

Hybrid and electric bus activities in Helsinki area

2. Fachkonferenz Elektromobilität im ÖPNV

25-26th November 2013

Kimmo Erkkilä & Nils-Olof Nylund

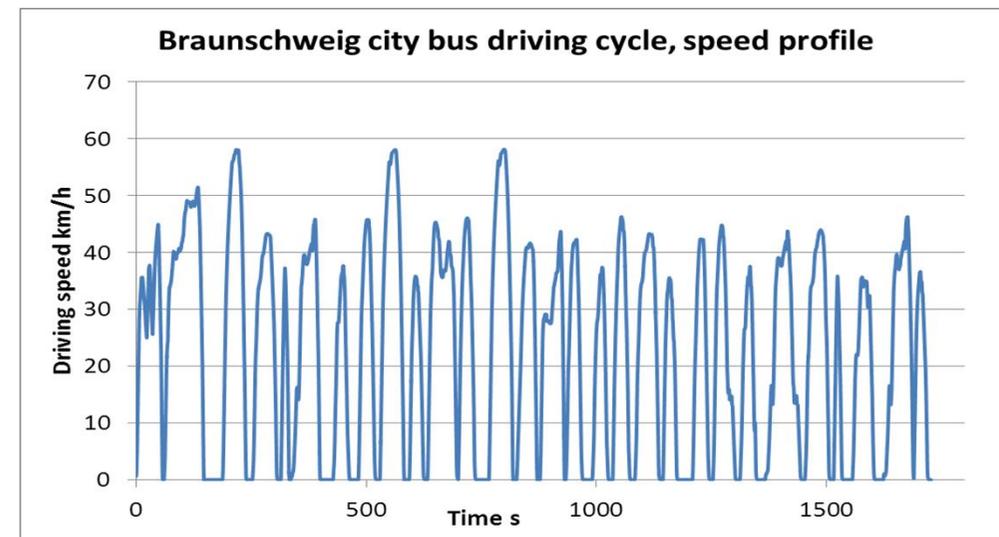
VTT Technical Research Centre of Finland

Index

- VTT's activities at bus research
- Hybrid buses in IEABUS project
- eBUS-project
- Summary

VTT's activities on HD vehicles

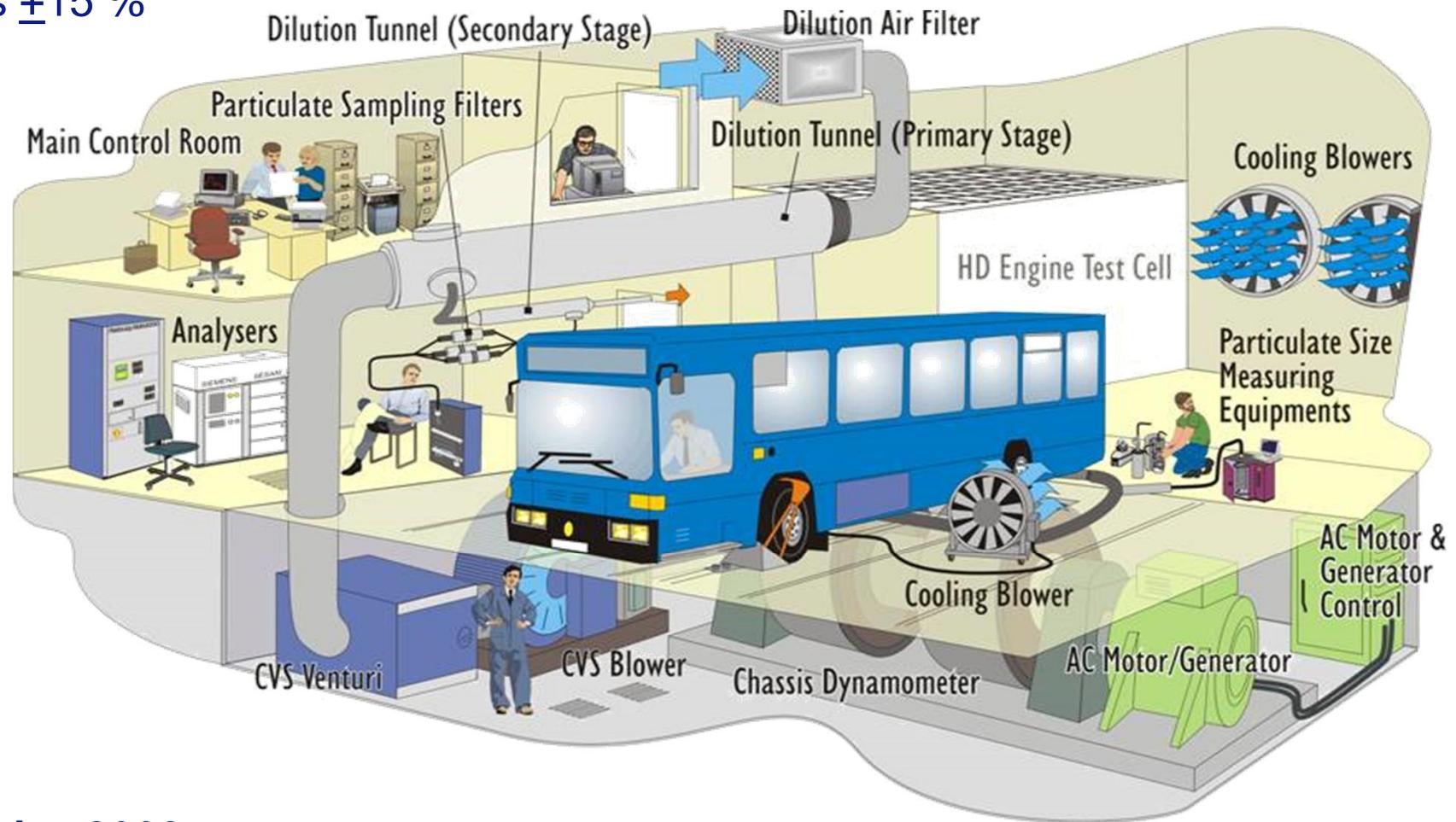
- VTT (Technical Research Centre of Finland) commissioned a new heavy-duty laboratory in 2002
 - Testing of complete vehicles on chassis dynamometer
 - Distance based "real-life" emissions and energy consumption
 - Effect of driving cycle
 - Comparison of technologies
 - Fuels
 - Drivelines
 - Available bus models
 - Calibrations and components



Accuracy:

- Fuel consumption ± 1 %
- Emissions ± 15 %

Chassis dynamometer



First tests in May 2002
 Today some 300 buses have been tracked by
 VTT (inc. follow-ups)

The Finnish Centre for Metrology and
 Accreditation granted accreditation for
 VTT's measurements in 2003

