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Electric buses in urban transport – the situation and development trends

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Electro-mobility is not just a science, but a LIVING PRACTICE

New electric bus Škoda/Solaris

Prague, Václavské náměstí, **now**

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Electro-mobility is not just a science, but a LIVING PRACTICE

Electric bus SOR/EKOVA Electric

Ostrava, in revenue service since 2010

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The presentation content

- The “Urban Transport E-mobility“ Study introduction
- The electric buses and their energy sources
- The transport markets for electric buses
- The energy consumption and cost
- The environment: GHG emissions and noise
- The life cycle cost
- The operational reliability
- The “smart grid“ context
- The conclusions

(Note: For complete descriptions concerning the charts and the related data sources in this presentation please see in the ETC paper full version)

The „Urban Transport E-mobility“ Study

- **Prepared by**: Ing. Jakub Slavík, MBA – Consulting Services
- **The Beneficiary**: The Czech Transport Operator Association and its members; the other stakeholders
- **The key objective**: To inform Czech public transport operators and their owners about the electric bus technologies, operational experience and expected development and to stimulate their interest in e-bus operation and involvement in the development projects
- Based on EU and US reports and own field research – **different values but very similar relations among them**
- **12 case studies** from Europe and the USA

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The Study partners and info sources

- **The Study partners**:

ABB s.r.o.

Cegelec Praha a.s.

EVC Group s.r.o.

SOLARIS CZECH spol. s r. o.

Siemens, s.r.o.

SOR Libchavy spol. s r.o.

ŠKODA ELECTRIC a.s.

VOLVO Truck Czech s.r.o.

- **Information sources:** Fuel Cells and Hydrogen Joint Undertaking – FCH JU (EU) a National Renewable Energy Laboratory – NREL (USA), The Ministry of Transport, The National Association of Electro-mobility and Modern Technologies, The Czech Technical University in Prague – Faculty of Transportation Sciences, The Ostrava Transport Company, EKOVA ELECTRIC a.s., ÚJV Řež, a. s., the Prague Transport Company, Transport for London (the UK) and SunLine Transit Agency (USA); product and operational information from the study partners; published outputs of HyFleet:CUTE, 100 Bus Electriques and Trolley projects; dedicated media: Proelektrotechniky.cz, FuelCellToday, Railway Gazette International and Eltis.org. (altogether referred to as “the field data”)

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The electric buses under research

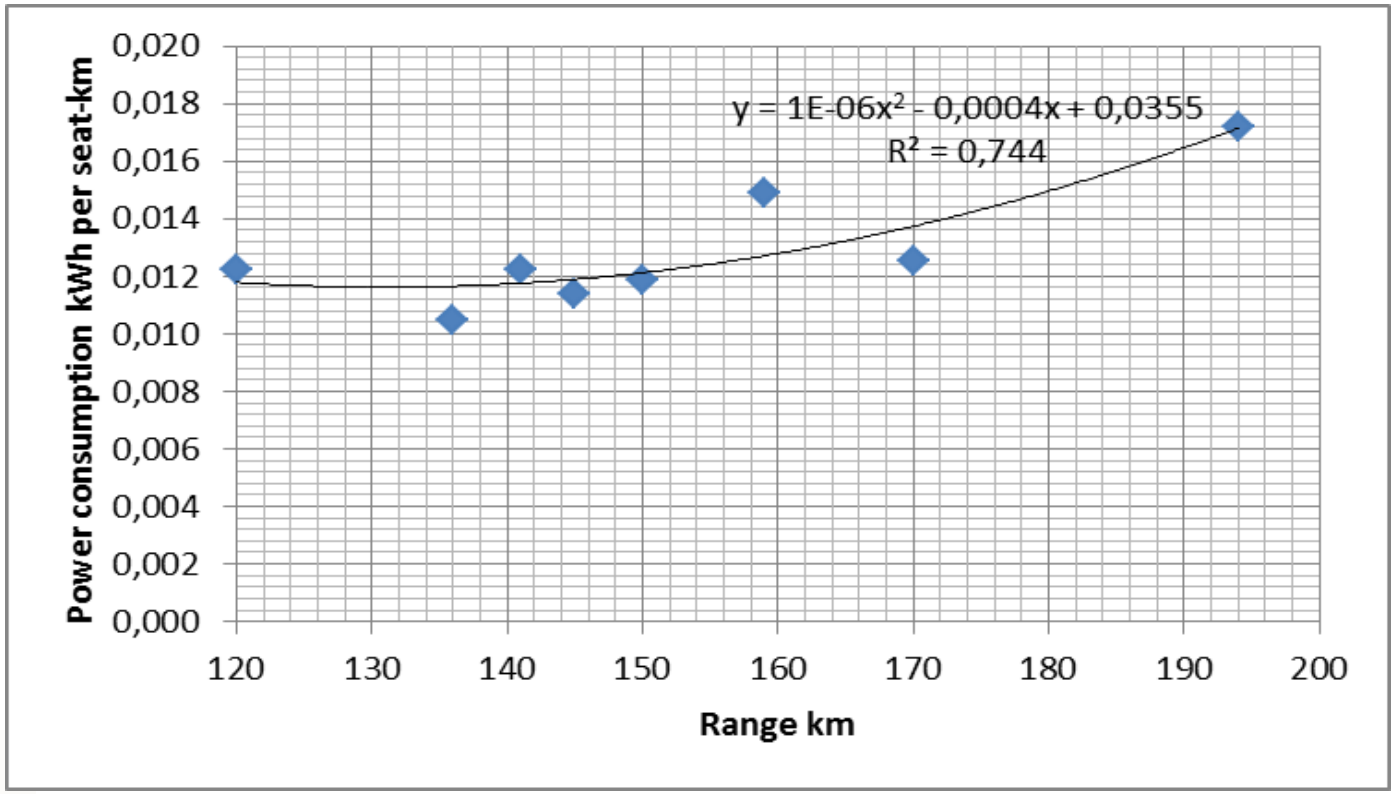
- **Trolley-bus** as a product in the mature market stage
- **Diesel hybrid** bus as a product in the market growth stage (serial, parallel and plug-in powertrains)
- **E-bus** using battery and/or capacitor energy storage; market development stage
  - Overnight e-bus
  - Opportunity e-bus
- **Fuel cell bus (FC-bus)** using fuel cell as the primary energy source; market development stage
- Compared with diesel and CNG powertrains

