

Figure 3 illustrates the change occurring in Finland's regional structure, which leaves public buildings without permanent users. In areas suffering from depopulation, some buildings will not be renovated, as their useful life is expected to be short.

Public sector example
A protected building owned by the University of Helsinki, built to serve as a bank branch in 1932, was renovated in 2012–2014 to provide premises for the Finnish Ministry of the Environment.

In terms of energy performance, the building was renovated in accordance with the requirements set for new buildings, which is a remarkable achievement when renovating a protected building. The energy concept includes district heating, district cooling by sea water and a solar power station of 100 square metres. The building has an energy-efficient ventilation system, and lighting (LED), cooling and ventilation are controlled according to need using occupancy, environmental and daylight sensors. The lifts are equipped with a braking energy recovery system. Heat loss has been reduced by new energy-efficient windows, as well as additional roof, floor and basement wall thermal insulation. Space efficiency improved by +40%.

http://www.ym.fi/en-US/Latest_news/Press_releases/Press_releases_2015/The_Ministry_of_the_Environment_moves_to(33269)

3.5. Minimum requirements for measures to improve energy performance

Measures to improve energy performance are presented in Tables 6, 8 and 9. When implementing such measures, the following requirements set for renovations must be observed (sections 3.5.1, 3.5.2 and 3.5.3).

3.5.1. Second lamp envelope

1. External walls: Original U-value x 0.5, however not exceeding 0.17 W/(m^2 K). When changing the intended use of a building, original U-value x 0.5, however at least 0.60 W/(m^2 K).
2. Roofs: Original U-value x 0.5, however not exceeding 0.09 W/(m^2 K). When changing the intended use of a building, original U-value x 0.5, however at least 0.60 W/(m^2 K).
3. Floors: The energy performance is improved as far as possible.
4. The U-value of new windows and external doors must be at least 1.0 W/(m^2 K). When repairing old windows and external doors, the thermal resistance must be improved where possible.

3.5.2. Technical systems

1. The amount of heat to be recovered from extracted air originating from a building's ventilation system must equal at least 45% of the amount of heat required to heat the ventilation system; in other words, the annual heat recovery efficiency must be at least 45%.
2. The maximum specific fan power of a mechanical supply and exhaust air system is 2.0 kW/(m^3/s).
3. The maximum specific fan power of a mechanical exhaust air system is 1.0 kW/(m^3/s).
4. The maximum specific fan power of an air-conditioning system is 2.5 kW/(m^3/s).
5. The efficiency of heating systems must be improved where possible, when the related equipment and systems are renewed.*
6. With regard to modernising water and/or sewage systems, the provisions applicable to new buildings must be observed.

*Further specifications being prepared:

The efficiency of heating systems must be improved when the related equipment and systems are renewed with respect to the refurbished components. After the renewal

- The ratio between the efficiency of the building's main heat production system and the efficiency of the spaces' main heat distribution system must be at least 0.8. This ratio must be calculated as the quotient of the annual efficiencies achieved by the main heat production system and the main heat distribution system.

- The annual efficiency of the main heat production system or the spaces' main heat distribution system must be at least 0.73. If, following a renovation, the main heat production system of a building is a heat pump, the ratio between the SPF (Seasonal Performance Factor) of the heat pump and the annual efficiency of the spaces' main heat distribution system must be at least 2.4. The ratio must be calculated as the quotient of the SPF of the heat pump and the annual efficiency of the spaces' main heat distribution system.

- After the renovation, the specific electrical energy consumption of the accessories of the spaces' main heat distribution system must not exceed 2.5 kWh/net m^2 (per heated net area).

3.5.3. Ensuring the proper functioning

1. Building envelope and technical systems

   Anyone undertaking measures to improve the energy performance of the building envelope of a building must ensure that the building envelope and the joints between all windows or external doors and the surrounding structures are sealed, so that the thermal insulation layers are protected from the detrimental effects of air flow on the thermal insulation properties.

   When planning or implementing a renovation or replacement project concerning the building envelope or technical systems, the measures must be selected so as to ensure the correct functioning of the thermal and acoustic insulation, moisture barriers and fire insulation of the structures.

2. Ventilation

   If necessary, plans detailing measures to improve the energy performance of a building must demonstrate how the correct operation of the ventilation system and a sufficient supply of supply air are ensured if the building is equipped with a mechanical exhaust air system or natural ventilation system.

   If the energy performance of a building is improved by adopting unit-specific mechanical supply and exhaust air systems equipped with heat recovery, these must be designed and installed so that the air intake or exhaust at an external wall does not cause adverse health effects in other units.

3. Functioning of technical systems

   In connection with improving the thermal insulation or airtightness of the building envelope of a building or a considerable part thereof, or in connection with improving the energy performance of the same or after measures aimed at improving ventilation, proof must be presented of the correct and energy-efficient functioning of the heating and ventilation system and that any necessary building service systems have been balanced and adjusted as needed.

Finland’s cost-optimal levels of minimum energy performance requirements for deep renovation were defined in Finland’s 2013 requirements for renovations that are subject to planning permission (Finnish Ministry of the Environment, 2013a).

4. Policies and measures that promote deep renovations

As part of the national implementation of the Energy Performance of Buildings Directive **(**EPBD**)** energy efficiency requirements have been set for individual building elements and systems as well as whole buildings in connection with renovations subject to planning permission (Finnish Ministry of the Environment, 2013a). All properties for sale or to let must have an energy performance certificate as of 2013.

Individuals who issue energy certificates must present cost-effective measures for improving the energy performance of old buildings.

4.1. Far-sighted property management

Energy efficiency can only be improved if the renovation project is carried out professionally and with the requisite quality from start to finish, and if the functioning of the building is considered as a whole. The client needs to specify what they want to achieve with the renovation in terms of energy efficiency, the engineers need to find means of meeting such objectives, and builders need to execute the measures and ensure that the energy efficiency targets set are achieved in practice. After this, responsibility usually returns to the owner of the building who must, either alone or together with service providers, ensure that the condition achieved due to the improvements is maintained.

Suggestions for promoting far-sighted property management:

⇒ *The **use of tools** developed to support property management **should be increased** (Property use and maintenance guide, Condition estimate, Long-term maintenance plan).*

⇒ *In addition to a short-term maintenance plan (5 years), property management and maintenance should be considered on a longer term basis (e.g. 10–15 years) by drawing up a **property strategy**.*

⇒ *Staged deep renovation would require **a longer period of validity for the building permit** than the current five years.*

4.2. Know-how, education and training of the labour force

In recent years, increasing attention has been paid to the concepts of energy efficiency and life cycle management in both education and training for young people and mature students, and continuing training for professionals who have already established themselves in the industry. At the level of universities of applied sciences, a specialisation option involving renovation has been established and specialisation courses (30 credit units) under the title “Energy performance of buildings” have been organised as continuing education. In addition, continuing education in renovation for professionals has been organised in relation to the preparation of energy performance certificates, condition surveys (qualifying to conduct such surveys) and the use of thermographic cameras. EU funding has been used to produce study material on best practices in energy-efficient construction in the Build Up Skills I and Build Up Skills II projects (https://www.motiva.fi/en/home_and_household/building/build_up_skills_finland). The Build Up Skills work continues.

