



Modern e-bus propulsion systems

4. International E-Bus-Conference in Hamburg

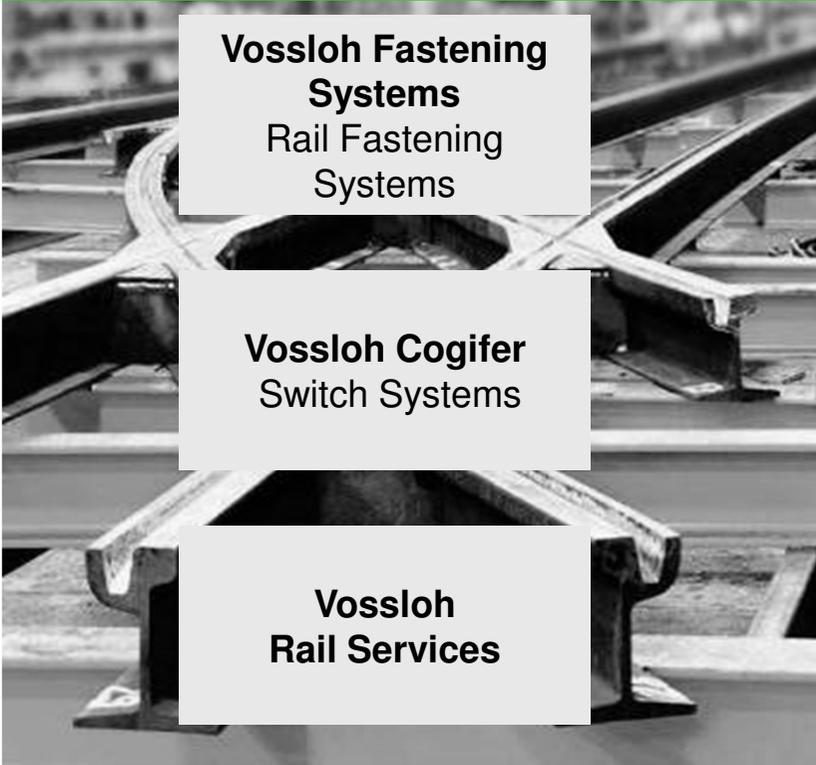
Erik Lenz 17.11.2014



Vossloh Kiepe
Kiepe in the Vossloh Group

Vossloh AG

Rail Infrastructure

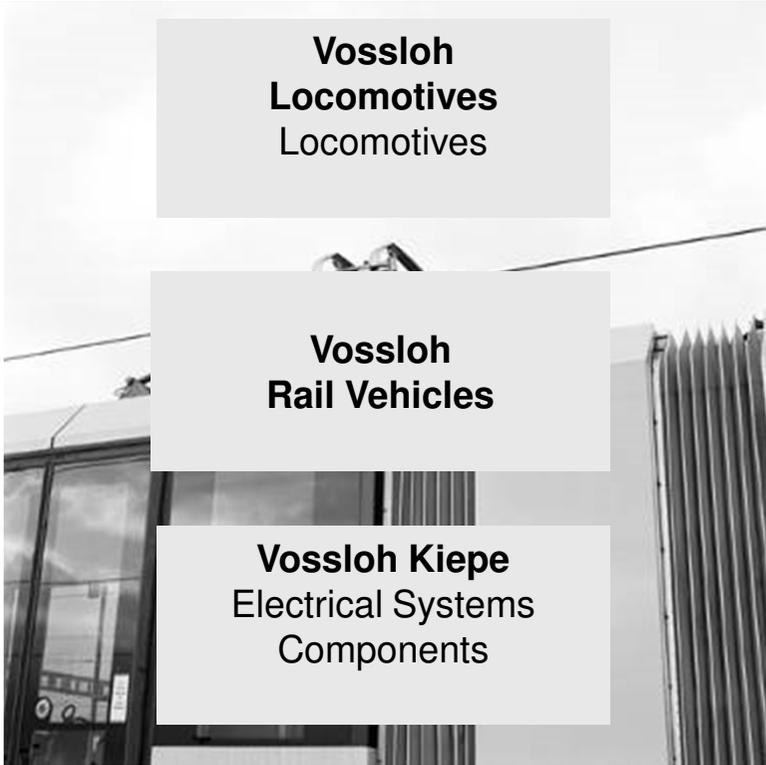


Vossloh Fastening Systems
Rail Fastening Systems

Vossloh Cogifer
Switch Systems

Vossloh Rail Services

Transportation



Vossloh Locomotives
Locomotives

Vossloh Rail Vehicles

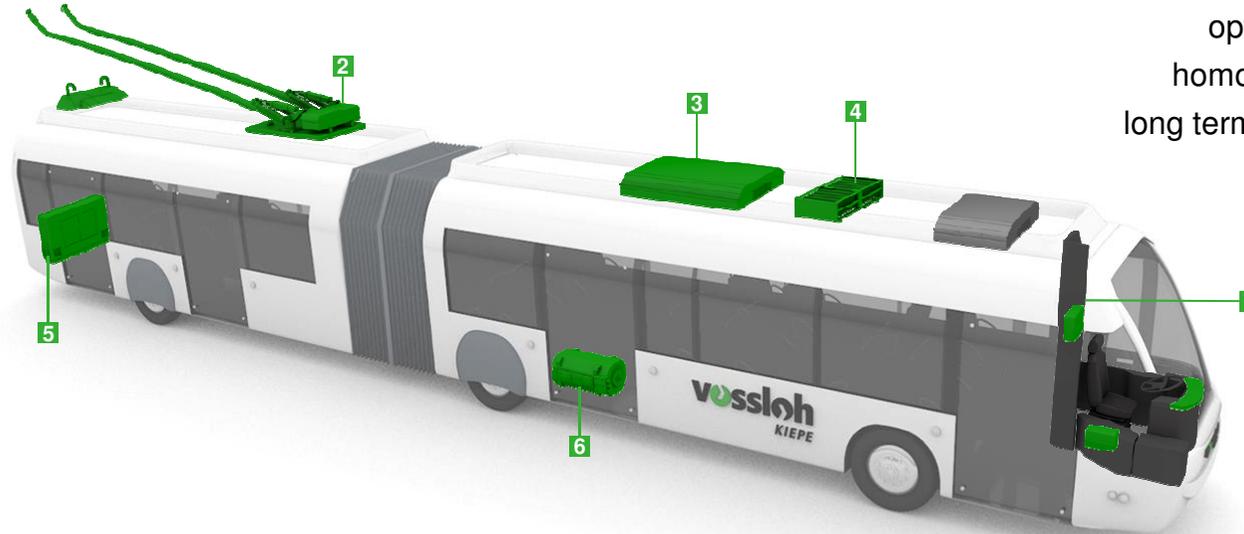
Vossloh Kiepe
Electrical Systems
Components

