Client: Ministry of Economic Affairs and Employment

Project: Assessment of the potential for energy from renewable sources and waste heat in heating and cooling

AFRY
ÅF PÖYRY

Contact
Jenni Patronen
Mobile phone
+358 407544922
Email
jenni.patronen@afry.com

Contact
Heidi Uimonen
Mobile phone
+358 406619229
Email
heidi.uimonen@afry.com

Date
9 December 2020

Client
Ministry of Economic Affairs and Employment

Assessment of the potential for energy from renewable sources and waste heat in heating and cooling

Copyright © 2020 AFRY Management Consulting Oy

All rights reserved

This report has been prepared by AFRY Management Consulting Oy (AFRY) for the Ministry of Economic Affairs and Employment (”Client”). The report has been prepared in accordance with the terms and conditions of the contract between AFRY and the Client. AFRY's liability relating to or arising out of this report is determined solely on the basis of the contractual terms.

In AFRY's view, the information in this publication is accurate and justified. Nevertheless, any party interpreting or using this report must exercise their own judgment and professional knowledge in the application of the information in it. This report is partly based on information that is beyond AFRY's control. Therefore, AFRY makes no representation or warranty, expressed or implied, as to the accuracy or completeness of the information or estimates provided in this report or any other representation or warranty whatsoever concerning this report. Pöyry disclaims any and all liability arising out of or relating to the use of this report by third parties, or for any indirect or consequential damages.

Contents

1 Background to the assignment

Article 14(1) of the EU Energy Efficiency Directive requires Member States to prepare a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling. According to Article 15(7) of the EU Renewable Energy Directive 2018/2001/EU, Member States must carry out an assessment of their potential of energy from renewable sources and of the use of waste heat and cold in the heating and cooling sector. That assessment must, where appropriate, include spatial analysis of areas suitable for low-ecological-risk deployment and the potential for small-scale household projects and shall be included in the second comprehensive assessment required pursuant to Article 14(1) of Directive 2012/27/EU.

The purpose of this report is to provide additional information for the assessment relating to the EU Energy Efficiency Directive for national reporting. The report describes, at a general level, assessments of the demand for renewable energy and its likely potential as well as major constraints. The report is mainly based on statistics and public sources.

2 Potential for energy from renewable sources

The main sources of renewable energy whose use for heat production could be increased in Finland are biomass and geothermal energy. This chapter assesses the potential for biomass and geothermal energy in Finland’s heating and cooling system. The assessment for both takes demand into account, with maximum demand assessed first, and then production potential in relation to that.

According to the assessment, the potential use of biomass could be a maximum of around 60 TWh in 2030, a level which is not limited by the theoretical availability of biomass in Finland. The theoretical potential of both ground heat and geothermal heat exceeds Finland’s heating energy need several times over, but this potential is currently largely untapped.

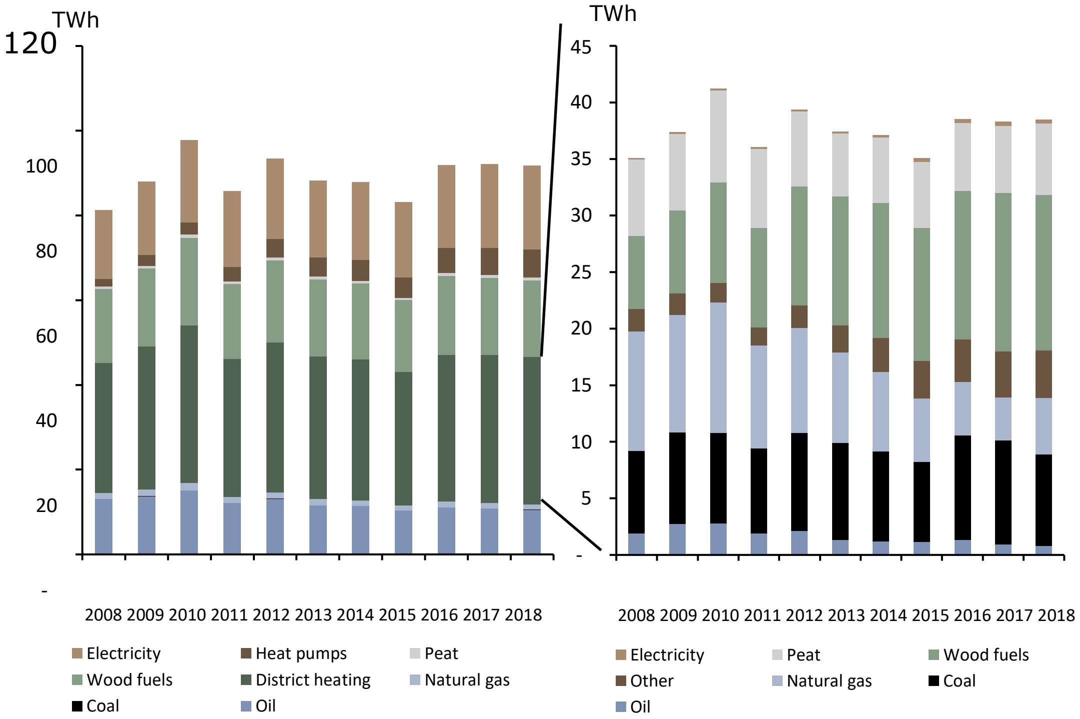
2.1 Potential for biomass

Demand for biomass

In this report, the maximum demand for biomass for property heating and industrial heat generation is assessed based on the amount of heat produced from incineration and the need up to 2030. The demand estimate is at a very rough level, based on the heating need forecasts provided by the Ministry of Economic Affairs and Employment, Statistics Finland’s data and other reports. In the assessment of maximum demand, it is assumed that current biomass energy use will continue and the additional potential is based on fuel changes in boilers to replace peat, for example, and new installations that use biomass to replace fossil fuel and peat. Overall, this report aims to outline the potential maximum demand for biomass in Finland in the current type of energy production and industrial production structure.