Proposed measures relating to the know-how, education and training of the labour force:

- ⇒ *The **use of research data** in education is promoted by enhancing cooperation between universities, universities of applied sciences and vocational upper secondary education and training institutions. At the moment, the possibilities are being examined of integrating universities and universities of applied sciences into the same concerns.*

- ⇒ *Awareness among renovation operators and access, based on digital services, to information on the industry's processes and operating methods are being promoted by one of the Finnish Government's key projects, the "**Digitalisation of the built environment and construction sector**" project.*

- ⇒ *All parties in the renovation process are being supported in **acquiring knowledge and skills in new areas.** New areas include the use of renewable energy sources in buildings (solar energy and heat pumps) and the related building services, overall performance (hybrid systems), life cycle cost (LCC, costs versus the properties of a building, such as health and safety aspects, functionality, lightness and accessibility).*

- ⇒ *The **smooth implementation of renovation projects** is being promoted by means of agreement templates (falls within the responsibilities of Building Information), by adopting new contract models in addition to traditional ones (such as cooperative contracting, life-cycle contracting) and by recommending that local authorities responsible for construction supervision take a proactive role in renovation projects and improve the competence of lay clients (falls within the responsibilities of operators such as the Finnish Real Estate Federation).*

- ⇒ *Based on existing schemes, a voluntary certification scheme is being developed for renovation and the **life cycle management** of buildings. The aim is to increase competencies in renovation and property maintenance, improve the reliability of such activities and raise their prestige as a whole. Responsibility for the development of the certification scheme lies with the Finnish Ministry of the Environment, FISE Oy and the Construction Quality Association (RALA ry).*

4.3. Digitalisation, innovations and business

Building stock information, renovation permits and the information process associated with energy performance certificates have been part of the eServices and eDemocracy project (SADe) launched by the Finnish Ministry of Finance. This has involved the development of several digital services for improving the efficiency of information management during renovation, such as:

- ⇒ ***Electronic permit services** relating to the built environment, which have been adopted in 1/3 of all municipalities.*

- ⇒ ***Website on energy performance certificates**, which includes guidelines on drawing up an energy performance certificate, calculation guidelines, a service for storing certificates and a database (open data), for example.*

- ⇒ ***Property price information service** for old buildings (open data) and*

- ⇒ ***Electronic forms and services** of the Housing Finance and Development Centre of Finland (ARA).*

The digitalisation of renovation will continue on the basis of one of the Finnish Government's key projects, the Digitalisation of the built environment and construction sector project, Kiradigi 2017–2019 (www.kiradigi.fi). Experimental projects are selected on the basis of open competition. The joint objective of the public and private sectors is:

⇒ *To test **digital models** of buildings and put standards into practice.*

⇒ *To promote practices that enable the use of harmonised/compatible **digital information** in various processes (such as remote control of consumption, real time monitoring of consumption, power demand monitoring, room-specific consumption monitoring and various consumption simulations and measurements) throughout the entire life cycle of the built environment.*

⇒ *To develop solutions to facilitate **information sharing** between design and construction as well as construction and use, and thus speed up change in key practices in the industry.*

All properties in Finland using electricity and almost all properties connected to the district heating network are covered by real time remote reading. Customers can monitor their energy consumption via the Internet or mobile user interface. This technology also enables verification of the effectiveness of energy efficiency measures. Such information can be used to improve the quality of models used in energy efficiency improvements and design/simulations. Energy management systems are already available for major property owners. Such systems provide guidance on improving energy efficiency by comparing properties and producing information on the basis of which renovation and energy efficiency investments can be targeted at the right properties and thereby achieve optimal life cycle profitability.

Real time remote reading also enables billing based on monitoring energy production costs. For both customers and the energy system, the joint objective is to reduce electricity consumption peaks during which higher quantities of energy than normal must be produced temporarily.

⇒ *Technologies should be tested that help to **cut power demand** during peak periods, by introducing flexibility in the energy consumption of buildings (automatic short-time turn-off of consumption).*

Extensive research has been performed on renovation construction and, in particular, energy renovations focused on improving energy management. Sound technical and economic concepts have been developed.

⇒ *Investments in the **commercial exploitation of the results of R&D&I projects** and new business should be increased (experimental building, promotion of agile development).*

Developing an energy renovation business requires efficient coordination between products, service processes, customers and construction processes. If the property to be renovated is in use, more attention can be paid to the production process rather than the end result. In addition to mechanical and technical components, the process involves customer care and communication, and user training. Surprises, running over-schedule and careless conduct on site are particularly likely to lead to dissatisfaction among customers.

⇒ *Business should be developed so that **services tailored** to match the range of energy efficiency improvements are available, as well as suitable production systems covering design, engineering, commissioning and contracting models (such as life cycle and alliance contracting).*

4.4. Communications

Information on energy efficiency is provided and sector-specific projects are implemented centrally by the Motiva service of the Finnish Energy Authority. Motiva provides separate services targeted at households (https://www.motiva.fi/en/home_and_household), municipalities (https://www.motiva.fi/en/public_sector) and businesses (https://www.motiva.fi/en/private_sector). Industrial associations and large cities also provide information accessible to all users, such as http://www.energiakorjaus.info/in-english/ offered by the City of Oulu.

The http://www.ymparisto.fi/korjaustieto website of the Finnish Ministry of the Environment offers information on information sources and research projects relating to the life cycle management of buildings, the systematic maintenance of properties and renovation construction. One of these information sources is the http://www.taloyhtio.net/korjausjaremontointi website of the Finnish Real Estate Federation, which includes a comprehensive selection of information on the planning of renovations, building element-specific measures, finances and the procurement of renovation services. Information on research projects is also provided by the RenoWiki database established by the Build Upon project at http://fi.buildupon.eu/

It is proposed that communications be further developed as follows:

⇒ *Promoting renovations by encouraging a domino effect* ***. Disseminating information on successful energy performance renovations*** *(the most cost-effective measures, technically and functionally feasible measures, indoor air quality improvements in connection with renovations) as well as risks relating to solution options.*

⇒ *Public database on* ***cost-effective measures*** *for experts issuing energy performance certificates.*

⇒ ***Indicators calculated per actual user*** *(kWh/resident or worker) or visitor (kWh/user or customer) for measuring energy efficiency if the efficiency of space utilisation is improved during a renovation project.*

⇒ *A* ***virtual model of implementing a renovation project*** *that requires planning permission (permits, design and engineering, supervision, surveys, inspections, implementation of the contract, commissioning and use).*

⇒ *Information on the* ***impacts of energy efficiency investments*** *on the value of the property and its operating costs throughout its life cycle for the market and customers (tax administration, insurance companies, tenants, owners).*

