

**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 on 30 April 2014**

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Name of the client, contact person and contact details Finnish Ministry of the Environment Jyrki Kauppinen PO Box 35 FI-00023 Government	Client's reference YM27/612/2013
Foreword This report relates to the implementation of Article 4 of the Energy Efficiency Directive in Finland. The report was drawn up by the Finnish Ministry of the Environment and the most important interested parties, with support from a research group comprising research scientists from Oulu University of Applied Sciences, Tampere University of Applied Sciences and VTT Technical Research Centre of Finland. In connection with the transposition of the Energy Performance of Buildings Directive (EPBD), Finland introduced cost-optimal levels of minimum energy performance requirements for renovations, which entered into force in 2013. The Finnish Ministry of the Environment promotes the objectives of the Renewable Energy Sources (RES) Directive with regard to buildings undergoing thorough renovation. Comprehensive requirements have been set for renovating the building stock with regard to energy performance. In fact, Article 4 of the EED is designed, instead of setting requirements, for finding ways to mobilise investment in the energy efficiency of public and private residential and commercial buildings and to implement these in a systematic and timely manner in connection with renovation.	
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1. EU and energy efficiency

Energy efficiency is one of the priorities of the EU's Europe 2020 strategy (EU 2010), which promotes smart, sustainable and inclusive growth and resource efficiency. The goal is to improve the security of energy supply, to cut emissions and to tap into the energy potential that is currently lost due to inefficiency.

In 2014 the European Commission introduced a proposal for EU-level climate and energy policy goals for 2030. These include a 40% cut in greenhouse gas emissions compared to 1990 levels and achieving at least a 27% share of renewable energy consumption (EU, 2014).

The plan for implementing the Europe 2020 strategy (EU, 2011) focuses, with regard to buildings, on improving energy performance in connection with renovations. The public sector is to lead by example by introducing energy saving agreements, by improving the energy performance of public buildings, by including energy efficiency considerations in public procurement and by obligating energy suppliers to help their customers to lower energy consumption.

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.

Article 4

Building renovation

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 (**2. Overview of Finland's building stock**);*
- b) identification of cost-effective approaches to renovations relevant to the building type and climatic zone (**3. Cost-effective deep renovations suitable for Finland's climate**);*
- c) policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations (**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 (**5. Decision-making, service provision and financing related to deep renovations**);*
- e) an evidence-based estimate of expected energy savings and wider benefits (**6. Expected energy savings and other benefits**).*

A first version of the strategy shall be published by 30 April 2014 and updated every three years thereafter and submitted to the Commission as part of the National Energy Efficiency Action Plans.

2. Overview of Finland's building stock

2.1 Types of buildings

Article 4 of the EED concerns residential buildings and commercial buildings, which include shops and offices (Annex A).

Migration in the last few decades has concentrated Finland's population and commercial activity in large urban areas, especially in Southern Finland (Statistics Finland, 2012). As a result, buildings are left empty in other areas while new buildings are developed and old ones renovated in the growth areas. This is why the housing stock (Statistics Finland, 2013A) and building stock (Statistics Finland, 2013B) referred to in Article 4 of the EED are examined as three separate groups in this report: 1) Helsinki sub-region, 2) other growing sub-regions and 3) sub-regions where population is expected to either decrease or at least not increase (Annex B).

Table 1. Finland's land area, population and floor area of residential and commercial buildings (Statistics Finland, 2012 and Statistics Finland, 2013B)

	Land area, m ²	Population in 2012, n	Residential buildings, m ²	Commercial and office buildings, m ²
Helsinki sub-region	5 100	1 445 200	67 447 500	19 434 400
Growing sub-regions	37 000	1 852 700	95 429 200	20 114 000
Other areas	261 800	2 100 400	117 488 200	24 876 000
Total	303 900	5 398 300	280 364 900	64 424 400

A considerable percentage of residential buildings in the Helsinki sub-region are terraced houses or apartment blocks with multiple housing units. Outside the growing sub-regions, the majority of residential buildings are detached houses (*Diagram 1*). Helsinki's share of commercial buildings is higher than its share of residential buildings due to the capital's sizeable office building stock (*Diagram 2*).

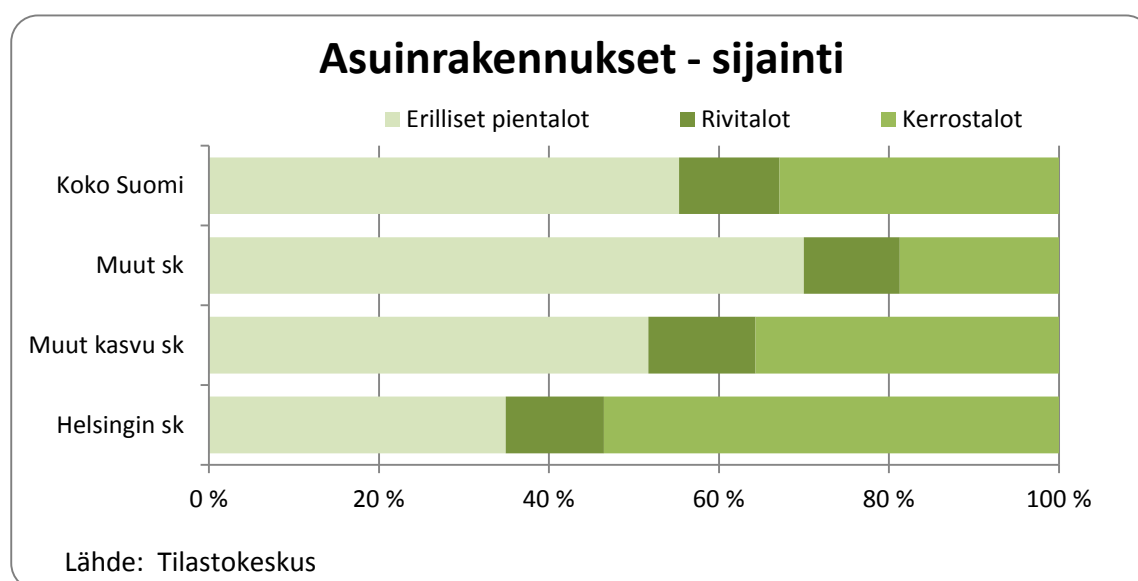


Diagram 1. Distribution of floor area in residential buildings by building type

Finnish	English
Asuinrakennukset – sijainti	Residential buildings – location
Erilliset pientalot	Detached houses
Rivitalot	Terraced houses

Kerrostalot	Apartment blocks
Koko Suomi	Finland, total
Muut sk	Other sub-regions
Muut kasvu sk	Other growing sub-regions
Helsingin sk	Helsinki sub-region
Lähde: Tilastokeskus	Source: Statistics Finland

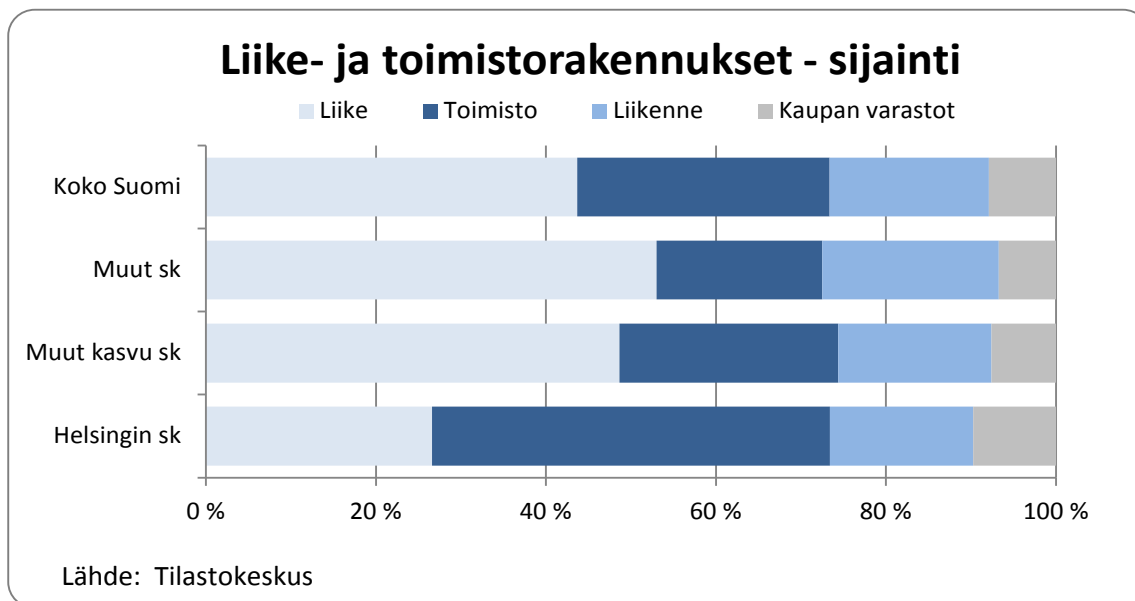


Diagram 2. Distribution of floor area in commercial and office buildings by building type

Finnish	English
Liike- ja toimistorakennukset – sijainti	Commercial and office buildings – location
Liike	Commercial buildings
Toimisto	Office buildings
Liikenne	Transport and communications buildings
Kaupan varastot	Commercial warehouses
Koko Suomi	Finland, total
Muut sk	Other sub-regions
Muut kasvu sk	Other growing sub-regions
Helsingin sk	Helsinki sub-region
Lähde: Tilastokeskus	Source: Statistics Finland

2.2 Energy performance of buildings

2.2.1 Finland's climate

Finland's climate is a so-called intermediate climate, combining characteristics of both a maritime and a continental climate. Weather in Finland depends very much on the prevailing wind direction and on how weather disturbances, i.e. low and high pressures, are situated. Finland's mean temperatures are largely determined by its location in the middle latitudes, mostly 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 (*Diagram 3*). 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 the 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 usually between -35 and -45 degrees. The lowest temperature recorded in the 20th century in Finland's meteorological observing stations was -51.5 °C in January 1999 (Pokka, Kittilä, 28 January 1999).

