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Forschung & Beratung GmbH

CIVITAS DYN@MO Summer University 2014
“Implementing city and citizen friendly electric vehicles”

“ebus. the smart way” – Electric buses in Europe: status quo

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Palma, 14 May 2014

ebus
the smart way

Outline

- **Why ebuses?**
- **ebuses – some examples**
- **ebus - the next generation?**

Why ebuses?

- **Trends and biggest impact on the electrification of urban mobility in EU cities / what political action would be required?**
- Oil dependency of public transport in EU is huge; **only 5% of European bus fleet is running on alternative fuels** (incl. electricity as clean power)!
- Replacing oil with alternative fuels will **save several billions of EUROS** per year on EU's oil import bill! ("€ 4.2 billion per year already in 2020, increasing to € 9.3 billion per year in 2030"; Prof. Müller-Hellmann, VDV Förderkreis)
- **Lack of (re)charging infrastructure in EU** for wider take up of electric Public Transport (PT)

Why ebuses?

Drivers for ebus systems

- Public pressure for **improved and green public transport** (PT) from politics, passengers and citizens
- Electric PT as the solution to **fight the environmental problems (incl. noise) of a city**
- **(Short-term) implementation of electro-mobility** in public transport for (mass) passenger transit
- **Visible modernisation of PT**, political story of success
- Support from research and **"forerunners"** for planning and reasonable cost estimate

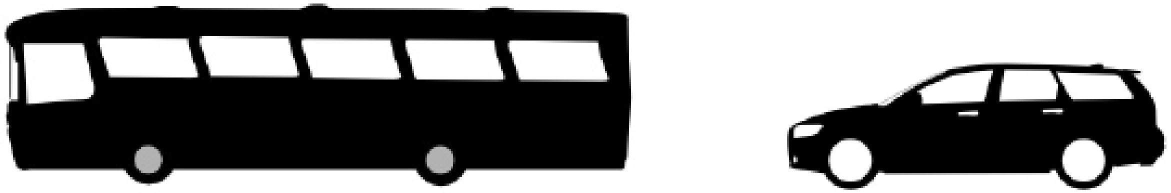
Why ebuses?

A new market is emerging : Public buses will be electrified before cars will!

- ► **Return on investment** (ROI) regarding battery system is faster with ebuses than with e-cars because they are used more. **Cars stand most of the time**.
- ► **Not only money counts**: Some customers (municipalities) apply **environmental and image considerations** in addition to funding aspects.
- ► **Cost-Trends**: Costs of electric buses will trend down since the most expensive compound – **the battery – is expected to improve in price and performance (but when?).**

Source: ISEA, RWTH Aachen University, Rohlfs, 2012

Why ebuses?