Actual bus performance – 2011 database

Braunschweig	Lukumäärä n	Ajomäärä Min	Max	CO g/km	HC g/km	CH4* g/km	NOx g/km	PM g/km	CO2 g/km	CO2 eqv** g/km	FC kg/100km	FC MJ/km
2 - akseliset												
Diesel Euro I	2	555025	672700	1.39	0.32		15.59	0.438	1219	1219	38.6	16.4
Diesel Euro II	13	180500	1125874	1.60	0.21		12.88	0.213	1258	1258	40.7	17.3
Diesel Euro III	14	15934	786184	0.85	0.12		8.48	0.209	1191	1191	38.4	16.3
Diesel Euro IV	8	6105	474152	2.96	0.10		8.36	0.112	1184	1184	38.2	16.2
Diesel Euro V***				2.96	0.10		7.51	0.089	1184	1184	38.2	16.2
Diesel EEV	18	1020	498819	0.81	0.04		6.65	0.068	1127	1127	38.6	15.6
Ethanol EEV	1	98032	98032		0.43		5.58	0.037	1153		65.3	16.6
Diesel Hyb, EEV	4	2602	44620	0.58	0.02		4.16	0.034	811	811	25.7	10.9
CNG Euro II	2	211000	672946	4.32	7.12	6.76	16.92	0.009	1128	1283	42.1	20.7
CNG Euro III	2	37600	237189	0.05	2.84	2.51	9.44	0.019	1177	1235	43.7	21.5
CNG EEV	8	1824	454480	2.00	1.11	1.05	2.99	0.008	1250	1274	46.3	22.7
2 - akseliset, kevyt												
Diesel****	3	993	28436	0.99	0.04		7.10	0.050	927	927	30.5	13.0
3 - akseliset												
Diesel Euro V	4	1400	232494	6.68	0.03		3.16	0.089	1362	1362	44.8	19.0
Diesel EEV	3	84836	94910	1.26	0.07		7.43	0.080	1482	1482	47.6	20.2
CNG EEV	4	121773	538360	8.61	1.53	1.45	6.22	0.014	1411	1444	52.4	25.7

(ind.x) = yksilöin tunniste

*Maakaasuautoille käytetty CH4 = THC * 0.95, dieselille CH4 = 0

** CO2 eqv = CO2 + 23 * CH4

*** Euro V tulokset arvioitu Euro IV tulosten perusteella

**** Euro III, Euro IV, EEV

Business from technology



FUEL AND TECHNOLOGY ALTERNATIVES FOR BUSES

Overall energy efficiency and emission performance

IEA AMF Annex XXXVII & Bioenergy Task 41/Project 3

TransEco Bus Seminar 6.2.2012

Nils-Olof Nylund

VTT Technical Research Centre of Finland



trans^{eco}

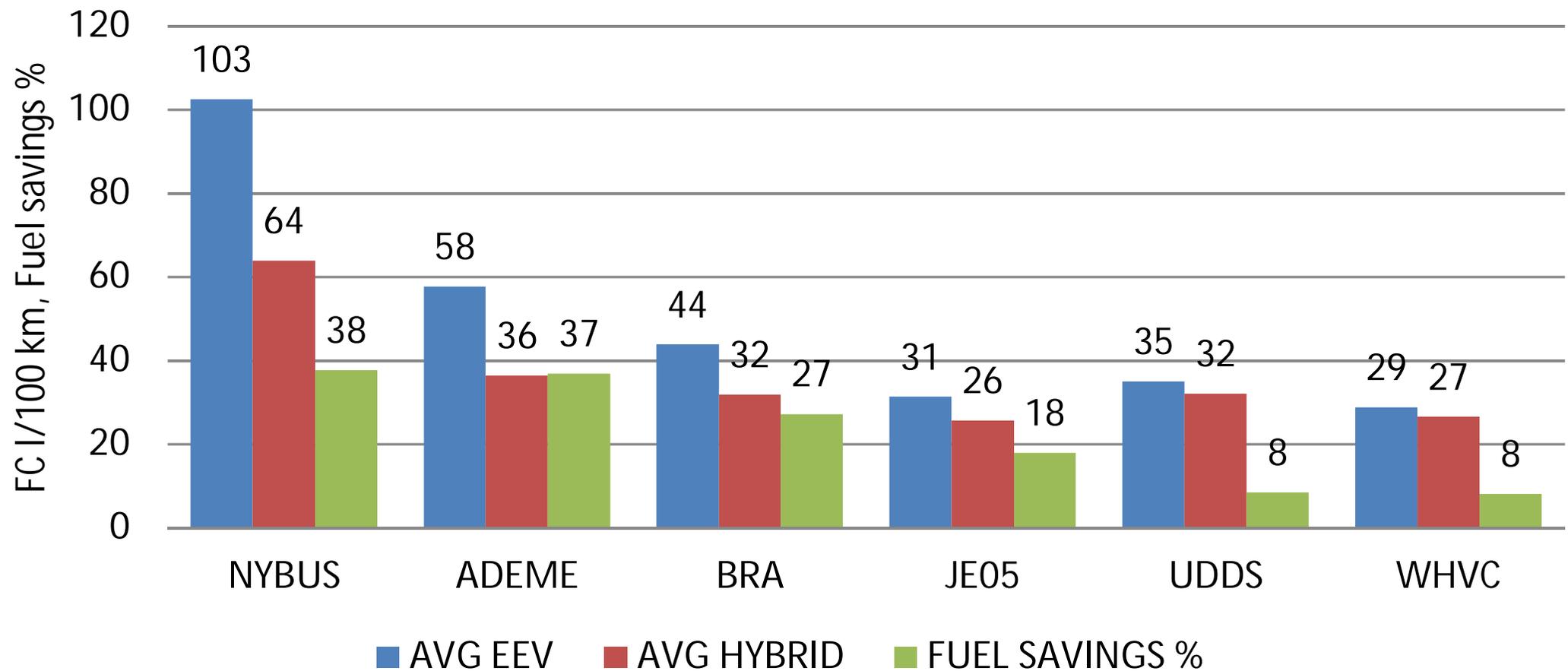
Contents of IEA BUS project

- Well-to-tank analysis
 - based on existing data for various fuel options
 - ranges depending on feedstock and process
- Tank-to-wheel analysis
 - actual testing of the most relevant technology and fuel options
 - fuel efficiency and exhaust emissions
 - effects of driving conditions
- Well-to-wheel analysis
 - synthesis of WTT and TTW
- Cost estimates
 - direct costs (infrastructure, fuel and vehicle)
 - external costs (valuation of exhaust emissions)