Finland has had to invest in energy efficiency because of the cold winters. Controlling overheating in indoor spaces is a new challenge brought about by the pursuit of energy efficiency during warm times of the year.

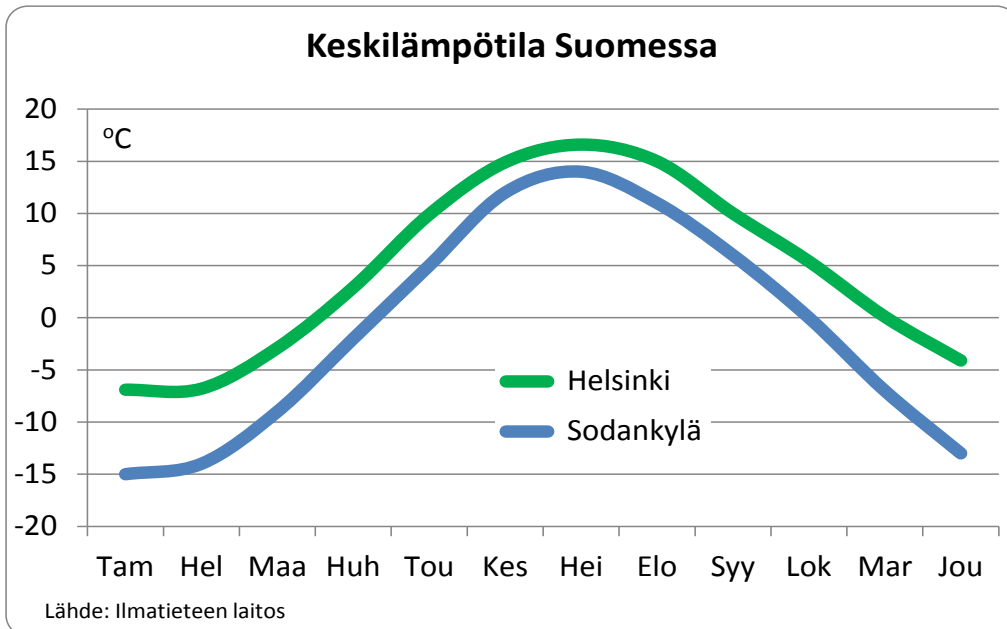


Diagram 3. Long-term mean temperatures (1981–2010) in Helsinki (Southern Finland) and in Sodankylä (Northern Finland) (Finland's Climate Guide)

Finnish	English
Keskilämpötila Suomessa	Mean temperatures in Finland
Tam	Jan
Hel	Feb
Maa	Mar
Huh	Apr
Tou	May
Kes	June
Hei	July
Elo	Aug
Syy	Sept
Lok	Oct
Mar	Nov
Jou	Dec
Lähde: Ilmatieteen laitos	Source: Finnish Meteorological Institute

2.2.2 Energy performance of buildings

Systematic efforts to improve the energy performance of buildings began after the 1970s energy crises. The first universal U-value requirements were set for building components in 1976 (National Building Code of Finland, C3 Thermal insulation in a building). Approximately

half of the floor area of Finland's building stock has been built after the U-value requirements entered into force.

A regulation concerning renovations that require a permit, changes to the intended use of a building and replacing technical systems was issued on 27 February 2013. The regulation obligates builders to improve the energy performance of buildings whenever renovations and changes are introduced that require a permit. The regulation entered into force in full on 1 September 2013. (Decree No 4/13 of the Finnish Ministry of the Environment)

As shown in *Table 2*, thermal insulation regulations were tightened the most dramatically in 1978 and 2010. This is why existing building stock and buildings that will be renovated in the future are examined separately as buildings built before and after 1980.

Table 2. Thermal insulation requirements for new buildings in Finland

U-values of building components	C3 1976	C3 1978	C3 1985	C3 2003	C3 2007	C3 2010
External walls	0.4	0.29	0.28	0.25	0.24	0.17
Roofs	0.35	0.23	0.22	0.16	0.15	0.09
Floors	0.40	0.40	0.36	0.25	0.24	0.17/0.09
Windows; glass panes in external doors	2.1	2.1	2.1	1.4	1.4	1
Solid parts of external doors	0.7	0.7	0.7			
Other baseline values						
n50 number	6	6	6	4	4	2
Annual heat recovery efficiency	0	0	0	30%	30%	45%
Margin for heat loss through walls and roofs	0	0	10%	20%	20%	30%

A clear difference can be seen in the combined specific consumption of heating, hot water, lighting and other electricity in residential buildings between these two groups of buildings (*Diagram 4*). Older detached houses consume a quarter and terraced houses and apartment blocks a fifth more energy by floor area than newer buildings.

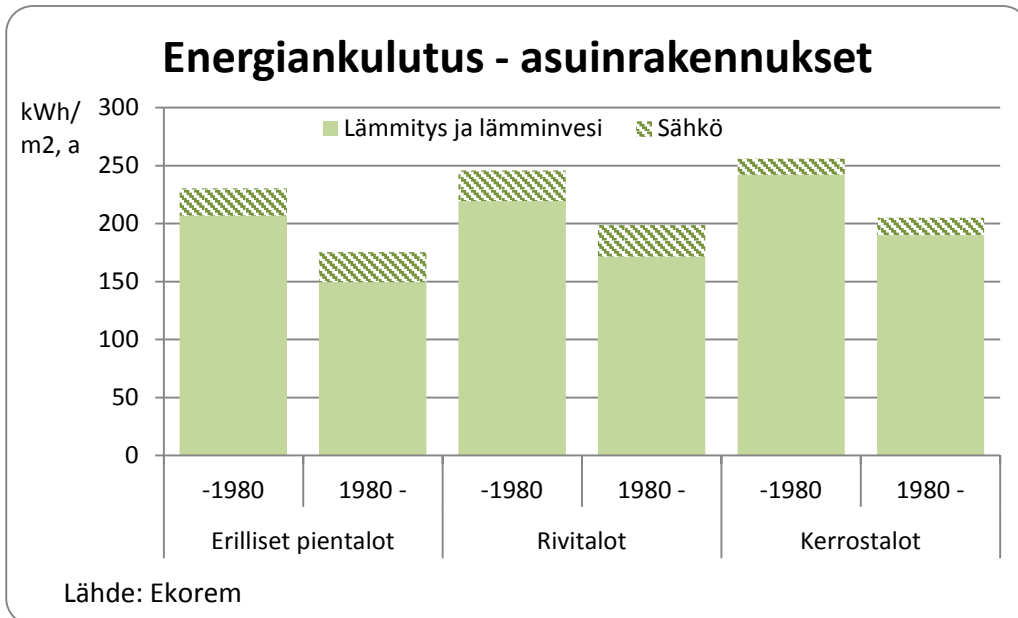


Diagram 4. Specific consumption of heating, hot water, lighting and other electricity in residential buildings by floor area (Heljo et al, 2005, Ekorem)

Finnish	English
Energiankulutus – asuinrakennukset	Energy consumption – residential buildings
Lämmitys ja lämminvesi	Heating and hot water
Sähkö	Electricity
Erilliset pientalot	Detached houses
Rivitalot	Terraced houses
Kerrostalot	Apartment blocks
Lähde: Ekorem	Source: Ekorem

Detached houses were originally heated with wood, oil and electricity (Statistics Finland, 2013B). Over the years heating systems have been modernised so that electricity has taken some of the share of both wood and oil (Diagram 5). Geothermal pumps have also been introduced for heat production.