Modern e-bus propulsion systems

Trolley Bus Propulsion System

System Integrator

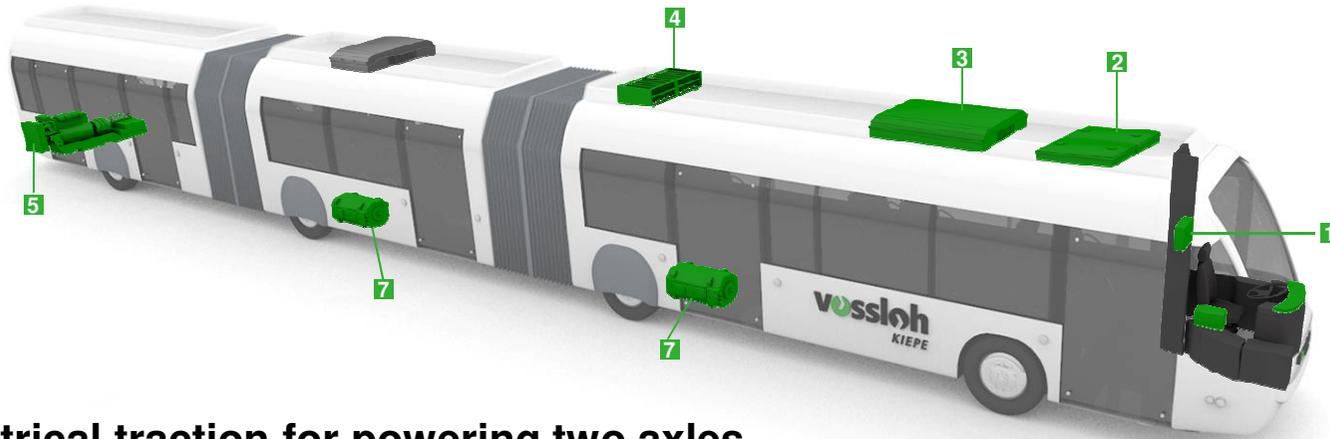
make it work reliable
optimize
homologation
long term availability



1 Energy Management Controlling Units, Diagnostics 				
2 Current Collector 	3 Power Electronics 	4 Brake Resistor 	5 Auxiliary Power Unit (APU) 	6 Traction Motor 

Modern e-bus propulsion systems

e-Bus Variations: Serial Diesel Electric Hybrid



Electrical traction for powering two axles

1 Energy Management Controlling Units, Diagnostics		
2 Energy Storage 	3 Power Electronics 	4 Brake Resistor 
5 Main Power Unit (MPU) 	6 Pantograph 	7 Traction Motor 

Project Rheinbahn

Concepts

Overnight charging Battery Bus

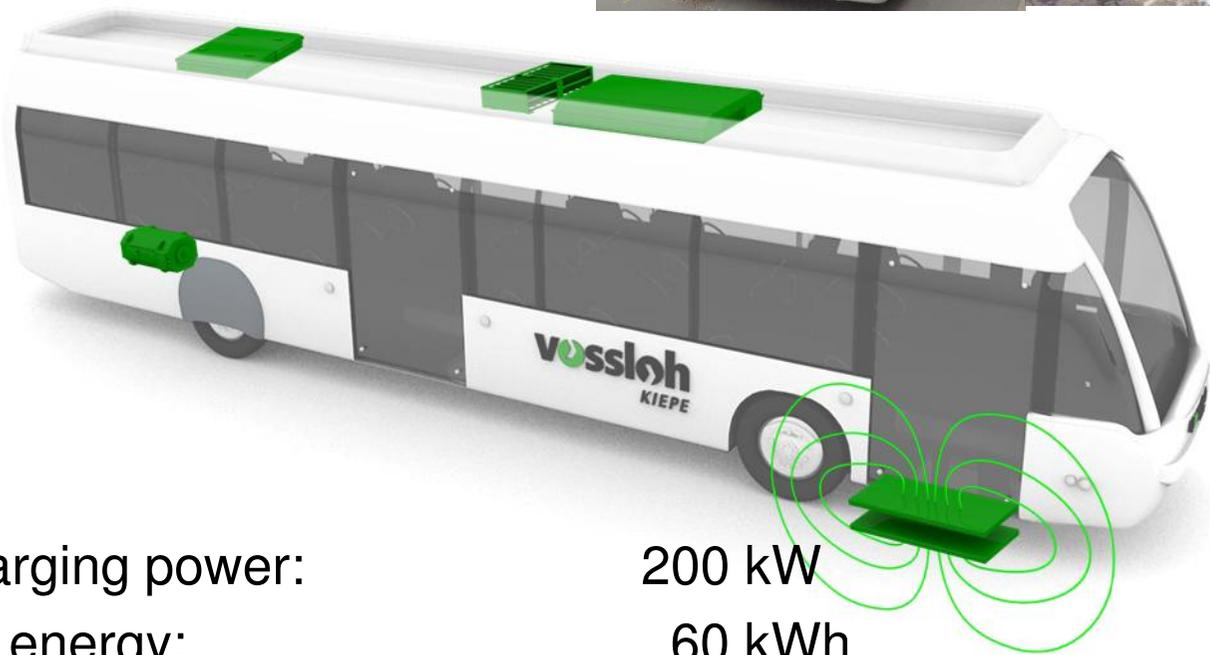


Max. charging power:	90 kW
Installed energy:	200 kWh
Range:	app. 110km
Charging time per day:	2,5h night + 0,5 h during breaks

Project Braunschweig

Concepts

Battery Bus inductive charging



Max. charging power:
Installed energy:
Average charging time per hour:

