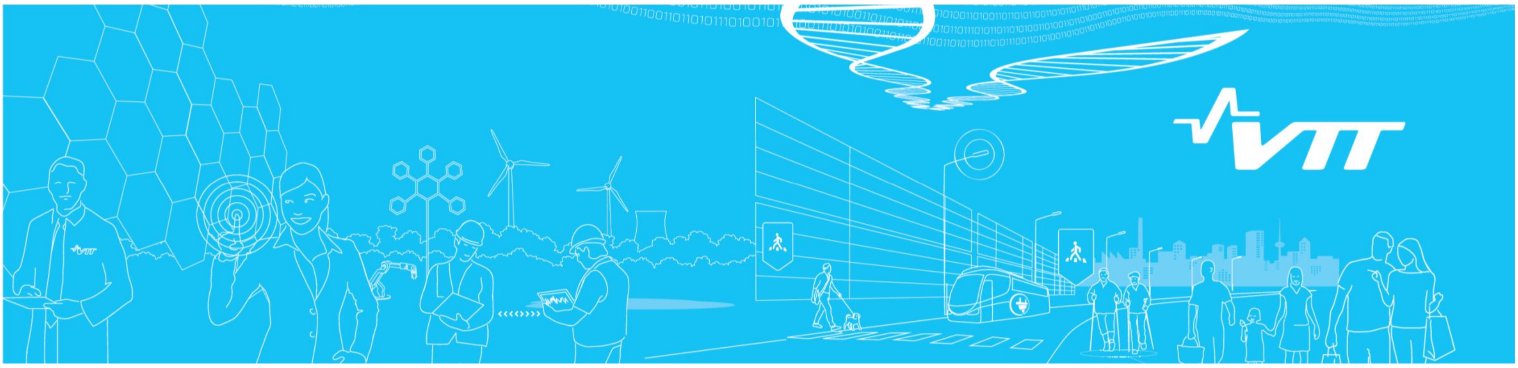
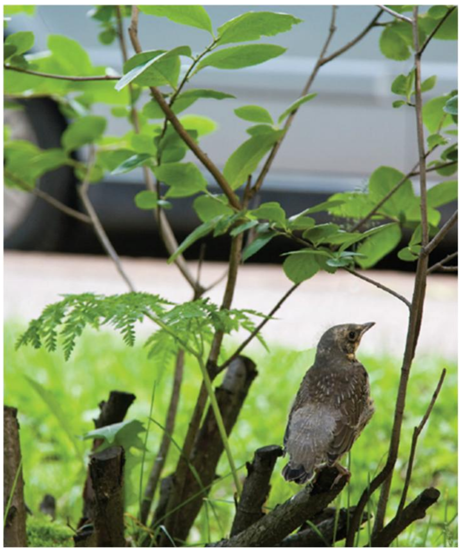


RESEARCH REPORT

VTT-R-04966-14



TransEco research programme in Finland: Energy efficiency and renewables in road transport

Authors: Päivi Aakko-Saksa, Nils-Olof Nylund and Juhani Laurikko (Eds.)

Confidentiality: Public

Report's title	
TransEco research programme in Finland: Energy efficiency and renewables in road transport	
Customer, contact person, address TransEco Steering Committee	**Order reference**
Project name TransEco research programme	**Project number/Short name**
Author(s) Päivi Aakko-Saksa, Nils-Olof Nylund and Juhani Laurikko (Eds.)	**Pages** 59
Keywords Energy efficiency, renewable energy, transport	**Report identification code** VTT-R-04966-14

Summary

In 2009, VTT Technical Research Centre of Finland initiated the five year (2009 – 2013) programme ”TransEco” on energy efficiency and renewable energy in road transport. There were no other national activities, which would have tied the stakeholders in this field together. TransEco brought the public sector (ministries, agencies, municipalities), private companies and academia to the same forum to discuss, how to best fulfil national and EU level energy and emission reduction targets in road transport in a cost effective way, while at the same time creating business opportunities for the Finnish actors. TransEco comprised four main research themes, i.e., vehicles, fuels, system level issues and international cooperation.

When TransEco was closed at the end of 2013, altogether 37 projects had been running within the programme. Funding came from 13 major financiers, and in addition, many companies contributed with smaller amounts of financial support. Overall, the budget of TransEco was some 10 million euros. There were 12 research organisations contributing to TransEco. In addition, several private company employees contributed to the work. On the whole, TransEco involved more than 50 researchers, representing a multitude of different research disciplines. To facilitate dissemination of the results, TransEco arranged five major seminars, several press conferences and thematic workshops. Dozens of project reports and scientific papers were produced. Some of the results were highlighted by producing brief “scorecards”.

All in all, TransEco was quite successful. The research work resulted in, e.g., new formulas for biofuels, high performance electric vehicle powertrains, solutions to reduce fuel consumption of heavy-duty vehicles and technology to assist drivers to minimise fuel consumption. In addition, TransEco supported decision-making and policy development in the areas of biofuels, electric vehicles and transport energy taxation.

Confidentiality	Public

Espoo, 29.10.2014

Written by	Reviewed by	Accepted by
Päivi Aakko-Saksa Principal Scientist	Juhani Laurikko Principal Scientist	Nils-Olof Nylund Research Professor

VTT's contact address
P.O.Box 1000, FI-02044 VTT

Distribution (customer and VTT)

Publicly available at the website of TransEco (www.transeco.fi) and TransSmart (www.transsmart.fi).

Preface

The five year (2009 – 2013) programme TransEco for energy efficiency and renewable energy in road transport gathered all key stakeholders in Finland around the same table to discuss how to best fulfil national and EU level energy and emission targets in road transport in a cost effective way, while at the same time creating business opportunities for the Finnish actors.

A comprehensive website (www.transeco.fi) with information on the programme itself and all TransEco projects was created. Now the website comprises reports for individual projects as well as annual reports of the programme integrate as a legacy.

The report at hand is the final report of TransEco. The annual reports were written in Finnish. However, it was decided that the final report should be in English. The final report is a montage of all technical projects within TransEco. It is intended to give the reader a general overview of the work within TransEco. For most projects, links to in-depth reports are provided for those who wish to learn more of the topic.

TransEco was closed in the fall of 2013, when a new program, TransSmart, was inaugurated. TransSmart covers the same themes as TransEco, energy efficiency and renewable energy, but it also encompasses intelligent transport systems and services. It also extends to other forms of transport than just road transport.

At his point, VTT wants to thank all parties who contributed to the success of TransEco, whether through financial support or through hard research work.

Espoo, October 27, 2014

Dr. Nils-Olof Nylund
Coordinator of TransEco & TransSmart

Contents

TRANSECO IN A NUTSHELL

Rationale

In 2008-2009, when the preparations for TransEco began, a number of important EU level and national targets and strategies had already been set up. On the EU level, these included the general climate and energy targets for the year 2020, i.e. the so-called 20/20/20 targets, calling for a 20 % reduction in greenhouse gas emissions, a 20 % share of renewable energy and a 20 % improvement in energy efficiency. Furthermore, the Directive on the promotion of renewable energy (RED) called for 10 % renewable energy in transport by 2020, and the Directive on fuel quality (FQD) called for a reduction of carbon-intensity of transport fuels. Simultaneously and as a response, a long-term climate and energy strategy was developed in Finland. Also, the Ministry on Transport and Communications presented its own action programme to reduce greenhouse gas emissions from transport.

At that time, there was no national research platform to tackle climate and energy challenges in road transport. TransEco, an initiative by VTT Techical Research Centre of Finland, was set up to fill out this need.

Objective

The objectives of TransEco were formulated as follows:

- Create a set of measures to cost-effectively adapt Finnish road transport to EU and national-level climate gas reduction and energy efficiency targets.
- Give input for the preparations of EU Directives to achieve solutions that are most suitable for Finland and facilitate high-technology export.
- Increase energy efficiency and use of renewable and low-carbon energies in road transport.
- Develop systematic processes and tools for the assessment of potential & performance of energy savings measures and their impacts.
- Modus operandi is based good cooperation among decision makers, companies, researchers and other actors within the whole transport sector.

Structure and main activities

TransEco was built on four columns, namely:

- Technology and research
- Demonstrations and piloting activities (mainly industry-driven undertakings)
- Decision-making and methods of steering (policy research)
- Interaction and cooperation

The actual activities of TransEco were grouped under four main themes; 1) vehicle-related activities, 2) fuel-related activities, 3) system level issues and 4) international cooperation. Energy efficiency of heavy-duty vehicles, electrification of vehicles and advanced biofuels, as well as policy support were among the key activities.

The main platforms for international cooperation were the Energy Technology Network (ETN) of the International Energy Agency (IEA) and Nordic cooperation within the Energy & Transport programme by Norden (NER).

Figure 1 presents the schematics of how TransEco generated support to decision making on all levels.

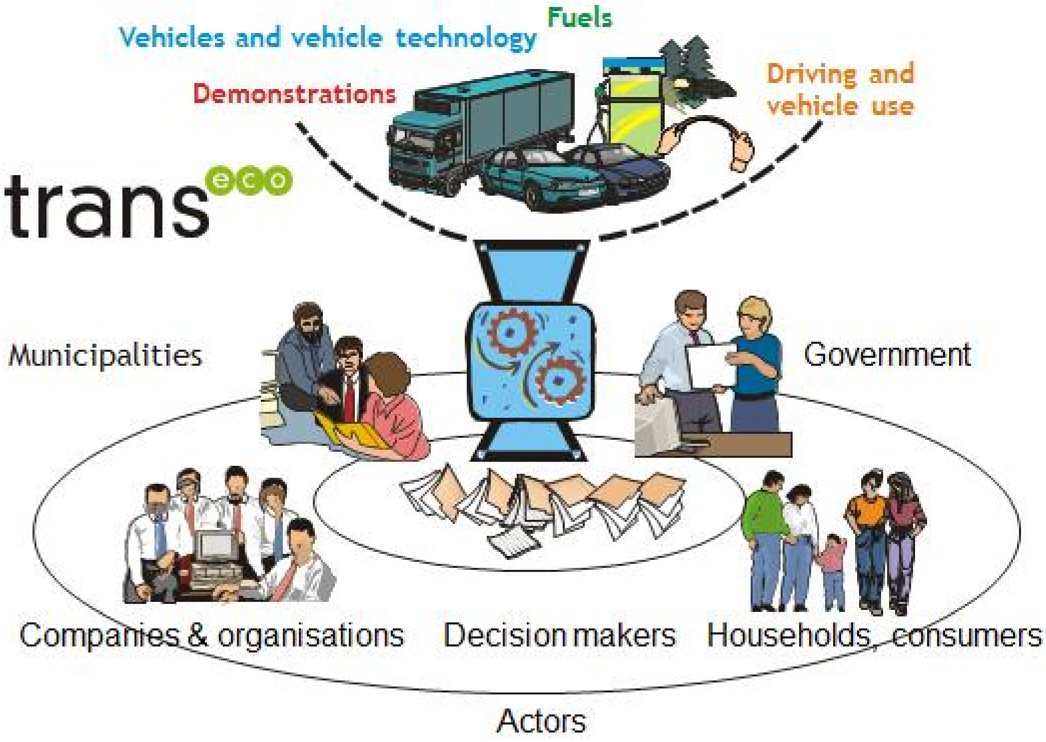


Figure 1. New technology is demonstrated and evaluated, and results are fed into the decision making process at various levels of the decision-making.

Management and partners

An external steering group was set up for the programme. The main tasks of this group were guiding the programme, identifying knowledge gaps and need for new activities and arranging funding for the activities.

Represented in the steering group were:

The public sector:

- Ministry of Employment and the Economy
- Ministry of the Environment
- Ministry of Finance
- Ministry of Transport and Communications
- Finnish Funding Agency for Innovation (Tekes)
- Finnish Transport Agency (LiVi)
- Finnish Transport Safety Agency (Trafi)
- Helsinki Region Transport (HSL)

Companies:

- Neste Oil
- St1
- Valmet Automotive

Interest organisations:

- The Association of Automobile Importers in Finland
- Finnish Petroleum Federation (ÖKL)
- Finnish Transport and Logistics (SKAL)

As the coordinator, VTT Technical Research Centre of Finland was responsible of the everyday running of the programme. External communications were handled by Motiva Oy, an expert company promoting efficient and sustainable use of energy and materials. Motiva Oy operates as an affiliated Government agency.

Information on TransEco can be found at www.transeco.fi, as well as on the website of Motiva at www.motiva.fi.

Partners in research, in addition to VTT and Motiva were:

- Aalto University School of Engineering
- Government Institute for Economic Research (VATT)
- Helsinki Metropolia University of Applied Sciences with its partners:
    - Lappeenranta University of Technology
    - Lahti University of Applied Sciences
- Ramboll
- Tampere University of Technology
- University of Turku
- Turku University of Applied Sciences
- University of Oulu

Overall outcome

When TransEco was closed at the end of 2013, altogether 37 projects had been running within the programme. Funding came from 13 major financiers, and in addition, many companies contributed with smaller amounts of financial support. The two single largest financiers were Tekes and TEM. The overall budget of TransEco was some 10 million euros.

There were 12 research organisations contributing to TransEco, and in addition, private company employees contributed to the work. All in all, TransEco involved more than 50 researchers, representing a multitude of research disciplines.

Technical achievements include, among other things:

- Aerodynamic fairings for heavy-duty vehicles
- Assisting systems for heavy-duty vehicle
- Efficient electric powertrains
- Test platform for electric bus development
- Technical support for vehicle procurement and a manual for eco-driving
- High concentration ethanol fuel formulation enabling operation in cold conditions

These and other technical achievements are highlighted in the following chapters.

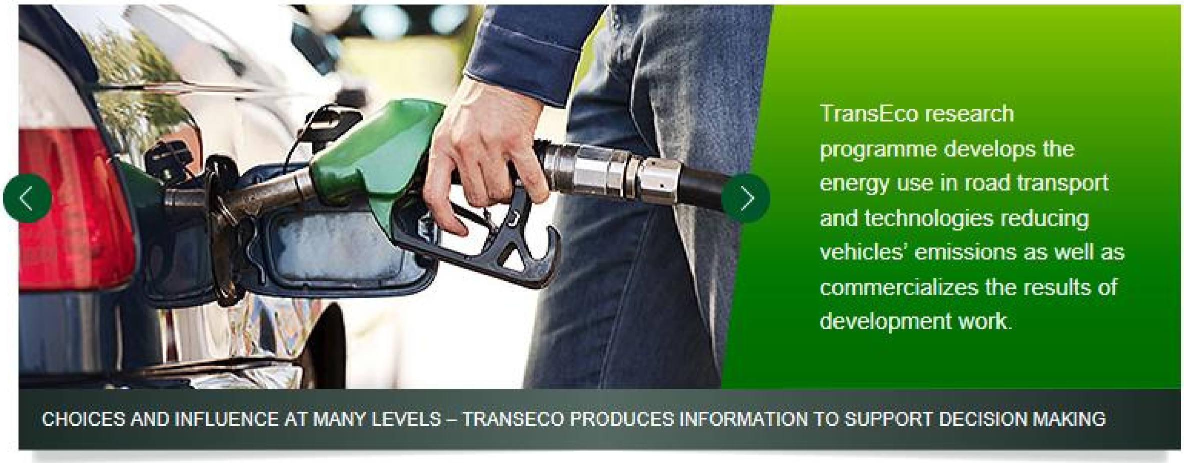
As for policy support, TransEco contributed to the formulation and/or establishment of:

- Electric vehicle policy for Finland
- Finnish biofuels obligation

    - 20 % biofuels by 2020, amendment 1420/2010 to the Act on Biofuel Distribution Obligation (446/2007)
- Revised taxation system for transportation fuels
    - Taxation based on energy content, carbon intensity and local emissions, Act on Excise Duty on Liquid Fuels, 1399/2010
- Future transport scenarios
- Forecasting and impact assessment tools

The ”ILARI” project looked forward to the year 2050. In the final report ”Transport sector policy packages for climate change mitigation in Finland up to the year 2050. Baseline-scenario, Urban beat or Cornucopia?” eight alternative scenarios for transport were presented. Although TransEco was a programme with technical focus, the “ILARI” project involved “soft values” in the sense that the visions of “ILARI” are based on the views of transport experts as well as of high school students. The project developed a method for preparing policy packages for climate change mitigation and assessed the potential of selected policy packages in achieving the futures set by alternative visions.

FUELS


TransEco research programme develops the energy use in road transport and technologies reducing vehicles' emissions as well as commercializes the results of development work.
CHOICES AND INFLUENCE AT MANY LEVELS – TRANSECO PRODUCES INFORMATION TO SUPPORT DECISION MAKING

1. High-concentration ethanol fuels for cold driving conditions

Low-carbon “Waste-to-Ethanol” Concept

St1, a Finnish energy company, has developed a novel “Waste-to-Ethanol” concept that has a record-low carbon footprint per litre ethanol produced. The key elements of the process are: using waste and industrial side streams as feedstock and apply new energy efficient processes and technology, combined with small-scale initial production phase to minimise transportation of material.

Figure 1 shows the schematics of this unique Etanolix™ concept with six plant now in operation. The next step was to make use of household-based bio-waste, based on a different process called Bio-nolix™. Those plants are slightly bigger in size, and first plant using this technology was started in 2010. However, bio-waste alone does not hold enough potential, so cellulose-based processes are needed. Therefore, development of the first Cellunolix™ plant using cardboard and other similar packaging material from household, as well as from industry and retail sector is already underway.

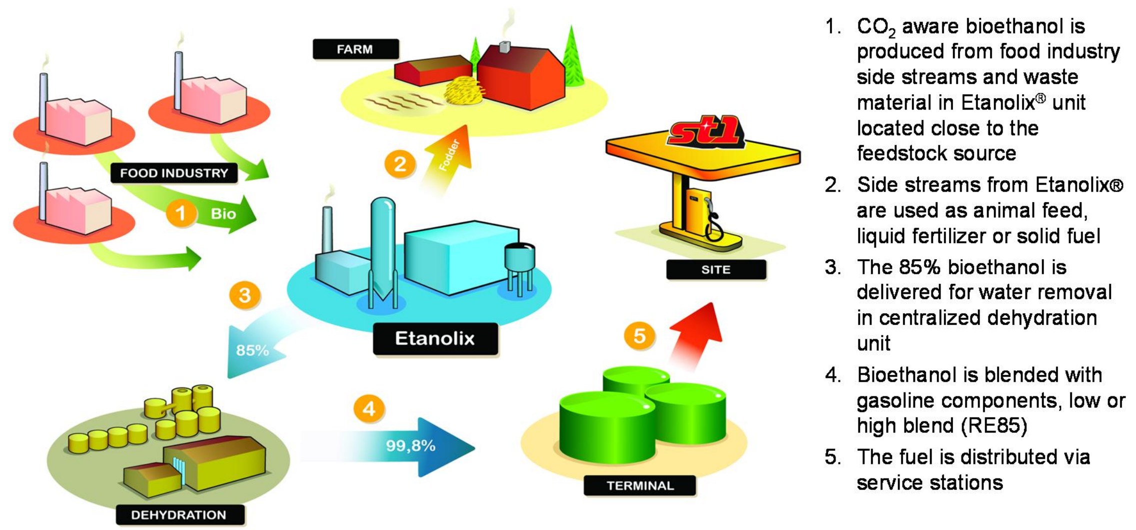


Figure 1. Schematic overview of the Etanolix™ bioethanol production process by St1.

Test procedures: fuels and temperatures

Altogether seven different fuel compositions were evaluated. They consisted of 70 to 85 % of anhydrous bioethanol and various different mixes of regular petrol components, as well as some specific species like ETBE, butane, isobutanol etc. As a reference, new Euro-quality petrol with 10 % ethanol was used. Fuel vapour pressure of each sample was adjusted according to test temperatures to match summer or winter condition and ensure effortless start-up.

Test matrix was composed of a selection of test cars from a pool of 6, and several ambient temperatures between +23 and -25 °C for each fuel composition. Over 150 test runs were completed in total, producing very in-depth and thorough material for assessing and comparing the performance of the fuels, as well as the cars, in all ambient conditions relevant to Finland and other Nordic countries. Therefore, exhaust gas collection set-up with insulated and heated connecting tubes must be used to avoid condensation of the water contained in exhausts from high ethanol content fuels. (The vehicle does not relate to this study)

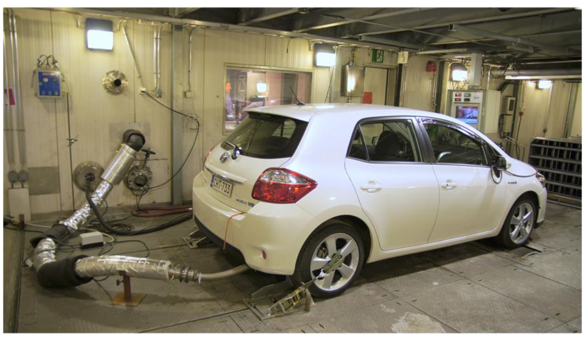


Figure 2. Test cell at VTT allows measurements at low ambient temperatures down to -30 °C.

