

BIOFUELS AND OTHER ALTERNATIVE FUELS IN ROAD TRANSPORT

Summary by Adviser Harri Kallberg from Tielikenteen Tietokeskus

Why is there a demand for biofuels in road transport, even though the system operates well based on petrol and diesel fuel?

The availability of energy and especially non-renewable energy sources is a key issue for the long-term wellbeing of humankind, and solving this issue requires improving energy efficiency in all sectors, including road transport. On the other hand, combating climate change and the international commitments involved require reductions in greenhouse gas emissions.

Traditional road transport fuels contain carbon, which is oxidized into carbon dioxide (CO₂) during combustion. CO₂ is the most significant greenhouse gas. From the perspective of CO₂, which causes climate change, the advantage of biofuels is that their use does not necessarily involve extracting carbon from fossil deposits into the biospheric carbon cycle. However, the requirement for the advantage is that the production and distribution of the biofuels do not result, during their lifecycle, in the use of fossil fuels that would eradicate the benefits of the actual energy source. This may occur due to the use of machinery or the production of fertilizer needed for growing raw materials for biofuels.

Why should the use of biofuels be increased in road transport in Finland, as they would be easier to use in the production of heat and power?

The EU Directive 2003/30/EC (8 May 2003) on the promotion of the use of biofuels or other renewable fuels for transport aims to replace diesel fuel and petrol for transport purposes with biofuels or other renewable fuels in each Member State. Under the Directive, Member States should ensure that a minimum proportion of biofuels or other renewable fuels is placed on their markets, and, to that effect, set national indicative targets. Based on the Directive, an Act (446/2007) on the promotion of the use of biofuels for transport was enacted in Finland. Under the Act, the national targets were 2% for 2008 and 4% for 2009. There was no national target for 2010. For the period 2011–2014, the targeted minimum proportion of biofuels is 6.0%, and thereafter as follows:

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| 2015 | 8% |
| 2016 | 10% |
| 2017 | 12% |
| 2018 | 15% |
| 2019 | 18% |
| 2020 | 20% |

The share of biofuels is calculated on the basis of energy content. Biofuels can be used as pure biofuels; as high concentrations with oil products; blended with oil products; or as liquids derived from biofuels.

Biofuels are expected to contribute to achieving the following objectives in road transport:

- Reduction of greenhouse gas emissions
- Improvement of energy efficiency
- Increase in energy self-sufficiency
- Promotion and competitiveness of clean technology

Which biofuels are suited for road transport?

Ethanol is used for replacing petrol as a liquid biofuel either in pure form or processed into ethyl-tertio-butyl-ether (ETBE). The use of ethanol and ETBE is limited by their suitability for automobiles. The Finnish motor vehicle population is divided in the compatibility of fuels containing ethanol. More than 70% of petrol vehicles, including nearly all new passenger cars, can use a petrol blend containing up to 10% of ethanol (E10). There are also automobiles in the market that are able to use blends containing 0–85% of ethanol (E85).

Also **biogas** can be used to replace petrol, but this requires modifications in automobiles and distribution networks. Purified biogas is equivalent to natural gas, and it can be used in natural gas vehicles. There are natural gas vehicles available already in the market.

Possible alternatives to diesel fuel that have first been tested include methyl-ester produced from vegetable oil (FAME, RME). However, the drawbacks of these first-generation **biodiesels** include poor storage stability and the 7% blend limit when mixed with conventional diesel fuel. Nevertheless, with modern processing technologies, it is possible to produce biodiesels that have no blend limits.

Neste Oil Corporation has started producing its own biodiesel. This biofuel (a hydrotreated vegetable oil called NExBTL) is a second-generation biodiesel, which is fully comparable with petroleum diesel fuel and does not have any blend limits or storage stability problems. In addition, the forest industry is currently developing a new, innovative wood-based biofuel. This fuel is based on the use of liquid raw materials and processes utilizing hydrotreatment technology and energy wood.

What other alternatives are there for replacing petrol and diesel fuel?

Liquefied petroleum gas (LPG) is produced as a by-product of oil and natural gas refining. LPG consists of light hydrocarbons, primarily propane and butane. The pressure of LPG blends used as fuel in motor vehicles is 7–20 bars.

Natural gas primarily consists of methane, and it can be stored at about 200–250 bar pressure or liquefied below -162 °C. The natural gas mostly used in road transport is compressed natural gas (CNG). The wide adoption of natural gas as a road transport fuel would reduce CO₂ and particulate emissions significantly. The reason for this is that methane contains less carbon and more hydrogen than petrol and diesel fuel.

