Kehittyvät hyötyajoneuvot (IEA COMVEC)

Juhani Laurikko

TkT, johtava tutkija

VTT

IEA – Advanced Motor Fuels Agreement (AMF) Annex 49: Fuel and Technology Alternatives for Commercial Vehicles (COMVEC)

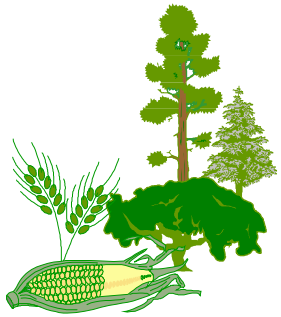
Tausta ja tavoitteet

- Hyötyajoneuvojen ***käyttövoimavaihtoehdot lisääntyvät*** jatkuvasti.
- COMVEC-***hankkeella halutaan tuottaa puolueetonta ja vertailukelpoista tietoa eri vaihtoehtojen suorituskyvystä, polttoaineen/energian kulutuksesta ja pakokaasupäästöistä***.
- Kun tähän ***yhdistetään dataa polttoaineen tuotannosta*** (well-to-tank, WTT), jolloin ***syntyy kokonaisvaltaista tietoa päätöksenteon tueksi***.

- Keskeiset osatavoitteet ovat:
- ***Luoda yhteneviä menetelmiä*** hyötyajoneuvojen pakokaasupäästöjen ja energian kulutuksen mittaamiseen
- ***Tuottaa tietoa vaihtoehtoisista polttoaineista ja energioista***, niiden energian kulutuksesta, päästöistä ja kustannuksista koko polttoaineketjun (WTW) yli
- Yhdessä aiempien/rinnakkaisten hankkeiden (Annexes 37, 38, 39 and 43), ***löytää parhaat käyttökohteet polttoainevaihtoehdoille***, joissa kustannukset ja hyödyt on optimoitu

Energiaketju - “lähteestä pyöriin”

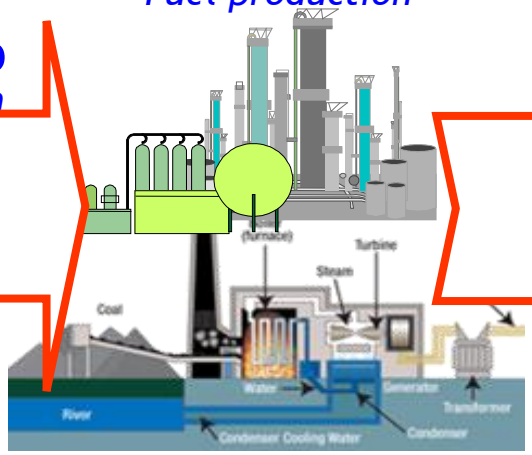
Pathway analysis – Well-to-Wheels (WTW)



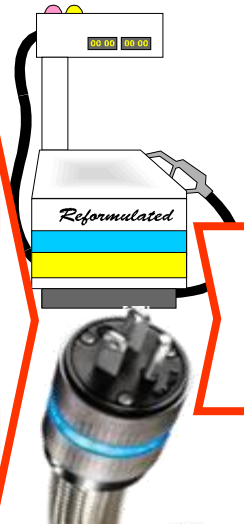
Raaka-ainetuotanto
Raw Material Extraction

