STUDY REPORT

High-efficiency CHP, district heating and district cooling in Finland 2010-2025

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Abstract

A significant portion of the heated building stock of cities and densely populated municipalities is connected to a district heating facility. Heating energy consumption and the statistics on district heating indicate that 90 % of apartment blocks, 30 % of industrial buildings, and more than 60 % of other buildings are heated by means of district heating. The figure for (semi-)detached houses is around 10 %. The total market share for district heating is 45 % (35.9 TWh, 2010). By 2025, the forecast for district heating is 40 TWh.

The period 2010-2025 could see new district heating capacity of 1 500 MW appear on the scene, of which CHP heating would account for 0-1 000 MW and power 0-500 MW, with the construction of new CHP plants. The figure for additional heating generation would be 4 TWh and for electric power 2 TWh. Primary energy savings would be approximately 14 % up comparing new and old CHP generation and 25 % of that for the separate production of power and heat. Part of the capacity would replace the old capacity. If the old heavy fuel boilers were replaced with CHP plants using renewable fuels, the figure for primary energy savings would be about 27 %.

Waste-to-energy plants are being built in Finland – in Tampere, Leppävirta and Salo. The total for district heat generation from them will be approximately 600-700 GWh per annum. Other multifuel investment projects now with the go-ahead will be located at Naantali (power station: district heating power of 250 MW) and Nokia (heating plant: district heating power of 68 MW).

The estimate for the potential use of heat from industrial processes using heat exchangers in district heating systems is approximately 1.6 TWh per annum. If heat pumps are used, the potential is two to three times that

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[1] VTT Technical Research Centre of Finland

[2] Finnish Environment Institute

figure.

The remainder of the planned demand for heat will be met using fuels suitable for the location in separate boilers, heat pumps, renewable energy sources, waste energy and the residual heat from industrial and other-heat-generating processes.

Each year around 1.4 TWh of energy is used to cool buildings and other facilities. Predictions suggest that the demand for cooling will grow to 1.7 TWh by the year 2030. The market share for district cooling in 2014 was a good 10 % of overall demand. It is possible that the increase in sales will continue at the present rate for the next 15 years, with the cooling market growing by around 20 GWh per annum. The market share could go up to as much as 25 % of the cooling market.

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Espoo 10.11.2015

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Distribution (clients and VTT)

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Finnish Energy

Foreword

This project was commissioned by the Ministry of Employment and the Economy, the Ministry of the Environment and Finnish Energy to examine the production capacity of district heating, its distribution, the demand for it, and the potential for all these factors up to the year 2025. An estimate has also been undertaken, in parallel with this survey, of the market potential for the cooling of the Finnish building stock.

The project involved the organisation of four management meetings. The management team consisted of:

Pentti Puhakka, Ministry of Employment and the Economy
Pekka Kalliomäki, Ministry of the Environment
Mirja Tiinen, Finnish Energy
Hille Hyytiä, Motiva (company promoting efficient and sustainable use of energy and materials)
Antti Rehunen, Finnish Environment Institute
Miimu Airaksinen, VTT
Kari Sipilä, VTT

We would like to thank the management group for their comments and their lively input.

Espoo 10 November 2015

The authors

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1. Introduction

1.1 Background

Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency (Energy Efficiency Directive) obliges Member States to report on their current situation with respect to the cogeneration of heat and power and consumption of district heating and present an assessment of the trend over a time horizon of approximately 10 Years. An assessment is required concerning the realisation of production capacity of electricity of 20 MW or more as CHP or using the residual heat from industrial processes.

1.2 Energy Efficiency Directive

The Energy Efficiency Directive (2012/27/EU) was adopted on 25 October 2012. Its purpose is to ensure that the European Union’s 20-20-20 targets for energy and climate are achieved as regards energy efficiency. The objective is for the overall consumption of energy to be at least 20 % less in 2020 than it would be according to the trend predicted in 2007.

According to Article 14 of the Directive, by 31 December 2015, Member States must carry out a national comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling. At the request of the Commission, the assessment must be updated and notified to the Commission every five years. Member States must encourage at local and regional level the use of efficient heating and cooling systems, in particular high-efficiency cogeneration.

A cost-benefit analysis should be undertaken if

> (a) a new thermal electricity generation installation with a total thermal input exceeding 20 MW is planned, in order to assess the cost and benefits of providing for the operation of the installation as a high-efficiency cogeneration installation;
>
> (b) an existing thermal electricity generation installation with a total thermal input exceeding 20 MW is substantially refurbished, in order to assess the cost and benefits of converting it to high-efficiency cogeneration;
>
> (c) an industrial installation with a total thermal input exceeding 20 MW generating waste heat at a useful temperature level is planned or substantially refurbished, in order to assess the cost and benefits of utilising the waste heat to satisfy economically justified demand, including through cogeneration, and of the connection of that installation to a district heating and cooling network;
>
> (d) a new district heating and cooling network is planned or in an existing district heating or cooling network a new energy production installation with a total thermal input exceeding 20 MW is planned or an existing such installation is to be substantially refurbished, in order to assess the cost and benefits of utilising the waste heat from nearby industrial installations.

According to Article 15 of the Directive, Member States must ensure that network users can implement energy efficiency improvement measures in the context of the deployment of smart grids without compromising security. Member States must also ensure that transmission system operators and distribution system operators ensure continuity in heat supply.

1.3 Directives related to energy efficiency

Several EU directives impose requirements governing heat and cooling consumption in buildings (Figure 1). The directives in question aim at reducing energy consumption and greenhouse gases and increasing the use of renewable energies.

Figure 1. Directives influencing the energy efficiency of buildings

Key

Uusiutuvien energialahteiden edististä koskeva direktiivi RES = Renewable Energy Directive

Rakennusten energiatehokkuusdirektiivi EPBD = Energy Performance of Buildings Directive

Tavoite 2020 Kasvihuonepäästöt -20 % Uusiutuvat energiakähteet +20 % Energiatehokkuus +20 % =

Europe 2020 strategy Greenhouse gases -20 % Renewable energy sources +20 % Energy efficiency +20 %

Ekosuunnitelu- ja tuotemerkintädirektiivi EcoDesign = Ecodesign Directive

Energiatehokkuusdirekttivi = Energy Efficiency Directive

1.3.1 Energy Performance of Buildings Directive

The aim of Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings (Energy Performance of Buildings Directive) is to reduce carbon dioxide emissions by improving the energy performance of buildings. The Directive is a recast version of Directive 2002/91/EC. It covers both new construction and renovations and focuses on three areas:

- the introduction of energy certificates
- minimum requirements for energy performance
- periodical inspections of boilers and air-conditioning installations or, instead, an advice-giving procedure that has the same overall effect

The Directive’s application at national level takes account of the country’s climatic conditions, local circumstances, the indoor climate environment and cost-effectiveness.

Finland's national requirements in line with the Directive are given in the Finnish building Code.

The Directive states, regarding nearly zero energy construction, that after 31 December 2020, new buildings under construction must be nearly zero energy buildings and that Member States must draw up national plans for increasing the number of nearly zero energy buildings. Nearly zero energy building means a building '*that has a very high energy performance, as determined in accordance with Annex I (of the Directive). The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.*' It remains to be determined nationally what is meant in the Directive by 'very high', 'nearly zero or very low', 'to a very significant extent', and 'nearby (i.e. the building)'. The 'statement version' of the regulations will be ready at the beginning of 2016.

1.3.2 Renewable Energy Directive (Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources)

The European Union's goal is to increase the share of final energy consumption of renewable energy to 20 % by 2020 and to 27 % by 2030. Renewable energy sources include solar energy, hydropower, wind power, energy from wood, bioenergy and heat pumps. The Renewable Energy Directive incorporates Member State-specific targets in order to achieve the overall effect. Counties may decide independently on the means employed to try to attain these targets.

According to the Commission proposal, Finland's share of energy from renewable sources in gross final consumption should rise to 38 %. Official estimates suggest that the share rose to 36.8 % in 2013[3]. The main forms of renewable energy in Finland are bioenergy (wood and wood-based fuels in particular), hydropower, wind power, geothermal energy and solar energy.

The Directive mainly covers the use of renewable energy and its promotion in general, but states with regard to the construction industry that *'Member States shall introduce in their building regulations and codes appropriate measures in order to increase the share of all kinds of energy from renewable sources in the building sector'*.

The most visible impact of the Renewable Energy Directive in the building sector concerns the share of renewable energy in building codes. The preoccupation at present is whether the minimum requirement for the share of renewable energy should be incorporated into the building codes or whether the requirements of the Directive should be met in other ways.

1.3.3 Energy Efficiency Directive

The Energy Efficiency Directive was very generally dealt with in section 1.2. The Directive, which replaces Directive 2006/32/EC of the European Parliament and of the Council on

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[3] http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_31&plugin=1

energy end-use efficiency and energy services and Directive 2004/8/EC of the European Parliament and of the Council on the promotion of cogeneration based on a useful heat demand in the internal energy market, also contains a good number of provisions directly affecting construction and the building sector. These include the creation of a building renovation strategy, the requirement for the exemplary status of public buildings, energy audits and management systems, measuring consumption, and sector-specific measures serving as the basis for energy savings agreements among the different sectors in Finland, whereby most municipalities, including the major cities, commit to reducing the energy consumption of their building stock by 2 % per annum.

1.3.4 EcoDesign Directive (Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-related products)

The EcoDesign Directive entered into force on 20 November 2009. In terms of its scope, it replaced the shorter Directive 2005/32/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-using products. It sets out the ecological requirements governing product design and development. The objective is acknowledgement of environmental considerations and life-cycle thinking in product design.

The EcoDesign Directive is a framework directive, pursuant to which actual product group-specific requirements concerning consideration of the environment are issued. Compliance with product requirements is the responsibility of the manufacturer within the context of internal production control, which also extends to the preparation of technical documentation, the EC declaration of conformity and the CE marking of products. The best-known example of the effects of the Directive is the gradual phase-out of incandescent light bulbs.