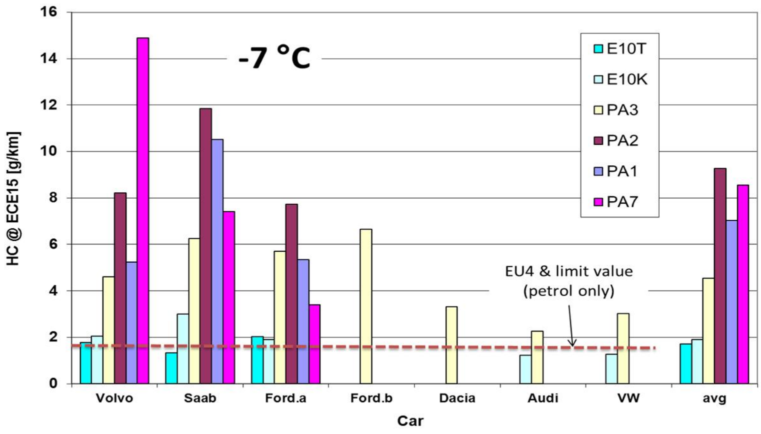


Figure 3. THC emissions over ECE15 test cycle at -7 °C with different cars and fuel formulations.

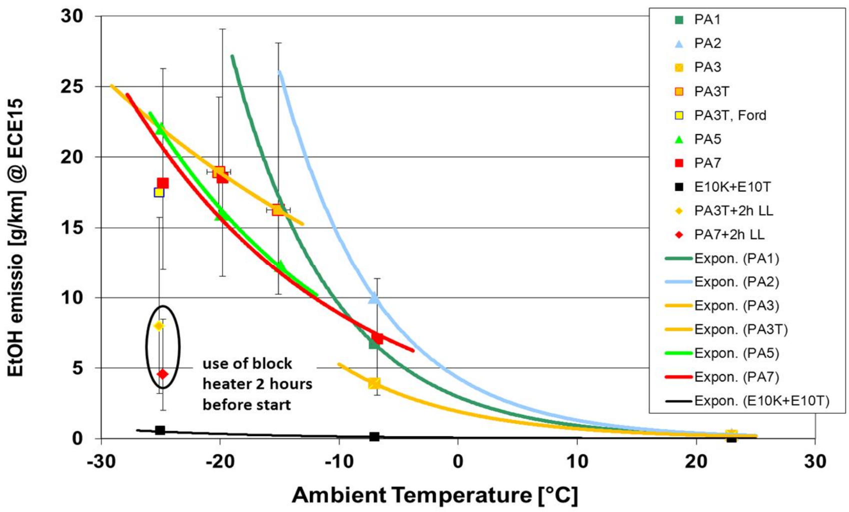


Figure 4. Average ethanol emissions over the ECE15 cycle as a function of ambient temperature with different fuel formulations.

Results and discussion

Test results showed that the composition of the fuel had marked influence on emissions. The lower the test temperature was, the more distinctive were the differences. Based on the results, about -15 °C would be the lower limit of operation with "straight-mix" E85 fuel com-posed of ethanol and petrol. On the other hand the more "engineered" fuels performed much better, and allowed starting as low as at -20 to -25 °C. With those formulations cold start and driving was possible at equal level of unburned hydrocarbons and other unwanted emissions (aldehydes, ethanol) at an ambient temperature more than 10 °C lower compared to "straight-mix" E85 fuel.

Conclusions

The results from the series of tests conducted using different fuel formulations and a batch of FFV-cars showed that the composition of the fuel has an effect on the emissions output. Furthermore, we were able to substantiate that the effects are not only related to the ethanol contents of the mixture, but it is possible by choosing the composition of the "non-ethanol" portion to affect positively to the levels of emissions. Therefore, the formula chosen for the commercial fuel "RE85" resulted in much better performance than the "industry-standard" formula for E85, which is just ethanol and 15 % gasoline.

Even if we also demonstrated that low ambient temperatures have an increasing effect on emissions, we have also constituted that this phenomenon has a highly transient nature. High levels of emissions occur only for those first few kilometers after a cold start in cold conditions. Once the engine warms-up and all the emission control systems reach their full performance, the levels of emissions drop to a low or at least reasonable level. According to our observations, this happens in two to four kilometers, even at the lowest ambient temperatures included in our study (-25 °C). Therefore, the total impact of these high levels remains modest, below 15 % on average, of the total annual emissions in Finland

Publications

Laurikko, J., Koponen, P. Korkeaseosetanolipolttoaineen optimointi kylmiin olosuhteisiin sopivaksi. Tutkimusraportti, VTT-R-05406-11. 54 s., 2011

Laurikko, J., Nylund, N-O., Aakko-Saksa, P. High-volume ethanol fuel composition optimized for cold driving conditions. Society of Automotive Engineers (2013) No: Technical Paper 2013-01-2613. doi-link: 10.4271/2013-01-2613.

Laurikko, J., Nylund, N-O., Suominen, J., Anttonen, M. (P. A.), Optimizing high-volume ethanol fuel composition for cold driving conditions. Paper T6.6C, Proc. XIX ISAF (International Symposium of Alcohol Fuels), Verona, October 2011. 7 p.
ISAF 2011

Laurikko, J., Nylund, N-O., Suominen, J., Anttonen, M. P. A., High-Concentration Ethanol Fuels for Cold Driving Conditions. Paper F2012-B01-040. Proc. FISITA 2012 World Automotive Congress, Beijing, China, November 2012.

Participants and budget

VTT Technical Research Centre Finland
ST1 Biofuels Oy

Budget: EUR 600 000

Contact information

Juhani Laurikko, VTT (juhani.laurikko@vtt.fi)

2. Biogasoline options for spark-ignition cars

Introduction

Ethanol is the world's most commonly used biofuel, but technical limitations mean it can only be used in the fuel of regular petrol-powered cars in mixtures up to 10 to 15 vol% (6.7 to 10 energy%). Today, high ethanol concentrations can only be used in specially manufactured flex-fuel cars, so that petrol biocomponents complementing ethanol are needed. When assessing new fuels, it is important to verify that they work acceptably at all stages of the energy chain. Other factors to note include the infrastructure of the production and end use stages, compatibility with the car stock, and health and environmental impacts. This work charted biocomponent alternatives and their effect on emissions, taking into consideration bioethers, biobutanol and biohydrocarbons, for example. Renewable hydrocarbons that can be used with petrol can be manufactured from biomass, and can also be generated as side products in the production of other biofuels.

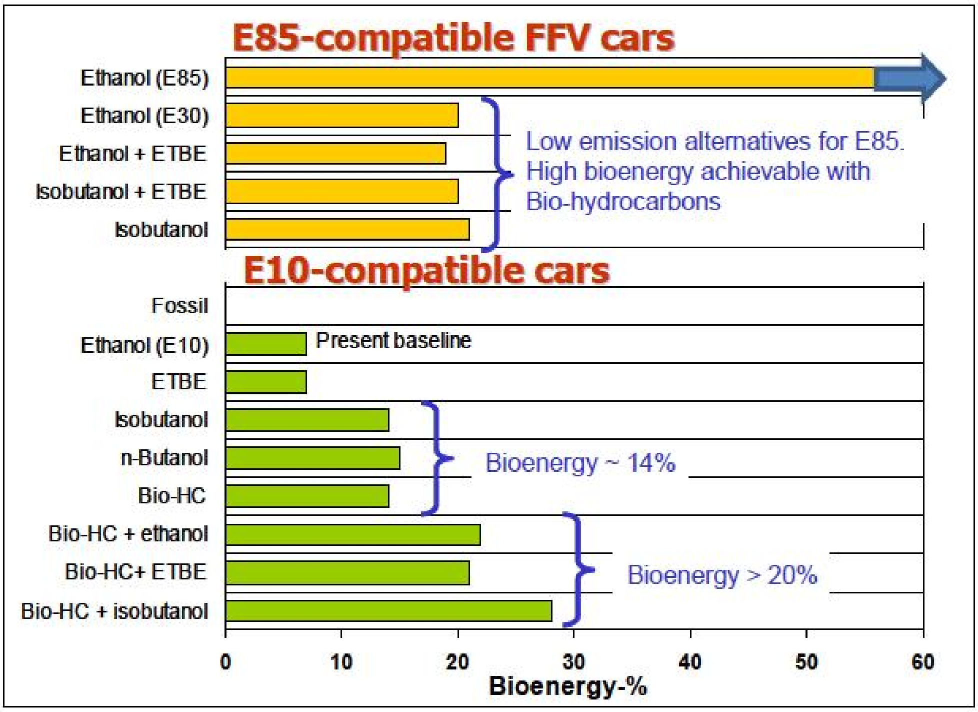
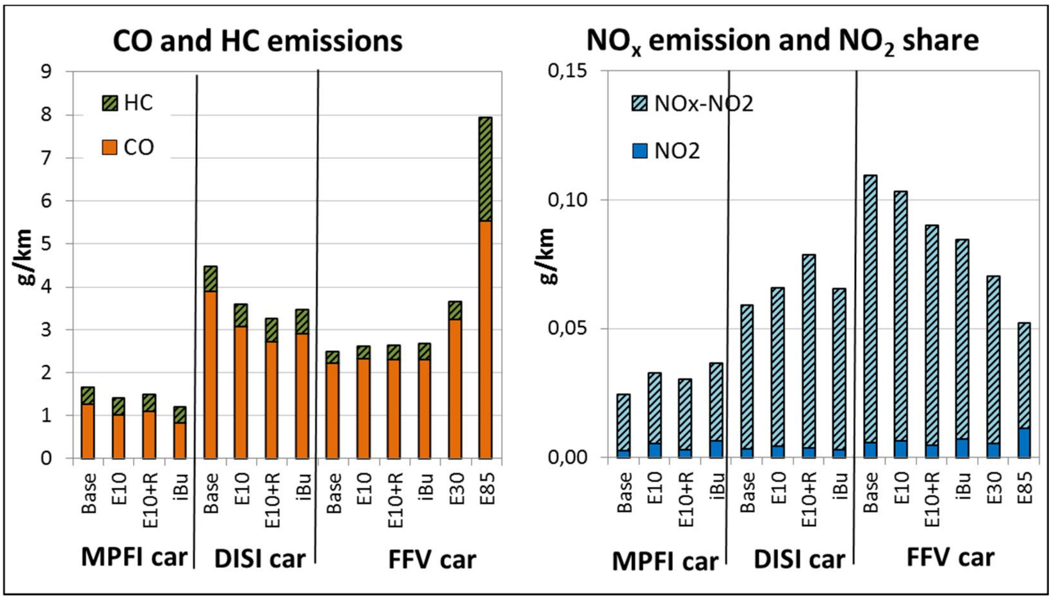
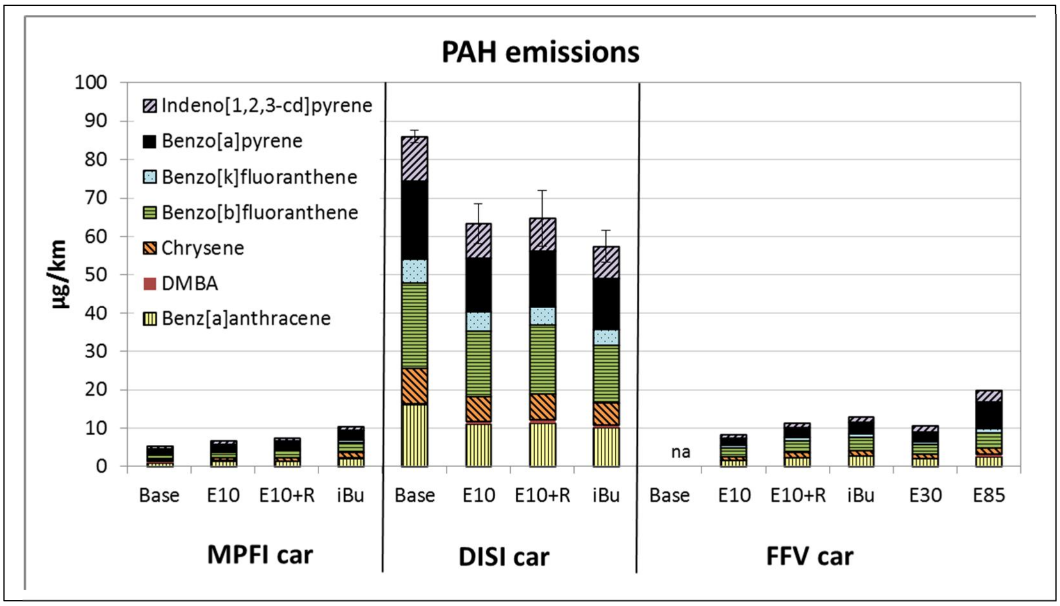


Figure 1. High bioenergy concentrations can be achieved for E10-compatible cars by combining different biocomponents.

Results

Petrol biocomponents and their combinations were researched from literature, and by performing car exhaust gas emission measurement at a temperature of -7 °C. The results indicate several possibilities for increasing the share of bioenergy in petrol to over 20% while retaining its compatibility with conventional petrol-powered cars (Figure 1). In most cases, the use of ethanol, isobutanol, n-butanol, ETBE or their mixtures together with renewable hydrocarbon components had no significant adverse effect on the emissions of conventional cars, and with the best combination, reduced the harmfulness of the emissions (Figure 2). The harmfulness of particles in exhaust gas at low temperatures was significant, particularly in direct-injection DISI petrol cars (Figure 3). Ammonia emissions were also detected, but were not primarily connected to the fuels.





Figures 2 and 3. CO, HC and NO_x emissions and the share of NO_2. Particle PAH emissions. MPFI, DISI and FFV cars in the European exhaust gas test at -7 °C.

Publications

Aakko-Saksa, P. Rantanen-Kolehmainen, L. & Skyttä, E. Ethanol, Isobutanol, and Biohydrocarbons as Gasoline Components in Relation to Gaseous Emissions and Particulate Matter. Environ. Sci. Technol. 2014, 48, 10489−10496.

Aakko-Saksa, P., Koponen, P., Kihlman, J., Reinikainen, M., Skyttä, E., Rantanen-Kolehmainen, L. & Engman, A., Biogasoline options for conven-tional spark-ignited engines. VTT W187, 2011.

Aakko-Saksa, P., Koponen, P., Kihlman, J., Rantanen-Kolehmainen, L. & Engman, A., Biogasoline options – Possibilities for achieving high bio-share and compatibility with conventional cars. SAE Int. J. of Fuels and Lubricants. Vol. 4 (2011) No: 2, 298–317. Also as SAE Paper 2011-24-0111.

Aakko-Saksa, P., Koponen, P., Rantanen-Kolehmainen, P. and Skyttä, E., Bensiini-autojen sääntelemättömät pakokaasupäästöt. Ilmansuojelu magazine, 4/2012, pp. 10–15.

Participants and budget

VTT Technical Research Centre of Finland
Neste Oil

Budget: EUR 330 000

Contact information

Päivi Aakko-Saksa, VTT (paivi.aakko-saksa@vtt.fi)

3. Operation of the particulate filters of diesel cars with biocomponents

Introduction

With the tightening emission requirements, a particulate filter is par for the course for new diesel-powered passenger cars. As its name suggests, a particulate filter captures the particles in exhaust gases very effectively, but in order to prevent clogging, the filter must be regenerated now and then, or cleaned by burning out the accumulated soot. The goal of this research was to study the effect of the fuel on the cleaning requirements of the particulate filter. The research was carried out using one vehicle, a 2009-model European passenger car equipped with a Common Rail injection system. Four different fuel grades were used. The reference fuel used was a fossil diesel fuel conforming to the EN 590 norm. The other fuels were a diesel mixture containing 30% HVO (Hydrotreated Vegetable Oil), pure HVO, and a diesel fuel containing 10% of conventional biodiesel, or the methyl ester of rapeseed oil (FAME, Fatty Acid Methyl Ester). The research was carried out as part of a Master's thesis using VTT's light-duty chassis dynamometer.

Results

The fuel could be seen to have a direct effect on the car's particle emissions and, further, on the regeneration need of the particulate filter. With the fossil EN 590 diesel fuel, the regeneration interval with the driving cycle used was around 330 km (Figure 1), and the same for the 30% HVO mixture. With 100% HVO, regeneration was needed significantly later; the average regeneration interval was slightly over 400 km, 22% longer than with the EN 590 fuel. The fuel containing 10% of FAME could also achieve an average regeneration interval of roughly 400 km, but the deviation of the results was exceptionally high. The reason for the deviation could not be found; there were no significant differences between temperatures or pressure loss increase between the different tests.

During the tests, the particulate filter slowly clogged as soot particles accumulated in the filter. The pressure loss caused by the particulate filter immediately before regeneration was typically around 85 mbar for all other fuels but the 100% HVO, which had a pressure loss over 10 mbar lower (Figure 2). If fuel characteristics and their effect on actual accumulation could be taken into consideration in the calculated particle mass accumulation, the regeneration interval with HVO fuel could be significantly longer than it was now. When regeneration began, the pressure difference over the filter rose to a level of 130 mbar, and dropped to around 40 mbar after the regeneration. The regeneration increased the average fuel consumption calculated for the entire driving distance by 0.2…0.4 l/100 km depending on the duration of regeneration.

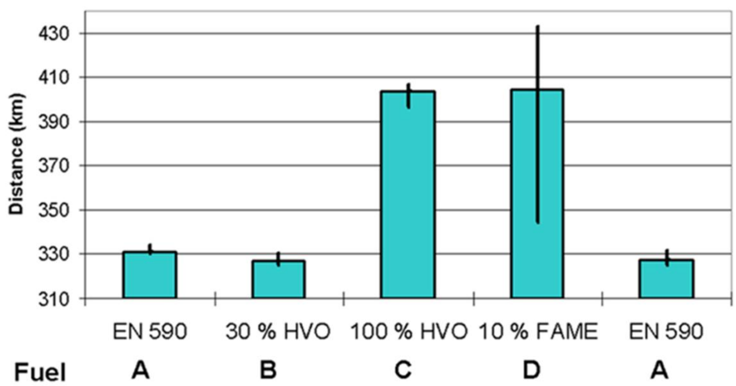


Figure 1. Regeneration interval of the particulate filter in kilometres driven with different fuels. The bar indicates the average regeneration interval, the black line indicates the range of variation, or the minimum and maximum values.

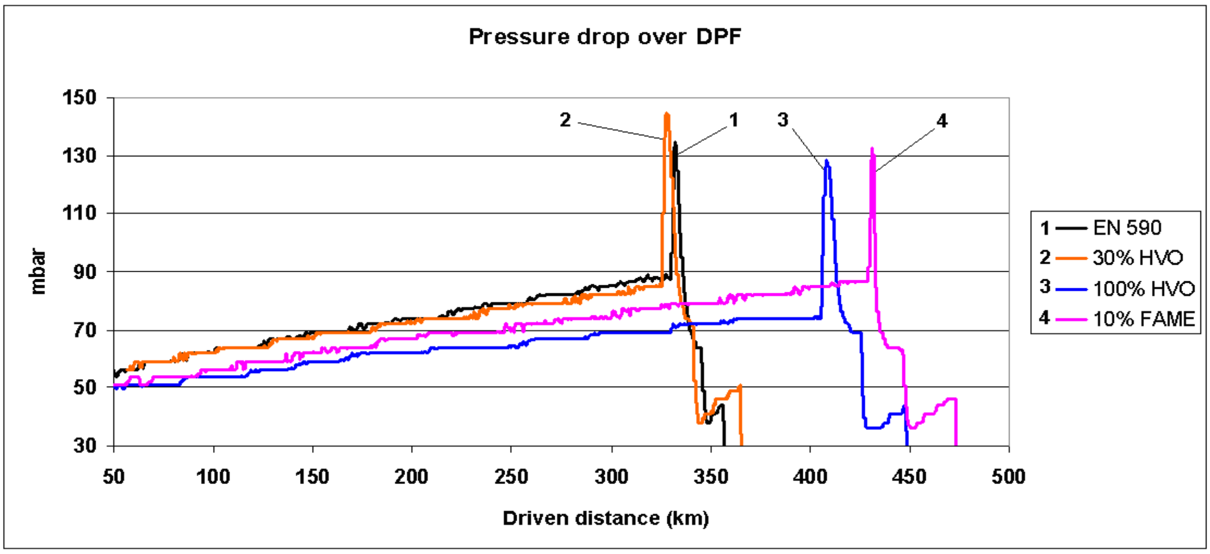


Figure 2. Typical pressure differences over the filter with different fuels during the constant speed phase. The curves in question are from individual tests.

