IEA-Advanced Motor Fuels
ANNUAL REPORT 2015

FINLAND

Finland

Introduction

In 2014, the total consumption of energy in Finland amounted to 1,350 petajoules (PJ) (about 32 million metric tons or megatonnes of oil equivalent [Mtoe]; about 374 terawatt hours [TWh]), which was approximately 2% less than that in 2013. The energy mix in Finland is well balanced, including contributions from wood fuels, oil, natural gas, coal, nuclear energy, and hydropower (Figure 1).[1] Greenhouse gas (GHG) emissions from the whole energy sector were 44.4 million tonnes of carbon dioxide equivalents (CO_2e) in 2014 (−8% when compared to 2013), when the total GHG emissions in Finland were 59.1 million tonnes of CO_2e.[2]

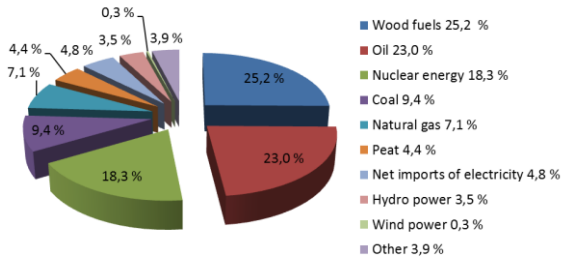

Fig. 1 Total Energy Mix in Finland in 2014[36]

The share of renewable energy of total energy consumption increased in 2014 and stood at 33%. European Union (EU) targets for renewable energy are calculated relative to total final energy consumption; calculated in this manner, the share of renewable energy was 39%. Wood fuels represented the majority of the renewable energy, about 25% of total energy used. In Finland, wood-based fuels are used for heat and power production for industry, and for municipalities in general. In addition, peat is used for energy purposes (+5% from 2013), and wood is used to heat small houses.[36]

Finland is a sparsely populated country with long (transportation) distances. Energy use for transportation work per capita, for both people and goods, is among the highest in the world. Transportation consumed about 174 PJ of Finland's primary energy in 2014, which was about 13% of the country's

[1] http://www.stat.fi/til/index_en.html → Energy supply and consumption.
[2] http://www.stat.fi/til/index_en.html → Environment and natural resources → Greenhouse gases.

total energy consumption (Figure 2) for that year.[3] The GHG emissions from the domestic transportation sector were 11.1 million tonnes CO_2e in 2014. About 94% of the GHG emissions in the transportation sector were caused by road traffic (56% from passenger cars, 38% from vans and trucks, and the rest from busses/coaches, motorcycles, etc.).[38]

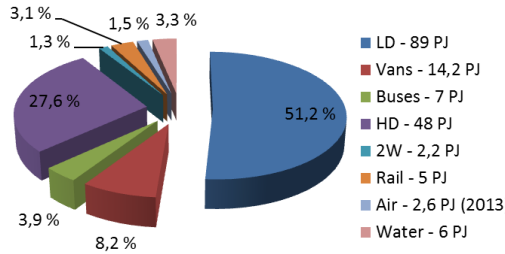

Fig. 2 Energy Consumption in Finnish Transportation Sectors in 2014[38] (The values have changed from previous years due to the renewal of LIPASTO; the data are now reported according to the international reporting system.)
(Sources: Figure by Roslund; data by LIPASTO, Mäkelä)

Table 1 presents the main types and numbers of vehicles in Finland as of December 2014, according to Trafi, the Finnish Transport Safety Agency. The size of the vehicle fleet that was registered totaled about 4.9 million vehicles (including nonroad vehicles and excluding all registered trailers), and the number in use amounted to about 4.0 million (including nonroad and excluding all registered trailers).

Table 1 Types and Numbers of Vehicles Registered (in Use) in Finland, December 2014, according to Trafi[a]

Passenger Cars	Vans	Trucks	Buses	Two-Wheelers	Other Vehicles	Nonroad
3,173,000 (2,596,000)	400,000 (304,000)	137,000 (95,000)	16,000 (12,000)	565,000 (434,000)	45,000 (26,000)	601,000 (537,000)

[a] There were about 474 passenger cars per 1,000 inhabitants in use (about 580 were registered). A share of about 25% of the passenger cars in use were diesel passenger cars.

The number of vehicles using alternative fuels in Finland in 2014 was still quite small. There were about 3,400 flex-fuel vehicles (FFVs) capable of using high-concentration ethanol fuel (E85), and about 1,900 methane gas

[3] http://lipasto.vtt.fi/en/index.htm.

vehicles that used only methane (natural gas or biomethane), or that were bi-fuel gasoline/methane vehicles. The number of electric vehicles (EVs) was 1,600.