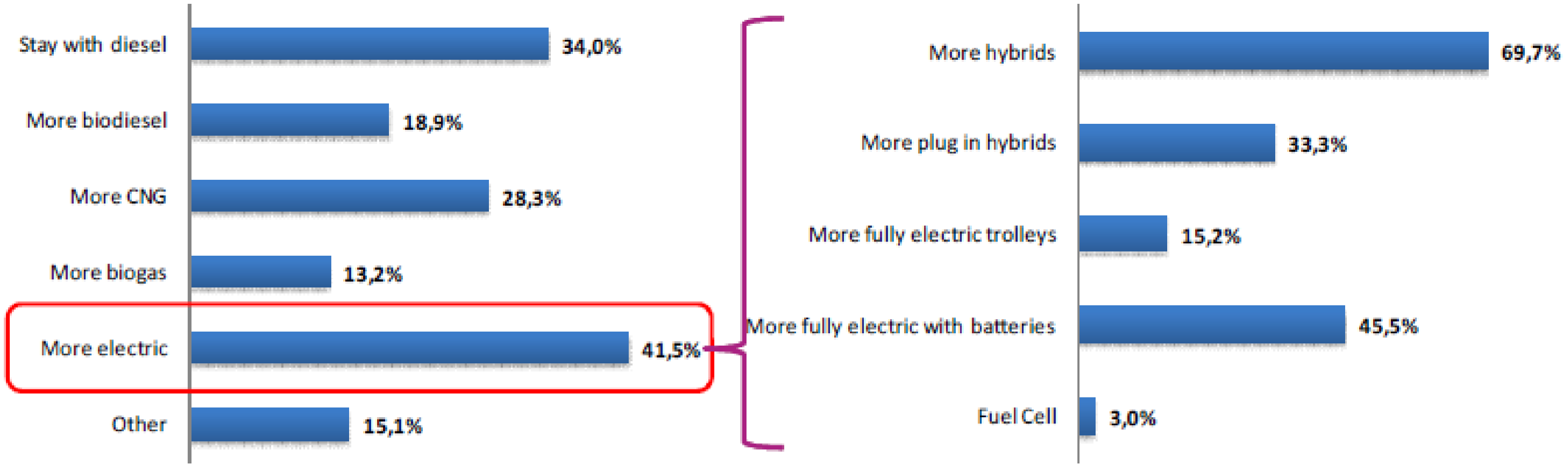


	Public Buses	Passenger Car
Range:	Depending on operation concept 10 - 50 km	>80 km
Operation hours per year	5,000 / year	400 / year
Average speed	18 km/h	30 km/h
15 years ➔	**16.875 full cycles** ⚡	**2.250 full cycles** ✔

Source: ISEA, RWTH Aachen University, Rohlfs, 2012

Why ebuses?

A trend towards electric bus systems



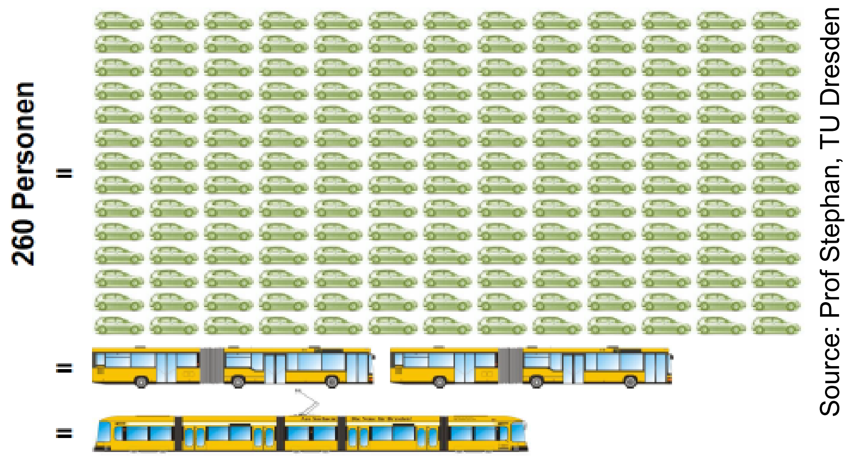
Future plans for propulsion technology change

Source: 3iBS Project (UITP, DG-R&I) / 70.000 bus / 130 M habitants

But: main barrier and challenge is the initial investment!

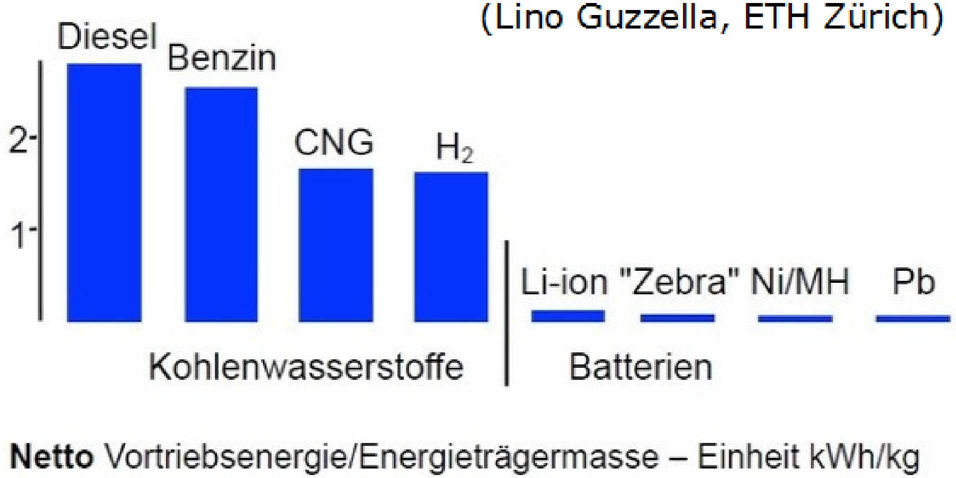
Why ebuses?