The use of solid biomass increased between 2008 and 2018 in the total for heating consumption (Figure 1). Biomass use in property-specific heating amounted to 18 TWh in 2018, while the total energy need of buildings for heating in 2018 was 92 TWh. A total of 12 TWh in fossil fuels, mainly oil, was used in property-specific heating. In 2018, district heating production consumed 38.5 TWh in fuels, of which some 36% was biomass and some 36% was fossil fuels.

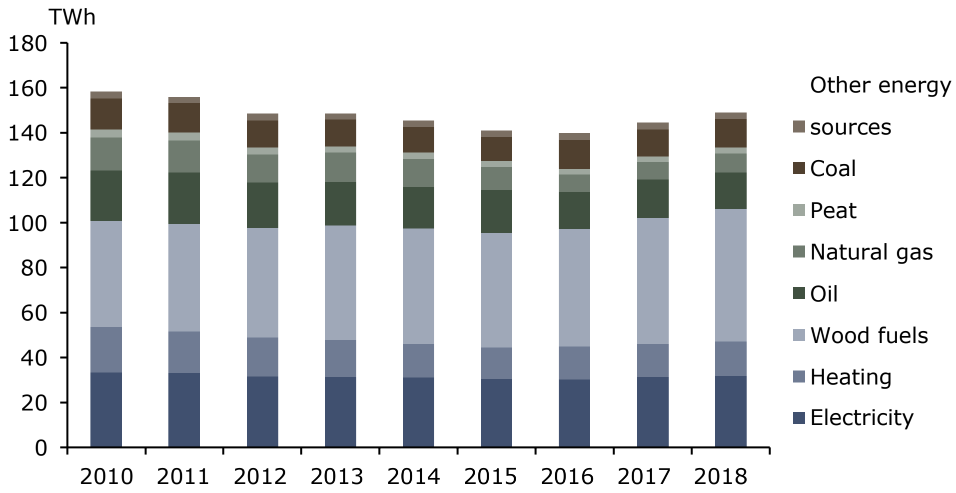
Figure 1: Building heating and district heating production by energy consumption source 2008–2018



Source: Statistics Finland

Total energy use in industry in Finland amounted to 149 TWh in 2018, with the forest industry being the largest industrial energy user with a share of 58%. In 2018, wood fuels accounted for 40% of all industrial energy use (Figure 2). In 2018, around 21% of the energy used was electricity, 10% was externally purchased heat and the rest consisted of other energy sources, which were used for the production of electricity and heating in industrial installations. The share of fossil fuels in heating in industry is decreasing and is expected to decrease further.

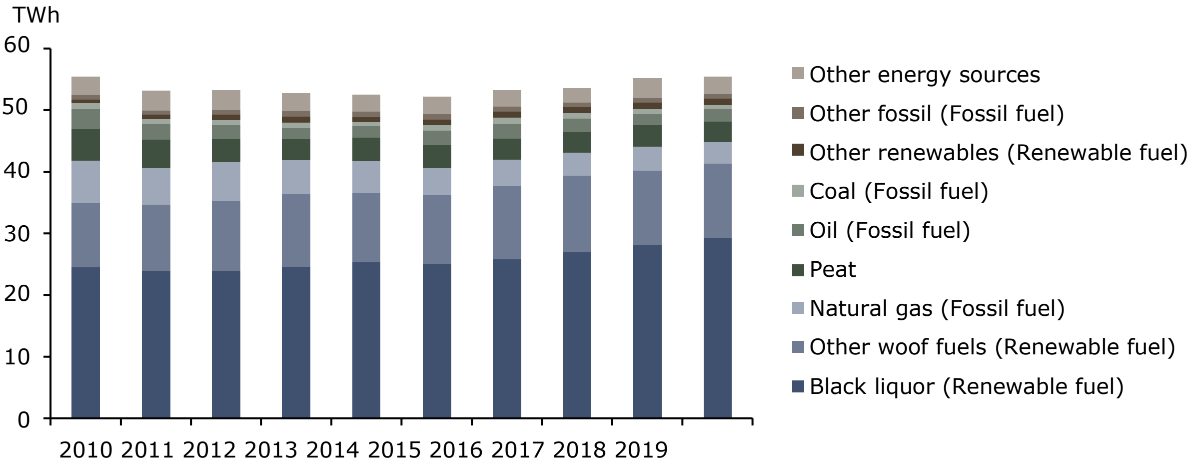
Fig. 2: Energy use in industry by energy source 2010–2018



Source: Statistics Finland

Heat generation in the industrial sector has remained relatively stable in the last decade, amounting to some 55 TWh in 2018 (Figure 3). Over 75% of heat generation is produced using renewable energy sources. The share of fossil fuels was 19%. The main renewable energy source is black liquor, which is generated in the forest industry.