1.4 National targets in the heating of buildings

National provisions are in place to implement the Energy Performance of Buildings Directive and promote Finland’s own aims to improve energy efficiency. The latest energy efficiency requirements for new buildings – the ‘E number requirements’ for forms of energy (Figure 2) – took effect in 2012. By taking into account the forms of energy, an attempt is made to take consumption in a direction where greenhouse gas emissions fall. The coefficient for electricity is 1.7, for district heating 0.7, for district cooling 0.4, for fossil fuels 1.0 and for renewable fuels 0.5. (Ministry of the Environment, 2011)

The requirements relating to energy efficiency used to apply to new buildings only. However, because the energy consumption of existing buildings is the main factor in the environmental impact of buildings, the Energy Performance of Buildings Directive has been expanded to cover refurbishments. In Finland, the energy performance requirements for building renovations were adopted in 2013.

Figure 2. Energy efficiency requirements roadmap

Key

2012 Lämmitysjärjestelmät Energiamoudot = Heating systems Forms of energy

2013 Korjausrakentaminen = Building renovations

2017 Lähes nollaenergiarakentamisen määräykset voimaan =

Regulations on nearly zero energy construction take effect

2018 Lähes nollaenergiarakentamisen määräysten soveltaminen alkaa =

Start of the application of the regulations on nearly zero energy construction

In the subsequent phase, 2017-2018, the requirements concerning nearly zero energy buildings are to be implemented. These will combine the energy performance of buildings with meeting energy demand using renewable energy sources (Figure 3).

Figure 3. Nearly zero energy construction combines high energy performance with the use of renewable energy

Key

Erittäin korkea energiatehokkuus = Very high energy performance

+

Energiantarve katetaan hyvin laajalti uusiutuvilla = Energy demand be covered to a very significant extent by renewables

Lähes nollaenergiarakennus = nearly zero energy construction

2. Objective and implementation

One objective of this study is to produce data on current generation of district heating at regional level, investment in new and replacement production capacity, and production efficiency. Of particular interest is combined generation (CHP). Another aim here is to produce data on the current share of district heating in the heating of buildings and the potential to increase it. The third aim is to examine the current and future cooling requirement for buildings and the potential for its centralised production.

The study is based very much on the results of the research conducted by VTT nationally and in the context of international collaboration into Finland’s building stock and its development, energy production and consumption, and technological development.

With regard to heating, the analyses are cross-sectional in nature and cover the years 2010 and 2015. Available to the 2010 study was the most comprehensive statistical data on district heating generation and the consumption of heating energy in buildings. The analysis period extends for 10 years from the time the study was conducted to the year 2025. The results for the country as a whole are presented in tabular format or as formulas. Regional results are given on a map template for the community in question.

The years chosen for the examination of the cooling of buildings are 2015 and 2030. The energy consumption connected with the cooling of buildings is estimated using the IDA-ICE simulation tool, for each building type. Three scenarios are presented for consumption in 2030. Again, the results for the country as a whole are given in tabular format or as formulas and regional results are shown on a map template for the community in question.

3. Results

Demand for heating and district heating

In 2010, approximately 89 000 GWh of energy was consumed to heat residential and commercial, office, public and industrial buildings and to supply hot water, taking into account efficiency factors. With regard to consumption as calculated in this way, the market share for district heating was 90 % for apartment blocks, around 60 % for commercial, office and public buildings, and 30 % for industrial buildings. The figure for (semi-)detached houses is less than 10 %. Owing to the large number of (semi-)detached homes, the share of consumption of district heating in the heating of buildings (Figure 4) is around 45 % (40 000 GWh; calculated using the VTT building database calculation tool with reference to figures from Statistics Finland, Finnish Energy and the Association of Finnish Local and Regional Authorities).

Figure 4. Heat sources in 2010 in residential and commercial, office, public and industrial buildings. Source: Statistics Finland and VTT

Key

Asuin-, like-, toimisto-, julkisten ja teollisuusrakennusten lämmitys (% energiankulutuksesta) =

Heating of residential and commercial buildings, office buildings, and public and industrial buildings (% of energy consumption)

Key

Öljy 22 % = Oil 22 %

Maalämpö 3 % - Geothermal energy 3 %

Puu; turve 7 % = Wood; peat 7 %

Sähko 23 % - Electricity 23 %

Kaukolämpö 45 % - District heating 45 %

New construction in the period 2011-2025 would increase heating consumption by a total of 8 000 GWh. In all, 97 000 GWh of energy would be used for heating in 2015. District heating would account for 50-75 % of the potential consumption of heating in new buildings, i.e. the volume of district heating could rise by 42 000-44 000 GWh per annum.

However, the aim is to improve the energy performance of existing buildings with repairs to building envelopes and to technical systems. Owing to the structural change of society, buildings are also either becoming unoccupied or are not being used on a permanent basis, so the consumption of heating energy of the building stock will be reduced. According to a national target forecast, the consumption of heating energy of the building stock could fall to 74 000-81 000 GWh per annum by the year 2025. Consumption would go down in particular in areas people are migrating from and in sparsely populated regions, where energy density is too low to make district heating a profitable business. District heating consumption has furthermore been reduced by the recycling of heating energy in buildings using heat recovery technology and exhaust air heat pumps, through the preheating of intake air using electric power, and electric underfloor heating.

District heating generation

Finland’s CHP capacity in 2010 was 4 700 MW of electricity and 6 730 MW of heat (power to heat ratio average 0.7). The capacity of heating plants was 14 470 MW (fixed 13 070 MW and movable 14 000 MW). Total available district heating capacity was 21 680 MW. District heating generation was 38 500 GWh, in connection with which CHP electricity generation was 1 650 GWh. District heating consumption was 35 900 GWh.

There is new district heating generation capacity in progress in Finland (waste-to-energy power plants in Tampere, Leppävirta and Salo; combined district heating generation estimated at 600-700 GWh per annum). There are other major investment projects in Naantali (multifuel power plant; district heating power 250 MW) and in Nokia (multifuel heating plant; district heating power 68 MW). In addition, Helsinki is to abandon the use of coal and replace it, at least partially, with renewable energy sources. Oulu, Lahti and Rovaniemi are also planning to switch over to renewable energy sources.

Finland’s climate and energy policy has as its target an increase in wood burning. The aim is to increase the use of wood both in current and new heat plants and power stations. According to the Ministry of Employment and the Economy, it would be possible to invest the equivalent of a thermal input of 3 500 MW for the wood power feed-in tariff over the period 2007-2020.

If the CHP plants and the heavy fuel oil boilers with a capacity of more than 10 MW built before 1985 are decommissioned by 2025 on account of their age and replaced with plants that use renewable fuels, and account is taken of the decisions already taken and known plans, new CHP additional capacity would be required for 0-1 000 MW of heat generation and 0-500 MW of electricity generation. Approximately 500 MW of more boiler capacity will be required for the growing cities. Other capacity construction will replace the old decommissioned CHP and boiler capacity with renewable energy sources.

If the CHP plants built before 1985 are replaced with new multifuel CHP installations, such as those planned for Tampere, Oulu and Lahti, there will be an approximate 14 % saving in primary energy (improved efficiency and power to heat ratio) and a 25 % saving compared to the separate production of power and heat.

If the heavy fuel oil boilers built before 1985 are replaced with CHP plants using renewable fuels, there will be an approximate 27 % saving in primary energy (taking into account the switch to CHP and the poor efficiency of the old boilers).

Utilisation of renewable energy sources, energy from waste and the residual heat from industrial and other heat-generating processes in district heating might further reduce the demand for primary energy for heating. At present, around 770 GWh of residual heat from industrial processes is used per annum. The potential additional use of heat from processes using heat exchangers was estimated at approximately 1 400 GWh per annum in the forest industry, 700 GWH for the wood and timber industry, 2 000 GWh for the metal industry, 500 GWh for the food industry and 100 GWh for the chemical industry. The total potential additional use of energy from industry is estimated at 4 700 GWh, two-thirds of which would nevertheless require use of a heat pump to raise the temperature to one suitable for district heating.

Demand for district cooling and its production

Every year, some 1 400 gigawatts of energy are consumed to cool buildings. Forecasts suggest that the demand for cooling will increase to 1 700 gigawatts by the year 2030. The market share for district cooling in 2014 with respect to demand determined realistically was 10 %. It is possible that the increase in sales will continue at the present rate for the next 15 years, with supply growing by 20 GWh per annum. The market share could also go up to as much as 25 %.

District cooling can be increased in existing and new building stock in a number of ways. The present district cooling networks can be extended, and its use could incorporate new technology as well as new, open business models. Examples of these are hybrid systems combining the heating and cooling of buildings or the use of the cool conditions of land (geothermal cooling) and water as well as groundwater in cooling.

4. The Finnish building stock

4.1 The Finnish building stock and its development 2010-2025

4.1.1 The Finnish building stock in 2010

The Finnish building stock in 2010 totalled some 550 million square metres, if all buildings are included (Figure 5). The figure is partly estimated with reference to data on new production, because the Building and Apartment Register does not include all buildings, especially old ones.

Figure 5. How building types accounted for the building stock in 2010. Missing data have been added to the Building and Apartment Register using the statistics on new constructions. Source: Finnish Population Register Centre and VTT.

Key

Rakennuskanta 2010 talotyypeittäin, yht. 550 milj.m² =

Building stock in 2010 by building type, 550 million square metres in total

Muut rakennukset 25 % = Other buildings 25 %

Teollisuus ja varasto 10 % = Industrial and storage 10 %

Liike ja toimisto 11 % = Commercial and office buildings 11 %

Julkiset rakennukset 6 % = Public buildings 6 %

Rivi ja kerrostalot 22 % = Terraced houses and apartment blocks 22 %

Omakotitalot 26 % = (Semi-)detached houses 26 %

In the Finnish statistics on district heating, the building stock divides into three: residential buildings (semi-)detached homes, terraced houses and apartment blocks), industrial buildings, and other buildings (includes commercial buildings, office buildings, public buildings, etc.). These account for about 75 % of the building stock gross floor area. The analyses exclude private summer cottages, agricultural buildings, outbuildings and warehouses.