Publications

Master's Thesis: Kopperoinen, A., Polttoainelaadun vaikutus dieselhenkilöauton hiukkassuodattimen toimintaan. University of Oulu, Department of Mechanical Engineering. May 2010. 80 p. + Appendices 1 p.

Kopperoinen, A., Kytö, M., and Mikkonen, S., "Effect of Hydrotreated Vegetable Oil (HVO) on Particulate Filters of Diesel Cars," SAE Technical Paper 2011-01-2096, 2011.

Participants and budget

VTT Technical Research Centre of Finland
Neste Oil

Budget: EUR 70 000

Contact information

Matti Kytö, VTT (matti.kyto@vtt.fi)

4. Fuel standards

CEN standardization procedure

- Compromise between 33 European countries; formal decision through enquiries and balloting; automotive, fuel and biofuel associations have right to speak.
- Preparing a new standard takes many years; updating an existing standard about two years.
- Finnish Petroleum Federation (ÖKL) represents Finland for liquid fuels.

Fuel standards

- Define fuel type and minimum quality.
- Engine manufacturers requirements in owner’s manuals
- Minimum fuel quality sold by fuel companies is valid at the point where fuel is sold for end customers
- Define fuel labelling, e.g. 95E10; standard shall be mentioned at fuel retail points.
- Meeting a standard is not mandatory.
- Standards available at www.sfs.fi

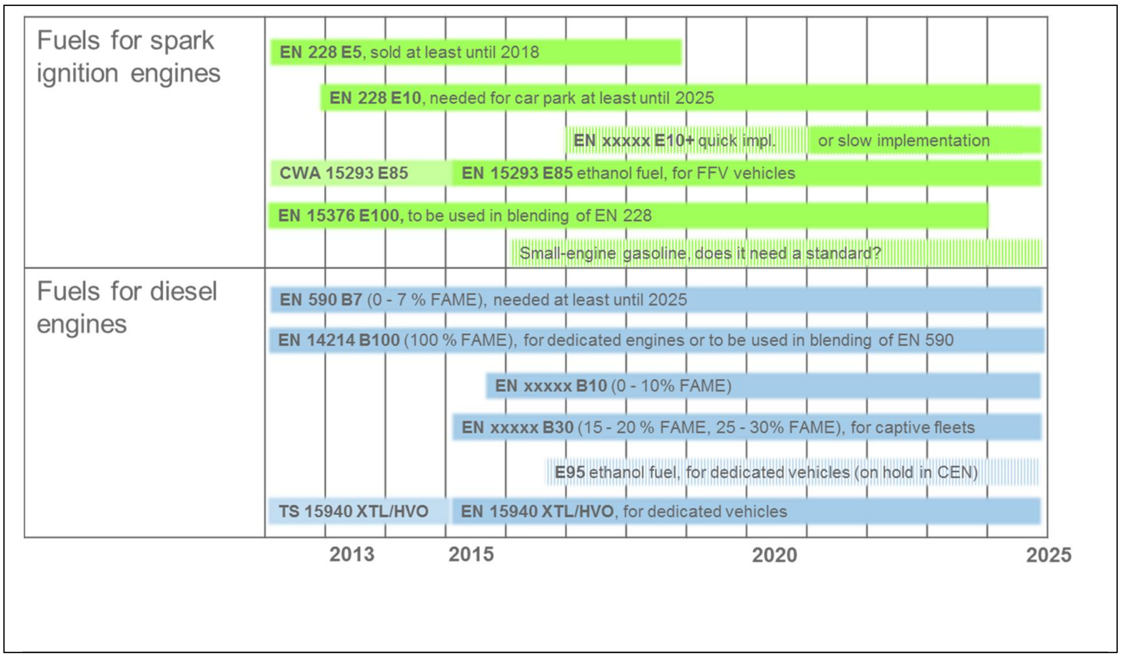
Automotive companies

Look more forward than standards; public Worldwide Fuel Charter “WWFC”.

Contact

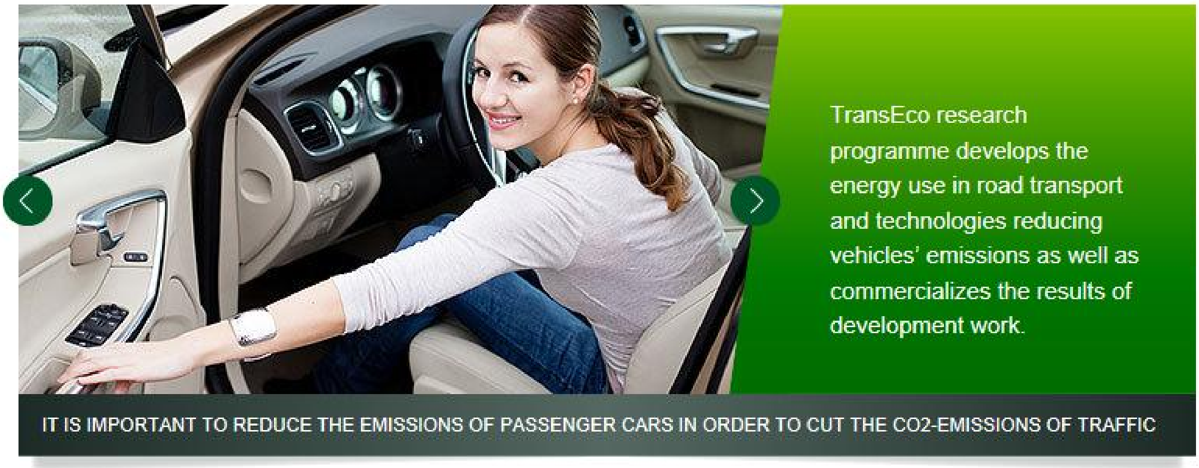
Seppo Mikkonen, Neste Oil, (seppo.mikkonen@nesteoil.com)

Automotive fuel standards & estimated schedules



EN xxxx: Standard in force; TS xxxxx: Technical specification, “pre-standard”; CWA xxxxx: CEN workshop agreement, 1st phase of a “pre-standard”; **E5** or E10 0-5% or 0-10% ethanol or corresponding amount of oxygenates; E10+: 20-25% ethanol or corresponding biocontent; **E85:** 50-85% ethanol; E95: 95% ethanol; E100: raw ethanol; **FAME:** Fatty acid methyl ester (biodiesel); XTL: GTL, BTL, CTL (paraffinic diesel fuel); HVO: Hydrotreated vegetable oil (paraffinic diesel fuel)

CARS AND LIGHT-DUTY VEHICLES



5. Improving the energy efficiency of passenger car traffic through user-driven measures, EFFICARUSE

Introduction

The energy efficiency of the use of a passenger car and passenger transport as a whole depends on several factors, the majority of which are user-dependent. The owner (or possessor) and the user of a vehicle can affect the energy consumption of the vehicle through their own actions. This project examines these user-driven actions and choices and the possibilities they offer for reducing the energy consumption of passenger vehicles.

Results

Energy-efficient car use

The energy-efficient use of a car can be divided into two areas: minimising the car's energy requirement, and generating the power required for driving economically. These can be affected by choosing the optimal vehicle for the intended use, choices over the car's life cycle (tyre selections, service and maintenance), route selection, and anticipation of traffic situations.

Tyre measurements using identical tyre sizes showed a difference of 7.3% in consumption between the extremes of the products of different manufacturers. The measurements showed that increasing the diameter of the tyre correlated with a slight decrease in fuel consumption.

Economical driving methods were measured using a diesel-powered passenger car. When driving at constant speed, a lower speed consumed less almost without exception. In city driving, specific consumption is high and efficiencies low (idling, low loading of the engine, braking). Additionally, driving speeds are low and accelerations moderate, preventing the engine load from rising into the optimal area. In city driving, the optimal consumption result can be achieved by minimising the amount of work by means of quick acceleration and rolling but raising the engine load high enough during acceleration. Using the optimal driving method, approximately 35% fuel was saved in city driving compared to the starting point. When driving on main roads, the differences in consumption were minor between different driving methods, and efficiency was better than in city driving, in line with expectations. Rolling in neutral was 1% more economical than engine braking. To sum up, lower fuel consumption can be achieved by avoiding changes in speed and driving at lower top speeds. As a rule, one should drive at a constant speed in the highest gear in which the engine still provides sufficient torque.

Consumption and emissions during "real" driving

Study was made of the effect on the vehicle's emissions and energy consumption of conversion kits enabling the use of high ethanol fuel, while also charting the official regulations related to the installation of the equipment and any risks caused by the equipment. The conversion is implemented by reducing the time that fuel nozzles remain open.

The operation of exhaust gas post-processing during "real" driving and the overall efficiency of new power plant alternatives are studied by measuring some twenty passenger cars. The technical alternatives represented consist of petrol and diesel cars, flex-fuel, battery-powered electric, and petrol and diesel hybrid.

The measurement of carbon dioxide emissions of passenger cars was studied using a measurement kit. When the measured consumption values were compared to those reported by the manufacturers, it was observed that the fuel consumption measured by weighing (EU combined) was on average 28% higher than the value reported by the manufacturer for petrol-powered cars, and on average 36% higher than that for diesel-powered cars. There are also references in the literature suggesting that the driving resistances used during type approval are often much lower than those specified for a rolling test in practical conditions.

The regulated and unregulated emissions were studied for 9 Euro 5 emission level cars over the European exhaust emissions driving cycle. Emissions typically increased when moving from +23 °C to -7 °C. The CO and HC emissions were mostly higher for spark-ignition cars than for diesel cars, whereas NO_x emissions were higher for diesel cars (Figure 1). Methane and ethene were dominating C1-C8 hydrocarbons for E85 and diesel, whereas benzene, toluene, and xylenes dominated for E10. High acetaldehyde and ethanol emissions were observed for E85. Formaldehyde emissions were high when using diesel fuel or E85 when compared with E10. Substantial ammonia emissions were observed for spark-ignition cars (induced by the three-way catalyst), but not for diesel cars. Particulate matter (PM), priority PAH emissions and Ames mutagenicity were highest for E10 fuelled FFV cars, the second highest for the other E10 and E85 fuelled cars, and the lowest for the DPF equipped diesel cars.

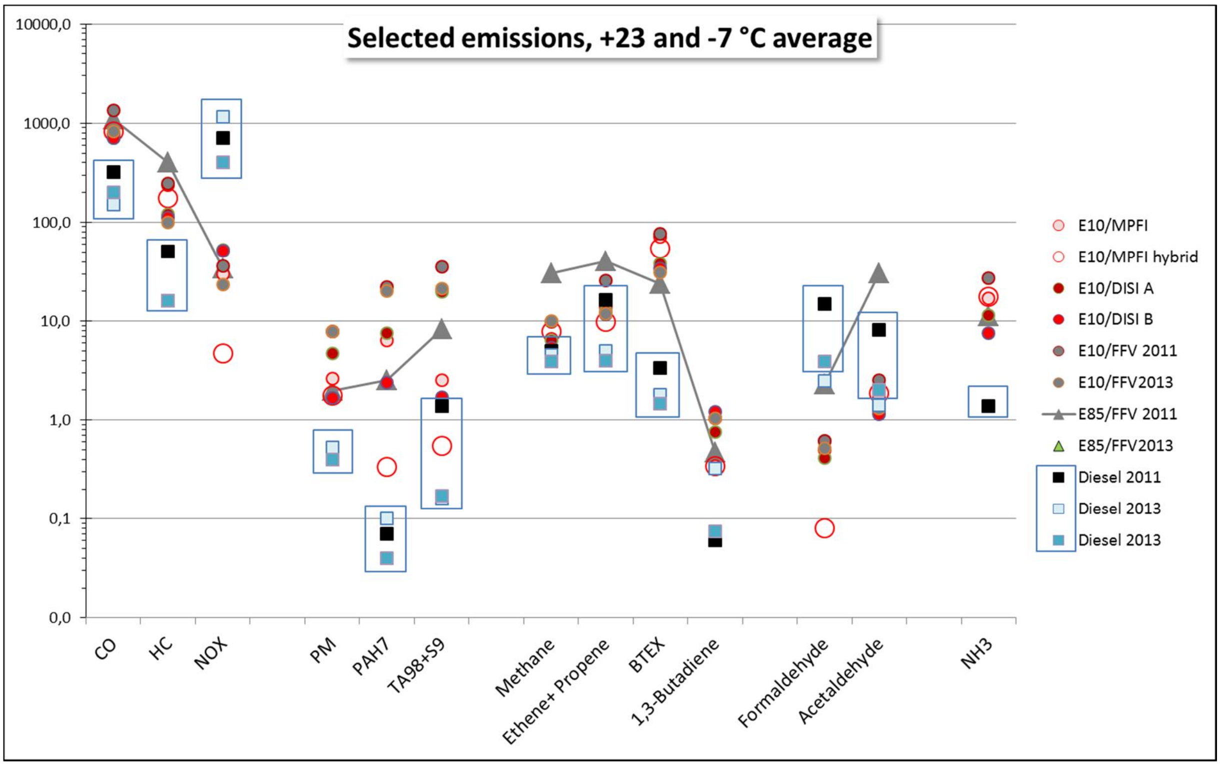


Figure 1. An overview on the selected emissions over the European driving cycle at +23 and -7 °C. Unit is mg/km for other emissions than PAH7 (µg/km) and Ames TA98+S9 (krev/km).

Energy balance and economy of electric vehicles

During the project, we studied the energy consumptions of hybrid (HEV) and plug-in hybrids (PHEV) using field testing and laboratory measurements, established a laboratory measurement system using a dynamometer, and studied the energy balance of electric vehicles and the energy economy of their subsystems (Figure 2). The laboratory measurements of electric vehicles generated data on the cold working of electric vehicles and supported the comparison study of a new power plant technology.

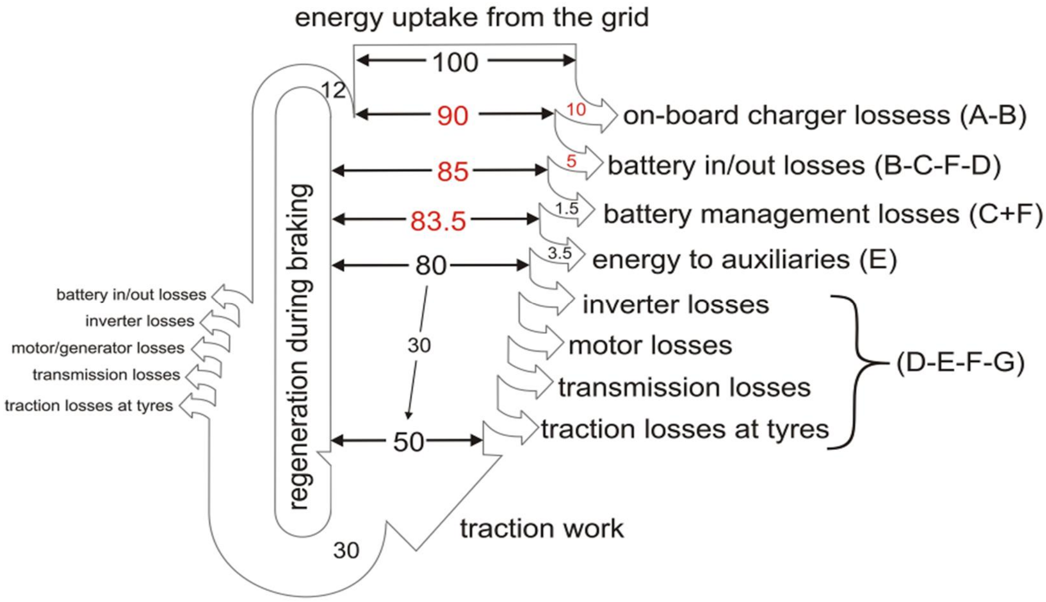


Figure 2. Energy balance of an electric vehicle and the energy economy of its subsystems.

Research on the preheating of cars

This subtask will expand the knowledge of passenger cars. The objective of the research was to accumulate data on the energy-saving potential and the factors affecting their energy requirements. In addition, the subtask also determined the effect of engine preheating on the energy consumption of a vehicle equipped with current engine technology.

<u>This research segment</u> will examine the effect of a vehicle's size category, load, power plant and mileage on its energy consumption and emissions. During the research, measurements will be performed on six cars.

<u>The engine preheating research</u> produced data that has been used in writing Motiva's new preheating guide. Measurements during the research were used to determine the effect of contact heater, hose and fuel-powered heaters on the emissions, energy consumption and engine-heating speed of a vehicle. Based on the results, the clearest measurable benefit of preheating is connected to the reduction of unburned hydrocarbons (UHC).

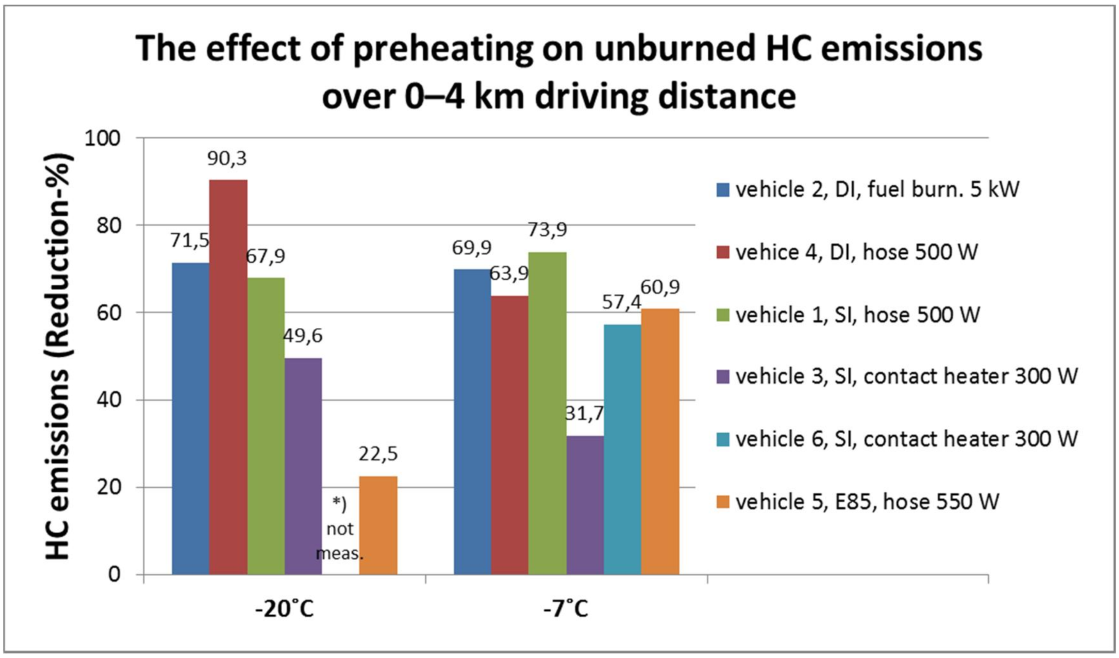


Figure 3. The effect of preheating on unburned HC emissions over 0 – 4 km driving distance

Publications

Laurikko, J. & Nuottimäki, J. Hiilidioksidipäästöjen mittaaminen henkilöautoista tyyppihyväksymistestin mukaisesti" (VTT-R-05402-12) and as an article in the Tekniikan Maailma magazine in issue 15/2012.

Laurikko, J., Pellikka, A.-P., Fuel Economy And Energy Consumption of Hybrid and Plug-In Hybrid Cars in Nordic Climate Conditions, Paper F2010-A-049, Proc. of the 25th World Electric Vehicle Symposium and Exposition (EVS25), Shenzhen, China, November 2010.

Laurikko, J., Erkkilä, K., Nuottimäki, J., Assessment of the Energy Efficiency of the Propulsion System in An Electric Vehicle – Methodology and Results. RHEVE2011. Dec 6–7, 2011. Paris, France.