Figure 3: Industrial heat production by energy source 2010–2019



Source: Statistics Finland

The total use of biomass for property-specific heating, district heating production and industrial heat production was 53.3 TWh in 2018.

Availability of biomass

Overall, this report aims to outline the potential for solid biomass in Finland in the current type of energy production and industrial production structure. In 2019, the use of solid wood fuels in heat and power plants amounted to approximately 36 TWh (Table 1). According to AFRY's estimate, the additional potential for solid biomass would be around 10 TWh in 2030, which raises the total potential of solid biomass to about 46 TWh by 2030. The additional potential is based on the assumption that industrial timber harvesting will remain at the level of 2019. The harvesting potential of low-grade timber is taken into account in accordance with the roundwood removal estimates of Natural Resources Institute Finland. The additional potential does not take into account possible changes in the production volumes and production structures of the forest industry, and the by-product supply is assumed to remain at the level of 2019. The additional potential related to imported timber is not taken into account in this report.

Table 1: Solid biomass use in heat and power plants in 2019 and estimate of additional potential by 2030, TWh

	TWh (2019)	**TWh (2030)**
Forest chippings, total	15.1	15.1 + 10
Forest industry by-products, total	21.2	21.2
Biomass used for heating, total	**36.3**	**46.3**

Source: Statistics Finland, AFRY

The cost and environmental factors associated with the purchase of biomass affect the availability of biomass and how much of it is used. The estimated potential consists of energy wood fractions gathered from the forest as forest residues (such as branches and timber unfit for industrial use), low-grade timber gathered from thinnings and forest industry by-products (mainly shavings and bark).

The use of stumps is not included in the aforementioned potential. The use of stumps has decreased significantly in recent years, partly due to the emphasis on environmental values in forestry.

The trend in the price development of biomass affects its competitiveness as a fuel, which is ultimately reflected in the price of the heat generated from it. As the price of district heating increases, alternative heat production methods will become more competitive and attractive in the heating sector. In addition to the domestic supply of biomass, supply can be increased through import markets. The main wood biomass import markets for Finland are currently Russia and the Baltic countries. The potential for imported biomass is not assessed in this report.

Natural Resources Institute Finland estimates that the maximum sustained timber yield would be 79 million m3 in 2030 (Table 2). Timber yield refers to the timber available for the forest industry. Energy wood yield refers to fractions used for energy, such as logging residues and low-grade timber. Natural Resources Institute Finland has estimated that the energy wood yield would be 48 TWh in 2030.
The energy wood yield estimated by Natural Resources Institute Finland does take into account industrial by-products, but does include stumps. Furthermore, the energy wood yield estimate of Natural Resources Institute Finland is based on the assumption that the timber yield would be fully utilised. In reality, the realised logging volumes of industrial wood determine the usable logging residue potential. Due to the different calculation method and assumptions, Natural Resources Institute Finland's estimate cannot be directly compared to AFRY's estimate of 25 TWh in 2030.

Table 2: Maximum sustained timber and energy wood yield

	2016–2025	**2026–2035**	**2036–2045**
Timber yield volume 1 000 m3 per year	74 595	79 001	79 531
Total volume of energy wood yield 1 000 m3 per year	19 373	23 783	24 424
Energy wood yield TWh	39	48	49

Source: Natural Resources Institute Finland (Luke) 2020

Note: The energy wood yield includes stumps, branches, tree tops and stemwood classified as energy wood. The energy wood yield does not include import or industrial by-products such as bark and shavings).

2.2 Potential for geothermal heat

The theoretical potential for both ground heat and geothermal energy exceeds Finland's heating energy need several times over[1]. According to Geological Survey of Finland GTK, the total theoretical energy potential for the uppermost 300 metres of the earth's crust in Finland is around 300 000 TWh, equivalent to nearly a thousand times the total energy consumption in Finland[2]. Geothermal energy is thermal energy that can be used directly for the production of district heating.

Currently, geothermal energy projects are still largely at the development stage, and only a fraction of the usable geothermal energy is being used in Finland[3].

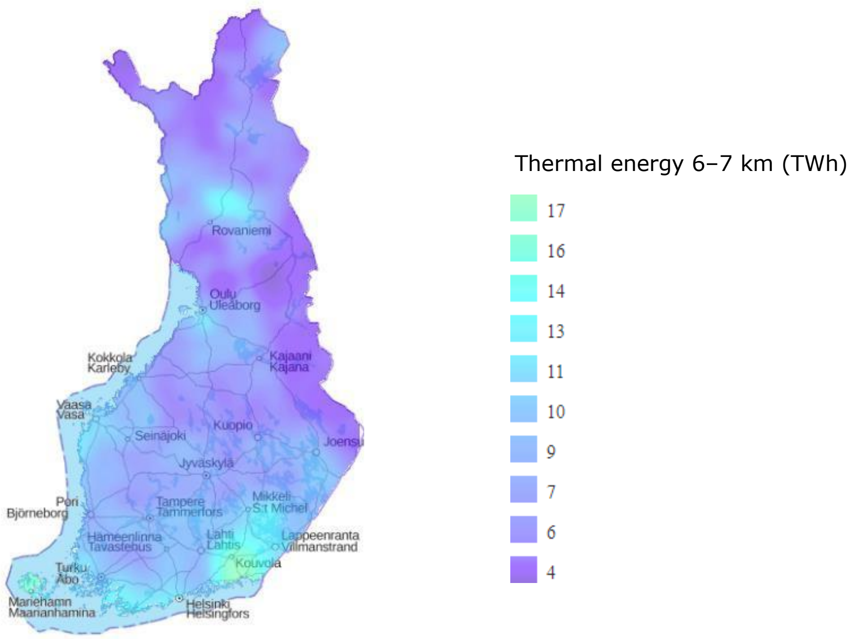
1 GTK geoenergy customer service team
2 GTK. Geoenergian ja geotermisen energian potentiaalikartoitukset: Suomessa on valtava puhtaan energian varasto. (Assessments of geoenergy and geothermal energy potential: Finland has a vast reserve of clean energy.) Available at https://www.gtk.fi/geoenergian-ja-geotermisen-energian-potentiaalikartoitukset-suomessa- on-valtava-puhtaan-energian-varasto/
3 Helen. Geolämmössä paljon mahdollisuuksia. (Many opportunities in geothermal heat.) Available at https://www.helen.fi/helen- oy/vastuullisuus/ajankohtaista/blogi/2020/geolampo

