Regional Study: The use of Renewable Energy Sources in South Ostrobothnia and Finland

2016
Thermopolis Oy
ZEROCO2

This report has been produced with the financial assistance of the Interreg Europe Programme. The content of this Report is the sole responsibility of Thermopolis Oy .and can under no circumstances be regarded as reflecting the position of the Interreg Europe Programme Authorities

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1. Presentation of Finland and South Ostrobothnia

Name of the region	South Ostrobothnia
Country	Finland
Area (region/country)	13 999 km^2/ 338 440 km^2
Population[1] (region/country)	
- Number	192 476 / 5 493 577
- **Density** (resident/km^2)	14,3 / 18,1

[1]june 2016

Figure 1. Map of Finland with South Ostrobothnia highlighted in red. Source: public domain.

1.1 A brief description of the region and country with an emphasis on the use of energy, especially renewable energy sources (RES)

Finland is a northern country of forests (72 % of area), lakes (10% of area is water), long distances and a low population density. Finland also has an energy intense industrial sector. With this as the setting it is not surprising that the three largest energy consumers are industry (45 % of all primary energy consumed in Finland), heating of buildings (26 %) and transport (17%). [Statistics Finland 8]

To produce the needed energy Finland uses a diverse palette of resources. The three main sources are wood fuels (25 %), oil (23 %) and nuclear power (18 %). Wood fuels include black liquor and other concentrated liquors (10.5 %), wood fuels used in industry and energy production (10 %) and small-scale combustion of wood (5 %). [Statistics Finland 4]

The use of other renewables is marginal. Hydro power produced 4 % of the consumed energy in 2014. Wind power's share was around 0.4 % in 2014 and with an increased to 0.6 % in the year 2015. All other renewables are very marginal on the overall scale. [Statistics Finland 4 and 5]

South Ostrobothnia is situated in Western Finland. 17 municipalities make up the region. The area has a large number of small and medium sized enterprises. Agriculture is important. The landscape is made of open fields and rivers. The region represents about 4 % of Finland's area and about 3.5% of Finland's population lives in the region.

The region consumes 40 % of its energy consumption for heating buildings. The three main sources of energy are oil (45 %), wood fuels (19 %) and peat (12 %).Regional values do not include rail transport. There are no large forest industry plants, thus there is no consumption of black liquor or other consecrated liquors that are by-products of the pulp and paper industry. [Statistics Finland 1-3, 11-13; Finnish Energy 1-5; Lipasto]

2 Use of energy

2.1 General statistics

The main source of energy in Finland in 2014 was wood fuels (25 %). Wood fuels include black liquor and other concentrated liquors, wood fuels used in industry and energy production and small-scale combustion of wood. Figure 2 presents the division of energy consumption in the whole of Finland and in South Ostrobothnia for the year 2014.

In South Ostrobothnia, oil is the most used source. The difference comes from the fact that there are no large pulp and paper factories in the Region, thus one category of wood fuels is not used.

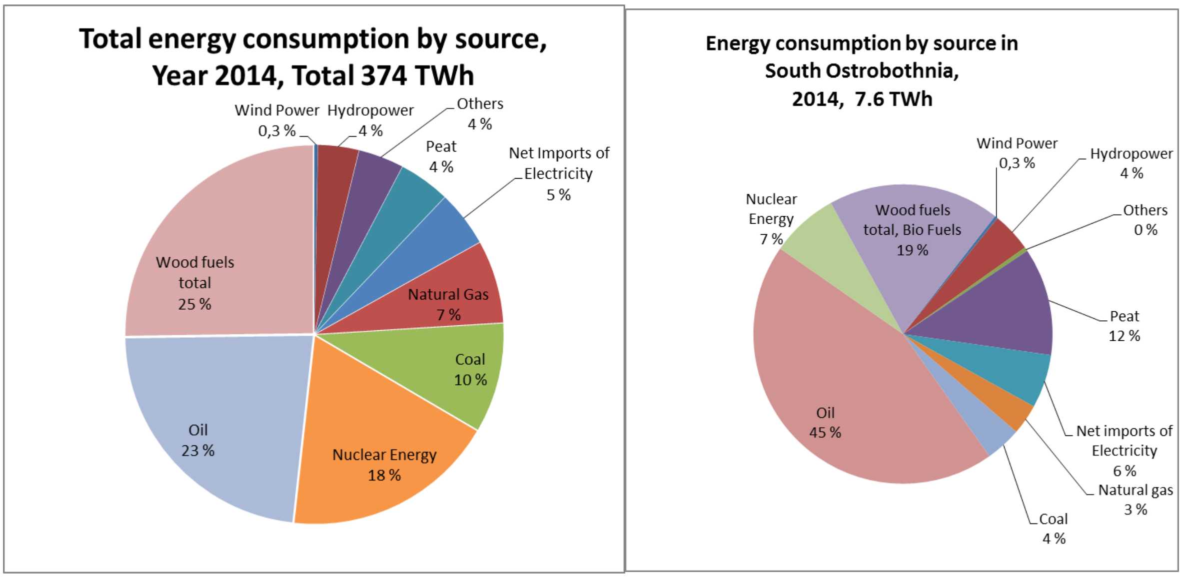


Figure 2. The total energy consumption in Finland and in South Ostrobothnia by source for the year 2014. [Statistics Finland 1-5,11-14; Finnish Energy 4; Lipasto]

Table 1 presents the energy consumption in Finland and in the region of South Ostrobothnia by source for the year 2014. Of all the consumed energy in Finland about 2 % is consumed in the region of South Ostrobothnia. For each person in Finland, 68 MWh of energy is consumed yearly. In South Ostrobothnia, this value is 38 MWh/a. The lack of large industry plants contributes to the Region's below average consumption.

For buildings Table 1 presents the energy consumption for space heating. The regional data has been calculated using estimations of building type specific heat coefficients created by Statistics Finland. Presented values are estimations as real data is not recorded at this level. The electricity used for non-space heating purposes in buildings cannot be reliable extracted from available statistics. Data on space heating for commercial and public buildings could be reliable extract for the whole of Finland, but not for the region.

Table 1. Energy consumption in Finland and in South Ostrobothnia by source and building type for the year 2014. [Statistics Finland 1-5,11-14; Finnish Energy 1-5; Lipasto]

Energy source	Region **Country** GWh[1]	Building sector space heating GWh[2]	Residential space heating GWh[2]	All non-residential space heating GWh[2]	Commercial and public space heating GWh
RES	1 764 **124 000**	1 009 **38 613**	632 **30 029**	3770 **8 584**	- **5 892**
Oil	3 384 **86 120**	1 117 **12 098**	628 **4 815**	490 **7 283**	- **3 227**
Natural gas	250 **26 493**	42 **9 990**	21 **5 320**	20 **4 670**	- **3 131**
Coal	294 **35 047**	61 **8 704**	32 **5 089**	29 **3 615**	- **2 652**
Nuclear Energy	557 **68 624**	175 **4 987**	90 **3 651**	85 **1 336**	- **533**
Peat	885 **16 463**	803 **5 358**	504 **3 128**	299 **2 701**	- **1 687**
Net import of Electricity	440 **17 966**	138 **3 703**	71 **2 886**	67 **1 056**	- **421**
Others[3]	33 **14 698**	6 **1 358**	3 **775**	3 **583**	- **440**
Total Energy Consumption	7 607 **374 000**	3 352 **85 050**	1 981 **52 694**	1 371 **29 828**	- **17 983**

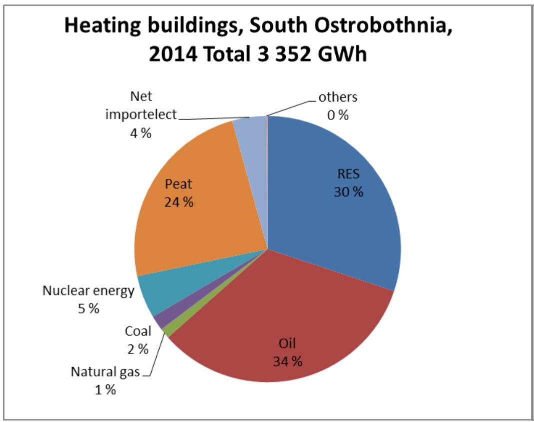
[1]Regional data does not include rail transport.

[2]Regional data does not include summer cottages or buildings that are used in agriculture. For the country total agriculture buildings are not included. Regional data is calculated from estimations of building type specific heat coefficients. The estimations have been done by Statistics Finland. Data for the whole of Finland is from table 7.3. Energy sources for space heating by type of building, Statistics Finland, [Referred: 30.8.2016].

[3]Includes vegetables-based fuels, animal-based fuels, landfill gas, biogas from wastewater treatment, industrial gas, other biogas, liquid biofuels, recovered fuels, demolition wood, impregnated wood (chemically treated), other mixed fuels, gasified waste, plastics waste, rubber waste, hazardous waste, other waste, exothermic heat from industry, electricity, used in electric boilers and heat pumps, hydrogen, other non-specified energy sources.

Heating of buildings covers around 44 % of the energy use in the South Ostrobothnia region and in the whole of Finland around 22 %. Residential buildings consume over half of this heating energy. The share of renewables in space heating is high, 45 % in the whole of Finland and 30 % in South Ostrobothnia (see Figure 3).

Almost all cities and towns have district heating plants. Some of them are combined heat power plants (CHP) and others only produce heat. Heating form district heating plants covers almost 40 % of the consumed space heating in Finland [Statistics Finland 14].



