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# Rethinking transport

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## On route to clean bus services

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### Abstract

PTAs have the possibility to act as trendsetters for sustainable mobility. Helsinki Region Transport (HSL) already has managed to cut both local and greenhouse gas emissions of buses significantly. The goals are quite ambitious; by 2025 HSL wants to achieve a reduction of 90 % or more for emissions of carbon dioxide and pollutants, compared to the year 2010. Within the partnership with HSL, VTT has tested more than 200 buses, and conducted several field tests. The technologies and fuels covered include diesel, renewable diesel, ethanol, methane (natural gas, biogas), hybrids and battery electric vehicles, creating a comprehensive database. This paper discusses the progress in the performance of buses with conventional powertrains. Furthermore, it presents the actions taken by HSL to introduce advanced biofuels as well as electric buses in Metropolitan Helsinki. Finally, it presents HSL's fleet strategy going towards 2030.

*Keywords:* bus services; greenhouse gas emissions; pollutant emissions; fuel alternatives

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### 1.1.1. Nomenclature

CNG	compressed natural gas
CO <sub>2</sub>	carbon dioxide
CO <sub>2eqv</sub>	carbon dioxide equivalent
CVD	clean vehicle directive
CVS	constant volume sampler
DPF	diesel particulate filter
EEV	enhanced environmentally friendly vehicle (emission certification class)
Euro xx	emission certification class
GVW	gross vehicle weight
HKL	Helsinki City Transport
HSL	Helsinki Region Transport
HVO	hydrotreated vegetable oil
LNG	liquefied natural gas
LPG	liquefied petroleum gas
NO <sub>x</sub>	oxides of nitrogen
PEMS	portable emission measurement system
PM	particle matter
PTA	public transport authority
RDE	real driving emissions
SCR	selective catalytic reduction
SI	spark-ignition
TWC	three-way catalyst
VTT	Technical Research Centre of Finland Ltd
WHVC	world harmonized vehicle cycle
WHTC	world harmonized transient cycle

## 2. Introduction

City buses are the backbone of many public transport systems, constituting a very important element of the system. Public transport authorities (PTAs) have the power to set the rules for bus service procurement, and thereby the PTAs can act as trendsetters for clean and sustainable mobility.

Helsinki Region Transport (HSL)<sup>1</sup> is a joint local authority whose member municipalities are Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi, Sipoo, Siuntio and Tuusula. Some 380 million journeys are made on HSL's transport services annually. HSL's annual operating income is some 710 M€(figures for 2018).

The responsibilities of HSL include:

- Plans and organizes public transport in the region and improves its operating conditions
- Procures bus, tram, metro, ferry and commuter train services
- Is responsible for the preparation of the Helsinki Region Transport System Plan (HLJ)
- Approves the public transport fare and ticketing system as well as ticket prices
- Is responsible for public transport marketing and passenger information
- Organizes ticket sales and is responsible for ticket inspections

Currently the procurement of bus services encompasses some 1350 buses. In the procurement of bus services, HSL takes into account environmental performance, i.e., regulated emissions, carbon dioxide (CO<sub>2</sub>) emissions and noise, as one element (Anttila (2019)). The scoring of environmental performance is such that the bus operators normally offer services with vehicles of the most recent emission certification class (see Chapter 7). In the fall of 2018, the first tendering requiring electric buses for certain routes was launched. HSL is also in the process of gradually introducing a requirement of 100 % biofuels in the conventional bus fleets.

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<sup>1</sup> <https://www.hsl.fi/en/helsinki-regional-transport-authority>

HSL and VTT Technical Research Centre of Finland<sup>2</sup> have been assessing and documenting performance of city buses for some 20 year. The data generated is used by HSL as an element supporting the tendering of bus services, but also to develop future bus fleet strategies. In addition to systematic evaluation of new bus models entering service, a number of research and piloting projects have been carried out as well. Fuel and drivetrain options evaluated include liquid renewable fuels (renewable diesel, additive treated ethanol), methane (bio/natural gas), hybrids and battery-electric buses. Retrofitted exhaust after-treatment systems have been evaluated, as well.

Between the spring of 2002 and end of 2018, VTT has tested in total 178 internal combustion engine powered city buses for HSL (Nylund et al. (2019)). The sample includes Euro I - Euro VI diesel buses, Euro II - VI gas (CNG) buses and EEV ethanol buses. This means that HSL has access to one of the most comprehensive performance databases for buses. VTT has also measured some electric buses, but these results are not yet incorporated in the main bus database.