The electric bus transport markets

- **Standard urban transport lines** (typically 12m bus)
  - Different traffic flows; line lengths ranging from single kilometres to tens of them; overall daily mileage of about 200 to 250 km, depending on local conditions
  - Operating in a dense street network with short distances between stops – frequent acceleration and stopping
  - Adapting to daily and weekly peak and off-peak demand periods
  - The service availability, reliability and punctuality against the timetable as the essential service quality parameters
  - Passenger ambience as another important focus
- **Short (often loop) lines in historic urban centres**, often serving to visitors, or dedicated shuttle services (typically 5-7m minibus)

The electric bus powertrains (1)

- **E-bus**: the battery and/or capacitor – a big variety of recharging technologies (plug-in, pantograph, induction, “flash charging“, etc.)
- Trade-off between range and power consumption
- Leading to the “opportunity e-bus“ concept



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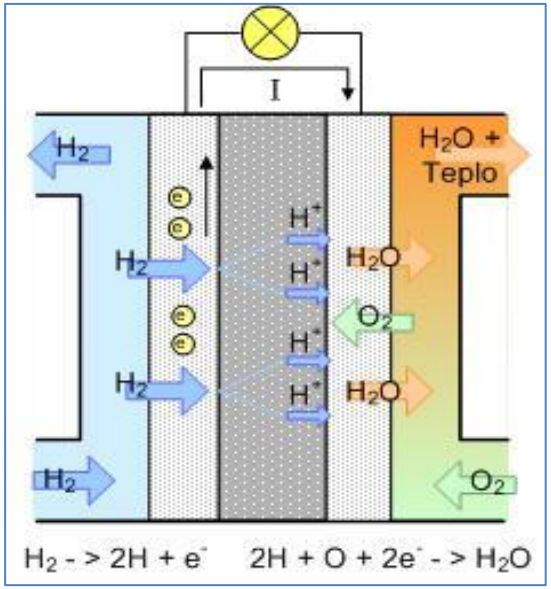
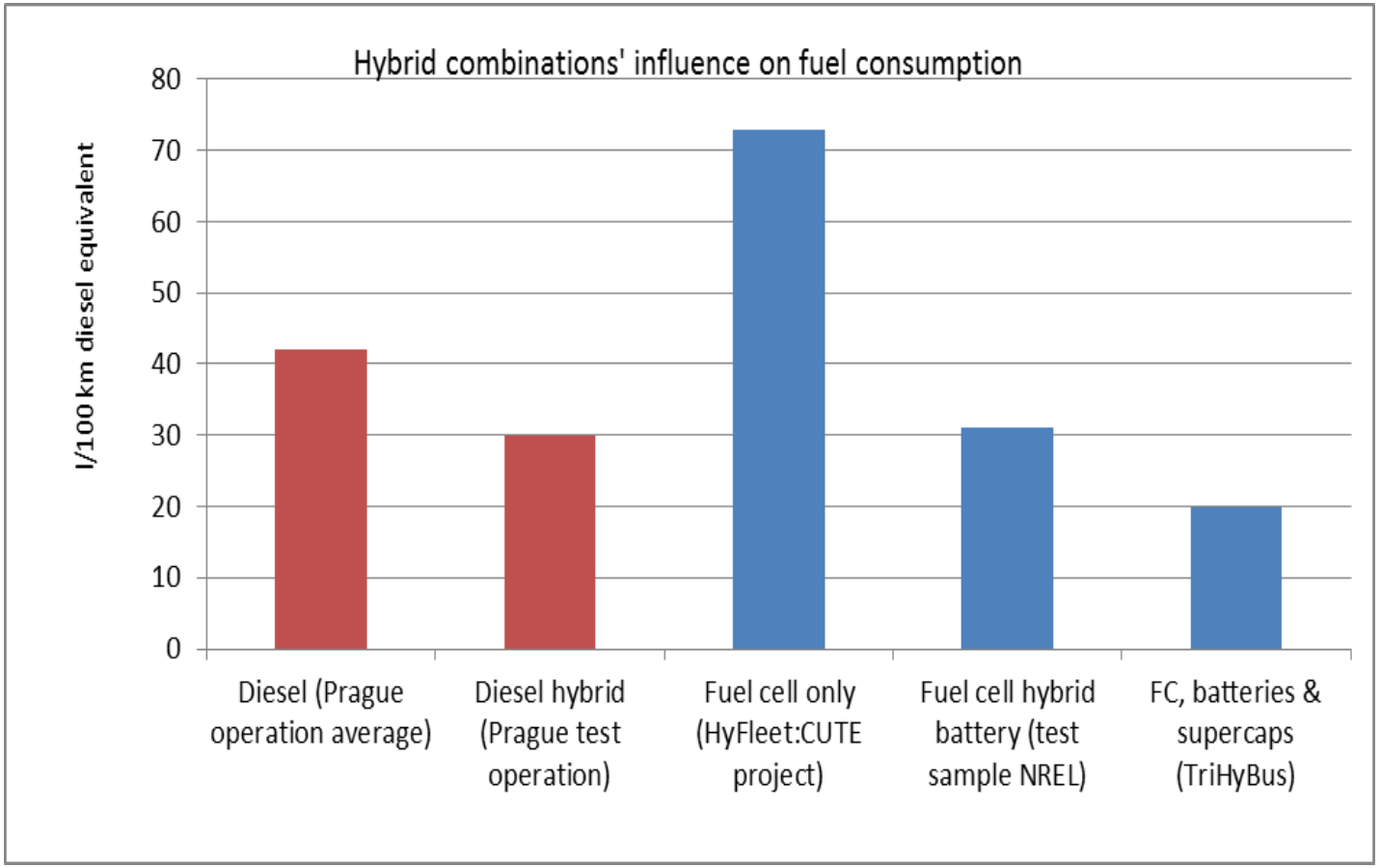
The electric bus powertrains (2)

- **Fuel cell buses** – pure hydrogen as the fuel and the PEM fuel cell technology most common
- Dependent on hydrogen infrastructure
- Range enabling tank filling once a day or two (depending on the tank capacity)
- First fc-bus generation using sole fuel cell; now mostly in hybrid combination with traction batteries and/or capacitors



The electric bus powertrains (3)