Rautalin, J. Moottorin esilämmityksen vaikutukset, Engineering thesis, 2013.

Rautalin, J. & Nuottimäki, J. Henkilöauton moottorin esilämmityksen vaikutus päästöihin ja energian kulutukseen, Research report VTT-R-06328-13.

Roslund, P., Aakko-Saksa, P., Koponen, P. and Nuottimäki, J. Unregulated emissions from Euro 5 emission level cars. Research Report VTT-R-04308-14, 2014.

Participants and budget

VTT Technical Research Centre of Finland

Budget EUR 1 274 500

Contact information

Juhani Laurikko, VTT (juhani.laurikko@vtt.fi)

6. Comparison and full fuel-cycle evaluation of passenger car power plant options, IEA-CARPO

Introduction

The objective of this project is to produce impartial data on the pros and cons of the different fuel and power plant options of passenger cars in Finnish driving conditions. Vehicle emissions and energy consumptions will be measured during the research at temperatures typical to Finland. The measurements for the vehicles will be combined with the full fuel-cycle analysis data gathered by the IEA BUS project, thus obtaining the total economy of different fuels covering the entire energy chain. The research will be carried out in co-operation with Canada, China and Sweden through the Advanced Motor Fuels (AMF) agreement of the International Energy Agency (IEA). In addition, Japan and the United States have agreed to supply for the use of this study the results of vehicle measurements already made. Participants in the research will carry out the measurements on a vehicle typical to their market areas.

Results

Analysis of the results will continue in 2015. The fuels used in the vehicle measurements are listed in Table 1.

Table 1. Fuels used in the measurements.

Fuel	Description
Gasoline (E10)	Market grade gasoline 95 E10 (EN 228)
Gasoline (95 renew.)	Gasoline containing 15% renewable component (EN 228)
Diesel (EN 590 B7)	Market grade diesel fuel (EN 590)
Diesel (HVO)	Hydrotreated oils and fats
CNG	Market grade compressed natural gas
E85	Market grade fuel containing high concentration of ethanol
BEV	Battery electric vehicle

The results will present the CO_2 emissions of the vehicles as so-called well-to-wheel (WTW) values, i.e., they will also take the emissions from the production chain of the fuels into consideration. The total carbon dioxide emissions of using a vehicle (well-to-wheel, WTW) depends to a large extent on the raw materials of the fuel used. The carbon dioxide emissions of using a vehicle (tank-to-wheel, TTW) depends on both the vehicle's power plant and the fuel used. The energy consumption of a more powerful engine is higher for the same mileage than that of a less powerful engine. **This means that the efficiency of a more powerful engine is poorer with identical mileages.**

In line with expectations, the measurements showed that the temperature has a clear impact in both energy consumption and the regulated emissions. In colder conditions, the energy requirement and emissions increased. Based on the results, no technical alternative can be said to be superior in all operating conditions.

The results can be summarised as follows:

- An electric vehicle is most energy-efficient in all mileages, but its use over longer distances is limited by the lower operating range.
- A diesel engine is energy-efficient, but suffers from its high NO_x emissions. The share of NO_2 of its NO_x emissions is higher than in the other alternatives
- Due to the fuel, LPG has the lowest tank-to-wheel CO_2 emissions of all carburettor engines, but its NO_x are higher, particularly during city driving in cold conditions. The energy consumption of an LPG-powered vehicle is at the same level as other carburettor engines.

- E85 fuel reduces the well-to-tank CO_2 emissions of a flexifuel vehicle with both the best and the worst fuel raw material. During driving on motorways and highways, the vehicle's NO_x emissions are somewhat higher than in other carburettor engines.
- The measurements revealed the difference of the tank-to-wheel carbon dioxide emissions between the most and least energy-efficient alternatives to be around 1.6:1
- The difference of well-to-wheel carbon dioxide emissions between fossil and renewable fuels was almost 4:1 at its highest

Publications

Jukka Nuottimäki, Comparison and Full Fuel-Cycle Evaluation of Passenger Car Powerplant Options, TransEco researcher seminar 4.12.2012

Participants and budget

VTT Technical Research Centre of Finland.

Budget: EUR 325 000

Contact information

Jukka Nuottimäki, VTT, jukka.nuottimaki@vtt.fi

HEAVY-DUTY VEHICLES

7. Energy-efficient and intelligent heavy-duty vehicle, HDENIQ

Introduction

HDENIQ project was focused on to the methodologies to reduce the energy consumption and emissions of heavy-duty vehicles and improve safety through technical means. The project produced data of the savings potential of different technologies and developed innovative ICT systems supporting the project's goals. Significant yet unexploited savings potentials were found, for example, in energy-saving aerodynamic solutions (limited by legislation on vehicle dimensions, among others), the manufacturing chain of superstructures, and comprehensive ICT systems.

Results

The aerodynamics demonstration vehicle: Aerodynamic body panels affect both the energy efficiency and safety of a vehicle. The difference of fuel consumption for a vehicle with a full body panels and an entirely stock vehicle was around 23%. The effect of side wind on the vehicle's dynamics was also simulated. The flow field was visualised using smoke dischargers attached to the vehicle.

Drive guidance system: VTT developed a centralised optimisation of a bus system's operation using a Web UI and tools for defining the service network, including the timetables and speed limits. A tracking system for measuring the success of a journey was also developed. The results of the driver guidance system showed a correlation between low fuel consumption, a small guidance deviation and a low speeding index. During the tracking period, guided vehicles consumed on average 1.5 l/100 km less than the unguided vehicles; the best up to 4.3 l/100 km less. During the tracking period the fuel consumption results indicated a downward trend in the savings achieved, which could be countered by regular feedback given to the drivers.

Measurements of city buses and trucks: The project produced data of the emissions and energy consumption of new bus types in drive cycles matching real-world city driving. In addition to vehicle types with an EEV emission level, measurements of hybrids, an ethanol-powered bus and a light-weight vehicle were performed. Methods for assessing the actual emissions and energy consumption of service transport vehicles were developed in the project. The project participated in the development of the competitive tendering of Helsinki Region Transport's bus transport by producing real-world performance data, among others.

Truck measurements concentrated on monitoring the development of the emissions and energy consumption of SCR and EGR vehicles per kilometre driven; additionally vehicles of the Euro V emission level were tested.

Methods for determining driving resistance, and the driving cycle selection for trucks were improved and extended with a city centre distribution cycle (previously so-called "district delivery").

Tyre research: The losses of drive-axle tyres change under traction, emphasising the differences between the tyres. Results were conflicting in many cases. Worn tyres on traction wheels proved to be more energy-efficient than new ones, although their rolling resistance did not decrease in the same ratio.

Energy consumption of auxiliary equipment: After the energy used for moving the vehicle, the largest energy consumer is temperature regulation. A fuel heater in cold weather consumed as much as 20% of the total energy in a city bus, and 6% in a full truck - trailer combination. The air conditioner compressor of a city bus consumed 3% of total energy in warm weather (air conditioning for the driver only). The energy consumption of engine cooling varies a great deal: in a delivery van 1–2%; in a city bus 6% in cold weather, and as much as 11% of total energy in warm weather (slow speeds). Depending on the vehicle type and time of year, an air compressor consumes 1–4% of the total energy.

Slipperiness detection system: VTT developed a system that collates the data obtained from vehicles and generates a real-time picture of the slipperiness of the roads, a so-called slipperiness map. In order to ensure commensurability of the vehicles, a calibration method for the system that allows the connection of different types of vehicles that react differently to slippery conditions was developed. The background system generates vehicle-specific slipperiness information packages for each vehicle connected to the system. This allows the vehicle terminals to warn the driver before arriving in the slippery area according to confirmed data founded on observations from several vehicles. The slipperiness information system supports the reception of slipperiness observations generated anywhere over a Web service interface, i.e., it is not hardware-dependent. Slipperiness warnings can be retrieved over the interface, or they can be sent to many different users: road users, parties responsible for road maintenance, meteorological institutes, road weather services, etc.

Figure 1. The drive guidance system helps the driver to drive economically and stay on schedule. The instructions are delivered via a simple and large display so that reading does not require excess attention, allowing the driver to concentrate on monitoring the traffic situation.

Publications

Laurikko, Juhani, Erkkilä, Kimmo, Laine, Petri, Nylund, Nils-Olof, Improving Energy Efficiency of Heavy-Duty Vehicles – A Systemic Perspective and Some Case Studies. Paper F2012-E01-024. Proc. FISITA 2012 World Automotive Congress, Beijing, China, November 2012. Artikkelin saa pyydettäessä kirjoittajalta: juhani.laurikko@vtt.fi.

Erkkilä, K., et.al. 2013. Energy Efficient And Intelligent Heavy Vehicle – HDENIQ – Final Report – VTT-R-08344-12. 139 p.

Erkkilä, K., et.al. 2012. Energiatehokas ja älykäs raskas ajoneuvo – HDENIQ – Vuosiraportti 2011. VTT-R-08343-12.

Erkkilä, K., et.al. 2011. Energiatehokas ja älykäs raskas ajoneuvo – HDENIQ – Vuosiraportti 2010. VTT-R-04847-11.

Erkkilä, K., et.al. 2010. Energiatehokas ja älykäs raskas ajoneuvo – HDENIQ – Vuosiraportti 2009. VTT-R-04540.

Erkkilä, K., et.al. 2010. Energy efficient and Intelligent Heavy duty Vehicle (HDENIQ) – Annual report 2009 VTT-R-02704-11.

Juhala, M., Kankare, J., Laamanen, M. Katsaus ajoneuvojen oheisjärjestelmien energiankulutukseen ja tuottamiseen. Raportti, 2010.

Erkkilä, K., Laine, P., Laurikko, J. Kaupunkibussien päästötietokanta – Yhteenveto VTT:n menetelmistä ja mittauksista. Raportti VTT-M-10542-10.

Laine, P., Erkkilä, K. Laurikko, J. Kaupunkibussien päästötietokanta 2011. Yhteenveto VTTn menetelmistä ja mittauksista. Raportti VTT-M-02018-12.

Karvonen, V. Linja-autokaluston optimointi ja kohdentaminen. Diplomityö, 2012.

Laamanen, M. Ilmastointijärjestelmän vaikutus ajoneuvojen energiankulutukseen. Diplomityö, 2010.

Naskali, T. Renkaiden epätasapainon, ilmanpaineen ja muotovirheiden vaikutus raskaan kaluston energiankulutukseen. Diplomityö, 2010.

Participants and budget

VTT Technical Research Centre of Finland
Aalto University
Tampere University of Technology
Turku University of Applied Sciences
University of Oulu

Budget: EUR 2 000 000

Contact information

Petri Laine, VTT (Petri.Laine@vtt.fi)

8. Estimating the mass and slippage of a heavy vehicle, RAMSES

Introduction

A modern vehicle contains various sensors that measure several aspects of its operating status, such as wheel rotational speeds, engine operation and vehicle location.

Often, this data remains internal to the vehicle and is not forwarded. Such data would nevertheless also be useful for many purposes in information systems outside the vehicle.

The RAMSES project continued the research begun in the RASTU project, developing the estimation of the mass of a heavy vehicle and its cargo and the slipperiness of the road surface based on data such as described above.

These are challenging problems, requiring intelligent features from the terminal installed on the vehicle and the background system connected to it in real-world driving situations, in order to adapt to different situations and vehicle characteristics.

Results

In the early part of the project, preliminary surveys were conducted on the potential of information and communications technology applications. The subjects included both heavy vehicle combinations and buses, but with different weightings.

Then, a vehicle data gathering system with a remote server backend was designed and implemented, and the terminal was installed on several vehicle combinations and buses of different types. The resulting huge data reserve, collected automatically, was used in method development.

First, we developed a new slipperiness detection system with the aim of eliminating non-linear effects using piecewise-linear adaptation where a base level is generated from the measurement data, and slipperiness detected as deviations from it. As a data-driven system, it is suitable for different vehicles, adapting to their characteristics.

Second, we derived a new freight mass estimation method, based on the law of conservation of energy and a robust regression model. According to the results, the accuracy is at one-per-cent level when driving situations unfavourable for the model are eliminated.

Finally, we combined the methods:

- A new energy model for the slipperiness detection method was derived.
- This was integrated with our energy-based mass estimation method.
- Now both slipperiness and mass can be estimated using a combined model, offering a clear synergy benefit

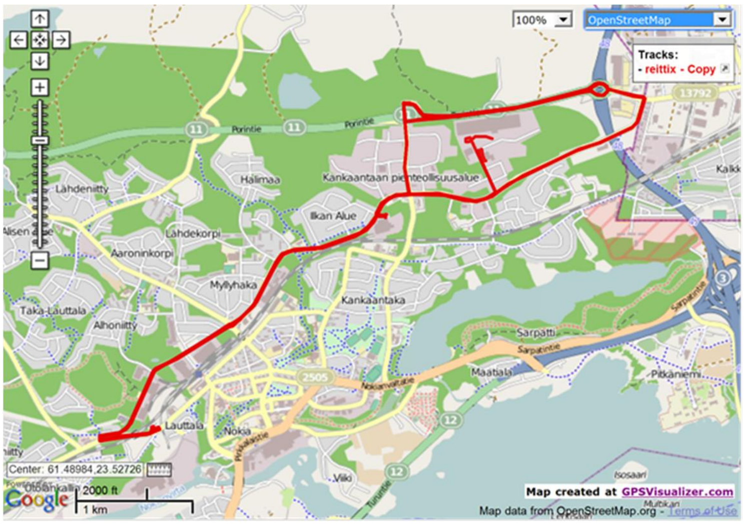


Figure 1. Test drive route on a map.

Publications

Annual reports of HDENIQ (Chapter 7)

Participants and budget

University of Oulu

Budget: EUR 330 000

Contact information

Prof. Tapio Seppänen, University of Oulu (tapio.seppanen@oulu.fi)

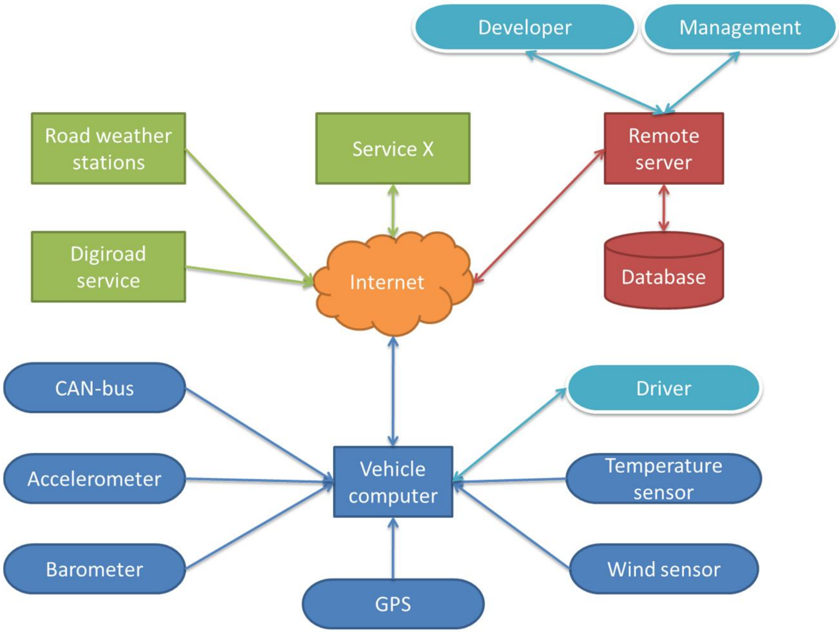


Figure 2. High level block diagram of the developed data gathering system.

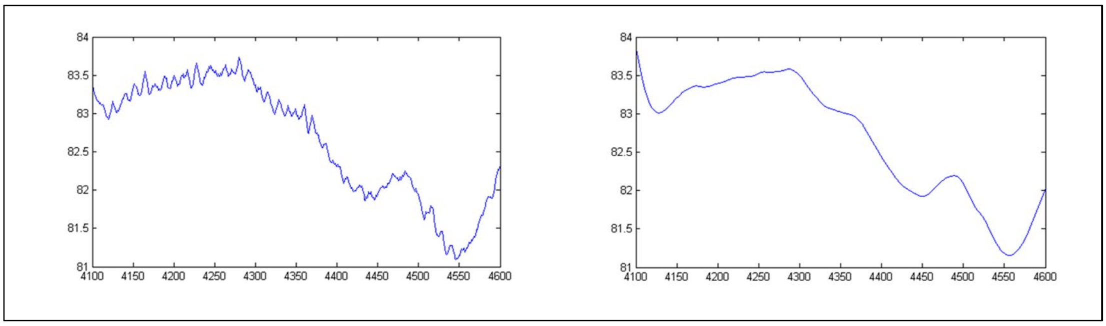


Figure 3. Example of the filtering of the measurement signals (speed at front axle).

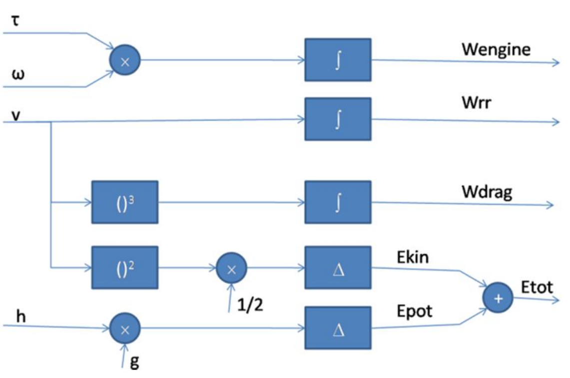


Figure 4. Calculation of energy model variables.

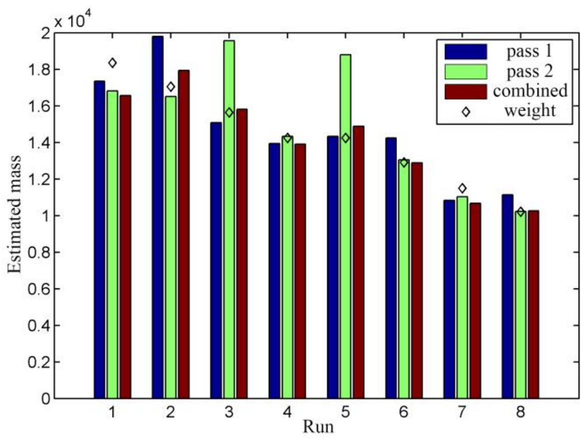


Figure 5. Weighed and estimated masses during test drive sessions.

9. Fuel and Technology Alternatives for Buses, IEA-AMF Annex 37

Introduction

Project on urban buses was carried out in cooperation with IEA's Implementing Agreements on Advanced Motor Fuels (Annex 37) and Bioenergy, with input from additional IEA Implementing Agreements. The objective of the project was to generate unbiased and solid data for use by policy- and decision-makers responsible for public transport using buses. The project comprised four major parts (Figure 1):

(1) a well-to-tank (WTT) assessment of alternative fuel pathways,

(2) bus end-use performance (tank-to-wheel, TTW) assessment,

(3) combining WTT and TTW into well-to-wheel (WTW) data

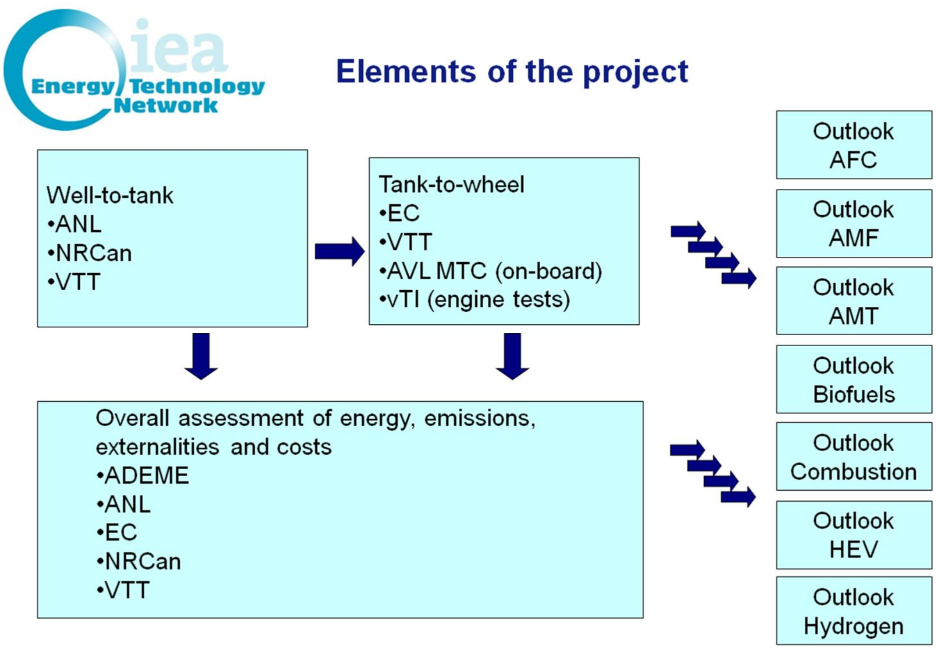
(4) a cost assessment, including indirect as well as direct costs.