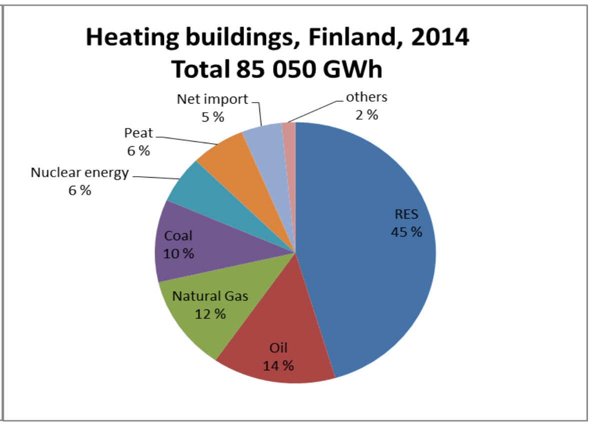


Figure 3. Heating buildings by energy source in South Ostrobothnia and in Finland, Year 2014. [Statistics Finland 1-5,11-14; Finnish Energy 1-5].

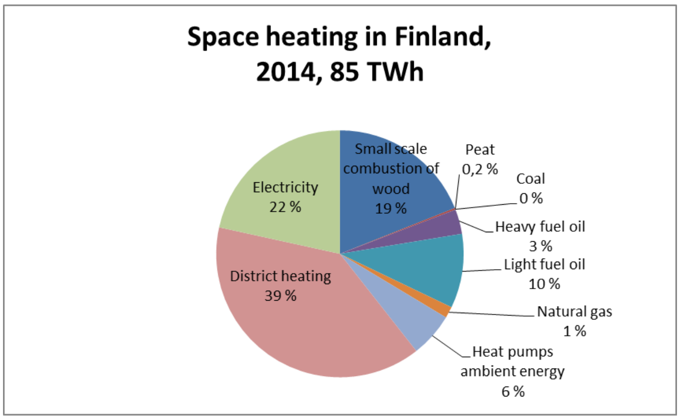


Figure 4. Space heating in Finland for the year 2014. District heating holds the largest share. [Statistics Finland 14]

So far the data we have been dealing with has been about energy consumption. The following figures present some data on energy production. Figure 5 and Figure 6 present electricity and district heating production by source for the year 2014. The graphs serve as a mean to see how South Ostrobothnia differs in energy production from the whole of Finland. The main differences are that natural gas pipelines do not extend to the Region, there are no nuclear power plants, coal is not used and peat is a significant resource in the Region.

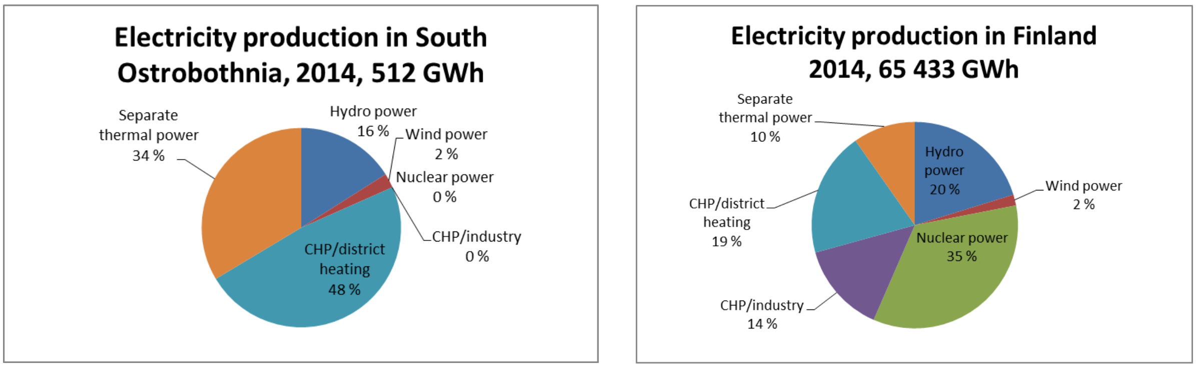


Figure 5. Electricity production by source in South Ostrobothnia and Finland for the year 2014. [Finnish Energy 4]

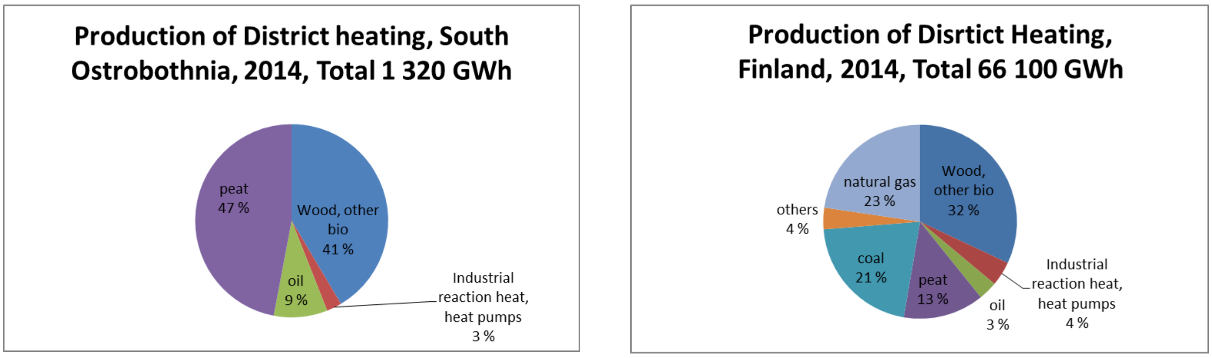


Figure 6. Production of district heating by source in South Ostrobothnia and Finland for the eyar 2014. Includes data from both CHP and separate heat production. [Finnish Energy 3]

2.2 Wood Fuels

Wood fuels are generally included in biomasses. However, as they hold a significant role in the Finland’s energy palette, they are reported in their own section.

Wood fuels contain the more common forms of wood fuels such as wood chip, pellets, logs, firewood etc. The grouping also includes the not so usual forms such as black liquor (a by-product of the pulp industry) and other concentrated liquors (other by-products from the wood industry) that are used to produce electricity and heat.

Forests cover 73 % of Finland’s land area. In the whole of Europe, 33 % of the land area is covered by forests. It has been calculated that the Finnish forest resources are currently 2.4 billion cubic meters, with an annual growth of 105.5 million cubic meters. The forest resources and the annual increase make the versatile use of forest material possible. The main consumers of this resource are the pulp- and paper industry, the wood products industry, and the energy industry. The way forest materials are consumed is guided by political decisions as well as economical drivers. Figure 7 presents the wood flows in the year 2015. [Luke 1]

WOOD FLOWS IN FINLAND 2015 (Source:Luke)

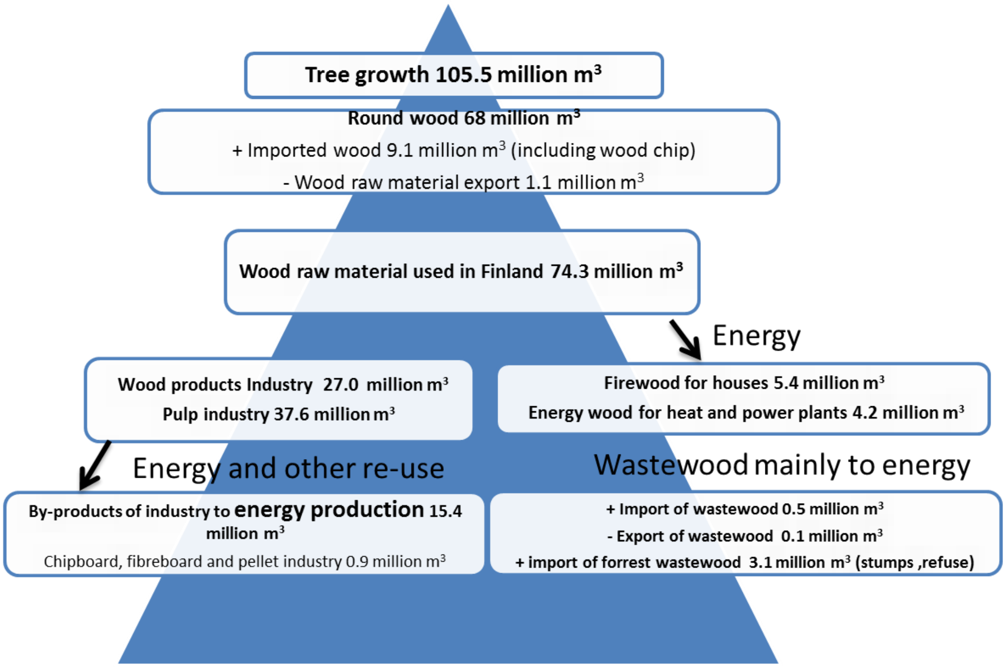


Figure 7. Wood Flows in Finland in the year 2015. [Luke 2]

The forest industry has a central role in using forest resources. The industrial use of wood raw material in 2015 was 64.7 million cubic meters (figure includes imported materials), which is 87 % of harvested forest resources (including imports). The direct energy use of the harvested forest resources accounts for the remaining 13 %. The re-use of by-products from the wood products and pulp industries increase the total amount of wood fuels used for energy significantly as over 23 % of the used material can be recover for energy purposes. [Luke 1]

The sustainable harvesting limit for the use of national forest material is around 81 million cubic meters a year and in the years 2012-2030 this value is foreseen to increase to over 86 million cubic meters a year. There are plans in the pulp industry to increase the intake of raw wood material by 14 million cubic meters a year by the year 2025. The Finnish government has set a goal that by the year 2020 the consumption of forest chips in the energy industry should be 13,5 million cubic meters. The Natural Resource Institute has calculated that both of these goals can be achieved if half of the material for wood chips is forest waste wood and stumps left behind from felling. [Luke 1]

The sustainable harvesting upper limit in Finland is 81 400 000 m^3/year. This equals around 162 800 GWh using a conversion factor of 2 MWh/solid-m^3. The energy need for the year 2014 was 374 304 GWh of which wood fuels covered 25 % (94 324 GWh). Wood fuels include black liquor and other concentrated liquors 10.5 % (39 450 GWh), wood fuels used in industry and energy production 10 % (37 584 GWh) and small-scale combustion of wood 5 % (17 289 GWh).