The volume of construction in Finland began to rise in the 1950s. More and more new buildings and built areas were constructed on a continuous basis from that time up until the end of the 1990s. Two-thirds of the Finnish building stock was built after 1970, when minimum requirements for the heat insulation of building envelopes were already in place (Figure 6). The building stock is, in overall terms, fairly energy efficient.

New construction has varied in recent years between 8 and 10 million square metres per annum, which is around 1.5 % of the total building stock (Statistics Finland 2011). Each year 1 % of the building stock is deducted to take account of destruction, fire, demolition or its not being used on a permanent basis as a result of migration, the wind-up of companies or public sector efficiency measures.

Figure 6. The extent to which buildings constructed in different decades accounted for a share of the building stock in 2010. Source: Finnish Population Register Centre and VTT.

Key

Rakennuskanta 2010 ikäluokittain, yht. 550 milj.m² = Building stock in 2010 by age, 550 million square metres in total

(chart with decades and percentages marked)

Most of the building types examined (68 %) are located in urban areas. The rest are located half in densely populated municipalities (16 %) and half in rural municipalities (16 %).

Table 1. Location of the building stock in municipalities classified according to their population density/concentration

	(Semi-)detached houses	Terraced houses	Apartment blocks	Commercial, office and public buildings	Industrial buildings	Total
Urban municipalities	51 %	67 %	90 %	72 %	65 %	68 %
Densely populated municipalities	24 %	17 %	7 %	14 %	19 %	16 %
Rural municipalities	25 %	16 %	3 %	14 %	15 %	16 %

4.1.2 Communities and building efficiency

With urbanisation, densely populated areas (population centres) account for a greater number of the country’s population and the gross floor area of buildings. In 2014, around 85 % of Finns lived in such an area. The land surface areas of densely populated areas in the period 1990-2014 increased by almost 40 %, the gross floor area of buildings located in them by about 55 %, and the number of inhabitants by some 18 %. The average population density in such areas has fallen, though area density has increased (Table 2).

There were 735 densely populated areas in Finland in 2014. Almost every municipality contains one. Only 10 municipalities, mainly in Åland, have none at all. Most are small in size. There were 31 densely populated areas with more than 20 000 inhabitants in 2014, 50 with more than 10 000, 105 with more than 5 000 and 151 with more than 3 000.

From the perspective of the demand for, and supply of, district heating, it is essential to look at the urban-planned densely populated areas where heat density is greatest and is therefore associated with great potential for district heating. Around 80 % of densely populated areas contain an area of urban planning. The remaining 20 % are structurally so widespread or small in size that they have no urban planning projects at all.

Table 2. Change in the surface area, population and gross floor area of buildings in densely populated areas in the period 1990-2014. The data source used is data on area delineations and land use from the Finnish Environment Institute and Statistics Finland population and building stock data, not including agricultural buildings or leisure homes.

	1990	1995	2000	2005	2010	2014	Change 1990-2014
Land, square kilometres	4 830	5 236	5 561	6 012	6 430	6 691	38.5 %
Population	3 895 000	4 066 000	4 186 000	4 316 000	4 473 000	6 603 000	18.2 %
Proportion of the population of the entire country	78.9 %	80.3 %	81.6 %	82.9 %	84.1 %	85.1 %	6.2 percentage points
Population density (inhabitant per square kilometre)	807	777	753	718	696	688	-14.7 %
Gross floor area (millions of square kilometres)	250.9	277.4	303.2	337.2	364.7	388.6	54.9 %
Proportion of the gross floor area for the entire country	82.4 %	83.0 %	83.5 %	83.8 %	84.2 %	84.4 %	2.0 percentage points
Area density	0.052	0.053	0.055	0.056	0.057	0.058	11.8 %

The urban planning area can be described very satisfactorily in statistical terms by the densely populated conurbation area delineation. The area density for each 250 metre statistical rectangle in a densely populated conurbation area calculated as the sum of the neighbouring rectangles is at least 0.02. The area of urban planning or densely populated conurbation generally covers just a part of a densely populated area. The other parts of the densely populated area are sparsely populated areas that do not normally have a municipal infrastructure/utilities.

In 2014, approximately 78 % of the entire country's inhabitants and of the gross floor area of buildings were located in densely populated conurbations (Table 3). The rate of growth of such areas in the period 1990-2014 was faster than the total for all densely populated areas.

Table 3. Change in the land surface area, population and gross floor area of buildings in densely populated conurbations corresponding to areas of urban planning in the period 1990-2014. The data source used is data on area delineations and land use from the Finnish Environment Institute and Statistics Finland population and building stock data, not including agricultural buildings or leisure homes.

	1990	1995	2000	2005	2010	2014	Change 1990-2014
Land, square kilometres	2 633	2 876	3 065	3 339	3 571	3 724	41.5 %
Population	3 479 000	3 652 000	3 781 000	3 916 000	4 072 000	4 206 000	20.9 %
Proportion of the population of the entire country	70.5 %	72.2 %	73.7 %	75.3 %	76.6 %	77.8 %	7.3 percentage points
Population density (inhabitant per square kilometre)	1 321	1 270	1 234	1 173	1 140	1 129	-14.5 %
Gross floor area (millions of square kilometres)	227.9	252.9	277.4	309.7	335.5	358.4	57.2 %
Proportion of the gross floor area for the entire country	74.9 %	75.6 %	76.4 %	77.0 %	77.5 %	77.8 %	2.9 percentage points
Area density	0.087	0.088	0.091	0.093	0.094	0.096	11.2 %

Area density, i.e. the relation of the gross floor area of buildings to the land area, has a clear connection, when examined by the statistical rectangle, with the use of district heating as a source of heat. In the statistical rectangles marked 0.1 for area density, most of the gross floor area for new residential and service buildings is located within the area covered by a district heating facility (Figure 7).

Figure 7. Share of district heating in the gross floor area of buildings by building type in a densely populated area of urban planning by area density in 2013. The share is defined solely in respect of buildings whose heat source is known. The analysis includes only those residential and service buildings completed in the 2000s, regarding which information on the form of heating can be said to be reliable. Area density is determined within a 250 metre rectangle as the sum of the neighbouring rectangles. Service buildings include commercial buildings, office buildings, and buildings used for transport, (health) care, assembly and education. Source: Finnish Environment Institute/Urban Regions, Finnish Population Register Centre/population information system 4/2014.

Key

Kaukolammön osuus = Share of district heating

Aluetehokkus = Area density

Asuin- ja palvelurakennukset yhteensä = Residential and service buildings total

Asuinrakennukset = Residential buildings

Palvelurakennukset = Service buildings

Area density varies a good deal within areas of urban planning. Residential areas with an area density rating of less than 0.1 are typically areas of relatively scattered (semi-)detached houses, and those with a rating of 0.15 are densely populated areas of (semi-)detached houses. The residential areas built more compactly than this are generally those where apartment blocks are dominant. Municipal/city centre areas are usually constructed compactly, but in other service and industrial areas the building density varies from area to area and industry to industry.

Only in the City of Helsinki was the average area density for the entire area in a densely populated conurbation corresponding to an area of urban planning more than 0.3. The figure was over 0.15 for the cities of Turku, Tampere and Kuopio (attached). Besides these, the average area density in 29 other densely populated conurbations grouped by municipality was between 0.10 and 0.15. The average area density for a separate densely populated conurbation in 250 different municipalities varied between 0.05 and 0.10 (Figure 8).

Statistical rectangles with an area density rating of at least 0.1 were located in approximately 250 separate densely populated conurbations grouped by municipality (Figure 9). More than 80 % of the gross floor area in these rectangles of at least an area density rating of 0.1 was located in the largest densely populated grouped by municipality.

Statistical rectangles with an area density rating of at least 0.2 were located in approximately 94 separate densely populated densely populated areas grouped by municipality. Statistical rectangles with an area density rating of at least 0.3 were located in approximately 53 separate densely populated areas grouped by municipality.

Figure 8. Densely populated conurbations corresponding to an area of urban planning according to area density and the volume of gross floor area added together for buildings by municipality in 2014. The densely populated areas in the analysis are intersected by municipal boundaries, with the sections located in the different municipalities within a densely populated area being treated as their own areas. Source: Finnish Environment Institute.

Key

Aluetehokkuus = Area density

Kerrosala (k-m2) = Gross floor area (square metres per floor)

Helsinki ja ympäryskunnat = Helsinki and surrounding municipalities

Tampere ja ympäryskunnat = Tampere and surrounding municipalities

Turku ja ympäryskunnat = Turku and surrounding municipalities

Figure 9. The combined gross floor area in statistical rectangles with an area density rating of at least 0.1 in densely populated conurbations by densely populated area and municipality in 2014. The densely populated areas in the analysis are intersected by municipal boundaries, with the sections located in the different municipalities within a densely populated area being treated as their own areas. Source: Finnish Environment Institute.

Key

Kerrosala aluetehokkuudeltaan vähintään 0.1 alueilla = b(k-m2) = Gross floor area in areas with an area density rating of at least 0.1

Helsinki ja ympäryskunnat = Helsinki and surrounding municipalities

Tampere ja ympäryskunnat = Tampere and surrounding municipalities

Turku ja ympäryskunnat = Turku and surrounding municipalities

The proportion of compactly built areas in relation to the numbers of inhabitants of densely populated areas and gross floor area has increased substantially in recent decades. In 2014, around 18 % of all inhabitants of densely populated areas lived in an area with an area density rating of more than 0.3, some 28 % in one of over 0.2 and about 52 % in one of over 0.1 (Figure 10). The proportions for gross floor area of buildings were a few percentage points greater (Figure 11).

Figure 10. Proportion of inhabitants of different areas in terms of area density compared with the population of the densely populated area in the entire country 1990-2014. The analysis covers an entire densely populated area. Source: Finnish Environment Institute/Urban Regions.