Dimethyl ether (DME) is a fuel being developed for diesel engines. In standard pressure, it is gaseous. Its physical properties are much like those of LPG – its storage in liquid form requires only modest pressure. DME can be produced from natural gas or, for example, coal or biomass.

Hydrogen can be liquefied by cooling its temperature to -253 °C. The production and storage process is rather complex and expensive, and also requires a great deal of energy. Its storage in vehicle tanks may also cause problems. As a road transport fuel, hydrogen would solve a part of emissions problems and would expand the alternatives in primary energy sources. Hydrogen can be produced from, for example,

hydrocarbons or water, and its combustion generates no HC, CO or CO₂ emissions. The only exhaust emissions produced by the combustion of hydrogen are water and nitrogen oxides.

An **electric vehicle** is powered by an electric motor, which receives its energy from batteries charged from an external electrical power network. Electric vehicles generate no emissions during use, so any potential emissions are related to the production of the electricity used by the vehicle. Batteries are a key challenge for the technical development of electric vehicles, because they are typically heavy and large, and still inefficient in storing energy when compared to liquid fuels. However, battery technology is developing rapidly.

A **hybrid electric vehicle** contains batteries, an electric motor and a combustion engine. This combination can improve the vehicle's energy efficiency especially in urban traffic, which is characterized by a constantly changing rhythm. Most hybrid electric vehicles currently in the market generate the electricity they need by using the combustion engine or by recovering the kinetic energy of deceleration. In addition, there are hybrid electric vehicles in the market that can be charged using mains electricity. These **plug-in hybrid electric vehicles** are more similar to electric vehicles, with the advantage of reducing the space required for batteries.

Electricity and hydrogen have similar challenges as energy sources for road transport. Neither represents an actual energy source, but a carrier of energy generated using other means. Their use generates no emissions, but the preceding phases of the energy chain need to be solved.

In public transport, electricity is used widely as an energy source in trains and trams. In this case, the electricity is distributed to the vehicles via a fixed network built along the routes, and therefore no batteries are required for storing the energy being used.

What criteria do alternative fuels need to meet in order to replace petrol and diesel fuel in significant quantities?

The technical target for alternative fuels is simple: they need to be usable. In practice, this translates into three key criteria:

- There must be enough primary energy available.
- There must be a solution for energy distribution.
- The energy must be suited to the power systems of vehicles.

All three criteria need to be met at a competitive cost when compared to other options available. Higher costs can be allowed during the adoption phase, but the viability of the solutions requires permanently competitive prices once a sufficient scale of use has been achieved.

Sufficient scale of availability refers to the total consumption of transport fuels in Finland: about 4.0 million tonnes of oil products per year. One percent of this amount is 40,000 tonnes.

Naturally, the fuel must be usable around the year and under all conditions in Finland.

Why is the distribution system so important?

If a fuel cannot be distributed using the existing system, changes need to be made to the existing system or entirely new parallel systems need to be built.

The most interesting liquid biofuels, ethanol and second-generation biodiesels, can be blended with standard fuels pro rata, which means that there is no distribution

problem until the critical limit in the blending ratio between petrol and ethanol is exceeded. However, there can be a serious distribution problem for gaseous fuels. Due to the high pressure required by natural gas and biogas, their distribution is more expensive than that of LPG.

The economical adoption of new distribution systems can be supported with the introduction of bi-fuel vehicles. A typical combination for these vehicles is petrol and methane. In addition, flex-fuel vehicles that are able to use different blends of petrol and ethanol can support the adoption of blends with higher concentrations of ethanol (E85 has 85% of ethanol).

Which vehicles are able to use alternative fuels?

Alternative fuels can be used in vehicles with or without modifications. Ethanol can be blended with petroleum-based fuels pro rata up to 5% and in E10 petrol, up to 10%. The highest permitted blend ratio for first-generation biodiesel (RME, FAME) is 7%. Second-generation biodiesels (e.g. NExBTL) have no blend limits.

The automotive industry is manufacturing flex-fuel vehicles, which are able to use blends of ethanol and petrol containing ethanol in concentrations of up to 85%. With these vehicles, changes in the fuel blend require no action from the driver. There are also bi-fuel vehicles in the market. These vehicles can use both gaseous and liquid fuels, such as natural gas and petrol, without any technical modifications.

The use of gaseous fuels, especially of natural gas and biogas, requires considerable modifications in standard vehicles. Furthermore, such modifications result in, for example, larger fuel tanks and a shorter operating range. In addition, due to sparse fuel distribution networks, these vehicles require an additional tank and fuel system for petrol.