- **The hybrid powertrain** benefits for fuel consumption



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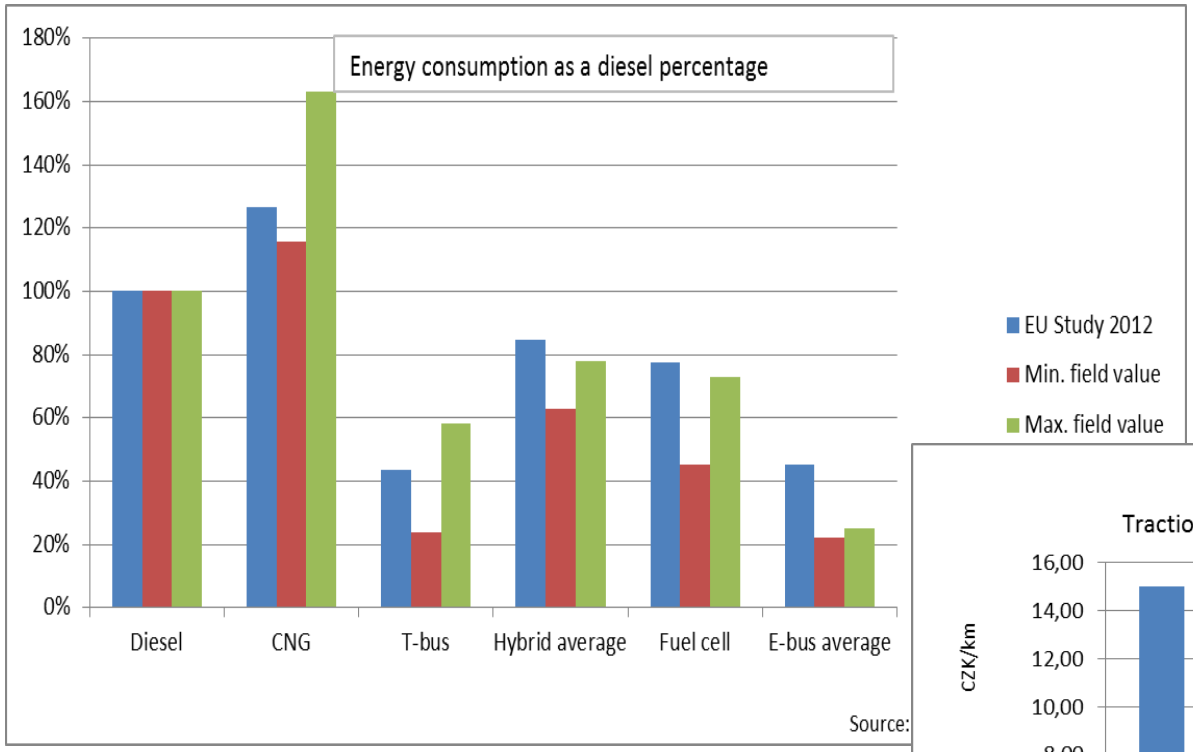
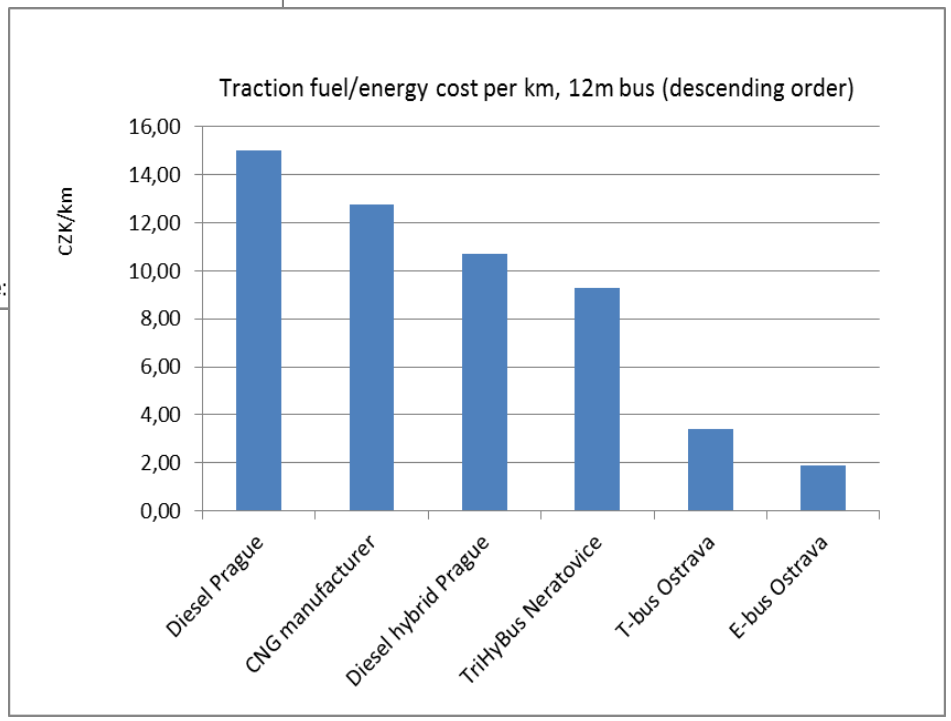
The energy consumption and cost