- **1:1 Substitution of electric passenger cars won't solve the intra-urban traffic problems**
  (Noise, particulate matter, emissions, limited space, increase in 2nd or 3rd car etc.)



- **But: energy densities of on-board energy carriers are too low for battery solutions:**

(Lino Guzzella, ETH Zürich)



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Why ebuses?

Operational Requirements for ebuses:

- **Long hours each day**: up to 20 hours, up to 300 km/day
- **Short charging duration** („few minutes“, charging time should be approx. 10% or less of „driving time“)
- Very **high reliability** even at bad weather conditions
- Fast & easy **exchangeability of components** in case of failures
- Heating in winter, cooling in summer (- on battery power?)
- **Benchmarking costs** near those of diesel buses

Source: ISEA, RWTH Aachen University, Rohlfs, 2012

ebus – examples

Hybrid trolleybus with batteries and supercaps

- Demonstrator in Eberswalde (Germany) funded by EU in TROLLEY project
- Battery system (72 kWh) designed to **cover 4 km on round trip of 18 km**
- First results from operation alongside other trolleybuses (with supercaps and diesel auxiliary power unit) are available
- Tested in winter (temperatures -1 to -3°) with normal heating for passengers
- Over whole day, **40 km of 240 km (17%) without overhead power supply**
- **Energy cost per km 32% lower** with hybrid trolleybus

ebus – examples

Trolleybus systems are economical: feasability study from Eberswalde -1 cent per scheduled km more expensive than diesel bus system

	Trolleybus	Diesel bus
Energy/fuel	264.000 €	442.600 €
Staff costs/driver	No difference	
Maintenance vehicle	80.000 €	72.000 €
Staff costs/garage	No difference	
Staff costs/cat.	126.000 €	---
Maintenance/cat.	19.000 €	---
Insurance vehicle	48.000 €	24.000 €
Investment/Recovery time	37.800 € 18 years	31.000 € 10 years
Difference	+5.200 €	
Difference/km	0,01 €	

Savings of 95% CO_2 emissions (based on green power mix) compared to diesel bus system

Source: TROLLEY project

ebus – examples

Greatest potential for further development of propulsion modes for public transport vehicles by 2020/2050?

- Which type of traffic is suitable for which type of electric PT (with ebuses)?

- Battery buses do not achieve the required distance (of 200-500 km/day) and capacity (?)

- Hybrid buses are not competitive without funding (case studies from Germany)

ebus – examples

Greatest potential for further development of propulsion modes for public transport vehicles by 2020/2050?

- Which type of traffic is suitable for which type of electric PT (with ebuses)?

- No adequate infrastructure for fuel cell buses; insufficient energy balance

- Inductive ebus systems are not mature yet (so far isolated application)

The ZeUS project

Zero Emission Urban Bus Systems - Core Demonstrations

8 Demonstrations / **6** Countries

- **Barcelona (ES)**
- **Bonn / Munster (DE)**
- **Glasgow / London (UK)**
- **Plzen (CZ)**
- **Italy (*To be Determined*)**
- **Stockholm (SE)**

35 Electric Buses >12m

- Full Electric
- Plug-in Hybrid

Charging Infrastructure

- Slow charging – bus depot
- Fast charging - bus stations, terminals, stops – induction, catenary, contacts

The ZeUS project

Main project outcomes

Provide decision makers with **Guidelines** and **Tools** to support decision on "**if**" "**how**" and "**when**" to introduce electric buses in the ***core*** bus network

Evaluate the economic, environmental and societal feasibility of electric urban bus systems through demonstrations

Facilitate the market uptake of electric buses in Europe with dedicated support tools and actions

The TROLLEY project

- Delivers **transferable strategies** for implementation of trolleybus systems
- Develops **innovative ways of promoting trolleybus systems** as an environmentally friendly transport mode and thereby
- Reshapes and **updates the image of trolleybuses** in Central Europe!