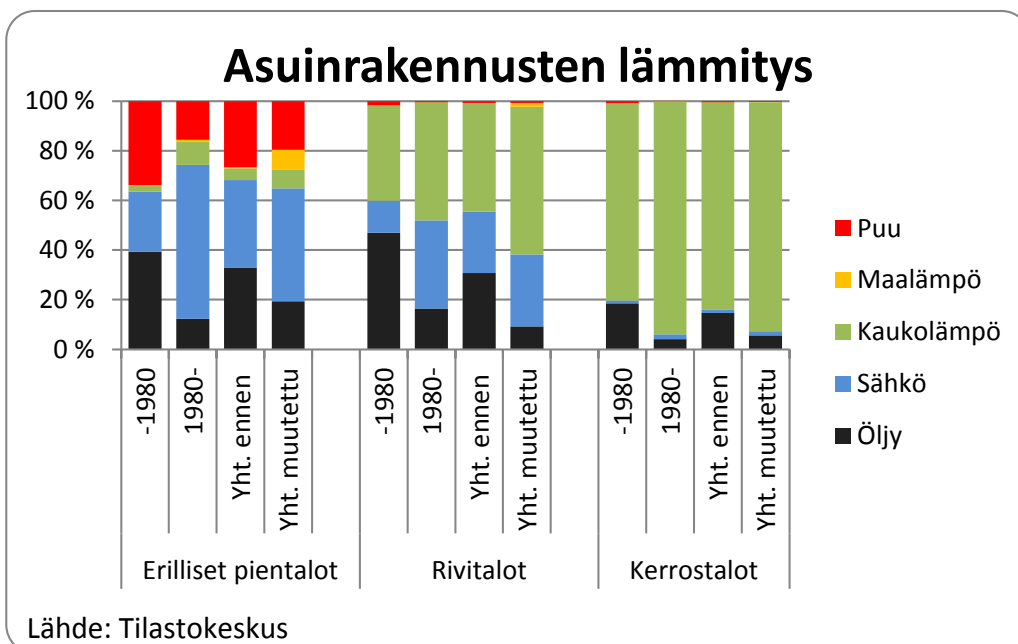


Diagram 5. Original and modernised energy sources in residential buildings (Statistics Finland, 2013B)

Finnish	English
Asuinrakennusten lämmitys	Heating systems in residential buildings
Puu	Wood
Maalämpö	Geothermal
Kaukolämpö	District heating
Sähkö	Electricity
Öljy	Oil
Yht. ennen	Original, total
Yht. muutettu	Modernised, total
Erilliset pientalot	Detached houses
Rivitalot	Terraced houses
Kerrostalot	Apartment blocks
Lähde: Tilastokeskus	Source: Statistics Finland

Terraced houses and apartment blocks have been converted from property-specific heat production to district heating. As *Diagram 6* demonstrates, the volume of terraced houses and apartment blocks multiplied by 3.5 between 1970 and 2010 while district heating consumption multiplied by 6.5 (Statistics Finland, 2014). The increase in consumption is the result of old buildings in cities and other built-up areas also having been connected to the district heating network in addition to new buildings.

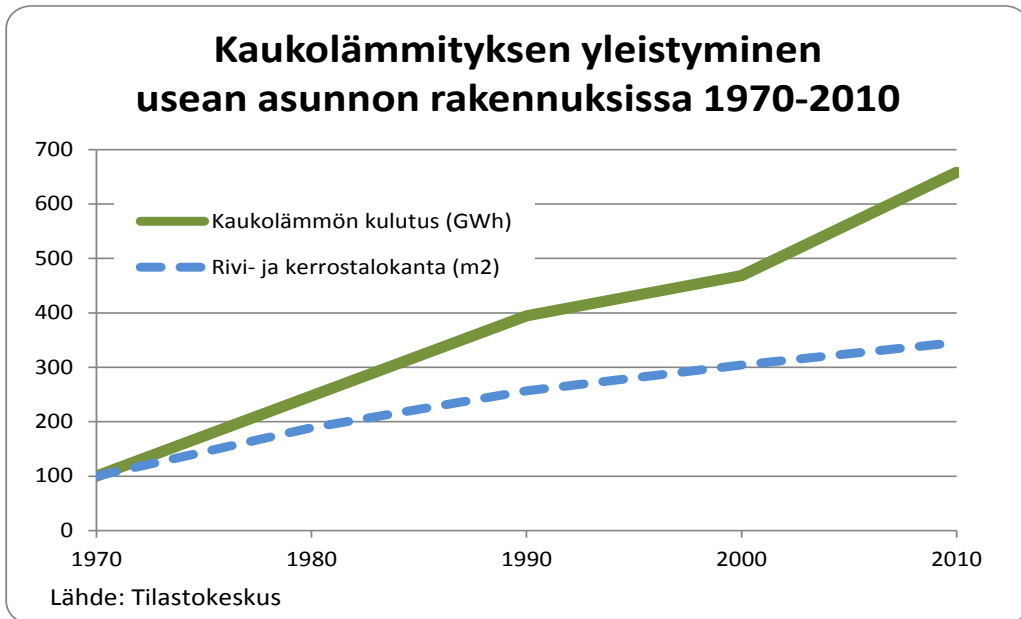


Diagram 6. District heating in buildings with multiple residential units (terraced houses and apartment blocks) has increased by more than the increase in building stock due to new development, as buildings built before 1970 have also been connected to the network. (Statistics Finland, 2014)

Finnish	English
Kaukolämmön yleistyminen usean asunnon rakennuksissa 1970–2010	Popularity of district heating in buildings with multiple residential units between 1970 and 2010
Kaukolämmön kulutus (GWh)	District heating consumption (GWh)
Rivi- ja kerrostalokanta (m ²)	Terraced houses and apartment blocks (m ²)
Lähde: Tilastokeskus	Source: Statistics Finland

The specific energy consumption of office buildings built after 1980 is smaller than that of buildings built before 1980. The specific energy consumption of commercial buildings has remained unchanged due to an increase in electricity consumption (*Diagram 7*).

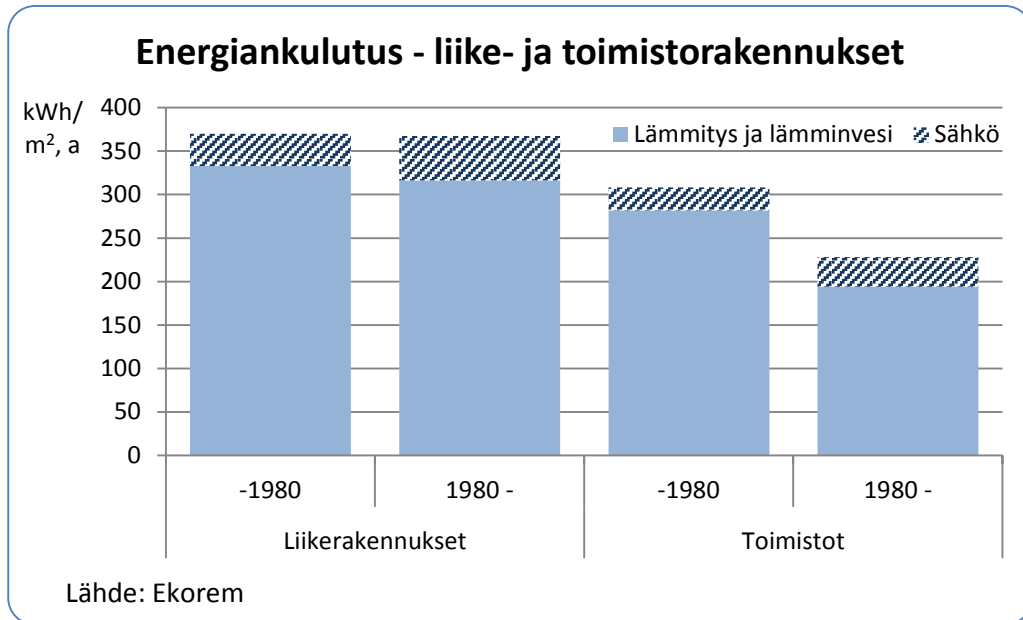


Diagram 7. Specific consumption of heating, hot water, lighting and other electricity in commercial and office buildings by floor area (Heljo et al, 2005, Ekorem)

Finnish	English
Energiankulutus – liike- ja toimistorakennukset	Energy consumption – commercial and office buildings
Lämmitys ja lämminvesi	Heating and hot water
Sähkö	Electricity
Liikerakennukset	Commercial buildings
Toimistot	Office buildings
Lähde: Ekorem	Source: Ekorem

The majority of commercial and office buildings are heated by means of district heating. Old buildings have been connected to the district heating network, and district heating is now considerably more widespread than what the statistics drawn up on the basis of the building register suggest (*Diagram 8*). This explains the disparity between the development of the building stock and district heating consumption in *Diagram 9* (Statistics Finland, 2014). The volume of commercial, office and public buildings has tripled while the district heating consumption of these types of buildings has grown 12-fold.