Geothermal energy projects are based on both medium-deep and deep energy wells. St1's Deep Heat pilot project for a deep energy well in Otaniemi will soon be launched, with a plant that can generate 40 MW of energy, or 200 GWh/a. The well reaches a depth of 6.4 kilometres. Fortum will purchase the heat produced by the geothermal heating plant for its district heating network. Other projects are under way in Finland in Koskelo, Espoo, in Kolho, Mänttä-Vilppula, and in Nekala and Hiedanranta in Tampere; of these, QHeat's plant in Koskelo is already operational with an instantaneous power of 500 kW.[4] Large projects such as St1's are still at the letter of intent stage.

It is estimated that the production potential for geothermal energy will be around 2 TWh by 2030. The estimate is based on the assumption that, by 2030, there would be a few plants like Deep Heat, more suitable for use in large cities due to the higher production level, and several medium-deep geothermal wells. The estimate is rough and takes into account the change in energy production needs and the development in drilling capacity by 2030. The estimate is in line with Finnish Energy's low-carbon roadmap[5].

Operational experiences will determine the future of deep geothermal energy in Finland. Geothermal heat is still a very uncertain area with regard to technological functionality and costs, for example. However, the Deep Heat project has had a considerable impact on the drilling sector. The project has involved developing drilling technology, introducing medium-deep (1–3 km) geothermal wells into the industry. The cost structure of a medium-deep geothermal well is considerably lighter compared to deeper wells, but it is not yet entirely competitive as an investment. State support will have an impact on the use of geothermal energy by 2030[1].

Figure 4: Geothermal heat potential at a depth of 6–7 kilometres[6]



2.3 Potential for ground heat

Property-specific heating uses ground heat obtained with heat pump technology and heat obtained from outdoor air with air-water and air-source heat pumps.

---

4 Yle. Suomen ensimmäinen geolämpölaitos käynnistyi. (Finland's first geothermal plant launched.) Available at https://yle.fi/uutiset/3-11158359

5 Finnish Energy Low carbon roadmap 2020. Available at https://energia.fi/files/4943/Finnish_Energy_Low_carbon_roadmap_FINAL_2020-06-01.pdf

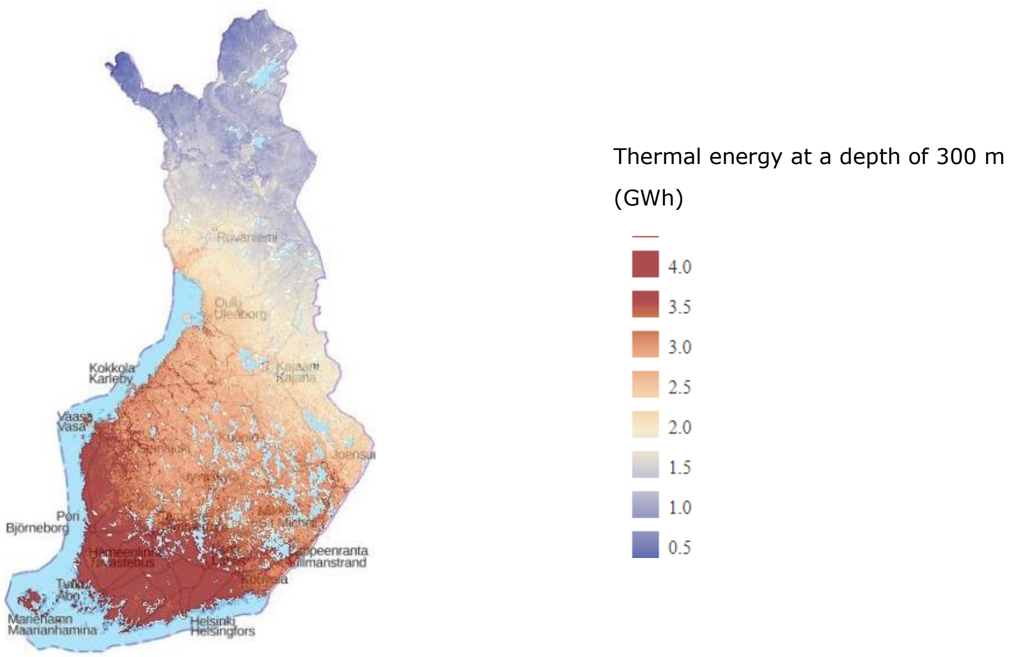
6 Source: Geological Survey of Finland GTK. The map service can be accessed at http://gtkdata.gtk.fi/Maankamara/index.html

Ground heat is usually obtained by drilling an energy well 100–300 metres deep. According to Statistics Finland, the amount of heat generated by ground-source heat pumps in residential and service buildings has increased in the past decade, reaching a level of 380 GWh in 2000 and 3.6 TWh in 2018. In 2018, heat pump energy, which statistically includes both ground heat and air-water heat pumps, covered about 8% of properties' heating needs[1]. In Sweden, ground-source heat pumps produced about 10% of the heat required by properties in 2018. Increasing the use of ground heat depends essentially on how many of the remaining oil-heated properties switch to ground heat by 2030. Phasing out oil heating is described in more detail in Chapter 5.