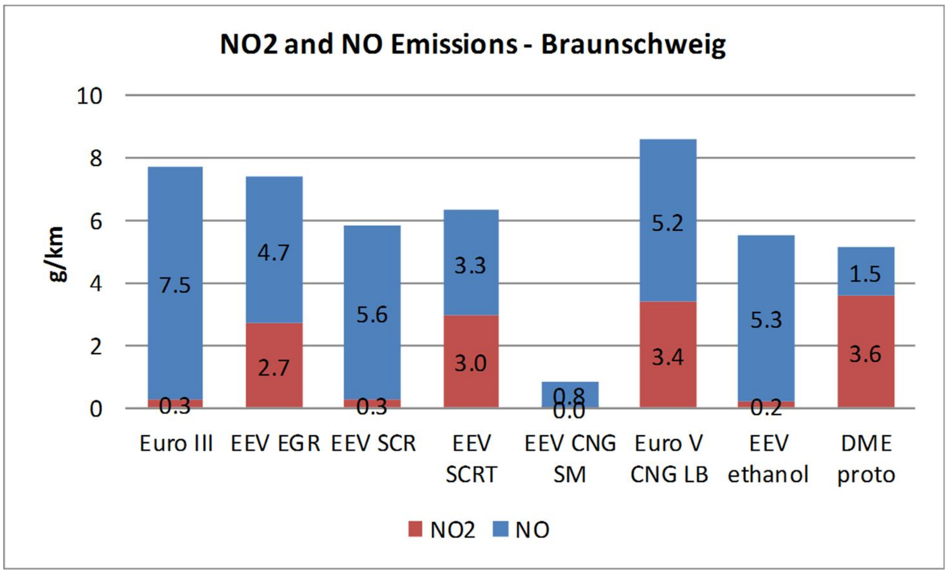
An example of comprehensiveness of work is the TTW part, in which Environment Canada and VTT studied 21 buses on chassis dynamometers. The fuels covered diesel, synthetic diesel, various types of biodiesel fuels, additive treated ethanol, methane and DME. Six different hybrid vehicles were studied. On-road measurements and some engine dynamometer work was carried out by other laboratories.

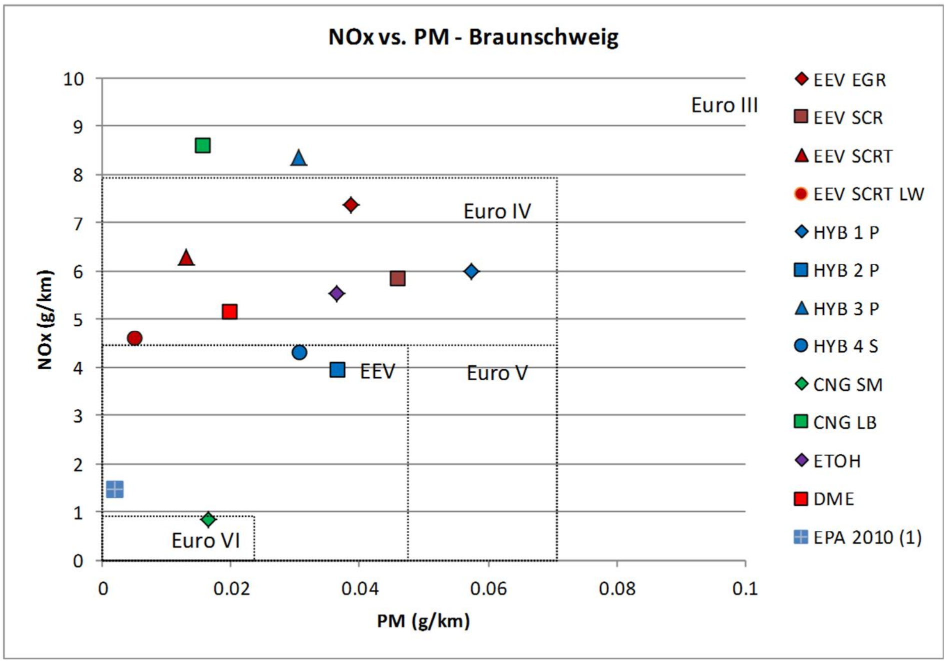
Results

Based on the findings of the project it is possible to establish the effects of various parameters on bus performance. The largest variations and uncertainties are found for the WTT part of the CO_{2eqv} emissions, especially for biofuels. The WTT results vary due to the differences in the assessed biofuel chains, the regions of biofuel production, the raw materials used and the technology choices made.

Over the last 15 years, tightening emission regulations and improved engine and exhaust after-treatment technology have reduced regulated emissions by a factor of 10:1 and particulate numbers with a factor of 100:1. The most effective way to reduce regulated emissions is to replace old vehicles with new ones. Hybridization or light-weighting reduce fuel consumption 20–30%, but otherwise the improvements in fuel efficiency have not been so spectacular. The driving cycle affects regulated emissions and fuel consumption by a factor of 5:1. The fuel effects are at maximum 2.5:1 for regulated emissions (particulates), but as high as 100:1 for WTW greenhouse emissions. Thus the most effective way to cut greenhouse gas (GHG) emissions is to switch from fossil fuels to efficient biofuels. WTW energy use varies a factor of 2.5:1.







Publications

Nylund, N.-O. & Koponen, K. 2012. Fuel and Technology Alternatives for Buses, Overall Energy Efficiency and Emission Performance. P. 294 + app. 94 p.

Koponen, K. & Nylund, N.-O. 2012. IEA Technology Network Cooperation: Fuel and Technology Alternatives for Buses: Overall Energy Efficiency and Emissions. SAE Technical Paper 2012-01-1981. 25 p.

Partners and budget

ADEME (the French Environment and Energy Management Agency)
Argonne National Laboratory (USA)
AVL MTC (Sweden)
Environment Canada, Natural Resources Canada
von Thünen Institute and Partners (Germany)
VTT Technical Research Centre of Finland (lead partner)

Budget: EUR 1 200 000

Contact

Nils-Olof Nylund, VTT (nils-olof.nylund@vtt.fi)

10. Commercial vehicles

Introduction

The "Commercial vehicles 2012" project collates research on the energy consumption and emissions of buses, lorries and vans. In combining these three areas of research, the objective is to produce better data on the effect of vehicle selection on energy consumption and emissions. In addition, the series of measurements performed during the research will build the foundation for instructions on the preheating of modern engines.

The overall research objective is to produce data for commercial transport on the effects of new vehicle technology and vehicle selection on the energy consumption and emissions of transport, and to update the emission database maintained by VTT with regard to new vehicle technologies.

Results

Bus research

The bus subtask continues the maintenance of the bus emission database created during earlier projects and offers support for the utilisation of the emission database. The project will involve performing emission measurements on new city bus models arriving on the market and following up on specific vehicles chosen from the fleet in use.

New city bus models have arrived each year in reasonably large numbers, and the same trend seems to be continuing. The results of the new city buses measured are updated in the bus emission database and the new version of the database published in connection with the reporting.

Measurements of the follow-up vehicles, i.e., we will continue the follow-up of the fleet in use with measurements of the city buses selected earlier; we have also included the Iveco Crossway EEV that is now in common use. Large variation has been observed in the nitrogen oxide emissions of the natural-gas-powered bus under follow-up using stoichiometric mixture. Significantly higher NO_x emission values than before were measured from this bus using a thin mixture. The best and most even particle emission results are achieved by Iveco-manufactured diesel-powered buses and natural-gas-powered buses. However, measurements on Iveco buses only reach 200 thousand km.

Lorry research

This subtask focuses on researching the performance of Euro VI vehicles and updates the lorry emission database created during earlier research. The planned extent involves the measurement of a total of nine vehicles, including new vehicles and follow-up vehicles. The main focus of the research is on Euro VI vehicles. Preliminary results from the performed measurements of Euro VI vehicles show that the emissions of vehicles of this level are quite low even in transient driving situations. The vehicles also seem to meet the emission levels set for them better than before with varying mileages.

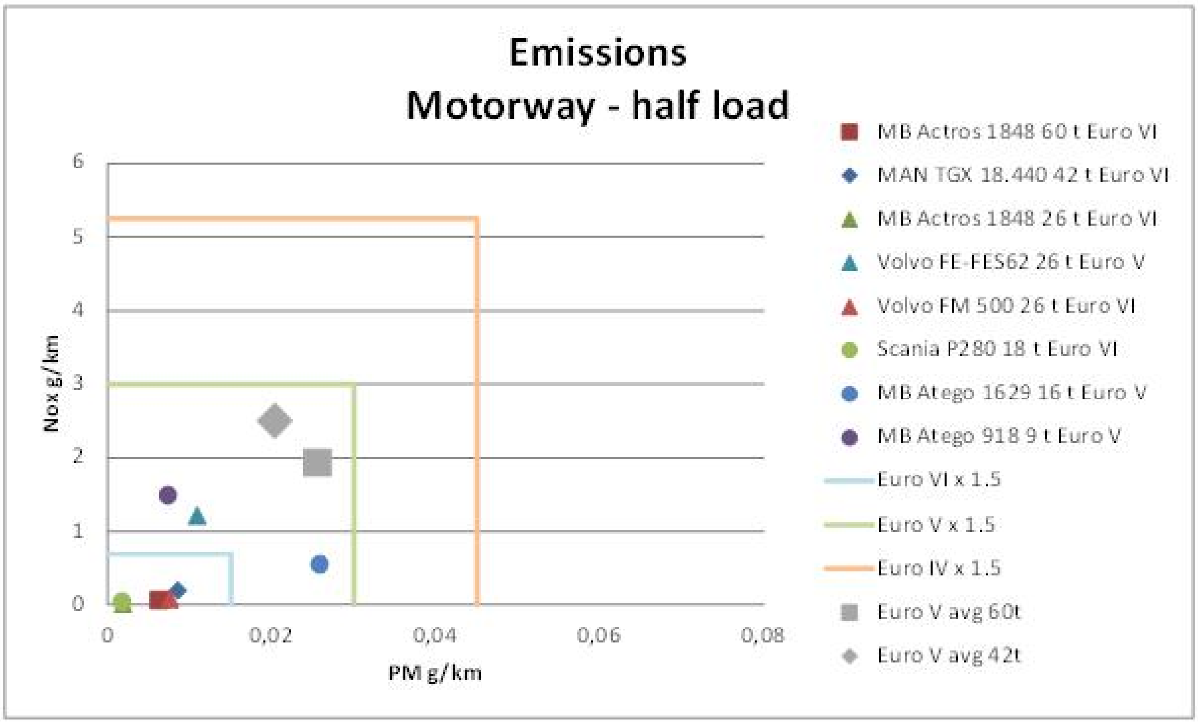


Figure 1. An example of emission results with trucks over the motorway cycle.

Publications

Erkkilä, K., Laurikko, J. & Karvonen, V. Kaupunkibussien päästötietokanta 2012 – Yhteenveto VTT:n menetelmistä ja mittauksista. Report VTT-CR-00455-14, 2014. In Finnish.

Laine, P. RakeTruck 2012 – Kuorma-autotutkimus 2012. Report VTT-R-04990-14. In Finnish.

Participants and budget

VTT Technical Research Centre of Finland

Budget: EUR 330 000

Contact information

Bus research: Veikko Karvonen, VTT veikko.karvonen@vtt.fi

Lorry research: Petri Laine, VTT petri.laine@vtt.fi

ELECTRIC CARS AND VEHICLES

11. The operating range of electric vehicles in real-world operating environment, RekkEVidde

Introduction

Although public opinion in the Nordic countries is favourable towards electric vehicles, the actual operating conditions are extremely demanding. Whereas cars powered by a combustion engine can offer plenty of waste energy to be utilised in heating the interior, electric vehicles must be heated with "prime goods", i.e. the electricity stored in the battery, which is in any case already insufficient for driving.

Studies show that cold air and the use of a heater may decrease the actual driving distance of an electric vehicle to as little as under half of that promised in normal conditions. As the current EU type testing clearly gives an overtly optimistic idea of an electric vehicle's operating range, Finland, Sweden, Norway and Iceland have aimed in the RekkEVidde project to develop a testing method for electric vehicles that would be suitable for Nordic conditions.

Main contents of the research

The energy consumption and operating ranges of electric vehicles on the market were measured during this research using different driving programmes and operating temperatures. The use of a heater was an important additional feature that is not part of the normal test. The effect of different road surfaces on rolling resistance was also simulated. In addition to laboratory measurements, measurements were also made on a test circuit located in the Swedish Lapland.

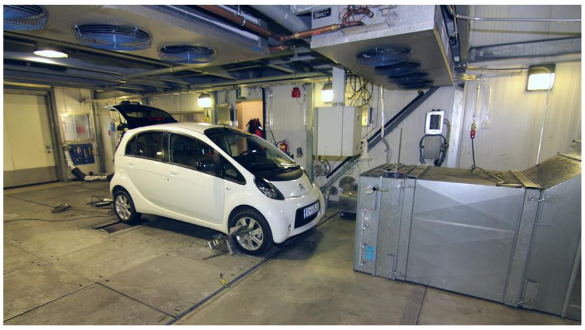


Figure 1. In VTT's vehicle laboratory, Nordic driving conditions can be replicated up to a cold snap of -30 °C.

Results

Significance of the driving programme

According to the measurements, the driving programme has a significant impact on driving distance. This is quite natural as such, because the different driving programmes have different theoretical energy requirements and an increase in driving speed, for example, will increase energy consumption as air resistance grows. What is unusual about an electric vehicle, however, is that because they can convert motion energy back to electricity, their specific energy consumption in city driving is not as high as that of combustion-engined vehicles, where all motion energy is lost during deceleration. For this reason, their driving distance in city driving can equal or even exceed the driving distance on a main road and, in particular, on a motorway.

Significance of temperature

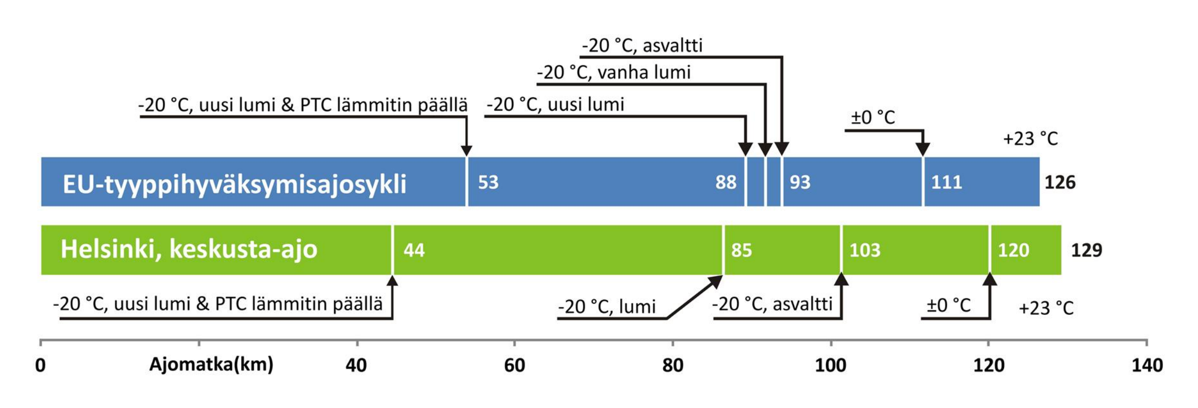
As the temperature of air falls, its density increases. For this reason, the driving resistance caused by air increases by around 10% when the temperature falls from around +20 °C to around -20 °C. According to the measurements, this causes an increase of over 30% in energy consumption. The effect is strongest when driving on a motorway, as the average driving speed, and thus air resistance, is highest.

Effect of the driving surface

Measurements were made on a test circuit in order to estimate the effect of the condition of the road surface on energy consumption. Compared to a clean asphalt surface, old snow increased energy consumption by around 2%, and where the road surface was covered by abundant fresh snow, energy consumption was increased by 5% on average.

Effect of the use of the heater

According to the measurements, however, a very significant increase in energy consumption was caused by using the heater. For example, in the Citroen C-Zero, where the interior is heated with a 4.5 kW electric heater, the driving distance in slow city driving was reduced to less than half, and the effect was around 20–30% on a main road.



Publications

Laurikko, J. Granström, R. & Haakana, A. Realistic estimates of EV range based on extensive laboratory and field tests in Nordic climate conditions. EVS27, Barcelona, Nov. 2013.

Laurikko, J. Granström, R. & Haakana, A. Assessing range and performance of electric vehicles in Nordic driving conditions – Project “RekkEVidde”. EVS26 Los Angeles, California, May 6-9, 2012.

Laurikko, J., Nuottimäki, J. & Nylund, N-O. Improvements in test protocols for electric vehicles to determine range and total energy consumption. FISITA F2012-E14-032.

Haakana, A, Laurikko, J., Granström, R. & Hagman, R. Assessing range and performance of electric vehicles in Nordic driving conditions – Project Final Report, 2013.

Participants and budget

GreenNetFinland (FI)
Lindholmen Science Park / TSS (S)
VTT Technical Research Centre of Finland
Supporting Partners: City of Stockholm (S), TOI (N), Icelandic New Energy (IS)

Budget: EUR 212 500 (Finland)

Contact information

Juhani Laurikko, VTT (juhani.laurikko@vtt.fi)

12. Inductive charging field test

Introduction

Electric vehicles are globally recognised as one of the major solutions for reducing the energy consumption of transport, and its local as well as greenhouse gas emissions. Several countries also hope and aim to advance the creation of new business related to electric vehicles in both manufacturing and service solutions of various types. As the rest of the electric power transmission technology is already sufficiently advanced, it can be stated that the major factors affecting the adoption of electric vehicles are the development of batteries, charging technology and services related to electric vehicles, and various subventions.

The objective of this project is to study and demonstrate inductive, or contactless, charging technology that plays a part in making the charging of electric vehicles easier and safer for users. Two test vehicles were built for this purpose, mainly utilising components supplied by Finnish companies. The vehicles are used to study and demonstrate the potential of an electric vehicle that uses contactless charging. Quick-charging systems are also installed on the vehicles, allowing their batteries to be charged fully in about an hour. The project thus includes all the charging methods used by today's fully electric vehicle.

Results

The first vehicle inspected and approved for road transport use on 19 March 2013. Quick charging, based on the CHAdeMO standard, has been tested at all quick-charging stations in the Helsinki Metropolitan Area. The first inductive charging system will be commissioned in late 2013.

Participants and the budget

Metropolia

Budget: EUR 685 000

Contact information

Ville Eskelinen, Metropolia (ville.eskelinen@metropolia.fi)

Auxiliary components

- DC-DC converter (300 V to 12 V)
  - Efore
- Over-night charger 3,3 kW
  - Efore
- 12V system (Power Switch Module)
  - Epec
- CHAdeMO charger interface
  - Efacec

Powertrain components

- Battery and Battery Management System
  - European Batteries
    - Energy 28 kWh
    - Nominal Voltage 307 V
    - Capacity 90 Ah
    - Total weight 275 kg
    - 6 liquid cooled modules

- Vehicle Control Unit
  - Elektrobit EB 6120
  - Simtools SW development chain
  - Control SW developed at Metropolia originally for Electric RaceAbout

Powertrain components

- Asynchronous motor
  - Ansaldo Electric Drive
  - Nominal Power 30 kW (60 kW peak)
  - Nominal Torque 130 Nm (260 Nm peak)
  - Nominal speed 2200 rpm
  - Weight 80 kg
- 5-speed gearbox
  - Fiat Dobló

13. Development of electric powertrain for vehicles and work machines

Introduction

The main objective of the project was to develop the electric propulsion of vehicles and work machines as a whole, including: drive motors, electric drives, vehicle propulsion control system, battery assemblies, battery charging and management system, and the required cooling system. The developed system was demonstrated as a complete entity in the E-RA electric vehicle of the Metropolia University of Applied Sciences.