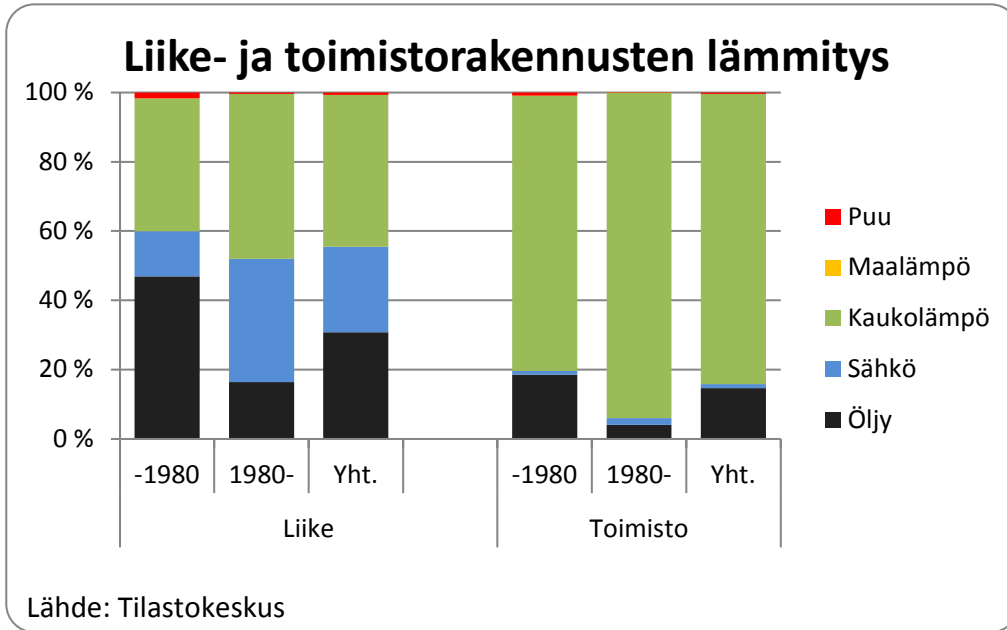
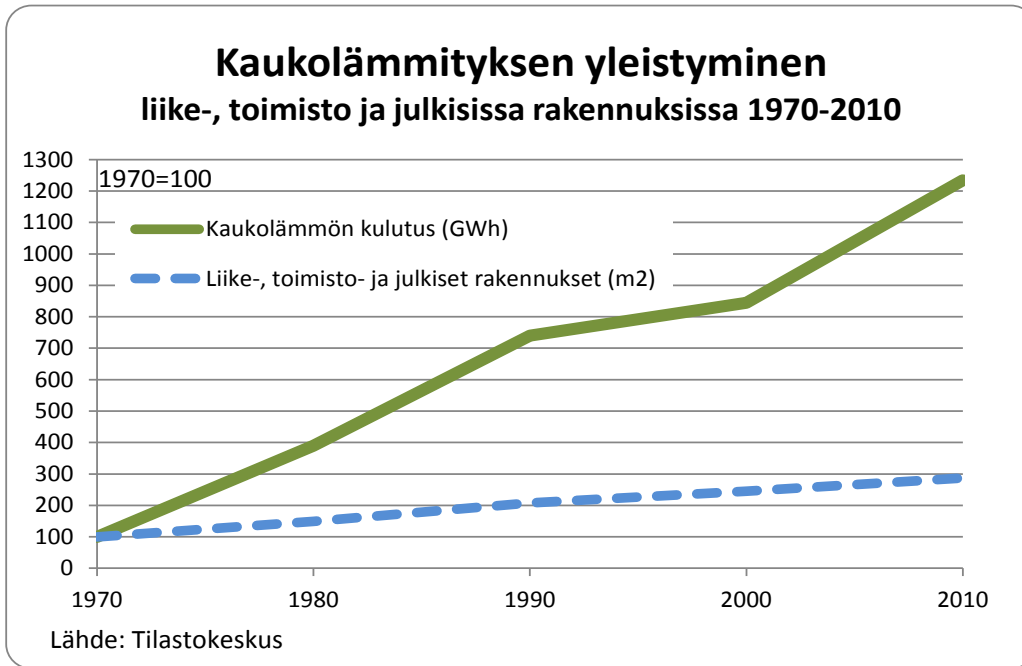


Diagram 8. Original energy sources in commercial and office buildings (Statistics Finland, 2014)

Finnish	English
Liike- ja toimistorakennusten lämmitys	Heating systems in commercial and office buildings
Puu	Wood
Maalämpö	Geothermal
Kaukolämpö	District heating
Sähkö	Electricity
Öljy	Oil
Yht.	Total
Liike	Commercial buildings
Toimisto	Office buildings
Lähde: Tilastokeskus	Source: Statistics Finland



Finnish	English
Kaukolämmityksen yleistyminen liike-, toimisto ja julkisissa rakennuksissa 1970–2010	Popularity of district heating in commercial, office and public buildings between 1970 and 2010
Kaukolämmön kulutus (GWh)	District heating consumption (GWh)
Liike-, toimitsto- ja julkiset rakennukset (m ²)	Commercial, office and public buildings (m ²)
Lähde: Tilastokeskus	Source: Statistics Finland

Diagram 9. District heating in commercial, office and public buildings has increased by more than the increase in building stock due to new development, as buildings built before 1970 have also been connected to the network. (Statistics Finland, 2014)

In Finland, three quarters of district heating is produced by cogeneration (CHP) plants. District heating is mostly produced by means of natural gas (32%), coal (23%) and biofuels (22%) (Finnish Energy Industries, 2014). There are plans to increase the percentage of biofuels. Studies show that there is no advantage to be gained from replacing district heating by property-specific renewable energy systems (Finnish Climate Panel, 2013).

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

3.1 Definitions of deep renovation and staged deep renovation

Finland's building regulations (Decree No 4/13 of the Finnish Ministry of the Environment), which entered into force in 2013, introduce cost-optimal levels of minimum energy performance requirements for renovations (Finnish Ministry of the Environment, 2013). These levels double as Finland's deep renovation / staged deep renovation levels.

Property owners have the discretion to decide how extensively to renovate their properties and what the best ways are to improve energy performance within the regulations and in accordance with the principles of systematic property management in each case. The national requirements for improving the energy performance of buildings can be waived on a case-by-case basis in connection with renovations and changes, if achieving the required standards is not technically, functionally or economically viable.

The timing of renovations is determined by the intended use of a building or any changes to the same, technology, functionality, economic viability and location.

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.

3.2 Deep renovations – measures and requirements

3.2.1 Requirements concerning building components

1. External walls: Original U-value x 0.5, however not exceeding 0.17 W/(m²K). When changing the intended use of a building, original U-value x 0.5, however at least 0.60 W/(m²K).
2. Roofs: Original U-value x 0.5, however not exceeding 0.09 W/(m²K). When changing the intended use of a building, original U-value x 0.5, however at least 0.60 W/(m²K).
3. Floors: Improvements to energy performance where possible
4. The U-value of new windows and external doors must be at least 1.0 W/(m²K). When renovating old windows and external doors, thermal insulation must be improved where possible.

3.2.2 Requirements concerning technical systems

1. The amount of heat to be recovered from the extracted air originating from a building's ventilation system must be equal to 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 specific electricity output of a mechanical air intake and extraction system may not exceed 2.0 kW/(m³/s).
3. The specific electricity output of a mechanical air extraction system may not exceed 1.0 kW/(m³/s).
4. The specific electricity output of an air-conditioning system may not exceed 2.5 kW/(m³/s).
5. The efficiency of heating systems must be improved where possible in connection with modernising equipment and systems.
6. With regard to modernising plumbing and/or sewerage systems, the regulations applicable to new developments must be observed.

3.2.3 Ensuring the proper functioning of a renovated building

1. External walls and roofs and technical systems

Anyone undertaking measures to improve the energy performance of the external walls or roof of a building must ensure that the walls and roof as well as window and door joints are insulated so that thermal insulation is shielded against the effects of air flow.

When planning and carrying out repairs or replacements of external walls and roofs or technical systems, the measures must be chosen so as to ensure correct thermal insulation properties, soundproofing properties and moisture barrier properties as well as fireproofing properties.

2. Ventilation

If necessary, plans detailing measures to improve the energy performance of a building must show how the correct functioning of ventilation and sufficient air intake are to be ensured in the case that the building is equipped with a mechanical air extraction ventilation system or a gravitational ventilation system.

If the energy performance of a building is being improved by installing unit-specific mechanical air intake and extraction systems with heat recovery, these must be designed and built so as to not cause health concerns in other units due to air intake or extraction.

3. Functioning of technical systems

In connection with improving the thermal insulation or airtightness of the external walls or roof 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 any necessary building systems balanced and adjusted as needed.

4. Policies and measures that promote deep renovations

Renovations that improve energy efficiency can be promoted by means of regulations, innovations, financial incentives, communications and education.

4.1 Regulations

As part of the national implementation of the European Energy Performance of Buildings Directive (EPBD), energy efficiency requirements have been set for individual components and systems as well as whole buildings in connection with renovations that are subject to planning permission (Decree No 4/2013 of the Finnish Ministry of the Environment). All properties for sale or to let must have an energy performance certificate as of 2013. Energy performance certificates also include recommendations for improving energy efficiency.

⇒ *Guidelines are provided for evaluating which repairs are technically, functionally and economically feasible.*

⇒ *Recommendations are also given for repairs that do not require a permit.*

Energy efficiency can only be improved if the renovation project is carried out professionally and with up-to-date technology from start to finish. The client 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 carry out the repairs and ensure that the energy performance targets set are reached in practice. Regulations and recommendations need to be supported by high-quality engineering and building know-how.

⇒ *The importance of careful planning and skilled builders in achieving a high-quality end result needs to be emphasised.*

4.2 Innovations

The energy performance of buildings is a goal and research topic shared by many countries. New technologies and solutions come from investing in a common objective. New solutions need to be tested in real environments.