If the growth rate of ground-source energy can be assumed to continue, AFRY's rough estimate is that 11 TWh of ground heat could be used in property-specific solutions in 2030. The estimate of the energy generated by ground-source heat pumps in 2030 is based on the assumption that the production of ground heat will increase by 9.8% per year in the 2020s. This is the same annual growth rate as the average growth in energy generated by ground source heat pumps in the period 2010–2018. The popularity of ground source heat pumps has been on the increase in Finland, as properties are transitioning away from other heating methods, such as oil heating, and the installation of ground source heat pumps has been subsidised. Transitioning from oil heating is described in more detail in Chapter 5. New properties are increasingly being fitted with ground source heat pump systems.

The growth in energy generated by ground heat may be limited by the long intervals between changing the heating method, as the transition is typically made in connection with a major renovation. The rapid increase in the use of ground heat may be constrained by drilling capacity. The use of ground heat may also be restricted by groundwater areas, which are described in more detail in Chapter 4.

Figure 5: Potential for ground heat at a depth of 300 metres[6]



3 Potential for the use of waste heat and cold in the heating and cooling sector

This chapter presents the potential for property-specific waste heat, which can be found in properties both in the groundwater and exhaust air. The property-specific waste heat potential was estimated through the potential of exhaust-air heat pump systems in residential buildings. The potential for waste cold is described as a qualitative assessment.

3.1 Potential for waste cold

The waste cold potential in Finland is considered to be very small. In industrial cooling, cold escapes through various surfaces, which means that the waste cold is technically very difficult to recover. The amount of waste cold could possibly be reduced with better insulation. In industrial processes requiring cooling, the recovery of waste energy focuses on waste heat. The temperature and technology of the coolant circuit for cooling do not easily allow the separate use of cold energy. In heating-cooling processes, such as the pasteurisation and recooling of milk, the sector is more commonly concerned with the use of waste heat or improving energy efficiency with heat recovery rather than utilising waste cold

Given conditions in Finland, free cooling has a far greater potential. Free cooling means that cold ambient temperatures are used for industrial cooling so that the process does not require the use of a compressor.

The potential for waste cold for cooling buildings is also negligible in practice, as cooling is still very rarely used in Finland. In district cooling, for example, utilisation is related to district heating production using the thermal energy of the cooling network, which could be counted as the use of waste heat.

3.2 Potential for waste heat in district heating

As regards district heating, the potential for waste heat is described in AFRY's report Overview of the potential for waste heat and cost-benefit analysis of efficient heating in accordance with the Energy Efficiency Directive[7].

3.3 Potential for waste heat in property-specific heating

Waste heat from buildings consists mainly of sewage water and exhaust air heat, which can be examined to assess the amount of waste heat in properties. Exhaust-air heat pump systems using heat recovery (EAHP systems) have become more common especially in blocks of flats built between 1960 and 1990[8]. The same properties are often also connected to district heating, and the system significantly reduces the consumption of district heating.

In this report, the examination of waste heat from buildings focuses on the potential of exhaust-air heat pumps, and their total potential is assessed on the basis of the building stock and the energy recovered in the example properties. The total potential for property-specific waste heat is based on VTT Technical Research Centre of Finland's report Poistoilmalämpöpumput kaukolämpöjärjestelmässä (Exhaust air heat pumps in district heating systems)[8]. The assessment of the potential of property-specific waste heat uses Statistics Finland's data on buildings and their heating methods.