Key

Aluetehokkuus = Area density

Figure 11. Proportion of gross floor area in different areas in terms of area density compared with the gross floor area of densely populated areas in the entire country 1990-2014. The analysis covers an entire densely populated area. Source: Finnish Environment Institute/Urban Regions.

Key

Aluetehokkuus = Area density

4.1.3 Development of the Finnish building stock 2010-2030

Regional population trends provide the main thrust for changes in the building stock. Demographic trends are one of the components of the demand for housing and have a major impact on the location of the construction of workplaces and new buildings that cater to the population.

The population of Finland will grow at least until the year 2060, which is as far as the official population forecast for the country extends (Statistics Finland, 2012). According to predictions, the population of mainland Finland will be approximately 5.7 million by 2025. A large number of municipalities (Figure 12) have seen a downward trend in population growth, with young people moving away to the ever-larger urban areas and minimal natural population growth. This trend will also serve to reduce migration from the countryside, because there will be few potential migrants than before. In the areas of population decline, both residential buildings and other types of premises remain empty.

Figure 12. Relative population growth by municipality

Key

Väestömuutos 2011-2025 = Demographic Change 2011-2025

The population is increasing in 126 municipalities in terms of relative population growth within the municipality. There is absolute population growth in approximately 20 municipalities, whose share of population growth is more than 2 % (Table 4).

Table 4. Location of population growth in municipalities that differ in terms of population density. Most of the population growth focuses on Helsinki (22 %), Espoo (13 %), Vantaa (10 %), Oulu (8 %), Tampere (6 %) and Jyväskylä (4 %). Other municipalities witnessing growth include Turku, Lahti, Seinäjoki urban area (3 % population growth per municipality) and, close to the Helsinki metropolitan area, Kirkkonummi and the Tuusula urban area (2 % per municipality), close to Tampere, Kangasala, Pirkkala, Nokia, Ylöjarvi and the Lempäälä urban area (2 % per municipality), as well as Hämeenlinna, Kuopio, Vaasa and the Rovaniemi urban area (2 % per municipality).

Demographic change				
	Population in 2010	Population in 2025	Inhabitants	%
Urban municipalities	3 680 866	4 029 102	348 236	9
Densely populated municipalities	888 209	921 023	32 814	4
Rural municipalities	796 108	758 010	-38 098	-5

The demand for housing according to population forecasts and due to loss of building stock will average 26 500 + 2 500 homes in the period 2011-2025. This figure is arrived at by calculating alternative trends for population and the loss of housing stock (Vainio et al., 2012) (Figure 13). The demand for housing is concentrated in the small number of urban areas referred to.

Figure 13. New housing scenarios

Key

Asuntotuotantao skenaariot = Housing scenarios

asuntoa = (number of) homes

Lisääntyvä maahanmuutto = Increasing in-migration

Nykyinen maahanmuuto = Current in-migration

Vähentyvä maahanmuutto = Declining in-migration

Lähde: VTT = Source: VTT

Residential buildings divide into (semi-)detached houses, terraced houses and apartment buildings. The market shares for types of housing have varied over the years (Figure 14). Market shares have been determined by such factors as individual preference, the availability of financing, the economic climate, housing policy and municipal planning. The future trend is for the prevalence of (semi-)detached houses and apartments. The prevalence of (semi-)detached homes is predicted to be the consequence of rises in the standard of living. The prevalence of apartment blocks is due more to the poor state of the economy, the ageing population, the concentration of the population in cities and eco-efficiency objectives. The type of dwelling has an effect on the future demand for district heating. Nearly all new apartment blocks, 60 % of terraced houses and just 15 % of (semi-)detached houses are connected to a district heating facility.

Figure 14. New homes by types of housing.

Key

Uudisasuntorakentamisen rakenne = The structure of new house construction

Omakotitalot = (semi-)detached houses

Rivitaloasunnot = Terraced houses

Kerrostaloasunnot = Apartments

Lähde: Tilastokeskus = Source: Statistics Finland

Trends in the economy and business do not just affect house construction. The Finnish economy is not expected to see growth again until the start of the 2020s. For this reason, until 2025, forms of construction other than housing will remain at quite a low level (Figure 15). The social structure is expected to continue to change. This indicates a concentration of growth in the service industries at the expense of primary production and processing (Ahokas et al., 2015). Economic growth and improved employment with the other building construction associated with it will be concentrated in the same geographical regions as population growth and house building.

Figure 15. The current and future situation in industrial construction and in the construction of commercial buildings, office buildings, and public buildings 1990-2025.

Key

Teollisuus-, like-, toimisto- ja julkinen rakentaminen - Industrial construction and the construction of commercial, office and public buildings

milj. m² = millions of square metres

Like-, toimisto- ja julkiset rakennukset = Commercial, office and public buildings

Teollisuusrakennukset = Industrial buildings

Lähde: VTT = Source: VTT

4.1.4 Market share of district heating

The share of district heating in residential and service buildings completed between 2000 and 2014 varied by more or less than 60 % (Figure 16). In recent years the share has risen to more than 65 %, with new construction focusing on apartment blocks. The change has been even more abrupt in the case of new residential buildings examined separately. The share of district heating as a heat source in completed residential buildings dropped from 54 % in 2000 to 48 % in 2006 but then rose again to 62 % in 2013. The share of district heating in new service buildings has mainly remained above 80 %.

Figure 16. Share of residential and service buildings completed between 2000 and 2014 located in areas covered by a district heating facility by year of completion in the urban planning area. The share is determined only for buildings whose heat source is known. Service buildings include commercial buildings, office buildings, and buildings used for transport, (health) care, assembly and education. Source: Finnish Environment Institute, Finnish Population Register Centre/population information system 4/2015.

Key

Palvelurakennukset = Service buildings

Asuin- ja palvelurakennukset yhteensä = Residential and service buildings combined

Asuinrakennukset = Residential buildings

4.2 Heating of the Finnish building stock

4.2.1 Heat consumption models

In this study, the energy consumption of the building stock has been estimated using the REMA tool (building stock energy efficiency and emission impact assessment model) (Tuominen et al., 2014) and EKOREM tool (building stock heat and energy consumption and greenhouse gas emissions limits model) (Heljo et al., 2012). REMAQ covers (semi-)detached houses, terraced houses, apartment blocks, and commercial and service buildings. The EKOREM model was used to estimate the energy consumption of industrial buildings. The models divide buildings into age categories according to the year in which they were or will be completed. This is because that way it is possible to take into account the changes in the requirements governing energy efficiency in Finland and renovation and repairs. For each category of building the energy consumption required to heat the building and for the supply of hot water is simulated, as is other energy consumption, such as lighting and the power needed for technical systems, as well as the free energy obtained from the use of the space.

New buildings are constructed in accordance with national and EU legal standards. When this study was being undertaken, the requirements in force were those that came in in summer 2012 for new construction and in autumn 2013 for renovations subject to a permit. The next major change is due in 2017-2018, when the requirements for new buildings will become tighter, approximating nearly zero energy construction level.

4.2.2 Changes in heat consumption

Changes in heat consumption over the coming 10 years or so will be the result of the construction of new buildings and changes in the existing building stock, i.e. losses due to buildings not being occupied at all or not being used on a permanent basis and improvements to energy performance owing to renovations. Energy efficient new construction will replace many old buildings that use up energy, at the same time cutting the energy consumption of the building stock. With renovation projects, energy efficiency will be improved with repairs to building envelopes (windows, additional insulation of facades) and the renewal of technical systems (more efficient new technology). Some heating energy will be re-used by means of heat recovery technology and heat pumps.

The consumption of heating energy in 2010 (89 000 GWh) includes the heating of buildings and water and divides up as follows with respect to building type: (semi-)detached houses (~ 30 %), commercial and public buildings (~ 30 %), terraced houses and apartment blocks (~ 25 %), and industrial buildings (~15 %). The market share for district heating is greatest with apartment blocks (90 %) and smallest with (semi-)detached houses (less than 10 %). The market share for district heating with commercial buildings, office buildings and public buildings is around 60 %. It needs to be realised, however, that some of the heating in buildings connected to a district heating facility is produced by electricity. Electricity may be used to preheat intake air and damp areas (electric underfloor heating).

The consumption of heating energy has been divided among the municipalities on the basis of their volume of building stock and its structure. Heating energy density (Figure 17) has been calculated by dividing the demand for heating for the buildings in a municipality by the area of built-on land in that municipality. Although a municipality might be large in area, the buildings are eventually concentrated within quite a small area of land.

Heating energy density is by far the greatest in Helsinki (90 kWh/m² on built-on land). In other large cities (Espoo, Vantaa, Turku, Tampere, Lahti), energy density is a lot less, at between 30 and 40 kWH/m².

Figure 17. Heating energy density or municipalities in 2015 (demand for heating energy in buildings within the municipality in kWh divided by the land area of the built environment there).

Key

Lämmitysenergiatiheys kWh/m² (kunnan rakennettu pinta-ala) =

Heating energy density kWh/m² (built-on area of municipality)

By 2025, new construction will be responsible for around 10 % more consumption (8 GWh per annum) than in 2010. Heating energy consumption could increase to 96 GWh by 2025. If repairs that improve the energy performance of buildings and the efficient use of heat (recovery, recycling) are accomplished to reflect national targets and buildings that have either become unoccupied or are not used on a permanent basis, heat consumption could fall to 74 000 GWh per annum (Figure 180). Table 5 shows the effect of loss, improvements to energy efficiency from renovations, and new construction projects on heat consumption. But for loss and repairs, the demand for heating energy would rise by 10 %.

The forecast is based on the assumption that economic growth will remain sluggish. If the economy were to become healthier than anticipated, or, alternatively, decline even more, there would either be more or less in the way of new construction projects. Improvements to the energy performance of the old building stock could be carried out earlier than planned or not at all. Loss of the building stock could be greater if energy efficiency is to be achieved through new construction, or less if, for example, renovations are favoured for the sake of material efficiency.

Figure 18. The consumption of heating energy could fall from 89 000 to 74 000 GWh per annum if old buildings are made more energy efficient and new buildings replace those that use up energy on a large scale.