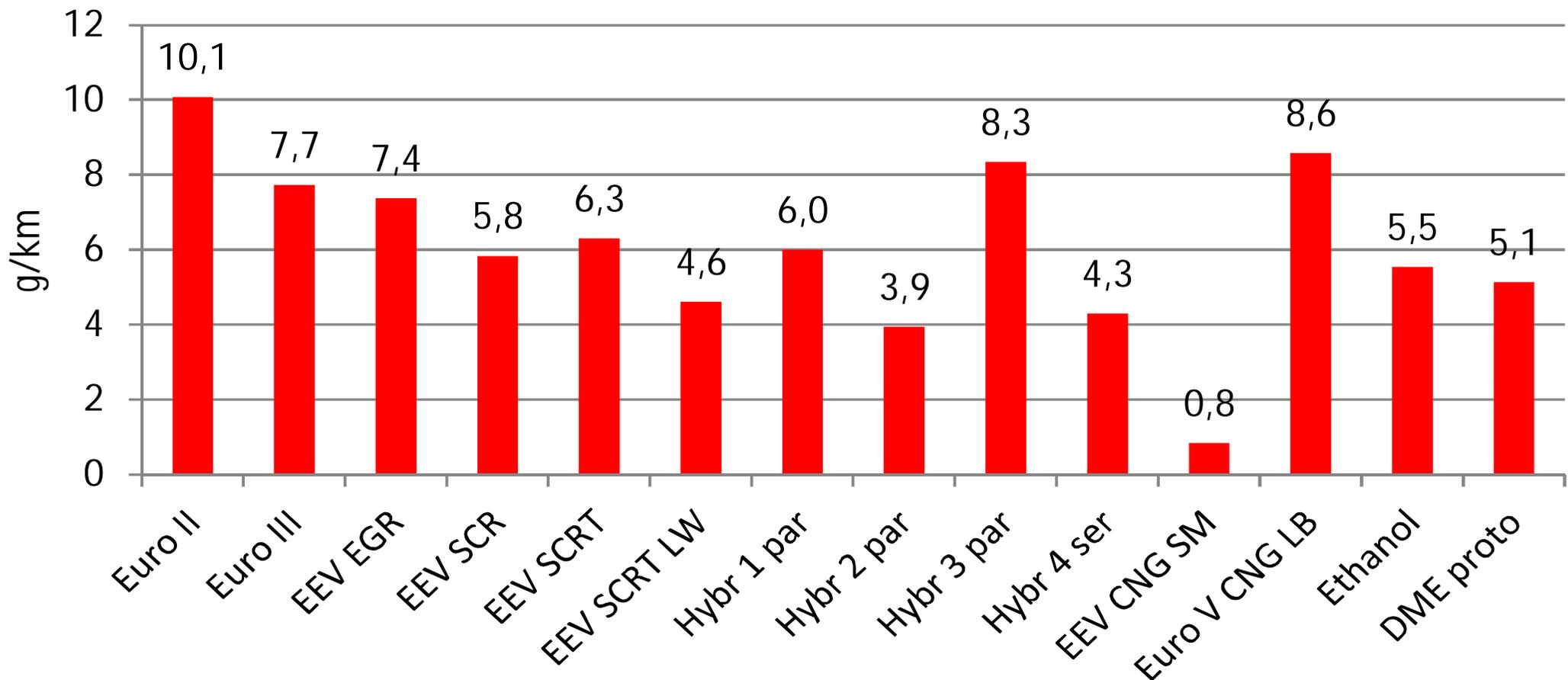
TTW Fuel economy of hybrids (average of four)