The TROLLEY project

Crucial discussion topics

Modern PT system vs old-fashioned reputation

Reliable and visible PT vs disturbing overheads

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- **ebus - the next generation?**

ebus - the next generation?

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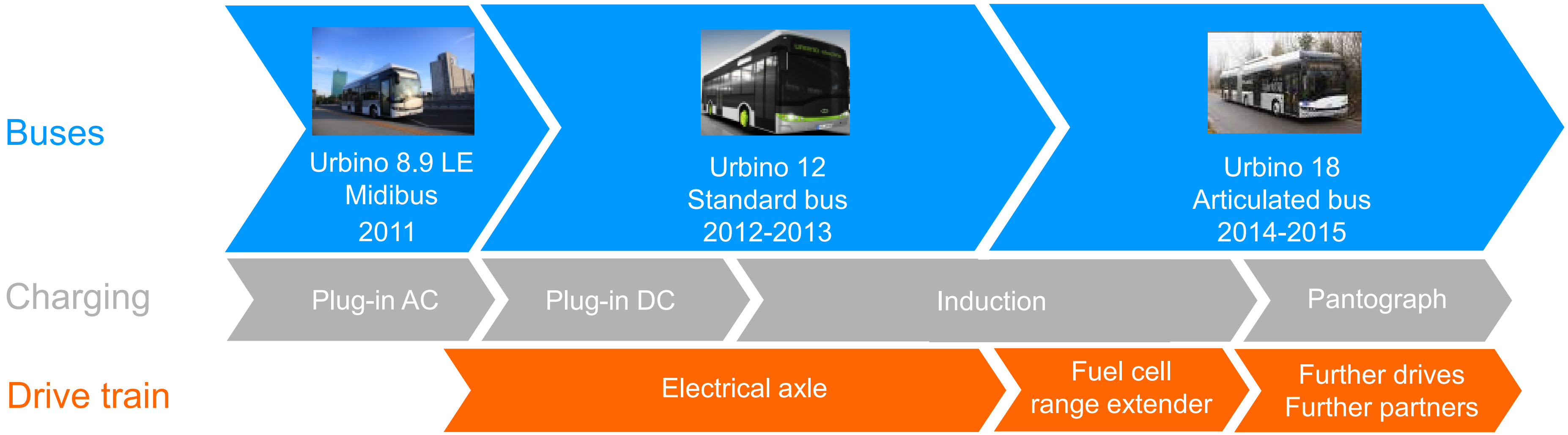
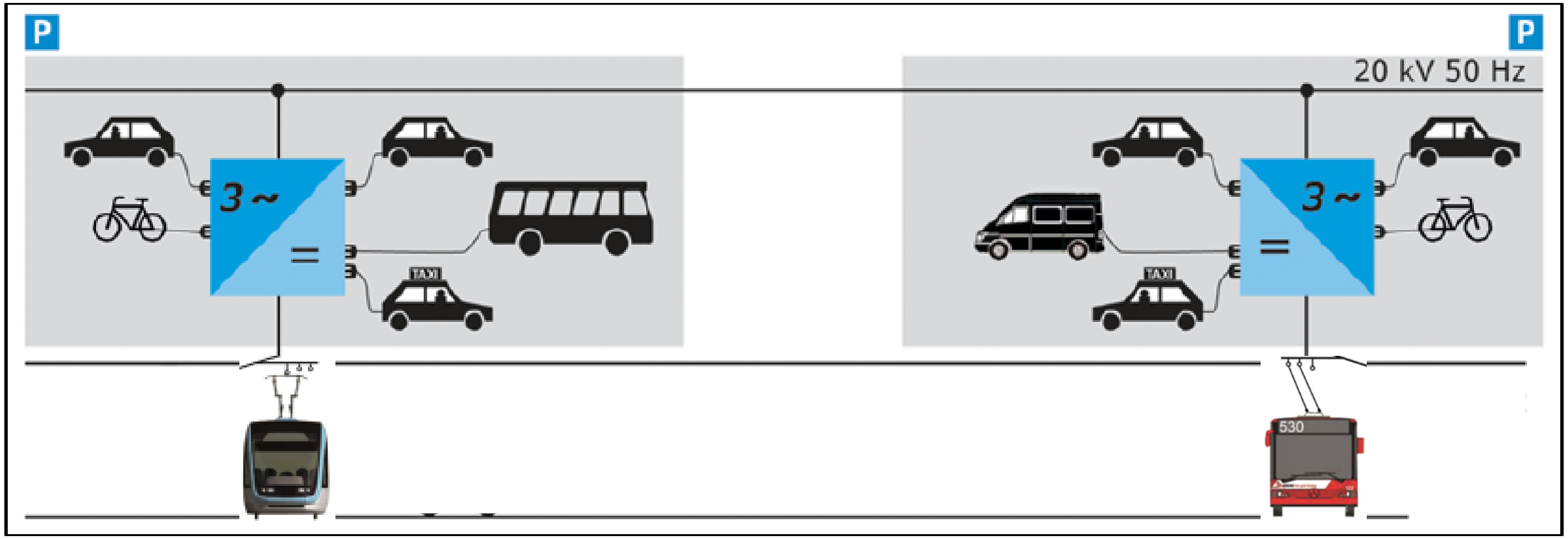
- Implement **experience & lessons learned** in **demonstrations & tests**
- Increase number of **options for powertrain and energy supply**
- Make use of improving battery technology to further **increase range**
- Add **articulated buses** to electric bus range



