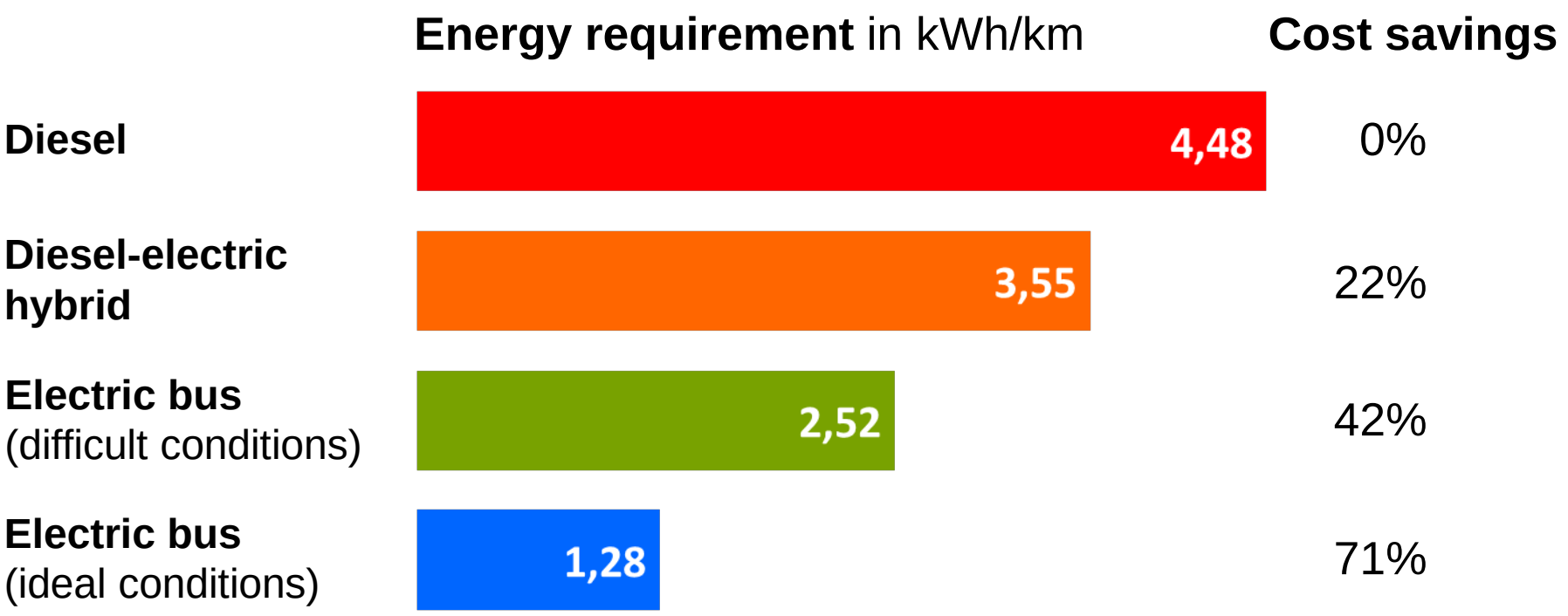
Charge station by induction on the street: Braunschweig

11a Jornada AMTU, May 5, 2015
Mataró - Tecnocampus

Agenda

1. **How to define electric buses?**
2. **Infrastructure and operational time**
3. **Inductive charging in practise**
4. **Experience and further development**