200 kW
60 kWh
8min + coupling

Project SEB Dresden

Concepts

Battery Bus fast charging via pantograph



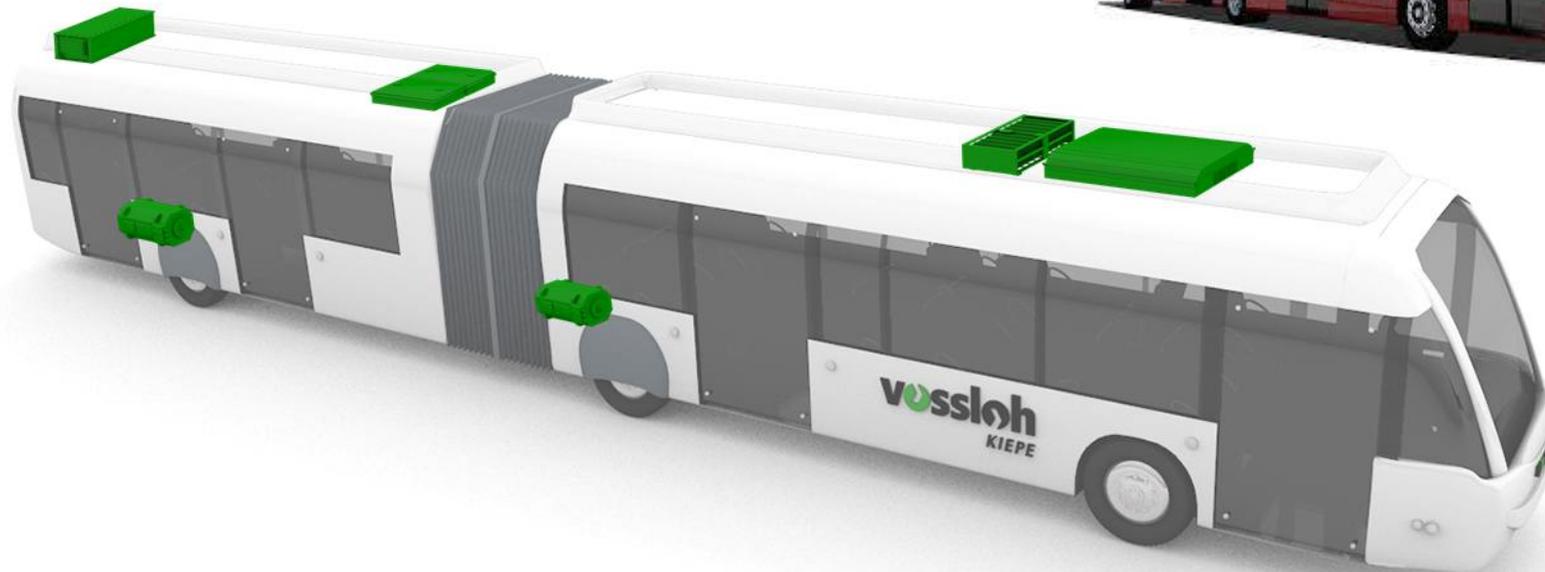
Max. charging power:	500 kW
Installed energy:	86 kWh
Average charging time per hour:	3min + coupling

3 min → Usable in normal line operation !?

Project Hamburg

Concepts

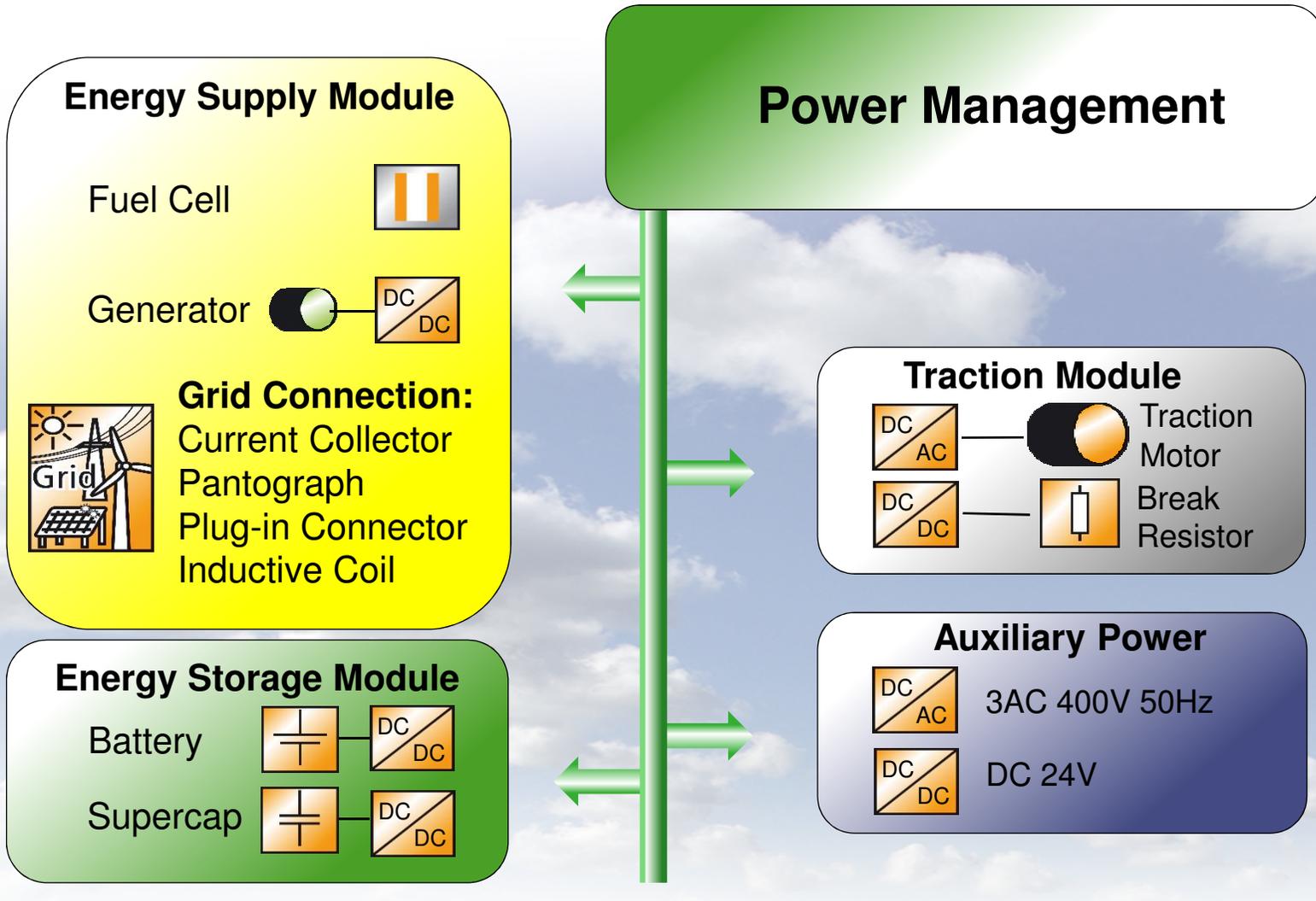
Battery Bus with Fuel Cell as Range Extender



Max. charging power:	90 kW
Installed energy:	120 kWh
Power Fuel Cell:	100 kW
Hydrogen tank:	45 kg (ca. 875kWh)
Total Range:	250 km

