

Helsinki Metropolitan Area, Finland

Buses running on clean renewable diesel in Helsinki Region

The OPTIBIO project on clean renewable diesel fuel successfully demonstrated that advanced biofuels can deliver complete fossil fuel replacement and significantly reduce emissions. Several important elements are addressed as part of the regional mobility plan: sustainable public transportation in wider Helsinki, climate protection, improved air quality and energy security.

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Abstract

Helsinki Regional Transport Authority (HRT) with its partners, including the Helsinki Metropolitan Area, carried out a three-and-a-half year project "OPTIBIO". The aim was to test and demonstrate the benefits of clean high-quality renewable diesel - paraffinic hydrotreated vegetable oil (HVO) - in city buses.

The fleet test involved some 300 buses from four bus operators. In total, the vehicles accumulated some 50 million kilometres between September 2007 and December 2010. Test fuels used were a 30 % HVO blend and 100 % HVO. The field test was supplemented by a comprehensive in-laboratory research programme.

The project confirmed that HVO works as a drop-in fuel, meaning that it can replace diesel fuel by 100 % without any modifications to the refuelling system or to the vehicles, and without causing any operational problems. The emission testing demonstrated significant and permanent emission benefits. Proven results have led to several bus operators using HVO on a commercial basis.

The Importance of this issue

Buses are the backbone of many public transport systems, and typically have a long lifespan. Considering the need for switching to non-fossil fuels, municipalities increasingly want to raise the share of renewable fuels – also for their bus fleets - to reduce greenhouse gas emissions and fossil fuel imports.

It is important for local decision-makers to understand which options are available and what the range of limitations and benefits are of each. As the service life of buses is quite long, measures which can help improve the environmental performance of existing vehicles are important. Leading local governments and their partner companies are ideally positioned to explore options together in the framework of local / regional climate or energy action plans.

OPTIBIO was a public-private partnership demonstrating the benefits of using advanced renewable diesel for fossil fuel replacement in city buses.



Population

1,060,912 (metro)

Land area

1537 km² (the seven municipalities served by HRT: Helsinki, Espoo, Kauniainen, Kerava, Kirkkonummi, Vantaa and Sipoo)

Municipal budget

Helsinki Regional Transport Authority 520 million Euro

Local economy

Services, industry

Municipal budget

Helsinki is the capital and largest city of Finland. Metropolitan Helsinki accounts for some 20 % of the total population in Finland.

Case Study

The European Directive 2009/28/EC on renewable energy (RE) sets ambitious targets. The EU aims to reach a 20% share of energy from RE sources by 2020 and a 10% share of RE specifically in the transport sector.

In Finland, a new ambitious obligation law for biofuels requires 20 % biofuels in 2020. Simultaneously, the fuels quality Directive for Europe, 2009/30/EC, limits concentration of conventional esterified biodiesel FAME in diesel to 7 % v/v (B7). FAME biodiesel is troublesome especially in diesel vehicles equipped with exhaust after-treatment devices, so the limit (“blending wall”) has been set to ensure proper functioning of vehicles, low emissions and integrity of vehicles including their exhaust after-treatment devices. Consequently FAME only delivers limited diesel fuel substitution.

Alternatives, such as paraffinic clean-burning diesel fuel, whether from fossil or biogenic sources, are required. These work as a “drop-in” substitute fuel, meaning that the fuel can be distributed using existing refuelling infrastructure, and can be used in the existing vehicle fleet without any limitations or modifications. Paraffinic fuels can be produced from renewable feedstock, through gasification and synthesis from solid biomass (biomass-to-liquids - BTL) and through HVO. Of these BTL is still in the development phase, whereas HVO is commercially available.

Advanced renewable diesel shows high impact

Helsinki Regional Transport Authority (HRT) is responsible for the planning and organisation of public transport services in its member municipalities, as well as for the preparation of the Helsinki Region Transport System Plan.

Commuting both within the Helsinki metropolitan area and between the neighboring municipalities continues to increase. Today the Helsinki region is also larger, and planning as well as organisation should address a larger geographical context. The transport system plan prepared for the entire Helsinki region which includes 14 municipalities. At the moment, member municipalities of the joint local transport authority are Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi and Sipoo. Other municipalities in the Helsinki region have the option to join in, namely Järvenpää, Nurmijärvi, Tuusula, Mäntsälä, Pornainen, Hyvinkää and Vihti.