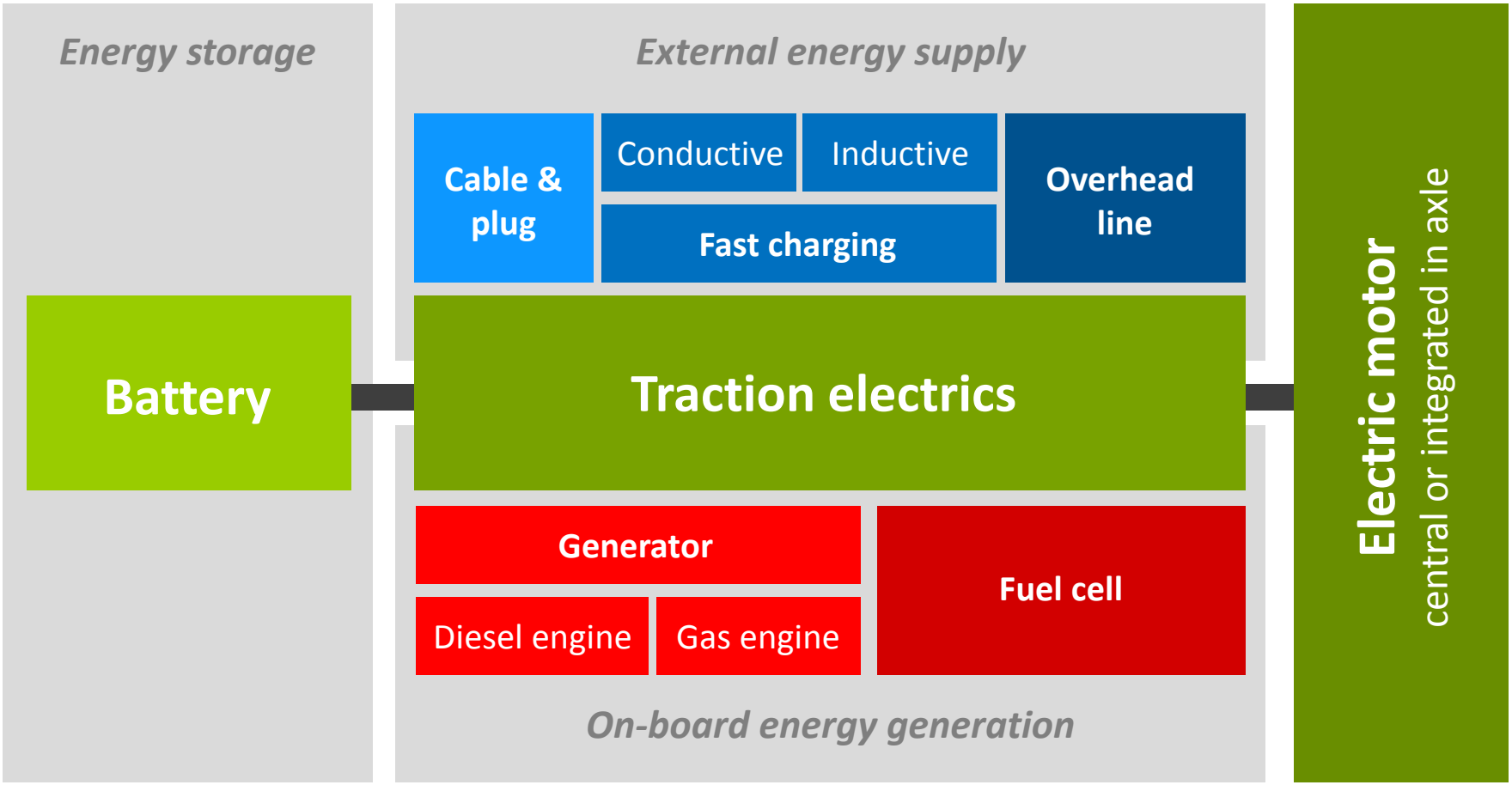
Electric buses are energy-efficient



Data for **12-metre standard bus**, according to **SORT 2** (without heating), own measurements
Cost of 1 litre diesel 5.52 PLN, cost of 1 kWh electricity 0.56 PLN

How to define electric buses?