Policies and Legislation

The new Finnish Government started its 4-year term in May 2015. Under its Government Programme, it announced that Finland's target will be to increase its share of sustainable, emission-free, renewable energy so that in the 2020s its share will be more than 50%, and the energy self-sufficiency will be more than 55%. In addition, the use of fossil oil should be cut in half; the target is to have a 40% share of renewable energy in transport by 2030. The Government also published five strategic priorities in the Government Programme. One of which is "Bioeconomy and Clean Solutions," consisting of five key projects, of which, one, in particular, "Towards carbon-free, clean and renewable energy cost-efficiently," is related to bioenergy.

In Finland, a national law requires that fuel distributors provide biofuels to the market. The target is 6% for 2011–2014, then it increases incrementally to 20% (share of energy) in 2020 (Figure 3).

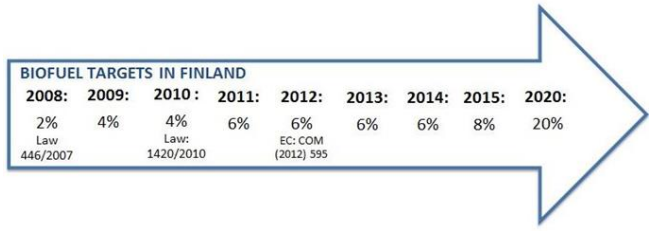

Fig. 3 Biofuel Laws and Target Energy Shares in Finland

The actual share of biofuels in 2014 was 12.3 % (energy share). Taking into account double-counting according to Directive 2009/28/EC, the share of biofuels was as high as 23.5 %. Thus the target for 2020 was met already in 2014.

According to the current national energy and climate strategy, in 2020, GHG emissions from the transport sector in Finland would be approximately 11 million tonnes CO_2e (−15% compared to 2005). If the proposed EU's 2030 climate and energy packet is realized, GHG emissions from the transport sector in Finland in 2030 could at the most be 8 million to 9 million tonnes CO_2e (−35% to −40% compared to 2005).[4]

[4] https://www.tem.fi/files/42670/TEMjul_25_2015-web_01042015.pdf.

The directive 2014/94/EU on the deployment of alternative fuels infrastructure came into effect in the EU in October 2014.

In May 2015, the Finnish Ministry of Transport and Communications published a report *Alternative Fuels Infrastructure – A Proposal for a National Framework until 2020/2030*.[5] According to the report, the primary concern of the state in Finland should be to ensure that new technologies using alternative propulsion systems will be increasingly used in vehicles. In addition, attention must also be paid to the development of the so-called drop-in biofuel markets in Finland and the entire EU.

In June 2015, a study — "How to Reach 40% Reduction in Carbon Dioxide Emission from Road Transport by 2030: Propulsion Options and their Impacts on the Economy" — of the impacts of biofuels and other alternative energy sources in transport on climate gas emissions and on the economy was published.[6] Different options and their costs were compared when the target was to reduce CO_2 emissions in the transport sector by 30% to 40% by 2030 compared to the reference year 2005. In short, it was concluded that the most cost-efficient way to reduce emissions in Finland is to invest in the production and uptake of domestic, advanced drop-in biofuels as they do not require changes to the vehicle fleet or fuel distribution system. Biogas would also be a relatively cost-efficient option in Finland, but it would require a significant increase in the number of gas-fuelled vehicles.

Taxes

Table 2 summarizes all the taxes related to the transportation sector and fuels in Finland. The CO_2-based purchase tax has been an effective instrument in reducing CO_2 emissions from new passenger cars. From 1993 to 2014, the average CO_2 value dropped by 34% for gasoline passenger cars (approximately 127 g/km in 2014) and by 35% for diesel passenger cars (approximately 130 g/km in 2014). In 2015, the new Finnish Government decided to further gradually reduce the level of purchase taxes for new low-emission vehicles.

Table 2 Taxes in Finland Related to the Transportation Sector and Fuels

Tax	Based On	Comments
Fuel taxes	• Volumetric heat	• Low volumetric heating value of

[5] http://www.lvm.fi/-/vaihtoehtoisten-kayttovoimien-jakeluverkko-ehdotus-kansalliseksi-suunnitelmaksi-vuoteen-2020-2030-860050.