Table 2. An estimation of the upper limit for sustainable use of forest raw material. [Luke 1]

Estimation of maximum sustainable yearly harvesting for the years 2011 – 2040 (million m^3/year)			
	2011 – 2020	2021-2030	2031-2040
Logs	33.9	34.5	34.4
Pulpwood	41.2	43.2	43.5
Energy wood total	20.5	20.9	20.9
-Of which logs (amount of logs in the industrial size)	6.2 (5.0)	8.3 (6.9)	8.2 (7.3)
- Branches	7.9	7.3	7.5
- Stumps and roots	6.5	5.3	5.2
Total roundwood	81.4	86.0	86.1

The use of energy wood (not including by-products such as black liquor) could be increased from the current level of 9.6 million cubic meters by around 3.9 million cubic meters (7 800 GWh) to the set target of 13.5 million cubic meters and the harvesting would still be within the sustainability limit at least according to the estimation above. If the planned industrial investments are not completed as for seen then there will be more growth potential for the forest energy industry.

Table 3. Total use of wood in Finland and in South Ostrobothnia. Year 2015. [Luke 3]

Year 2015	Raw wood (1 000 m^3)			Forest industry by-products and waste wood (1 000 m^3)		
	Forest industry	Energy production	Total	Forest industry	Energy production	Total
Finland	64 670	9 605	74 275	8 915	15 398	24 313
South Ostrobothnia	1 063	572	1 635	94	374	468
Share	1.6 %	6 %	2.2 %	1 %	2.4 %	1.9 %

South Ostrobothnia does not have large paper or pulp factories. The forest industry is typically small saw mills, furniture factories etc. Table 3 presents the total use of wood in Finland. The total share of raw wood used in South Ostrobothnia is only 2.2 %. However, 6 % of the raw wood used for energy production is used in South Ostrobothnia. Wood chips are a significant fuel in the region's district heating and CHP plants.

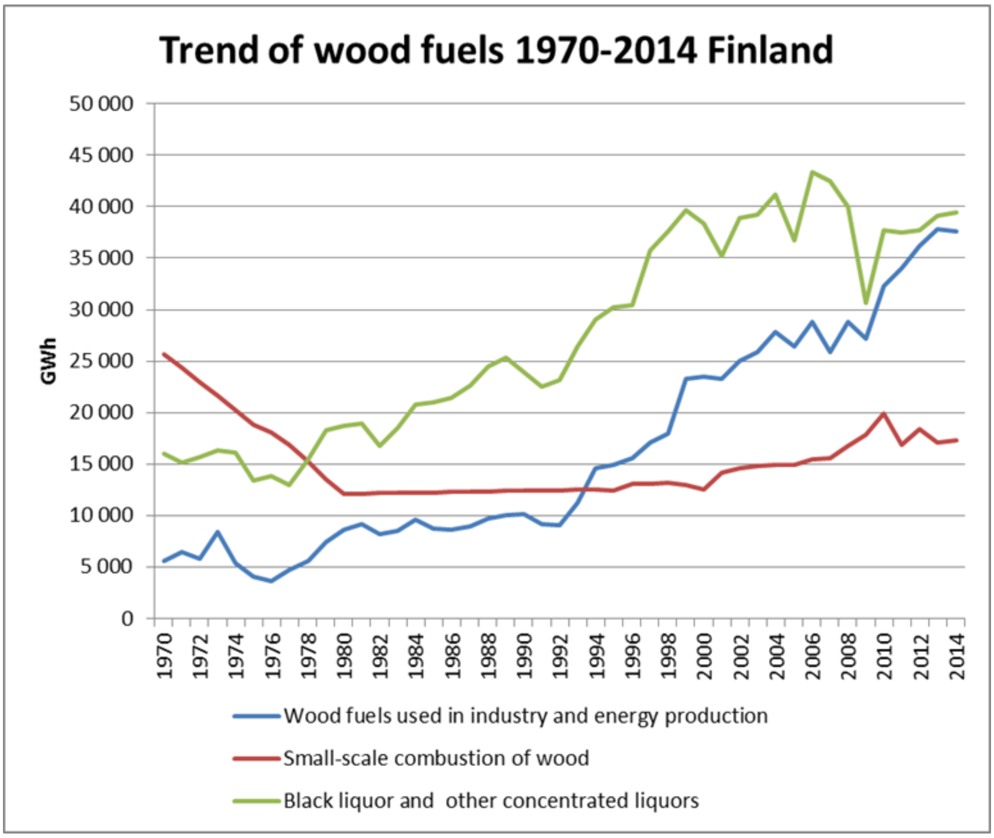


Figure 8. The trend of wood fuels in Finland. [Statistics Finland 16]

Figure 8 presents the historic trend of wood fuels in Finland for the years 1970-2014. In earlier years small-scale combustion of wood was the most important method of using wood fuels. From 1970 however the amount of wood fuels used in small-scale combustion started to decrease. This happened as buildings switched from wood fuelled boilers to other heating systems such as oil boilers, electric heating and district heating. At the beginning of millennium small-scale combustion of wood started to increase as wood fuelled boilers and fireplaces became popular again.

The industrial and energy use of wood fuels have growing trends. The use of black liquors and other concentrated liquors follows the economic development as it is directly related to industrial production.

2.3 Hydro power

Hydro power holds a significant role in the production of electricity in Finland. In 2014, 15.9 % (13 260 GWh) of the consumed electricity was hydro power. It also is the second most used renewable energy source in Finland after wood fuels, producing 4 % of the all the energy need in 2014. The share of hydro power in electricity production varies yearly from 10% to 20 % depending on the water storage levels. [Hydropower]

In South Ostrobothnia 14 % of the produced electricity is from hydro power. The region’s hydro power plants are small scale hydropower plants (<10 MW).

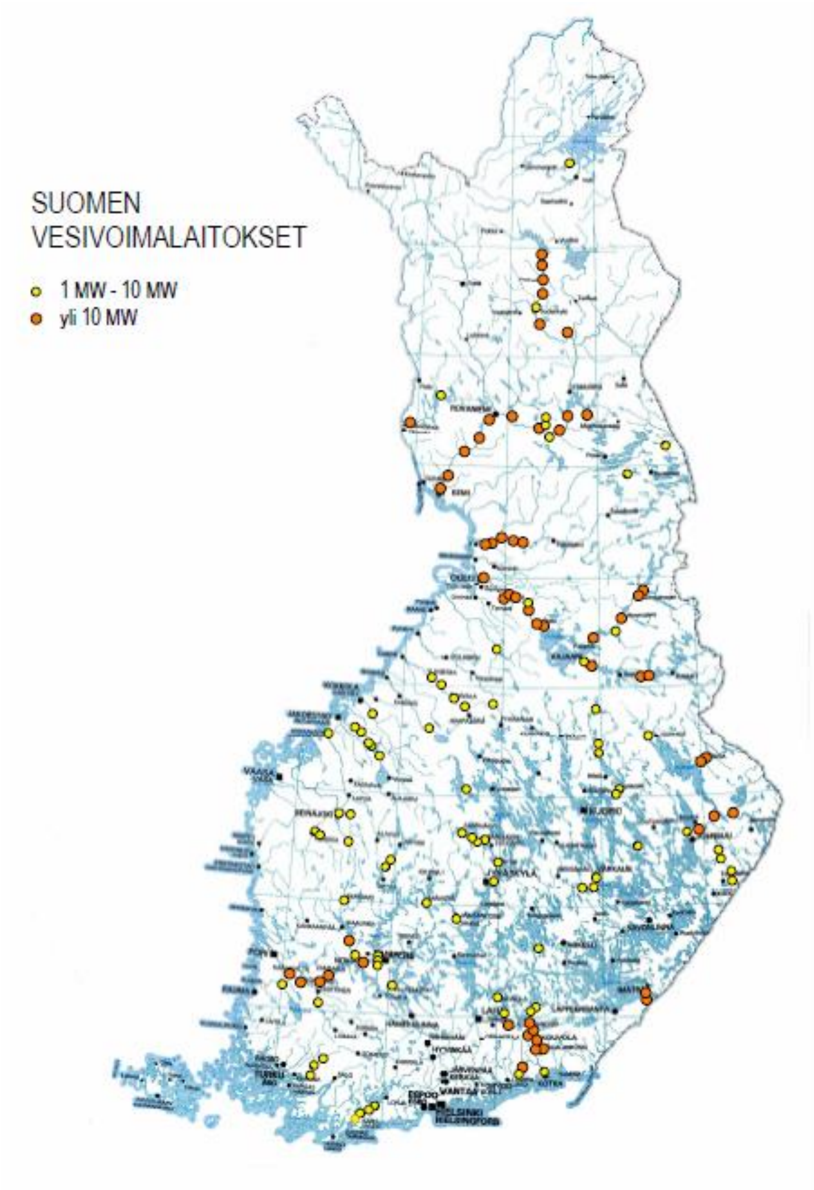


Figure 9. Hydro power plants in Finland. Yellow dots: 1MW-10 MW, Red dots over 10 MW. [Voimaa vedestä]

There are over 220 hydro power plants in Finland with a total power of 3 100 MW. Figure 9 presents a map of Finland onto which plants that are 1MW or larger have been placed. In 2008, a report on hydro power and its future in Finland was completed. According to a report on hydro power, published in 2008, there remains about 1 700 MW of potential hydro power that has yet to be harnessed. The report estimated that by 2020 it would be possible to increase the hydro power capacity to 470 MW. About a fourth of this potential could be achieved by updating existing plants. For small scale hydro power (less than 10 MW) there is a potential of around 60 MW. [Voimaa vedestä]

Since the report was completed there has been an increase in hydro power capacity of around 162 MW mainly through the updating of existing plants. This is more than the predicted increase of 117 MW. This increase is shown in Figure 10. [Statistics Finland 10]

There has been hardly any increase in small scale hydro power and hardly any foreseen.

The largest hydro power plant is Imatra (185 MW, 1000GWh/a, 25 m) in the south-east part of Finland. The rest of the larger hydro power plants are located in the northern part of Finland. In the region of South Ostrobothnia, there are only small scale hydro power plants (less than 10 MW). [Statistics Finland 10]

Protection of nature will prevent most new hydro power investments in Finland.