Primaarienergia
Primary energy

Polttoainetuotanto
Fuel production

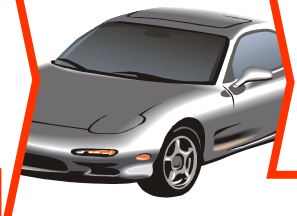


Sähkön tuotanto
Electricity production

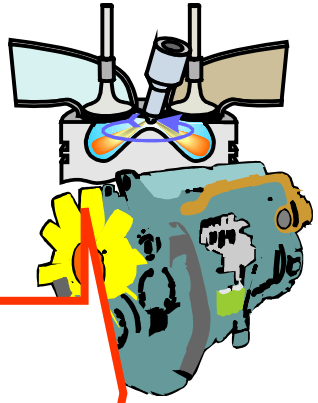


Jakelu ja tankkaus & lataus
Distribution, Refuelling, Recharging

Polttoaine tankissa
On-board fuel



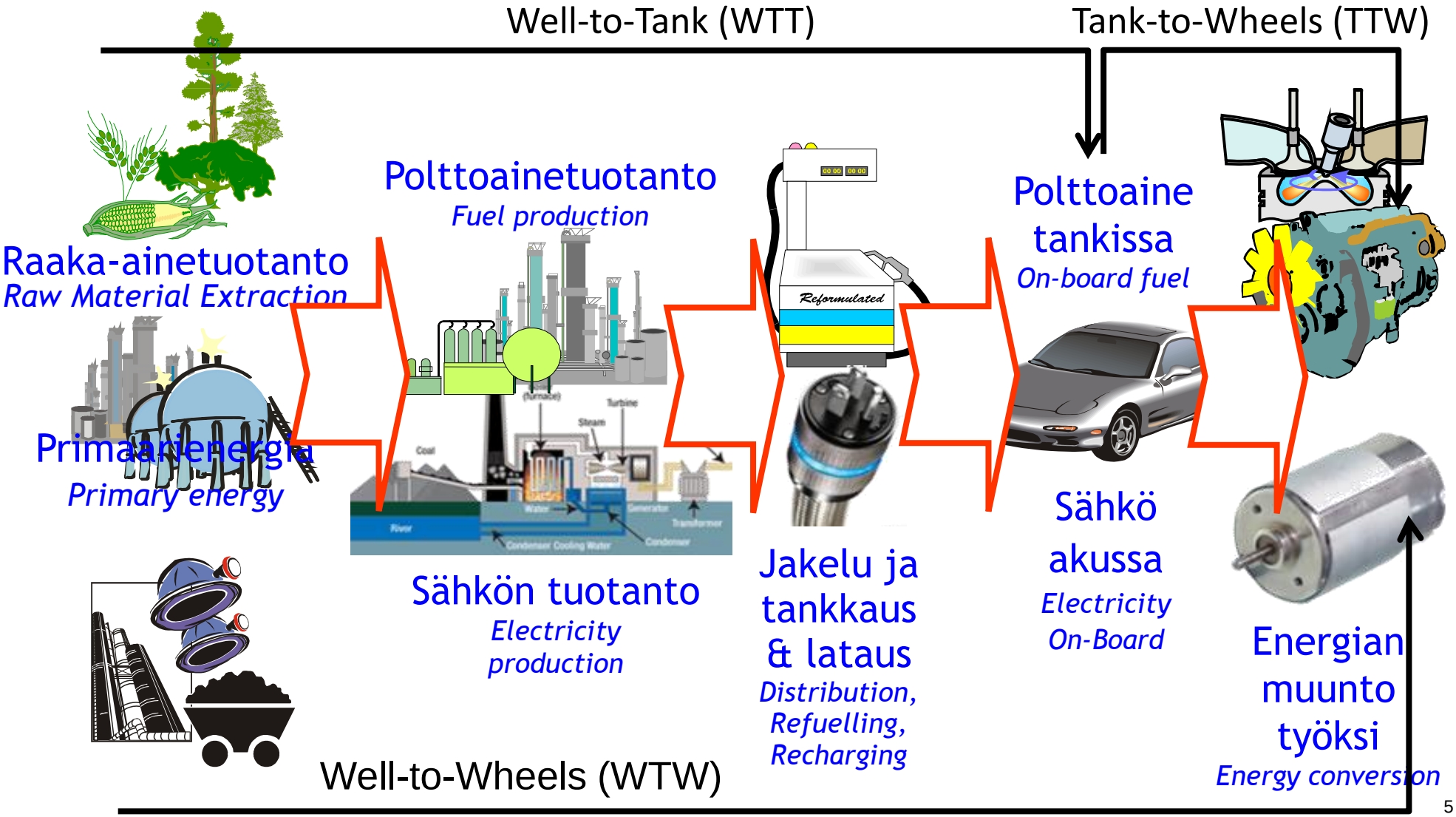
Sähkö akussa
Electricity On-Board



Energian muunto työksi
Energy conversion

Energiaketju - “lähteestä pyöriin”

Pathway analysis – Well-to-Wheels (WTW)

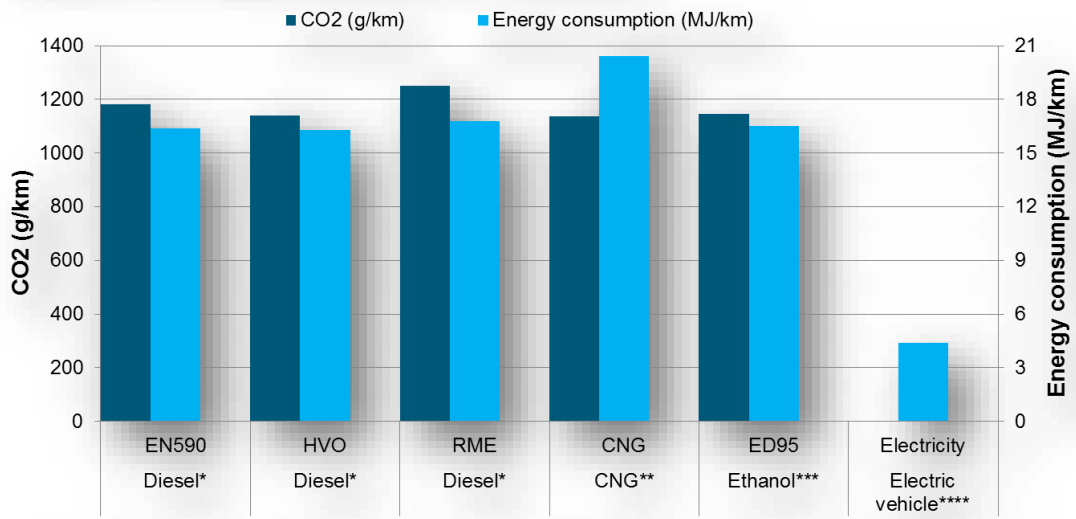


Aikaisemmat tutkimukset @ VTT

- Annex 37: IEABUS - Fuel and Technology Alternatives for Buses: Overall Energy Efficiency and Emission Performance (2009 – 2011)
- Mittauksia kaupunkibussien eri voimalaite/polttoaine -yhdistelmillä

Tank-to-Wheel Test Results

Measured Tailpipe Emissions of Busses



* EEV emission class city bus, compression ignition, NO_x after-treatment with EGR
** Euro V emission class city bus, spark-ignited lean-burn engine
*** EEV emission class city bus, compression ignition and dedicated engine for ethanol
**** Light-weight construction city bus with battery electric powertrain, vehicle mass equivalent to other options