[6] VTT-R-00752-15.

	value • CO_2 emissions • Local emissions such as nitrogen oxides (NO_X) and particulate matter (PM)	biofuels is compensated for. • Biofuels are exempt from carbon component tax depending on wheel-to-wheel GHG emissions. • Bonus is given for paraffinic diesel and methane. • Biomethane is exempt from taxes.
Vehicle purchase tax	• Tailpipe CO_2 emissions	• Revised in 2015 • Minimum: 0 g/km CO_2 tax = 4.4% in 2016, 3.8% in 2017, 3.3% in 2018, and 2.7% from 2019 onward. • Maximum: 360 g/km CO_2 = 50% tax.
Annual vehicle tax	• Tailpipe CO_2 emissions or • A base tax and a "fuel-fee" tax depending on the energy source	• Minimum: 0 g/km CO_2 = €70 per year. • Maximum: 400 g/km CO_2 = €618 per year. • The annual "fuel-fee" tax for a 1,500-kg car is, for example, €301 for diesel, €82 for electricity, €170 for methane.

Research Programs

Special funds have been made available to stimulate research in and the demonstration of next-generation biofuels in Finland.

Smart Mobility Integrated with Low-carbon Energy, aka "TransSmart," is a research program that the VTT Technical Research Centre of Finland Ltd. started in 2013. TransSmart is a multidimensional framework for transportation-related research that enables the cooperation of private and public sectors for common goals. TransSmart focuses on four core areas: low-carbon energy, advanced vehicles, smart transportation services, and transportation systems.[7]

Tekes (the Finnish Funding Agency for Technology and Innovation) had a research program dedicated to EVs. The program, called EVE, ran from 2011 to 2015. The total volume involved in the EVE program was €100 million, with a contribution of €35 million from Tekes. The main target of the program was to create an electric mobility ecosystem that could

[7] http://www.transsmart.fi/transsmart/in_english.

generate new knowledge and competence in EV-related technologies and services.[8,9]

A 5-year project called LignoCat (lignocellulosic fuels by catalytic pyrolysis) funded by Tekes started in October 2013. In this project, the companies Fortum, UPM, and Valmet have joined forces to develop a new technology to produce advanced high-value, lignocellulosic fuels, such as transportation fuels or higher-value bioliquids. The idea is to develop catalytic pyrolysis technology for upgrading bio-oil and to commercialize the solution.

The energy company St1 Biofuels Ltd. and VTT signed a 2-year €1.2-million contract in autumn 2014 to start a development project to optimize the production process for wood-based bioethanol. The research project is part of Tekes' BioEthanol2020 (Green Growth) project, which aims to secure the competitiveness of the Finnish bio-economy.[10]

Implementation: Use of Advanced Motor Fuels

In 2014, the dominant fuels used in Finland were gasoline and diesel. The total consumption of gasoline and diesel was approximately 3.93 Mt, of which 38% was gasoline and 62% diesel. In 2014, the national biofuels obligation required 6% of biofuels (energy share) (Figure 3). In total, the contribution from alternative liquid fuels, including fossil fuel options, was around 556 kilotonnes of oil equivalent (ktoe). In 2014, the actual biofuel portion in the transportation sector was 12.3%. It is estimated that using different biofuels reduced GHG emissions by 1.5 million tonnes CO_2e in 2014.[11]

Ethanol is used on its own and as fuel ethers ETBE (ethyl tertiary-butyl ether) and TAEE (tertiary amyl ethyl ether). With regard to diesel, the bio portion mainly consists of hydrotreated vegetable oil (HVO)–type, paraffinic renewable diesel fuel. In 2014, the contribution to liquid fuels from biofuels fulfilling the EU's sustainability criteria amounted to about 495 ktoe. Table 3 shows the use of different road transportation fuels in Finland.

Table 3 Road Transportation Fuels Used in Finland in 2014

[8] http://www.tekes.fi/tekes/julkaisut1/eve--electric-vehicle-systems-2011-20152/.
[9] http://sahkoinenliikenne.fi.
[10] http://www.tekes.fi/en/programmes-and-services/tekes-programmes/green-growth/.
[11] http://www.stat.fi/til/index_en.html → Environment and natural resources → Greenhouse gases.

Gasoline (Mt)	Diesel[b] (Mt)	Ethanol and Ethers[c] (Total/Bio Portion[d]) (Mtoe)	Renewable Diesel[b] (Total/Bio Portion[d]) (Mtoe)	Natural Gas (Mtoe)	Biomethane (Mtoe)
1.5[a]	2.4	0.129/0.068	0.421/0.421	0.003	0.0009

[a] E10 = 0.91 Mt, E5 = 0.60 Mt, and E85 = 0.0072 Mt.
[b] Diesel contains mainly HVO as a renewable component in Finland.
[c] Ethanol is used partly as fuel ethers in Finland.
[d] Fulfills the EU's sustainability criteria according to Renewable Energy Sources Directive 2009/28/EC.