4.5. Financial incentives

Financial incentives should be long-lasting and predictable. Short-term, countercyclical incentives distort the markets and raise prices temporarily. Incentives should also be introduced for renovation projects that go above and beyond what is required, as well as for testing new technologies and concepts. Other proposals relating to financial incentives:

⇒ *Investigating the possibility of promoting deep renovation* ***by supporting project planning in the renovation of residential buildings****. The amount of such aid should be significant, for example, 50% of planning costs if it can be demonstrated that they result in an energy efficiency improvement that is significantly higher than the required level and an impact assessment confirms that higher quality has been achieved. Project plans and information on savings achieved should be publicly available for use, so as to ensure that best practices can be applied to the improvement of planning in similar projects.*

⇒ *Promoting measures that allow* ***tenants to influence*** *the level of their rent by saving on heating energy or electricity costs, for example.*

⇒ *Promoting measures that **support the smooth functioning of** residential and commercial property **markets**. Far-sighted property management and good property maintenance should be reflected in the prices and rents of dwellings and premises. Correspondingly, neglect of maintenance, low energy efficiency and aesthetic repairs should mean lower prices and rents on the market.*

5. Scenarios and impacts

5.1. Preparation of the scenarios

Six different scenarios have been prepared on the impact of the renovation of buildings on energy end-use and primary energy consumption. The premise is that measures to improve energy efficiency are performed when a decision has been made to renovate the building, building element or technical system for some other reason. This proportion of the building stock is included in the calculations, by using the coefficient “frequency of renovations in the building stock”. With respect to the frequency of renovations, two alternatives are examined. The number of renovations either remains at the current level (scenario 0, scenario 1, scenario 2 and scenario 3) or it is doubled (scenario 2B and scenario 4). The renovation frequency depends on the age of the building. Renovations are most frequently performed on buildings built in the 1960s and 1970s. The renovation frequency also varies among building elements and systems.

Energy efficiency is improved in either some or all renovations. This is defined by the coefficient ”frequency of energy renovations among renovations” (Table 11). The impact on energy consumption depends on the measures implemented. These variables are used to calculate the annual energy saving achieved (Figure 18).

Table 10. *The frequency of renovations in the scenarios varies according to type of building, age of building and building elements/technical systems.*

	ONE-DWELLING BUILDINGS					
	Conduction losses	**ventilation**	**Warm water**	**Electricity for building services**	**Electricity use by users**	**Cooling**
	1980-.					
Scenarios 0-3	1%	0.5%	0.5%	1%	1%	1%
Scenarios 2B,4	2%	1%	1%	1%	1%	1%
	1960-1979					
Scenarios 0-3	3%	2%	3%	1%	2.5%	1%
Scenarios 2B,4	5%	4%	5%	1%	2.5%	1%
	.-1959					
Scenarios 0-3	1%	1%	1%	1%	1%	1%
Scenarios 2B,4	2%	2%	2%	1%	1%	1%

	MULTIPLE-DWELLING BUILDINGS					
	Conduction losses	**Ventilation**	**Warm water**	**Electricity for building services**	**Electricity use by users**	**Cooling**
	1980-.					
Scenarios 0-3	1%	0.5%	0.5%	1%	1%	1%
Scenarios 2B,4	2%	1%	1%	1%	1%	1%
	1960-1979					
Scenarios 0-3	3%	2%	3%	1%	2.5%	1%
Scenarios 2B,4	5%	4%	5%	1%	2.5%	1%
	.-1959					
Scenarios 0-3	2%	2.5%	4%	1%	2.5%	1%
Scenarios 2B,4	4%	4%	6%	1%	2.5%	1%

	COMMERCIAL AND PUBLIC BUILDINGS					
	Conduction losses	**Ventilation**	**Warm water**	**Electricity for building services**	**Electricity use by users**	**Cooling**
	1980-.					
Scenarios 0-3	1%	0.5%	0.5%	1%	1%	1%
Scenarios 2B,4	2%	1%	1%	1%	1%	1%
	1960-1979					
Scenarios 0-3	3%	2%	3%	1%	2.5%	1%
Scenarios 2B,4	5%	4%	4%	1%	2.5 %	1%
	.-1959					
Scenarios 0-3	2%	3%	4%	1%	2.5%	1%
Scenarios 2B,4	5%	4%	5%	1%	2.5%	1%

Building X Frequency of X Frequency of X Impact of = Energy saving

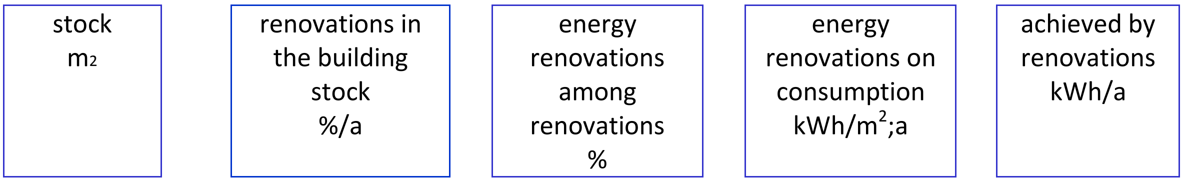


Figure 18. Energy saving achieved through energy efficiency improvements, evaluation principles.

Renovation measures included in the scenarios

Scenario 0 (Business as usual (BAU) in history)

Scenario 0 describes the situation in 2012 before the start of the national implementation of the Energy Performance of Buildings Directive **(**EPBD**)** in connection with renovations subject to planning permission (Finnish Ministry of the Environment, 2013a). Energy efficiency was improved in 25% of renovations of the building envelope or technical systems before the requirements were set. Measures were carried out as follows:

Conduction losses

In connection with façade renovations, the U-values of external walls were halved and windows modernised. In 1970s apartment blocks, for example, this means that the original wall U-value of 0.45 W/m^{2}K drops to 0.22 W/m^{2}K. The window U-value drops in 1970s apartment blocks from 2.0 W/m^{2}K to 1.0 W/m^{2}K. In detached houses, insulation is added to the roof so as to halve the roof U-value. In other types of buildings, insulation is added to the roof, where possible.

Hot water

In connection with replumbing old properties, the goal is to lower the pressure and introduce modern, economical bathroom suites. Hot water consumption is reduced by 25%.

Ventilation

Ventilation system remains unchanged.

Electricity consumption

Electricity consumption remains unchanged.

Type of heating

By 2050, the share of electrical heating systems will drop to 75% of the 2012 level. The share of oil heating systems will drop to 40% of the 2012 level. Oil heating systems will disappear from residential properties altogether by 2050.

Scenario 1 (BAU) = Scenario 0 plus the following:

When building elements are renovated, energy efficiency is improved in half of all renovations (building envelope, ventilation, hot water).

Scenario 2 (Pursuit) = Scenario 1 plus the following:

Energy efficiency is improved in all renovations of building elements (building envelope, ventilation, hot water). Insulation is added to external walls, even with respect to façade renovations of buildings completed after 1980.

Ventilation systems will be equipped with heat recovery units in all ventilation renovations performed after 2020.