The tasks of HRT include:

- planning and organisation of public transport in the region,
- improving operating conditions for public transport,
- procurement of bus, tram, metro, ferry and commuter train services,
- preparation of the Helsinki Region Transport System Plan,
- public transport marketing,
- passenger information and ticket inspection,
- approval of fare and ticketing systems, as well as ticket prices.

HRT also helps to further increase the modal share of public transport and this will enable a viable transport system despite of increasing traffic. All this will contribute to a vibrant and competitive Helsinki region, improve the residents’ living conditions and quality of the environment as well as help to achieve the energy and climate targets in the region.

Setting up a public-private partnership (PPP)

The world’s largest field test on paraffinic renewable diesel fuel was initiated between 2007 and December 2010 by HRT with several partners, including Neste Oil and Proventia Emission Control. The objective was to demonstrate the feasibility of high-concentration paraffinic renewable diesel fuels for city buses - for reduced local emissions, improved air quality, as well as for increased use of biofuels and thus a reduced dependence on imported fossil fuels.

Some 300 buses in the test fleet were used in everyday service over a period of three and a half years. The field test was supplemented by a comprehensive in-laboratory research programme on fuel effects on exhaust emissions and low-temperature operability. Four bus operators in Metropolitan Helsinki took part in this exercise. Technical support came from VTT Technical Research Centre of Finland, Aalto University and TEC TransEnergy Consulting Ltd.

Each partner had its own special interest – which also shows the diversity and potential win-win of a PPP. HRT wanted to demonstrate the environmental benefits of using renewable paraffinic diesel fuel in buses. For fuel producer Neste Oil, the OPTIBIO project with its comprehensive emission measurements and long-running field test constitutes an important reference in the development and market introduction of advanced renewable diesel fuel. For Proventia Emission Control (manufacturer of retrofit exhaust after-treatment devices), the project provided an opportunity to test various kinds of exhaust after-treatment systems with the new fuel and to collect data from actual bus service. The municipalities making use of HRT services have their own climate protection goals, are interested in offering quality public transport services to their citizens and in improved air quality in their urban centers. The City of Helsinki had problems in meeting the air quality standards for nitrogen dioxide (NO₂) and particulates (PM).

The primary partners invited three technical experts and a bus manufacturer to join the project. VTT Technical Research Centre of Finland, Aalto University (formerly Helsinki University of Technology) TEC TransEnergy Consulting Ltd, and bus manufacturer Scania. In addition, the four bus operators (Helsingin Bussiliikenne, Pohjolan Liikenne, Porvoon Liikenne, Veolia Transport Finland), operated the 300 buses participating in the project.

Addressing the challenge

When using conventional biodiesel there are technical limitations on how much fatty acid methyl ester (FAME) can be added to standard diesel fuel - in most cases replacement is below 10 %. Further to this, some alternative fuels require new dedicated vehicles.

The OPTIBIO project needed to explore how to optimise fuels that can be used in both existing and new vehicles, using high quality paraffinic renewable diesel (HVO) as fossil fuel replacement of up to 100 %. The value, in addition to fuel replacement, would be the reduction of harmful emissions which are most crucial for urban air quality, namely nitrogen oxides and particulates.

HRT had taken into account vehicle emission performance for nitrogen oxides (NO_x) and particles (PM) in its tendering system for bus services. Fuel efficiency and the use of biofuels were later included in the bonus system of the tendering process, so there is an economic incentive for operators to offer fuel efficient vehicles and/or vehicles operating on biofuels. HRT developed its tendering system in cooperation with VTT Technical Research Centre of Finland, which also annually performs a high number of emission tests on buses for HRT.

The large field test and associated emission measurements formed a core part of the project. Field testing helped to establish a number of critical aspects, among them the general functionality and performance of the new fuel, the effects of HVO fuel on engine wear, and possible operational problems (e.g. driveability, low-temperature operability, fuel leaks, filter blocking etc.).



View from central Helsinki: buses leaving the main railway station.