Electro mobility with Vossloh Kiepe

One System – plenty possibilities

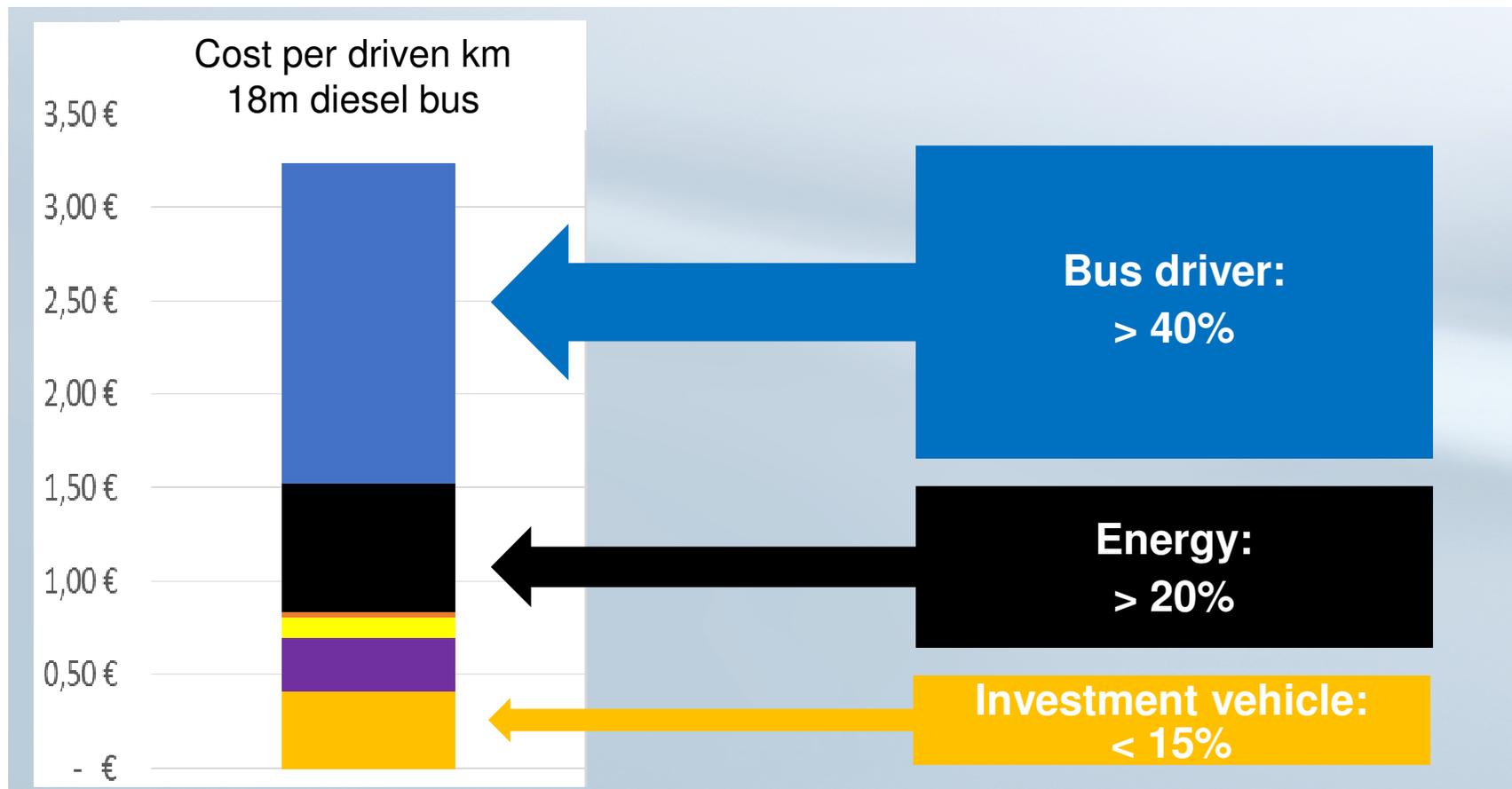


Facts and Figures



Facts and Figures

TCO: Cost Factors Diesel Bus per km



Facts and Figures - Bus Driver Cost

Time to Charge a 12m Battery Bus (Opportunity Charging)

Charging time depends on velocity

Time to load =

$15\text{km/h} * 1,5\text{kWh/km} / 250\text{kW}$

15km/h \Leftrightarrow 5min

20km/h \Leftrightarrow 7min

30km/h \Leftrightarrow 11min

Charging Power (250kW)

Time is Money

Cost

=120 buses x 2 bus drivers/bus
x (30.000€ salary + 20.000€ over head)
x (charging time/60min)

5min/h \Leftrightarrow 1,0M€/a

7min/h \Leftrightarrow 1,4M€/a

11min/h \Leftrightarrow 2,2M€/a



Concepts

Battery Bus with In-Motion-Charging (IMC)

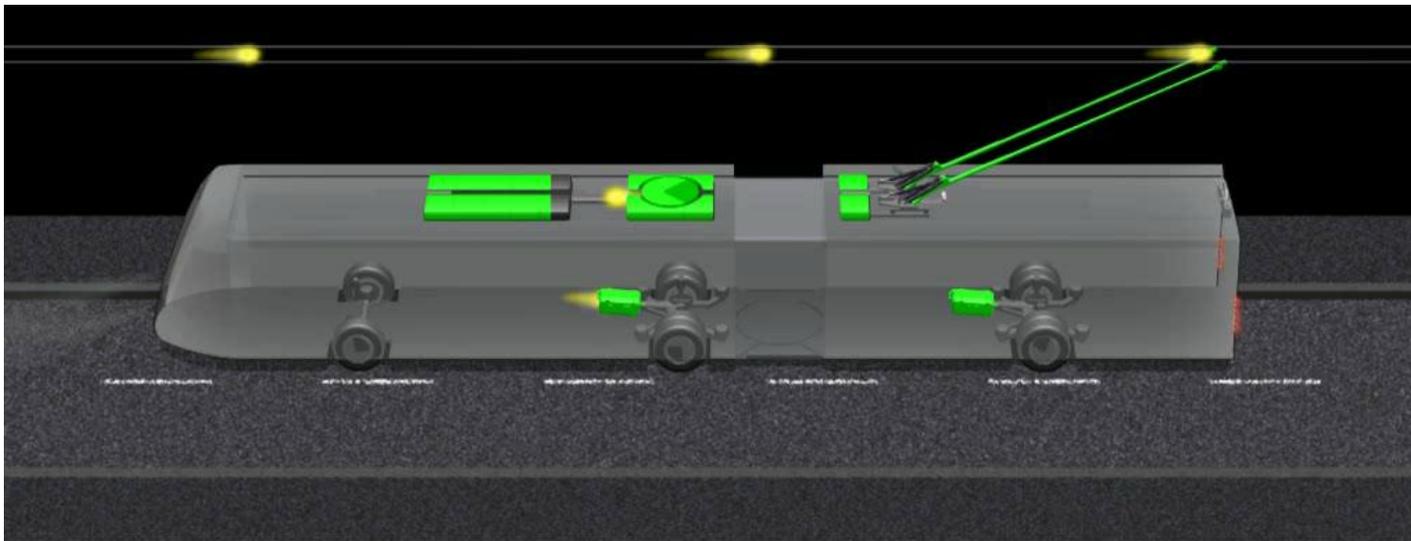
Advantages:

50% wireless sections

Lower infrastructure costs

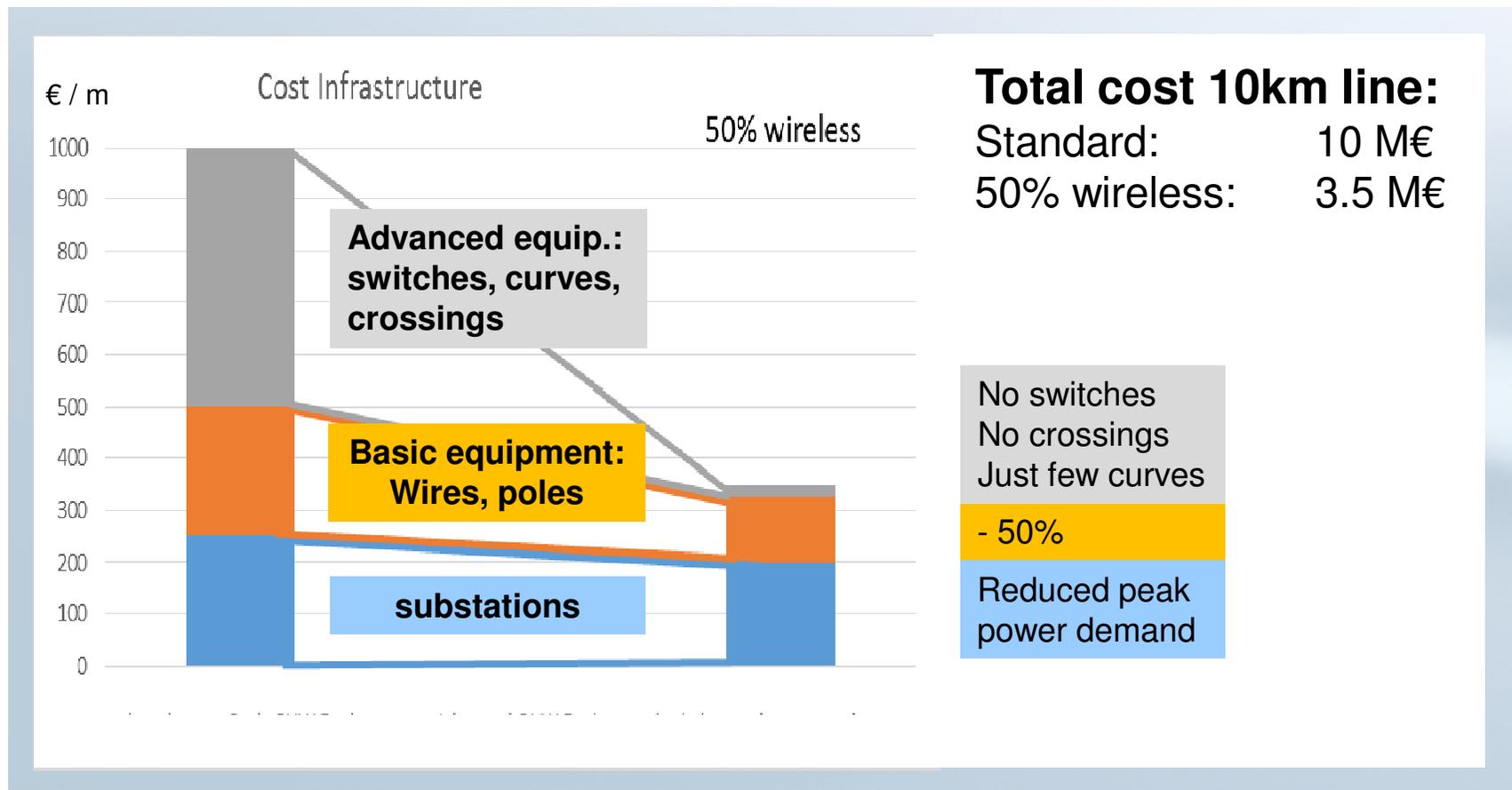
Reliable e-bus operation

**Proven Technology
in combination
with high-tech batteries**



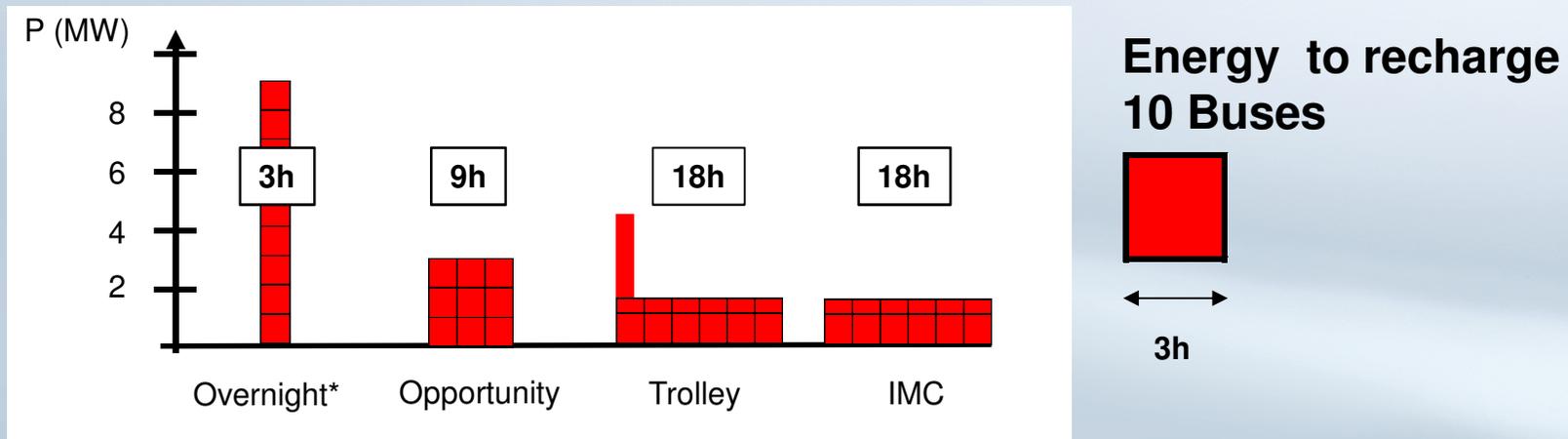
Facts and Figures - Infrastructure

Infra structure cost reduction due to partly wireless operation



Facts and Figure - Infrastructure Cost for charging station

Needed Charging power for 90 Buses (12m)



The shorter the charging time
→ The higher the power
→ The higher the costs

Example:
90 overnight battery buses
 $90 \times 100 \text{ kW} = 9 \text{ MW}$
(gas power?)

