Electric buses – experiences and strategies with charging

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Preface

- What is mode 2 research?
  - ”In Mode 2 multidisciplinary teams are brought together for short periods of time to work on specific problems in the real world for knowledge production.” © Wikipedia

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- What is mode 2 research?
  - ”In Mode 2 multidisciplinary teams are brought together for short periods of time to work on specific problems in the real world for knowledge production.” © Wikipedia
- How about implementing electric buses in the public transport system?

Outline

- Helsinki region – integrated approach
- Charging systems and operation
- Cost effectiveness and reliability requires system approach
- Summary and conclusions

Helsinki region - integrated approach

”Vehicles”: ECV-eBus project

- The aim is to find out usability of electric buses in commercial transport
- Field study and laboratory research
  - Electric bus test line 11 Tapiola-Friisilänaukio
  - Four commercial eBuses in operation from 2012
  - Chassis dynamometer tests for every bus
  - Vehicle technology analysis
    - Full-size VTT-owned electric bus prototype as a development platform
  - Battery laboratory
    - climatic chambers for components
  - Simulation tools for system performance and energy use
- Challenging weather conditions

The prototype bus became so good it was operating one week in commercial passenger traffic in 5/2014

”System”: eBusSystem – the Espoo demonstration

Public sector
Private sector
Bus operator
Research

The transport system

How do electric buses fit into the public transport system?

- Ministry of Transport
- Helsinki Region Transport
- City of Espoo
- Transdev, Aalto University

Green Public E-Mobility

The vehicle

How do electric buses perform?

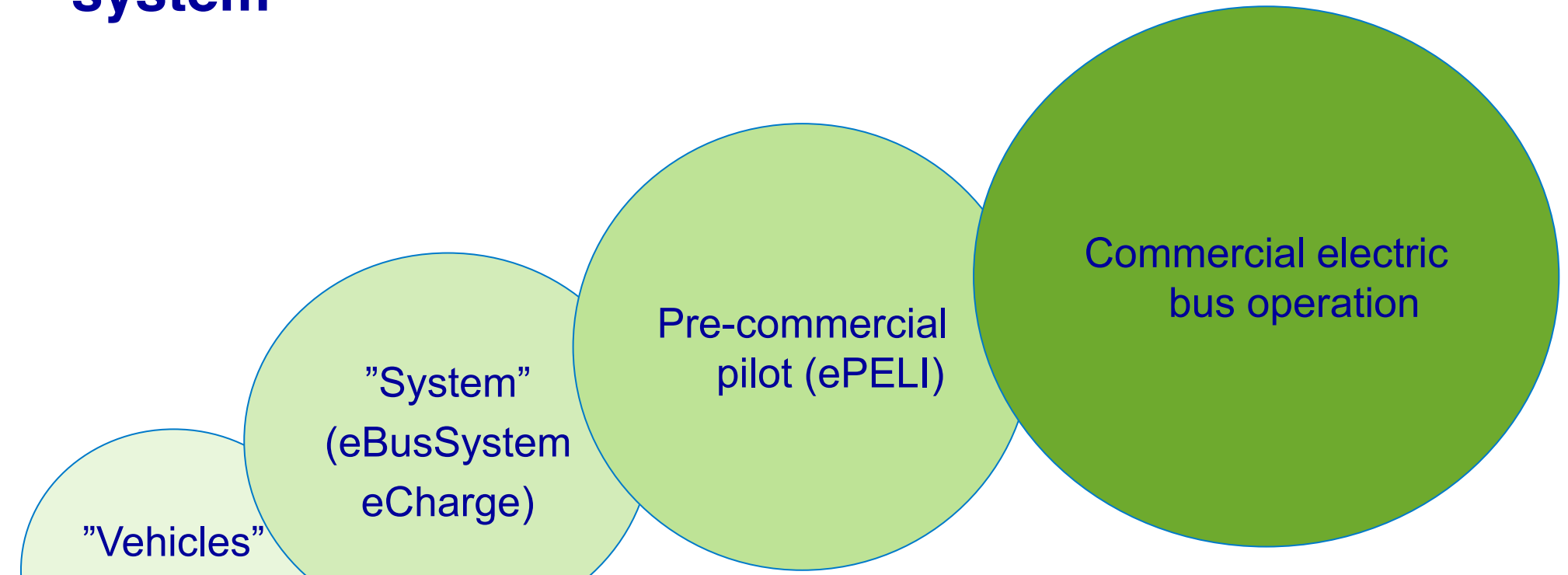
- Transdev, VTT
- Bus manufacturers (BYD, Caetano, Ebusco, VDL)
- Component manufacturers (Visedo, Tamware, Vacon)
- Transport Safety Agency

The energy supply

How can electric buses be charged and how is the grid affected?