Results

A functioning four-motor electric power transmission integrated into the E-RA vehicle

Achievements of the E-RA

- Second place in the Progressive Insurance Automotive X Prize competition in Michigan, summer of 2010
- Winner of the electric car rally, and the Prototype & Concept Design Award and Environmental Award in the Michelin Challenge Bibendum event in Berlin, 2011
- Track record at Nürburgring Nordschleife for electric cars designed for road use in September 2011
- Ice speed record for electric vehicles in March 2012

Publications

Ruotsalainen, S. Ajoneuvojen ja työkoneiden sähköisen voimansiirron kehittäminen. Loppuraportti. Metropolia Ammattikorkeakoulu. 26. maaliskuuta 2012.

1 PhD thesis

1 Master's thesis

24 Bachelor's theses

Participants and budget

Metropolia University of Applied Sciences (project coordination, systems integration, construction of the demonstration vehicle)

Lappeenranta University of Technology (verification of the electric motor design)

Vacon Oyj (electric drives)

Axco Motors Oy (manufacture of the electric motors)

Fortum Oyj (commissioning of the quick-charging station)

Budget: EUR 709 840

Contact information

Sami Ruotsalainen, Metropolia (sami.ruotsalainen@metropolia.fi)

14. ECV / eBus – Test mule

Introduction

The general objective of the eBUS project was to offer an internationally significant testing platform for manufacturers:

- Testing of electric buses
- Development in public transport and demanding conditions regardless of make and technology
- Co-operation between the authorities, service contractors, research and educational institutes, and the operator

Figure 1. The hill-climbing ability of the mule being tested.

City bus – Test mule

- A city bus is a typical application for heavy-duty electric vehicle technology
- A "bus mule" was built as a testing platform
- Based on a light weight city bus chassis (Kabus) that is converted into an electric bus (Metropolia)
- Independent test environment in Nordic conditions
- Components to be tested: batteries, electric motors, inverters, control logics, range extender, interior heating/cooling solutions, etc.

Finnish know-how in electric vehicle components can be used to build a complete powertrain for an electric bus, for example for independent bus manufacturers – or even an entire bus.

As result for the project a new start-up, Ekabus, have been established to commercilize both electric drivertrains and to start production of entire electric buses.

Powertrain

Battery assembly supplied by European Batteries Oy

- Nominal voltage 614 V
- Capacity 56 kWh

- Tested components: batteries, electric motors, frequency converters, control logics, range extender, interior heating/cooling solutions, etc.

Permanent magnet motor from Visedo Oy

- Power (IEC 60034-1) 210 kW
- Nominal torque 900 Nm (max. 2700 Nm)

Inverters (frequency converters) from Visedo

- Max. phase current 300 A rms
- Max. power 250 kW

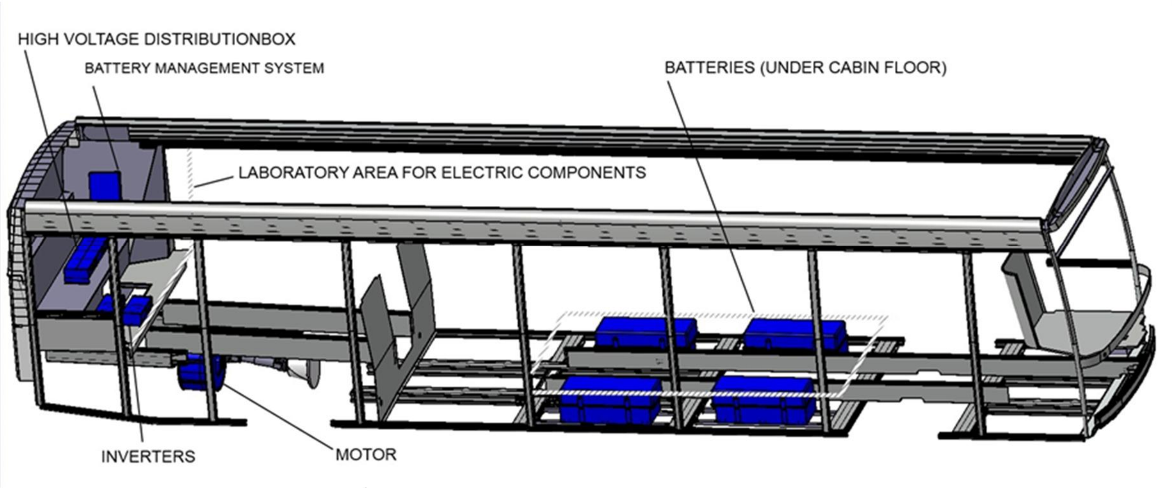
Elektrobit control system

- Elektrobit's EB 6120 controller
- Simtools model-based software development environment
- Software developed for the Electric RaceAbout car of the Metropolia University of Applied Sciences

Testing

Both on a chassis dynamometer and on the Espoo bus line No. 11

- Energy consumption <1 kWh/km
- Driven around 2,000 km on the dynamometer and on the road, conditions varying between -20 °C and +30 °C



Participants and budget

Helsinki Region Transport (HRT) Veolia
City of Espoo
Aalto University
Metropolia
VTT Technical Research Centre of Finland

Project belongs to Tekes EVE program, website http://www.ecv.fi/

Contact information

Teemu Halmeaho, (teemu.halmeaho@vtt.fi), Ari-Pekka Pellikka, (ari-pekka.pellikka@vt.fi)
Nils-Olof Nylund, VTT (nils-olof.nylund@vtt.fi)

Lasse Tiikkaja
(lasse.tiikkaja@veolia-transport.fi)

Otto Pietikäinen, Veolia
(otto.pietikainen@metropolia.fi)

Kimmo Erkkilä, Ekabus
(kimmo.erkkila@ekabus.com)

15. Battery technology for heavy-duty electric commercial vehicles "eStorage"

Background

Heavy duty electric commercial vehicle (ECV), such as a mining or a cargo handling vehicle:

- Have very demanding work cycles
- Operate under wide an often elevated temperature conditions
- Have high utilization rates

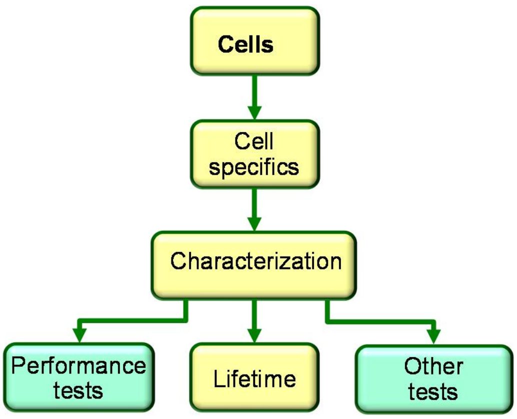
Therefore, typical heavy duty ECV battery needs to have:

- High cycle life
- Excellent fast charging capability
- High discharge power rating

High specific energy/power and energy/power density are typically less important criteria because of weight carrying capability and easier access to free space for the battery.

Battery renewal is often required either once or multiple times during the lifetime of an ECV. This translates to low calendar life requirement as cycle life will be the limiting factor.

Three stages of testing



1. Comprehensive characterization and performance tests conducted in different environmental conditions

2. Calendar and lifetime testing with cycles and temperatures representing heavy duty use cases

3. Battery pack design principles and thermal management and modelling

Preliminary results

As stated above, the fast charge capability of a heavy duty ECV battery is important. Figure 1 shows the state of charge (SOC) of a cell at the end of 1C constant current charge. In this case, LTO cells perform very well as they can be charged to over 99 % SOC with constant current.

Discharge power capabilities of the cells are shown in the Figure 2. Note that the discharge currents used vary so that comparisons between chemistries should be done with care. Manufacturer allowed maximum currents were used. Here, it can be seen that NMC cell has very high discharge power density combined with high pulse energy efficiency. LTO cell has also good power performance but its energy efficiency is smaller.

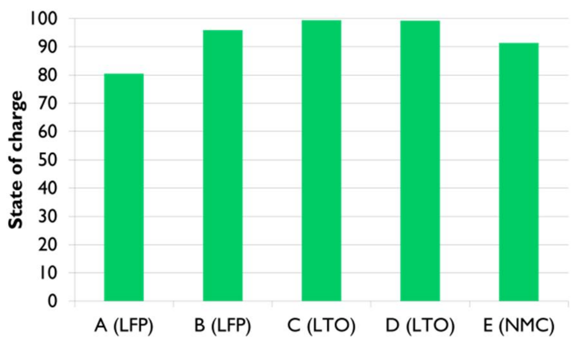


Figure 1. State of charge at the end of 1C constant current charge.

Conclusion

- Baseline for a battery database has been established
- All relevant battery parameters can be obtained in a relatively short time with the chosen characterization methods

Based on the initial results

- LTO cells are very competitive for application in heavy duty ECVs
- LTO cells have the best charge capabilities

→ LTO is very suitable for fast charging

- NMC cells have good discharge power performance but limitations on charging

Furthermore, LTO is reported to have:

- Very low volume change during cycling → high cycling stability
- High thermal stability

However, the low specific energy of a LTO cell is one of the few limitations it has, but as already mentioned, it often is less important as a selection criterion for ECVs.

Future work

- Characterization tests in various temperatures
- Charging performance near 0 °C and overall cell performance in different temperatures
- Lifetime testing to study the effect of different ΔSOC on ageing
- Considerations related to safety requirements

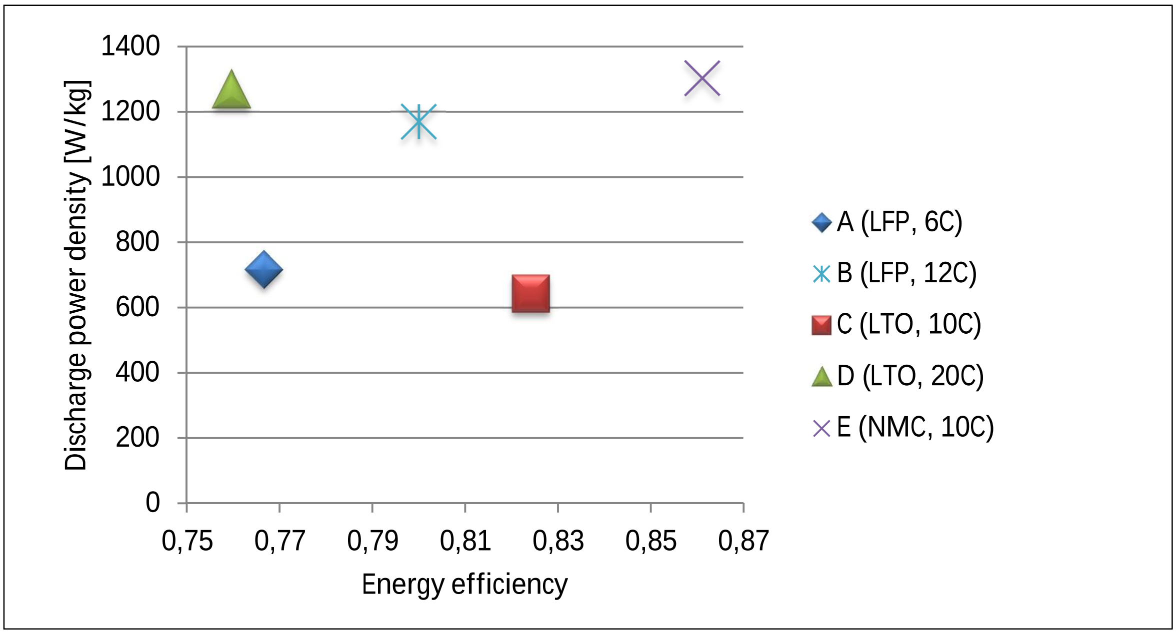


Figure 2. Discharge pulse power density vs. pulse energy efficiency at 50 % SOC.

Publications

Pihlatie, M., Kukkonen, S., Erkkilä, K., Laurikko, J., Nylund, N.-O., Kankare, J., Sainio, P. & Suomela, P. eSTORAGE Sähköajoneuvojen energiavarastot. Loppuraportti 31.5.2011.

Participants and budget

VTT Technical Research Centre of Finland
Aalto University

Project belongs to Tekes EVE program, website http://www.ecv.fi/

Contacts

Samu Kukkonen, VTT (samu.kukkonen@vtt.fi)

16. Incentives for electric vehicles, INTELECT

Main contents of the research

A number of new environmentally friendlier vehicle alternatives have been introduced over the last few years. In many countries, the public sector uses various incentives to speed up the proliferation of these cars. Most typical of these incentives include various forms of tax relief and other "carrots" such as exemptions from road tolls and parking fees.

The objective was to gather a Nordic consortium as broadly based as possible, collect data and develop a Web-based calculator that could be used to compare the costs of different alternatives. There was also the hope that the information on the practices in different countries and their effects would assist in decision-making.

The project was coordinated by Iceland, and managed to involve all other Nordic countries (Finland, Sweden, Denmark and Norway) and the small autonomous areas (Greenland and the Faroe Islands).

The project collected comprehensive information on the incentives for electric vehicles and other environmentally friendlier vehicles and fuels used in the Nordic countries. In addition to taxation, information was collected on other incentives not directly monetary.

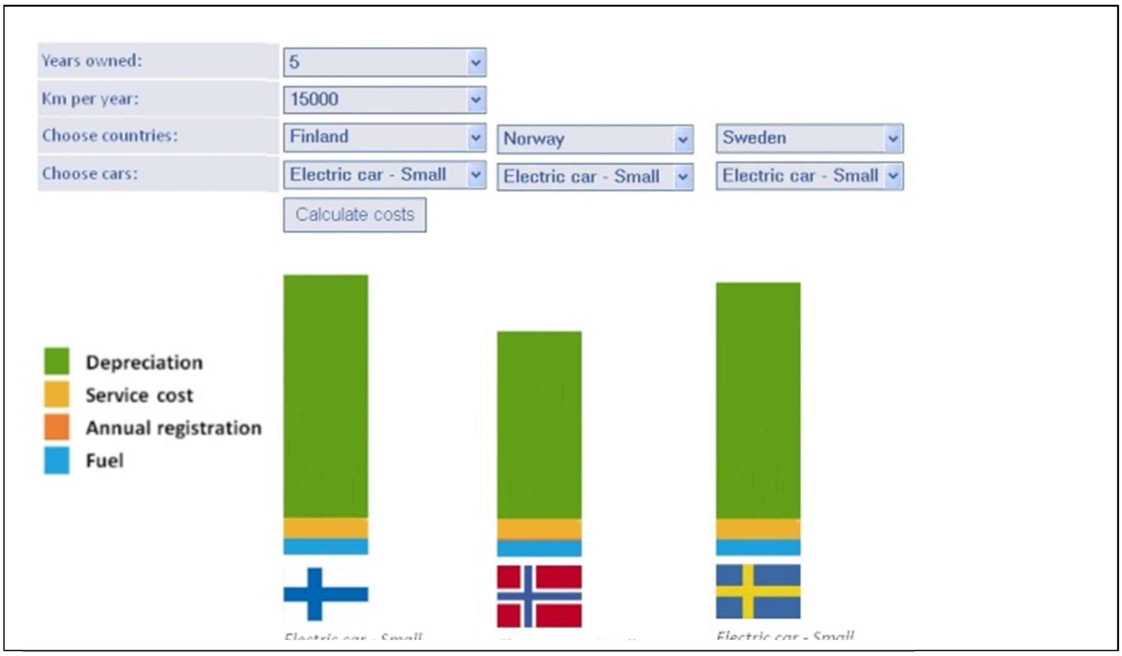


Figure 1. The Web calculator http://www.gronnbil.no/intelect/ can be used to compare the costs of driving with different options and in different Nordic countries.

Results

When comparing vehicle taxation, for example, it became apparent that all participating countries had different taxation practices. The amount of other incentive measures also varied greatly from one country to another.

In Finland, the aim has been to make both vehicle and fuel taxation technology neutral, i.e., taxation is identical regardless of the motive power. As there is differentiation in the taxes, however, less tax is paid for alternatives with a good performance, such as electric vehicles or sustainably manufactured fuels, than for regular alternatives.

In Norway, the incentives for electric vehicles are the highest, as they are exempt from all taxes. Charging and parking are free, and electric vehicles are also exempt from road tolls and ferry fees on state-maintained ferries. These vehicles are also allowed to use bus lanes. Such heavy incentives have allowed Norway to assume top position in sales of electric vehicles when compared to normal vehicles. Indeed, there are already almost 16,000 electric vehicles in Norway; however, this is only less than 1% of the approximately 2.5 million passenger cars in Norway.

Publications

Skúlason, J. B., Laurikko, J., Hannisdahl, O. H. and Haraldson, K. INTELLECT – End of Project Report. July 2012. http://orkusetur.is/page/int_home

Participants and budget

Icelandic New Energy (Iceland)
AF Industry AB (Sweden)
Grönn Bil (Norway)
Nukissiorfiit (Greenland)
SEV (Faroe Islands)
Orkusetur (Iceland)
Dansk Energi (Denmark)
VTT Technical Research Centre of Finland

Budget: EUR 21 753 (Finland)

Contact information

Juhani Laurikko, VTT (juhani.laurikko@vtt.fi)

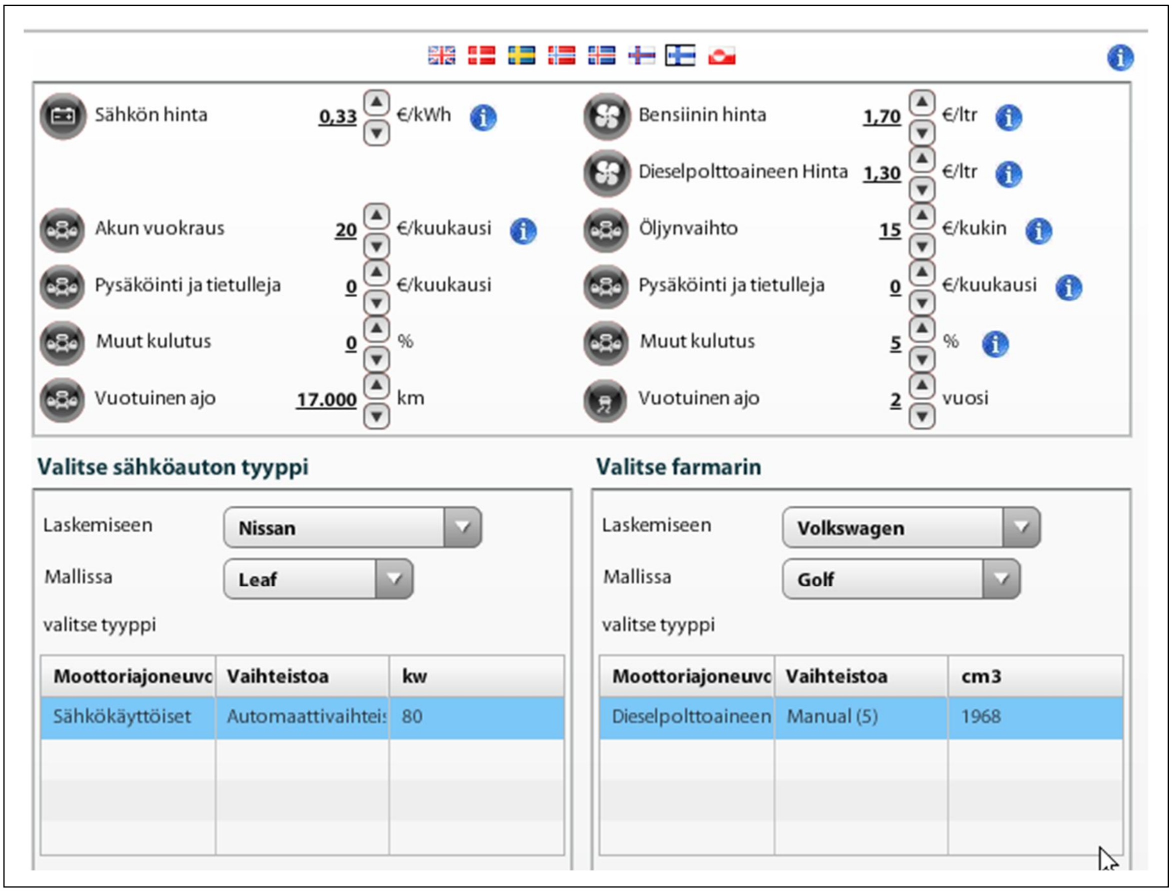


Figure 2. Another calculator even more detailed with regard to costs can be found at the following address: http://orkusetur.is/id/12353

TRANSPORT SYSTEM

17. Manual of economical driving

Introduction

Three main factors affect the energy requirement, or fuel consumption, of a vehicle: *the vehicle, the conditions and the driver*. Of these, the importance of the vehicle is often overemphasised, the importance of the conditions underestimated, and the driver's part almost forgotten.