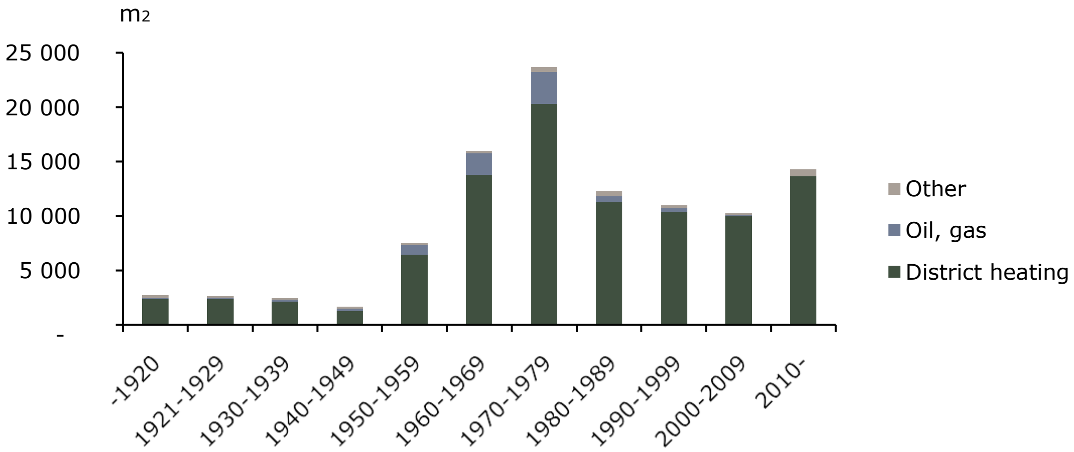
---

7 AFRY, Overview of the potential of waste heat and cost-benefit analysis of efficient heating in accordance with the Energy Efficiency Directive, 2020, https://tem.fi/documents/1410877/2897650/EEDselvitys+l%C3%A4mmityksest%C3%A4_loppuraportti+2020.pdf/88a0e63b-e2b6-eef9-1b4c-8c5411a0e531/EEDselvitys+l%C3%A4mmityksest%C3%A4_loppuraportti+2020.pdf?t=1601627038073

8 VTT Technical Research Centre of Finland 2015. Poistoilmalämpöpumput kaukolämpöjärjestelmässä (Exhaust air heat pumps in district heating systems). Available at https://www.vttresearch.com/sites/default/files/julkaisut/muut/2015/VTT-CR-00564-15.pdf

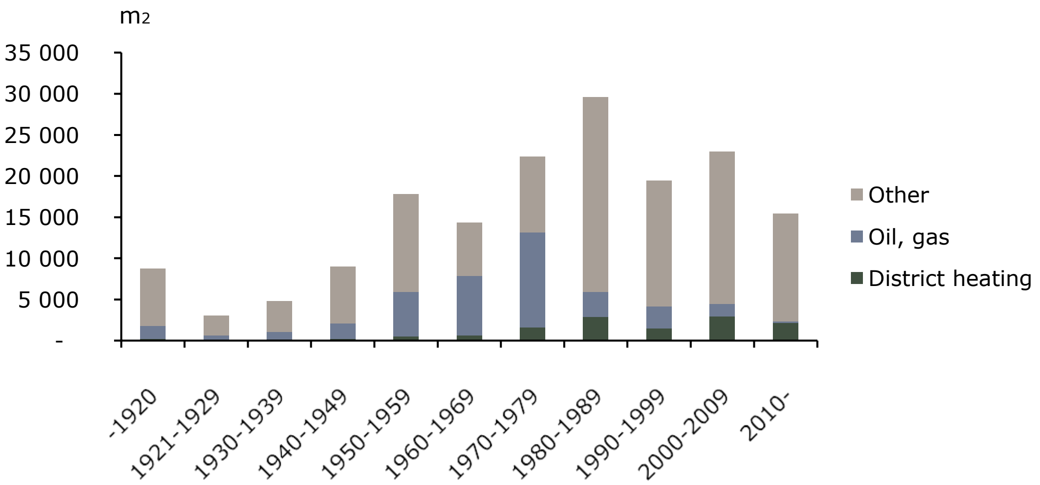
The potential for waste heat recovered in Finland by means of exhaust-air heat pump systems was assessed by establishing the total floor area of residential buildings connected to district heating and other heating methods and using the specific consumption of buildings in VTT's study. Buildings completed after 1990 and connected to district heating have a low specific consumption reflecting their better energy efficiency, which reduces the potential for heat recovered from exhaust air. Figure 6 shows the total floor area of blocks of flats by heating method and construction year. Figure 7 shows the total floor area of detached houses by heating method and construction year.

Figure 6: Floor area of blocks of flats by heating method and construction year



Source: Statistics Finland

Figure 7: Floor area of detached houses by heating method and construction year



Source: Statistics Finland

Table 3 presents the calculated waste heat potential for heat recovered from exhaust air. The utilisation of heat from exhaust air reduces the amount of heat needed from district heating or other heating systems. The reduction in buildings connected to district heating after the installation of exhaust-air heat pumps is expected to bring savings of 50% in heating energy. For other heating methods, the assumed savings of an exhaust air system is 30%.

Exhaust-air heat pumps can considerably reduce the need for heating, and the potential of heat from exhaust air might be as high as 13 TWh, if 80% of buildings were fitted with an EAHP system.

Table 3 Potential for waste heat from exhaust air in residential buildings

Assumed proportion of built area with EAHP system installed	Amount of waste heat from exhaust air in residential buildings with district heating (GWh)	Amount of waste heat from exhaust air in buildings heated using other heating methods (GWh)
10%	868	784
20%	1 735	1 587
30%	2 603	2 381
40%	3 471	3 174
50%	4 339	3 968
60%	5 206	4 761
70%	6 074	5 555
80%	6 942	6 348

Source: Statistics Finland, VTT Technical Research Centre of Finland, AFRY

It should be noted, however, that this report only very roughly assesses the potential for exhaust air heat in property-specific heating, and the potential for using the heat from sewage water, for example, has not been calculated. Neither does the report assess the utilisation rate of exhaust air in buildings of different ages at a detailed technological level.