### 3. Methodology for vehicle testing

VTT carries out chassis dynamometer measurements as well as on-road testing using a Portable Emission Measurement System (PEMS) to evaluate the performance of buses. Chassis dynamometer measurements deliver exact and repeatable results, whereas PEMS type testing is mainly performed for in-service-compliance pass-or-fail type testing. In addition, some Euro VI certified diesel buses have been equipped with on-board equipment for continuous monitoring of nitrogen oxide (NO<sub>x</sub>) emissions (Söderena et al. (2018)).

VTT's comprehensive bus performance database builds on chassis dynamometer testing. Parameters are typically reported in the form of g/km, i.e. relative to driven distance. Although there is no universal methodology or standard for chassis dynamometer measurements of heavy-duty vehicles, several laboratories around the world are producing emission results for complete heavy-duty vehicles. One widely recognized guideline for this kind of measurements is SAE J2711, SAE Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles<sup>3</sup>.

For transient-type measurements of heavy-duty vehicles on a chassis dynamometer, VTT developed its own in-house method covering both emission and fuel consumption measurements. The method is partly based on SAE J2711, partly on the European Directive 1999/96/EC<sup>4</sup> on emission measurements. In June 2003, FINAS, the Finnish Accreditation Service, granted accreditation for the method of VTT (T259, In-house method, VTT code MK02E).

VTT's heavy-duty chassis dynamometer is capable of simulating the inertia weight and road loads that buses and trucks are subjected to during normal on-road operation. The machine is a single-roller, 2,5 meter diameter chassis dynamometer with electric inertia simulation. The system has the capability of testing vehicles from 2,500 to 60,000 kilograms of GVW. Maximum absorbed power (continuous) is 300 kW at the driven wheels. The machine is thereby ideal for measurements on buses. For emission measurements VTT uses full-flow CVS dilution system. The analytical equipment (Pierburg CVS-120-WT CVS and analyser set AVL AMA i60) is compliant with Directive 1999/96/EC. The analytical equipment was renewed in 2018.

VTT's standard test cycle for buses is the German Braunschweig bus cycle, depicting bus service in a mid-sized European city, and also describing quite well driving in Helsinki. Up to the year 2017, testing for the bus data based was done using only the Braunschweig cycle. As of 2017, testing is carried out using the World Harmonised Vehicle Cycle (WHVC), as well. The transient engine testing cycle used for homologation, World Harmonised Transient Cycle (WHTC), was originally derived from a vehicle cycle, the WHVC. The WHVC is carried out as a combination of a cold start test (from room temperature) and a hot start test. The pause in between the test is 10 ± 1 minutes. The result is reported as a weighted average, based on cold start cycle (14 %) and hot start cycle (86 %). The combined WHVC was added to the program, as it provides a link to the engine certification cycle, and that it, in addition, accentuates the temperature-sensitivity of the newest and most sophisticated emission control systems.

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<sup>2</sup> <https://www.vttresearch.com/>

<sup>3</sup> [https://www.sae.org/standards/content/j2711\\_200209/](https://www.sae.org/standards/content/j2711_200209/)

<sup>4</sup> <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2000:044:0001:0155:EN:PDF>

Figure 1 presents a photo of VTT's heavy-duty vehicle test facility.



Fig. 1 View of the test facility, the CVS dilution tunnel can be seen in the upper right-hand corner

## 4. Evolution of emission performance

### 4.1. Performance data

It is fair to say that current buses are much cleaner than the ones of the early 90's (Euro I vs. Euro VI). Figures 2 ( $\text{NO}_x$ ) and 3 (particulate matter PM) clearly show the positive development over the years (data for the Braunschweig test cycle, fully warmed-up engines, average values). It is also evident that the step from Euro V/EEV to Euro VI brought about the biggest relative reduction so far. To meet the Euro VI emission limits, diesel engines in practice have to be equipped with a combination of diesel particulate filter (DPF) for PM control and a selective catalytic reduction (SCR) catalyst with a urea additive feed system for  $\text{NO}_x$  control. On an average, the  $\text{NO}_x$  and PM emission levels of Euro VI diesel buses are below the levels which can be derived from the legislative limits for engine homologation. It is also worth noticing, that even though Euro VI brought a significant reduction in  $\text{NO}_x$  and PM emissions, the average energy consumption was reduced slightly, as well.