⇒ *Regulations are waived to enable the testing of breakthrough technologies.*

Energy services companies (ESCOs) provide independent energy consultants to coordinate investments and measures to cut energy consumption (ESCO, 2014). The costs of the ESCO service, including the investment, are covered by the savings brought about by lower energy bills.

⇒ *The ESCO concept needs to be made use of in the adoption of new technologies.*

Building information modelling (BIM) should be introduced for renovations in old buildings as well. New technologies, such as laser scanning, should be used where possible to gather

basic information about the property. A computerised model of the building site would help builders to visualise the project and serve as a tool for ensuring occupational safety and efficient communication.

⇒ *Modelling and new technologies need to be used in renovation projects.*

The information generated by modelling (PRE, 2014) could be used to produce dynamic energy production and consumption simulations to find the optimal renovation solution for each property. Incorporating cost calculations into the model would allow engineers to find the most cost-effective solution considering the remaining life of the building.

⇒ *Dynamic energy consumption simulations need to be made use of when choosing between renovation alternatives.*

⇒ *Information generated by modelling and simulation software needs to be made use of in property management.*

4.3 Financial incentives

The availability of renovation and energy subsidies for housing companies has been relatively limited, and they have mostly been used to revive the economy and boost employment.

In order to make financial incentives more effective, they need to be longer-lasting and less changeable. Incentives could also be introduced for renovation projects that go above and beyond what is required as well as for testing new technologies and concepts. Comprehensive energy performance renovations could also be promoted.

⇒ *Financial incentives need to be targeted at renovations that make a bigger impact on energy performance.*

4.4 Communications

Information needs to be disseminated about the best ways to improve energy efficiency as well as successful projects. Misconceptions also need to be cleared up. The benefits and costs of renovations need to be discussed equally.

⇒ *It is important to invest in making information about renovations widely available so that news about breakthrough technologies can be disseminated effectively.*

⇒ *Successful energy performance renovations need to be advertised to encourage a domino effect.*

⇒ *Disseminating information about renovation concepts and best practices as well as risks associated with specific solutions is especially important.*

In the context of deep renovations, the effect of efficient use of space on energy performance could be a more informative indicator than energy consumption by floor area. This is the case especially with projects in which changes are introduced to how and for what purpose space is used.

⇒ *One useful indicator for measuring improvement in energy efficiency could be energy consumption per actual user (kWh/resident or worker) or visitor (kWh/user or customer) if changes are made to how space is used in connection with a renovation project.*

4.5 Labour force, know-how and education

The concept of energy efficiency as an integral part of all renovations should be emphasised by incorporating it into the curriculum at all levels of construction education. Energy efficiency

and renovations are essential elements of life cycle management, a discipline that has so far been largely neglected in education in favour of courses focusing on new development. Courses are needed for both young people and mature students and for both new recruits and professionals who have already established themselves in the industry.

- ⇒ *Material efficiency as part of life cycle management needs to be factored into teaching.*
- ⇒ *Courses focusing on renovation projects need to include lessons on ways to improve energy efficiency as well as new technologies.*
- ⇒ *Virtual learning resources need to be produced.*

5. Decision-making, service provision and financing relating to renovations

With regard to renovation projects, crucial decisions are made in connection with target-setting even before planning begins. Engineers are responsible for finding solutions that satisfy the objectives set, builders for carrying out the work, and property managers for maintaining the level of energy performance achieved. Ultimately, decisions are made by property owners.

The majority of residential buildings (95%) and commercial and office buildings (90%) in Finland are privately owned (Statistics Finland, 2013B). Private property owners include individual households (detached houses), housing associations of householders (terraced houses, apartment blocks), joint-stock property companies (rental properties, rented commercial and office buildings) and businesses (owned commercial and office buildings). Compared to the private sector, the public sector owns relatively few rental properties (5%) and commercial and office buildings (10%). However, the public sector has shares in multiple joint-stock property companies that are listed as private-sector companies in statistics.

5.1 Decision-making

5.1.1 Householders (detached houses)

Householders who own their homes make all decisions concerning their properties and also often carry out any necessary repairs themselves. Detached houses are maintained by their owners. A (voluntary) property inspection is carried out in connection with most sales. Provisions on energy performance certificates were enacted in connection with the implementation of the Energy Performance of Buildings Directive (EPBD). Financial incentives for renovations include tax credits and lower energy bills. Other incentives include functional and qualitative improvements to the property, such as increased comfort of living and usability.

Renovations are often triggered by sales, as new owners often have needs that make alterations necessary. Detached houses are left empty in areas where population is decreasing. It is also worth investing in improving energy performance when renovating detached houses, as this helps to optimise life cycle costs (Finnish Ministry of the Environment, 2013).

- ⇒ *Renovation concepts that incorporate measures to improve energy performance need to be favoured.*
- ⇒ *With regard to individual properties, it makes sense to examine the potential benefits of different forms of energy, including renewable sources of energy.*

5.1.2 Housing associations (terraced houses, apartment blocks)

Housing associations are legal entities that either own or lease plots of land and own any properties on that land. The occupants of the units in the properties act as shareholders in the housing association. According to the Finnish Limited Liability Housing Companies Act, responsibility for maintaining the building and any basic utility systems of a housing association lies with the Board of Directors and the Manager appointed by the Board, who must act in accordance with the decisions of the General Meeting. The division of responsibilities laid down in the Articles of Association specifies the responsibilities of the housing association and the occupants of individual units. The shareholders decide on renovations and pay for any repairs to the buildings and basic utility systems of the company together. In Finland, the building stocks of housing associations are usually relatively small. The average housing association controls 21 units (Statistics Finland, 2013A).

The Finnish Limited Liability Housing Companies Act (1599/2009), which entered into force in 2010, obligates housing associations to draw up and present to the General Meeting a condition survey of their properties every five years. When selling shares in a housing company, the vendor must present a certificate from the building manager, which includes technical details and the company's financial statements as well as information about the condition of the property and its energy performance certificate.

The shareholders of a housing association are not entitled to tax credits for repairs for which the company is responsible. The state budget includes annual renovation subsidies for housing associations.

⇒ *Condition surveys should ideally factor in energy performance improvements to be carried out in connection with repairs that are more far-sighted than the mandatory five years.*

5.1.3 Joint-stock property companies, businesses and the public sector (rental properties, commercial and office buildings)

These kinds of buildings are either used by their owners or let out. In both cases, the use of the building plays a big role when deciding on renovations. Businesses that operate in their own premises pay little attention to property management costs. Properties that are let out, on the other hand, can bring 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, 2014), which is designed to help Finland meet its international obligations in mitigating climate change. Voluntary energy efficiency agreements have been signed with the property sector, the service sector and the local government 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 most important goals of the agreement scheme is to promote the adoption of new, energy-efficient technologies and services among businesses and local governments.

The state supports participating businesses and non-governmental organisations in carrying out energy audits and analyses and can also contribute towards energy efficiency investments and the costs of adopting new, energy-efficient technologies.

⇒ *Improvements in energy performance need to be incorporated into renovations.*

⇒ *The best practices, technologies and partnerships discovered in the course of the energy efficiency agreement schemes need to be put to use.*

⇒ *The services of ESCOs need to be made use of to improve energy efficiency.*

The Finnish Association of Building Owners and Construction Clients has developed a number of operating models and tools that are designed to improve eco-efficiency in contracts between landlords and tenants (Finnish Association of Building Owners and Construction Clients, 2011). Tenancy agreements can include provisions on energy efficiency targets, forms of energy, metering and cost sharing.

⇒ *The green lease and light green lease concepts need to be made use of.*

5.2 Business

For many construction sector businesses, renovations have represented a market that can be used to offset fluctuations in demand for new development. For companies, it has been important to operate in several market segments in order to secure the continuity of operations. Such companies have been found to last longer than highly specialised companies. Some construction concepts are equally well suited to both new developments and renovations.

While the best-run companies in the industry focus on catering to today's needs, they may miss out on future business opportunities, i.e. products and services that are specifically suited to renovations.

⇒ *Deep renovations are an opportunity for new businesses to focus on developing renovation products and on conquering future markets.*

Renovation construction and especially energy renovations that are focused on improving energy management have been studied extensively. Sound technical and economic concepts have been developed.

⇒ *Commercial exploitation of the results of R&D&I projects and new business need to be promoted.*

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 focus can be given to the production process instead of the end result. In addition to the mechanical and technical components, the process also includes customer care and communication.

Customers are especially likely to be dissatisfied with surprises, failed schedules and careless conduct on site.

⇒ *Services need to be tailored to match the range of products available, and suitable production systems and know-how need to be developed.*

5.3 Financing

The state has mostly granted financial support to housing associations according to economic trends. Households have benefited from tax credits.

The building's owners finance any necessary repairs themselves (savings, revenue, reserves, funds) or apply for bank loans or, in special circumstances, loans or interest subsidies from the Housing Finance and Development Centre of Finland. Funding from the Housing Finance and Development Centre of Finland is generally only available for non-profit organisations.

The availability of bank loans depends on the applicant's ability to pledge collateral. In areas where house prices are low, the required loan amount may be too high considering the market value of the property.