Aikaisemmat tutkimukset @ VTT

Properties of Fuel Alternatives – Specific $gCO_{2eq.}/MJ$

Fuel	Raw material	Energy consumed (MJ/MJ final fuel)	WTT GHG emitted (gCO_{2eq}/MJ final fuel)	GHG emitted during combustion (gCO_{2eq}/MJ final fuel)	GHG factor of the fuel (incl. combustion)
95 E10	Wheat straw + crude oil to gasoline	0.26	13.7	68.3	82.0
95 E10	Maize, CH_4 to Combined Heat and Power, residues as AF + crude oil to gasoline	0.29	15.8	68.3	84.1
CNG	Shale gas (EU)	0.1	7.8	55.0	62.8
CNG	CNG, pipeline 7000 km	0.29	22.6	55.0	77.6
CBG	Liquid manure (closed storage)	2.01	16.0	0.0	16.0
EN590 B7	diesel	0.26	17.7	66.0	83.2
FAME100	Waste cooking oil	0.28	14.0	0.0	14.0
FAME100	Rape seed: Meal and glycerine as animal feed	1.18	51.7	0.0	51.7
HVO100	waste and residues	0.16	12.4	0.0	12.4
HVO100	Rape seed oil, meal to animal feed	1.12	44.0	0.0	44.0
Electricity	Wind offshore	0.16	0.0	0.0	0.0
Electricity	Finnish average electricity	2.21	68.3	0.0	68.3
Electricity	EU-mix, medium	2.07	141.1	0.0	141.1
Electricity	EU-mix, coal	1.81	292.4	0.0	292.4

Source: Directive 2009/28/EC (RED) and CONCAWE /EUCAR/JRC -report Well-to-tank Appendix 4, Version 4a, April 2014

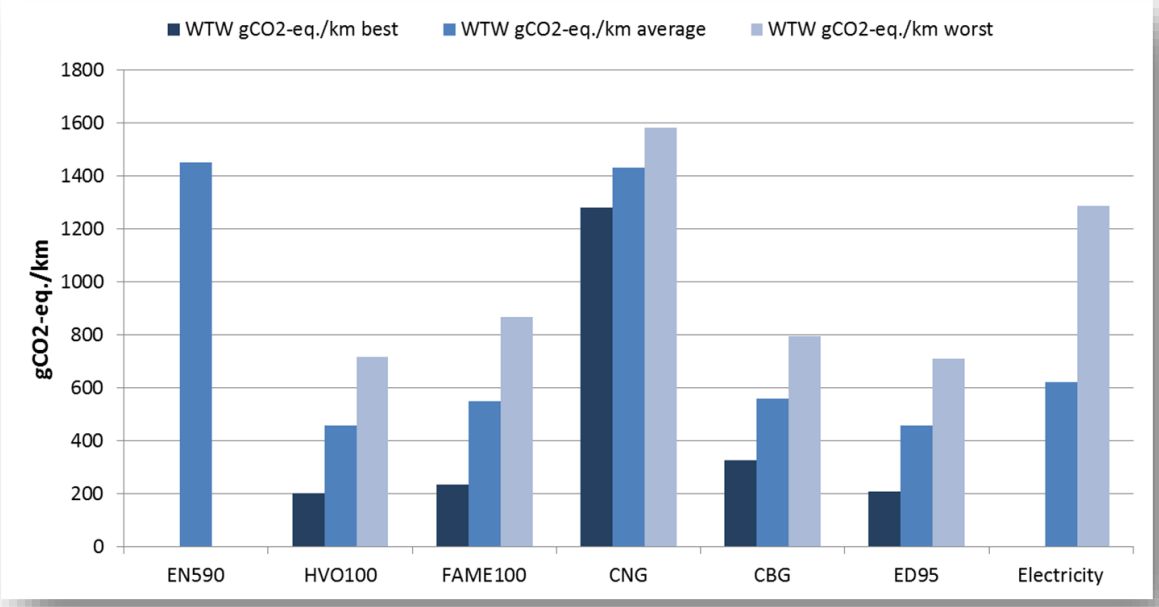
Source: Directive 2009/28/EC (RED) and CONCAWE /EUCAR/JRC -report Well-to-tank Appendix 4, Version 4a, April 2014

Aikaisemmat tutkimukset @ VTT

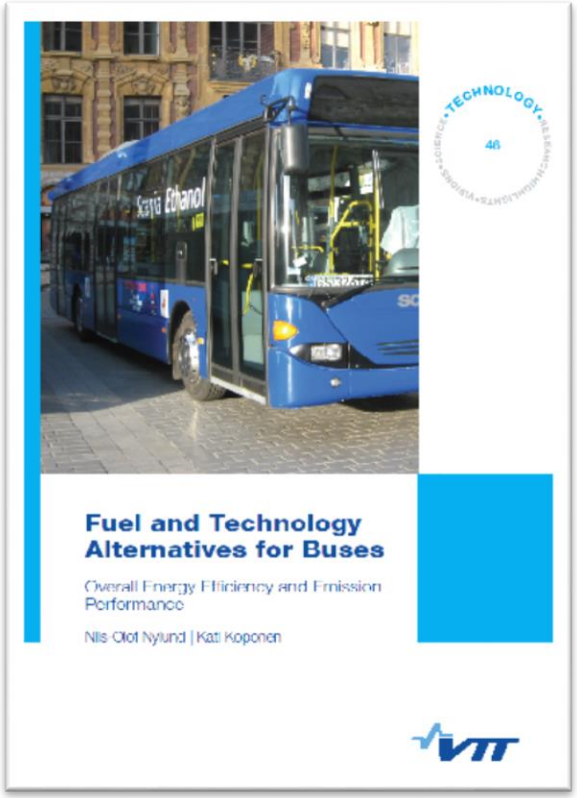
- Annex 37: IEABUS - Fuel and Technology Alternatives for Buses: Overall Energy Efficiency and Emission Performance (2009 – 2011)
  - Raportti: http://www.iea-amf.org/app/webroot/files/file/Annex%20Reports/AMF_Annex_37.pdf