In the case of CNG buses, Euro VI means a significant reduction in  $\text{NO}_x$  emissions. For Euro V/EEV, there was mix of both lean-burn and stoichiometric engines. Lean-burn gas engines tend to have high  $\text{NO}_x$  emissions, even higher than their diesel counterparts. This is evident in Figure 2, which shows that in the case of Euro II and Euro III vehicles, CNG vehicles have higher  $\text{NO}_x$  emissions than corresponding diesel vehicles. For Euro VI CNG vehicles, all manufacturers use stoichiometric combustion in combination with a three-way catalyst (TWC), bringing  $\text{NO}_x$  emissions to a very low level.

Figure 3 shows that CNG vehicles have, independent of the certification class, very low PM emissions equivalent to Euro VI diesels. Earlier on, the big advantage of CNG was specifically low PM emissions, but with Euro VI, this advantage is now gone.

As stated above, emission reductions have been remarkable. However, regarding tailpipe  $\text{CO}_2$  emissions and fuel consumption, the development has not been that impressive as shown by Figures 4 and 5. Over the years, for vehicles with conventional architecture, fuel consumption has gone down only some 7...8 % (diesel Euro I vs. Euro VI, CNG Euro II vs. Euro VI). At the Euro II level, CNG had 18 % higher energy consumption than diesels, at the Euro VI level the difference is 26 %. These figures are for the Braunschweig cycle. In the WHVC cycle, Euro VI CNG vehicles consume 26...29 % more energy than their diesel counterparts.

Natural gas (methane) has a more favourable hydrogen-to-carbon ratio than diesel fuel, resulting in a specific  $\text{CO}_2$  emission ( $\text{g CO}_2/\text{MJ}$ ) some 25 % lower compared to diesel. However, due to the use of spark-ignition (SI) engines, the higher energy consumption of CNG vehicles compared to diesel in practise nullifies this advantage. At the Euro VI level, CNG provides a reduction of tailpipe  $\text{CO}_{2\text{eqv}}$  emissions of some 5 %, compared to diesel.

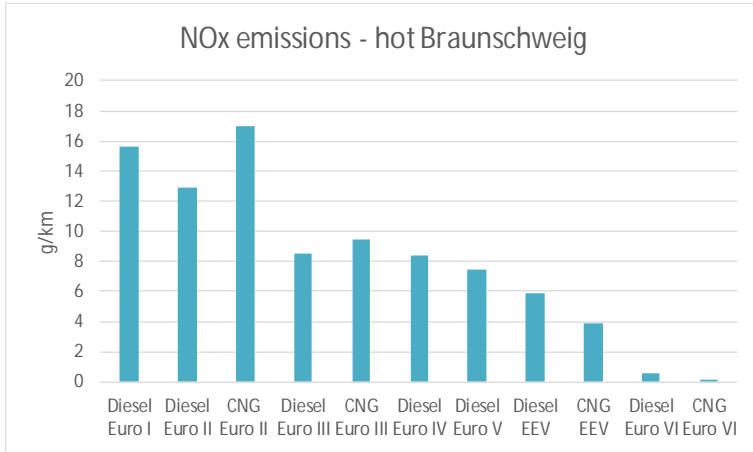


Fig. 2 NO<sub>x</sub> emissions (hot Braunschweig test cycle, 2-axle buses, average of all measurements)

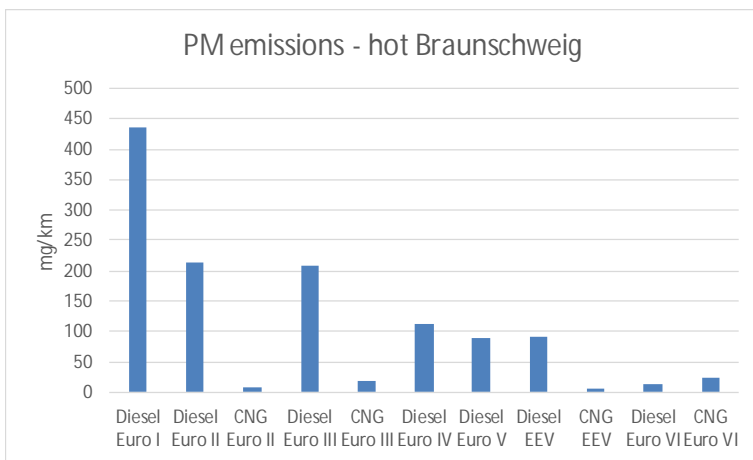


Fig. 3 PM emissions (hot Braunschweig test cycle, 2-axle buses, average of all measurements).