By 2050, the share of electrical heating systems in the building stock will drop to 20% thanks to heat pumps.

Scenario 2B (Pursuit – double speed) = Scenario 2 plus the following:
The number of renovations has approximately doubled.

Scenario 3 (Ambitious) = Scenario 2 plus the following:
During the renovation of building elements, energy efficiency is improved to meet the requirements set for new buildings.

Scenario 4 (Ambitious – double speed) = Scenario 3 plus the following:
Half of all renovations carried out meet the requirements set for new buildings.

Table 11. *The level of ambition and number of renovations in the scenarios relative to current renovation construction.*

Level of ambition	Inclusion of energy efficiency improvements in renovations of building elements and technical systems			
	In one in every four	In one in every two	In all	Double the number
To meet requirements set for renovations	Scenario 0 (BAU in history)	Scenario 1 (BAU)	Scenario 2 (Pursuit)	Scenario 2B (Pursuit – double speed)
To meet the requirement set for new buildings			Scenario 3 (Ambitious)	Scenario 4 (Ambitious – double speed)

5.2. Energy consumption in the scenarios

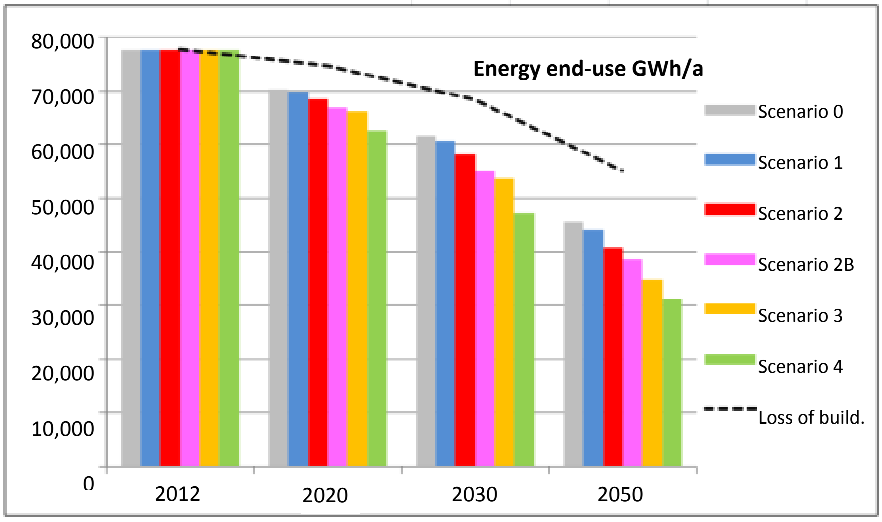
Table 12 and Figure 19 show the impact of the energy efficiency improvements implemented in the scenarios and the decommissioning of buildings on **energy end-use, primary energy consumption(E indicator) and emissions.**

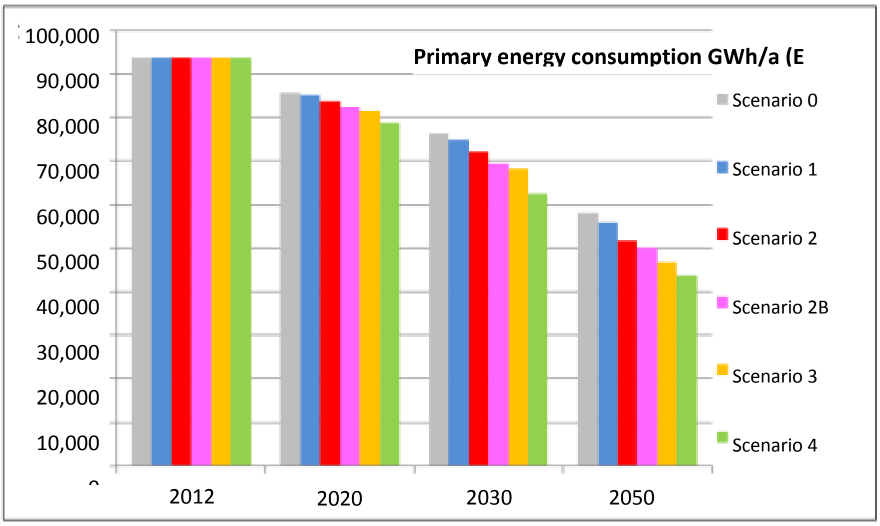
The number of structural renovations, in which measures to improve energy performance can be easily incorporated, is relatively low. That is why the energy savings achieved by means of renovations are also low. By 2020, renovations will only help to cut energy consumption slightly more than the loss of old buildings. By 2050, renovations will contribute more to the decrease in energy consumption than the loss of old buildings.

Table 12 The impact of the measures included in the scenarios and the loss of old buildings on energy end-use, primary energy consumption (E indicator or E-value) and carbon dioxide emissions. Decrease in comparison with the 2012 level. The figures include the impact of both renovations and the loss of old buildings.

	CURRENT STOCK (built before 2012 - loss)								
	2020			**2030**			**2050**		
	Energy	**E**	**CO2-eq**	**Energy**	**E**	**CO2-eq**	**Energy**	**E**	**CO2-eq**
Scenario 0	-10%	-8%	-14%	-21%	-19%	-31%	-41%	-38%	-58%
Scenario 1 Business as Usual	-10%	-9%	-15%	-22%	-20%	-32%	-43%	-40%	-59%
Scenario 2	-12%	-10%	-17%	-25%	-23%	-35%	-48%	-45%	-63%
Scenario 2B	-14%	-12%	-18%	-29%	-26%	-38%	-50%	-46%	-64%
Scenario 3	-15%	-13%	-19%	-31%	-27%	-40%	-55%	-50%	-68%
Scenario 4	-19%	-16%	-24%	-39%	-33%	-47%	-60%	-53%	-71%

It is important to promote and steer all measures aimed at improving energy efficiency. This is demonstrated by the 3.3% decrease in heating energy consumption by the end of 2015 compared to the 2012 level. This decrease corresponds to the target set when the effectiveness of the decree on improving the energy performance of buildings undergoing renovation or alteration (4/2013) was assessed.





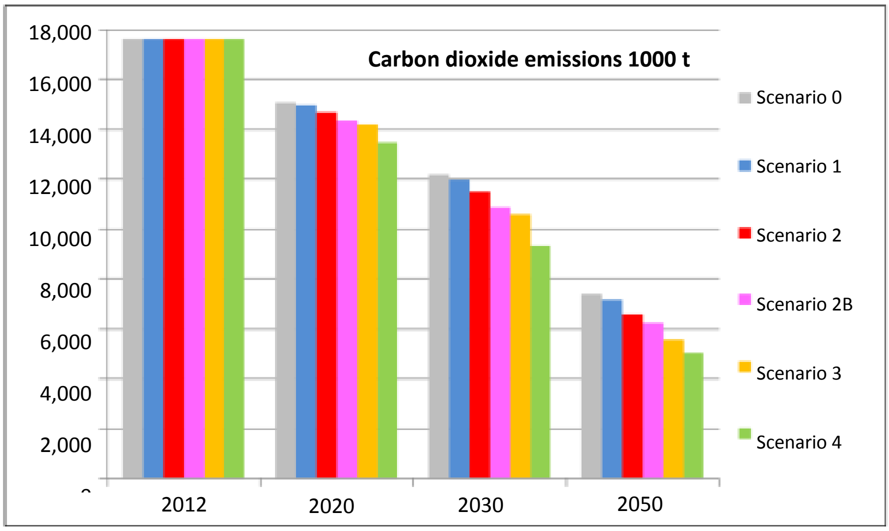


Figure 19. The impact of the measures included in the scenarios and the loss of old buildings on the energy end-use, primary energy consumption and greenhouse gas emissions (CO2-eq) of buildings built before 2012.