In housing associations, the shareholders pay back any loans through their service charges. According to the renovation barometer of the Finnish Real Estate Federation, half of all housing associations that have taken out loans have a loan term of less than 10 years (Finnish Real Estate Federation, 2013). In rental properties and rented business premises, the costs of renovation are carried over to the rent charged by the owner for the property in question or the owner's entire property portfolio.

In the residential sector, the problem lies in the high costs of renovations relative to households' wealth (Oja, 2013).

Housing associations have recently begun to finance renovations by applying for new planning permissions and selling land to developers. Parking is a critical issue in these cases. Solving the parking issue requires timely support from planning authorities and sometimes also centralised parking facilities. From the perspective of local governments' infrastructure and services, adding more floor space to an existing residential property is a cheap alternative to acquiring planning permission for a completely new area (Nykänen, 2013).

It often makes more financial sense to demolish residential and commercial properties that are in poor repair than to renovate them if a building with more floor space can be built in their place. In these cases, improvements in energy performance stem from the new buildings satisfying modern energy efficiency regulations.

⇒ *Options other than traditional forms of financing also need to be explored when contemplating deep renovations.*

In Finland, the ESCO concept is used to finance renovations in buildings owned by the public sector and businesses, especially in production facilities. The ESCO concept has not been popular among housing associations, as individual housing associations generally only control a small amount of building stock. The ESCO concept could be used to promote the adoption of new technologies.

⇒ *Financing through ESCOs needs to be taken advantage of to promote deep renovations in both residential and commercial properties.*

6. Energy savings, reductions in emissions and other benefits

6.1 Energy savings and reductions in emissions

The premise is that renovations aimed at improving energy efficiency are carried out in connection with renovations necessitated by other reasons. The frequency of repairs (Vainio, 2002) depends on the age of the building and its components (façades, ventilation, hot water, building services and electrical systems). Some buildings are demolished or decommissioned otherwise. Loss factors have been calculated for the purpose of drawing up energy consumption forecasts (Nippala, 2012).

Conduction losses

In connection with façade renovations, the U-values of external walls are halved and windows modernised. In 1970s apartment blocks, for example, this means that the original wall U-value of 0.45 W/m²K drops to 0.22 W/m²K. The window U-value drops from 2.0 W/m²K to 1.0 W/m²K.

In detached houses, insulation is added to the roof so as to halve the roof U-value. It is not always possible to add insulation to the roofs of apartment blocks, which is why apartment block roofs are excluded from these calculations.

Hot water

In connection with replumbing old properties, the goal is to lower the pressure and introduce modern, economical bathroom suites. This lowers energy consumption resulting from the use of hot water, as the same end result can be achieved with smaller volumes of water.

Ventilation

Ventilation systems are equipped with heat recovery units whenever new mechanical air intake and extraction systems or mechanical air extraction systems are installed.

Electricity consumption

The premise is that electricity consumption remains unchanged. The number of appliances increases, but as they are increasingly energy-efficient, there is no increase in electricity consumption (e.g. laptops instead of desktop computers and LEDs instead of incandescent light bulbs).

Heating

By 2050, the share of electrical heating systems will drop by 75% from the current level (Table 3) and oil-based heating systems will disappear from residential properties altogether. In commercial and office buildings, the share of oil-based heating systems will drop by 60% from the current level (Table 4).

Table 3. Share of electrical heating. Source: Statistics Finland (2013B)

	Percentage in 2013	Target for 2050
Detached houses	45%	11%
Terraced houses	29%	7%
Apartment blocks	2%	1%
Commercial and office buildings	12%	3%

Table 4. Share of oil heating. Source: Statistics Finland (2013B)

	Percentage in 2013	Target for 2050
Detached houses	19%	0%
Terraced houses	9%	0%
Apartment blocks	6%	0%
Commercial and office buildings	18%	7%

The energy savings to be achieved by means of renovation are substantial for a single property but across the entire building stock their impact is relatively minor (*Diagram 10a, b*), as the number of renovations is low relative to the volume of buildings (Table 5). In addition to renovations, the decommissioning of old buildings also affects energy consumption. By 2020, renovations can help to cut energy consumption in residential, commercial and office buildings by four per cent, while the loss of old buildings will contribute a similar decrease.

In the long term (until 2050), renovations will contribute slightly more to the decrease in energy consumption than the loss of old buildings.

Carbon dioxide emissions will decrease by more than energy consumption (*Diagram 10c*), as fossil fuel heating systems will be replaced by emission-free fuels in connection with renovations.

Table 5. Estimated impact of renovations on the energy consumption and greenhouse gas emissions attributable to residential, commercial and office buildings in the light of research and statistics. The figures include both traditional renovations (“BAU”) and deep renovations (Airaksinen & Vainio, 2013).

	2012	Cumulative change			
		2020	2030	2040	2050
Impact of loss of old buildings, GWh	90 958	-3 638	-7 277	-11 370	-15 463
Impact of renovations, GWh		-4 082	-9 610	-13 817	-18 024
Energy consumption, GWh _e	109 469	-8 115	-18 035	-27 462	-36 889
Reduction in greenhouse gas emissions, CO ₂ -1 000 tn	20 587	-2 622	-5 621	-8 114	-10 607
Impact of loss of old buildings, GWh/%		-4%	-8%	-13%	-17%
Impact of renovations, GWh/%		-4%	-11%	-15%	-20%
Total, GWh/%		-8%	-19%	-28%	-37%
Reduction in greenhouse gas emissions, CO ₂ -1 000 tn / %		-13%	-27%	-39%	-52%

6.2 Societal impacts

Renovations cover all basic repairs, modernisation and maintenance. A total of approximately EUR 7.5 billion was spent on repairs in the kinds of residential, commercial and office buildings discussed in this report in 2013. Between 20 and 30 per cent of these renovations are such that can incorporate measures to improve energy efficiency.

Measures to improve energy efficiency (BAU + deep renovation) increase the cost of renovation projects by 5–15% (Vainio, 2012). With the average increase in costs attributable to measures to improve energy efficiency (10%), the increase in the volume of renovations in residential, commercial and office buildings amounts to between EUR 150–200 million per year at 2013 prices.

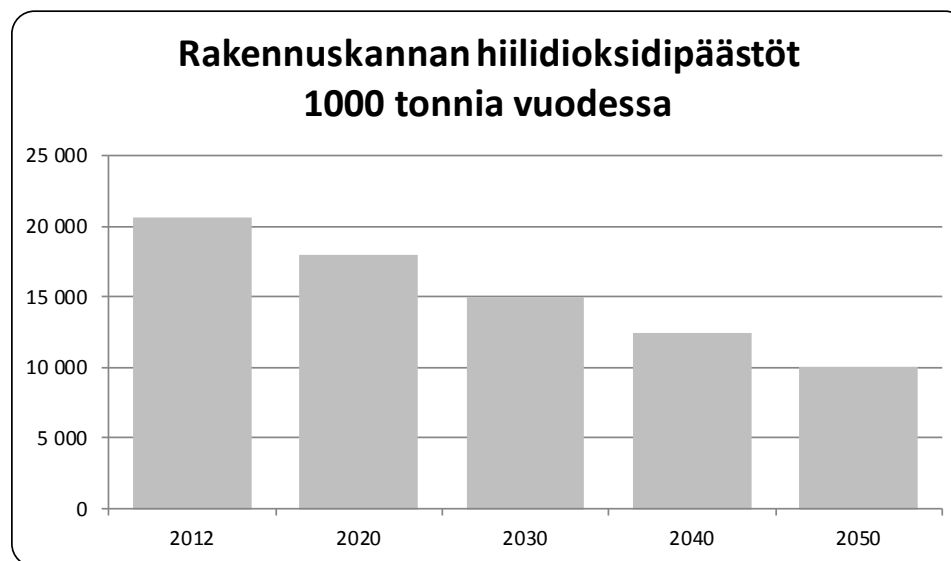
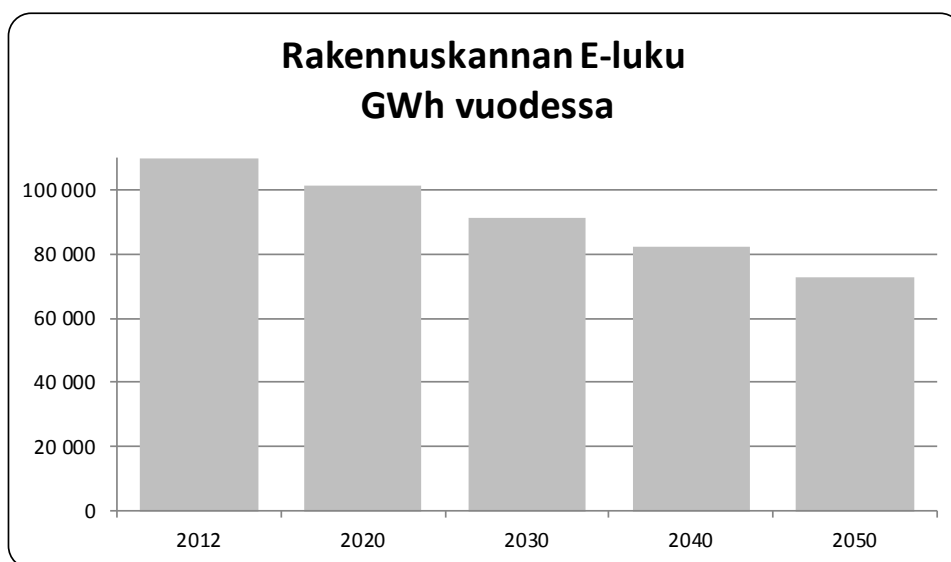
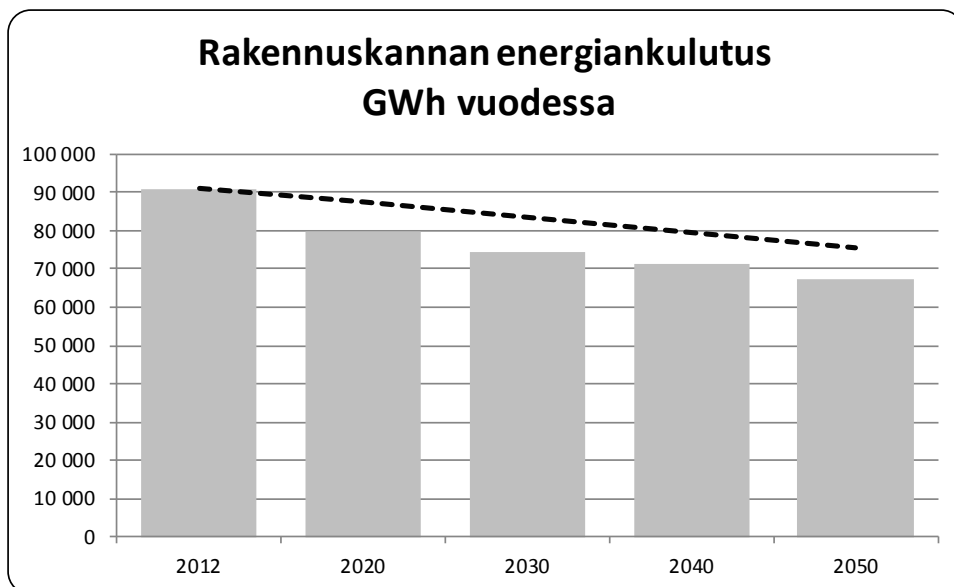