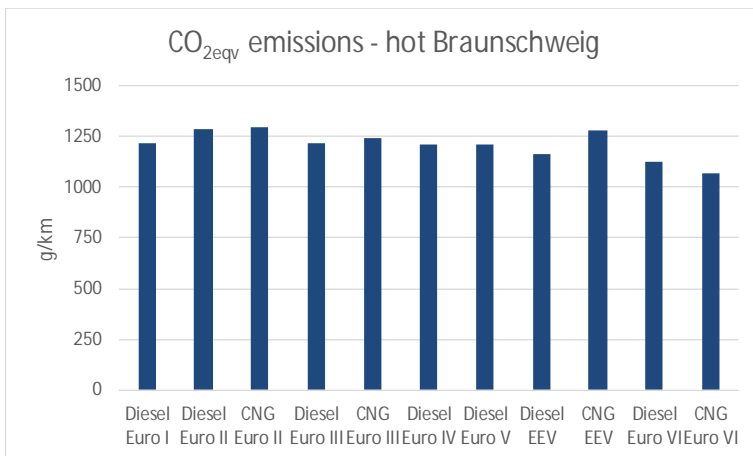


Fig. 4 Tailpipe CO<sub>2eqv</sub> emissions (hot Braunschweig test cycle, 2-axle buses, average of all measurements)

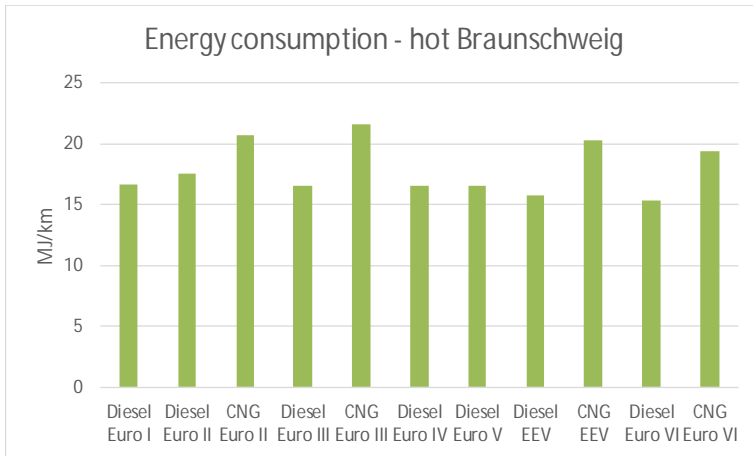


Fig. 5 Energy consumption (hot Braunschweig test cycle, 2-axle buses, average of all measurements)

#### 4.2. Cost of emissions

The Directive 2009/33/EC<sup>5</sup> on the promotion of clean and energy-efficient road vehicles presents a methodology to calculate the external costs of emissions. The maximum costs for NO<sub>x</sub> and PM are (applying a multiplier of 2 to the baseline values):

- NO<sub>x</sub> 0.0088 €/g
- PM 0.174 €/g

Figure 6 present the calculatory emission costs for NO<sub>x</sub> and PM, the most crucial emission components for urban air quality. The emission values used as input in the calculation are average values for diesel buses from VTT's bus performance database. For the oldest vehicle class, Euro I, the aggregate cost for NO<sub>x</sub> and PM emissions is 0.21 €/km, for Euro VI the cost is only some 0.01 €/km, a reduction of some 95 %.

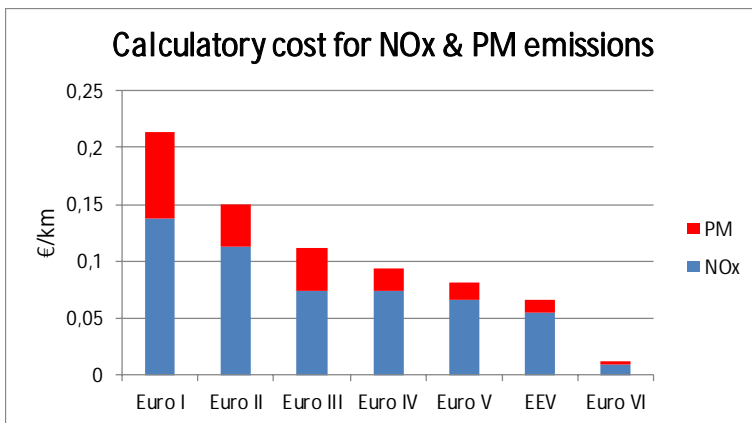


Fig. 6 Calculatory cost for NO<sub>x</sub> and PM emissions

As said, one element in HSL's tendering process for buses is scoring emission performance, making it advantageous for the operators to offer services with low emitting buses. In defining the emission performance scoring of the tendering process, HSL makes use of VTT's bus database and the calculation of emission costs. By doing so, HSL makes sure that the increased direct cost of cleaner vehicles is in balance with the calculatory emission benefit.