4 Spatial analysis of areas suitable for the low ecological risk deployment of energy from renewable sources

The greatest location-related ecological risk with the utilisation of renewable heating technologies is related to ground heat and geothermal heat. Groundwater aquifers may restrict their potential for use in some areas, as the risks involved in well drilling include the contamination of groundwater due to surface water runoff or changes in groundwater flow, for example. Figure 8 presents Finland's groundwater areas. Just under 4% of Finland's land areas are groundwater areas[9]. The areas are typically located in the vicinity of sandy eskers. The Salpausselkä ridge system extending from Joensuu to Hanko, in particular, passes through a number of towns. Of the 57 permit applications for geothermal heat wells submitted to the Regional State Administrative Agencies in 2014–2019[10], 80% were rejected or withdrawn[11]. In the future, geothermal heat wells will likely not be planned in groundwater areas, as the rejection decision published in the Supreme Administrative Court's Yearbook 2019 states that the wells pose a significant risk to groundwater quality[12]. Groundwater-related restrictions are usually very local, however, and it is difficult to assess how great a restriction groundwater areas impose on the potential for using ground heat throughout Finland.

[9] Finnish Environment Institute
[10] Geothermal heat wells require an action permit from municipal building control. In the case of groundwater areas, the permit application may be forwarded for a decision to the Centres for Economic Development, Transport and the Environment (ELY Centres) and on to the Regional Sate Administrative Agencies.
[11] Energiakaivot ja pohjavesi (Energy wells and groundwater), Juha Helin, Regional State Administrative Agency for Southern Finland, presentation 30 January 2020. https://docplayer.fi/181043468-Energiakaivot-ja-pohjavesi-luvittajan-nakokulmasta-juha-helin-esavi.html
[12] Supreme Administrative Court case KHO:2019:37 (Turku)

Figure 8: Finland's groundwater areas[13]

The use of oil involves ecological risks especially relating to oil spills. Oil may be required as a start-up fuel in installations using biomass, and peak power plants may use bio-oil. The possibility of oil spills can be prevented by leak protection measures, and the use of oil does not significantly restrict the use of renewable energy. However, the locations of new installations are considered carefully due to the presence of groundwater areas, among other factors. Local restrictions do not, however, restrict the total potential for installations using biofuels.

The construction of new heating and cooling installations may involve risks to the habitats of endangered species. The risks depend on the case, and, overall, they do not significantly limit the use of renewable energies for heating in Finland.

5 Potential for small-scale household projects

Small-scale household projects under the REDII Directive are interpreted here as changing the heating method of a detached house. Detached houses have a significant potential for increasing the share of renewable energy in heating by replacing oil or gas heating with heating methods based on renewable energy. Detached houses may switch their heating method to a more cost-effective one, such as ground source heat or air-water heat pumps. It should be noted, however, that the total investment required to change the heating method may make people less willing to replace an oil- or gas-based heating solution. This supplementary report does not take into consideration the share of renewable fuels in energy production.

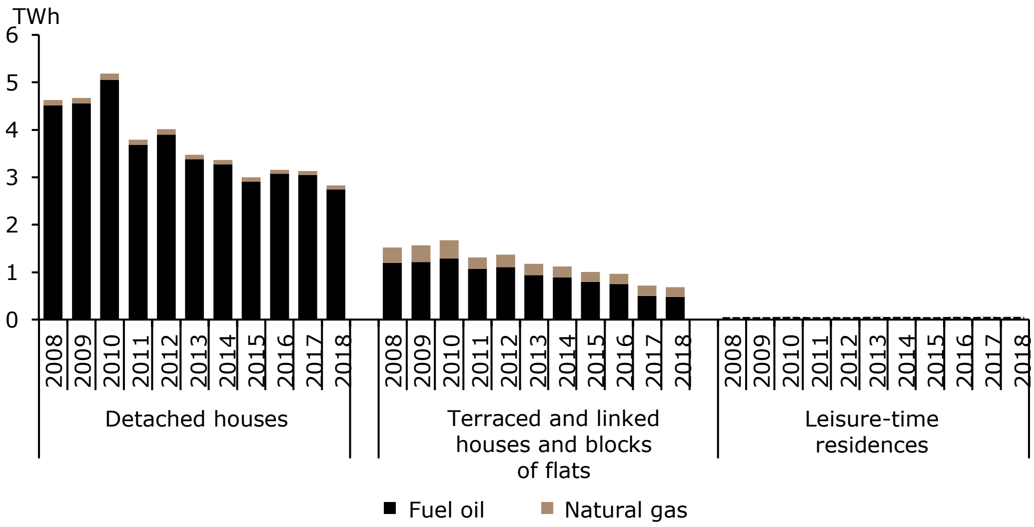
---

13 Source: Finnish Environment Institute. The map service is available at https://kartta.paikkatietoikkuna.fi/, where the groundwater-related map layer options can be found under the Geology map layer options.

Oil heating in households and phasing out oil heating

Oil, coal and natural gas constitute the fossil-based property heating fuels. Of the fossil duels, coal is negligible, as it only accounts for 0.3%. The overall shares of oil and natural gas heating in the context of the total energy need for heating residential buildings are also small compared to other energy sources. In 2018, oil heating only accounted for 8% of the total energy need of detached houses. In terraced and linked houses and blocks of flats, the share was 2%, and in leisure-time residences, it was 2%. In 2018, gas heating only accounted for 0.2% of the total energy need of detached houses. In terraced and linked houses and blocks of flats, the share was 0.9%, and in leisure-time residences, it was 0.03%. In 2018, the total need for oil and gas for the heating of residential buildings was 3.6 TWh, of which oil accounted for 3.3 TWh. Figure 9 shows the figures for oil and gas heating in residential buildings by building type.