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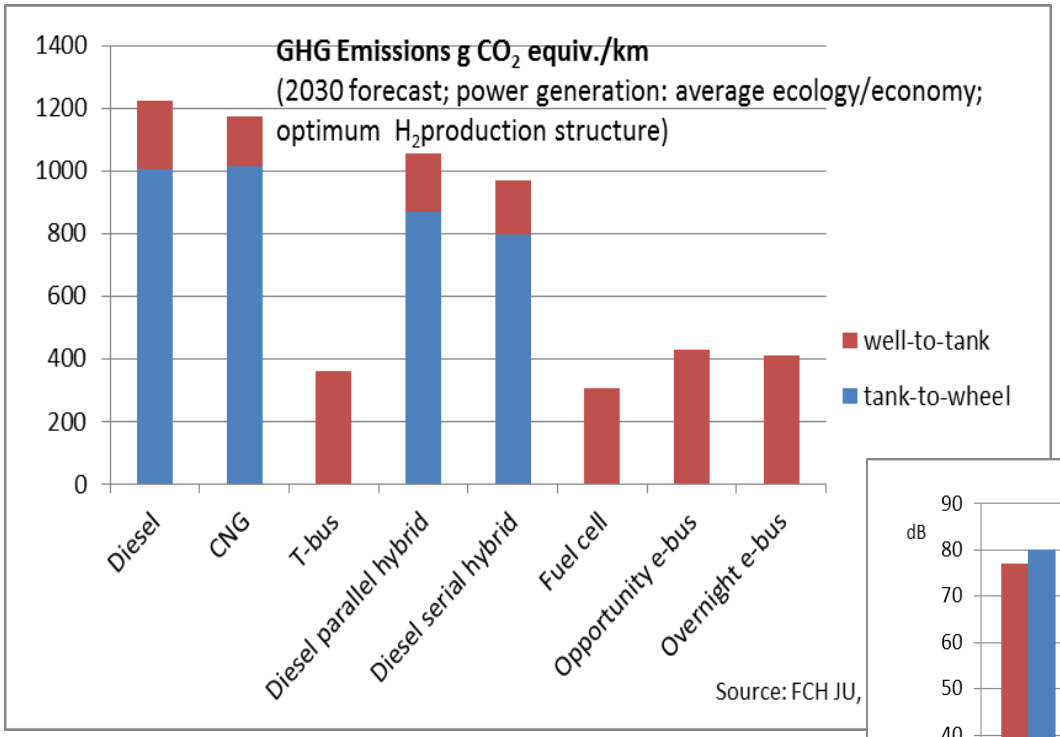
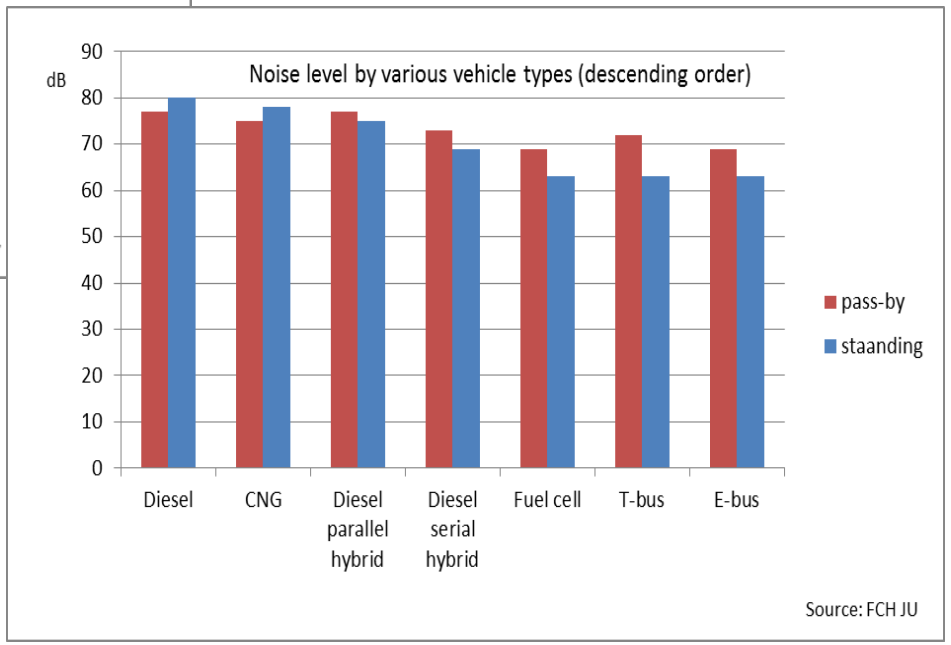
The environmental effects