A similar methodology is applied to tailpipe CO<sub>2</sub> emissions. The use of biofuels is stimulated with the help of an environmental bonus system. This bonus system is also based on competitive tendering and analyzing the cost/benefit ratio of the bids.

<sup>5</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0033&from=EN>

Taking into account pollutant emissions (mainly NO<sub>x</sub> and PM) as well as CO<sub>2</sub> emissions on a well-to-wheel bases (full fuel cycle), the combination of Euro VI vehicles and sustainable renewable fuels, whether liquid or gaseous, is a good combination for both local environment and climate alike.

## 5. Stimulating the uptake of biofuels

Already in 2007 - 2010, HSL was one of the partners in the project “OPTIBIO” testing paraffinic renewable diesel (hydrotreated vegetable oil HVO). At that time the fleet test in Metropolitan Helsinki, which encompassed some 300 buses was, the largest one in the world to demonstrate the new fuel. The fuels were a 30 % blend of renewable diesel and 100 % renewable diesel (Nylund et al. (2011)).

All in all, the vehicles accumulated some 50 million kilometres between September 2007 and December 2010, of which some 1.5 million kilometres on 100 % HVO. Average distance per vehicle was some 170,000 km. The amounts of fuel used were about 22 million litres of blended fuel and 1 million litres of neat HVO.

The project confirmed that HVO actually works as a drop-in fuel, meaning that HVO can replace diesel fuel 100 % without any modifications to the refuelling system or to the vehicles, without causing any operational problems. The emission testing, both the screening and the follow-up measurements, demonstrated significant and permanent emission benefits. Based on the findings of the OPTIBIO project, Scania approved the use of 100 % HVO (Neste’s NExBTL, now called Neste MY Renewable Diesel) in its city and intercity buses with DC9 engines.

The project also spurred HSL to stimulate the use of biofuels. For several years, HSL has paid extra for the bus operators to use biofuels, using the environmental bonus mentioned in the previous chapter. On an annual basis, HSL has used on an average 1.7 M€ for stimulating the use of biofuels, resulting in some 10...15 million “additional” litres of biofuels annually. This in on top on what the national biofuels obligation calls for. All in all, in 2019, the share of biofuels in the bus services procured by HSL is approaching 50 %.

The environmental bonus is technology neutral, so renewable diesel, additive treated ethanol (ED95) and biogas are all competing on an equal basis. However, the biofuels must be based on wastes or residues, eligible for double counting according the Directive 2009/28/EC<sup>6</sup> (first version of the Directive on promotion of renewable energy). As the numbers of gas and ethanol buses are limited, the overwhelming part of the additional biofuel volumes has been renewable diesel.

HSL is now preparing to include the use of 100 % biofuels as a mandatory requirement for new contracts. In preparation for this, HSL is running a multi-partner project called “BioOneHundred”, covering the years 2016 - 2019. Partners in this project are three energy companies, Neste, St1 and UPM, the cities of Helsinki, Espoo and Vantaa, Posti (the Finnish Post), the Smart & Clean Foundation and VTT. The main sponsor of the project is the Ministry of Economic Affairs and Employment, responsible for Finnish biofuel policies.

The objectives of the project are:

- The bus services procured by HSL and the vehicles (road vehicles, mobile machinery and boats) of Helsinki City Construction Services (Stara) will gradually switch to sustainable biofuels
- HSL and Stara act as forerunners in promoting carbon neutral traffic, proving instance for other operators in Helsinki metropolitan area as well as for other municipalities
- In addition to advancing biofuels, electrification will be promoted in parallel activities
- The aspiration is to also increase the share of biofuels and electrification in, e.g., airport and harbour operations

The preliminary phase encompassed, e.g., assessment of vehicle manufacturers’ approvals for biofuels and assessment of the readiness of the bus operators to switch to biofuels. In addition, performance measurements (energy consumption, exhaust emissions) were carried out on renewable diesel as well as on biogas.