Source: Finnish Petroleum and Biofuels Association and Finnish Customs

Hydrotreated Vegetable Oils (and Fats)

HVO is currently the main renewable component in Finnish diesel fuel. NEXBTL, produced by Neste Corporation (formerly Neste Oil), is a renewable paraffinic diesel fuel. The EN590 specification for diesel fuel can be met with blends containing up to about 30% NEXBTL. Neste's worldwide NEXBTL production capacity was about 2 Mt/year in 2014. Production of NEXBTL is based on crude palm oil and different wastes and residues (e.g., waste animal fats, waste fish fats, and vegetable oil fatty acid distillates). In 2014, the percentage of waste and residues in NEXBTL production was 62% (52% in 2013). In Finland, Neste is marketing a premium diesel fuel, "Neste Pro Diesel," containing at least 15% NEXBTL.

The Finnish pulp and paper company UPM has built a biorefinery in Lappeenranta. The plant uses hydrotreatment to produce renewable biofuels from crude tall oil. UPM's biorefinery will produce approximately 120 million liters (L) (approximately 100 ktoe) of hydrotreated renewable diesel, UPM BioVerno. The commercial production of UPM BioVerno started in January 2015, and 10 vol% of the renewable diesel UPM BioVerno is currently blended with fossil diesel fuel. The blend is sold at St1 (Diesel Plus) and ABC (Smart Diesel) refuelling stations in Finland.

Fatty Acid Methyl Esters (FAME)

A minor amount, about 12 ktoe, of conventional esterified biodiesel (fatty acid methyl esters, i.e., FAME), was used in Finland in 2014. Rapeseed methyl ester (RME) has been produced on a small scale, mainly on farms.

Bio-ethers

Neste has processed ETBE since 2004. Also, methyl tertiary-butyl ether (MTBE) and tertiary amyl methyl ether (TAME) are currently produced at the Porvoo refinery. In 2014, about 64 ktoe of different bioethers, mainly MTBE, ETBE, and TAME, were blended in gasoline in Finland.

Bio-alcohols

In 2011, gasoline containing 10 vol% ethanol (E10) was launched in Finland. E10 sales in 2014 were around 60% of all the gasoline sold. Forty percent of all the gasoline sold was still E5 (5 vol% ethanol), even though the majority of gasoline cars are E10 compatible in Finland. High-concentration ethanol, E85, was sold at 110 refuelling stations, and about 3,400 FFVs were registered in Finland in 2014.[12]

Since 2011, RED95 ethanol-diesel has been tested in the Helsinki region in Finland, using Scania's ethanol-diesel engines in three trucks and two buses.

St1 Biofuels is focusing on the decentralized production of fuel bioethanol in Finland using side streams from the food industry, via a process called Etanolix®, and from domestic waste, via a process called Bionolix™. In these processes, the waste is converted into an ethanol (85%)-water (15%) mixture at food industry sites, and then the ethanol is concentrated/dried to a purity of 99.8% in a dehydration facility. St1 Biofuels has a centralized dehydration facility in Hamina that has a capacity of 70 kt/year (approximately 44 ktoe). Five decentralized ethanol units (four Etanolix® and one Bionolix™) are currently running with a production capacity of about 800 to 5,500 metric tons (t)/year (0.5–3.5 ktoe/year) bioethanol per unit. The Bionolix™ unit in Hämeenlinna is also combined with a biogas production plant to convert side products of ethanol into green energy; it uses biowaste from households.

However, the majority of transportation fuel bioethanol consumed in Finland is still imported.

[12] FFV classification was not systematically registered for the Euro 4 car models, which may lead to underestimation of the FFV car population.

Natural Gas and Biomethane

A total of about 1,900 natural gas vehicles, consisting mostly of passenger cars and vans running on either solely methane or bi-fuel using methane and gasoline/diesel, were running in Finland in 2014.[13]

Electric and Hybrid Electric Vehicles

Hybrid electric vehicles (HEVs) have not made a major breakthrough in Finland, and approximately 1,600 EVs (battery electric vehicles and plug-in hybrids together) were in use in 2014. The Finnish CO_2-based purchase tax has increased the competitiveness of hybrids and EVs.

The first Finnish demonstration of fully electric buses started in the City of Espoo in 2012. In February 2015, the Helsinki Regional Transport Authority (HSL) announced it will purchase 12 electric buses from the Finnish start-up company Linkker. The first electric buses started operation in Espoo in 2015, and in Helsinki, the electric buses will start to operate in 2016. The aim is to have 400 electric buses operating in the Helsinki region by 2025.