Key

Rakennusten lämmitysenergian kulutus (GWh/vuosi) = Consumption of heating energy in buildings (GWh per annum)

Poistuma = Loss

Energiatehokkuus korjaukset = Energy performance repairs

Rakenettu ennen 2010 = Built before 2010

Rakenettu 2011-2015 = Built 2011-2025

Omakotitalot – (semi-)detached houses

Rivitalot ja kerrostalot – Terraced houses and apartment blocks

Liike- ja julkiset rakennukset = Commercial and public buildings

Teollisuusrakennukset = Industrial buildings

Table 5. Components of the change in heat consumption

GWh per annum	(semi-)detached houses	Terraced houses and apartment blocks	Commercial and public buildings	Industrial buildings	Total
Heating of buildings 2010	25 600	21 700	26 000	15 200	88 500
Market share of district heating	< 10 %	~80 %*	~55 %	~25 %	~45 %
New construction 2010-2025	1 750	1 080	2 160	3 060	8 050
Subtotal	27 360	22 780	28 160	18 260	96 550
Loss of buildings 2010-2025**	-3 130	-2 120	-3 980	-2 280	-11 510
Improvements to the energy performance of buildings 2010-2025***	-3 470	-2 080	-2 620	-3 220	-11 390
Heating of buildings 2025	20 800	18 600	21 600	12 800	73 000

* Terraced houses 50 %; apartment blocks 90 %
** Loss either entirely or due to buildings not being used on a permanent basis
*** Reduction in heat loss from building envelope; more efficient use/recycled purchased energy

The change in energy density in each municipality from 2010 to 2010 has been calculated on the assumption that renovation work will be accompanied by energy performance improvement measures and that buildings will be lost from the building stock (Figure 19). New housing and the construction of new commercial and public buildings have been divided among those localities in which population growth is in evidence. New industrial construction has been divided among municipalities in relation to the existing industrial building stock.

The map describes a scenario where the heating energy consumption of the building stock is 74 GWh per annum. Heating energy consumption for the country as a whole would fall by around 15 %. In areas where new construction is concentrated and it replaces part of the fall in consumption of the old building stock, consumption of heating energy would go down by less than 10 %. In areas people are migrating away from, the fall in consumption will lessen energy density by a fourth or more.

Figure 19. Change in heating energy density (kWh/m² built-on land) from 2010 to 2015, if the energy performance of the building stock is improved and buildings either become unoccupied or are not used on a permanent basis. The consumption of energy divided among municipalities will be 74 GWh by 2025.

Key

Lämmitysenergiatiheyden muutos 2010-2025 = Change in heating energy density 2010-2025

The demand for purchased energy in new buildings constructed between 2010 and 2025 (8 000 GWh per annum) will relate to those municipalities where district heating already has a significant market share now. Current trends suggest the aim will be for new construction to be located in the cities within the old building stock as much as possible, either to supplement the old building stock or in the re-use of areas. These sites will typically be located in areas where there is a connection to a district heating facility and are potential users of such a facility.

5. Production of district heating in Finland

5.1. Heat production capacity in Finland

5.1.1 Data sources

The project assessed district heating production capacity and the volume of heat generated, using as sources the district heating statistics produced by Finnish Energy, those from the Association of Finnish Local and Regional Authorities (small heat plants), VTT's plant database, and the plant database used by the Finnish Environment Institute. Additional data were obtained from applications for environmental permits from plants, company presentations, news archives, and data acquired through information searches.

Finnish Energy's statistics on district heating cover a large part of district heating production. The coverage in terms of output in MW is around 95 % and in terms of energy produced (GWh) around 97 %. The remainder represents the production of several small plants whose share has been determined based on other sources, including the statistics produced by the Association of Finnish Local and Regional Authorities. Production is divided into that from actual district heating plants and industrial production.

5.1.2 District heating plants

According to the statistics put out by Finnish Energy and the Association of Finnish Local and Regional Authorities, district heating was produced in 213 municipalities in 2010 (Figure 20). The total capacity was 20 660 MW. The largest figure for capacity is that for Helsinki (just over 3 600 MW). That is followed by Espoo (approximately 1 500 MW) and, in third place, Tampere (approximately 1 000 MW). In addition, there were in Finland six district heating systems with a production capacity of 500-1 000 MW, 14 such systems with a capacity of 200-500 MW and 14 with a capacity of 100-200 MW.

Producers of district heating have to make provision for consumption spikes in cold winters and possible plant failures. The average annual uptime of district heating plants was approximately 1 900 hours in 2010. Most district heating generation took place in Helsinki, where plants produced around 7 800 GWh of heat in 2010. Next came Espoo and Tampere, both producing around 2 300 GWh of district heating (Figure 21).

Figure 20. Production capacity of district heating plants in Finland (MW) by municipality in 2010.

Key

Pääkaupunkiseutu = Helsinki metropolitan area

KL tuotantokapasiteetti (MW) Julkinen tuotanto = District heating production capacity (MW) Public production

Pääkaupunkiseutu = Helsinki metropolitan area

Figure 21. District heating produced in district heating plants (GWh) by municipality in 2010.

Key

Pääkaupunkiseutu = Helsinki metropolitan area

KL-tuotanto (GWh) Julkinen tuotanto = District heating production (GWh) Public production

Pääkaupunkiseutu = Helsinki metropolitan area

5.1.3 District heating produced by industry

The volume of heat produced by industry (actually generated + residual heat from processes) totalled around 1 100 GWh, according to the statistics on district heating. Sales of heating were greatest in Varkaus, Raahe, Heinola and Jämsä. Figure 22 shows the district heating capacity for industrial operators and Figure 11 district heating sold by industry in 2010.

Figure 22. Production capacity of district heating from industry (MW) by municipality in 2010.

Key

KL tuotantokapasiteetti (MW) Teollisuustuotanto = District heating production capacity (MW) Industrial production

Figure 23. District heating sold by industry (GWh) by municipality in 2010.

Key

KL-tuotanto (GWh) Teollisuustuotanto = District heating production (GWh) Industrial production

5.1.4 The trend in heat production capacity 2010-2025

In the period 2010-2014, around 800 MW of capacity for the generation of district heating was built. The most remarkable new investment ventures were the waste-to-energy plants in Vantaa, Mustasaari (close to Vaasa) and Oulu. Their combined output is around 200 MW. In addition, 50 smaller district heating facilities and heat plants were completed – their heat being produced from wood or peat. The investment served to increase capacity only partially, because the new plants replaced older district heating production facilities that ran on fossil fuels.

According to the Finnish Solid Waste Association, by 2018 there will be waste-to-energy plants in Tampere, Leppävirta and Salo. Their combined district heating output will be around 600-700 GWh per annum. In Finland there are also 24 co-incineration plants that use good quality waste fuels (Pöyry, 2015). There are also co-incineration plants planned for Lahti and Rovaniemi, ready sometime in the 2020s.

Other major investment projects include the Naantali multifuel power plant and the heat centre at Nokia. The Naantali plant would be capable of using as much as 100 % biofuels, its output would be 250 MW of district heating, and the supply would extend beyond Naantali to Turku in 2017. The fuels used at the 68 MW heat plant in Nokia will include wood, peat and paper mill slurry (Nokia News, 2015).

Finland’s climate and energy policy has as its target an increase in the use of wood fuels in both existing and future plants. According to the Ministry of Employment and the Economy, a renewable energy subsidy for forest chip power production would permit new investment the equivalent of a thermal input of as much as 3 500 MW over the period 2007-2020 (Ministry publications 2010). This would be a substantial increase on levels for 2007. Some of the investment has already been made. Moreover, Helsinki is partly ending the use of coal and replacing it with renewable energy sources. Tampere, Oulu, Lahti and Rovaniemi are also planning to switch to renewable energy sources.

The new pulp mill at Äänekoski is to start operations towards the end of 2017, according to the current schedule. The district heating produced may be used in Äänekoski's district heating network. In 2010, total consumption of district heating in Äänekoski was around 140 GWh with some 90 % of it purchased from industry (MetsaBotnia, Kumpuniemien Voima, Äänevoima).

The Directive proposed on the limitation of emissions of certain pollutants into the air from medium combustion plants, adopted in 2015, will have a long-term impact on many small district heating plants. The Directive allows existing plants long transitional periods. That for plants with a rated thermal input of less than 5 MW will extend to 2030 and for plants with a rated thermal input of 5-50 MW to 2025 (Ministry of the Environment, 2015b). The Directive will therefore not affect current capacity during the period for which this report is under review.

5.1 District heating systems in Finland

5.1.1 Existing district heating systems

According to the statistics put out by Finnish Energy, there are district heating networks in 171 municipalities. Their combined length was 12 630 kilometres in 2010 and 14 300 kilometres in 2014 (Finnish Energy, 2010, 2014). In four years there was growth of around 13 %. This was due to network expansions to reach new customers.

There are also numerous municipalities where the municipal centre has a short district heating network and fuel is mainly acquired from its own area or that of neighbouring municipalities. In 2014 there were 350 district heating networks in total (Finnish Energy, 2014).

5.1.2 The energy density of district heating systems

Average sales of heat from district heating systems per length of pipe, i.e. energy density, was 2.84 GWh per kilometre of pipe per annum in 2010, while in 2014 it was 2.21. The year 2014 was warmer than 2010 and heat consumption was around 14 % less, with fewer heating days (5 403 °C days/2010 and 4 312 °C days/2013) (Finnish Meteorological Institute statistics). The mean temperature in 2010 was 1.5 °C lower than the 30 year average and the mean temperature in 2014 was 1.1 °C higher than the long-term average (Finnish Meteorological Institute). The generally regarded threshold for profitability in the district heating business is 0.5 GWh per kilometre of pipe per annum. Figure 27 shows the energy density of heat from district heating systems (energy sold per kilometre of pipe, GWh/kilometre) by municipality. In most municipalities, demand for district heating is concentrated in urban-planned areas in the centre. District heating operations are broader in scope in the cities.

Figure 24. Volumes of sold energy from districting heating systems per length of pipe (energy density) (GWh/km) by municipality in 2010.