* $300 \text{ kWh} / 3\text{h} = 100 \text{ kW}$

Modern e-bus propulsion systems

Battery charging “stations”



Foto: Marcus Fey (Obus Museum Solingen)

In Motion Charging

How to plan an IMC overhead wire system

Take care about time



Wireless Section(s)

- Up to 50% of line
- Up to 50% of time
- ca 4km per section (max 15km)

Charging Sections

Charging time

- Slow roads
- End stations

Energy consumption

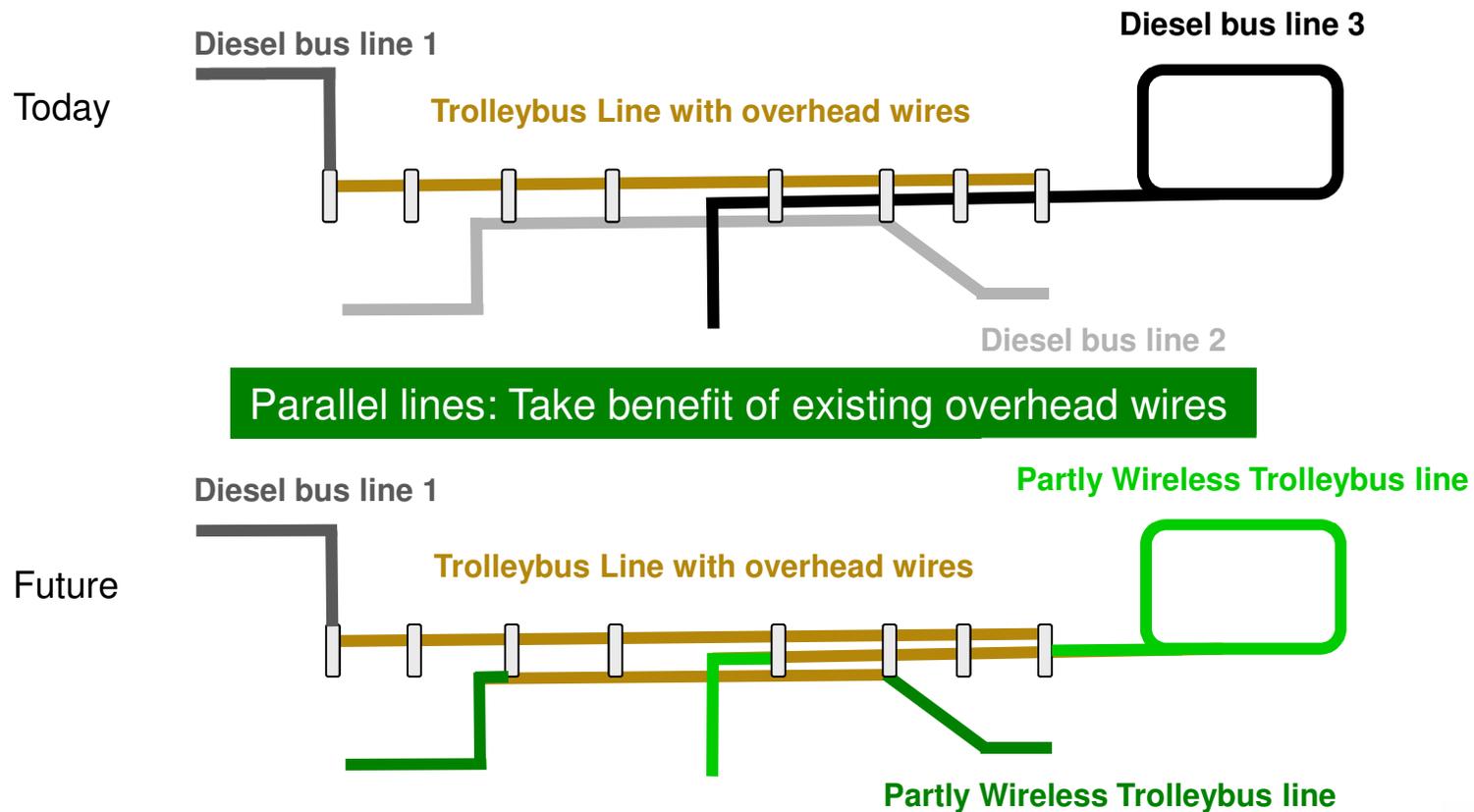
- Steep roads

Inexpensive installation

- Straight roads

The future of Electro-Mobility with Vossloh Kiepe

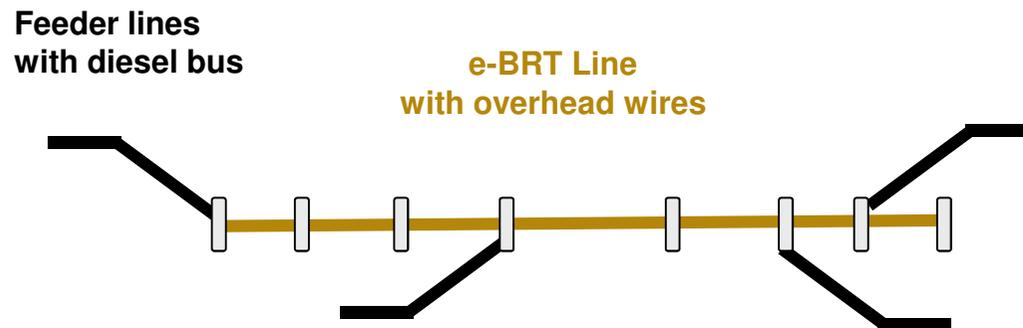
Transforming Diesel bus lines into partly wireless Trolley bus lines