Hydrogen

The demonstration of fuel-cell-powered working machinery began in the harbor of Helsinki in 2013. The first commercial and hydrogen fuelling station opened in March 2014 for private cars and buses at the Port of Helsinki. At Voikoski, one hydrogen fuelling station opened in January 2014 for Finland's first, and so far only, hydrogen car taken into service by national gas manufacturer Woikoski Oy.

Outlook

Bioethanol and renewable diesels will be used as biofuels more and more over time in Finland.

The use of ethanol produced by St1 Biofuels in Finland is increasing as the company broadens its feedstock sources to include straw and waste fibers. St1 Biofuels is constructing a bioethanol plant in Kajaani that will use sawdust and chips as feedstock. In 2016, the plant will produce around 5 ktoe/year of Cellunolix™ bioethanol.

Suomen Bioetanoli Oy received €30 million in support from the Ministry of Employment and the Economy in December 2014 to invest in a new bioethanol plant at Myllykoski (Kouvola). The Myllykoski plant will produce about 72 000 t/year (about 45 ktoe/year) of bioethanol from straw.

[13] http://epublications.uef.fi/pub/urn_isbn_978-952-61-1875-8/urn_isbn_978-952-61-1875-8.pdf.

In November 2015, the Finnish company Neste (the world's leading supplier of renewable diesel) and Boeing (the world's largest aerospace company) announced that they will work together to promote and accelerate the commercialization of renewable aviation fuel.[14]

With regard to a potentially new alternative feedstock source for NEXBTL production, Neste and Renewable Algal Energy (RAE, a U.S.-based algae biomass producer) signed a contingent commercial algae oil off-take agreement.[15] In December 2014, Neste was also granted €3.3 million in support from the Finnish Ministry of Employment and the Economy to develop the continuous refining of biofuels (biodiesel, biogasoline, and other renewable fractions), involving a total of about 40 000 t/year from tall oil pitch at its Naantali refinery.

In the long-term, cellulosic BTL (biomass-to-liquid) fuels are expected to cover a significant share of the diesel pool in Finland. UPM was awarded €170 million for a solid-wood-based biorefinery project in Strasbourg, France. However, it has now announced that it will currently concentrate on its biorefinery in Lappeenranta.

Interest in the use of biomethane for transportation has been increasing. Gasum, together with Helen, a Helsinki-based utility, and Metsä Group, has biomethane-related plans, including plans for a large-scale wood-based bio-SNG (synthetic natural gas) plant in Joutseno. Total production of biogas could be around 1,600 GWh/year (about 138 ktoe/year), and the biogas would be transferred via Gasum's natural gas transmission network to end users (power plants, transportation). A final investment decision on construction has not yet been made.

In Finland, the liquefied natural gas (LNG) infrastructure is currently being built up for marine transportation as a result of sulphur regulations. The Ministry of Employment and the Economy granted energy investment support for four LNG terminal projects in 2014. In addition, Finland and Estonia have announced a plan to construct a gas pipe, Balticconnector, between the two countries, but only if sufficient (i.e., 75%) EU support for the project is granted. All these plans offer an opportunity to consider LNG

[14] https://www.neste.com/en/neste-and-boeing-lead-industry-commercialization-renewable-aviation-fuels.

[15] https://www.neste.com/en/neste-oil-strengthens-its-algae-oil-procurement-program-new-take-agreement.

options for transportation other than marine transportation (e.g., long-haul and heavy-duty transportation).

The first integration of wood-based pyrolysis oil production in a power boiler was done by Metso for Fortum in Finland in 2013. The bio-oil plant produced bio-oil amounting to approximately 50,000 t in 2014. Currently, bio-oil substitutes for heavy and light fuel oils in heating applications. However, in the future, bio-oil could also be feedstock for producing transport fuels and various chemicals.

Major Changes

The new Finnish Government started its 4-year term in May 2015. Under its Government Programme, it announced that Finland's target will be to increase its share of sustainable, emission-free, renewable energy so that in the 2020s its share will be more than 50%, and the energy self-sufficiency will be more than 55%. In addition, the use of fossil oil should be cut in half; the target is to have a 40% share of renewable energy in transport by 2030. The Government also published five strategic priorities in the Government Programme. One of which is "Bioeconomy and Clean Solutions" consisting of five key projects, of which one, in particular, "Towards carbon-free, clean and renewable energy cost-efficiently," is related to bioenergy.

The national target of 20% (calculatory share) biofuels in transport by 2020 was reached already in 2014.

In 2015, the new Finnish Government decided to gradually reduce the level of purchase taxes for new low-emission vehicles.