Towards sustainable urban transport

City buses cause greenhouse gas, local emissions and traffic noise. Euro 6 emission standards have achieved a reduction in nitrogen oxide and particulate matter emissions from diesel buses, however, carbon dioxide emissions remain high. Carbon dioxide emissions must be reduced in order to meet emissions reduction targets.

Utilising alternative fuels and technologies in city buses

- City buses can use a variety of alternative means of propulsion and fuels to contribute to overall well-being in cities by reducing carbon dioxide and local emissions, as well as traffic noise.
- When purchasing alternative means of propulsion, a comprehensive assessment of propulsion properties and propulsion suitability for each area should be carried out. The procurement must take into account the greenhouse gas and local emissions of the means of propulsion and fuels, traffic noise, acquisition and operating costs, and the cost of the necessary infrastructure. In addition to this, local availability of fuels, as well as special features of the area and bus lines, must be taken into account.
- The emissions reduction potential of alternative propulsion systems depends on a number of factors, and emissions reductions should be assessed critically over the entire lifecycle.

The era of fossil fuels is over

In Finland, urban buses are primarily fuelled by fossil diesel. Finland is committed to emissions reduction targets that will require the replacement of fossil fuels with alternative fuels and means of propulsion. They can also help reduce other environmental impacts of bus and coach transport, such as local emissions and traffic noise.

The EU has adopted the revised Clean Vehicles Directive, which also directs the procurement of alternative means of propulsion in the procurement of public sector vehicles. According to the Directive, 41% of urban buses purchased between 2021 and 2025 should be 'clean vehicles', and this should rise to 59% for vehicles purchased between 2026 and 2030. Half of the procurement target should be met by all-electric buses and the rest can be 100% biofuel buses.

41% of urban buses purchased in 2021–2025 should be clean vehicles and the proportion they account for will rise to 59% in 2026–2030.

This publication from the Canemure project presents alternative means of propulsion and fuels currently available on the urban buses transport market. Every means of propulsion and fuel has its pros and cons, which should be comprehensively assessed before purchasing decisions are made.

Commercial technologies

RENEWABLE DIESEL

Renewable biodiesel, or the second generation of biodiesel (Hydrotreated Vegetable Oil, HVO), is made from waste and residues. In Finland, the raw materials used for renewable biodiesel include waste cooking oil (WCO), animal fat, tall oil and palm fatty acid distillate (PFAD). Renewable biodiesel is the only alternative means of propulsion that can be used as such in an existing diesel fleet, i.e. it does not require investment in a new fleet or refuelling infrastructure. Biodiesel is about 10% more expensive than fossil diesel.

In Seinäjoki, for example, Härmän liikenne has switched to Neste MY renewable diesel™ fuel for local bus traffic.

BIO-ETHANOL

Bioethanol is an alcohol-based biofuel. In Finland it is produced from the likes of biowaste and by-products from the sawmill industry. Bioethanol cannot be used as such in diesel vehicles, and the use of bioethanol requires technical modifications to the existing bus fleet or acquisition of new vehicles. Scania, for example, manufactures ethanol-powered bus engines. The operating costs of bioethanol are slightly higher than those of diesel. Sustainably produced ethanol is also needed to meet the blending obligations for 95 E10 petrol, which makes the ethanol supply uncertain.

Bioethanol buses are still relatively unknown in Finland, however, over 400 ethanol buses operate in Stockholm, for example.

BIOGAS

Biogas is created by microbes in the anaerobic digestion of biomass. Biogas is produced from organic raw materials such as biowaste, sewage sludge and manure. The use of biogas requires a fleet of CNG buses that can use not only biogas but also natural gas. The purchase price of a biogas bus is about 10–15% higher than a diesel bus, and maintenance costs are about 10% higher. On the other hand, slightly lower energy costs than diesel allow for low operating costs. The use of biogas requires a gas refuelling infrastructure

Twelve gas-powered buses have been introduced in Vaasa and two in Lappeenranta, for example.

ALL-ELECTRIC

The electric motor of a full (battery) electric, or all-electric, bus is powered by rechargeable batteries. The all-electric bus has a number of benefits – it is locally emissions-free, silent and the level of travel comfort is high. On the other hand, an all-electric bus has a limited range of operation. That requires careful consideration of the lines serviced by an all-electric bus, as well as where and how the charging will be realised. The purchase price of an all-electric bus is the highest of the technologies presented. The energy costs, however, are the lowest (about 70% lower than for diesel). All-electric buses equipped with a large battery require less investment in charging infrastructure compared to those with a small battery that need fast charging terminals. On the other hand, manufacturing large batteries requires a lot of raw materials and energy.

One bus line has been electrified in both Turku and Tampere, for example. There are six electric buses in Turku and four in Tampere. In the Helsinki Metropolitan Area, Pohjolan Liikenne has introduced 30 electric buses on several lines.