Parallel lines: Take benefit of existing overhead wires

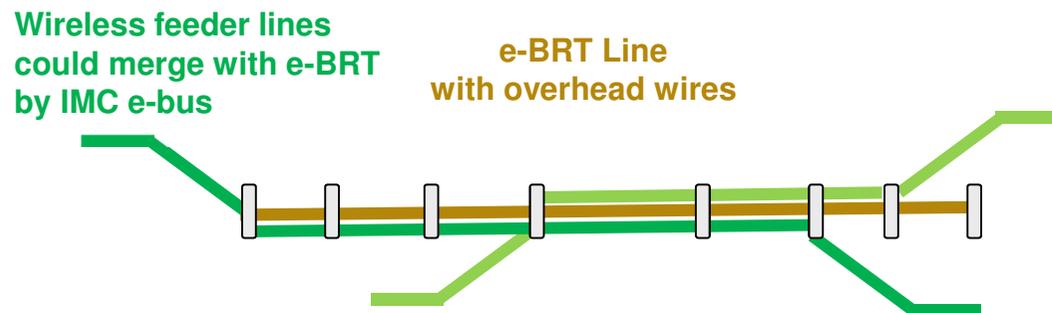
The future of Electro-Mobility with Vossloh Kiepe

New electric Bus Rapid Transit (e-BRT) system with IMC bus feeders



Passengers change bus from feeder bus to e-BRT bus

IMC feeder buses arrive at e-BRT destinations → less bus exchanges needed



Modern e-bus propulsion systems

Time for new branding name

Once upon a time....(1882)

a trolley (wagon)

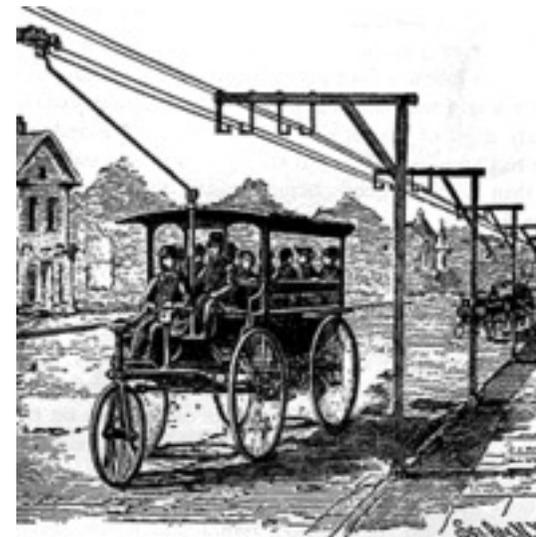
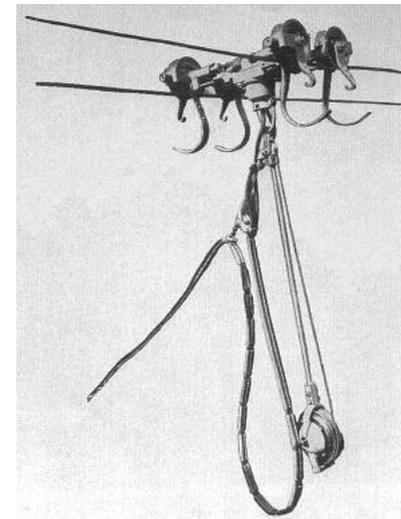
on the over head wire
collected the current for powering a the

“trolley bus”

Time for a new name:

- ▶ Electrical bus IMC (in Motion Charging)
- ▶ E-bus (with dynamic Range Extender)
- ▶ Tram bus (combining the advantages from tram and bus)
- ▶Lucerne: BHLS (**B**uses with a **H**igh **L**evel of **S**ervice)

1881 first tram



Modern e-bus propulsion systems Innovations and new Concepts



- ▶ New vehicle size:
24m double articulated bus with 200 passengers
e.g. Geneva (CH), Malatya (Turkey),



- ▶ New technology:
Accumulator (battery or super cap)
Zurich (CH).... / Milano, Parma (Italy)



- ▶ New design:
Tram look
e.g. Riad/Saudi Arabia (Limoges/France, ...)