- Smart grid, grid services and smart bus depot
- Utilities (Fortum), Siemens, charger manufacturers
- Rail traffic synergy, cities
- VTT, TUT, LUT

Comprehensive steps into electrifying the bus system



- Components
- Vehicular technology
- Single vehicles

- Systemic view
- Charging technology
- Operation concepts
- A few vehicles

- Market dialogue: building the business ecosystem
- Pre-commercial pilot with operators
- Innovation platform
- Small fleet & charging infrastructure

- Normal commercial procurement
- Value chains and service providers established
- Several bus operators active
- Charging infrastructure available

HRT timeline: 2012 2014 2015 2016 - 2017 →

Charging systems and operation

Technology and concepts

Things to address

- Charging technology development and standardisation
- Electric vehicle, powertrain and traction battery development
- Vehicle performance analysis both in laboratory and fleets
- Lifetime and life cycle cost of key components
- Concepts of operation (depot charging vs opportunity charging)
- Dimensioning of charging infrastructure and traction battery

Charging concepts

Charging concept	Infrastructure costs	Vehicle costs	Operation costs	Concept feasibility
1. Overnight charging in the depot	Low, Chargers only in the depot	High, Large battery capacity	High, low battery lifetime, high energy consumption	Possible in demonstrational phase
2. Overnight charging + fast charging during the day	Moderate, Chargers both in the depot and terminals	Moderate, slightly smaller battery capacity	Moderate, slightly longer battery lifetime, additional costs if extra buses and drivers needed	Possible in demonstrational phase, parking space in bus terminals limits in wider scale use
3. Opportunity charging (automatic high-power charging)	High, expensive charging systems in terminals	Moderate, small battery, expensive technology depending on system	Low, no changes into normal bus operations	Feasible only as a large system where there are enough vehicles to take advantage of the investment

Potential charging methods

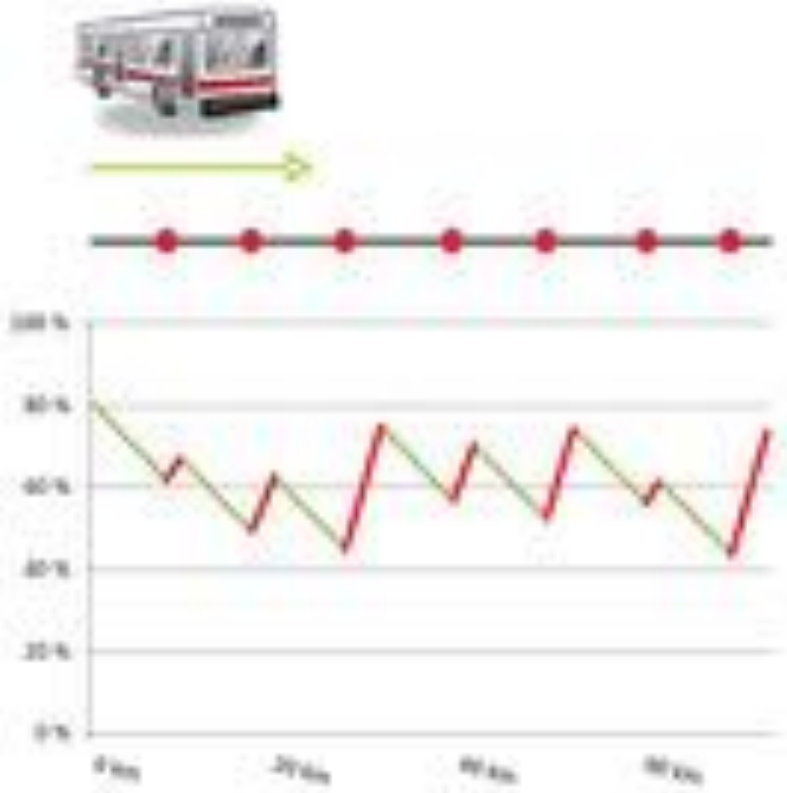
Siemens

ABB

Conductix

Fast opportunity charging during the day vs the usage of battery

- Charging in bus terminals, end stops or along the line
- Battery is mostly used in the middle area of state of charge
  - →Extended battery lifetime
  - →Extra capacity always available in case that one charging would fail
- Design and dimensioning of the battery system based on operational system analysis