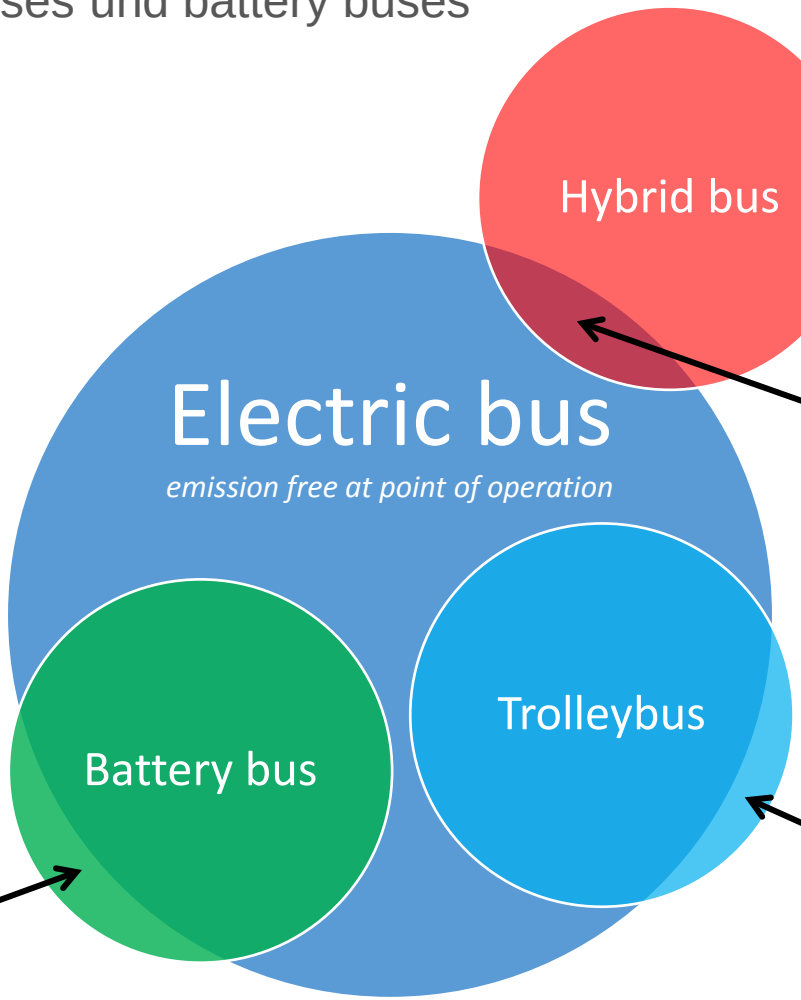
Electric drivetrain is at the heart of all electric buses



How to define electric buses?

Hybrid buses, trolleybuses und battery buses

= electric buses



Zero emission operation

Diesel auxiliary power unit

Oil/diesel heater / range extender with diesel engine

How to define electric buses?

Electric mobility – without dogma

- For Solaris, **electric buses can be**:
  - Hybrid buses
  - Plug-in hybrid buses
  - Trolleybuses
  - Hybrid trolleybuses
  - Battery buses
    - Overnight charging
    - Conductive opportunity charging
    - Inductive opportunity charging
    - Range extension with fuel cells