Well-to-Wheels

GHG Emissions of City Busses



Source of data: Directive 2009/28/EC (RED) and CONCAWE /EUCAR/JRC -report Well-to-tank Appendix 4, Version 4a, April 2014, see VTT R-03914-14 for details

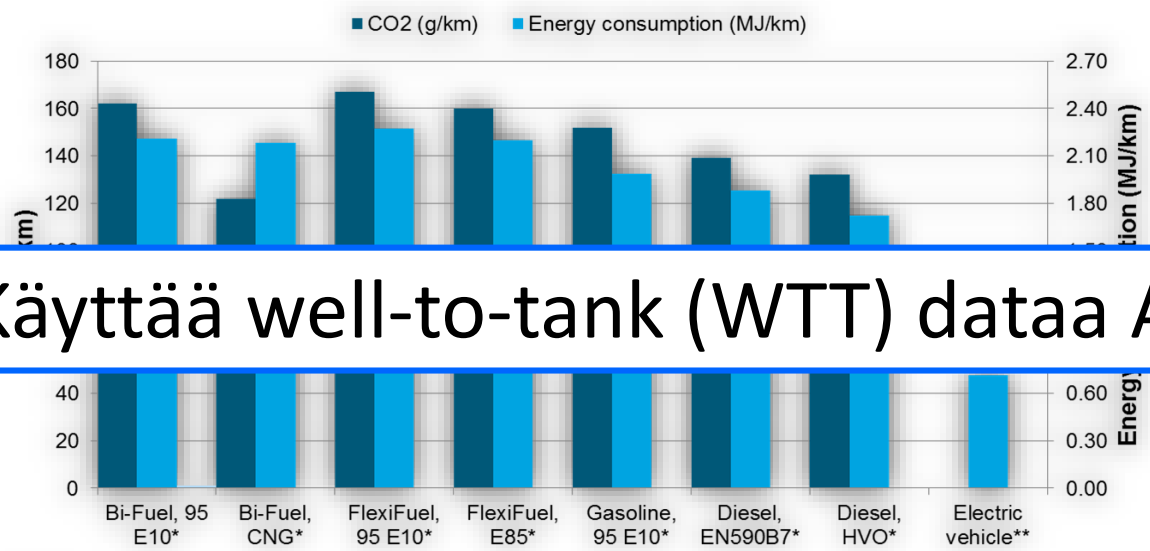


Aikaisemmat tutkimukset @ VTT

- Annex 43: CARPO - Performance Evaluation of Passenger Car Fuel and Powerplant Options (2012-2014)
  - TTW määritykset eri moottori/polttoainevaihtoehdoille henkilöautoissa

Tank-to-Wheel Test Results

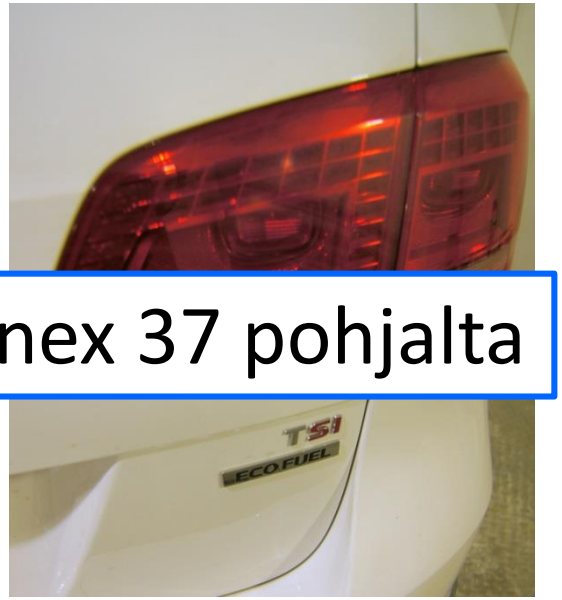
Measured Tailpipe Emissions of Passenger Cars



All of the vehicles are of same make and model, only powertrains differ between vehicles
* Factory made upper middle-class vehicle, in compliance with Euro 5 emission standards
** Battery Electric Vehicle (BEV), conversion was made on a upper middle-class diesel vehicle