5.3. The increase in costs attributable to measures to improve energy efficiency in the scenarios

Renovations cover all refurbishment, modernisation and maintenance. A total of approximately EUR 10 billion was spent on repairs in the kinds of residential, commercial and office buildings discussed in this report in Finland in 2016. Between 20 and 30 percent of these renovations are such that they may incorporate measures to improve energy efficiency (scenario 1, BAU).

The increase in costs attributable to measures to improve energy efficiency is EUR 1 million/saving of 0.8 GWh for renovations (Finnish Environment Institute, 2016), and EUR 0.1 million/saving of 0.8 GWh for buildings that are demolished (Nippala & Heljo 2010). Calculated using these unit costs, the costs given in the scenarios are as shown in the figure (Figure 20). When the number of renovations and the level of ambition increases under these scenarios, the increase in costs attributable to measures to improve energy efficiency compared to normal renovations increases from 8 percent to 19 percent. The annual cost and total cost for the period of 2012–2050 for improving energy efficiency is calculated in the table below (Table 13).

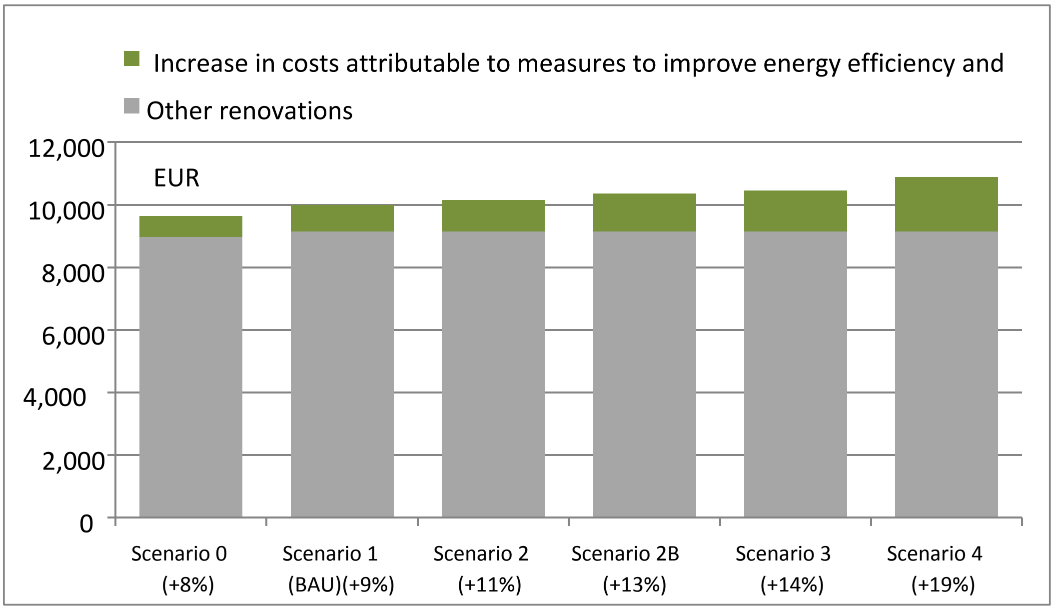


Figure 20. Increase in costs attributable to measures to improve energy efficiency and the costs of conventional renovations under the scenarios.

Table 13. *Increase in costs attributable to the energy efficiency measures included in the scenarios Annual cost (*) relates to the years 2012–2020. In the long-term, the cost per GWh saved decreases as the impact of the loss of buildings increases.*

	Decrease/year* GWh	Cost/year* EUR mill.	Decrease/2012-2050 GWh	Cost/2012-2050 EUR mill.
Scenario 0 (+8%)	930	790	32,200	9,500
Scenario 1 (BAU) (+9%)	990	850	33,700	10,700
Scenario 2 (+11%)	1,150	1,010	37,200	13,500
Scenario 2B (+13%)	1,350	1,210	39,200	15,100
Scenario 3 (+14%)	1,450	1,310	43,000	18,200
Scenario 4 (+19%)	1,880	1,740	46,500	21,000

5.4. Positive impact of the renovation services market on the economy and employment

More business

For renovations to have a genuine impact on energy consumption, the number of renovations, including renovations that improve energy efficiency, should be considerably higher than at the moment. This is possible, since the maintenance backlog of the building stock is estimated to be significant (ROTI, 2017). This can be further stimulated by businesses developing their offering, i.e. products and systems suitable for renovations. In this respect, international cooperation and interaction should be sought so that **advanced technology and affordable products** can be brought to the market.

For many businesses in the construction sector, renovations have represented a market that can be used to level the effects of economic fluctuations in new development. Operating in several market segments has been important for the continuity of their operations, as such businesses seem to last longer than specialised businesses. Some construction products are suitable for both renovations and new buildings. While the best managed businesses in the sector focus on current customer needs, they may miss future business opportunities, i.e. products and services designed for renovations. Deep renovations offer **new businesses the opportunity** to focus on the development of products for renovations and to dominate future markets.

As a rule, measures to improve energy efficiency are carried out as part of normal renovations. The Finnish Ministry of the Environment has commissioned a study on renovation needs in the period 2016-2035 (Figure 21). Businesses can even use information provided for the authorities to develop their own business activities.

A renovation project must be carried out professionally and with the requisite quality from start to finish. The owner of the property needs to specify what they want to achieve with the renovation in terms of energy efficiency, the engineers need to find the means to meet these objectives, and the builders need to perform the measures and ensure that the energy efficiency targets set are achieved in practice. After the completion of the project, the responsibility returns to the owner of the property who must ensure that the savings achieved are maintained.