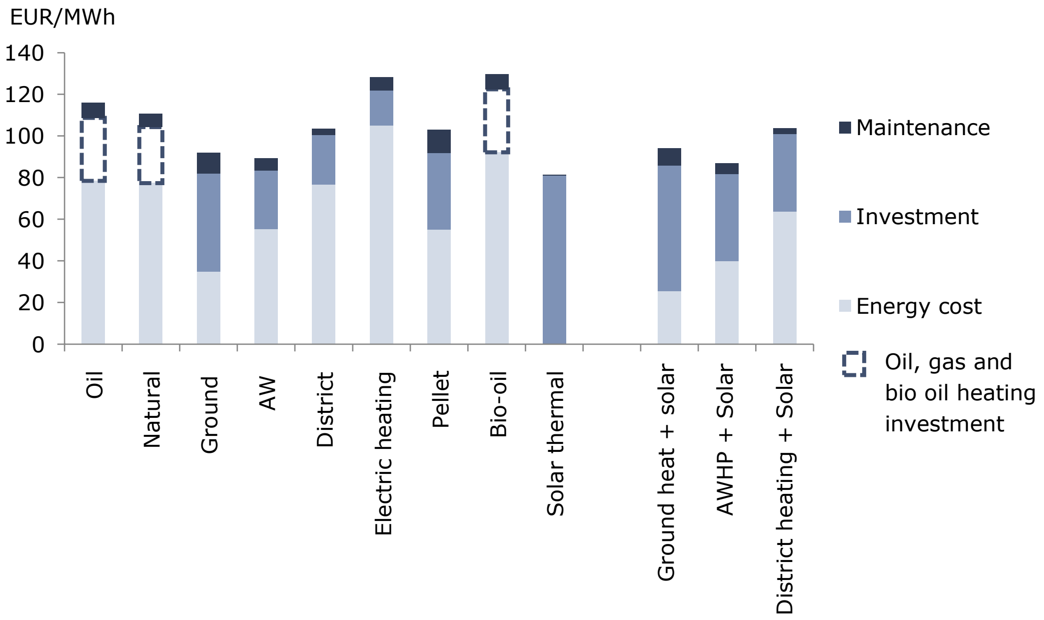
Figure 9: Heating of residential buildings with fuel oil and natural gas by building type 2008–2018



Source: Statistics Finland

Heating technologies in detached houses include oil heating, gas heating, district heating, ground heat, air-water heat pumps, bio-oil heating, pellet heating, electric heating, solar thermal, and hybrids consisting of solar thermal and other heating technologies. A comparison of the costs of different heating methods employs LCOE (levelised cost of energy) calculation, where different heating methods are assigned mutually comparable production prices (EUR/MWh), including variable costs (such as fuel or electricity costs and the associated taxes) and investment costs. The calculations take into account capital costs incurred when the entire heating system is replaced. Figure 10 presents the costs of alternative heating solutions for detached houses.

Fig. 10: Costs of alternative heating solutions for detached houses



Notes: The LCOE values do not include VAT. The example building is a detached or semi-detached house with an annual energy need of 18 MWh. Lifetime is modelled as 20 years in the LCOE calculation, and the WACC value is 3%.

AWHP and solar thermal technologies require a backup system, which is not taken into account in the LCOE calculation for the respective technology. Hybrid forms of solar thermal and other heating technologies take the required backup capacity into account.

The price assumptions are EUR 97.3 per MWh for oil, EUR 44.0 per MWh for electricity and EUR 47.7 per MWh for the electricity network charge. Investment costs indicated with a dashed line refer to oil, gas and bio-oil heating investments, which are not needed in properties already equipped with an oil heating system.

Source: AFRY, Finnish Energy, Nordpool, Statistics Finland, technology suppliers

On the basis of the LCOE calculations, switching from oil heating to other heating methods is often a cost-effective alternative in detached houses, if the investment costs of oil heating are also taken into account. Oil-heated detached houses are often outside built-up areas, which means that joining district heating may not be an option. Of renewable energy sources, pellet heating, air-water heat pumps and ground-source heat pumps have lower costs than oil heating. Bio-oil heating is more expensive than ordinary oil heating, as the fuel costs are higher. If there is no need to replace the oil boiler, switching to bio-oil could be a more attractive option than other renewable energy heating methods. The availability of bio-oil for heating is currently very limited. If the investment costs of oil heating are not taken into account, the costs of other heating methods are higher than the fuel and maintenance costs of oil heating.

Adding solar thermal heating to the heating methods may lower overall costs, but the more heating needs solar thermal heating can cover and the larger the collector area, the greater is the benefit of its addition. Solar thermal heating has a low LOCE value, as there are no energy costs. It should be taken into account, however, that solar thermal energy requires backup capacity, as there is practically no solar thermal heat available during the heating season. This backup capacity must be another heating system, such as district heating, which increases the total costs. Air-water heat pumps also require backup capacity.

Households usually also consider the property’s value trend when changing heating methods. In sparsely populated areas, for example, the total investment involved in replacing oil heating with a ground-source heat pump may be considerable relative to the value of the property, which makes the change of heating method less attractive.

In (semi-)detached houses with oil heating, economical forms of renewable energy to switch to include ground heat, AWHP technology or pellet heating, if the oil heating system has reached the end of its service life and requires new investment. Adding solar thermal heating reduces the relative production price, but the benefit will be greater in larger properties with a greater need for energy than detached houses.

In 2018, oil consumption in the heating of residential buildings was the equivalent of 3.3 TWh, which can be entirely generated with renewable energy.