Source: VTT's measurements, see VTT-CR-03914-14 for details

Käyttää well-to-tank (WTT) dataa Annex 37 pohjalta



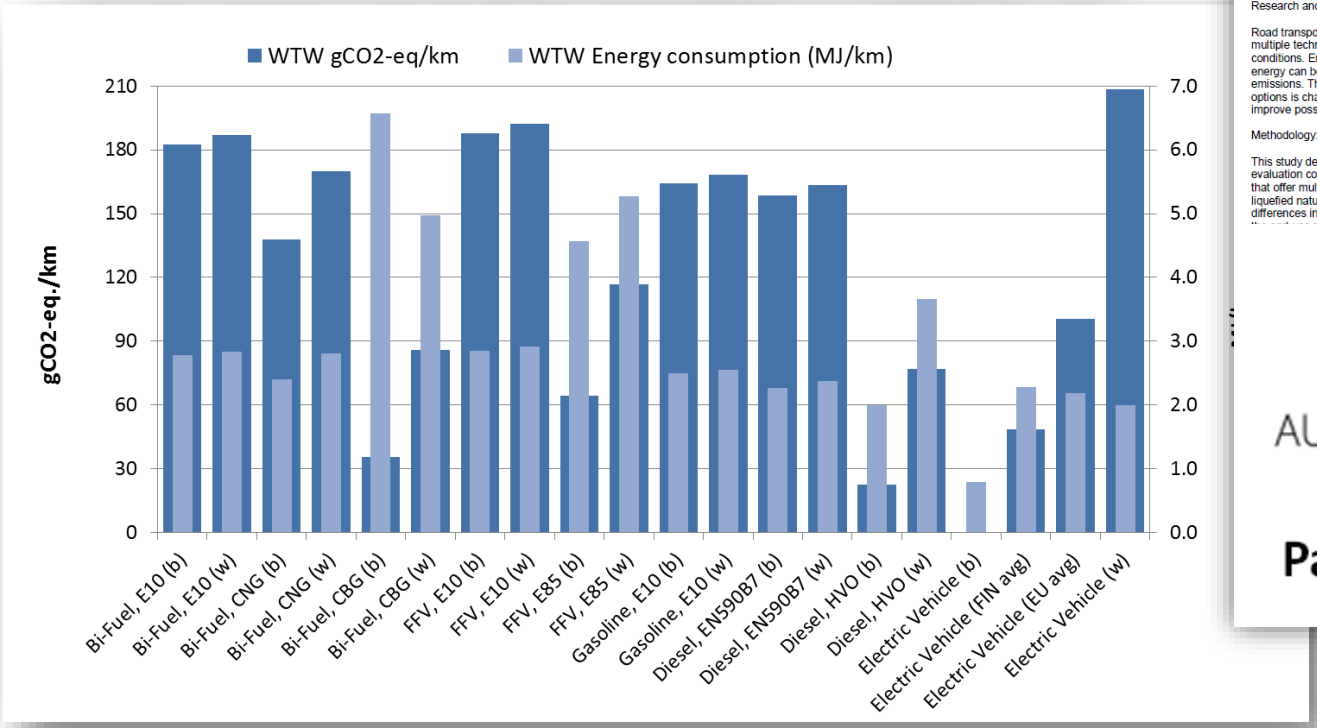
Single vehicle platform with multiple powerplant/fuel options

Aikaisemmat tutkimukset @ VTT

- Annex 43: CARPO - Performance Evaluation of Passenger Car Fuel and Powerplant Options (2012-2014)

Well-to-Wheels

GHG Emissions and Energy Consumption of Passenger Cars



F2014-CET-040

PERFORMANCE EVALUATION OF PASSENGER CAR, FUEL AND POWERPLANT OPTIONS

Nuottimäki, Jukka*; Laurikko, Juhani; Nylund, Nils-Olof
VTT Technical Research Centre of Finland, Finland;

KEYWORDS – Alternative fuels, Energy efficiency, Propulsion system, Exhaust emission, Well-to-wheels

ABSTRACT

Research and /or Engineering Questions/Objective:

Road transport needs de-carbonising actions, but no single solution can solve this challenge. Therefore, multiple technologies must be entertained to find the best-suited alternatives for each given set of boundary conditions. Engine downsizing, dieselization and hybridization contribute to fuel efficiency. Renewable energy can be introduced either through biofuels or electricity from renewable sources to further reduce CO2 emissions. There are numerous individual vehicle types, makes and models, thus the evaluation of future options is challenging. This project aims to deliver first-hand primary data for this kind of evaluations, and improve possibilities to make right-kind of choices among available options.

Methodology:

This study demonstrates the differences in efficiency arising from fuel, engine type and size. The core of the evaluation consists of benchmarking a set of passenger cars ("vehicle platforms") of such make and model that offer multiple choices for engine, i.e. gasoline, flex-fuel (E85), diesel, compressed natural gas (CNG), liquefied natural gas (LPG), hybrid or EV variations. In addition, the project also demonstrates the differences in efficiency arising from engine type and size. Chassis dynamometer testing provides data on

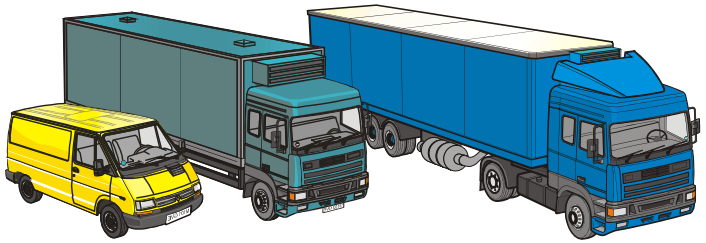
FISITA WORLD AUTOMOTIVE CONGRESS

Paper F2014-CET-040

Source of data: Directive 2009/28/EC (RED) and CONCAWE /EUCAR/JRC -report Well-to-tank Appendix 4, Version 4a, April 2014, see VTT R-03914 -14 for details