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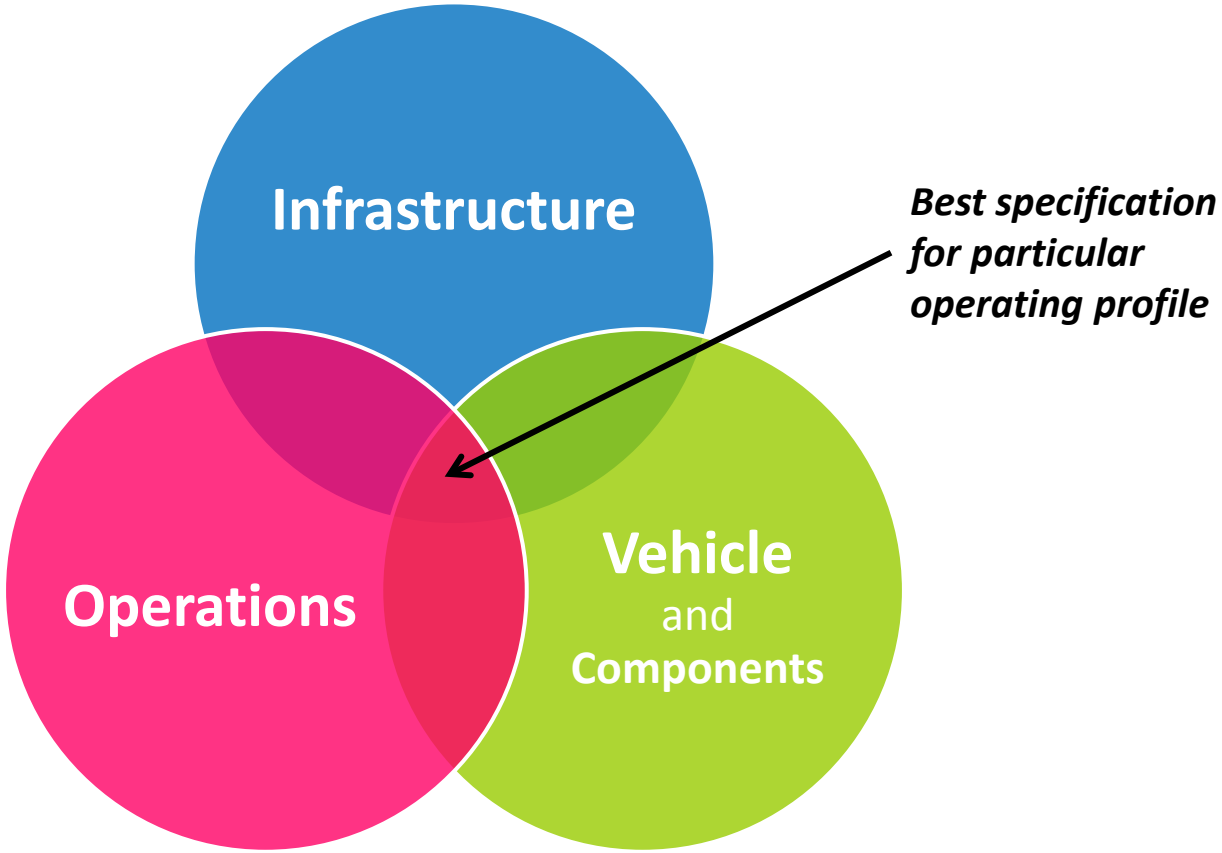
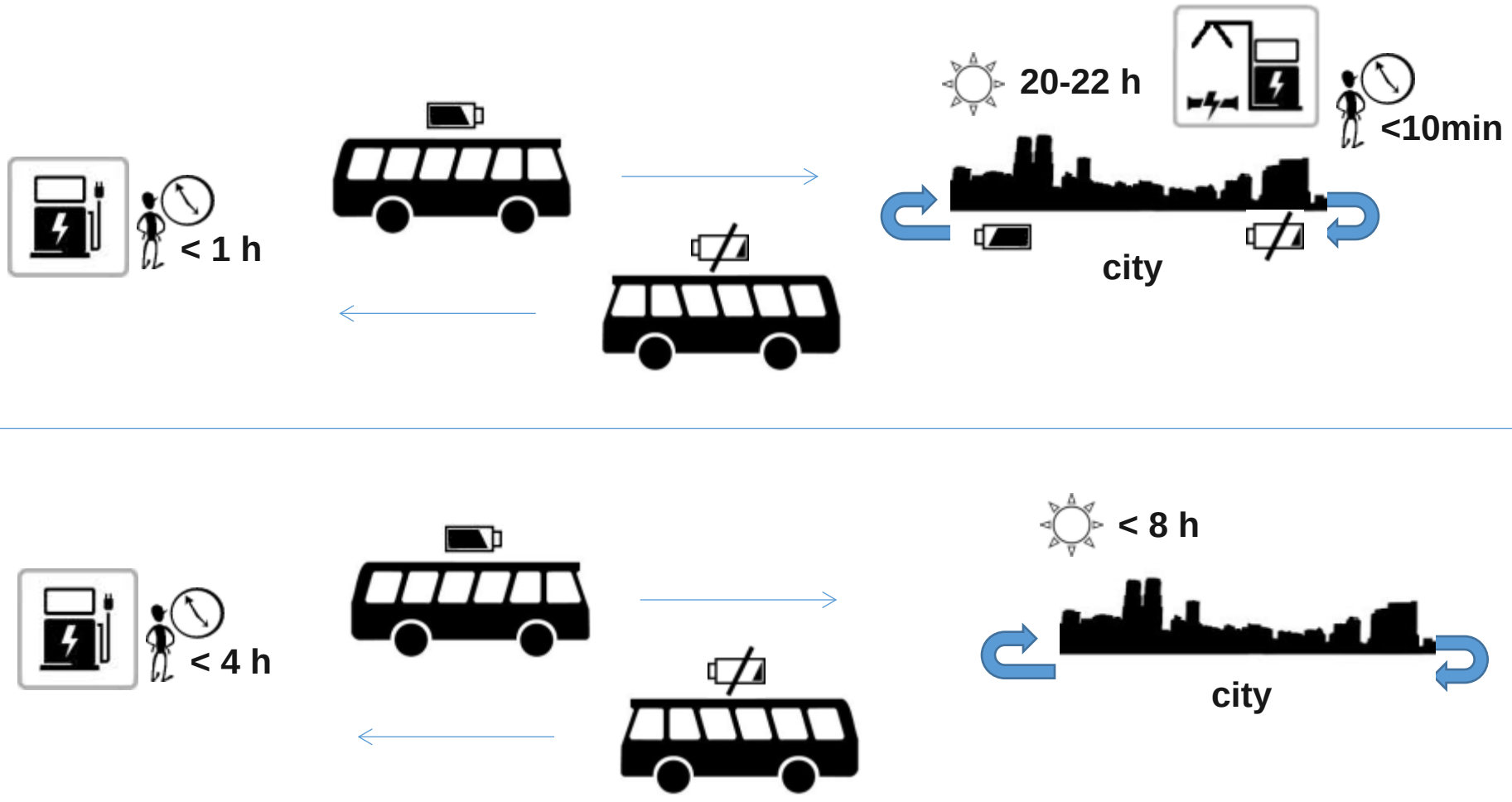
Infrastructure and operational time