Renovation needs in residential buildings in 2016-2025, in total EUR 9.4 billion/year

Legend for the colours	No. of municipalities
EUR 1,100 mill.	1 projects
EUR 300-400 mill.	5 projects
EUR 100-200 mill.	14 projects
EUR 50-100 mill.	13 projects
EUR 30-50 mill.	30 projects
EUR 15-30 mill.	61 projects
EUR 5-15 mill.	112 projects
< EUR 5 mill.	61 projects

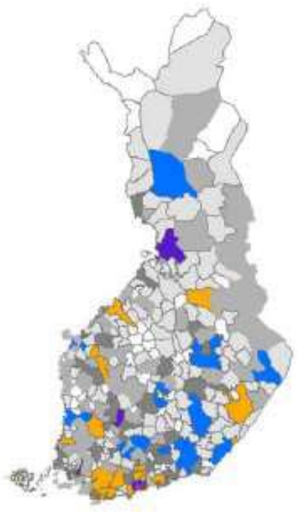


Figure 21. The annual renovation need of residential buildings in Finland in the period 2016–2025 is EUR 9.4 billion at 2015 prices. Of the total renovation need, 30 percent is accounted for by the six largest cities in Finland, i.e. Helsinki, Espoo, Vantaa, Turku, Tampere and Oulu. Source: Vainio & Nippala, 2016.

More jobs

The impact of renovations on employment is calculated on the basis of end products: the amount of work needed to design and make the products and services used in renovations, to deliver them to the construction site and to install them.

For example, adding insulation and a new coat of paint to existing façades on site requires more work than doing the same using elements pre-cast in a factory. Demolition requires labour force on site but contributes nothing to the construction products industry. Adjusting a heating system requires engineering and installation work, but few construction products.

Each million-euro investment in renovation provides employment for a total of approximately 16 people across the entire chain in Finland, including the engineering sector. A million-euro investment equates to eight person-years of work at a renovation site, to five person-years of work at an industrial site, and to three person-years of work in the service sector (Vainio, 2013). Demolition provides three person-years of work per million-euro investment. Improving energy efficiency in connection with a renovation project increases workload by 3–12%, depending on the scenario in question, compared to a normal renovation of a residential, commercial or office building carried out before 2013 (Table 14).

Table 14. *Impact of renovations and associated measures to improve energy efficiency on the volume of residential, commercial and office buildings and employment across the entire chain, including contractors' purchases.*

	Normal renovation and energy efficiency improvements, person-years of work	Increase in employment attributable to energy efficiency improvements, person-years of work	Increase, %
Scenario 0 (BAU before 2012)	152,900		
Scenario 1 (BAU after 2012)	156,800	3,900	3%
Scenario 2	159,300	6,400	4%
Scenario 2B	162,500	9,600	6%
Scenario 3	164,000	11,100	7%
Scenario 4	170,900	18,000	12%

Income for households and revenues for the public sector

Renovations are paid for by property owners, the majority of whom are private householders (detached houses, housing companies) and businesses. In renovation projects, labour accounts for approximately 30%, domestic construction products for 50% and imported products for 15% of costs. The remainder is made up of machinery costs, taking into account depreciation. In demolition, all work is carried out by machinery on site.

The construction chain includes businesses from multiple sectors (construction, trade, transport and manufacturing). With the help of the input-output model used in national economy statistics, labour costs and imported products used in manufacturing can be separated from the contribution of manufacturing industry.

The volume of work is substantial. Depending on the scenario, net income for households would increase by EUR 13–95 million. The state, municipalities and church would receive EUR 13–97 million in tax revenue and levies and insurance companies EUR 7–47 million in insurance premiums. High quantities of metal industry products (building services) are used in renovation projects, which increases the percentage of products that need to be imported. A total of 80% of construction products imported by Finland originate in the EU. The combined profits and capital expenditure of the businesses involved in the chain amount to EUR 10–74 million (*Table 15*).

Table 15. *Conversion of the added costs resulting from measures taken to improve energy efficiency included in the scenarios on how revenue benefits the national economy. The analysis is based on the year 2016.*

increase in income/revenue, EUR mill.	Households	Construction and specialist works	Other services and industry	Insurance	Taxes and social insurance contributions	Imports	Total
Scenario 0	174	32	103	87	178	229	790
Scenario 1 (BAU)	187	34	111	94	191	247	850
Scenario 2	222	40	131	111	227	293	1,010
Scenario 2B	266	48	157	133	272	351	1,210
Scenario 3	288	52	170	144	295	380	1,310
Scenario 4	383	70	226	191	392	505	1,740
Change, EUR mill.							
Scenario 1 (BAU)	13	2	8	7	13	18	60
Scenario 2	35	6	20	17	36	46	160

Scenario 2B	44	8	26	22	45	58	200
Scenario 3	22	4	13	11	23	29	100
Scenario 4	95	18	56	47	97	125	430

6. Summary

Overview of Finland's building stock

Finland has 290 million square metres of residential buildings and 100 million square metres of commercial and public buildings. Half of the building stock was built after 1980 and heat loss through the building envelope is relatively low, as the energy efficiency requirements applicable to new buildings were tightened in 1978 in response to the 1970s energy crises. The most cost-effective renovation measures with the greatest impact on energy efficiency and emissions relate to the heating and ventilation systems of buildings.

Most multiple-dwelling buildings (more than 90% of the gross floor area) as well as commercial and public buildings (more than 60%) are connected to the district heating network. Three quarters of all district heating is produced by means of cogeneration (CHP). The proportion of renewable fuels is 32%. Finland's energy and climate strategy aims to replace fossil fuels used for heat production with renewable fuels and heat pumps.

Electricity currently accounts for 45% of the heating energy of one-dwelling buildings, and oil for 19%. According to Finland's energy and climate strategy, unit-specific oil heating systems will disappear altogether by 2050. Biocomponents will be added to fuel oil during the transitional period. Alternatives to oil include heat pumps and biofuels. In addition, it is recommended that consumption in buildings with direct electric heating be reduced by installing air-source heat pumps.

Cost-effective deep renovations suitable for Finland's climate

(deep renovation; staged deep renovation)

A Ministry of the Environment decree, on improving the energy performance of buildings undergoing renovation or alteration, was issued in Finland in 2013. The decree requires energy performance improvements in connection with the renovation of a building, changes to its intended use, and the replacement of its technical systems. The decree introduces cost-optimal levels of minimum energy performance requirements for individual building elements and for total energy consumption.

The levels laid down in the decree also double as Finland's deep renovation levels. The decree includes guidelines for both one-off deep renovations and staged deep renovations.

Policies and measures that promote deep renovations

This national strategy emphasises digitalisation, innovation, communications, skilled labour and education. Information on the best ways of improving energy efficiency and successful projects must be communicated to professionals and students in the industry, as well as to property owners and property managers.

In **one-dwelling buildings**, the most cost-effective measures for reducing heat loss include adding the thickest possible additional thermal roof insulation and replacement of the original windows. If the cladding of external walls needs to be replaced, it pays to add thermal insulation as well. With respect to heating systems, switching to renewable energy sources is a profitable measure.

In **multiple-dwelling buildings**, the most cost-effective measures for reducing heat loss relate to using ventilation to reduce consumption. Forced general ventilation should be equipped with heat recovery and the transfer of heat to either central heating or hot water heating. If windows have reached the end of their service lives, they should be replaced with new ones that meet the requirements set for new buildings. Lowering the pressure is an efficient way of reducing water consumption. Energy can be recovered from waste water centrally. If external wall cladding needs to be replaced, it also pays to add thermal insulation.