The factors affecting fuel consumption and their mutual ratios were itemised in the preparation of the manual of economical driving. The subjects for study were how the use of energy is divided into overcoming the different driving resistances in different conditions, in different driving situations and while using different driving styles.

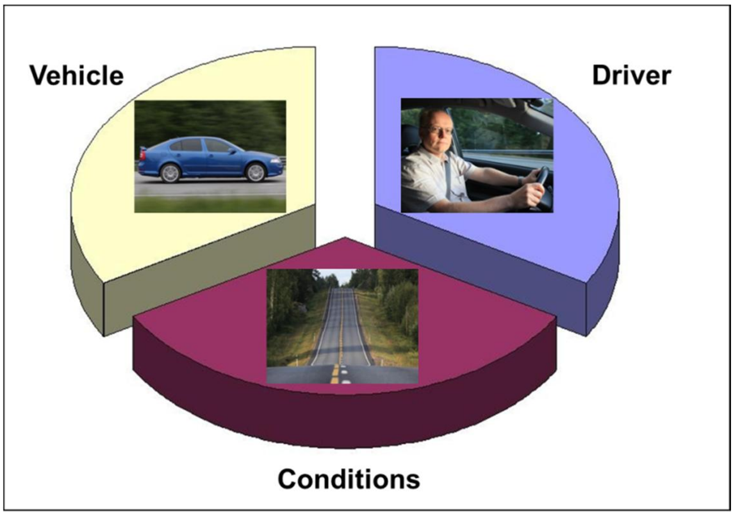
The driving style instructions prepared according to the consumption analyses were based on sample calculations that were used to determine the effect of different variables on fuel consumption. The variables included driving speed, the number and method of accelerations and decelerations, wind speed and direction, atmospheric pressure, cold-starting temperature, the number of cold starts and the differences in altitude. Special attention was given in the study to the potential of the driver for minimising consumption. The optimal driving style of a hybrid vehicle was studied separately.

Results

Achieving the lowest consumption possible involves minimising both the energy required from the vehicle's traction wheels (kWh) and the engine's specific consumption (g/kWh), because the fuel mass required for a given distance is formed when these variables are multiplied together. It is important to note that the driver can affect both of these variables.

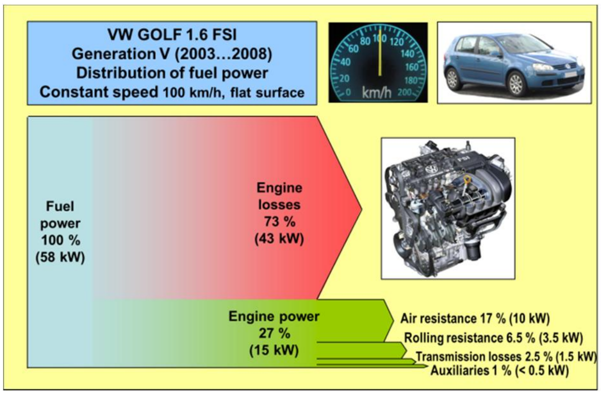
A driving style anticipating traffic obstacles is essential in minimising the energy required to move the vehicle, allowing the achieved speed to be maintained and thus minimising the need for accelerating. Moderate driving speed is another significant factor, reducing the air resistance.

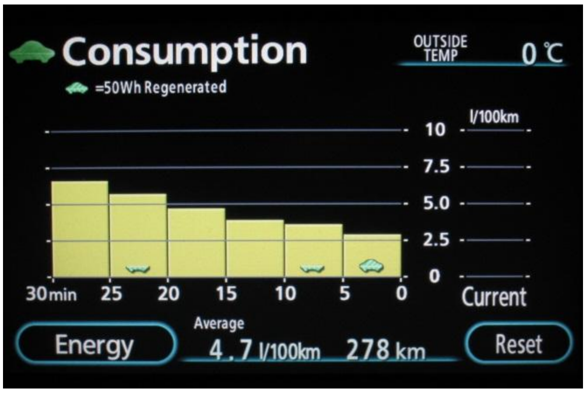
In minimising the specific consumption of the engine, or running the engine at best possible efficiency, the essential part is to use higher gears and rapid acceleration by heavily loading the engine, but shifting up early. In vehicles with an automatic transmission, which is becoming increasingly common, shifting up must be advanced by momentarily letting up on the accelerator when you know that the engine is also able to accelerate the vehicle in the next gear.



Training in economical driving has typically resulted in a 10–40% decrease in fuel consumption in city driving for different drivers. The average decrease has been around 20%. For instance, with a fuel consumption of 8 l/100 km and an annual driving distance of 20,000 km, a 20% decrease amounts to around EUR 500 per year.

On a national level, it can be estimated that systematic training in economical driving could produce annual fuel savings of 76,500–153,000 m^3. The corresponding reduction in CO_2 emissions would be 190,000–380,000 tons. The range is caused by two scenarios in which the variables are different estimates of the number of drivers who would permanently use the economical driving style.





VW Golf 1.6 FSI, Generation V (2003...2008) Additional consumption caused by mass increase in absolute and relative values in the NEDC test cycle (approximately)				
Mass of the vehicle and load	Combined cycle (11.007 km) Official consumption 6.4 l/100 km		Urban part of the tests (4.052 km) Official consumption 8.5 l/100 km	
[kg]	[l/100 km]	[%]	[l/100 km]	[%]
1375 kg				
+ 50 kg	0,1	1	< 0.2	2
+ 100 kg	0,2	< 3	0,3	> 3
+ 150 kg	< 0.3	4	< 0.5	5
+ 200 kg	< 0.4	5	0,6	7
+ 250 kg	< 0.5	7	0,7	9
+ 300 kg	0,5	8	0,9	10
+ 350 kg	0,6	9	1,0	12
+ 400 kg	0,7	11	1,2	14

Publications

Ikonen, M. 2013. Aja taloudellisesti – ajoneuvon, kuljettajan ja olosuhteiden vaikutus polttoaineenkulutukseen. Turku: Turun ammattikorkeakoulu. In Finnish.

Participants and budget

Turku University of Applied Sciences

Budget: EUR 37 500

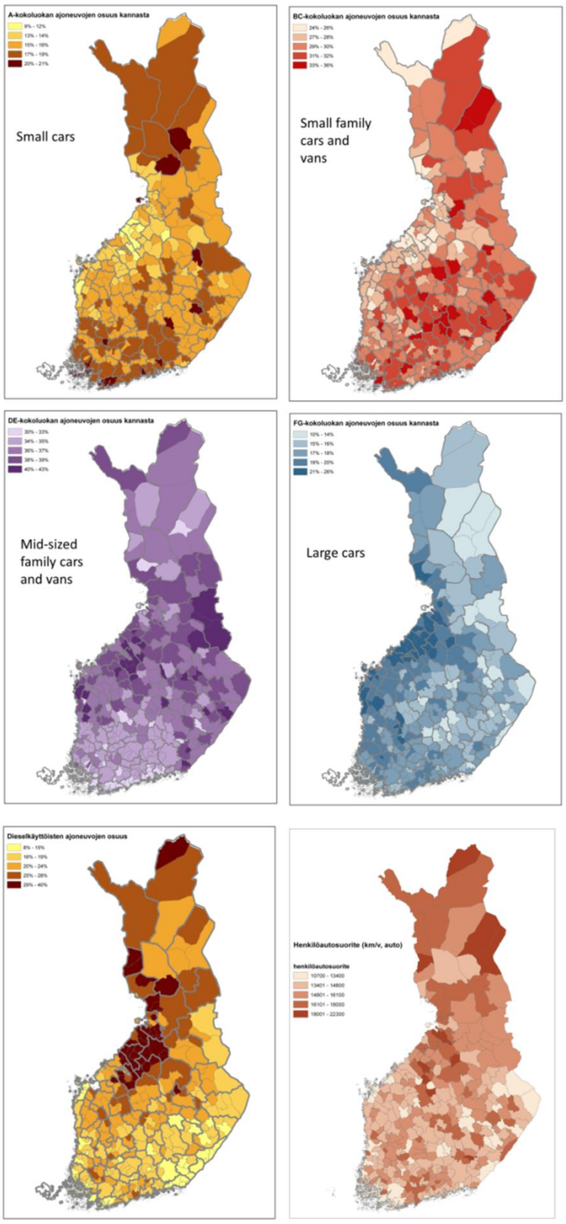
Contact information

Markku Ikonen, TUAS (markku.ikonen@turkuamk.fi)

18. Car fleet forecast model, AHMA

Introduction

A vehicle fleet model, AHMA, serves as a forecasting tool for passenger car fleet development in Finland. By using the AHMA forecast model, the impacts of policy measures, such as legislation and taxation, on the car fleet and mileage can be evaluated. The model takes into account regional structure and demographics, car ownership and car use behaviour models, amongst others. Results of the AHMA forecast model are useful when the energy consumption and environmental impacts of transport are projected. AHMA covers forecasts of car fleet from 2013 until 2030.



Results

Development of the AHMA forecast model started within the TransEco research program, and the model is planned to be finalised by the end of 2014.

Participants and budget

Tampere University of Technology, Transport Research Centre Verne

VTT Technical Research Centre of Finland

Budget: EUR 110 000

Contact information

Hanna Kalenoja, Tampere University of Technology (hanna.kalenoja@tut.fi)

19. Truck fleet management model, KAHMA

Introduction

Truck fleet is in constant change with new truck registered and old vehicles removed from use, and also the way the trucks are used changes. These changes are linked with the economic situation, for example, registrations of new trucks decrease in weak economical situation. In addition, the maximum truck height and gross weight limits changed in 2013. These issues have a significant impact on the energy consumption and emissions of road transport, which was evaluated in this study.

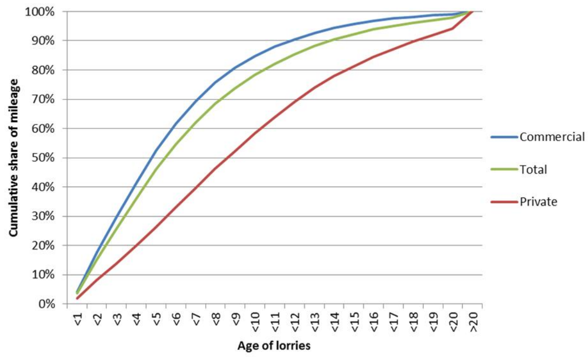


Figure 2. The share of mileage of trucks of different ages, average of years 2000–2012.

Results

The truck fleet is very old in Finland. As a result of the economic crisis, around 500 fewer new trucks were bought between 2009 and 2012 than usual. EURO V trucks thus entered into general use at a slower than normal rate. As a result, NO_x emissions were 650 t higher than, if the vehicles had been sold at the normal rate. There are differences in operational average age of trucks between the sectors, and between the licensed and private trucks

Out of the 45 types of goods in the goods transport statistics, the transports of four commodities are almost always full-loaded based on mass. These transports obtain the most benefit out of the increase in mass limits. All in all, the theoretical maximum effects of the increase in mass limits are EUR 189 million annually in cost savings, 7.7% reduction in mileage, and a 0.14 Mt reduction in CO_2 emissions (after transition period of 2013-189).

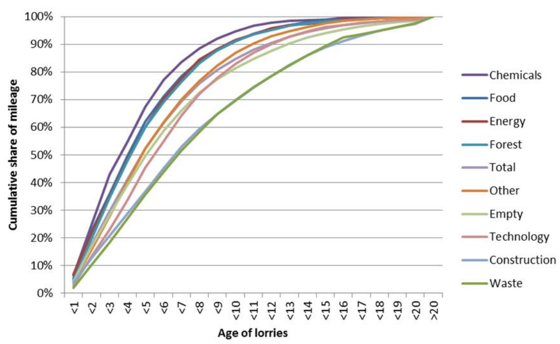


Figure 1. The share of mileage by sector of trucks of different ages subject to a permit, average of years 2000–2012.

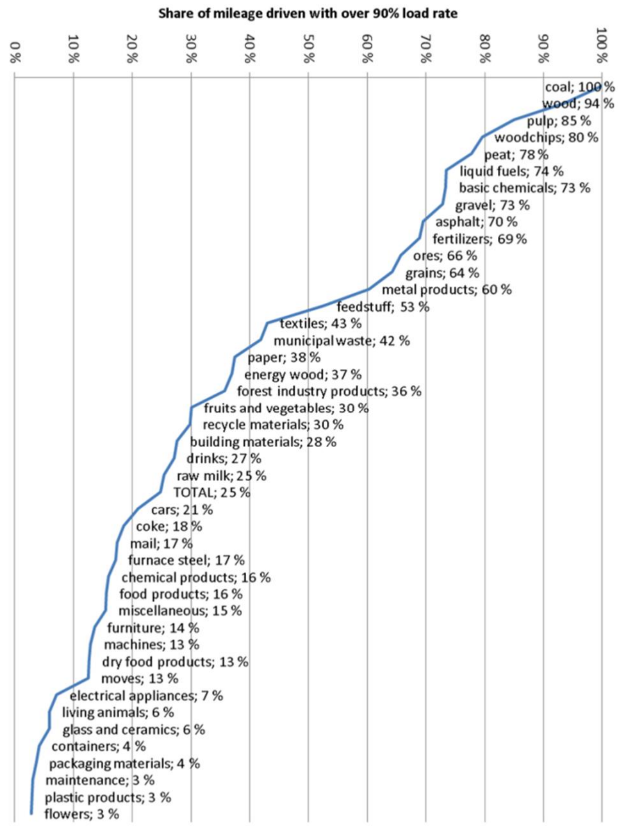


Figure 2. The share of mileage driven with over 90% load rate.

Publications

Nykänen, L. and Liimatainen, H. 2014. Possible impacts of increasing maximum truck weight; case Finland. Transport Research Arena Proceedings. 14–17 April 2014, Paris.

Liimatainen, H. and Nykänen, L., 2014. Truck fleet management model. Final report. In Finnish.

Participants and budget

Verne Transport Research Centre

Budget EUR 30 000

Contact information

Heikki Liimatainen, Tampere University of Technology (heikki.liimatainen@tut.fi)

20. Public transport: Monitoring, reporting and development of the energy efficiency, JOLEN

Introduction

The goal of the public transport energy efficiency agreement is 9% energy saving between 2008 and 2016 with an 80% coverage.

- How is energy efficiency measured in public transport?
- What energy efficiency measures are available to public transport and how widely have they been adopted?
- Are bus companies interested in the energy efficiency agreement?

Results

- The measurement of energy efficiency presents challenges.
- Problems arise in collecting data on passenger numbers and combining this with fuel consumption data.
- The cheap and easy energy efficiency measures have been adopted, but those requiring investment have not.
- Joining the energy efficiency agreement fails to motivate → joining the agreement should become a criterion for competitive contract tendering.

Publications

Metsäpuro, P., Liimatainen, H., Rauhamäki H. ja Mäntynen, J. Joukkoliikenteen energiatehokkuuden seuranta, raportointi ja kehittäminen. Sektoritutkimuksen neuvottelukunta. Kestävä kehitys. Raportti 1-2011.

Metsäpuro, P., Liimatainen, H. 2011. Energy efficiency in local public transport. European Transport Conference Proceedings. October 10-12, Glasgow, United Kingdom. (http://abstracts.aetransport.org/paper/index/id/3615/confid/17)

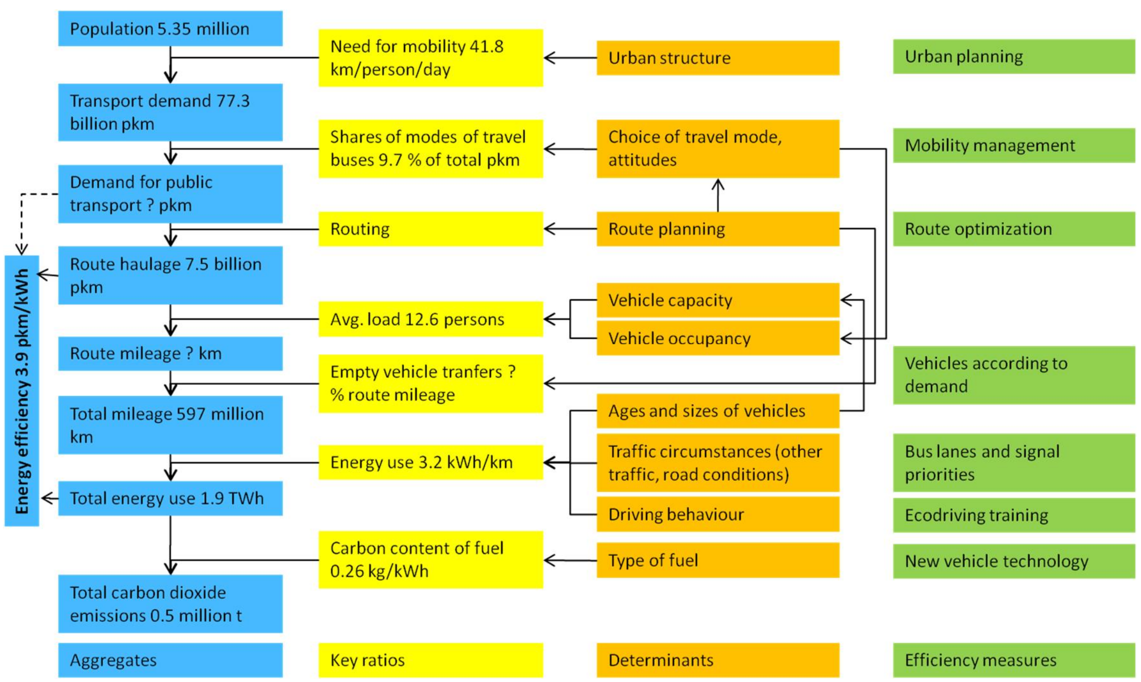
Participants and budget

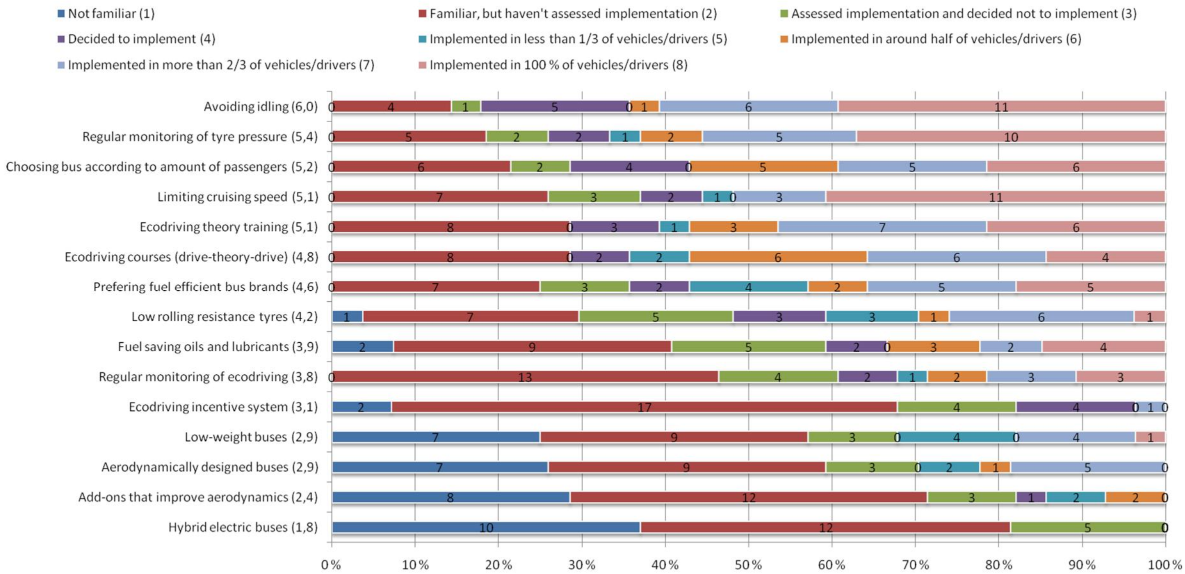
Verne Transport Research Centre
Tampere Public Transport
Tampere City Transport