Infrastructure and operational time



External charging concepts

- **Cable & plug**
  - **16–80 kW** charging power (limited by plug)
- **Conductive opportunity charging with pantograph**
  - **200–450 kW** charging power
  - Two systems
    - Solaris (with Eko Energetyka)
    - Schunk Smart Charging
- **Inductive opportunity charging**
  - **200 kW** charging power
  - Bombardier Primove

Range extension

- Buses can be fitted with **fuel cells to extend the operational range**
  - Battery remains source of traction power
  - Fuel cells are used to recharge the battery
- First buses for **Hochbahn of Hamburg for operation on Innovation Line 109**, supported by German Ministry of Transport and Digital Infrastructure
- To be used in **bi-articulated electric buses** currently under development

Choice of length

- Electric bus range covers the most common vehicle lengths
  - **Midibus** (8.9 metres, low entry)
  - **Standard bus** (12 metres, low floor)
  - **Articulated bus** (18 metres, low floor)
  - **Extended articulated bus** (18.75 metres, low floor)
  - *Under development:* **Bi-articulated bus** (24 metres, low floor)



Available battery sizes

	High Power[1]					High Energy[2]			
kWh	*Bombardier*		*Solaris*			120	160	200	240
	60	90	75	100	125				
Cable & plug	✓	✓				✓	✓	✓	✓
Pantograph				✓		✓	✓	✓	✓
Induction	✓	✓							

[1] Lithium-titanite ($Li_4Ti_5O_{12}$): warranty for 10,000 cycles within 5 years
[2] Lithium-iron-phosphate ($LiFePO_4$): warranty for 3,300 cycles within 5 years

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Inductive charging in practise