In **commercial and public buildings**, the most cost-effective measures relate to ventilation (efficient ventilation units, heat recovery, ventilation according to need) and lighting (LED lighting).

Decision-making, service provision and financing related to deep renovations

With regard to renovation projects, crucial decisions are made in connection with target-setting before planning begins. In Finland, such decisions are mainly taken by householders, as they own 65 percent of buildings. Property owners cannot be obliged to renovate structures and systems that are otherwise sound simply in order to improve their energy performance, as this is not cost-effective. That is why property owners are encouraged to introduce structural energy efficiency improvements in connection with normal renovation measures and fault repairs.

In Finland, public subsidies to incentivise the renovation of residential buildings have been targeted at the owners of one-dwelling buildings (tax credit for domestic expenses), social housing (interest-subsidy loans for the renovation of rental and right-of-occupancy dwellings), housing companies (deficiency guarantee), ARA rental properties (demolition subsidy) and improving the housing conditions of special-needs groups. The measures required by the Decree of the Finnish Ministry of the Environment must be carried out during a renovation (Finnish Ministry of the Environment, 2013a).

Businesses and the public sector are encouraged to conserve energy through energy efficiency agreements and green leases, which are based on an agreement between the landlord and tenant and set obligations on both parties to conserve energy.

Expected energy savings and other benefits

Improvements of energy efficiency during renovations undertaken for other reasons (e.g. to repair structural damage or convert spaces for new uses) in accordance with this strategy are expected to lead to an energy saving of at least 10 percent during the period 2012–2020. Carbon dioxide emissions will decrease by more than energy consumption (15%), as fossil fuel heating systems are replaced by low-emission fuels due to renovations.

Measures to improve energy efficiency are expected to increase the annual volume of renovations by approximately EUR 1,000 million at 2016 prices. This would increase the workload in property renovations, measured in person-years of work, by three percent. This figure is similar to expected growth in GDP. Increases in employment generate income for households and tax revenue for the public sector.

Proposal for measures to be promoted during the next three years, developed in cooperation with property owners and local authorities as well as businesses, educational institutions and research institutes in the sector

Proposed measures relating to systematic and far-sighted property management

- ⇒ *Promoting the use of tools developed in support of property management (Property use and maintenance guide, Condition estimate, Long-term maintenance plan).*
- ⇒ *Investigating the possibility of granting a building permit with a longer period of validity for staged deep renovation projects.*

Proposed measures relating to the know-how, education and training of the labour force

- ⇒ *Launching specialisation training in renovations*

- ⇒ *Increasing the utilisation of research results by enhancing cooperation between universities and universities of applied science.*
- ⇒ *Supporting all parties to the renovation process in acquiring knowledge and skills in new areas (renewable energy sources, new energy production technologies and building services, hybrid systems, life cycle cost, benefits/costs).*
- ⇒ *Promoting the awareness of renovation operators and broadening the scope of the renovation industry's processes and operating methods to digital material, via the "Digitalisation of the built environment and construction sector" project.*

Proposed measures relating to digitalisation, innovations and business

- ⇒ *Consolidating electronic permit services relating to the built environment and the related electronic forms and services of the Housing Finance and Development Centre of Finland (ARA).*
- ⇒ *Increasing use of website on energy performance certificates and the property price information service for old buildings when developing services.*
- ⇒ *Testing and trying out data models and data exchange standards in practical applications.*
- ⇒ *Promoting the smooth implementation of renovation projects by means of agreement templates developed by Building Information and by adopting new contract models.*
- ⇒ *Promoting the commercial exploitation of the results of R&D&I projects and new business (experimental building, promotion of agile development).*

Proposed measures relating to communications

- ⇒ *Promoting renovations by encouraging a domino effect. Disseminating information about successful energy performance renovations (the most cost-effective measures, technically and functionally feasible measures, indoor air quality improvements in connection with renovations), as well as risks relating to solution options.*
- ⇒ *Information on the impacts of energy efficiency investments on the value of a property and its operating costs throughout its life cycle, for the market and customers (tax administration, insurance companies, tenants, owners).*

Proposed measure relating to financial incentives

- ⇒ *Exploring the possibility of promoting deep renovation by supporting project planning.*

References

Abel, E. (2010) Ekonomisk bedömning. BELOK Totalprojekt – Energieffektivisering av befintliga lokalbyggnader. http://www.belok.se/docs/Kortrapporter/Lonsamhetsmodell.pdf

Airaksinen, M. & Vainio, T. (2012) Rakennuskannan korjaamisen ja kunnossapidon energiantehokkuustoimenpiteiden vaikuttavuuden arviointi energiansäästön, CO2 ekv päästöjen, kustannuksien ja kannattavuuden näkökulmista (*Assessment of the effectiveness of renovations and measures aimed at improving energy efficiency from the perspective of energy consumption, CO2-equivalent emissions, costs and profitability*). Working paper for the Finnish Ministry of the Environment.

ARA, Energiatodistus (*Energy performance certificate*). http://www.ara.fi/fi-FI/Ajankohtaista/Energiatodistus

ARA, Housing finance. http://www.ara.fi/en-US/Housing_finances

Finnish Limited Liability Housing Companies Act (2009). http://www.finlex.fi/en/laki/kaannokset/2009/en20091599.pdf

EKOREM (2005) Rakennusten energiankulutus ja CO2-ekv –päästöt Suomessa (English abstract: Energy consumption and CO2-eq. emissions of buildings in Finland) http://webhotel2.tut.fi/ee/Materiaali/Ekorem/EKOREM_Loppuraportti_051214.pdf

Finnish Energy, Kaukolämpö ja kaukojäähdytys (*District heat and district cooling*). http://energia.fi/ajankohtaista_ja_materiaalipankki/tilastot/kaukolampotilastot/kaukolammitys_ja_-jaahdytys

EU (2010) Europe 2020. http://ec.europa.eu/europe2020

EU (2011) Energy Efficiency Plan 2011. http://europa.eu/legislation_summaries/energy/energy_efficiency/en0029_en.htm

EU (2012) Energy Efficiency Directive. http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

EU (2014) 2030 framework for climate and energy policies. http://ec.europa.eu/clima/policies/2030/index_en.htm

Heljo, J., Vihola, J. (2012) Energiansäästömahdollisuudet rakennuskannan korjaustoiminnassa (*Feasible energy savings potential in the building stock*; English abstract). https://tutcris.tut.fi/portal/en/publications/energiansaastoemahdollisuudet-rakennuskannan-korjaustoiminnassa(41cdc76a-30f8-44bd-bcec-7da8b85f68d3).html

Kauppinen, J. (2013) Ministry of the Environment decree on improving the energy performance of buildings undergoing renovation or alteration. Explanatory memorandum. Available at http://www.ym.fi/en-US/Land_use_and_building/Legislation_and_instructions/The_National_Building_Code_of_Finland/Energy_efficiency_of_buildings