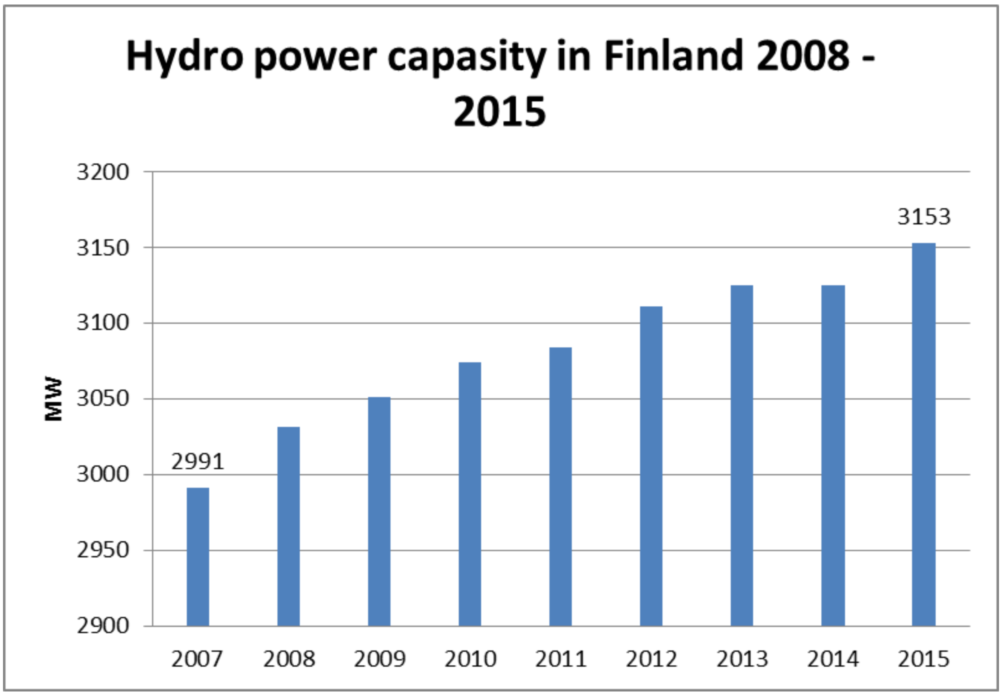


Figure 10. Hydro power capacity in Finland 2007-2015. [Statistics Finland 10]

2.4 Wind Power

Wind Power is still marginal on the overall energy production of energy in Finland and in the region of South Ostrobothnia (see Figure 2 and Figure 5). In spite the relatively low figures, there has been a surge in installed wind power capacity (see Figure 11). This is largely due to the feed-in tariff that was implemented in 2011. The impact of the feed-in tariff can be seen in the increase of installed capacity starting from the year 2013. New wind turbines can be added to the system until 2500 MW of installed wind capacity has been reached. Currently the amount of placed applications to join the feed-in tariff system is more than the set upper limit. [Statistics Finland 10]

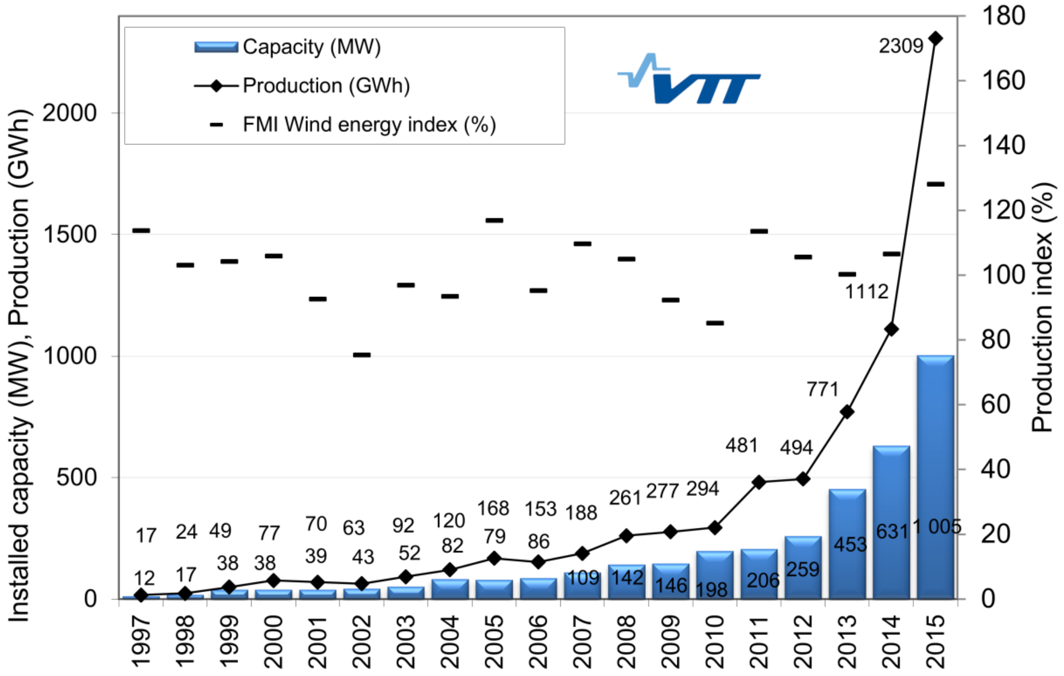


Figure 11. Wind power data for the whole of Finland. [VTT]

The goal of the feed-in tariff is to increase annual wind power production to 6 000 GWh by 2020. That is almost 3 times the wind power production of 2015. The set goal is likely to be met by 2018. According to the Finnish Wind Association's yearly survey of wind power projects, at the beginning of April 2016 nearly 13 000 MW of wind power projects had been announced in Finland. Planned offshore projects accounted for 2 000 MW. [Finnish Wind Association]

Finland's first off-shore wind farm is under construction and will be completed in 2017. The farm will consist of 10 x 4 MW turbines. The annual energy production is estimated to be 155 GWh. The cold and icy conditions have required special technical solutions. [Hyotytuuli]

The Regional Council of South Ostrobothnia has mapped the larger potential wind farm sites in its ongoing regional land use planning. [Land use plan]

2.5 Field Biomass

Field biomasses are only a marginal source of energy in Finland. Reed canary grass has been the most important energy crop grown in Finland. The cultivation of reed canary grace peaked in 2007, when the produced crop equalled 500 GWh [Mikkola]. In 2015, Reed canary grass was grow on 4 600 ha, which equals only 120 GWh in produced crop (24,4 MWh/ha). [Luke 1]

In 2015, Finland had 2 273 300 ha of agricultural land, of which 271 300 ha was fallows. The Finnish Ministry of Agriculture and Forestry has estimated that around 500 000 ha of field area could be used for energy crop production. If reed canary grass was grown on the estimated 500 000 ha that would amount to 12,2 TWh of energy. That would be around 3 % of the primary energy consumed in Finland, in 2014. [MMM]

It is also possible to use the by-products of crop to produce energy. Pahkala & Lötjönen (2012) estimated that the technical energy potential in crop by-products is 11,9 TWh, of which the economically viable potential is 2,4 TWh. [MTT]

Table 4. Energy potential of farming by-products. [MTT]

Plant	Technical potential TWh	Technical and economic potential TWh
Grain	10.6	2.1
Oil plants	0.6	0.1
Potato	0.4	0.1
Pulse crops	0.0	0.0
Sugar beet	0.3	0.1
	11.9	2.4

2.6 Biogas

In 2014, around 710 GWh of biogas was produced [Statistics Finland 16]. The goal set for biogas production by the Finnish government is 1,2 TWh by the year 2020. To reach this goal new biogas plants that produce electricity can apply to join the feed-in tariff system. The plant must have a nominal electric power of 100 kW.

Figure 12 shows how the production of biogas has increased over the years 1995-2014. There has been a more or less steady increase in biogas production.

Biogas is used to produce heat and electricity and some of it is refined to be used in gas powered vehicles. In 2014, biogas was used by transportation (17 GWh), to produce 455 GWh of heat and 158 GWh of electricity. 101 GWh was burned without use. The main source for biogas in Finland is landfills. [Huttunen & Kuittinen]

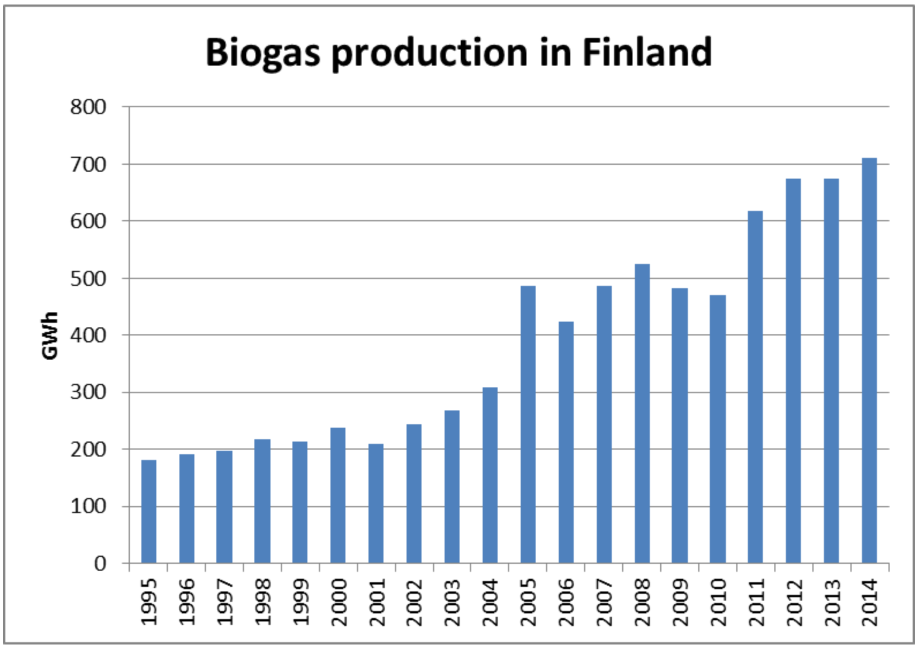


Figure 12. Biogas production in Finland 1995-2914. [Statistics Finland 16]

There still remains a large potential for biogas. Tähti & Rintala have estimated the potential to be 9.2 TWh/a (see Table 5). The greatest potential is in field biomasses and manure. There is potential for biogas in the region of South Ostrobothnia. However, financing has proven to be a problem in larger biogas plant investments.