The implementation phase started in 2017 when Stara switched to renewable diesel in three of its filling stations.

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<sup>6</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN>



As mentioned, HSL facilitates uptake of biofuels in the bus fleet with the help of its environmental bonus system. The fuel specifications of the environmental bonus system and the BioOneHundred project were harmonized.

Within the BioOneHundred project, measurements are carried out both in VTT's vehicle emission laboratory and on vehicles in normal operation. Parameters to be measured are, e.g., fuel consumption and exhaust emissions. The measurement program encompasses:

- The effect of various fuels on vehicle performance, measurements carried out in VTT's heavy-duty chassis dynamometer (with emphasis on Euro VI certified vehicles, which were not available at the time of the OPTIBIO project)
- Periodic performance testing of selected follow-up vehicles in VTT's chassis dynamometer
- Continuous monitoring of selected on-road vehicles and pieces of mobile machinery using on-board equipment
- Determination of real driving emissions (RDE) of vehicles and mobile machinery using PEMS equipment

So far no technical problems have been encountered. However, there are still some issues regarding supply, distribution and pricing of 100 % biofuels, issues that need to be tackled before going for 100 % biofuels in bus operations.

## 6. Steps towards electrification

In 2011 - 2015, a national research program "EVE - Electric Vehicle Systems" was carried out<sup>7</sup>. VTT's activities within the program were focused on commercial vehicles, within the project entity "ECV - Electric Commercial Vehicles"<sup>8</sup>.

Two ECV subprojects were directly related to electric buses, namely "eBus", which was a testing and development platform for prototype and pre-production electric buses and their components, and "eBus System", with a focus on the system and charging of buses. The Finnish electric bus manufacturer Linkker<sup>9</sup> is a spin-off from VTT and the eBus project. HSL was a partner in these electric bus related activities right from the start.

It soon became evident that it would not be possible to go directly from research type activities to commercial procurement of electric bus services. Especially solutions involving opportunity charging require cooperation of several stakeholders and the creation of a business ecosystem.

HSL therefore decided to set up a pre-commercial pilot, "ePELI"<sup>10</sup>, to build a bridge towards commercial operations. HSL normally does not own or operate buses. In the case of "ePELI", HSL took both the technical and economic risks by procuring 10 opportunity charged Linkker buses. As a part of the learning process, these buses were then borrowed to various public transport operators. The charging infrastructure in Metropolitan Helsinki was provided by the City of Helsinki through Helsinki City Transport (HKL) and by the city of Espoo. In addition to running pilot vehicles, the project integrate that was formed was also researching procurement processes suitable for electric bus services (Pihlatie and Mäkinen (2016)).

Figure 7 shows a schematic presentation of the steps towards electrified bus services. Figure 8 shows a Linkker bus and charging infrastructure in front of the Finnish National Theatre in downtown Helsinki.

In the fall of 2018 HSL was ready for the first tendering with a requirement of electric buses, with services starting in 2019. For one bunch of feeder lines in Espoo, the requirement was 5 opportunity charged buses. HSL naturally got the 5 electric buses required, but in addition, the operator who won the Espoo contract added 30 electric buses more, 20 to Espoo and 10 to Kerava, without any additional requirements or incentives. These 30 buses represent a different technology: large batteries and slow charging at the bus depot. The set-up will provide an interesting opportunity to compare opportunity charging and slow charging. The outcome of this first tendering round including electric buses also indicates that electrification might progress very rapidly.

<sup>7</sup> [https://www.businessfinland.fi/globalassets/julkaisut/eve\\_final\\_report.pdf?\\_t](https://www.businessfinland.fi/globalassets/julkaisut/eve_final_report.pdf?_t)

<sup>8</sup> <https://www.ecv.fi/in-english/>

<sup>9</sup> <http://www.linkkerbus.com/>

<sup>10</sup> "ePELI" could be translated as "electric game"