Source: Solaris Bus & Coach , Poland; TROLLEY. Summer University 2013

ebus - the next generation?

- **Promising strategies and business models to boost the introduction of electric public transport in future European smart cities:**
- **Double use of power supply infrastructure** of existing tram and trolleybus systems as loading stations for further electrification of urban mobility (ebuses, e-cars, e-bikes etc.)



Source: Prof. Müller-Hellmann, VDV-Förder-kreis; adapted)

ebus - the next generation?

- **Need for flexible, modular, and efficient charging infrastructure for** different business models and **double use of existing power supply of PT** (e.g. COMBO 2 plug-in system combines both AC charging and fast DC charging)

Normal charging time: 5.5 hours | With 40 kW DC: 30 minutes
(AC charging) (DC charging)

Source: PHOENIX CONTACT GmbH & Co. KG; Prof. Müller-Hellmann, VDV-Förder-kreis)

ebus - the next generation?

R&D and demonstration to:

- develop, test and evaluate **advanced hybrid electric-electric drive train concepts** combining wire-based and autonomous modes of operation:
    - smart **combinations of ebus technologies (charging systems, batteries, supercapacitors**)
    - adapted to different operating conditions (climate, geography, etc.)
- develop, test and evaluate **innovative energy storage and charging systems** (contact and contact-less), combining vehicle-based with infrastructure-based **energy management** (smart grids, stationary energy storage systems, remote battery performance management etc.)

ebus - the next generation?

Support for transfer, take-up, experience exchange and learning to:

- foster **interdisciplinary research activities** with integration of electromobility in Sustainable Urban Mobility Planning (SUMP)

- develop **life-cycle assessment approaches/tools** (incl. environmental assessment and energy source methods) necessary for comparability of (electric) PT solutions (integration into EU's **Clean Vehicle Directive**)

- develop **comprehensive business models** for PT systems and funding schemes (e.g. Public-Private Partnership; start-up incentives)