5.1.3 Potential new areas for district heating

There are potential new areas for district heating in the growing cities, where new residential, work and service areas are being built. New, small district heating networks are starting up in areas of dense habitation, where the aim is for the largest buildings (schools, churches, shopping centres, libraries, etc.) to be connected to the same heating system, fuel for which is acquired from nearby areas.

6. Assessment of the demand and production of district heating and of system enhancement

6.1 Assessment of the demand for district heating and of the building stock connected to a district heating facility in 2025

In 2010, the consumption of energy used to heat buildings and for the supply of hot water (89 000 GWh) was accounted as follows: (semi-)detached houses some 30 %, commercial and public buildings about 30 % again, terraced houses and apartment blocks around 25 % and industrial buildings about 15 %. The greatest potential for district heating in terms of consumption here is large buildings. The market share for district heating is greatest with apartment blocks (around 90 %) and commercial, public and office buildings (around 60 %).

The energy consumption of new buildings constructed between 2010 and 2024 totals 8 000 GWh. It is concentrated in cities and towns, where the market share for district heating is already significant. The aim with new construction now is to locate it within the areas of old building stock in district heating zones, making them potential district heating sites. A total of 50-75 % of the new demand might count as the relevant market potential for district heating.

By 2025, however, new construction will replace some of the fall in the consumption of heating energy of the old building stock. The consumption of heating energy of the old building stock will fall, thanks to loss and repairs that improve energy performance. Because of the energy efficiency targets set for the building stock, the consumption of heating energy in 2025 should fall to a level of 74 000 GWh.

Although the gross floor area of the building stock may increase slightly, consumption of heating energy in buildings will not go up. District heating may account for a greater share of the consumption of heating energy, however, as new buildings tend to be constructed in cities and the building stock that is becoming unoccupied is located in sparsely populated areas.

There is nevertheless a degree of uncertainty associated with this forecast. Whether there would be more or less in the way of new construction projects depends on the economic climate. Improvements to the energy performance of the old building stock could be carried out earlier than planned or not at all. Loss of the building stock could be greater if energy efficiency is to be achieved through new construction, or less if, for example, renovations are favoured for the sake of material efficiency.

6.2 Assessment of district heating generated with CHP 2025

In 2010 CHP capacity in Finland was 6 300 MW of heat and heat production from CHP power plants 27 400 GWh. CHP electric power capacity was 4 700 MW and production 16 500 GWh. Combined power production is predicted to fall to 15 000 GWh in 2030, if CHP heat production were to fall by 7.5 % (Pöyry, 2011).

If 70 % of the difference between 2010 levels of district heating production and CHP heat production (Finnish Energy, 2010) were to be covered by new CHP plants, the demand for additional CHP rated thermal input of 3 000 MW would be achieved as well as the additional demand for electric power of 2 500 MW. The increase would be spread over 58 plants (Figure 26). A total of 600 MW of additional rated thermal input and 415 MW of electric power would result from CHP supplied by industry/wholesalers, divided among 15 plants (Figure 26) (method of calculation from source, Sipilä et al., 2005).

In addition, small plants (< 5 MW) could produce around 9 GWh of CHP power per annum (Gaia, 2014), which corresponds to around 30 GWh of heat production.

Investment in CHP capacity only partly relates to new production, as some is used to replace the old CHP and boiler capacity. The trend in demand and the price of electricity and heat will in the long term affect the investment made in production capacity.

Figure 25. Potential number of CHP plants belonging to district heating undertakings by district heating capacity classification by the year 2025.

Key

Energialaitosten CHP potentiaali Suomessa = CHP potential of energy plants in Finland

CHP laitosten lukumäärä = Number of CHP plants

Lämpöteho = Rated thermal input

määrä = number

thuippu – 6 000 h/a = peak production = 6 000 h/a

Figure 26. Potential number of CHP plants belonging to industry/wholesalers by district heating capacity classification by the year 2025.

Key

Teollisuuden ja energiatukkurien CHP potentiaali Suomessa =

CHP potential of industry and energy wholesalers in Finland

Lämpöteho = Rated thermal input

määrä = number

thuippu – 6 000 h/a = peak production = 6 000 h/a

By the end of 2018, the waste-to-energy plants at Tampere, Leppävirta in eastern Finland, and Salo will have been built. Their combined district heating production will be around 600-700 GWh per annum.

According to the Ministry of Employment and the Economy, it would be possible to increase the use of wood fuel for the feed-in tariff by a total of 3 500 MW over the period 2007-2020. Some of the investment has already gone ahead.

Decisions have now been taken regarding the Naantali multifuel power plant and Nokia heat centre investment projects. The power plant at Naantali should be ready in 2017. Its rated thermal input will be 250 MW and it would produce heat for both Naantali and Turku. Naantali could operate 100 % on biofuels. The rated thermal input of the power plant at Nokia will be 68 MW. The fuels used here will include wood, peat and paper mill slurry.

The new pulp mill at Äänekoski is to start operations towards the end of 2017, according to the current schedule. The district heating produced may be used in Äänekoski's district heating network. In 2010, total consumption of district heating in Äänekoski was around 140 GWh with some 10 % of it purchased from industry. Heat from the new pulp mill could be used to replace the old oil boiler capacity.

A new paper machine is planned for Varkaus. Its process heat could be used to replace the old oil boiler capacity.

The demand for data server cooling means new producers of heat that are locally significant as producers of district heating. Similarly, the heat in buildings connected to a district cooling facility could be used for district heating.

Ignoring loss and energy performance improvements, the demand for heating in buildings is estimated at 97 000 GWh in the year 2025. Of that, district heating could account for 44 000 GWh. The share of CHP in the generation of district heating will be 70 %, i.e. 30 000 GWh, and the remainder will be produced using boilers or from other heat sources, such as the residual heat from industrial processes, heat pumps, heat from district cooling, the sun, etc. Estimated in this way, the total demand for CHP capacity would be 5 000 MW of heat and 2 500 MW of electricity.

If the CHP plants and the heavy fuel oil boilers with a capacity of more than 10 MW built before 1985 are decommissioned by 2025 on account of their age and replaced with plants that use renewable fuels, and account is taken of the decisions already taken and known plans, with a comparison made with the forecast for the demand for heat in buildings in 2025, new CHP additional capacity would be required for 0-1 000 MW of heat generation and 0-500 MW of electricity generation. Approximately 500 MW of more boiler capacity will be required for the growing cities. Other capacity construction will replace the old decommissioned CHP and boiler capacity with renewable energy sources.

6.3 The potential for savings of primary energy

The demand for heating energy depends enormously on the outside temperature. The upward trend in the mean annual temperature will contribute to a reduction in demand; on the other hand, the demand for cooling in buildings will increase. What primary energy source is used for cooling in the future depends on the production method employed.

In areas where the demand for heating is falling, the demand for primary energy will decrease. In areas of growth, the demand for primary energy for heating may go up to some extent, despite tighter building regulations for new construction ventures.

CHP can cut the demand for primary energy by about 30 % compared to the separate production of power and heat, if the operating times of plants are sufficiently long.

If the CHP plants built before 1985 are replaced with new multifuel CHP stations, such as those planned for Tampere, Oulu and Lahti, according to Directive 2012/27/EU there will be an approximate 14 % saving in primary energy (improved efficiency and power to heat ratio) compared to the old CHP production scenario and a 25 % saving compared to the separate production of power and heat.

If the heavy fuel oil boilers built before 1985 are replaced with CHP plants using renewable fuels, there will be an approximate 27 % saving in primary energy (taking into account the switch to CHP and poor efficiency of the old boilers).

Utilisation of renewable energy sources, energy from waste and the residual heat from industrial and other heat-generating processes in district heating might further reduce the demand for primary energy for heating. At present, around 770 GWh of residual heat from industrial processes is used per annum. The potential additional use of heat from processes using heat exchangers was estimated at approximately 1 400 GWh per annum for the forest industry, 700 GWH for the wood and timber industry, 2 000 GWh for the metal industry, 500 GWh for the food industry and 100 GWh for the chemical industry. The total potential additional use of energy from industry is estimated at 4 700 GWh, two-thirds of which would nevertheless require use of a heat pump to raise the temperature to one suitable for district heating. Waste-to-energy plants that are new or approved will produce approximately 700 GWh of additional district heating per annum.

6.4 Assessment of the potential for improving the energy performance of the district heating infrastructure

Heat loss from Finnish district heating networks averages 8-9 % per annum, being the difference between the heat generated and that sold. The calculation includes a measurement error. The average quantity of heat supplied to customers is 2.5 MWh per kilometre of pipe.

Ways to improve the energy efficiency of district heating systems:

- Fall in temperature in the district heating network (115 °C > 80 °C > 60 °C)
    - current network: potential fall in flow temperature by around 5 °C in current system. If the temperature falls further, the heat distribution centres have to be replaced and the heating system for buildings redesigned for the improved release of heat
    - allow the use of inferior heat sources and promote the use of heat pumps in the district heating system
    - heat loss potential of around 8 % (300 GWh), if both the flow and return flow falls by 5 °C overall
    - new construction connected to the current network; flow temperature mainly as in the current network; a low temperature network could be connected to the main network in the regional centre
    - new separate networks: potential/volume small > impact small
- Fall in pressure and pumping in the network
    - potential for reducing pumped energy relatively small, but the pressure levels can be lowered; cost-effective. The potential for greater efficiency is around 20 % (from approx. 25 GWh to 20 GWh). If new construction lessens the heat density, the relative share of pumped energy may increase slightly
- Adequate heating load for CHP generation in the district heating network
    - not in itself significant for heat loss, but a fall in temperature in the network permits additional power generation, i.e. the CHP power to heat ratio rises. The effect of the flow temperature on CHP power generation is around five times that compared to the effect of the return temperature
- Additional construction density and a larger number of storeys in buildings in urban areas

  - what would the potential be?