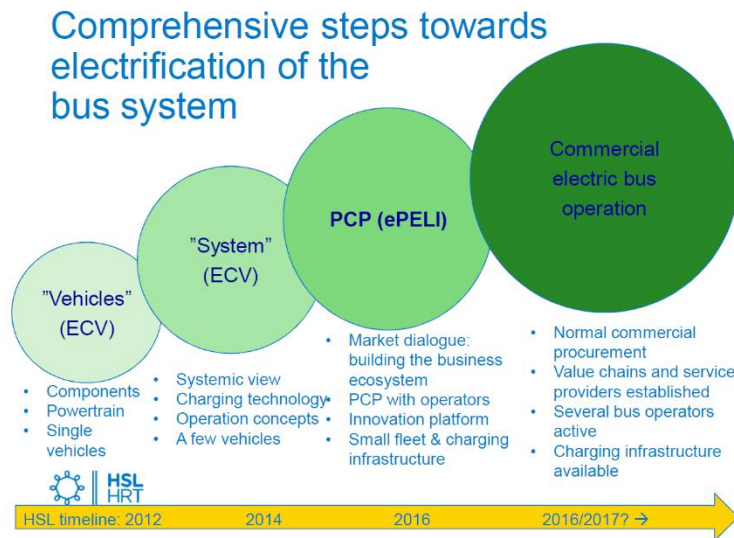


Fig 7 The steps towards electrified bus services (Pihlatie and Mäkinen (2016))



Fig 8 A Linkker bus at a charging station in Helsinki (January 2019)

## 7. Evolution of the bus fleet and HSL's fleet strategy

HSL's tendering and scoring system for bus services is such that it spurs the transport operators to offer services for new contracts using the cleanest available vehicles. This is evident from Figure 9, showing the bus kilometers by emission certification class. In 2018, Euro VI vehicles (including EEV vehicles retrofitted to meet Euro VI requirements) accounted for 55 % of the total vehicle kilometers accumulated. The contribution of Euro III vehicles was less than 2 %. In 2018, the share of biofuels was some 35 %.

Compared to the year 2010, in 2018 the following relative emission reductions were achieved:

- NO<sub>x</sub> -73 %
- PM - 82 %
- CO<sub>2</sub> -39 % (on a well-to-wheel basis, mainly through the use of biofuels)

For the year 2025, HSL has set the following emission reduction goals (relative to 2010):

- NO<sub>x</sub> -92 %
- PM - 95 %
- CO<sub>2</sub> -90 %

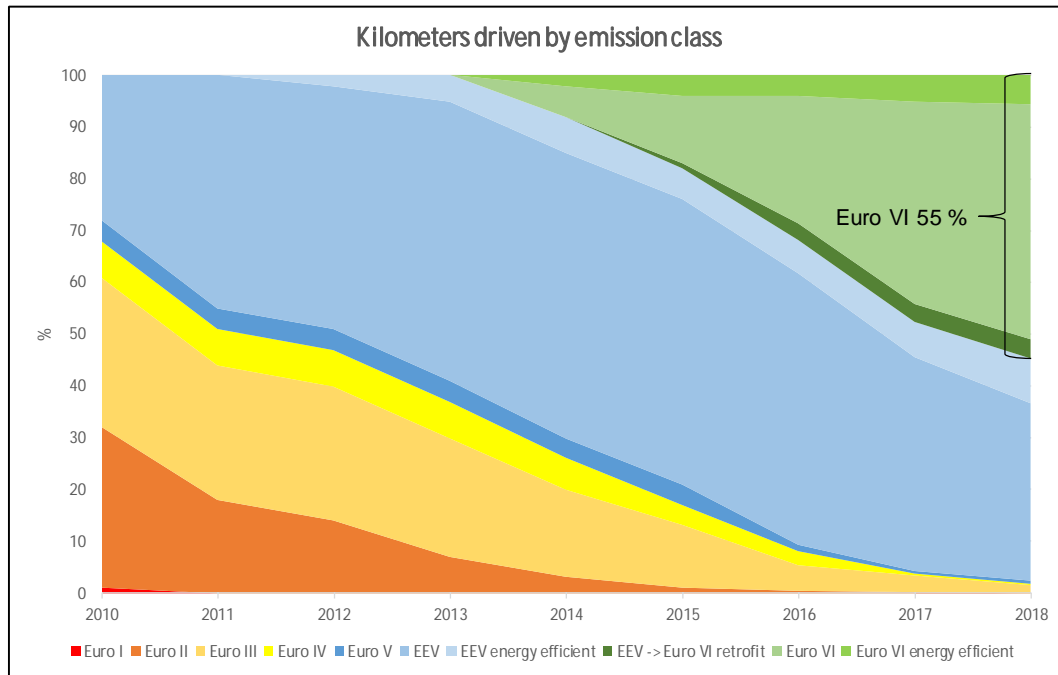


Fig 9 Evaluation of the bus fleet in Metropolitan Helsinki (shown as share of kilometers driven by emission certification class)

The emission goals for 2025 can in principle be achieved both using the best renewable fuels in Euro VI certified vehicles or by implementing electric buses. HSL strives for a combination of both these pathways. There is, however, a clear strategy to ramp up the use of electric buses, by requiring electric buses for certain services.