Conventional Vehicles vs. Hybrids



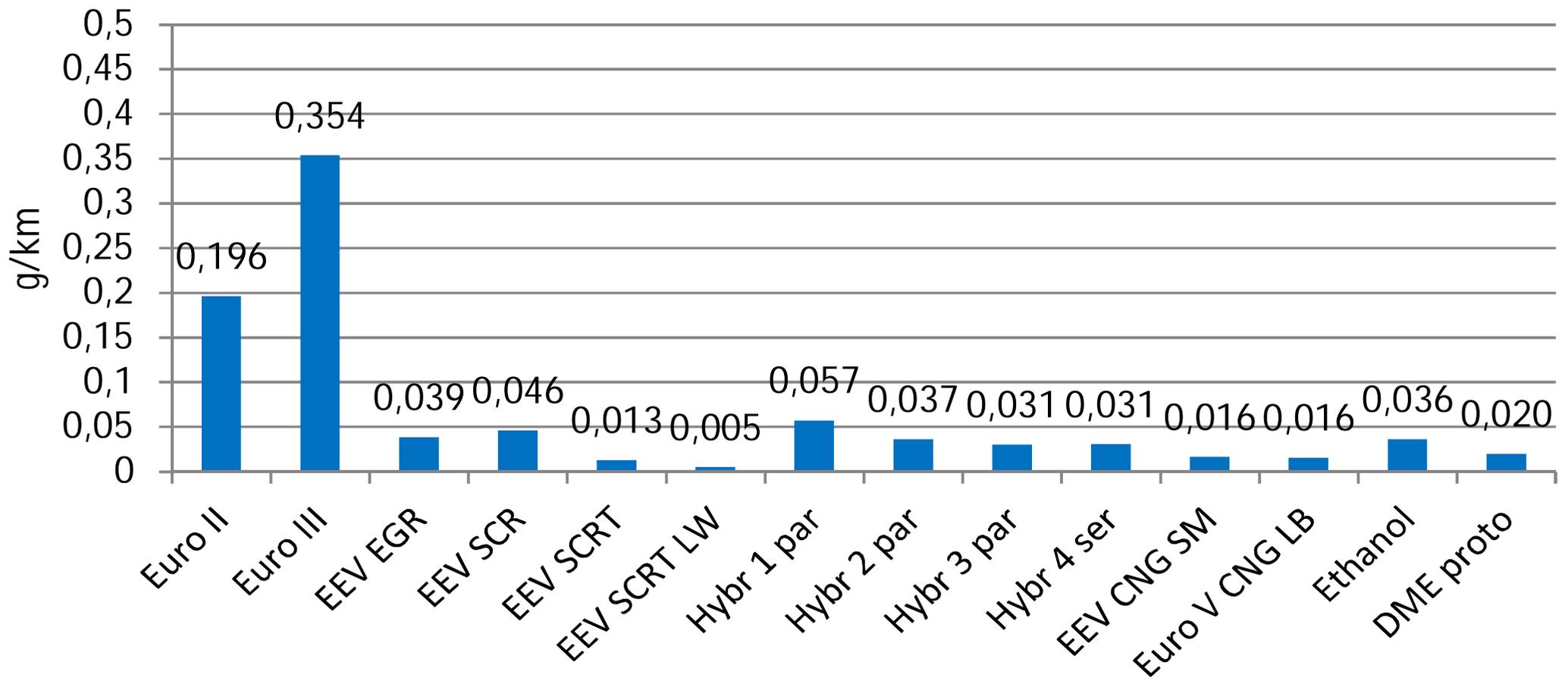
TTW Nitrogen oxides

NOx Emission - Braunschweig

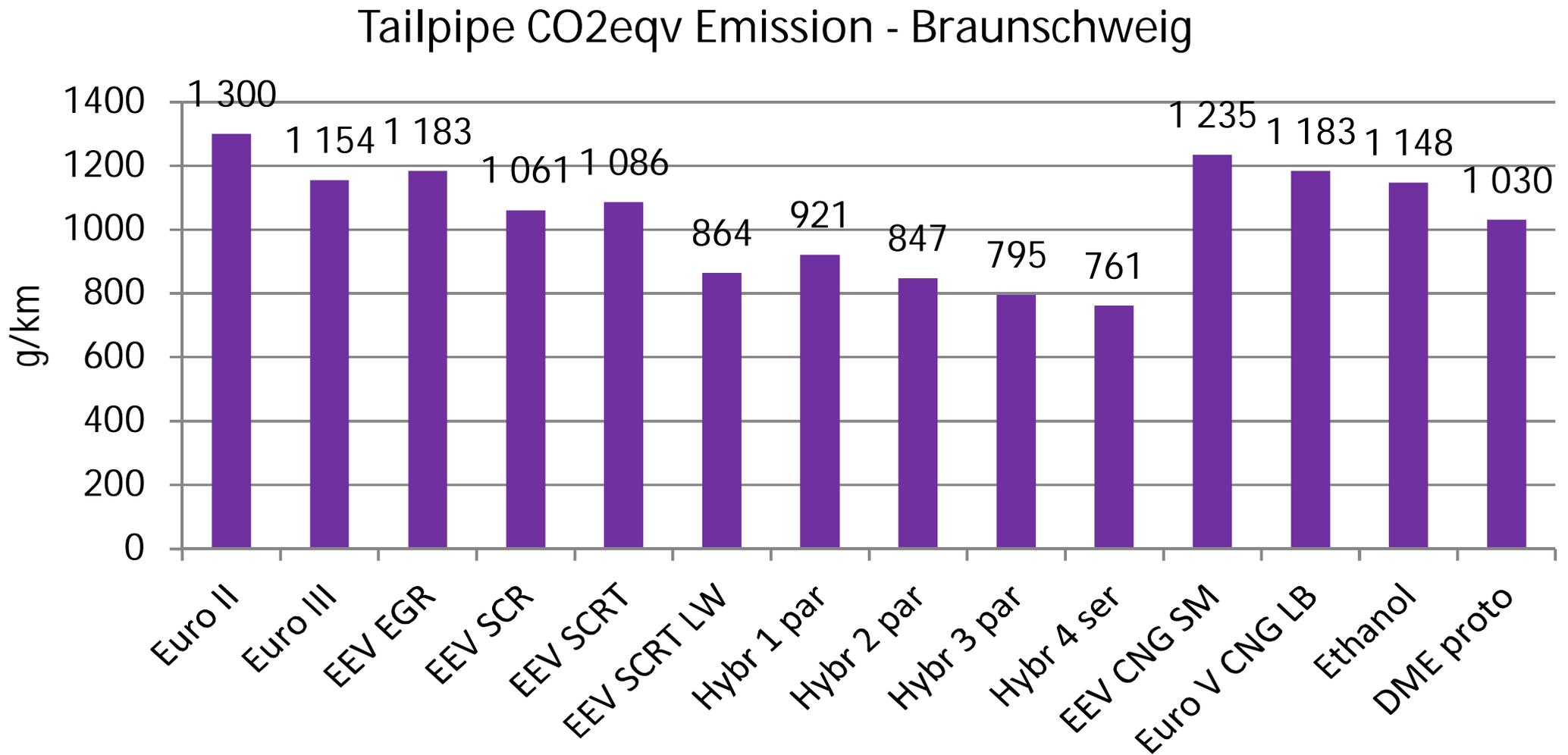


TTW Particulate Matter

PM Emission - Braunschweig



TTW green house gases



eBUS – Tekes funded project

- EV city bus test field and facilities
 - Unique test platform for EV city bus research
 - Test line including charging points (Friisilä - Tapiola), Veolia operate buses
 - Chassis dynamometer measurements at VTT – comparison database of over 100 city buses + follow ups with different fuels and technologies
 - Finnish challenging climate conditions – if the bus works in Finland it will work in most of places
- Budget ca. 4.6 M€
- Four year project, from 2012 to 2015

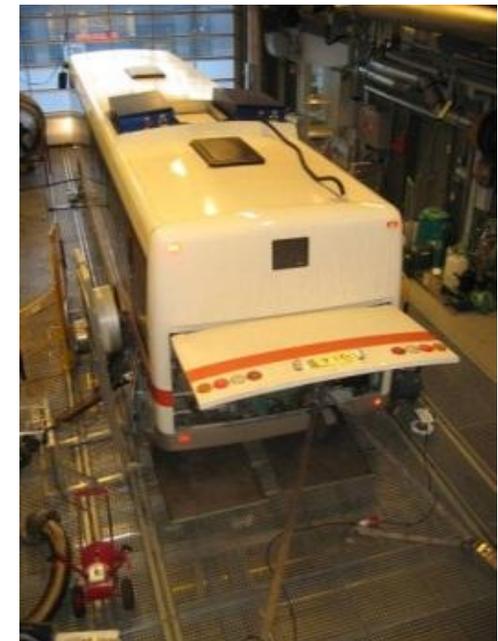
Participants

- Tekes – Finnish Funding Agency for Technology and Innovation
- HSL – Helsinki PTA
- Espoo – City
- LVM – Ministry of Transport and Communication
- Trafi – Road safety agency
- Fortum - Energy company
- Veolia – Operator
- European Batteries – Batteries
- Vacon – Electric drives
- Kabus – Bus manufacturer
- VTT, Aalto University, Metropolia - Researchers



eBUS test platforms

- Four test platforms
 - Actual city bus test line (Espoo 11)
 - Laboratory for testing complete vehicles
 - Full-size test mule for testing components
 - Simulation tools



eBUS research objectives

- Chassis dynamometer measurements
 - Energy efficiency on different driving cycles
 - Energy flows and losses
 - Comparison between bus types
 - Battery deterioration during the field tests

- Dataloggers
 - Effect of extreme conditions on energy consumption and life span
 - Real life usage cycles for EV-buses and it's partial systems

”Veolia operates, VTT monitors, Metropolia builds, Aalto simulates”

eBUS research objectives

- Simulations
 - Guidelines for bus line planning
 - Battery demands

- Acceptance
 - Drivers
 - Passengers

- Component and systems development
 - Adaptable city bus test mule
 - Testing possibilities for electric motors, batteries, power electronics, IT-systems, etc.

”Veolia operates, VTT monitors, Metropolia builds, Aalto simulates”

First electric buses on eBUS project (Veolia) Caetano, BYD, Ebusco, more under negotiation

BYD signs up Finland as electric bus customer

INDUSTRY NEWS | ASH | MARCH 13, 2012 AT 5:47 PM

Veolia, the Finnish public transport company, has inked a deal with **BYD** to supply electric buses to Espoo city, a suburb of Helsinki. As part of the agreement, Veolia Transport Finland will conduct real operations with **BYD** eBUS-12 in Espoo for three years. The Technical Research Centre of Finland (VTT) will take the role of monitoring and measuring during **BYD** eBUS-12's daily operations, so that *EV buses can be verified as one of the key solutions for Veolia Transport Finland to ensure sustainable mobility*.

Henry Li, Senior Director of **BYD** stated: "**BYD** is the significant project in Finland, which gives **BYD** reliable even in such harsh climatic conditions. **BYD** reduce pollution in large cities, reduce the operating costs. We believe that this project in Finland will be a big success for us."

The **BYD** eBUS-12 is able to run 250 km (155 miles) on a single charge.