- Increased heating load in summer, e.g. in building-specific absorption or adsorption cooling
  - the cost-effectiveness/profitability should be assessed
- Using small pipes in the same casing (twin-pipe system)
  - no need with the present network / not worth refurbishing existing one pipe structures to turn them into twin-pipe systems
  - in new construction smaller dimensions apply – in about two-thirds of twin-pipe structures. If that rate goes up to 90 %, heat loss will fall by around 30 GWh, i.e. just under 1 %.
- Improved insulation: superinsulation
  - product development and prices will determine whether it will be commercially feasible on a large scale in 2025. Potential for cutting heat loss with current insulation thickness is around 20-30 %.
- Evening out fluctuations in hot water output
  - water heater
- Weather forecasts and their accuracy
  - forecasting accuracy improves planning of the operating times of production and the network
- District heating network control systems, that optimise the network's operation
  - permits improved optimisation of flow, pressure and temperature. The potential is, for example, a 5 °C average fall in temperature
- Bidirectional heat trading
  - if it becomes common and results in a fall in temperatures, the potential should be examined
- Fall in the temperature of the return water in the district heating network
  - potential 5-10 °C: improved cooling. Matches the fall in temperature of the flow water of 1-2 °C for CHP power generation
- Refurbishment of the district heating network
  - The potential from the refurbishment of old pipe structures is just under 200 GWh, a saving of around 5 %, if old structures account for about a sixth of

    the network length, i.e. 2 500 kilometres. Structures are responsible for around 40 % of all heat loss, i.e. 1 500 GWh. If they are refurbished at twice the rate they are now, i.e. at the rate of 80 kilometres per annum, heat loss per metre would fall by approximately 30 %.

- New districting heating network construction
    - depending on the structure, this might reduce the relative share of heat loss. If heat loss in 2 000 kilometres of new construction is 7 %, that for the whole network in 2025 will fall by 9 %, i.e. to 8 %. With a fall in heat intensity, the relative loss could also increase.

7. Cost-benefit analysis of heating and cooling

EU Directive 2012/27/EU[4] and the (Finnish) Energy Efficiency Act[5] oblige operators to conduct cost-benefit analyses to promote the combined production of power and heat and to exploit the use of any feasible residual hear from industry.

A cost-benefit analysis to evaluate costs and assess the benefit should be carried out in the following situations:

1. Where there are plans for a new, or a substantial refurbishment of an existing, thermal electricity generation installation with a total thermal input exceeding 20 MW

2. Where there are plans for a new, or a substantial refurbishment of an existing, industrial installation with a total thermal input exceeding 20 MW

3. Where there are plans for a new district heating and cooling network in an area where there is an industrial installation with a total thermal input exceeding 20 MW

4. Where there are plans for a new, or a refurbishment of an existing, energy production installation with a total thermal input exceeding 20 MW in an existing district heating and cooling network

7.1 Definition of the cost-benefit analysis

A cost-benefit analysis is a plan of investment, or most commonly, an analysis of alternatives to enable an examination on a broader basis than what would be afforded by an individual company, for example. In the planning of investment, a cost-benefit analysis may be seen as expanding the scope of normal business investment calculations, to take account of the

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[4] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:FI:PDF

[5] http://www.finlex.fi/fi/laki/ajantasa/2014/20141429?search[type]=pika&search[pika]=energiatehokkuuslaki

benefits and costs that would also result outside the planned venture, such as new jobs, subcontractor chains or pollution.

A cost-benefit analysis, however, is not merely a mechanical approach to the calculation of net present value, as the issues involved are not just what might be termed the trivial ones. It can be a challenge to assess costs and benefits and the parties that either have to bear costs or that enjoy the benefits, but if an adequately in-depth view is taken of matters it may bring better results. An assessment also has to be undertaken of the scope of the analysis conducted. If we are assessing the effects of CHP, for example, the effect of district heating is restricted to the area the municipal or city network covers, the effect of electric power is restricted within national borders or within the Nordic electricity exchange market, and the purchase of fuel is limited to a local area or within state borders. Cost-analyses divide into three phases:

1. A theory is required concerning the project measures and their impact within a certain period, the behaviour of housekeepers, market adaptation, choice of discount interest rate, etc.
2. Methods are required: the calculation of the present value of investments and other influential factors over time, estimates of annuities, econometrics, comparison of prices not regulated by the market, etc.
3. A cost-benefit analysis should always be defined and conducted separately for the case being examined and its basic considerations. It should take account of all the available relevant energy sources within the boundaries of the system and geographical borders, using available data, including the waste heat from power production plants and industrial installations and renewable energy, and the type of demand there is for heating and cooling as well has future trends.

7.2 Present value of investment

The present value of investment proposed by Directive 2012/27/EU for ventures lasting around a year is calculated by discounting revenues and costs to the initial point:

$$NPV = \Sigma n/t\ = 0\ Bt/(1 + i)t - \Sigma n/t\ = 0\ Ct/(1 + i)t$$

where i = discount rate, Bt = revenue in year t, Ct = costs (capital + operational) in year t, and n = duration of compared periods in years

Where the totals for revenue and costs after year N are the same, the investment has repaid itself. The cost term includes all the direct and indirect costs and revenues associated with the investment, depending on the demarcation.

To the revenue and cost term can be added, in addition to the investment, for example, environmental impact and social impact, if they can be expressed in terms of cash.

A cost-benefit analysis of a project has a favourable outcome if the amount for discounted benefits according to the financial analysis exceeds the amount for discounted costs.

7.3 Conducting a cost-benefit analysis

A cost-benefit analysis generally involves the following:

1. Determination of the project alternatives to be examined and the baseline to compare them with
2. Decision regarding to whom incurred benefits and costs are relevant
3. Determination of the project's impact and the measuring units used (direct and indirect advantages and disadvantages)
4. Prediction of future impact throughout the time of the project (alternative scenarios)
5. Conversion of all impacts to cash values (social/economic)
6. Future costs and benefits discounted to present value (B and C)
7. Calculation of the net present value (NPV) of each project alternative
8. Sensitivity analysis undertaken with respect to the most significant parameters, e.g. energy prices, cost of investment, interest rates
9. Recommendation made on the basis of the NPV criterion and sensitivity analysis

All the alternatives relevant to the baseline are examined. Scenarios that cannot be realised, for technical or financial reasons, should be excluded from the cost-benefit analysis early on, if justified. There should be a description of the planned plant or plants for comparison used as the basis for the cost-analysis, and this should cover, where relevant, their power and heat capacity, fuel type, planned usage and the number of hours of operation each year planned, location, and the demand for power and heat. A time horizon should be chosen to take account of all the relevant costs and benefits of the various scenarios. For example, in the case of gas or bioenergy plants, a suitable period could be 25 years, for a district heating system 30 years, and for heating equipment, such as boilers, 20 years (Directive 2012/27/EU).

Only high-efficiency cogeneration, efficient district heating and cooling or efficient individual heating and cooling supply options should be taken into account in the cost-benefit analysis as alternative scenarios compared to the baseline.

A cost-benefit analysis should include at least the following costs:

- Capital costs of plants and equipment
- Capital costs of the associated energy networks
- Variable and fixed operating costs
- Energy costs
- Environmental and health cost, to the extent possible

To calculate demand for heat nationally, such sources as the data on the building stock produced by Statistics Finland and the Finnish Population Register Centre's forecast for demographic trends compared to the predicted trend for the building stock might be used, for example. If a model for measuring the consumption of energy in buildings based on forecasts, such as REM[6], EKOREM for building stock and IDA-ICE[7] for building types, an estimate of the demand for heating energy can be obtained. The TIMES calculation model [8] (Integrated MARKAL-EFOM System) can be used to calculate nationally the demand for capacity for power and heat; and to estimate energy generation in a district heating area, KOPTI[9], for example, may be used. To calculate the district heating network there is APROS[10], and for the indirect effects of a network there is, for example, Vattage[11]. There are also other similar calculation models in existence.

Example 1: cost-benefit analysis of Helsinki scheme for abandoning coal and switching to geothermal or bioenergy production:

http://docplayer.fi/1231118-Irti-kivihiilesta-kustannus-hyotyanalyysi-uusiutuvienenergialahteiden-lisaamisesta-helsingissa.html

Example 2: cost-benefit analysis of the treatment of water in Helsinki dock areas:

http://www.hel.fi/static/ymk/julkaisut/julkaisu-21-14.pdf

8. District cooling of buildings

8.1 Evaluation

The cooling requirement for the building stock in 2015 was modelled by building type and age using the IDA-ICE dynamic simulation tool. The tool features the thermal properties of Finnish buildings and standard usage under the building regulations to depict power and water consumption. For some types of building, measured consumption data was also available. The current situation has been calculated with reference to weather year 2013 produced by the Finnish Meteorological Institute.

The Finnish Building Register has been used to locate consumption of cooling energy in municipalities. Concentrations of demand for cooling - potential areas for district cooling – have been examined with reference to the Corine regional land use database kept by the Finnish Environment Institute.

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[6] http://www.sciencedirect.com/science/article/pii/S036013231400033X

[7] http://www.equaonline.com/iceuser/pdf/ICE45eng.pdf

[8] http://www.etsap.org/Docs/TIMESDoc-Intro.pdf

[9] http://www.vtt.fi/inf/julkaisut/muut/2011/VTT-R-05372-10.pdf

[10] https://www.simulationstore.com/apros

[11] http://www.taloustieteellinenyhdistys.fi/images/stories/kak/kak12009/kak12009honkatukia.pdf

The consumption of cooling energy in 2030 has been plotted on the same principles as for the current situation just described for 2015. The simulation for demand for cooling was based on the weather year for 2030.

8.2 Demand for cooling energy within the building stock

8.2.1 Building stock 2015 and 2030

The gross floor area of the most relevant buildings as regards the demand for cooling was around 385 million square metres in 2015 (Figure 27), of which 75 % comprises actual residential buildings. By the year 2030, the gross floor area for such buildings will increase to 400 square metres. The modest increase is due to the fact that some new construction will replace lost building stock, the efficient use of space in office buildings will improve and new approaches to work will become commonplace.