TROLLEY BUS

A trolley bus gets the electricity it needs from the overhead lines above the street, like a tram does. The benefits of a trolley bus are the same as of an all-electric bus, but its use requires an investment in overhead lines. In addition to this, it is not possible to change the routes of cable-dependent buses flexibly due to the reliance on fixed overhead lines. The flexibility of a trolley car can be improved with a small battery that allows short distances driven independently of the overhead lines.

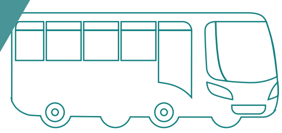
HYBRIDS

Hybrid buses utilise an internal combustion engine and an electric motor. Hybrids help to reduce energy consumption, local emissions and traffic noise, and the hybrid system can be either a full hybrid or a plug-in hybrid. In the case of the full hybrid system, the emissions reduction potential is fairly small. Full hybrids can be used, for example, to improve the efficiency of biofuel-powered buses in city driving. The principle of a hybrid is that energy is recovered during braking, and the greatest benefit is achieved by placing the hybrid bus on lines with plenty of braking and acceleration. Plug-in hybrids require the same charging infrastructure as all-electric buses. However, plug-in hybrids have a longer range thanks to an internal combustion engine, compared to all-electric buses, but they offer lower emissions reduction potential than other alternative propulsion systems.

Hybrid buses have been used in many cities, such as Turku, Tampere and Helsinki.

Emissions reduction potential depends on calculation method

Alternative fuels and technologies can reduce the greenhouse gas emissions of buses.



All the alternative fuels and technologies presented can reduce the greenhouse gas emissions of buses. However, the emissions reduction potential depends on several factors and it may be difficult to determine the exact emissions reduction potential.

When assessing biofuels, the biofuel production method, the raw materials used and their definition in the EU Renewable Energy Directive (RED) should be considered. The calculated emission reduction potential of biofuels depends largely on whether the raw materials used in their production are defined as a waste, a residue or a by-product. In Finland, for example, Palm Fatty Acid Distillate (PFAD) is defined as a residue, while in some European countries it is classified as a by-product. The emission reduction potential of raw materials defined as waste or a residue is higher than that of by-products and therefore the calculated emission reduction potential of biofuels may vary from country to country.

Due to the limited availability of domestic waste raw materials, the increased demand for biofuels increases the need for foreign raw materials, which can affect the lifecycle emissions of biofuels. When assessing the sustainability of biofuels, it is also necessary to consider other potential uses for the biomass used to produce biofuels and whether its use causes indirect land use changes. The limited availability of biofuels also needs to be considered from the perspective that biofuels should be available for heavy-duty long-distance, maritime and air transport, which are challenging to electrify.

The emissions reduction potential of electric vehicles depends on how the electricity used is produced. When considering the lifecycle emissions of electric buses, the lifecycle emissions of the batteries used should also be taken into account.

According to the manufacturers, the emission reduction potential of the technologies and fuels studied compared to fossil diesel is 50–90% for renewable biodiesel, 80–90% for bioethanol, 85–90% for biogas, 25–30% for full hybrids, 50–70% for plug-in hybrids and 90% for all-electric buses.

Summary

RENEWABLE DIESEL	▼ Claimed emission reduction of 50–90% over the lifecycle (depending on the feedstock and production method). ▼ 'Drop-in' fuel, suitable for regular diesel buses, no need to modify the fleet or the fuel distribution network. ▼ Limited availability of domestic waste feedstock. ▼ More expensive than fossil diesel. The price might further increase due to potential tax relief removal.
BIO-ETHANOL	▼ Claimed emissions reduction of 80–90% over the lifecycle (depending on the feedstock and production method). ▼ Cannot be used in regular diesel buses without modifications. ▼ Local availability of the fuel is uncertain. ▼ Limited availability of domestic waste feedstock.
BIO-GAS	▼ Claimed emissions reduction of 85–90% over the lifecycle (depending on the feedstock and production method). ▼ Requires a new bus fleet, as well as a new fuel distribution network. ▼ Low energy costs and only a slightly higher purchase price. ▼ Potential methane leaks along the production chain.
HYBRIDS	▼ Potential emissions reduction of 25–30% for full hybrids and 50–70% for plug-in hybrids over the lifecycle (depending on the type of electricity used in plug in-hybrids and the duty cycle of a combustion engine and an electric motor). ▼ Full hybrids do not require charging infrastructure. ▼ Plug-in hybrids need charging infrastructure. ▼ Battery production requires large amounts of raw materials and energy, limited lifespan of batteries.
ALL-ELECTRIC	▼ Potential emissions reduction of 90% over the lifecycle (depending on the type of electricity used). ▼ Locally emissions free, low noise levels. ▼ Needs charging infrastructure. ▼ Low running costs, high purchase price. ▼ Limited range. ▼ Battery production requires large amounts of raw materials and energy, limited lifespan of batteries.

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