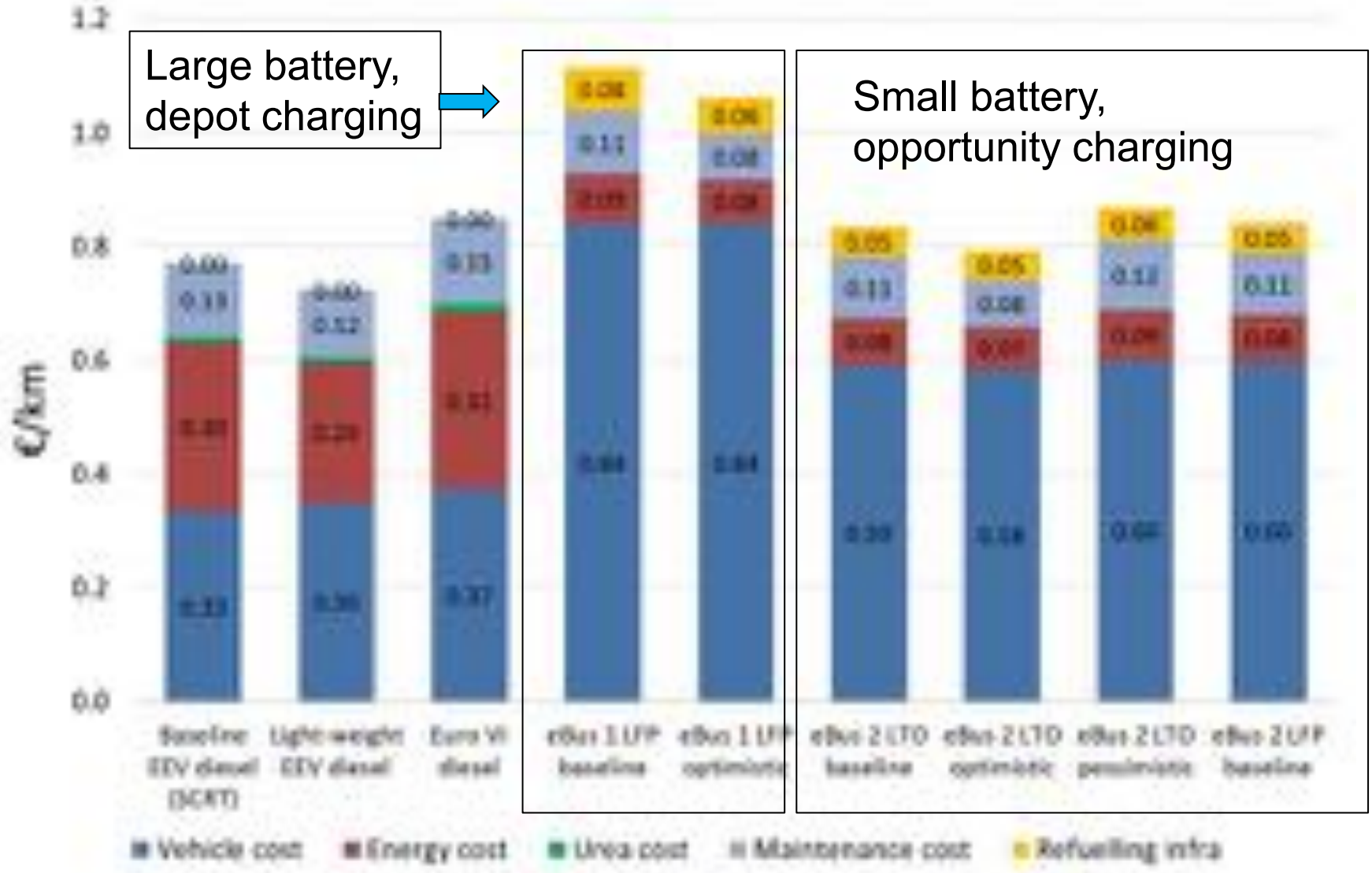
An example: opportunity charging with several charging points

Message to take:
Cost effectiveness and reliability requires system approach

PTA requirements for a good eBus system

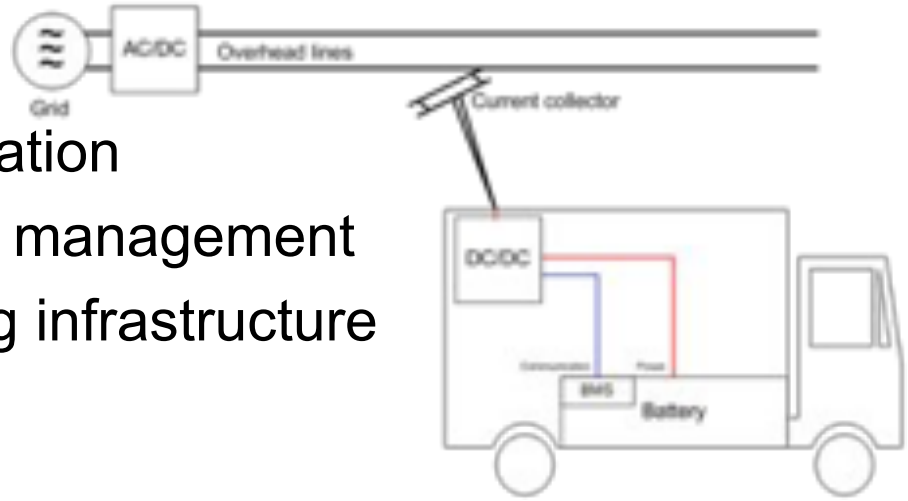
- Productivity: the size of the bus fleet must not be increased when replacing conventional buses with electric ones
- Operability: the operability of the electric buses must be at the same level as that of the conventional buses
- Reliability and comfort: the level of service, reliability and passenger comfort need to be the same or better compared with conventional buses
  - → Proven and reliable technology
  - → Innovative new concepts and businesses
  - → Established value network and actors