Table 5. Biogas potential in Finland [Tahti & Rintala]

Biogas raw materials	Technical potential TWh	Technical and economic potential TWh
Landfill gas	0.5	0.5
Bio waste	0.5	0.3
Sewage sludge	0.4	0.2
Manure[1]	3.5	1.4
Field biomass[2]	17.8	5.8
Food industry waste	0.6	0.3
Industrial wastewater sludge	0.7	0.6
Industrial wastewaters (pulp, paper and food)	1.6	-
Others[3]	0.4	0.09
Total	**26 TWh/a**	**9,2 TWh/a**

[1]Manure, litter and wash water
[2]Fallow + straw + second harvest of grass (for silage)
[3]Includes animal waste from reindeer and fur farming, as well as waste and inventory losses from cultivation of vegetables and grains.

2.7 Solar power and thermal

The use of solar energy in Finland is marginal. In 2014, a total 24 GWh of solar energy was produced. From Figure 13 and Figure 14 the increasing of installations and energy production can be seen. In 2014, the installed solar power capacity was 11 MWp and production was 7 752 MWh. This equals a production of 690 MWh for each installed MWp. In 2015, around 7.9 MW of solar power had been connected to the grid. [Statistics Finland 18; Finsolar]

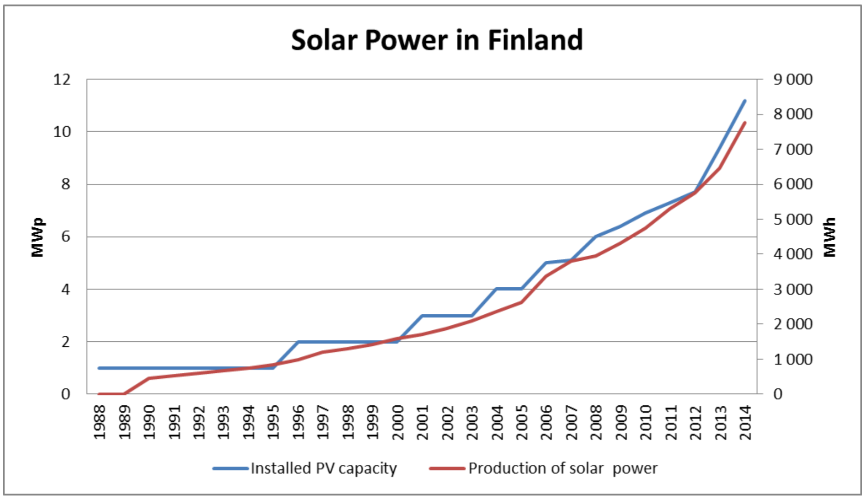


Figure 13. Solar power in Finland. Installed capacity and produced electricity. Years 1988 – 2014. [Statistics Finland 18]

In 2014, there were 45 000 m^2 of installed solar collector area and the thermal energy production was 16 GWh. That equals 34.8 kWh per collector m^2.

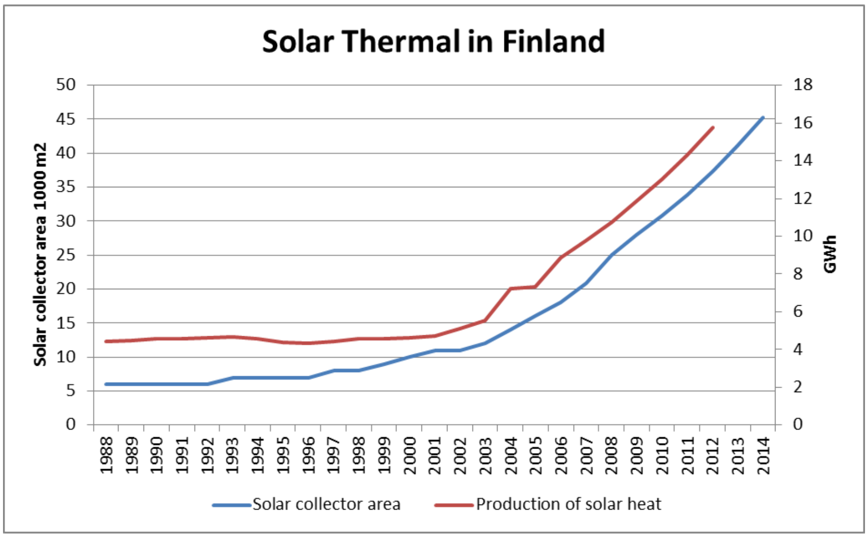


Figure 14. Installed solar thermal collector area and produced heat in Finland. Years 1988-2014. [Statistics Finland 18]

Table 6 presents the yearly total electricity production and received irradiation on an optimally inclined and free-standing 1 kWp PV system at different locations in Europe. The data is from PVGIS, which differs from measured values, but gives a good enough estimation for this comparison. It is interesting to see that the difference in irradiation and production values between Helsinki, Kaunas and Berlin are not that great. Yet Germany is considered a much better location for solar energy. In cooler temperatures the efficiency of traditional PV-panels increases, so it is likely that the actual production of PV in Finland could be even closer to the yearly production in Germany.

Table 6. Yearly total electricity production and received irradiation on an optimally inclined and free-standing 1 kWp PV system at different locations in Europe. [PVGIS]

	Optimal inclination angle (degrees)	Yearly total production 1 kWp estimated losses 14 % (kWh/a)	Yearly total of global irradiation received by modules (Wh/m2/day)
Lapua, Finland	44	851	1100
Helsinki, Finland	41	870	1120
Kaunas, Lithuania	36	888	1170
Berlin, Germany	37	962	1260
Ptuj, Slovenia	35	1160	1510
Marseille, France	37	1470	1940
Chania, Greece	29	1560	2130
Msida, Malta	32	1680	2240

There is potential for solar energy in Finland and there have been some larger PV installations on industrial buildings. However, the foreseen growth in both the region of South Ostrobothnia and in Finland is mainly in small systems installed on private homes. At the moment there are no governmental financial supports that would increase interest in solar energy.

2.8 Geothermal

The energy company ST1 has started a drilling the first bore hole for the first geothermal heating plant in Finland. On the 1.8.2009 the holes depth was 3 000 m. The final depth will be 7 km. A total of two holes will be drilled. The plant should be operational in 2017. Depending on the success of this first plant ST1 is planning on investing in future geothermal plants in Finland. The estimated power capacity of the plant is 40 MW of heating. The produced heat will be used in the district heating of the Espoo area. (Source: http://www.st1.fi/deepheat)

2.9 Transport biofuels

The Finnish national goal is to raise the use of transport biofuels to 7 TWh by 2020. In 2014 the use of transport fuels was 6 TWh. Examples of transport fuels are biodiesel, bioethanol, bio methanol, bio oil, biogas, wood gas etc. [Motiva, Statistic Finland 16]

2.10 Recovered biofuels

Recovered biofuels are the biodegradable part of fuels produced from municipal waste or comparable fuels produced from waste of retail shops and industry. These fuels are used to produce both heating and electricity. In 2014, the amount of recovered fuels was 2 499 GWh. [Statistics Finland 20]

3 Use of renewable resources in building

3.1 Renewables used in buildings

Table 7 presents the different types of renewables used in Finland and their share. As can be expected the most significant renewable source is wood fuels.

Table 7. Break down of use of renewable resources for the year 2014. Renewables accounted for 33 % of all energy consummed in Finland in 2014. [Statistics Finland1-3,10-14, 16; Finnish Energy 1-5; Lipasto]

RES	Region **Country** %	Building sector space heating %	Residential space heating %	Non-residential space heating %	Commercial and public space heating %
Hydro power	17 **11**	7 **4**	5 **7**	11 **9**	- **5**
Wind power	1 **1**	1 **0,35**	0 **1**	1 **1**	- **0,43**
Wood fuels total[2]	77 **76**	87 **43**	88 **74**	83 **80**	- **82**
Small-scale combustion of wood	- **14**	- **24**	- **49**	- **16**	- **14**
Black liquor and other concentrated Liquors	- **32**	- **-**	- **-**	- **-**	- **-**
Wood fuels used in industry and	- **30**	- **19**	- **25**	- **64**	- **68**

energy production					
Heat pumps[1]	4 **4**	4 **9**	5 **18**	2 **10**	- **12**
Recovered fuel (bio-fraction)	- **3**	- **-**	- **-**	- **-**	- **-**
Transport biofuels	- **5**	- **-**	- **-**	- **-**	- **-**
Other	1 **-**	1 **-**	1 **-**	3 **-**	- **-**

[1] Ambient heat

[2] Small-scale combustion of wood+ Black liquor and other concentrated Liquors+ Wood fuels used in industry and energy production

3.2 Heating buildings and domestic hot water and

3.2.1 General

Space and the domestic hot water are usually heated by the main heating system. Sometimes different heating systems are combined to create hybrid heating systems. Figure 15 presents the heating degree days for the normal period 1981-2010. The space heating need follows the presented graph. The domestic hot water heating load follows water consumption.