Sisältö

- WP 0: Olemassa olevan tiedon keruu ja yhdenmukaistaminen
- WP 1: Yhtenäisten tutkimusmenetelmien kehittäminen
- WP 2: Ajoneuvojen mittaukset
- WP 3: Polttoaineketjun alkupään (well-to-tank) tietojen yhdentäminen
- WP 4: Tiedonkeruu eri osallistujamaiden käyttämistä vaihtoehdoista
- WP 5: Koko polttoaineketjun laskenta; yhdentää WP2 ja WP3 tiedot
- WP 6: Elinkaarikustannusanalyysi
- WP 7: Hankkeen koordinointi, synteesi ja raportointi



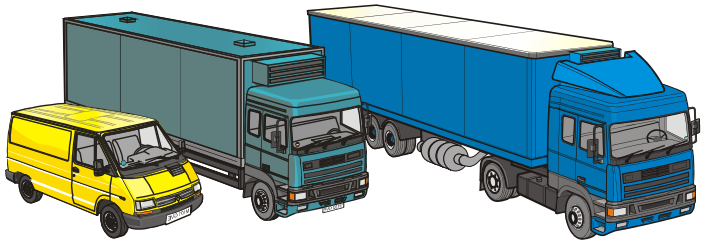
Suunniteltu aikataulu

		2013							2014												2015					
WP	**Description**	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
0	Collection and consolidation of the existing data	■	■	■	■	■	■																			
1	Development of common test procedures and preparations of the project	■	■	■	■	■	■																			
2	Vehicle testing						■	■	■	■	■	■	■	■	■	■	■	■	■							
3	Aggregation of well-to-tank information												■	■	■	■	■	■	■	■						
4	Regional information from project participants												■	■	■	■	■	■	■	■						
5	Full fuel-cycle evaluation																		■	■	■	■				
6	Life-cycle cost analysis												■	■	■	■	■	■	■	■						
7	Co-ordination of the project	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Vehicle and fuel alternatives in this project

Vehicle categories to be tested

- Category 1: Light-duty commercial vehicles (GVW 2500 – 5000 kg)
  - Delivery van –type vehicles; EU: N_1
- Category 2: Medium heavy-duty trucks (GVW 5000 – 18000 kg)
  - Delivery & garbage trucks etc. 2 axles
  - EU: N_2
- Category 3: Tractors (GVW ~ 40000 kg)
  - Long haul semi-trailer tractors; EU: N_3



Available technologies

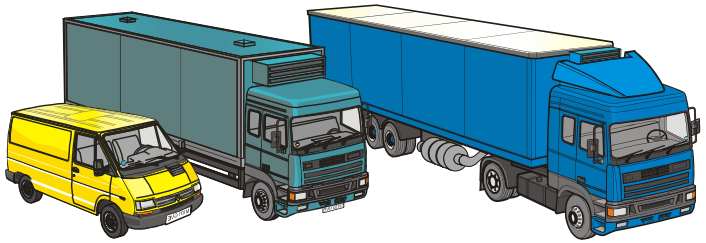
- Category 1:
  - Diesel, gasoline
  - CNG, LPG
  - Electricity
- Category 2:
  - Diesel
  - CNG (spark-ignited & dual-fuel)
  - Ethanol (ED95, Scania's concept)
- Category 3:
  - Diesel
  - LNG (dual-fuel & HPDI)
  - DME

Mittausmatriisi - Suomi

Koepolttoaineet

- EN590 B0 diesel
- 20 % HVO (WWFC cat 5 diesel)
- 100 % HVO
- 95 E10
- CNG
- RED95
- (LNG*)
- (Sähkö*)

*Autojen saaminen mittauksiin ei ole vielä varmistunut



Ajoneuvot

- Category 1 (GVW 2500 – 5000 kg)
  - Diesel: Opel Combo
  - CNG/bensiini: Opel Combo
  - BEV: Nissan NV200* ja/tai Renault Kangoo
- Category 2 (GVW 5000 – 18000 kg)
  - RED95: Scania P270 Ethanol
  - Dual-fuel: Volvo FLH 42 PD
  - Diesel: [ei vielä valittu]
- Category 3 (GVW ~40000 kg)
  - Dual-fuel: Iveco*
  - Diesel: [ei vielä valittu]

Osallistuvat maat ja organisaatiot

Maa	Organisaatio
Kanada	Environment Canada
Kiina	CATARC
Chile	3CV Vehicle Control and Certification Center
Tanska	Danish Technological Institute
Suomi (Operating Agent)	VTT
Israel	n/a
Japani	LEVO/NTSEL
Korea	KATECH
Ruotsi	AVL MTC
Thaimaa	PTT Research and Technology Institute

- Toimintamalli: task-sharing action, n. 900 M€ kokonaisbudjetti

Task sharing contribution of Canada

- Canada will provide chassis dynamometer emission measurements on a category 1 LDV and a category 3 HDV

- Test fuels/energies are:
  - For LDV: gasoline E0, E10, CNG, LPG, ultra-low sulphur diesel (ULSD), biodiesel (B20 FAME), renewable diesel (B20 HVO) and electricity
  - For HDV: diesel, renewable diesel (B20 HVO) and LNG