Which taxes does the use of alternative fuels affect?

The use of alternative fuels affects the excise duty on fuel, or the corresponding fuel fee, as well as vehicle tax. Vehicle tax consists of a basic tax component and tax on motive power (so-called diesel tax). The primary purpose of the fuel fee could be interpreted as preventing the unauthorized use of tax-free fuels in road transport.

Are users of alternative fuels eligible for tax benefits?

Passenger cars and vans using methane-based fuel are not subject to tax on motive power or the fuel fee.

In addition, trucks and buses using LPG, natural gas or similar gaseous fuels are not subject to the fuel fee.

Motor vehicles primarily using wood- or peat-based fuels are not subject to vehicle tax (basic tax component or tax on motive power). Nevertheless, these vehicles are subject to the fuel fee, unless the fuel has already been subject to an excise duty corresponding to the level of petrol or diesel fuel.

Is the fuel tax on biofuels lower than that on petrol and diesel fuel?

The taxation of fuels is based on energy content and specific emissions during combustion. These taxes are called energy content tax and carbon dioxide tax.

Energy content tax levied on fossil fuels and biofuels has reduced particularly the tax levied on ethanol. Carbon dioxide tax takes into account the CO₂ cuts achieved using biofuels when compared to fossil fuels. This provides tax benefits for biofuels that produce lower CO₂ emissions. Biogas is tax-free. Paraffinic diesel is the only transport fuel for which energy content tax is divided into quality categories based on near emissions. The near emissions benefits of natural gas and biogas are taken into account as a factor reducing the tax on motive power levied on passenger cars.

What is the availability of alternative fuels and vehicles using alternative fuels like in the market?

In the Finnish market, there are currently several automobile models that are able to use both natural gas (or biogas) and petrol.

There are thousands of natural gas filling stations across Europe, and their numbers are growing rapidly especially in Sweden, Germany, Switzerland, Austria, the Netherlands and Italy. At the beginning of 2012, there were sixteen filling stations for gas vehicles in Finland. New stations are under construction.

In Europe, LPG is available at about 10,000 filling stations. The densest networks are found in the Netherlands, Belgium, France, Italy and the UK. In Finland, LPG can only be filled into vehicles at depots.

In the Finnish and Swedish markets, several car manufacturers (e.g. Ford, Saab, Volvo, Dacia, Renault, Audi and Volkswagen) currently sell flex-fuel vehicles (vehicles able to use different blends of ethanol and petrol).

Flex-fuel vehicles are relatively common in the United States due to benefits related to fuel economy standards, but they are operated almost entirely using petrol.

Can a used automobile be converted to run on alternative fuels?

To convert a diesel engine for LPG use, its compression ratio must be reduced, combustion chamber reshaped and diesel fuel system replaced with gas equipment, including a pressure tank and plumbing. Usually converting a petrol engine for LPG use requires less modification. However, as in diesel vehicles, the entire fuel system must be replaced with gas equipment.

Natural gas is well suited for petrol engines, but due to its high compression endurance, it is not suited for the diesel process in its pure form. The conversion of a used automobile into a natural gas vehicle or a bi-fuel vehicle able to use both natural gas and petrol is technically a relatively demanding process, for example, due to the high pressure required by natural gas.

How do alternative fuels affect an automobile's value and warranty?

When considering any alternative fuel, it should be noted that the warranty of an automobile is only valid when fuels intended and approved for the particular model are used.

The use of fuels incompatible with an automobile may cause malfunctions that will reduce the vehicle's market value. Car dealerships are responsible for the vehicles they sell, and the salesperson must provide accurate information on relevant issues affecting the vehicle's value. The use of fuels incompatible with an automobile may reduce the vehicle's market value even if no malfunctions caused by their use have been detected.

Do alternative fuels help in reducing road transport emissions?

There are no high expectations for liquid biofuels in reducing regulated emissions. On the one hand, this is due to the fact that no major gains can be made in the performance of new automobiles, and on the other, biofuels are not unquestionably better alternatives in this sense – their better performance usually depends on the emission component being weighed. However, second-generation diesel fuels have achieved clear emission cuts when compared to corresponding fossil fuels. The room for further improvement is limited because these emissions are already near zero and continue to decrease in new automobiles thanks to regulations and technical development.

Depending on the engine, the use of natural gas (and purified biogas) can result in minimal emissions thanks to its

- consistent molecular structure, good combustion properties and lack of substances hazardous from the perspective of emissions
- suitability for petrol engines, in which exhaust gas emissions can be purified using three-way catalytic converters