„Emil“ project: electric mobility line M19 in Braunschweig

emil
BRAUNSCHWEIG FÄHRT INDUKTIV

SOLARIS

Ihre Braunschweiger Verkehrs-AG

BOMBARDIER

BS ENERGY

Technische Universität Braunschweig

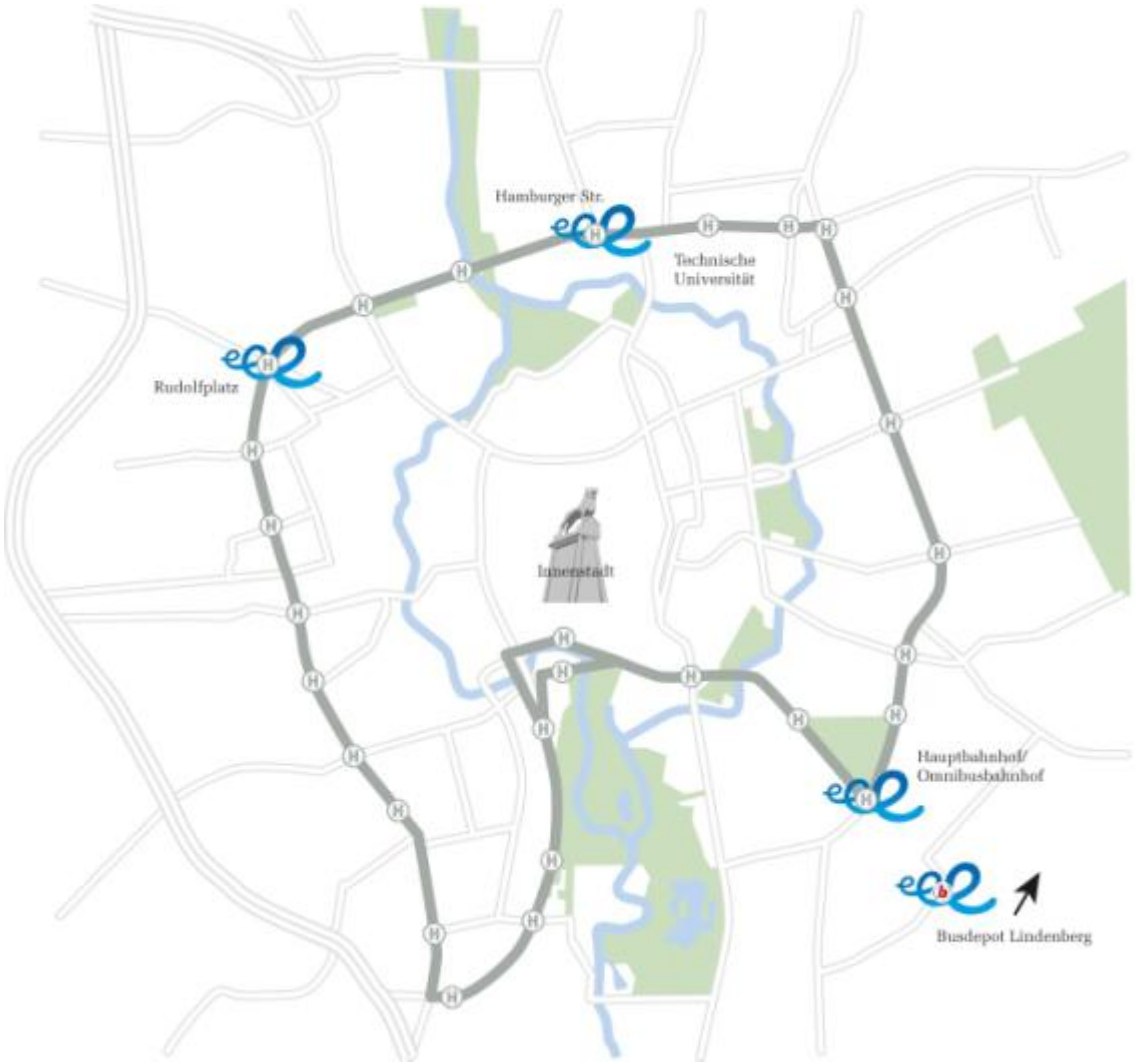
Gefördert durch:
Bundesministerium für Verkehr, Bau und Stadtentwicklung