- Test cycles:
  - For LDV: FTP 75 shall be used for all test configurations. The tests will be conducted in ambient temperature of +23 °C with additional tests conducted at -7 °C and -18 °C. WHVC tests shall be performed on limited test configurations.
  - For HDV: WHVC and the North American UDDS

Task sharing contribution of China

China will provide chassis dynamometer emission measurements on category 1 LDVs and possibly on category 2/3 MDV/HDVs (tbd)

- Test fuels are:
  - For LDV: diesel, biodiesels (B5 FAME & B15 FAME), gasoline and CNG
  - For MDV/HDV: possibly gasoline, diesel and CNG

- Test cycles:
  - For LDV: NEDC at 25℃, the use of WHVC is under investigation.
  - For MDV/HDV: Measurements will be conducted either in an engine test bench or on a chassis dynamometer. The test cycles would be WHVC, ETC and ESC

Task sharing contribution of Denmark

- Test program mainly on spark-ignited CNG vehicles
  - Tail pipe and noise emission
  - EURO-norm VI vehicles
  - Evaluate and compare with similar vehicles powered by diesel
- DTI has been waiting availability on vehicle and filling stations
- DTI has performed pre-test of WHVC Duty Cycle
- DTI is waiting ordered Industrial gas analysis, FT-IR, and Coriolis mass flow meter gas to arrive – both expected to arrive in June 2014

Task sharing contribution of Japan

- Japan's task sharing contrition will be via LEVO, and comprise of testing of an engine for a light-duty commercial vehicle in cooperation with NTSEL (National traffic safety and environment laboratory)
- The outline of tests is:
  - Engine: A diesel engine for a light duty commercial vehicle with payload of 3 metric tons. The engine specification is same as that used for Annex 38, with the latest emission regulation (Japanese 2009 regulation).
  - Fuel: Diesel fuel (JIS (Japan Industrial Standard) #2), BDF (blend ratio: TBD), HVO (blend ratio: TBD)
  - Test cycle: WHTC (hot start)
- If necessary, NTSEL can also provide emission data conducted by JE05 test cycle on CNG, LNG, and/or DME engine for a commercial vehicle for WP0.