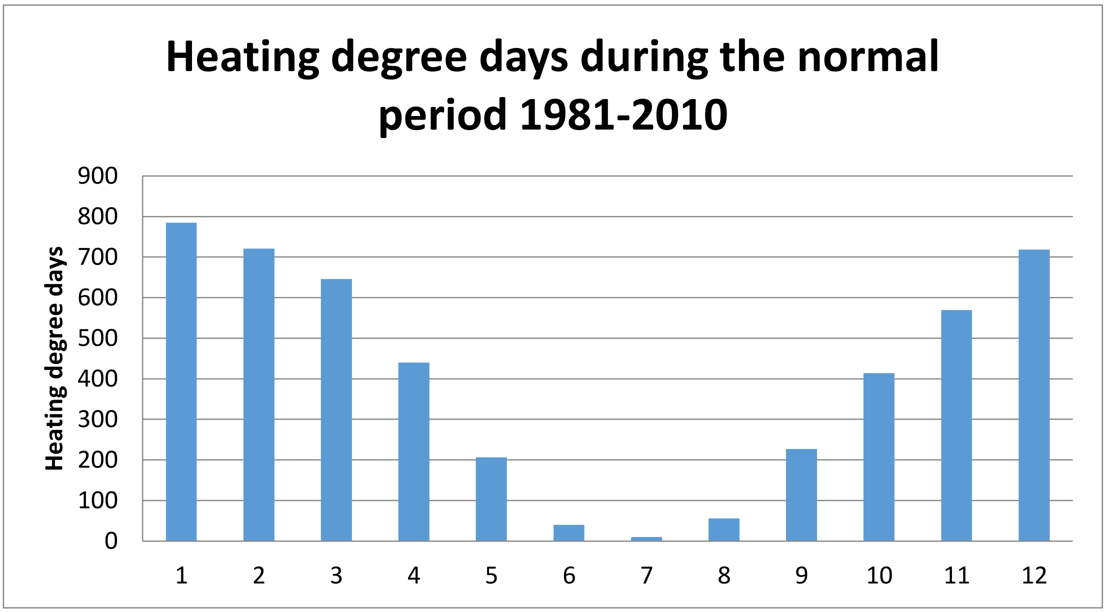


Figure 15. Heating degree days during the normal period 1981-2010. [Ilmatieteenlaitos]

3.2.2 District heating

39 % of buildings in Finland are heated using district heating (see Figure 4 on page 4). The country average for district heating produced using renewables is 36 %. For South Ostrobothnia the average is 44 %. (See Figure 6 on page 5)

For buildings in Finland district heating accounts for the use the category of "wood fuels used in industry and energy production" presented in Table 7. For Non-residential buildings this is the main type of wood fuel.

Some district heating plants use only renewable fuel, usually wood. For houses connected to fully renewable district heating applying the ZEROCO2 concept could be easy. They would have to concentrate on electricity use only. Perhaps install PV on their roof.

For buildings that are connected to district heating that is not 100 % renewable, applying the ZEROCO2 building concept could mean that they disconnect from the district heating network and opt for their own renewable energy source in heating. This is not necessary advisable as having several district heating customers leave the network will decrease the energy density along the district heating network. This will increase the ratio of heat losses per delivered heat and decrease the efficiency of the district heating. Also, providing supplement heat (via a fireplace or other renewable heating source) will cause a decrease in the energy density along the district heating network. For such buildings a ZEROCO2 option could be to install a surplus of electricity production units to cover not only the yearly electricity need, but also produce enough renewable electricity to counter the produced CO2 emissions created by heating. They could aim at being nearly ZEROCO2 buildings.

Those connected to district heated should also try to influence their heating supplier to increase the share of renewables used in the district heating plant. For example the district heating and electricity company in Helsinki (Helen LTD) aims at increase the share of renewables in their district heating production to 20 % by 2020. Helen also offers their clients the option of purchasing renewably produced district heating, thus providing a method to influence the company. [Helen]

3.2.3 Oil boilers and natural gas boilers

Around 16 % of buildings use oil and natural gas as their source for heating (see Figure 4 on page 4).

Buildings that have oil boilers and natural gas boilers to provided space heating can apply the ZEROCO2 concept by using supplement heat sources e.g. fireplaces, solar thermal systems, air-to-air heat pumps etc. The other option is to switch the heating system completely and opt for a ground source heat pump, wood pellet or wood chip boiler or some other combination of renewable heating.

3.2.4 Electric heating

22 % of buildings in Finland use electric heating (see Figure 4 on page 4). The share of renewables in electricity production is 39 % [Finnish Energy 2].

Applying the ZEROCO2 concept to buildings heated using electricity would mean installing renewable electricity production on site. Also adding supplemental heating systems (e.g. fireplace, solar thermal, air-to-air heat pumps) should be part of the process. Depending on the method of heat distribution in the building pellet and wood chip boilers could also be considered. These require a central heating system in the building.

3.2.5 Heat pumps

Heat pumps are gaining popularity in Finland. In 2014, heat pumps provided 6 % of the heating used in buildings from ambient heat sources (see Figure 4 on page 4).

Table 8 presents data on heat pumps used in residential, commercial and public buildings. The most popular heat pump is the air-to-air heat pumps (air heat pumps), which have been used to provide supplement heating in buildings for several years. Ground-to-water (ground source) heat pumps are usually installed in new buildings and even in larger building complexes such as shopping malls. Air-to-water (air-water) heat pumps have been gaining popularity, as the Finnish building code is driving new buildings closer to zero energy buildings. Air-to-water heat pumps are slightly cheaper to install than ground source heat pumps. Exhaust air heat pumps serve best in places where the needed fresh air volumes are great. 94 % of all heat pumps are installed in residential buildings [Statistics Finland 17].

Table 8. Heat pumps of residential, commercial and public buildings in 2014 in Finland. [Statistics Finland 17]

	Quantity, Number of heat pumps (share, %)	Capacity, MW	Production and recovery of heat, GWh (share, %)	Use of electricity, GWh	Primary energy production[1], GWh
Ground-to-water heat pump	93 817 (15 %)	882	2 687 (31 %)	776	1 911
Air-to-water heat pump	10 871 (2 %)	127	290 (3 %)	160	130
Air-to-air heat pump	496 836 (79 %)	2 365	5 657 (65 %)	3 143	2 514
Exhaust air heat pump	24 733 (4 %)	83	134 (2 %)	43	91
Heat pumps total	**626 257**	**3 457**	**8 768**	**4 122**	**4 646**

[1]Primary energy is the energy taken from the heat source (production and recovery of heat - use of electricity = primary energy).

3.2.6 Wood fuelled boilers and fireplaces

Small-scale combustion of wood has a 29 % share in the renewables used in buildings (See Table 7 on page 16). This includes fuels burned in small scale wood chip, pellet, firewood and wood briquette boilers, and fireplaces.

Boilers can be used as a main heating system. Depending on the type of fuel they use they can be fully automatized (e.g. wood pellet burners) or require a lot of manual labour (e.g. firewood burners). Wood fuelled boilers are available from a nominal capacity of a few kilowatts. The smaller wood fuelled boilers for smaller residential buildings have a yearly efficiency of around 75 %. Larger wood fuelled boilers for larger buildings have a yearly efficiency of around 84 %. [D5]

Fireplaces are a viable supplement heating method especially in residential buildings. Most detached single family homes in Finland have fireplaces.

Hybrid boilers are also an option for providing heating in buildings. The traditional form of a hybrid boiler combined the possibility to use oil or firewood. Modern hybrid boilers offer many different combination options for example oil, firewood, wood pellets and electricity.

3.2.7 Solar thermal

In Finland, solar thermal is usually used as a supplement heating system. For example it can be combined with a wood fuelled boiler to produce the needed heating during the summer months of June, July and August. During these months the boiler usually works at lower efficiency as its nominal capacity is designed to be sufficient for even the coldest days.

On average solar thermal system produce 0.5 MWh/m^2 [Statistics Finland 18].

3.3 Electricity

3.3.1 Solar power

Solar power installations on buildings are increasing. The largest solar power installation in the whole of Finland is around 420 kWp (2015) [Finsolar]. Solar power is mainly growing in smaller installations at the moment.

Grid companies are required by law to allow small electricity production units to connect. However, the sales of excess electricity have to be agreed on between producer and buyer. Net metering is not available.

3.3.2 Small wind power and small CHP

Small wind power (less than 50 kW) systems could be used to produce all of the buildings electricity need. However, getting permits for small wind power in cities can be difficult. The main focus in wind power has been on industrial sized installations.

Small CHP is an interesting yet still minor form of energy production for buildings in Finland. For example Volter produces a CHP plant with a electricity production of 40 kW and a heating power of 100 kW of heated water and 20 kW of heated air. The used fuel is wood chip (4.5 lose m^3/24 h). The size of the unit is as follows: length 4,8m, width 1,2m and height 2,5m. [Volter]

3.3.3 Renewable energy bought from the grid

In Finland consumers have the possibility to choose who they buy their electricity from. It is possible to specify that you want to by only renewable energy. Even though this option is a bit outside the scope and target of this project, it is important to note that choosing renewably produced electricity from the grid encourages electricity producers to invest in renewables.

3.4 Space Cooling

The need for cooling is increasing in Finland, as new buildings are built to be near zero energy buildings.

3.4.1 Night ventilation

The ventilation system is put on maximum settings during the night to cool down the building structures. This provides cooling in the day. In buildings with large mass structures night time ventilation can decrease the cooling power up to 40 % and the used energy for cooling up to 20 %. [TTY]

3.4.2 District cooling

A relatively new form of cooling is district cooling. District cooling is provided in very restricted areas. In 2014 a total of 435 buildings in Finland were connected to district cooling and the sold energy amounted to 190 999 MWh. District cooling is produced by absorption heat pumps (13 %), heat pumps (56 %), compressors (6 %) and free cooling (24 %). [Finnish Energy 6]

3.4.3 Heat pumps

Air-to-air heat pumps are often used to provide cooling as well as heating. Also ground sourced heat pumps are used to provide both active and free cooling.

3.4.4 Free cooling in air ventilation

Free cooling and pre-heating for ventilation air can be provided by coupling bore holes to heat exchangers in a buildings ventilation system. A refrigerant is circulated in through the bore holes and heat exchangers. As the ground temperature remains relatively steady during the year the fresh air can be preheated or cooled as needed.