Results

The project results confirm that HVO works perfectly as a drop-in fuel, and can thus replace diesel fuel 100 % without any modifications to the refuelling system or to the vehicles. The tests show that HVO also does not cause any operational problems, even during exceptionally cold winters as sometimes experienced in the Helsinki region (e.g. below -25 oC). During a de-briefing workshop for the bus operators one of them said that the project was “invisible”, meaning no problems in everyday operation.

The emission testing demonstrated significant and permanent emission benefits. All in all 33 vehicles were subjected to regular emission follow-up. Within the screening activities, 17 buses representing different emission certification classes from Euro II (late 90's) to EEV (new vehicles) were tested to demonstrate the effect of HVO fuel on exhaust emissions and fuel consumption. Average emission reductions for 100 % HVO fuel were 10 % for nitrogen oxides (NOx), 30 % for particulates (PM), 30 % for carbon monoxide (CO) and 40 % for unburned hydrocarbons (HC). In absolute terms, the clean burning HVO fuel delivers the highest emission reductions in older high-emitting vehicles.

Typical relative emission reductions with 100 % HVO:

Component	CO	HC	NOx	PM	PAH in particulates*
Relative reduction (%)	-30	-40	-10	-30	-80

* the most toxic exhaust constituents (PAH = polyaromatic hydrocarbons)

Based on these and other excellent findings the bus manufacturer Scania has approved the use of 100 % HVO (NExBTL) in its DC9 bus engines used in city and inter-city transport. Some operators have now started using HVO on a commercial basis.

HVO was introduced on a commercial basis in services which started in the fall of 2011 and in the beginning of 2012. 60 Buses are running on 100 % HVO and 95 buses on a HVO blend. HVO is not a part of the formal tender requirements, but HVO based on waste (e.g. waste animal fats) gets an additional bonus in the tendering system.

Lessons Learned

The OPTIBIO project is an example of a successful public-private partnership. The combined interests and resources of the partners made possible the successful demonstration of hydrotreated vegetable oil (HVO) in the largest field test of its kind in the world.

The project was set up so that it didn't induce any additional costs or risks for the bus operators. This resulted in good cooperation with the bus operators, essential for the execution of the project.

The project received public research funding from the BioRefine programme by Tekes, the Finnish Funding Agency for Technology and Innovation, and in addition, a tax exemption for the biocomponents used in the project.

Technically the project was also a success. It confirmed that even 100 % HVO works well in severe conditions without causing any operational problems. HVO can deliver total fossil fuel replacement for old as well as new vehicles. In addition it provides significant emission reductions and improves the performance of exhaust after-treatment devices.

High quality paraffinic HVO is the fast track to biofuels implementation. It can be implemented without any “blending wall” limitations in existing refuelling infrastructure and vehicles over-night, delivering significant emission reductions especially for particulate matter, polyaromatic hydrocarbon components and exhaust toxicity. From the operator’s point of view, HVO is an easy solution, not causing additional maintenance or operational problems at low temperatures.

The widespread use of high concentration paraffinic fuels is possible on condition that the fuel is covered by fuel standards, and that the vehicle manufacturers approve the fuel. Within the timeframe of the OPTIBIO project, CEN (European Committee for Standardization) launched a pre-standard, CWA, for paraffinic diesel fuel. This is now in the process of developing an actual standard for paraffinic diesel.

The next step before a formal EN 15940 standard is to update CWA to a Technical Specification TS 15940. This is expected to happen in 2012. When markets of paraffinic diesel fuels are considered to be mature enough, TS will be updated to a formal EN 15940 standard

Now markets need to determine the future of high concentration HVO fuels. In Finland, low-level blending is already used commercially to fulfil the general biofuels obligation and some operators have started using high-concentration HVO on a commercial basis.

The reduction of greenhouse gas emissions of biofuels does not depend on the fuel concentration used, but on the total volume of biofuel. However, to achieve reductions in local emissions low-level blending is not enough. One has to strive for high-concentration paraffinic fuels, preferably neat paraffinic fuels. Thus a policy recommendation is that when high-quality renewable paraffinic diesel fuel is available, its use should be targeted to high-concentration blends for city buses, thus bringing about air quality improvements in urban conditions.

Replication

Bus operators worldwide could potentially use HVO. The test fuel HVO is based on vegetable oils and waste animal fat. HVO has almost identical end-use properties as actual BTL (biomass-to-liquids) diesel from gasification and synthesis. The end-use experiences gained with HVO can readily be carried to BTL when BTL becomes commercially available. A standard for paraffinic diesel will help inspire confidence in this option.