Diagram 10a, b, c. Total impact of renovations and the loss of old buildings on the energy consumption and greenhouse gas emissions of residential, commercial and office buildings calculated according to the source data and assumptions given in Chapter 6.1 of this report.

Rakennuskannan energiankulutus GWh vuodessa	Energy consumption of buildings, GWh/a
Rakennuskannan E-luku GWh vuodessa	Energy rating of buildings, GWh/a
Rakennuskannan hiilidioksidipäästöt 1000 tonnia vuodessa	Carbon dioxide emissions of buildings, 1 000 t/a

6.2.1 Impact on employment

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 requires more work than doing the same to pre-cast elements at a factory. Demolition requires labour force on site but contributes nothing to the construction products industry. Adjusting a heating system requires labour force but only a little engineering and no construction products.

A million-euro investment in renovation provides employment for a total of approximately 16 people across the entire chain. The chain used in this figure is more comprehensive than that used in official structural statistics on national economy, which are based on the input-output model. According to the official definition, the multiplier effect of a construction site only covers any products and services sourced for the site and excludes any engineering and construction works, as these are not per se sourced for the site. This analysis, however, also covers engineering and construction.

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, 2001; Vainio, 2011). Improving energy efficiency in connection with a renovation project can increase workload by between two and three per cent compared to a normal renovation of a residential, commercial or office building (Table 6).

Table 6. 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.

Volume of renovations in residential, commercial and office buildings in 2013, EUR million	7 500	Measures for improving energy efficiency	
		+150	+200
Construction sites, person-years of work	60 000	1 200	1 600
Construction materials industry, person-years of work	37 500	750	1 000
Construction-related services, person-years of work	22 500	450	600
Total impact on employment, person-years of work	120 000	2 400	3 200
Increase, %		2.0%	2.7%

6.2.2 Impacts on national economy

Renovations are paid for by property owners, the majority of whom are private householders (detached houses, housing associations) and businesses. In renovation projects, labour accounts for approximately 30% of costs, domestic construction products for 50% and

imported products for 15%. The remainder is made up of machinery costs, taking into account depreciation.

A 10% renovation subsidy generates a total of 32% tax revenue in the form of income tax, company tax, value added tax and social insurance contributions.

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 the manufacturing industry.

Table 7. Conversion of the added costs resulting from measures to improve energy efficiency (EUR 200 million) into revenue benefiting the national economy. The analysis is based on the year 2013.

Households	44	Households	44
Developers' revenue	8	Construction and specialist works	8
Developers' productive capital	4	Other services and industry	26
Other businesses' revenue	14		
Other businesses' productive capital	8	Insurance	22
Earnings-related pensions	18		
Unemployment, accidents	4	Taxes and social insurance contributions	45
Social security and sick pay	2		
State tax	8		
Value added tax	22		
Church tax	1		
Council tax	12	Imports	58
Imports	58		
Total, EUR million	200	Total, EUR million	200

The volume of work is substantial. An additional investment in energy efficiency (EUR 200 million) would generate EUR 44 million in net income for households. The state, local governments and church would receive EUR 45 million in tax revenue and insurance companies EUR 22 million in insurance premiums. A lot 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 from the EU.

The combined profits and capital expenditure of the businesses involved in the chain amount to EUR 34 million, of which profits for construction firms and specialist engineering companies account for EUR 8 million.

7. Conclusion

Overview of Finland's building stock

Finland has 280 million square metres of residential properties and 64 million square metres of commercial properties. Approximately half of the building stock was built after 1980 and the energy performance of these buildings is relatively good, as the energy performance regulations governing new development were tightened in 1978 in response to the 1970s energy crises.

The majority of buildings with multiple residential units and commercial buildings are connected to the district heating network. Three quarters of all district heating is produced by means of cogeneration (CHP). In 2013, coal accounted for 23%, natural gas for 31% and biofuels for 22% of district heat generation. There are plans to increase the percentage of biofuels.

Electricity currently accounts for 45% of the heating energy of detached houses and oil for 19%. Oil-based heating systems in particular are usually replaced by heat pumps in connection with property-specific heating system modernisation projects.

Cost-effective deep renovations suitable for Finland's climate

The Decree of the Finnish Ministry of the Environment, passed in 2013, obligates all individuals undertaking a renovation, alteration or system modernisation project that requires permission to also incorporate measures to improve energy efficiency into the project. The regulation introduces cost-optimal levels of minimum energy performance requirements for individual building components and for total energy consumption.

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

The component-specific requirements are as follows:

1. External walls: Original U-value x 0.5, however not exceeding 0.17 W/(m²K). When changing the intended use of a building, original U-value x 0.5, however at least 0.60 W/(m²K).
2. Roofs: Original U-value x 0.5, however not exceeding 0.09 W/(m²K). When changing the intended use of a building, original U-value x 0.5, however at least 0.60 W/(m²K).
3. Floors: Improvements to energy performance where possible
4. The U-value of new windows and external doors must be at least 1.0 W/(m²K). When renovating old windows and external doors, thermal insulation must be improved where possible.

The requirements applicable to technical systems are as follows:

1. The amount of heat to be recovered from the extracted air originating from a building's ventilation system must be equal to 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 specific electricity output of a mechanical air intake and extraction system may not exceed 2.0 kW/(m³/s).
3. The specific electricity output of a mechanical air extraction system may not exceed 1.0 kW/(m³/s).
4. The specific electricity output of an air-conditioning system may not exceed 2.5 kW/(m³/s).
5. The efficiency of heating systems must be improved where possible in connection with modernising equipment and systems.
6. With regard to modernising plumbing and sewerage systems, the regulations applicable to new developments must be observed.

Policies and measures that promote deep renovations

Finland's national strategy emphasises innovation, communications, skilled labour and education. The energy performance of buildings is a goal and research topic shared by many countries. New technologies and solutions come from investing in a common objective, and these need to be widely disseminated. Lessons learnt about the best ways to improve energy efficiency as well as successful projects need to be shared.

The concept of energy efficiency as an integral part of all renovations should be emphasised by incorporating it into the curriculum at all levels of construction education. Energy efficiency and renovations are essential elements of life cycle management, a discipline that has so far been largely neglected in education in favour of courses focusing on new development. Courses are needed for both young people and mature students and for both new recruits and professionals who have already established themselves in the industry.

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

With regard to renovation projects, crucial decisions are made in connection with target-setting even before planning begins. In Finland, these decisions are taken by householders and businesses, as 95% of residential properties and 90% of commercial properties are privately owned.

Property owners cannot be obligated to renovate structures and systems that are otherwise fine just to improve their energy performance. This is why the way forward is to encourage property owners to introduce these kinds of improvements in connection with normal structural repairs and system upgrades.

In order to increase awareness among property owners, energy performance certificates need to be presented in connection with all sales and lettings. Property owners also need to be offered voluntary models such as energy efficiency agreements and green leases, which are based on an agreement between a landlord and a tenant and provide obligations on both parties to conserve energy.