Liikenne 26.11.2012 klo 8:55 | päivitetty 26.11.2012 klo 9:24

Ensimmäinen sähköbussi starttaa liikenteeseen Espoossa

Helsingin Seudun Liikenteen sähköbussikokeilu käynnistyy tänään ensimmäisellä linjalla. HSL testaa eri valmistajien sähköbussien toimintaa Suomen kesä- ja talvioloissa lähivuosina.

Suosittelen

35 henkilöä suosittelee tätä.



Portugalilainen sähköbussi on ensimmäinen testiajossa olevista ajoneuvoista. Kuva: Veolia

HSL:n ja Veolian ensimmäinen testikäytössä oleva sähköbussi starttaa tosi toimii maanantaina Espoossa. HSL testaa tulevana vuosina eri valmistajien sähköbusseja pääkaupunkiseudun liikenteessä. Ensimmäinen bussi kulkee Espoon sisäisellä linjalla 11.

eBUS proto Vehicle Platform “test mule”

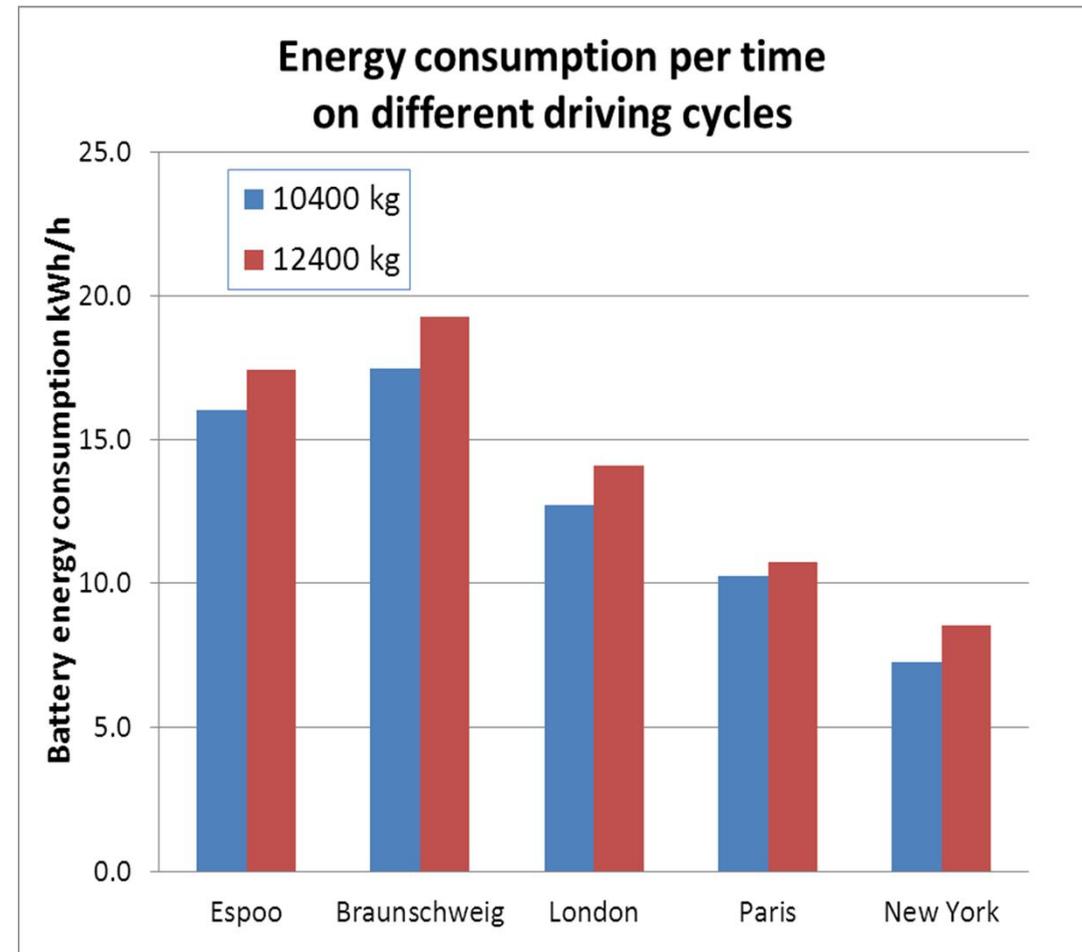
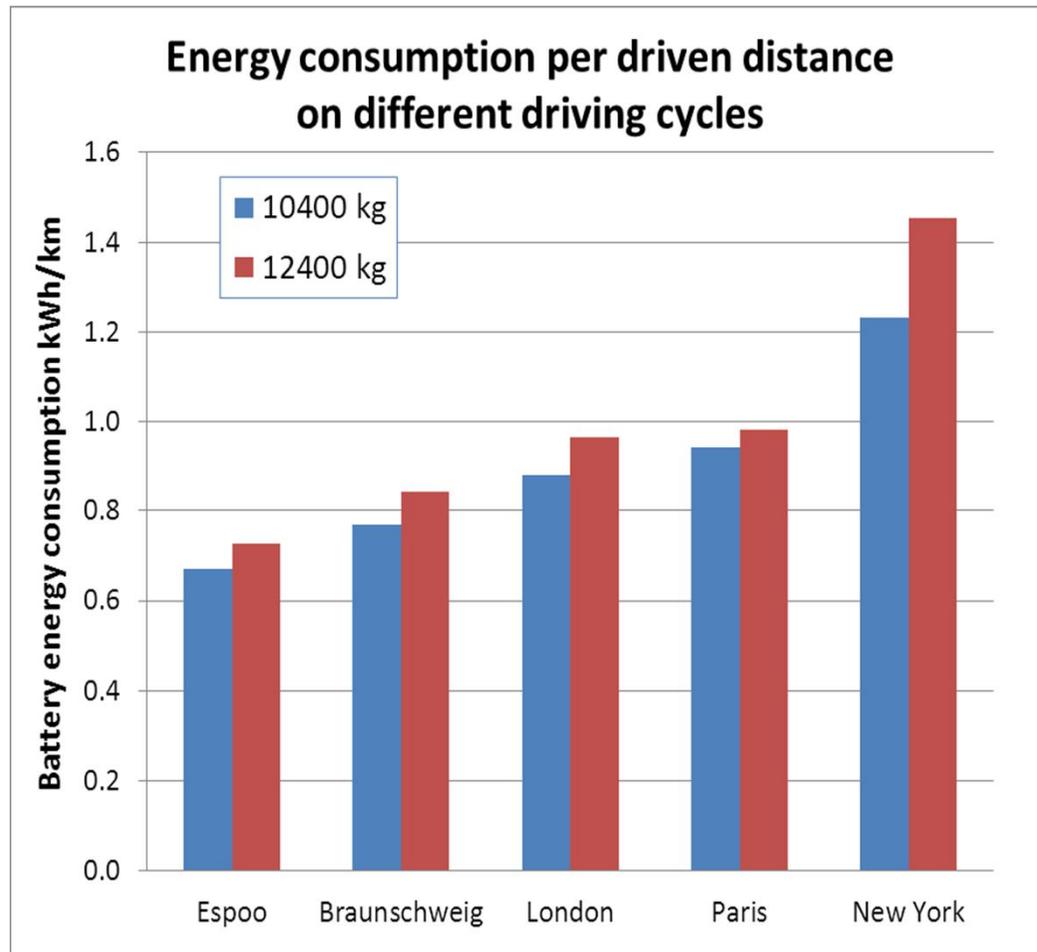
- Kabus City Bus
 - Full aluminium lightweight body
 - Length 12 m
 - Weight just over 8000 kg including electric powertrain and excluding seats