Market developments can be driven by local governments in cooperation with their local bus fleet partners. In the context of developing and implementing sustainable energy or mobility action plans, all municipalities need to address transport. The switch from fossil fuels to sustainable fuels, preferably from a renewable energy source, is a much needed solution. Yet, it is also critical to stress

NOx and PM emissions over the Braunschweig city bus -cycle:

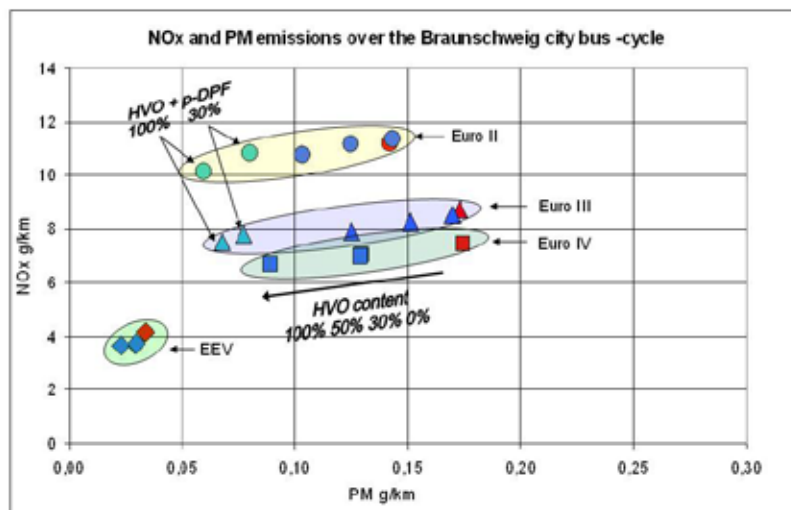


Image: OPTIBIO final report

Effect of HVO on NOx and PM emissions - graph by VTT

- Red marks EN590 diesel fuel.
- Blue marks 30, 50 and 100 % HVO.
- For Euro II and III vehicles, results are also shown with retrofitted flow-through filters (p-DPF, 30 and 100 % HVO).

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the need for sustainable solutions. This means that production of biofuels should not be at the expense of ecosystems, human rights or food security.

By including tender criteria in the public procurement process, the supplies can be made aware of municipal requirements that address environmental and other concerns.

Budget and Finances

The OPTIBIO project budget was around 3.2 million Euro. Financial support by Tekes was 35 % - some 1.1 million Euro, while the rest of the budget was covered by Helsinki Region Transport, Neste Oil and Proventia Emission Control (shares 60, 30 and 10 %, respectively). Scania made a significant contribution outside the project budget.

The bio-component was exempted from fuel tax, a waiver worth some 2.7 million Euro (The amounts of fuel used were about 22 million liters of blended fuel and 1 million liters of neat HVO. The total amount of HVO was some 7.5 million litres).

Sources

- Nils-Olof Nylund, Kimmo Erkkilä, Matti Ahtiainen, Timo Murtonen, Pirjo Saikkonen, Arno Amberla & Hannu Aatola. Optimized usage of NExBTL renewable diesel fuel. OPTIBIO. Espoo 2011. VTT Tiedotteita – Research Notes 2604. 167 p. + app. 5 p.
- Erkkilä, K., Nylund, N.-O., Hulkkonen, T., Tilli, A., Mikkonen, S., Saikkonen, P., Mäkinen, R. & Amberla, A. (2011). Emission performance of paraffinic HVO diesel fuel in heavy duty vehicles. JSAE/SAE Technical Paper JSAE 20119239. SAE 2011-01-1966. 12 p.
- Mäkinen, R., Nylund, N.-O., Erkkilä, K., Saikkonen, P. & Amberla, A. (2011). Bus Fleet Operation on Renewable Paraffinic Diesel Fuel. JSAE/SAE Technical Paper JSAE 20119172/SAE 2011-01-1965. 8 p.
- “Guide to sustainable biofuels procurement for transport” from the Biofuel Cities - the European Partnership project http://www.biofuel-cities.eu/fileadmin/template/projects/biofuels/files/Publications/Procurement_Guide.pdf

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