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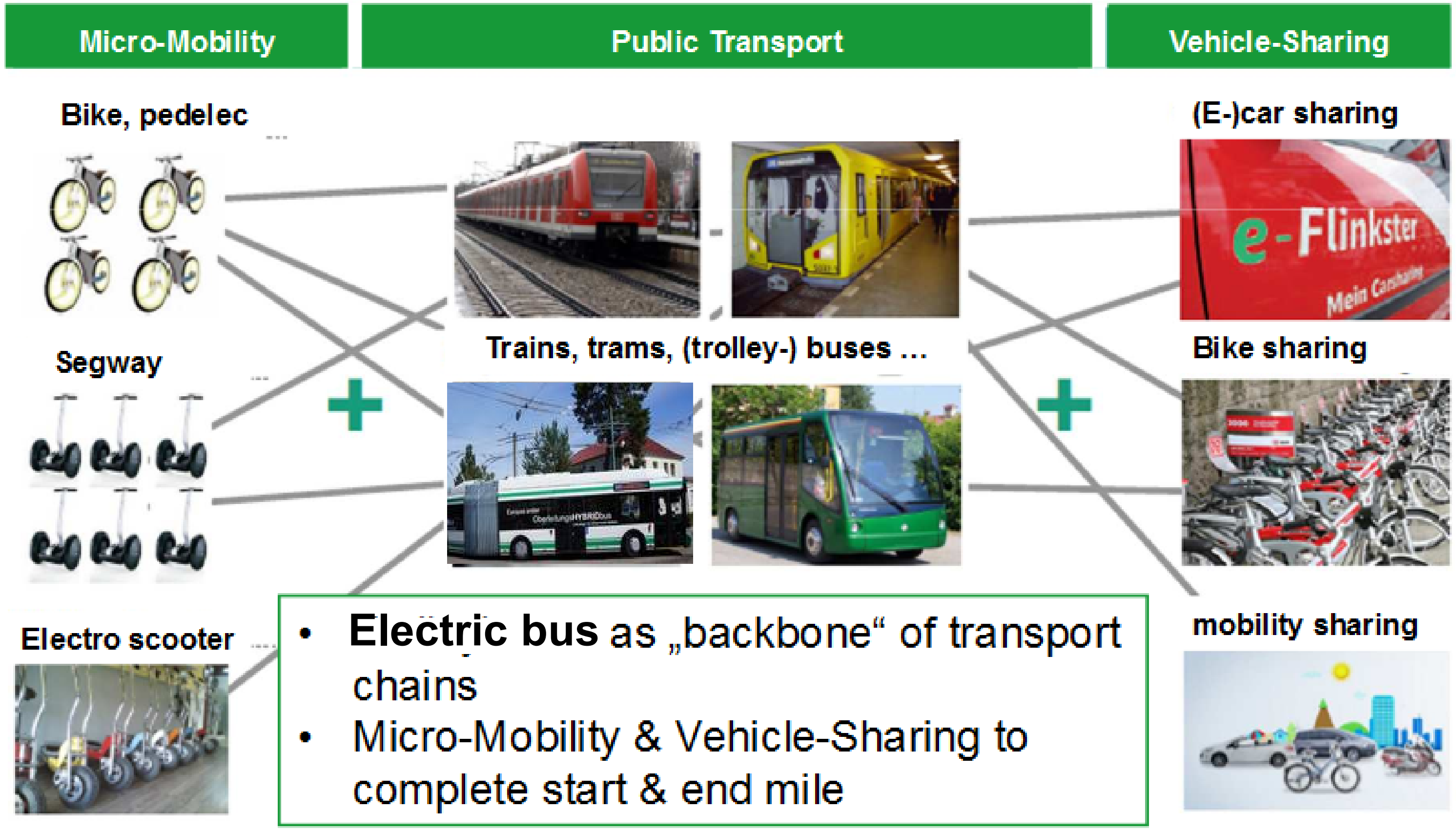
ebus - the next generation?

Promising strategies and business models to boost the introduction of electric public transport in future European smart cities?



Source: Spath, IAO, 2011

ebus - the next generation?

Support for transfer, take-up, experience exchange and learning to:

- develop new and adapt existing **staff training** for/of PT operators for **driving/maintenance of electric buses**
- develop **open standards** to prevent “lock-in solutions” and as precondition for public funding and market uptake
- develop a **regulatory framework** for the development of ebus systems in EU (procurement rules etc.)

Co-funded by the Intelligent Energy Europe
Programme of the European Union

Muchas Gracias!

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