KTI & RAKLI (2014) Kiinteistöalan ja yhteiskunnallinen ja kansantaloudellinen merkitys (*The social and economic impact of the Finnish property sector*). http://www.rakli.fi/media/tietoa-kiinteistoalasta/faktaa-alasta/2014_kiinteistoalan-yhteiskunnallinen-ja-kansantaloudellinen-merkitys_nettires.pdf

KTI (2016) KTI Market Review. https://kti.fi/wp-content/uploads/post/KTI_Market_Review_A16_net.pdf

Kurvinen, A. & Heljo, J. (2012) Energiasäästötoimenpiteiden kannattavuusmalli (*Profitability model for energy-conservation measures*). http://www.ara.fi/download/noname/%7B769C920A-753B-41C1-9A42B20B596F93A0%7D/22779

National Building Code of Finland. Lämmöneristysmääräykset C3 (*Thermal insulation in a building*). http://www.edilex.fi/rakentamismaaraykset

Motiva, Energy Efficiency Agreements. http://www.energiatehokkuussopimukset.fi/en/

Motiva, Energy performance certificate. https://www.motiva.fi/en/home_and_household/housing_companies/energy_performance_certificate

Nykänen Veijo et al. (2013) Asuntoyhtiöiden uudistava korjaustoiminta ja lisärakentaminen (English abstract: Urban infill and residential redevelopment). http://www.vtt.fi/inf/pdf/technology/2013/T97.pdf

Oja, L., Vaahtera, A., Vehviläinen, I., Ahvenharju, S. & Hakala, L. (2013) Selvitys energiaköyhyydestä. Kotitalouksien energiakustannukset (*Report on energy poverty. Households' energy costs*). http://www.ym.fi/fi-FI/Ajankohtaista/Julkaisut/YMra212013_Selvitys_energiakoyhyydesta%2817083%29

PRE (2014) Built Environment Process Re-engineering. http://rym.fi/program/pre/

RAKLI (2011) Ekotehokkaat sopimuskäytännöt (*Energy efficient contractual practices*). http://www.rakli.fi/kaytto-yllapito/energiatehokkuus/ekotehokkaat-sopimuskaytannot.html

SULPU (2017) The Heat Pump Industry Back on Track towards Growth in Finland. http://www.sulpu.fi/documents/184029/189661/Heat%20Pump%20Industry%20Back%20on%20Track%20towards%20Growth%20in%20Finland%2C%20Press%20Release%201.2017%2Cf.pdf

Finnish Climate Guide. https://ilmasto-opas.fi/en/

Finnish Climate Change Panel (2013) Energiajärjestelmä ja päästöjen vähennystoimet, yhteenvetoraportti (*Energy system and measures to cut emissions – summary report*). http://www.ilmastopaneeli.fi/uploads/selvitykset_lausunnot/Yhteenvetoraportti-Energiaj%C3%A4rjestelm%C3%A4%20ja%20p%C3%A4%C3%A4st%C3%B6v%C3%A4hennystoimet%2029-1-2013.pdf

Finnish Environment Institute (2016) Rakennusten energiankulutuksen perusskenaario Suomessa 2015-2050 (*Baseline scenario for energy consumption of the building stock in Finland for 2015–2050*; English summary). https://helda.helsinki.fi/bitstream/handle/10138/166673/SYKEra_35_2016.pdf?sequence=4

TEM (2016) Energia- ja ilmastostrategia - taustaraportti (*Energy and Climate Strategy – preparatory report*). http://tem.fi/documents/1410877/3570111/Energia-+ja+ilmastostrategian+TAUSTARAPORTTI_1.2.+2017.pdf/d745fe78-02ad-49ab-8fb7-7251107981f7

Vainio, T (2011) Rakentamisen yhteiskunnalliset vaikutukset (*Societal impacts of construction*). Confederation of Finnish Construction Industries RT. http://www.rakennusteollisuus.fi/RT/Tilastot/Rakentamisen+yhteiskunnalliset+vaikutukset/

Vainio, T. & Nippala, E. (2016) Asuinrakennusten korjaustarve 2016-2035 (English abstract: The need for renovation in residential buildings in 2016-2035). http://www.vtt.fi/inf/pdf/technology/2016/T274.pdf

Finnish Tax Administration (2017) Kotitalousvähennys (*Tax credit for domestic expenses*). https://www.vero.fi/fi-FI/Henkiloasiakkaat/Kotitalousvahennys

Virta, J & Pylsy, P. (2011) Taloyhtiön energiakirja (*Energy management book for housing companies*). http://www.taloyhtio.net/ajassa/energiakirja/default.aspx

VTT (2013) Selvitys huoneistokohtaisten lämpömäärämittareiden ja lämmityskustannusten jakolaitteiden käytön edellytyksistä Suomessa (*Report on technical and economic conditions for unit-specific metering and cost allocators in Finland*). VTT-CR-07573-13

Finnish Ministry of the Environment (2012) Rakentamismääräyskokoelma. Historia (*The National Building Code of Finland. History*). http://www.ym.fi/download/noname/%7B5B35372D-D13D-4087-8C1EA855F9C3F6CE%7D/101066

Finnish Ministry of the Environment (2013a) Ministry of the Environment decree on improving the energy performance of buildings undergoing renovation or alteration 4/13. English version available at http://www.ym.fi/en-US/Land_use_and_building/Legislation_and_instructions/The_National_Building_Code_of_Finland/Energy_efficiency_of_buildings

Finnish Ministry of the Environment (2013b) Energiatehokkuutta koskevien vähimmäisvaatimusten kustannusoptimaalisten tasojen laskenta (*Calculation of cost-optimal levels of minimum energy performance requirements*). http://www.ym.fi/download/noname/%7B6F36DF567D90-4223-84BF-41F9C4067CCE%7D/123867

Finnish Ministry of the Environment (2013c) Selvitys energiaköyhyydestä (*Report on energy poverty*). http://www.ym.fi/fi-FI/Ajankohtaista/Julkaisut/YMra212013_Selvitys_energiakoyhyydesta%2817083%29

Ympäristölehti (2015) Kunnan talot kuntoon (*Municipal buildings require renovation*). http://www.ym.fi/fi-FI/Ajankohtaista/Julkaisut/Ymparistolehti/2015/Kunnan_talot_kuntoon(32687)

Statistics

Finnish Meteorological Institute, monthly statistics. http://ilmatieteenlaitos.fi/kuukausitilastot

Finnish Meteorological Institute, heating degree days. http://en.ilmatieteenlaitos.fi/heating-degree-days

Statistics Finland, Population projection (2015). http://www.stat.fi/til/vaenn/index_en.html

Statistics Finland, Dwellings and housing conditions (2016). http://www.stat.fi/til/asas/index_en.html

Statistics Finland, Buildings and free-time residences (2016). (http://www.stat.fi/til/rakke/index_en.html

Statistics Finland, Energy supply and consumption (2016). (http://www.stat.fi/til/ehk/tau_en.html)

Finnish Population Register Centre, Building and Dwelling Register (2015). (http://vrk.fi/en/building-information)