"well-to-wheel" approach



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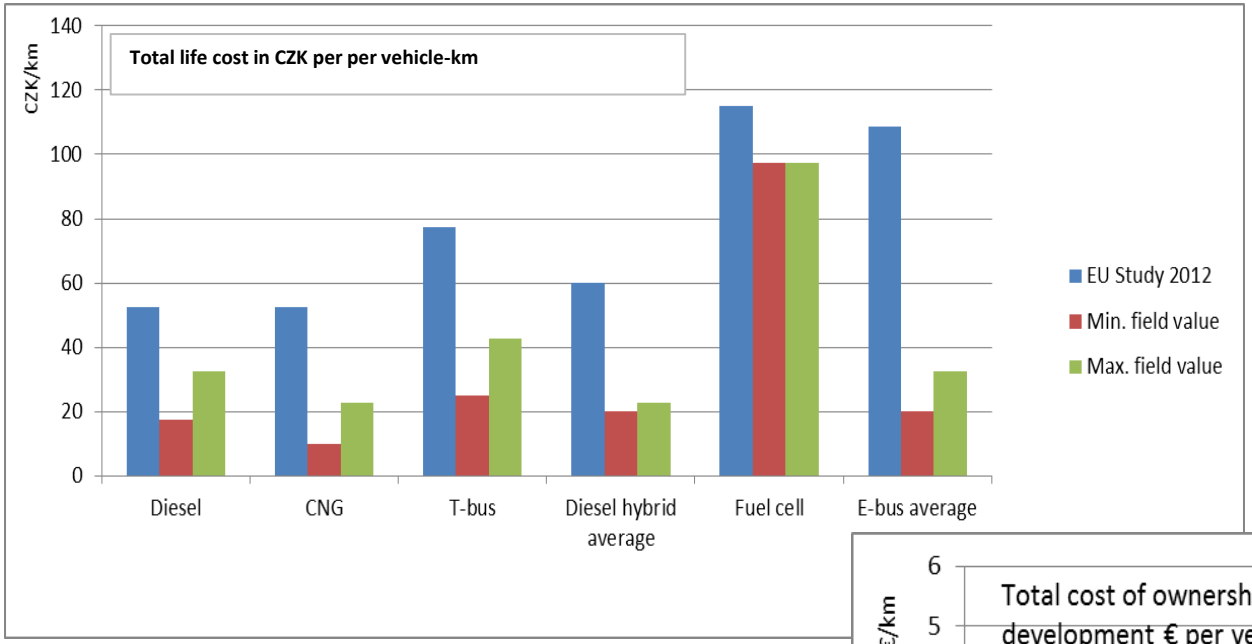
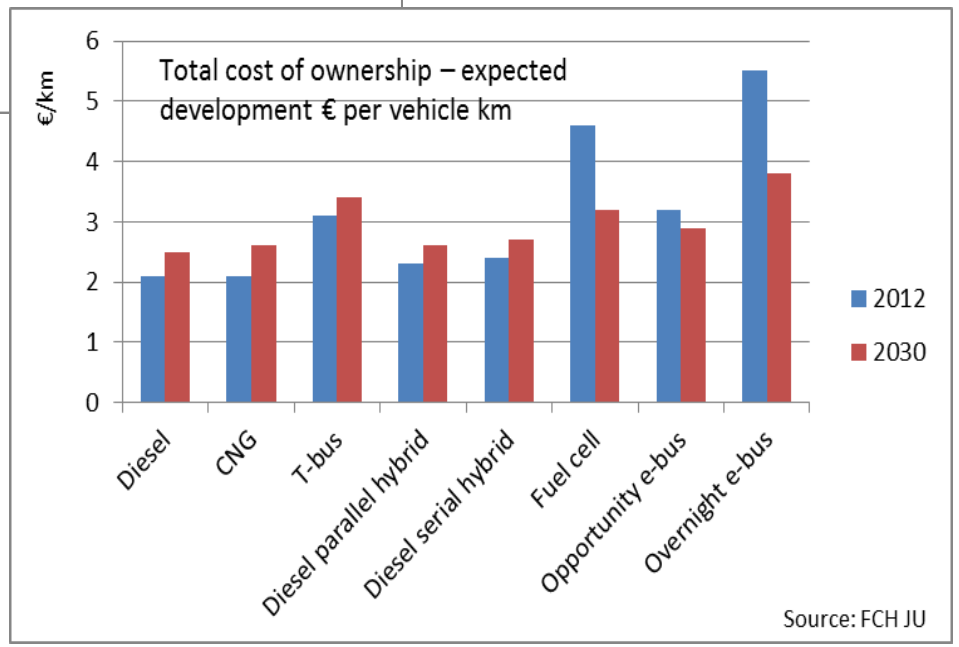
The unit costs