Measures aimed at improving the energy performance of buildings are likely to gain popularity once products that offer better value for money and services relating to engineering and installation become available.

Expected energy savings and other benefits

Improving energy efficiency in connection with renovations undertaken for other reasons (e.g. to repair structural damage or convert spaces for new uses) in accordance with the strategy is expected to lead to an energy saving of four per cent by 2020. A similar saving will result from the loss of old buildings. Carbon dioxide emissions will decrease by more than energy consumption (13%), as fossil fuel heating systems will be replaced by low-emission fuels in connection with renovations.

Measures to improve energy efficiency (BAU + deep renovations) are expected to increase the annual volume of renovations by EUR 150–200 million at 2013 prices. This would increase the workload in residential and commercial property renovations by two person-years of work. This figure is similar to the expected growth in GDP. Increases in employment generate income for households and tax revenue for the public sector.

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ANNEX A CLASSIFICATION OF BUILDINGS

The classification of buildings used in Finland (Statistics Finland, 1994) divides buildings into 13 categories according to use. Article 4 of the EED applies to the classes written in bold.

Residential buildings	A	Residential buildings	01 Detached and semi-detached houses 02 Attached houses 03 Blocks of flats
	B	Free-time residential buildings	
Commercial and office buildings	C	Commercial buildings	11 Wholesale and retail trade buildings 12 Hotel buildings 13 Residential buildings for communities 14 Restaurants and other similar buildings
	D	Office buildings	15 Office buildings
	E	Transport and communications buildings	16 Transport and communications buildings
	F	Buildings for institutional care	
	G	Assembly buildings	
	H	Educational buildings	
	J	Industrial buildings	
	K	Warehouses	711 Industrial warehouses 712 Commercial warehouses
	L	Fire fighting and rescue service buildings	
	M	Agricultural buildings	
	N	Other buildings	

All residential buildings (detached and semi-detached houses, terraced houses and apartment blocks) belong to the same category. Commercial buildings include commercial buildings, offices and transport and communications buildings as well as commercial warehouses.

Statistics Finland (1994) http://www.stat.fi/meta/luokitukset/rakennus/001-1994/index_en.html

ANNEX B DISTRIBUTION BY REGION

Distribution of residential, commercial and office buildings in growing and shrinking areas. According to the latest population projection published by Statistics Finland, which covers the period until 2040 (Statistics Finland, 2012), population will grow in Helsinki and 11 other sub-regions (Statistics Finland, 2013). Population figures elsewhere in the country will shrink or remain unchanged.

		2012	2040	Change, %
011	Helsinki sub-region	1 445 167	1 776 599	23%
	Other growing sub-regions	1 852 718	2 147 233	16%
015	Porvoo sub-region	58 078	66 111	14%
023	Turku sub-region	313 848	352 745	12%
051	Hämeenlinna sub-region	94 627	109 415	16%
052	Riihimäki sub-region	46 629	55 717	19%
064	Tampere sub-region	125 720	141 775	13%
071	Lahti sub-region	202 869	219 893	8%
112	Kuopio sub-region	123 427	134 242	9%
131	Jyväskylä sub-region	177 212	207 707	17%
142	Seinäjoki sub-region	382 405	462 344	21%
152	Vaasa sub-region	94 749	111 524	18%
171	Oulu sub-region	233 154	285 760	23%
	Other areas	2 100 428	2 024 190	-4%

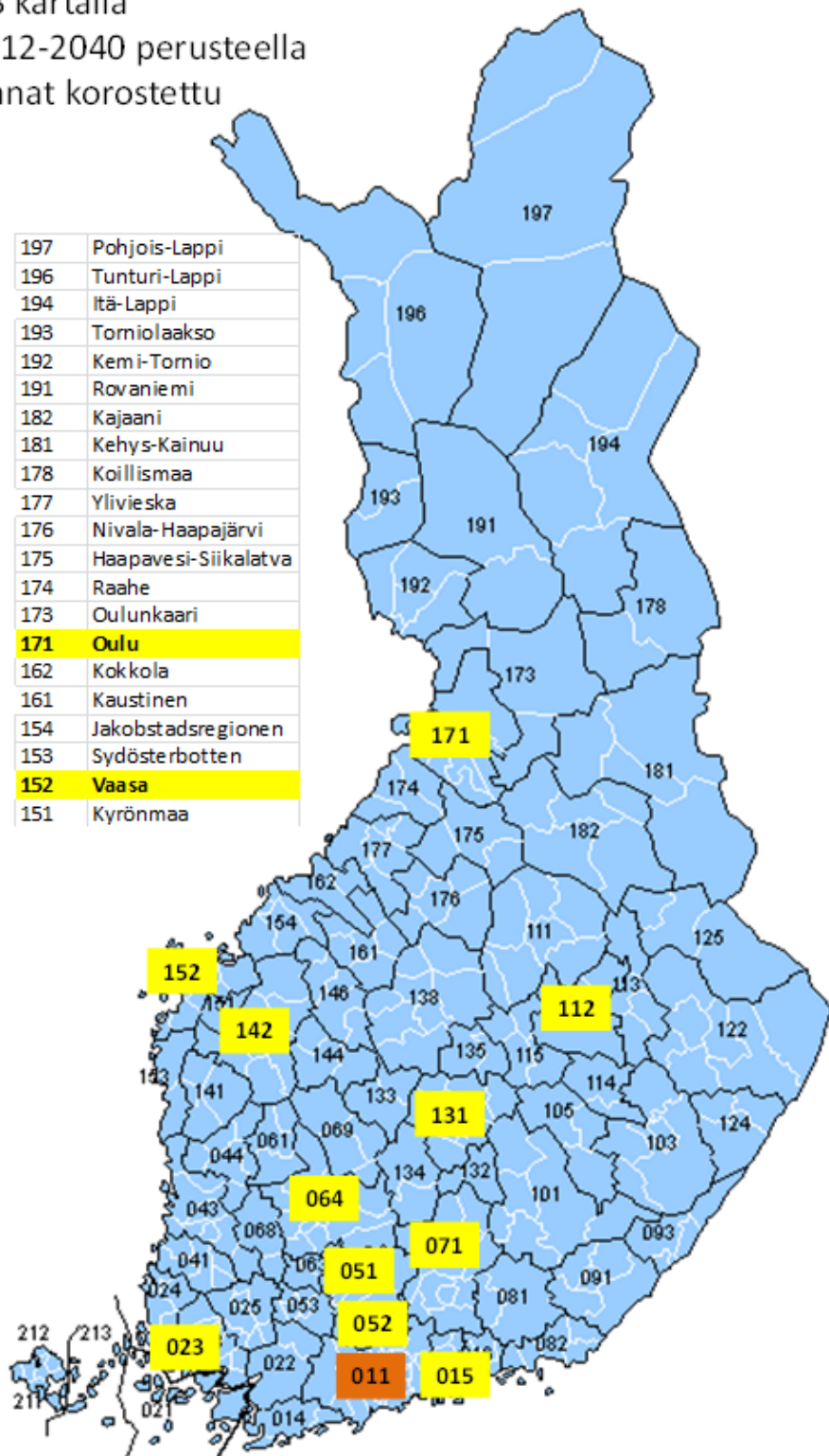
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Seutukunnat 2013 kartalla
- väestökehitys 2012-2040 perusteella
kasuvat seutukunnat korostettu

146	Järviselä
144	Kuusikunta
142	Seinäjoki
141	Suupohja
138	Saarijärvi-Viitasaari
135	Äänekoski
134	Jämsä
133	Keuruu
132	Joutsa
131	Jyväskylä
125	Pielisen Karjala
124	Keski-Karjala
122	Joensuu
115	Sisä-Savo
114	Varkaus
113	Koillinen-Savo
112	Kuopio
111	Ylä-Savo
105	Pieksämäki
103	Savonlinna
101	Mikkeli
093	Imatra
091	Lappeenranta
082	Kotka-Hamina
081	Kouvola
071	Lahti
069	Ylä-Pirkanmaa
068	Lounais-Pirkanmaa
064	Tampere
063	Etelä-Pirkanmaa
061	Luoteinen-Pirkanmaa
053	Forssa
052	Riihimäki
051	Hämeenlinna
044	Pohjois-Satakunta
043	Pori
041	Rauma
025	Loimaa
024	Vakka-Suomi
023	Turku
022	Salo
021	Åboland-Turunmaa
016	Loviisa
015	Porvoo
014	Raasepori
011	Helsinki

197	Pohjois-Lappi
196	Tunturi-Lappi
194	Itä-Lappi
193	Tomionlaakso
192	Kemi-Tornio
191	Rovaniemi
182	Kajaani
181	Kehys-Kainuu
178	Koillismaa
177	Ylivieska
176	Nivala-Haapajärvi
175	Haapavesi-Siikalatva
174	Raahe
173	Oulunkaari
171	Oulu
162	Kokkola
161	Kaustinen
154	Jakobstadsregionen
153	Syösterbotten
152	Vaasa
151	Kyrönmaa



Finnish	English
Seutukunnat 2013 kartalla	Map of sub-regions in 2013
- väestökehitys 2012-2040 perusteella	- population projection for 2012–2040
kasuvat seutukunnat korostettu	growing subregions highlighted