Total ownership costs of electric buses – Espoo case (note: the results do not apply generally)

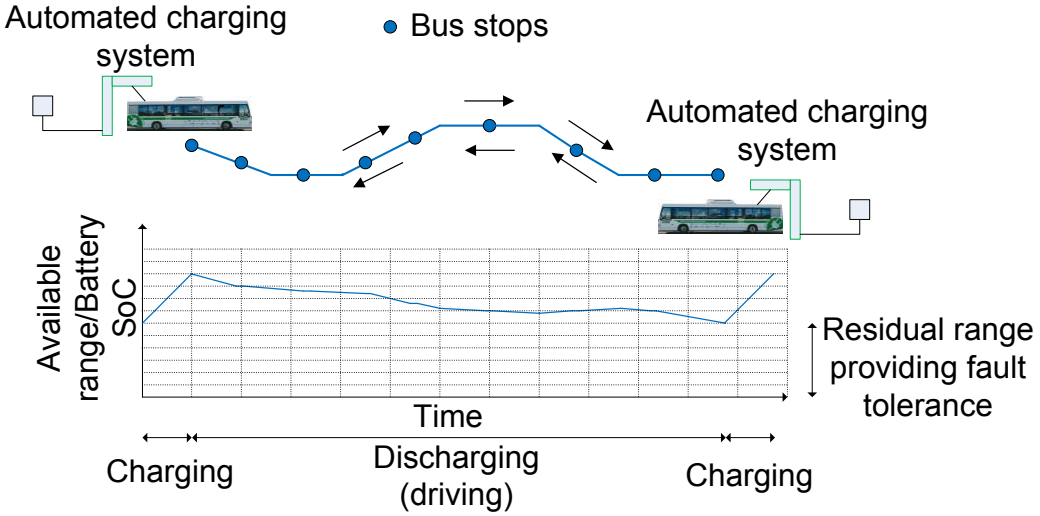


Ref: M. Pihlatie et al, Fully electric city buses – the viable option, IEEE IEVC 2014, Florence 17-19 December, DOI: 10.1109/IEVC.2014.7056145

Charging infrastructure and system design



- Charging technologies and standardisation
- Concepts of operation, system energy management
- Dimensioning and location of charging infrastructure
- Electric powertrain dimensioning
- Vehicle performance



Electric bus systems GIS planning tool

- Electric buses have system-level constraints that need to be addressed
- VTT is developing a GIS tool for public transportation planning
- Utilises existing data from environment, road network and public transportation system registers, schedules etc.
- Utilises electric bus database provided by VTT

→ **Find the optimal <u>system</u> parameters: lines, vehicles, chargers, energy**

- Intended contents
  - Cost and functionality analysis
  - Reliability and sensitivity analysis
  - Charging station capacity analysis
  - Interfaces for scheduling and operational planning tools
- Intended users are
  - Transport system and infrastructure planners
  - Public transport schedule planners
  - Public transport operation planners

Helsinki region experiences with chargers

- High power opportunity charging appears as the most cost efficient solution for large scale deployment
- The utilisation rate of electric buses and charging equipment should be maximised
- Practical issues need time and consideration
  - Finding and involving key players
  - Procurement process
  - Charging technology compatibility with buses
  - Business models for charging services not established
  - Styling of the charging equipment

Summary and conclusions

- Electric bus systems are fast emerging
  - Both vehicle technology and charging equipment available
- Electric city buses are heavy duty sweet spot, other use cases and applications will follow
- Designing an efficient eBus system requires systemic approach
  - Optimised vehicle and battery
  - Operation concept analysis and design
  - Charging infrastructure design
  - Fleet and energy management
- Co-operation of key players required: city, PTA, PTO, energy company, service providers (e.g. charging service)
- Our value proposition: reduced system-level TCO


TECHNOLOGY FOR BUSINESS