4 CO2 emissions

Table 9. CO2 Emmisions by source and type of building for 2014 (preliminary data). Regional and building CO2 emissions calculated from energy consumption data. [Statistics Finland 1-5,11-15, 21; Finnish Energy 1-5; Lipasto],

	CO2 Emission in ton/year				
Source	Region **Country**	Building sector space heating	Residential space heating	Non-residential space heating	Commercial and public space heating
Oil	926 000 **9 700 000**	257 000 **3 310 000**	157 000 **1 317 000**	100 000 **1 992 000**	- **883 000**
Transport[1]	526 000 **10 900 000**	- **-**	- **-**	- **-**	- **-**
Coal	114 000[2] **8 100 000**	23 800 **3 386 000**	12 000 **1 980 000**	11 000 **1 406 000**	- **1 032 000**
Natural Gas	50 000[2] **5 300 000**	8 300 **1 978 000**	4 300 **1 053 000**	4 000 **620 000**	- **620 000**
Peat	39 000 **6 300 000**	146 000 **1 966 000**	60 000 **1 148 000**	85 000 **991 000**	- **619 000**
Mixed fuels and other fossil fuels	- **700 000**	- **-**	- **-**	- **-**	- **-**
TOTAL Fossils	1 654 000 **43 400 000**	435 000 **10 640 000**	234 000 **5 498 000**	200 000 **5 314 000**	- **3 153 000**

[1]Regional data does not include train transport data.

[2]These CO2 emissions are actually produced outside of the region where the electricity imported into the region is produced.

The building sector is responsible for 29 % of the CO_2 emission in Finland. Encouraging ZEROCO2 buildings would have a significant impact on the CO_2 emissions. Regionally the largest shares of CO2 emissions from buildings come from oil and peat. Nationally the largest shares of CO2 emissions from buildings come from coal and oil.

Since 1990 the CO2 emissions from residential, commercial, service and public building has been decreasing. Replacing fossil fuelled energy with renewables will encourage this trend.

Wood fuels release CO2 when burnt to produce energy. However, they are considered net zero CO2 fuels. That is trees store the same amount of CO2 as is released when wood fuels are used for energy production. For this reason their CO2 emissions are not presented in this report.

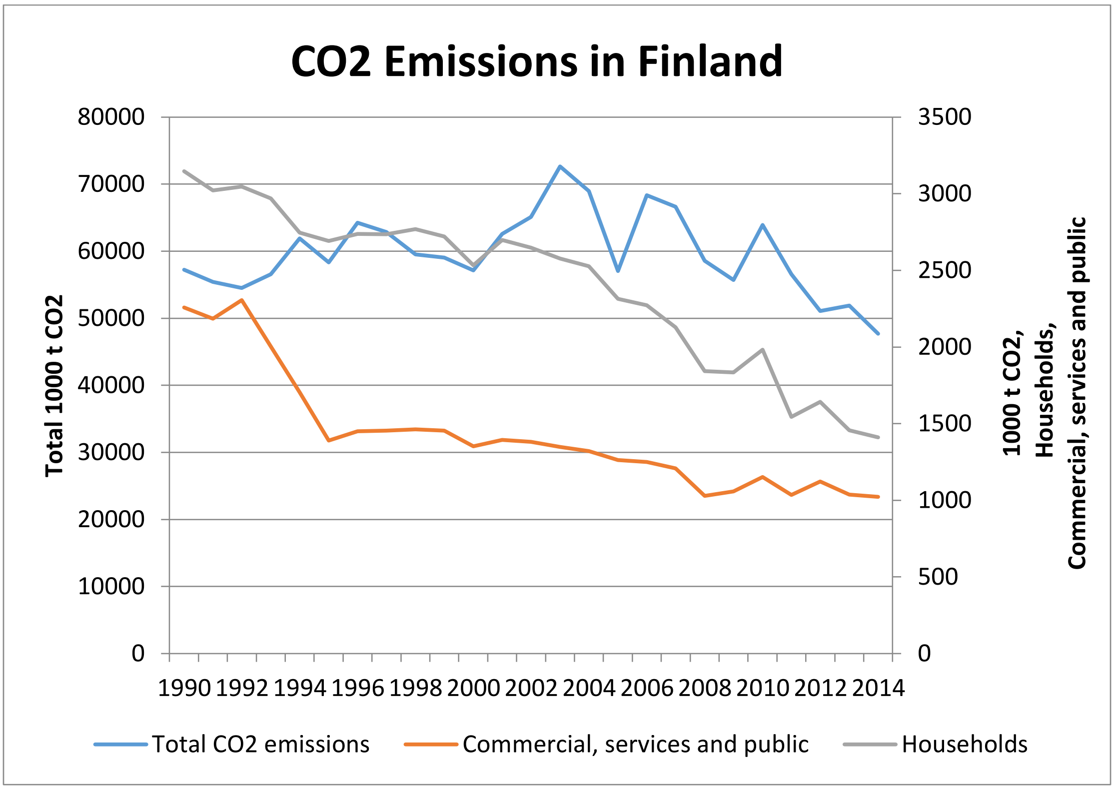


Figure 16. CO2 emissions in Finland. [Statistics Finland 21]

5 Potential of using RES in South Ostrobothnia and Finland

Some estimates of potential growth have been stated in the previous section.

5.1 Finland

Policies drive the direction of energy production. The Energy and Climate Strategy 2016 for Finland is being prepared and the main focus for renewables will be on the promotion of bioenergy and biofuels for transport. The goal will be to stop the use of coal completely and cut the use imported oil consumption by half by the year 2020. [TEM]

Wood fuels are the most significant renewable energy source used in Finland. And both nationally and regionally the largest growth will be seen in the use of these fuels.

Nationally, the Finnish government has set a goal that by the year 2020 the consumption of forest chips in the energy industry should be 13,5 million cubic meters. The use of energy wood (not including by-products such as black liquor) could be increased from the current level of 9.6 million cubic meters by around 3.9 million cubic meters (7 800 GWh) to the set target of 13.5 million cubic meters and the harvesting would still be within the sustainability limit at least according to the estimation above. If the planned industrial investments are not completed as for seen then there will be more growth potential for the forest energy industry [Luke 1].

The installed wind power capacity is increasing rapidly as the current government was planning on closing the feed-in tariff system, for wind power, early. At the moment the applications to be admitted into the feed-in tariff system more than full fill the maximum capacity of 2 500 MW. It is likely that when the feed-in tariff closes for new applications, the growth in wind power installations will slow down. However, it is unlikely to stop completely. A new area in the wind power industry might be off-shore installations.

Solar energy will increase steadily as equipment prices drop. However, at the moment it is unlikely to become very significant in overall energy picture.

The use of other biomasses has a lot of potential for growth both regionally and nationally. Estimation of growth has been stated in the previous section.

5.2 South Ostrobothnia

The Council of South Ostrobothnia has published the Energy and Climate Strategy for South Ostrobothnia 2014 – 2020. This report states that in the energy sector the future main focus will be on forest and field biomasses as well as wind power. [EPliitto]

Regionally the increase of wood based fuels will depend on the local district heating companies and their technical possibilities to replace peat with wood chip. For example the district heating company in Kauhava invested in a new 10 MW forest chip fuelled heat plant. The plant was completed in 2015.

Regionally the land use plan has increased the number of wind turbines in the region. The goal is to replace the 1 270 GWh/a of electricity imported into the region at least partially by wind power. To encourage instalments in the region wind power has been included in the regional land use planning. [Regional partial land use plan 1]

The effect of the feed-in tariff can be seen regionally. For example the wind power production in South Ostrobothnia in 2014 accounted for 2 % of electricity produced in the region. In 2015, wind power held a share of 6% and this is likely to increase even more in the year 2016.

Field biomass has great potential in South Ostrobothnia as agriculture is important to the region. The effective use of this potential will require policies that encourage the use of field biomass and agricultural by-products.

6 Policies promoting energy efficiency and use of renewable energy resources

Table 10. National, regional and local policies promoting energy efficiency and renewable energy resources.

Name of the policy	Area that it covers (Local, regional, national)	Actions that are promoted	For which sector is it meant	Type of support (subsidy, …)
Energy support	National	Introduction of new energy technology to the market and to use	Companies, municipalities and other communities	Varies between 30 % -60 % of eligible costs
Feed-in tariff	National	New renewable energy power plants	For power plants fuelled by wind, biogas, forest chips and wood-based fuels meeting the prescribed preconditions	The subsidy varies on the basis of a three-month electricity market price or the market price of emission allowances.
Energy support for homeowners	National, application from municipality	Increase energy efficiency of detached single family homes or installing of a heating system that uses renewables	For private homeowners of low income	25 % of eligible costs
Household tax reductions	National	Bought services to upkeep, Maintain or improve your owned residential building (e.g. household cleaning services, the work done to install a new heating system)	Encourage households to buy services and thus create jobs	Tax reductions up to 2400 €/year/person. Calculated from wage costs only (15 to 45 %).
The Finnish building code	National	After 2020 new buildings will be	all	

and related legislation		near zero energy		
Energiatehokkuuslaki (The law on energy efficiency)	National	Energy audits, cost-benefit analysis, and responsibility to guide clients towards energy efficiency	Grid owners, Power producers and sellers, large companies, district heating and cooling producers and network owners, industrial companies that produces energy by-products	
The Regional Strategy of South Ostrobothnia and related documents	Regional	Promotion of low carbon economy	All	Guidelines
Regional partial land use plan 1, accepted 11.5.2015	Regional	Wind energy production	Wind energy companies	Set apart locations that are fit for wind farms of over 10 turbines
Ongoing municipal partial land use plan	Local, City Of Ilmajoki	Wind energy production	Wind energy companies	Set apart all areas fit for wind energy production in the City of Ilmajoki

[Short description of each policy, max 500 characters each]

Energy support can be applied for by companies, municipalities and other communities that undertake investment and/or implementation research projects:

- to increase the use or production of renewable energy, to increase energy savings or energy efficiency of energy production or consumption,
- to increase energy savings or energy efficiency in energy production or consumption
- to decrease the environmental impacts of energy production or consumption

The amount of support varies depending on the applicants status (company, municipality other community) and the type of project. The maximum available support varies between 30%-60 % of eligible costs. Smaller shares can be used. Projects eligible for the feed-in tariff cannot receive energy support. [Energy Support]

The feed-in tariff was implemented in 2011. New wind (nominal power > 500kW), bio gas (electricity production nominal power > 100 kW), forest chips (electricity production nominal power > 100 kW) and wood-based fuel (100 kW < electricity production nominal power < 8 MW) power plants that have not received any governmental support can apply.