According to the official population forecast in 2012, the population of Finland will.be around 5.8 million in 2030 (Statistics Finland, 2012.) Population growth accompanied by the construction of new housing, service buildings and workplaces will be concentrated in large urban areas, mainly in southern Finland.

Figure 27. Gross floor area of buildings relevant to demand for cooling energy in 2015.

Key

Rakennuskannan kerrosala 2015 ja 2030 = Gross floor area of building stock in 2015 and 2030

milj. m² = millions of square metres

Asuinrakennukset = Residential buildings

Liike- ja toimistorakennukset – Commercial and office buildings

Julkiset rakennukset – Public buildings

8.2.2 Demand for cooling in buildings

The Finnish building regulations oblige planners to conduct an analysis of summertime room temperatures, so that any overheating problems can be addressed at the planning stage. Basic planning incorporates the aim to make the space resource-efficient to avoid overheating of buildings using passive means (e.g. protection from the sun, night-time enhanced ventilation, etc.). Table 6 gives the cooling limits decided for different building types, the aim for which is to try and avoid any significant excess.

Table 6. Cooling limits by building type in summer temperature analyses (Ministry of the Environment, 2012)

Type of building	**Cooling limit in degrees Celsius**
Detached, semi-detached and terraced house	27.0
Apartment block	27.0
Office building	25.0
Commercial building	25.0
Accommodation building	25.0
Educational building and day care facility	25.0
Fitness centre (sports hall)	25.0
Hospital	25.0

According to energy calculation test year 2012, demand for cooling is only 190 degree days, but that for heating is 3 793. The need for cooling because of outside temperatures is minimal compared to that due to building heating load (solar radiation, people, electrical equipment and lighting).

Several simulations were undertaken of the heat requirement of buildings. The simulations varied the buildings, weather years and protection from the sun to obtain minimum and maximum values for the cooling requirement. The simulations served to produce the figures for the cooling requirement given in Table 7.

The year 2010 saw more stringent energy performance requirements in effect for new construction in Finland. For this reason, buildings constructed before and after 2010 are examined separately.

Table 7. Cooling requirement as a function of the date of construction

kWh/per square metre of floor	Built before 2010	Built between 2010 and 2030	Built before 2010	Built between 2010 and 2030
	no protection from the sun		protection from the sun	
(Semi-)detached houses	2	12	0.5	2
Apartment blocks	1	6	0.5	3
Office building	34	39	6	7
Commercial buildings	12	15	12	15
(Health) care sector buildings	34	39	6	7
Educational buildings	13	14	7	8

The need for cooling falls substantially if account if taken of protection from the sun. A basic premise in planning is always to consider passive means to minimise energy consumption. A minimal cooling requirement may be met, for example, by increased ventilation. Residential buildings should also have window ventilation as a general feature, especially in areas of (semi-)detached houses.

Cooling requirement scenarios (Figure 28) have been calculated on various assumptions: that 1) all buildings are fitted with effective means of solar protection ([roller] blinds, etc.), 2) all detached and semi-detached houses are fitted with means of solar protection and half of large buildings have solar protection and half do not, 3) buildings have no solar protection.

Of the alternatives, 2) is the most realistic, and it has been made the basis of regional investigations. The cooling requirement of buildings with this option is just under 1 400 GWh in 2015. That will increase over the next 15 years to 1 700 GWh. The cooling need for office building buildings will increase most in absolute terms and that for apartment blocks most in relative terms.

Figure 28. Scenarios of the requirement for cooling energy.

Key

Rakennusten jäähdytystarve 2015 ja 2030 = Cooling requirement of buildings in 2015 and 2030

GWh vuodessa = GWh per annum

Pientalot = Detached and semi-detached houses

Asuinkerrostalot = Apartment blocks

Opetusrakennukset = Educational buildings

Hoitoalan rakennukset – (Health) care buildings

Liike ja liikenteen = Commercial and transport

Toimistorakennukset – Office buildings

Key

1. ylilampöä torjuttu aurinkosuojauksella ja tuuletuksella =

   avoidance of overheating using solar protection and ventilation

2. osittainen aurinkosuojaus = partial solar protection
3. ei aurinkosuojausta = no solar protection

The cooling requirement for 2030 has been located in municipalities and the cooling energy density for each municipality has been calculated by dividing the cooling requirement for buildings (kWh) by the area of the built-on land (m²).

The cooling energy density (Figure 29) is in its own class in Helsinki (1.65 kWh per square metre of built-on land), compared to the rest of the country, or even to other large cities. Helsinki accounts for 14 % of the demand for cooling.

The next energy density category depicted on the map (~ 0.6 kWh per square kilometre of built-on land) covers other large Finnish cities, such as Espoo, Vantaa, Tampere, Turku, Jyväskylä, Lahti, Kuopio and Oulu, and a number of small municipalities. This category accounts for 38 % of the demand for cooling.

Municipalities of relatively scattered construction (the two lowest categories for cooling energy density) account for 48 % of demand.

Figure 29. Cooling energy density by municipality (cooling requirement of buildings in kWh divided by built-on land area).

Key

Jäähdytyspotentiaali = Cooling potential

8.3 District cooling

8.3.1 Current situation with regard to district cooling

In 2014, 191 000 megawatt hours of district cooling was sold. Most of it is produced by Helsingin Energia (70 % of the business for which there are statistics). Helsingin Energia operates in the region in which cooling energy density is greatest.

Other big operators include Turku Energia (almost 20 %), and Fortum, in Espoo, (almost 10 %). The other 2 % share of district cooling is supplied by five companies. Among these is Tampereen Sähkölaitos/Kaukojäähdytys, in Tampere, which is establishing district cooling in the most built up parts of the city centre.

The combined length of the district cooling networks was 100 kilometres in 2014, which shows just how limited the area is in which there is a supply: amid the commercial and public buildings and office buildings of large cities.

According to statistics put out by Finnish Energy, sales of district cooling have gone up 2.5 times and the number of customers has doubled in the past five years (Figure 30 and Figure 31). More than half of cooling energy is produced using heat pumps and a quarter comes from free cooling sources.

Figure 30. Sales of cooling energy 2011-2014 (Source: Finnish Energy)

Key

Kaukojäähdytysenergian myynti ja sopimusteho = District cooling energy: sales and contracted output

Myynti MWh = Sales MWh

Sopimusteho MW = Contracted output MW

Energiateollisuus = Finnish Energy

myynti = sales

sopimusteho = contracted output

Figure 31. Production capacity of district cooling. The figures for 2014 break down as follows: heat pump 56. 1 %, free cooling 24.4 %, absorption 13.3 % and compressors 6.2 % (Source: Finnish Energy)

Key

Kaukojäähdytyksen tuotantoteho = District cooling production capacity

Huom! Eri tuotantomuotojen maksimitehot eivät ole yhtä aikaa käytettävissä, esim. Vapaajäähdtyksestä saatava teho riippuu meriveden/ulkoilman lämpötiloista =

NB! The maximum output from the different forms of production is not available at the same time, e.g. the output from free cooling depends on the temperature of seawater / outdoor air

vapaa jäähdytys = free cooling

lämpöpumppu = heat pump

absorptio = absorption

kompressorit = compressors

Energiateollisuus = Finnish Energy

8.3.2 The potential for district cooling by 2030

A tentative estimate suggests that the energy used for the cooling of buildings could amount to around 1 400 gigawatt hours annually. According to a forecast, the cooling requirement will increase to 1 700 gigawatt hours by the year 2030. The market share for district cooling in 2014 is 10 % of demand determined realistically. It is possible that sales will continue to increase at the current rate for the next 15 years, with supply going up by 20 GWh per annum. The market share would increase to around 25 % of the relevant demand.

The sites with the most potential for district cooling are top quality apartment blocks, and commercial, office and public buildings that are located in the most built-up parts of cities or otherwise make up concentrations of buildings (for example, leisure centres).

New potential sites can be found amid both the current and the new building stock. Among the existing building stock, the most auspicious and economically sensible site to connect to a district cooling facility would be where the lifetime of a technical system in a property is coming to an end and so there is a need to invest in a new system anyway. An option with both new and old buildings may be to connect to a district heating network or smaller local network.

The companies that supply district cooling at present will be expanding their distribution network as property owners become interested in connecting to a district cooling facility.

There has already been some interest, and, for example, provision has been made in new apartment blocks to allow connections to be carried out at a later date.

The present district cooling systems have been or are being built in the largest cities in Finland, and it is in those same large cities that future new construction will be concentrated.

Large buildings (apartment blocks, commercial and office buildings, public buildings) in cities and other built-up areas have been connected to district heating facilities. The aim is for new construction in the future to be located within the built environment, i.e. the area served by an existing district heating network. It will be possible to accommodate hybrid systems in such an environment, combining supplies of heating and cooling (CHC). Technologically advanced buildings could serve as solar heat recycling units, where excess heat would be recovered and channelled into the district heating network (Shemeikka et al., 2015).

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Annex: Area density by statistical rectangle in the largest cities

HELSINKI

Key

Aluetehokkuus naaputiruutujen keskiarvona vuonna 2014 = Are density as an average of neighbouring rectangles in 2014

Tajaama-alue 2014 = Densely populated area 2014

Rakennukset = Buildings

YKR/SYKE ja TK = Urban Structure Monitoring System/Finnish Environment Institute and Statistics Finland

Maanmittauslaitos = National Land Survey of Finland

Taustakartta: ESR/Maanmittauslaitos = Background map: European Social Fund/ National Land Survey of Finland

TAMPERE

Key

(as before)

TURKU

Key

(as before)

OULU

Key

(as before)

LAHTI

Key

(as before)

JYVÄSKYLÄ

Key

(as before)

KUOPIO

Key

(as before)

PORI

Key

(as before)

VAASA

Key

(as before)

JOENSUU

Key

(as before)

KOUVOLA

Key

(as before)

KOTKA

Key

(as before)

LAPPEENRANTA

Key

(as before)

ROVANIEMI

Key

(as before)

HÄMEENLINNA

Key

(as before)

SEINÄJOKI

Key

(as before)

MIKKELI

Key

(as before)