Pre-results from laboratory tests (new methods)

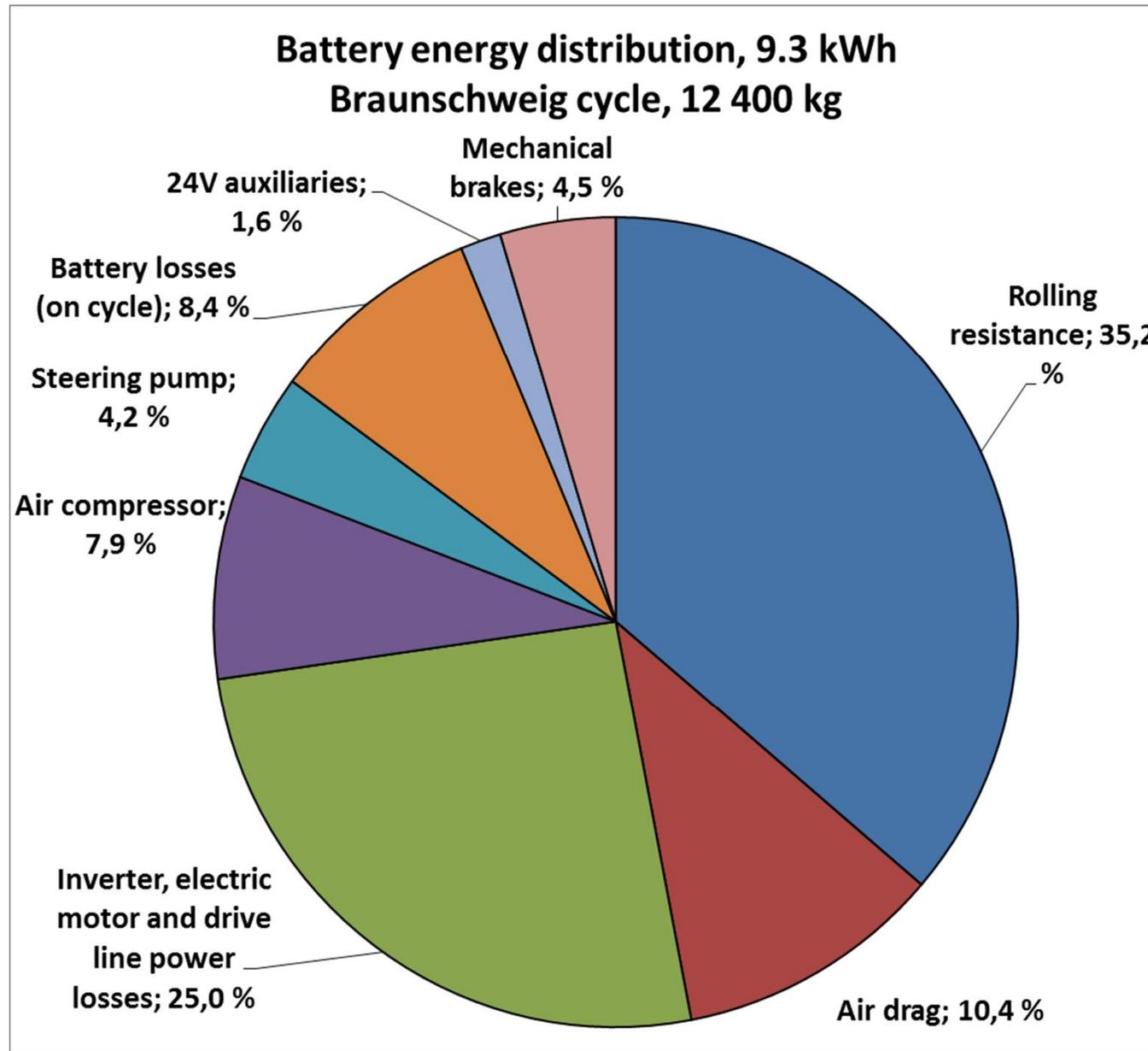


Pre-results from laboratory tests (new methods)