Inductive charging in practise

Line M19

- **12 km distance**
- 1 end stop
- 25 stops on route
- **18 km/h average speed**
- Operating freequency
  every 10 minutes (working days)
  every 15 minutes (weekends)

More often charging operations allows to use smaller and lighter battery. Thanks to this we can keep high passenger capacity of the bus



Battery charging

- **Inductive charging**
  Bombardier Primove system
  - Dedicated pick-up coil under bus floor
  - Dedicated inductive coil under the surface of the street
  - Charging station integrated with advertising column
- **200 kW charging power**
- **4 charging points/stations**
  with different charging times
  - 1 at the end stop (up to 11 minutes)
  - 2 at the bus stops (up to 30 seconds)
  - 1 at depot (up to 15 minutes)

Inductive charging in practise

Vehicles

1 standard bus

- Inductive fast charging
- 60 kWh battery
- In service from March 2014

4 articulated buses (+ 1 option)

- Inductive fast charging
- 90 kWh battery
- In service from late 2014

Inductive charging in practise

Reliable drive and charging technology

- **Initial operating experience confirms reliability of electric drives and charging systems**
- Urbino 12 electric and Urbino 18 electric in **Braunschweig** in service since March and December 2014 respectively, inductively charged with Bombardier Primove
  - 80% availability in first five months of operation of Urbino 12 electric
  - Energy consumption of Urbino 18 electric 1.7 kWh/km
  - Quiet and smooth drive characteristics
- Urbino 12 electric in long-term test in **Kraków**, cable & plug charged

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Battery buses operated and tested in numerous European cities

- **Operators** (includes orders)
- **Long-term tests**
- **Tests and demonstrations** (selection)

Solaris is a partner in the **European Union**'s ZeEUS project

ZeEUS
Zero Emission Urban Bus System

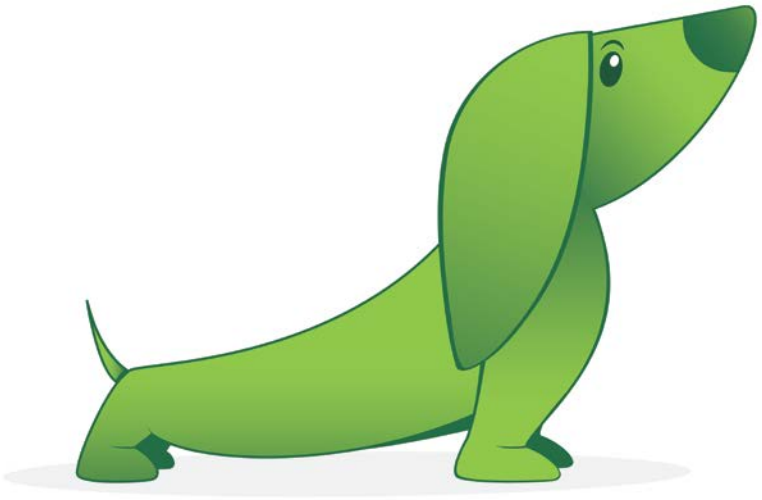
Finding the right technologies

- Market currently is in a phase of **testing different concepts** for electric buses
- **No clear indication yet which technologies will become preferred choices**
- Solaris supports exploration of opportunities with wide range of drive and charging technologies, adapted to individual operators‘ requirements
- Open questions surrounding operational integration **to be explored in practice**

- **What will the future mix of fleets be?**
  - Only battery buses?
  - Mix of battery and plug-in hybrid buses?
  - Mix of battery and diesel buses?
  - Opportunity charging or range extenders?

Thank you for your attention!

Any questions?



Mateusz Figaszewski
PR Director

Solaris Bus & Coach S.A.
ul. Obornicka 46
62-005 Owińska
Poland

Phone **+48 61 667 23 47**
mateusz.figaszewski@solarisbus.com