Budget: EUR 100 000

Contact information

Heikki Liimatainen, Tampere University of Technology (heikki.liimatainen@tut.fi)



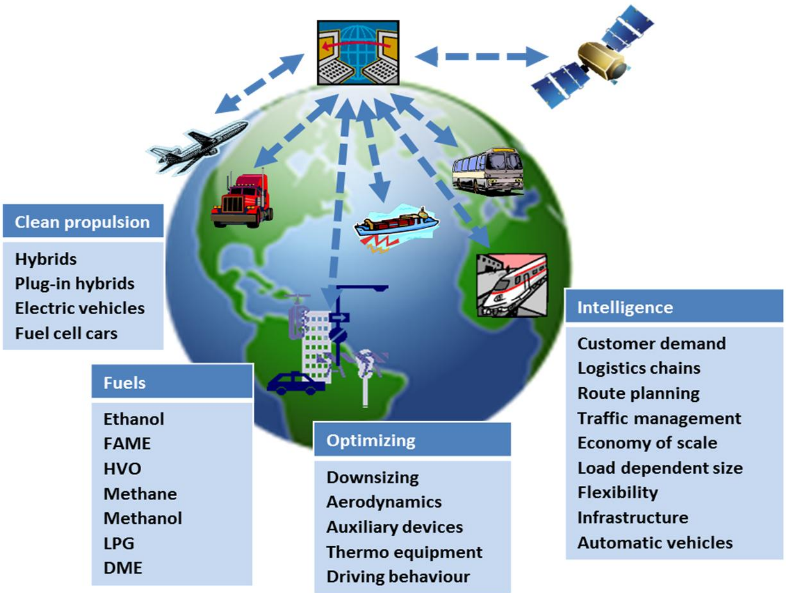

Not familiar (1)
Familiar, but haven't assessed implementation (2)
Assessed implementation and decided not to implement (3)
Decided to implement (4)
Implemented in less than 1/3 of vehicles/drivers (5)
Implemented in around half of vehicles/drivers (6)
Implemented in more than 2/3 of vehicles/drivers (7)
Implemented in 100 % of vehicles/drivers (8)
Avoiding idling (6,0)
Regular monitoring of tyre pressure (5,4)
Choosing bus according to amount of passengers (5,2)
Limiting cruising speed (5,1)
Ecodriving theory training (5,1)
Ecodriving courses (drive-theory-drive) (4,8)
Prefering fuel efficient bus brands (4,6)
Low rolling resistance tyres (4,2)
Fuel saving oils and lubricants (3,9)
Regular monitoring of ecodriving (3,8)
Ecodriving incentive system (3,1)
Low-weight buses (2,9)
Aerodynamically designed buses (2,9)
Add-ons that improve aerodynamics (2,4)
Hybrid electric buses (1,8)
0 % 10 % 20 % 30 % 40 % 50 % 60 % 70 % 80 % 90 % 100 %

21. Nordic Sustainable Logistics, NoSlone

Introduction

Nordic Sustainable Logistics Network "NoSlone" aimed at building a network on sustainable logistics. Each of five Nordic countries had a specific focus area. Through a cross-national cooperation a network with deep knowledge on several aspects of sustainable logistics was formed. The country-specific topics:

- Denmark: E-mobility business models and commercialization
- Finland: Alternative fuel types
- Iceland: Marine applications
- Norway: Light duty electric transportation
- Sweden: Heavy duty transportation



Results

Over two years, presentations, seminars, workshops, meetings and discussions on sustainable logistics were experienced in five Nordic countries. Seminars organized in Finland covered "Liquid bio-origin/alternative fuels, 4.6.2012", "Emissions and sustainability aspects for transport sectors, 1.11.2012", "Liquid (bio)methane – opportunity for heavy-duty transport? 17.12.2012" and "International cooperation (TransEco) 4.12.2012". NoSlone contributed also in the seminars, such as EVE Northern Collaboration Seminar, 23.5.2013. organized by Tekes. In this event, three presentations were held by NoSlone participants. Contribution was realized also in the workshop "Responsibility model for transport logistics", organized by Trafi on 31.10.2013. In international level, NoSlone organized three seminars. In Norway, Grønn Bil organized a seminar on electric vehicles on 22.5.2012. In Iceland, a conference "Electromobility in the North Atlantic Regions" was organized on 4.10.2012. In Denmark, a virtual conference was held on 16.1.2014. Presentations on sustainable logistics are available at web. Seminars have reached a large number of industries and organizations related to transport logistics.

The main deliverable of the project was a "Policy recommendation" report. In addition to policy analyses, this report includes basic information from Nordic countries and also case examples. It is noted that Nordic countries are different from each other by e.g. varying geography, density, distances and regulatory setup. One solution does not to fit all countries. Many common challenges were identified and the policy recommendations were defined to address these challenges. The common denominators identified are:

- Sizes of company vary from multinational to one-person.
- The opening of the EU towards low-cost countries put economical pressure on the industry.
- Tight economy leaves little room for investments.
- The industry is relatively conservative towards changes.
- The primary motivation for change is the economic and not the environmental aspect
- Governments in all countries target to CO_2 reduction

Political interference with the commercial market should be done with caution. Sudden changes in policies can result in the bankruptcy of companies, if the investments will not pay off under the new regulations. When implementing new policies, it is important to: 1. Acknowledge emission reduction is possible 2. Accept that one will be tampering with a commercial market and therefore the risk of critical voices is high 3. Create an incentive package that is both big and impactful – needs to be verified and afterwards discussed with the organizations who will be affected by it 4. Make certain that the framework will exist for at least 3-5 years and will not disappear from one day to another 5. Communicate it clearly and simply. With this framework in mind the policy measures were identified in order to drive the change towards greener technologies.

Publications

Lodberg Høj, J C, Aakko-Saksa, P., Skulason, J B, Hannisdahl, O H, Swan, M & Arvidsson, N. Policy recommendations for the transformation of the Nordic transport logistics to become sustainable. Norden Energy & Transport. Nordic Sustainable Logistics Network (2014), 64 p.

Participants and budget

DK: Insero E-Mobility, Jens Christian Lodberg Høj (coord.)

FI: VTT, Päivi Aakko-Saksa

IS: Icelandic New Energy, Jón Björn Skúlason

N: Grønn Bil, Ole Henrik Hannisdahl

S: Gothenburg University, N. Arvidson; NTM, M. Swan

Budget: EUR 63 000 (Finland)

Contact information

Päivi Aakko-Saksa, VTT (paivi.aakko-saksa@vtt.fi)

www.noslone.com

Policy objective	Policy measure/Initiative
Increase sales of greener vehicles and fuels	1. Vehicle taxation based on CO_2 emissions 2. Positive support on greener fuels through taxation/ subsidies
Reduce city congestion	3. Congestion charges with green zones
Reduce marine emission	4. Emission restrictions for marine harbour areas
Public organisations to catalyse sustainable transport logistics	5. Inclusion of green aspects such as CO_2 emissions in call for tenders on transport logistics 6. Creation of necessary certification to answer to call for tenders 7. Own investments in greener fleets
Creation of a basis for a long term strategy	8. Creation of a technical road map for the combined Nordic area
Create green long haul logistics	9. Creation of green corridors 10. Test of new technologies
Optimized and intelligent transport	11. Optimization of existing fleet 12. Promote smart operations, support to open data

22. The future of the energy efficiency and carbon dioxide emissions of the road transport sector, KULJETUS

Introduction

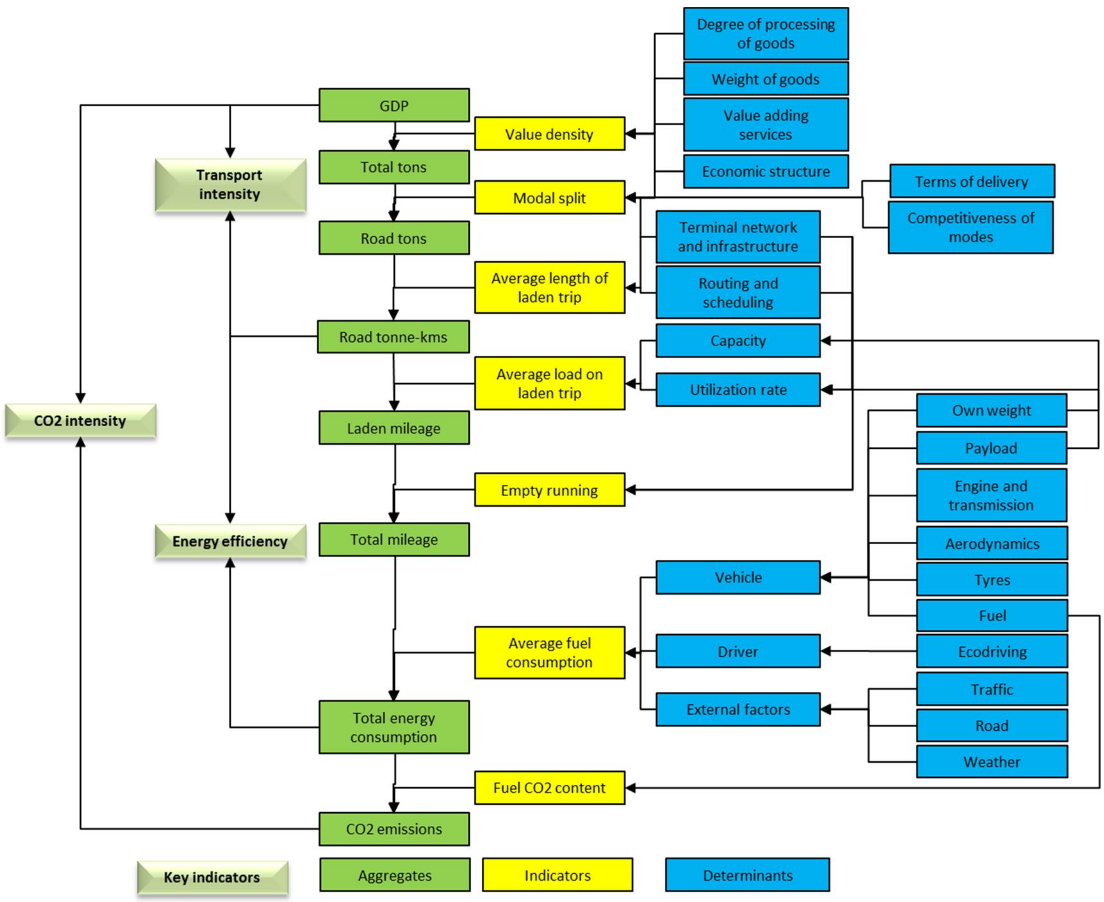
The goal of the EU's White Paper on transport is to achieve a 60% reduction in greenhouse gas emissions by 2050. The national goal is even more challenging: a reduction of 80%. The intermediate goal of -30% by 2030 means an emission level of 1.6 Mt CO_2 in Finland. Can these goals be achieved? How are the CO_2 emissions from road transport formed? How can the development be affected? The project examined the development of emissions with the help of a comprehensive evaluation framework.

Results

In 1995–2010, road transport mileage increased with economic growth while energy efficiency remained at the same level, which led to an increase in greenhouse gas emissions. In the future, the development of the economies and transport needs of the different sectors will determine the development of transport intensity and energy efficiency. A goal of 3.41 tkm/kWh by 2016 can be set for energy efficiency based on the energy efficiency agreement on goods transport and logistics. Energy efficiency is now at a level of 3 tkm/kWh. The goal can be achieved through different development paths.

In order to reach the greenhouse gas emission goal for 2030, roughly half of the baseline scenario, for example, comes from improving energy efficiency through increasing the average load and reducing empty running, and lowering fuel consumption, raising energy efficiency to around 3.96 tkm/kWh.

Alternative fuels have been assumed to reduce carbon dioxide emissions by 33% compared to diesel fuel. In the basic scenarios, the share of alternative fuels of the total energy is 20%, in the ecological economy scenario 33% and in the recession scenario 8%. The CO_2 emission goal (1.6 Mt by 2030) can thus be achieved through many different development paths. In the basic scenario, small changes in the right direction



will result in a large reduction of emissions.

Publications

Liimatainen, H. 2010. Kuljetusalan energiatehokkuuden raportointi ja tehostamistoimenpiteiden vaikutusten arviointi. Tampere University of Technology Department of Information Management and Logistics. Transport Systems. Research report 77.

Liimatainen, H. 2010. Shippers' Views on Environmental Reporting of Logistics and Implications for Logistics Service Providers. Logistics Research Network Conference 2010 Proceedings. September 8-10, Harrogate, UK.

Liimatainen, H., Pöllänen, M. 2010. Trends of energy efficiency in Finnish road freight transport 1995–2009 and forecast to 2016. Energy Policy, Vol. 38, Issue 12, pp. 7676–7686.

Liimatainen, H., Nykänen, K. 2011. Carbon footprinting road freight operations – is it really that difficult? Logistics Research Network Conference 2011 Proceedings. September 7–9, Southampton, United Kingdom.

Liimatainen, H., Pöllänen, M. 2011. The impact of economic development on the energy efficiency and CO_2 emissions of road freight transport. 16th International Symposium on Logistics (ISL 2011), July 10–13, Berlin, Germany.

Liimatainen, H., Pöllänen, M., Kallionpää, E., Nykänen, L., Stenholm, P., Tapio, P., McKinnon, A. 2012. Tiekuljetusalan energiatehokkuuden ja hiilidioksidipäästöjen tulevaisuus. Publications of the Ministry of Transport and Communications 1/2012.

Liimatainen, H., Kallionpää, E., Pöllänen, M. 2012. Building a national action plan for improving the energy efficiency and reducing the CO_2 emission of road freight transport. Proceedings of the 17th International Symposium on Logistics (ISL2012). July 8–11, Cape Town, South Africa.

Liimatainen, H., Stenholm, P., Tapio, P., McKinnon, A. 2012. Energy efficiency practices among road freight hauliers, Energy Policy, Vol. 50, pp. 833–842.

Liimatainen, H. 2012. Toimialarakenteen vaikutukset tiekuljetusten määrään, tehokkuuteen ja hiilidioksidipäästöihin Suomessa 1995–2030. A seminar presentation at the Väylät & Liikenne 2012 seminar 29–30 August 2012, Turku.

Liimatainen, H., Pöllänen, M. 2013. The impact of sectoral economic development on the energy efficiency and CO_2 emissions of road freight transport. Transport Policy, Vol. 27, pp. 150–157.

Liimatainen, H., Kallionpää, E., Pöllänen, M., Stenholm, P., Tapio, P., McKinnon, A. 2013. Decarbonising road freight in the future – Detailed scenarios of the carbon emissions of Finnish road freight transport in 2030 using a Delphi method approach. Technological forecasting and social change. DOI: 10.1016/j.techfore.2013.03.001.

Liimatainen, H. 2013. Future of Energy Efficiency and Carbon Dioxide Emissions of Finnish Road Freight Transport. Thesis. Tampere University of Technology. Publication 1124.

Participants and budget

Verne Transport Research Centre, University of Turku, Heriot-Watt University, Ministry of Transport and Communications, Ministry of Employment and the Economy, Finnish Transport Agency, SKAL

Budget: EUR 90 000

Contact information

Heikki Liimatainen, Tampere University of Technology (heikki.liimatainen@tut.fi)

23. Visions and action portfolios for fighting climate change in the transport sector until 2050 Baseline development, Urban Pulse or Horn of Plenty? ILARI

Introduction

In 2011, the Finnish domestic transport greenhouse gas (GHG) emissions amounted to about 12.4 million tonnes of carbon dioxide equivalent (CO_2 eq.). According to the Baseline development, the carbon dioxide emissions from transport will settle around the level of year 1980, slightly over 8 million tons, by 2050. However, the reduction target set by the EU's transport sector means reducing the emissions to around 5 million tons (CO_2 eq).

During the ILARI-project, eight visions of the future of transport greenhouse gas emissions were created based on the views of experts and youths. The Urban Beat and the Cornucopia visions, where the emissions decreased to a 2–4 million ton level in 2050, were given a closer examination, and policy packages were prepared for achieving the futures they describe.

Results

The “Urban Beat” is a radical vision, based on compact cities and high use of ICT. The economy will grow strongly, and modal shares will change radically towards soft modes and public transport, particularly to rail transport.

The “Cornucopia” vision is based on radical technological development and new transport solutions that will help to cut CO_2 emissions without significant behavioural change.

The policy packages aiming at the greenhouse gas emission reductions depicted in the visions are very different in nature. The 7 policy packages aiming at achieving the Urban Beat vision focus on modal shifts and changes in attitudes and values of transport system users. The policy packages for the Cornucopia emphasise the potential of new technology.

The results achieved with the proposed method present an overall picture of the possible futures and how to prepare for them. The primary purpose of the results is to illustrate possible directions the future may take, not to present exact calculations or predictions. It is nevertheless possible to conclude from these results that opportunities exist for achieving the long-term CO_2 goals. Achieving these goals will require significant investments, however.

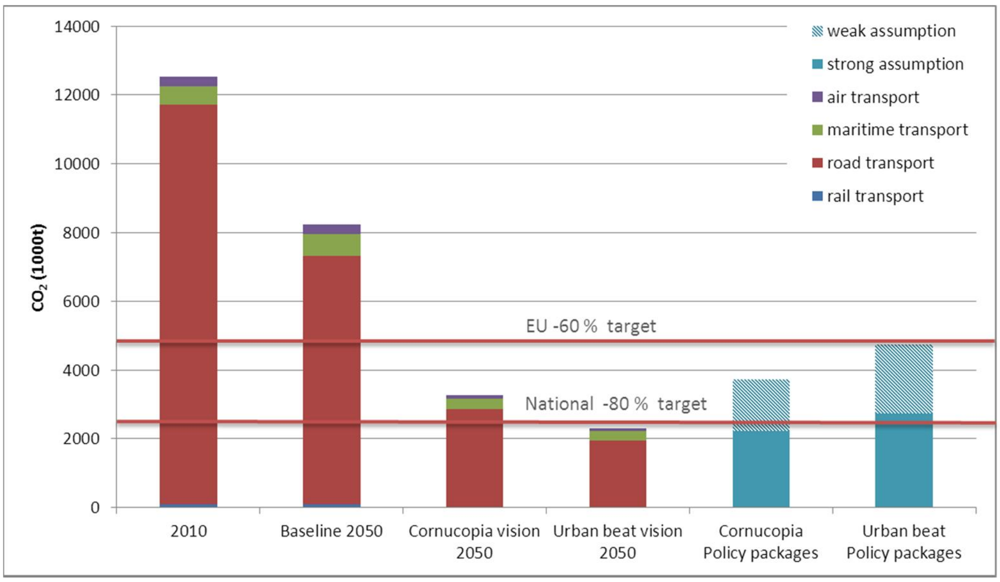


Figure 1. Transport CO_2 emissions in Finland in 2010 and according to the Baseline development and the two visions (expert and high school student views) by 2050. The two outermost columns on the right indicate potential CO_2 emissions of vision paths with policy packages (weak-strong assumptions) by 2050.

Publications

Tuominen, A., Tapio, P., Varho, V., Järvi, T. and Banister, D. Pluralistic backcasting: Integrating multiple visions with policy packages for transport climate policy. *Futures*. Elsevier. Vol. 60 (2014) No: August, 41 – 58. doi-link: 10.1016/j.futures.2014.04.014

Tuominen, A., Järvi, T., Wahlgren, I., Mäkelä, K., Tapio, P. & Varho, V. 2012. Ilmastonmuutoksen hillinnän toimenpidekokonaisuudet liikennesektorilla vuoteen 2050. Baseline-kehitys, Urbaani syke vai Runsaudensarvi? Publications of the Ministry of Transport and Communications 15/2012.

Tapio, P., Varho, V., Järvi, T., Nygrén, N. & Tuominen, A. 2011. Liikennepolitiikan ilmasto. Baseline-kehitys sekä asiantuntijoiden ja nuorten visiot liikenteen hiilidioksidipäästöistä vuoteen 2050. Publications of the Ministry of Transport and Communications 19/2011.

Participants and budget

VTT Technical Research Centre of Finland: Anu Tuominen, Tuuli Järvi, Kari Mäkelä, Irmeli Wahlgren

The Finland Futures Research Centre of the University of Turku: Petri Tapio, Vilja Varho

Budget: EUR 150 000

Contact information

Anu Tuominen, VTT (anu.tuominen@vtt.fi)

Petri Tapio, the Finland Futures Research Centre of the University of Turku (petri.tapio@utu.fi)