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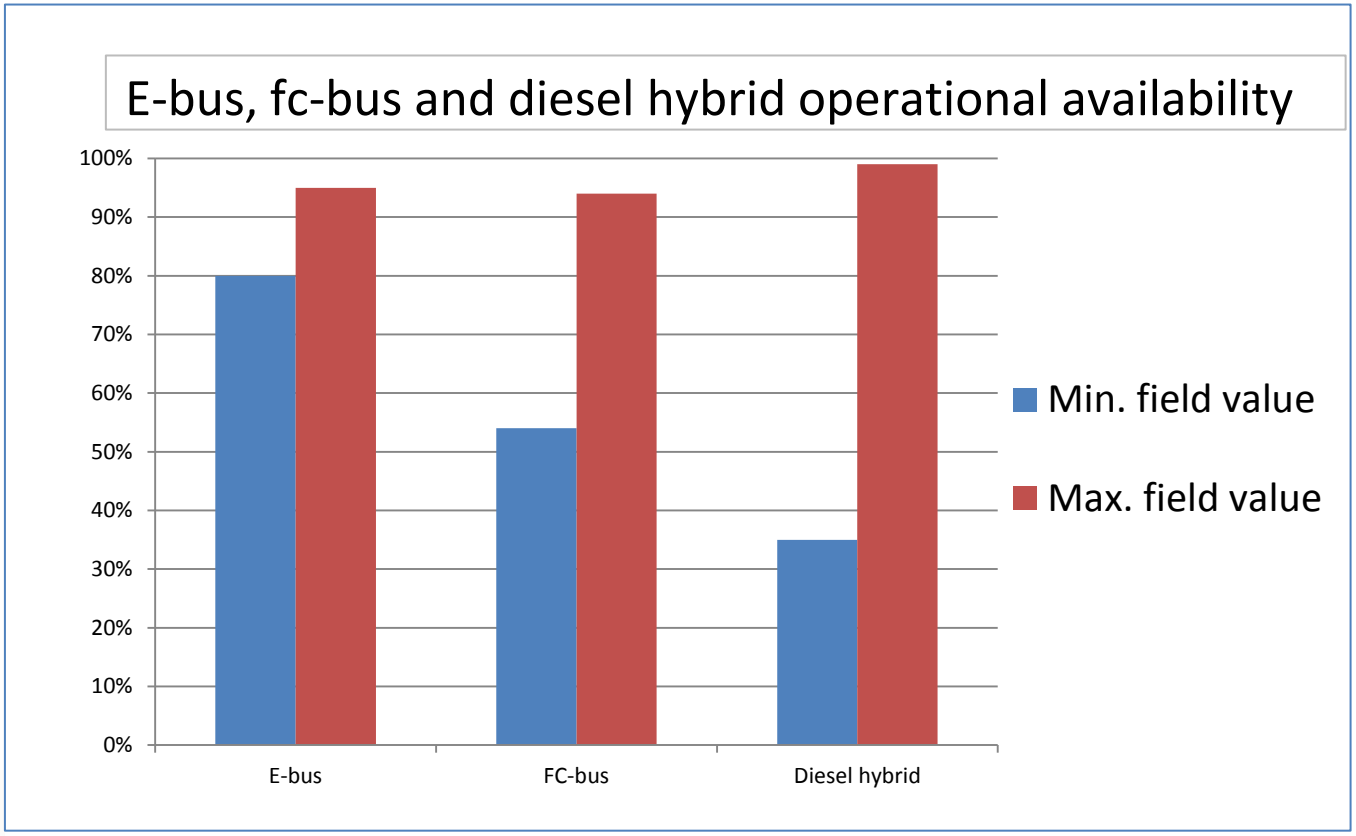
The electric bus reliability

- Operational availability as the measure (not technically precise but imaginable in practice)
- Based on the field research
- Plain mechanical failures as the most common causes of unavailability