In 2018, the number of electric buses was 10, jumping to 45 in 2019. The target for 2025 is now set for 400 - 600 units, meaning that the relative share of electric buses in the bus fleet would be some 30 - 40 %.

In June 2019, Directive (EU) 2019/1161<sup>11</sup>, amending Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles (CVD), was finally approved. The revised Directive, among other things, extends the scope of the Directive to cover all types of public procurement (including bus services) and presents definitions of clean vehicles. In the case of heavy-duty vehicles, the clean vehicle definition is based on alternative fuels, with a separate “zero emission” definition (Dubolino (2019)):

- All fuels mentioned in Directive 2014/94/EU<sup>12</sup> on the deployment of alternative fuels infrastructure, i.e., electricity (including plug-in hybrids), hydrogen, CNG/LNG, biofuels, synthetic and paraffinic fuels, LPG
- “Zero-emission heavy-duty vehicle”: zero-emission at tailpipe

A Euro VI vehicle running on 100 % biofuel is counted as a clean vehicle. However, biofuels produced from high indirect land-use change-risk feed stock are excluded.

In the case of heavy-duty vehicles and certain types of services, the CVD sets minimum shares for clean vehicles. These minimum shares vary by type of vehicle, application and by member country. The requirements apply to new contracts only, not to the total legacy fleet. In the case of Finland, the minimum procurement targets for city buses (coaches are excluded) are (numbers related to vehicle numbers, not driven kilometers):

<sup>11</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1161&from=EN>

<sup>12</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0094&from=FI>

- 41 % in the time period 2021 - 2025
- 59 % in the time period 2026 - 2030

In addition, there is a sub-target for zero-emission vehicles, and in the case of buses it is 50 %. So, in the case of Finland and HSL, for new contracts in 2021 - 2025, the share (of vehicle numbers) of electric buses (alternatively fuel cell buses) must be 20.5 %, and 29.5 % in 2026 - 2030.

As HSL is targeting a 30 - 40 % share (share of vehicles in the fleet) of electric buses already in 2025, HSL's strategy for 2025 is in fact already surpasses the 2030 requirements of the CVD. In 2018, already 55 % of the bus kilometers driven were covered with Euro VI vehicles, and as the share of sustainable biofuels is increasing, fulfilling the remainder of the CVD requirement is no issue for HSL.

## 8. Summary

PTAs have the power to set the rules for bus service procurement, and thereby the PTAs can act as trendsetters for clean and sustainable mobility. In fact, the updated CVD puts stringent requirements for public procurement to go for clean vehicles and services provided by clean vehicles.

HSL and VTT have a long common history in working for clean bus services. Between the spring of 2002 and end of 2018, VTT has tested in total 178 internal combustion engine powered city buses for HSL. The sample includes Euro I - Euro VI diesel buses, Euro II - VI gas (CNG) buses and EEV ethanol buses. This means that HSL has access to one of the most comprehensive performance databases for buses. The data generated is used by HSL as an element supporting the tendering of bus services, but also to develop future bus fleet strategies. In addition to systematic evaluation of new bus models entering service, a number of research and piloting projects have been carried out as well. Fuel and drivetrain options evaluated include liquid renewable fuels (renewable diesel, additive treated ethanol), methane (bio/natural gas), hybrids and battery-electric buses.

It is fair to say that current buses are much cleaner than the ones of the early 90's (Euro I vs. Euro VI). Already some 55 % of the bus services in Metropolitan Helsinki are provided by Euro VI level vehicles. A Euro VI bus running on renewable fuel is good for the local environment as well as for the climate. However, development will not stop here, as the penetration of electric buses will progress rapidly. From 45 electric buses in 2019, the number is expected to grow to some 400 - 600 by 2025. By 2025, the combination of best available conventional buses and gradually increasing shares of renewable fuels as well as electric buses will bring both pollutant and CO<sub>2</sub> emissions at least 90 % compared to the reference year 2010. HSL's strategy for 2025 is in fact surpasses what the CVD is requiring for the year 2030.

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