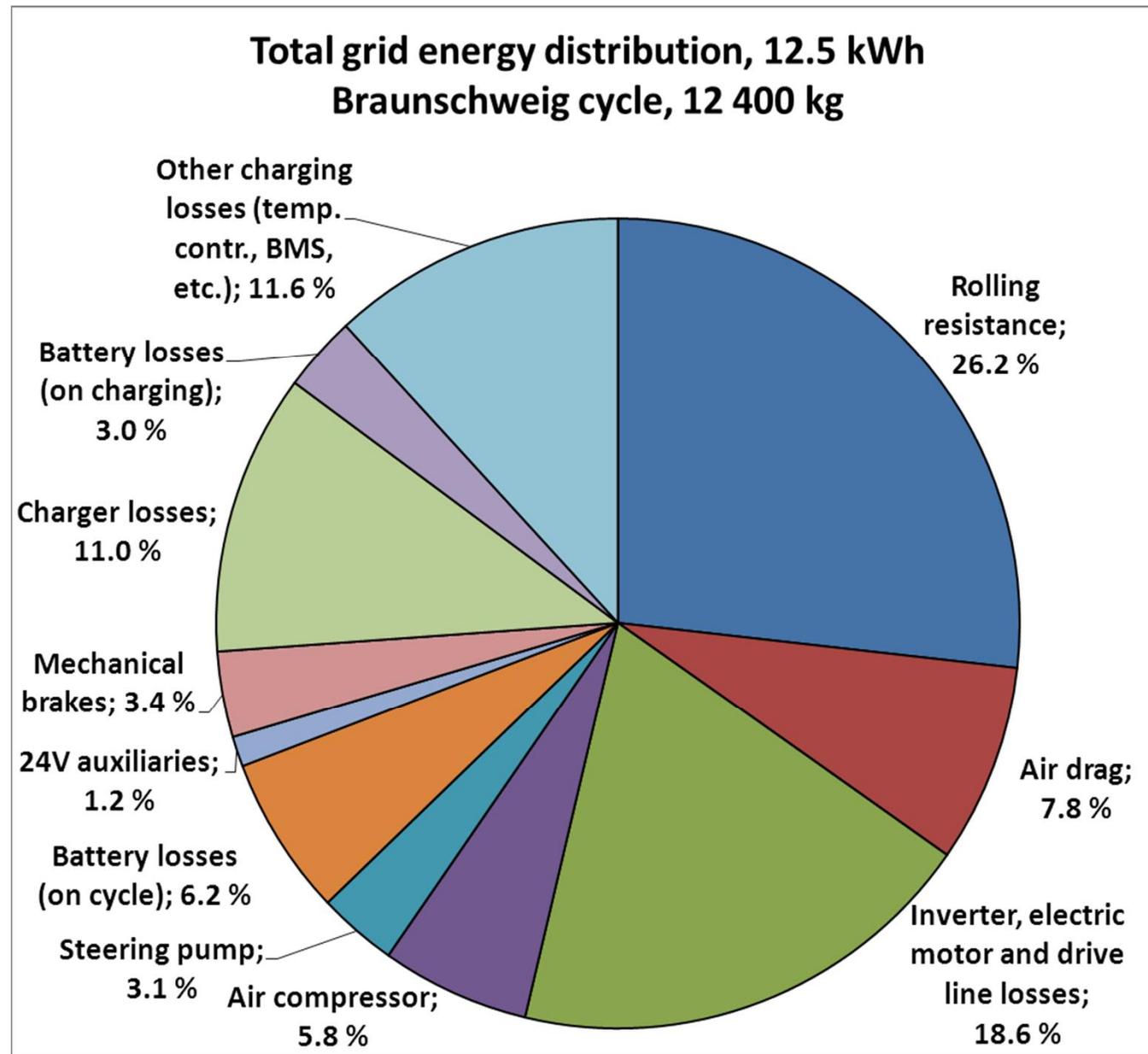


Heating, cooling and ventilation not included

Pre-results from laboratory tests (new methods)



Pre-results from laboratory tests (new methods)



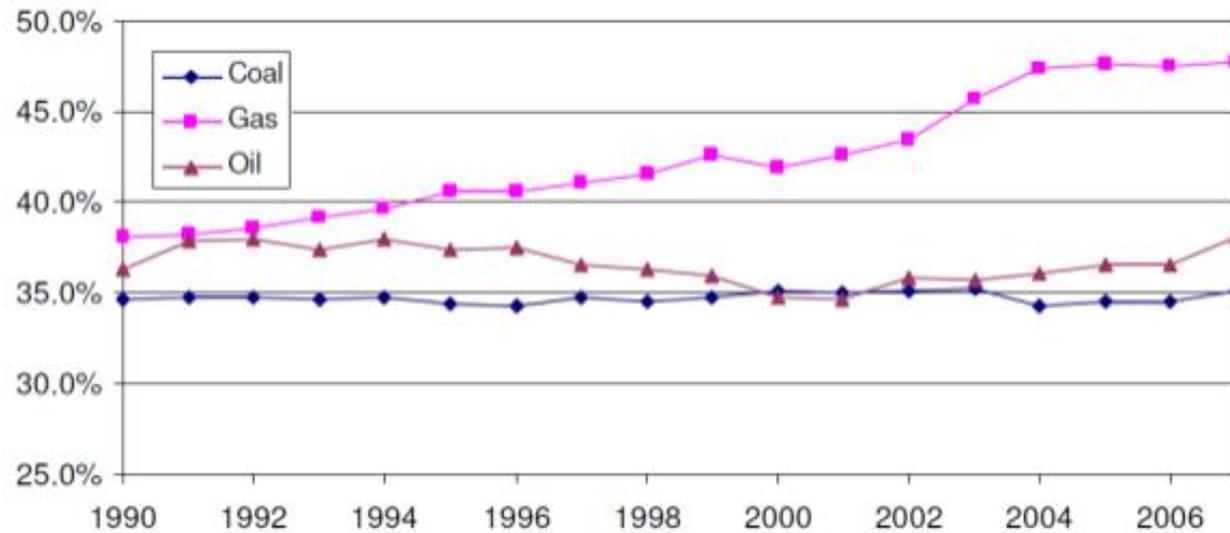
Overall status of the eBUS project 16.11.2013

- By the end of the year, project will reach it's halfway
- Four test platforms has been set up
- Chassis dynamometer updated for measuring electric vehicles
 - Power source and measurement systems
- Test mule built for component testing
- Electric bus test line for benchmarking vehicles and their subsystems in harsh conditions
- Late 2013 there should be 3 different electric buses on test line + test mule and fourth is coming early 2014

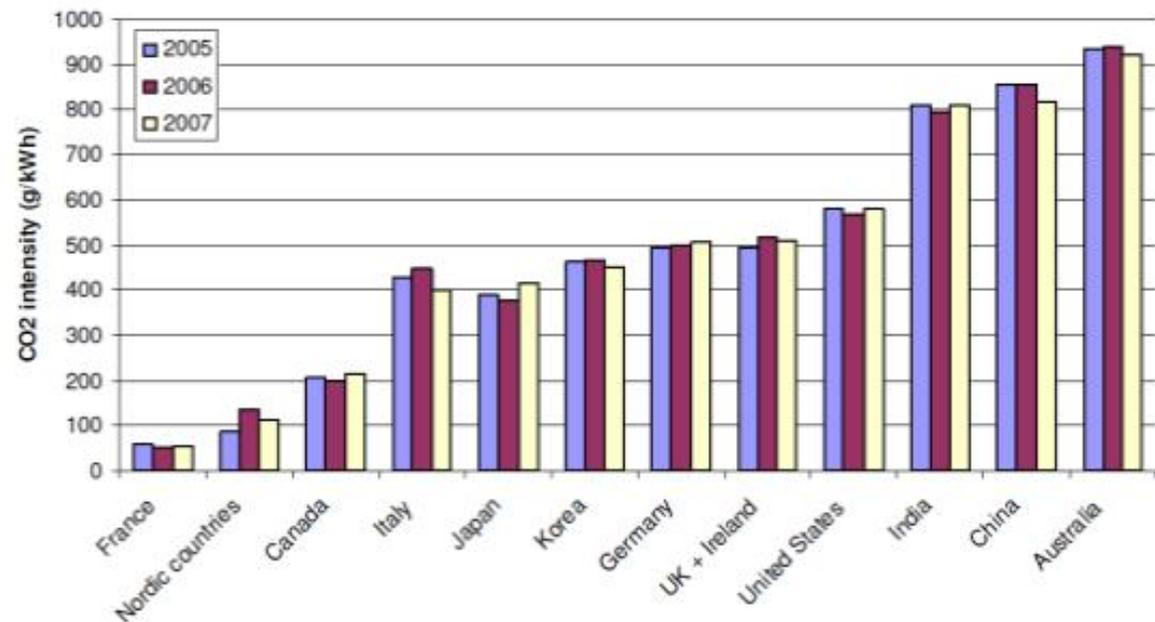
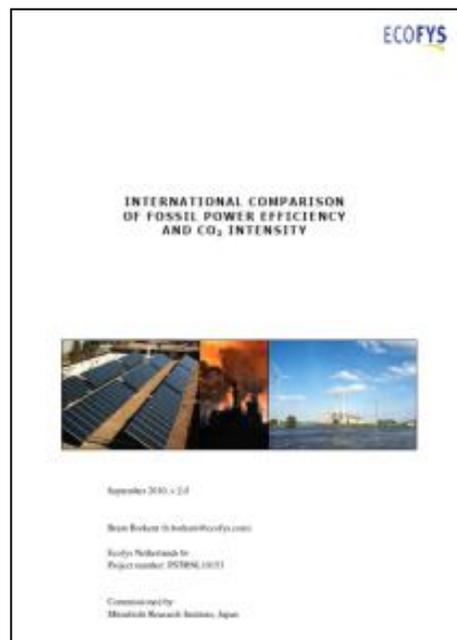
Climate effects of electric buses