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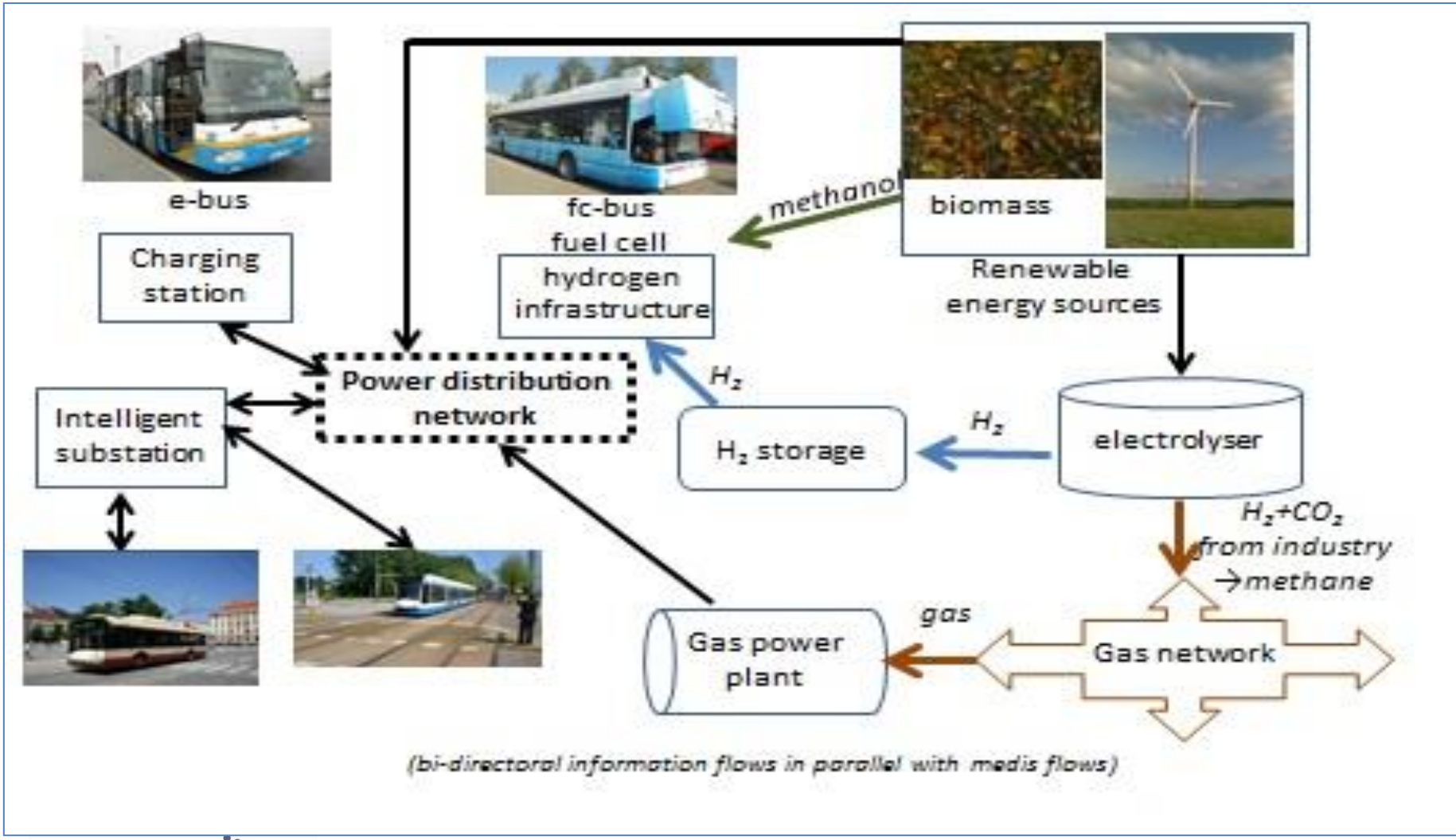
Electric buses and the smart grid concept



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The Study summary (1)

- Fast development in technologies – opportunity e-buses and fc-buses as most promising
- Diesel-hybrids as a good temporary solution
- Trolley-buses – catenary-free operation as the dependence problem solution
- CNG powertrain – a greedy eater of a cheap fuel; usually “greener“ than conventional diesel, but not “greener“ than diesel-hybrid – very much depending on what is actually being compared
- Electric buses are not a panacea; the technology can (and must) be tailored to each particular market needs

The Study summary (2)

- More research and development necessary to bring e-buses and fc-buses to commercial markets
- Transport operators' involvement essential; necessary to be compensated for the related operational risks
- Public-private project consortia involving research, industry and operation as the way forward
- Cultural aspects – previous "electrical" experience as an advantage for electric bus operation

"We have a substation nearby. We'll just pull a cable from there, no problem."

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More information

The presented issues are explained in more detail in English in the author's ETC Paper

The Study full text in Czech language is free accessible on www.proelektrotechniky.cz

Other questions or comments:

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Thank you! ☺