The feed-in tariff will close for wind power when the sum of the nominal power of all the wind power plants in the feed-in tariff system reaches 2 500 MW. For biogas power plants the feed-in tariff will close when the sum of nominal power reaches 19 MW. For wood-based fuels the feed-in tariff will close when the sum of nominal power reaches 150 MW and there are more than 50 plants. Forest chip power plants have no limit.

The subsidy varies on the basis of a three-month electricity market price or the market price of emission allowances. The target price is 85.50 € + extras that have prerequisites. Power plants accepted in the feed-in tariff system will receive support for 12 years. [Finlex]

Energy support for detached single family home owners of low income has a maximum support limit of 25 % of eligible costs. Brute income limits for single person households is 1760 €, for 2 person households 2940 €, for 3 person households 3920 €, for 4 person households 4995 € and for households larger than 4 persons +850 € for each additional person. Support can be given for adding insulation to building envelop, for changing windows to more energy efficient ones, installing a ground source heat pump, an air-to-water heat pump, a wood pellet or other wood fuelled boiler or a hybrid renewable energy system. [Ara]

Household tax reductions are 45 % of wage costs, if you hire a company to preform maintenance, upkeep, or installation services at your home. If you hire a private person the available tax reduction is 15 %. The total maximum deductible sum is 2 400 €/person/year.

The Finnish building code has been directing the construction of buildings towards zero energy building since 2008. Currently the ongoing updates to the building code will mean that new houses that apply for building permit after the start of 2018 will be zero energy buildings. If the renovation of older buildings requires a permit, the national building code has regulations on the required energy efficiency state that the renovation must achieve. [Finnish Building Code]

The law of energy efficiency is focused on grid owners, power producers and sellers, large companies, district heating and cooling producers and network owners, industrial companies that produce energy by-products. It has requirements for energy audits, cost-benefit analysis, and responsibility to guide clients towards energy efficiency. [Energy efficiency law]

The Regional Strategy of South Ostrobothnia and related documents serve as guideline for political decisions and admitting funding in the region. One of the stated goals is the promotion of low carbon economy. [Regional strategy]

The Regional Partial Land Use Plan 1 maps out the best locations for wind farms with several turbines. The goal is to increase the amount of wind power produced in the region. [Regional partial land use plan 1]

Ongoing municipal partial land use plan in the city of Ilmajoki will map out the exact locations of wind turbines. In spite of the regional partial land use plan, municipality land use plans most also be completed before wind turbines can get building permits. Usually the land use plan for wind turbines is put in motion when potential wind turbine investors are interested. The city of Ilmajoki has taken initiative in the matter and is updating their land use plan so that wind turbine investors can skip on step if they choose Ilmajoki as their location. [Ilmajoki]

7 Sources

Table 11. List of sources from Statistic Finland. Official Statistics of Finland. Data from these sources have been used through-out this report. In Text this table is referred to by [Statistics Finland #].

#	Name of source	Description	Point of access	Date
1	R09D Rakennukset käyttötarkoituksen, lämmitysaineen ja kerrosalan mukaan. 'Tilastokeskuksen arvioidut rakennusten lämmityksen ominaiskulutuskertoimet'	Excel- table, Estimations of building type specific heat coefficients, For South-Ostrobothnia and for Finland	email	16.8.2016
2	Tilastokeskus, Ympäristö ja energia	Excel- table, Environment and energy-data,	email	16.8.2016
3	Tilastokeskus, Rakennuskanta (kevytöljym raskas öljy ja kaasu kulutus, Etelä-Pohjanmaa	Excel-table, Buildings stock – in South Ostrobothnia	email	16.8.2016
4	1.Total Energy Consumption by Source and CO2 Emissions	E-database, SOURCE, YEAR, SEASON, SHARE OF TOTAL ENERGY CONSUMPTION %, ENERGY CONSUMPTION TJ AND KTOE, ANNUAL CHANGE, QUARTELY CHANGE	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/?tablelist=true	23.8.2016
5	2. Total energy consumption by source (detailed)	E-database, YEAR, ENERGY SOURCE, QUANTITY, TJ, TWh, SHARE %, ANNNUAL CHANGE %	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/?tablelist=true	23.8.2016
6	9. Fossil fuels and renewables	E-database, YEAR, FUEL, TJ, TWh, SHARE %, ANNUAL CHANGE %	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/?tablelist=true	23.8.2016
7	10. Consumption of renewable energy sources	E-database, YEAR, SOURCE, QUANTITY, TJ, TWh, SHARE %, ANNUAL CHANGE %	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/?tablelist=true	23.8.2016
8	11. Final consumption by sector	E-database, YEAR, SECTOR, TJ, TWh, TWh, PROPORTION %,	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene_	23.8.2016

		ANNUAL CHANGE %	_ehk/?tablelist=true	
9	19. Supply of electricity by energy source	E-database, SUPPLY OF ELECTRICITY BY ENERGY SOURCE, YEAR, GWH, ANNUAL CHANGE, %, SHARE %	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/?tablelist=true	23.8.2016
10	21. Capacity of Electricity Generation, Nominal Capacity of production Engines at Beginning of Year	E-database, PRODUCTION TYPE, YEAR, SHARE %, MW		
11	1. Teollisuuden energian käyttö toimialoittain (TOL 2008)	E-database, Energy Use in industry, YEAR, INDUSTRY CLASS, ENERGY SOURCE, TJ, GWh	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__ene__tene/?tablelist=true&rxid=e3053293-ca24-4d35-a233-9b33493cc350	25.8.2016
12	2. Teollisuuden energiankäyttö maakunnittain muuttujina Maakunta, Tiedot ja Vuosi	E-database, , Energy Use in industry by region, YEAR, REGION, TJ, GWh	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__ene__tene/?tablelist=true&rxid=e3053293-ca24-4d35-a233-9b33493cc350	25.8.2016
13	3. Teollisuuden sähkönkokonaiskäyttö maakunnittain ja toimialaryhmittäin (TOL 2008) muuttujina Maakunta, Toimialaluokka, Tiedot ja Vuosi	E-database, Electricity use in industry by region, REGION, YEAR, INDUSTRY CLASS, ELECTRICITY CONSUMPTION GWh	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__ene__tene/?tablelist=true&rxid=e3053293-ca24-4d35-a233-9b33493cc350	25.8.2016
14	7.3. Energy sources for space heating by type of building	Excel-table, YEAR, BUILDING TYPE, ENERGY SOURCE, TJ	http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2015/html/suom0006.htm	30.8.2016
15	12.3.1. Carbon dioxide emissions by fuels	Excel-table, YEAR, FUEL, mil. T CO2	http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2015/html/suom0011.htm	30.8.2016
16	2.8 Renewable energy sources	Excel-table, YEAR, SOURCE, TJ, SHARE OF RENEWABLE ENERGY IN TOTAL ENERGY CONSUMPTION %, ELECTRICITY	http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2015/html/suom0001.htm	30.8.2016

		GENERATION FROM RENEWABLES GWh, SHARE OF RENEWABLE ENERGY IN GROSS FINAL ENERGY CONSUMPTION (FINLAND'S TARGET: 38 % FOR 2020) %		
17	2.11 Heat pumps of residential, commercial and public buildings	Excel-table, YEAR, HEAT PUMP TYPE, QUANTITY, CAPACITY MW, PRODUCTION OF HEAT GWh, UDE OF ELECTRICITY GWh, TOTAL PRODUCTION AND RECOVERY HEAT GWh, USE OF ELECTRICITY GWh,PRIMARY ENERGY PRODUCTION GWh AND TJ	http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2015/html/suom0001.htm	30.8.2016
18	2.12 Solar energy	Excel table, YEAR, SOLAR POWER INSTALLED CAPACITY MWp, PRODUCTION OF SOLAR POWER MWh AND TJ, SOLAR COLLECTOR AREA $1000M^3$, PRODUCTION OF SOLAR HEAT TJ, SOLAR ENERGY TOTAL TJ	http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2015/html/suom0001.htm	30.8.2016
19	Fuel classification 2014	Excel-table, FUEL, FUEL SPECIFIC UNIT, CO2 DEFAULT EMISSION FACTOR (t/TJ)	http://tilastokeskus.fi/tup/khkinv/polttoaineluokitus_edelliset.html	30.8.2016
20	2.10 Recovered and waste fuels	Excel-table, YEAR, DIFFERENT TYPES, SHARE OF FOSSIL TJ, SHARE OF BIO TJ, TOTAL TJ,	http://pxweb2.stat.fi/sahkoiset_julkaisut/energia2015/html/suom0001.htm	30.8.2016
21	1. Kasvihuonepäästöt Suomessa	e-database, Greenhouse gas emissions in Finland,	http://pxnet2.stat.fi/PXWeb/pxweb/fi/StatFin/StatFin__ymp__khki/?tablelist=t	1.9.2016

		EMISSION CLASS, GAS, YEAR, EMISSIONS 1000 t CO2-ekv.	rue	

Finnish Energy 1, ENERGY YEAR 2014 - DISTRICT HEATING, http://energia.fi/en/slides/energy-year-2014-district-heating, Published: 21.01.2015, Updated: 16.11.2015, [referred 24.8.2016]

Finnish Energy 2, ENERGY YEAR 2014 – ELECTRICITY, http://energia.fi/en/slides/energy-year-2014-electricity-0, Published: 21.10.2015, Updated: 21.10.2015, [referred 24.8.2016]

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