- Climate effects
 - totally dependent on how the electricity is generated
 - carbon intensity ranges from 0 to some 1000 g CO₂/kWh
 - Electromobility advocates say:
 - EVs always run on renewable electricity
 - Electromobility antagonists say:
 - EVs will always run on marginal electricity

Performance on power generation



Source: Ecofys 2010



WTW GHG emissions (based on JEC 2013 values)

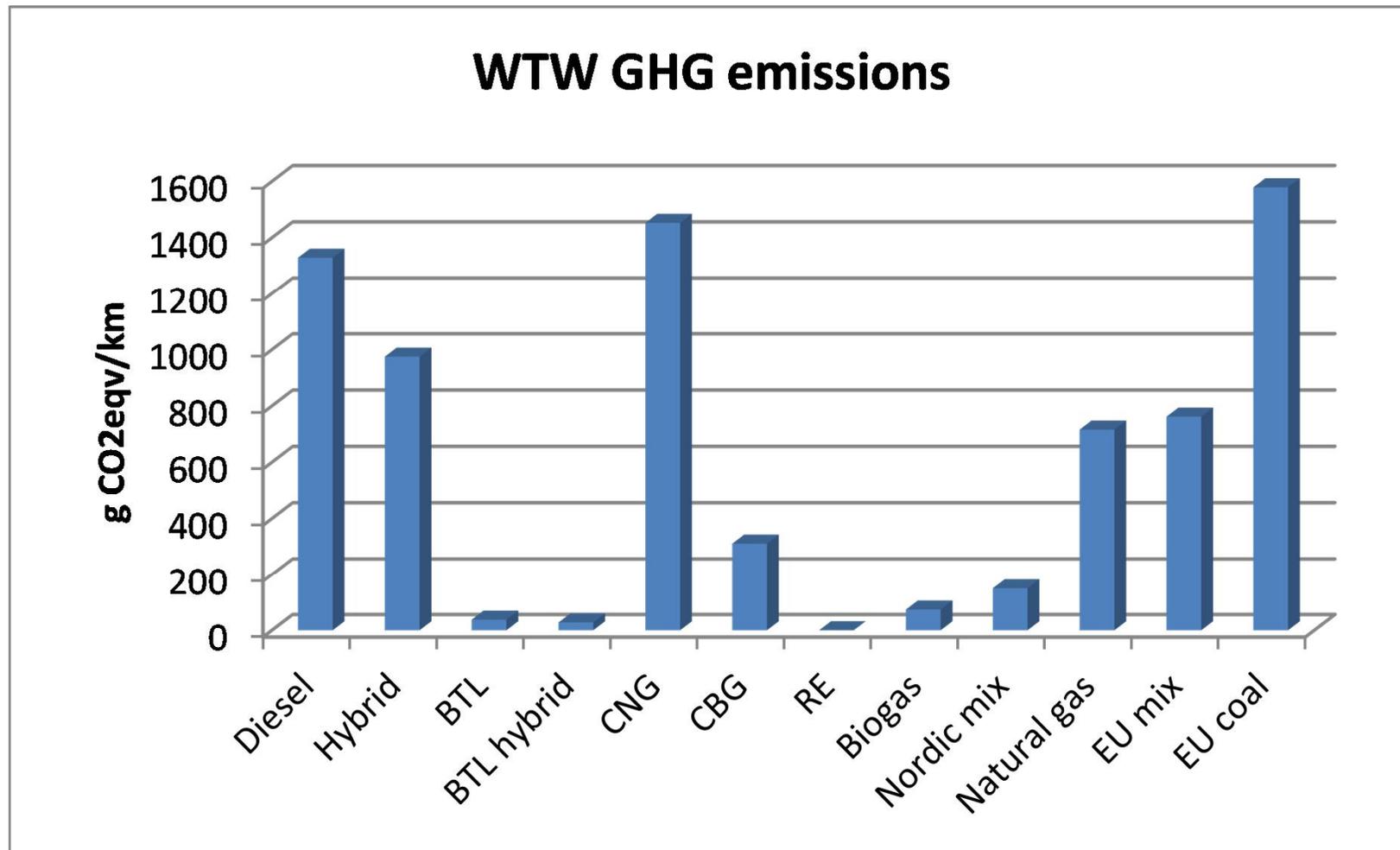
ICE

- Diesel: $15 * (15,4 + 73,2) = 1329$ g CO₂/km, hybrid 975 g CO₂/km
- BTL: $15 * 2,5 = 38$ g CO₂/km, hybrid 28 g CO₂/km
- CNG: $21 * (13 + 56,2) = 1453$ g CO₂/km
- CBG: $21 * 14,8 = 311$ g CO₂/km

BEV

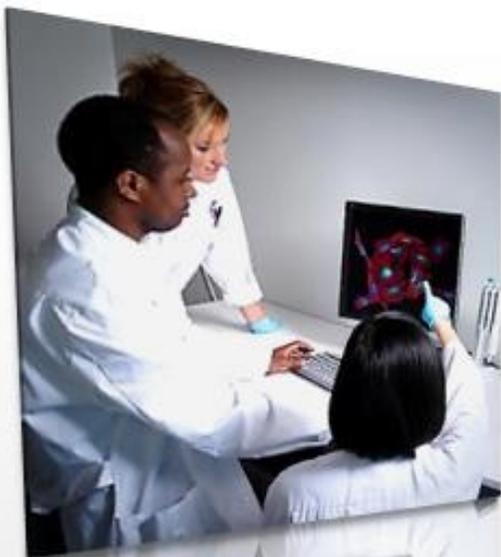
- Renewable electricity: 0 g CO₂/km
- Local biogas mw: $1,5 * 49 = 74$ g CO₂/km
- Nordic mix: $1,5 * 100 = 150$ g CO₂/km
- EU natural gas (4000 km): $1,5 * 477 = 716$ g CO₂/km
- EU mix medium: $1,5 * 508 = 762$ g CO₂/km
- EU coal conventional: $1,5 * 1053 = 1579$ g CO₂/km

WTW GHG



Summary

- VTT has created a comprehensive city bus emission database
- Driving cycle has a great effect on fuel savings of hybrid buses
- Local emissions of hybrid buses are not automatically lower than on conventional diesel buses
- eBUS project is about to reached halfway
 - Four test platforms has been set up
 - Test methods were validated with the test mule
 - More busses are expected during the coming few months, target 4 buses running spring 2014, still room for 2 busses
- Electric busses gives freedom to choose the overall green house gas emission by choosing the energy origin
 - Best options gives zero GHG
 - Worst options are worse than diesel buses using fossil fuel



VTT creates business from technology