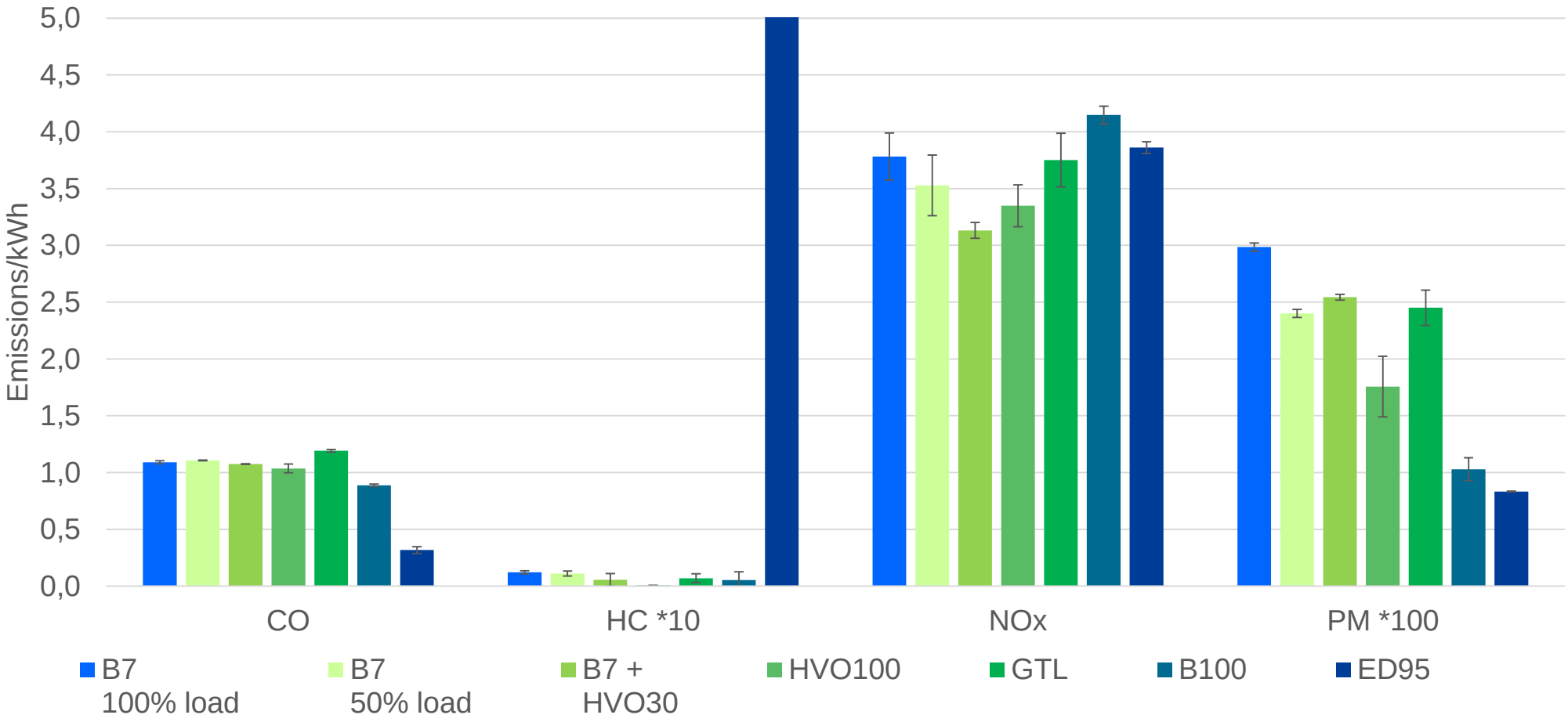
Task sharing contribution of Korea

- Testing of city bus and commercial vehicles like as light/medium/heavy duty commercial vehicle.
- Test fuels are:
  - ULSD (Ultra Low Sulphur Diesel) with 2 % biodiesel for the commercial vehicles, and
  - CNG (Compressed Natural Gas) for the city bus.
- The vehicles comply with Euro V level of emission regulations
- Test cycle is WHVC.
- Korea can also provide some data such as regulated and unregulated emissions, as well as GHG emissions.

Task sharing contribution of Sweden

- Testing of medium and heavy-duty commercial vehicles with WHVC test cycle.
- Each test shall be conducted with one cold start and two hot starts.
- Test fuels are:
  - Swedish Environmental Class 1 (EC1) diesel with 7 % FAME
  - EC1 with 7 % FAME, and up to 30 % HVO
  - Neat (100 %) HVO
  - Synthetic diesel fuel (GTL)
  - FAME (30 % or 100 %
  - Ethanol for diesel (ED95)
  - possibly also DME
- The diesel fuels shall be tested in the same Euro V vehicle while ED95 and DME will be tested on dedicated vehicles.
- In addition to regulated emissions also unregulated emission such as PAH, alkenes and aldehydes will be measured.

Regulated emissions, weighted results



Task sharing contribution of Israel

- WP 2: Vehicle testing
  - Share results from our study at Annex 44: Research on Unregulated Pollutants Emissions of Vehicles Fuelled with Alcohol Alternative Fuels, ending on 30.06.2014.
- WP 4: Regional information on transportation sectors energy options
  - Share information regarding the Israeli's 'fuel choice initiative'
- WP 5: Full fuel-cycle evaluation (integration of WP2 & WP3)
  - Well-to-wheel fuel consumption, energy efficiency and emissions- share results from our studies on CNG, Methanol, GTL, EV, PHEV, 2nd generation biofuels (from waste): biodiesel, ethanol and biogas
- WP 6: Life-cycle cost analysis
  - How alternative fuel and vehicle technology, together with the operation of vehicle, influences on life-cycle costs. The objective is to find a cost-effective way to reduce emissions and energy consumption in given vehicle use.
  - share results from our techno-economic analysis on CNG, Methanol, GTL, EV, PHEV, 2nd generation biofuels (from waste): biodiesel, ethanol and biogas.

Task sharing contribution of Thailand

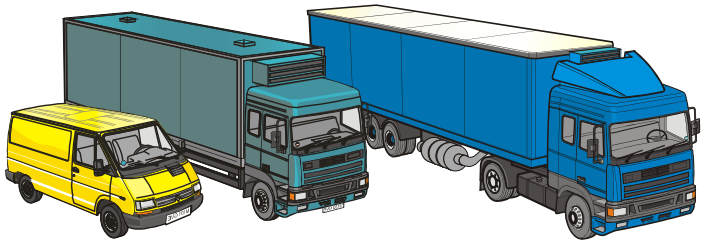
- The test cycle “WHVC” has been created in the new light-duty chassis dynamometer. The first commissioning with Euro IV LD vehicle will be conducted by June.

- If the new created WHVC does work well, the NEDC cycle shall be neglected. Thailand will conduct the hot WHVC. The test matrix has been considered as below. Tentatively, the test will cover all type of vehicle, while the number of vehicles is under consideration.
- The ambient temperature can be controlled only for 25 °C, sub-zero testing conditions are not available.

Vehicle Type / Technology	Test Fuels	OEMs Availability
Euro IV LD – Diesel Pick-up Truck	ULSD (50 ppm S), B7 FAME, HVO, B7 FAME, HVO, B7 FAME + HVO 5, B7 FAME + HVO 10, B7 FAME + HVO 20	Toyota Isuzu Nissan Ford Mazda Mitsubishi Chevrolet TATA
Euro IV LD – Bi-fuel CNG Pick-up Truck	E0, E10, E20, CNG, LPG (Optional)	Toyota Nissan Mitsubishi
Euro III – Dedicated CNG	CNG	TATA

Yhteenveto

- IEA-COMVEC hanke on kv. yhteistyötutkimus, joka ***kokoaa ja päivittää tietoja hyötyajoneuvojen polttoaineen/energian kulutuksesta eri moottoriteknologioilla***
- Mukana on ***Suomen lisäksi yhteensä 9 maata***
- Tutkittavat ***ajoneuvot edustavat kaikkia N-luokkia*** (2500 kg … 42 000 kg)
- Käytön (TTW) tiedot yhdistetään polttoaineen tuotannon (WTT) tietoihin, jotka on kerätty aiemmissa IEA-hankkeissa, jolloin ***saadaan koko polttoaineketjun yli*** (WTW) ***laskettu GHG-päästö*** (gCO_{2eq}/km) ***ja energian kulutus*** (MJ/km)
- Vastaavat hankkeet on aiemmin toteutettu busseille ja henkilöautoille



TEKNOLOGIASTA TULOSTA