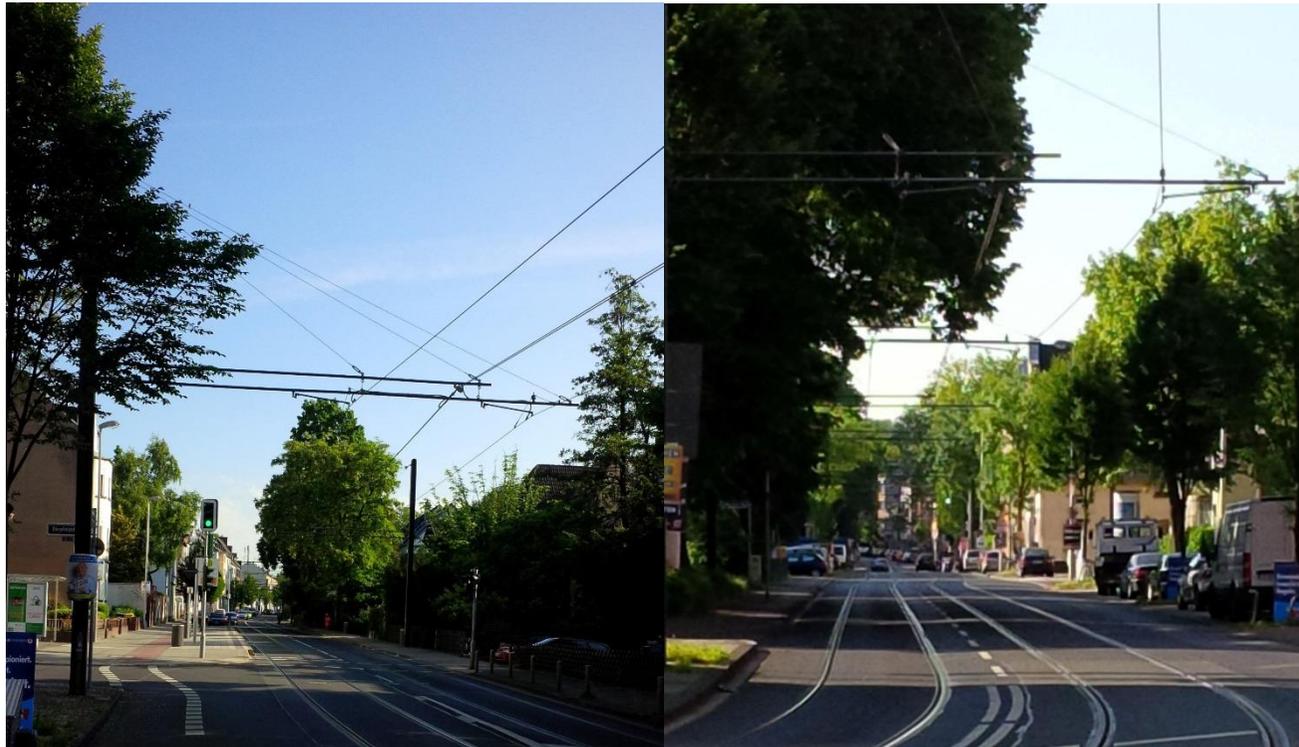


Modern e-bus propulsion systems
System of overhead wires – Düsseldorf/Germany



Modern e-bus propulsion systems

System of overhead wires – Düsseldorf/Germany



Modern e-bus propulsion systems

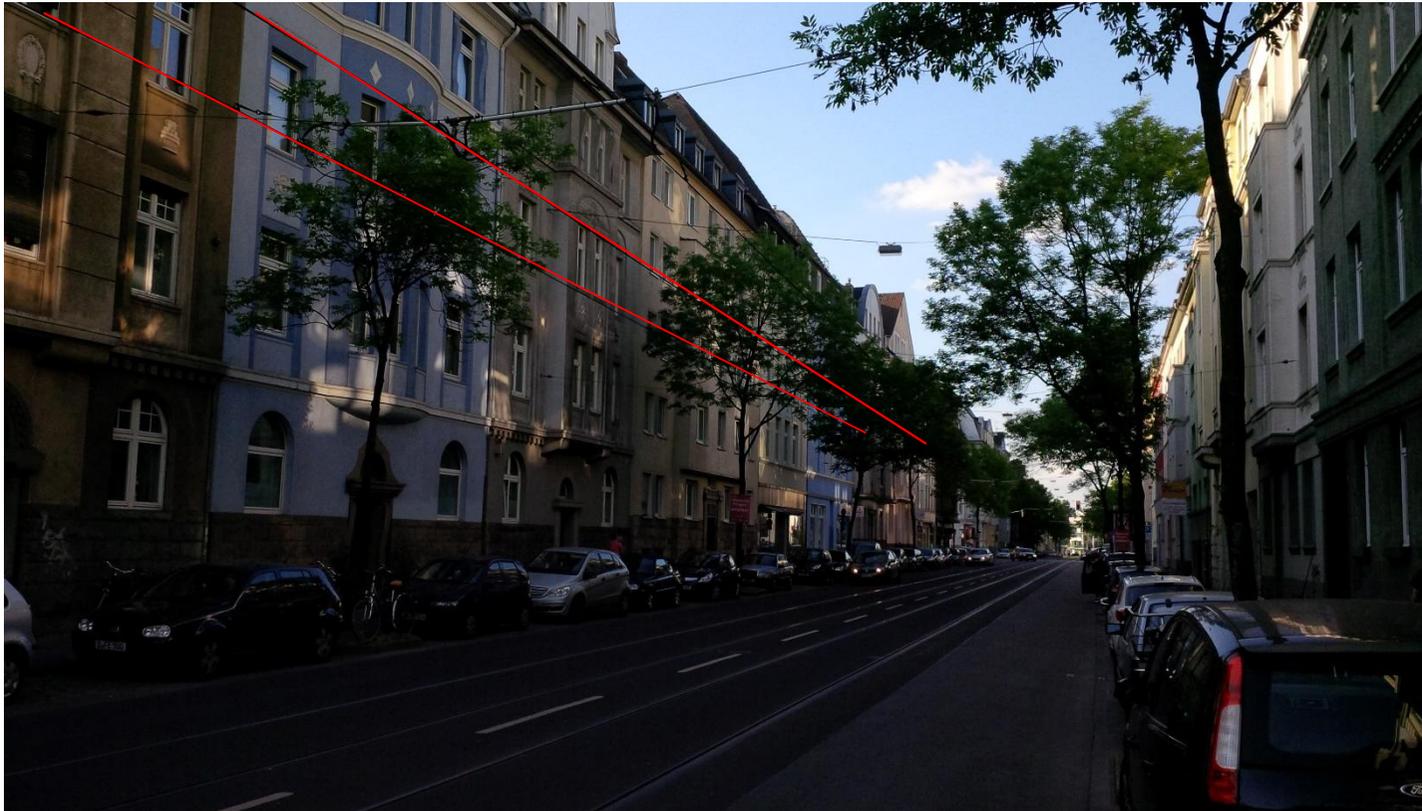
System of overhead wires – Düsseldorf/Germany



Modern e-bus propulsion systems
System of overhead wires – Düsseldorf/Germany



Modern e-bus propulsion systems
System of overhead wires – Düsseldorf/Germany



Modern e-bus propulsion systems

System of overhead wires – Düsseldorf/Germany



Field of Vision
Perception of ceiling

Where is that?



Field of Vision

Perception of ceiling in shopping centers



Field of Vision

Perception of ceiling in shopping centers

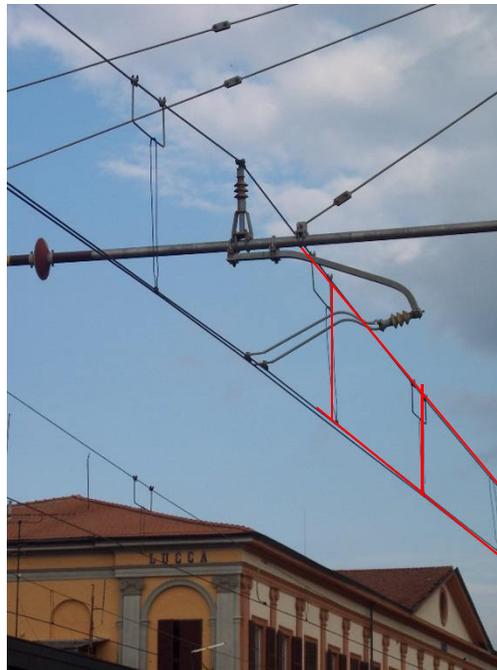


Customers just don't perceive the ceiling / the "sky"

Modern e-bus propulsion systems

Different visual impact of overhead wire system?

Tram / Light rail vehicle



Trolley bus



→ The visual impact is the same

In Germany exist already 68 overhead wire systems (65+3)

→ **Over head wire systems are already known and accepted**

Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here trees



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here trees



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here trees



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here trees



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here trees



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here trees



Modern e-bus propulsion systems

System of overhead wires – Montreux / Switzerland

Straight overhead wire lines are almost not perceived
Without background: free sky



Modern e-bus propulsion systems

System of overhead wires – Montreux / Switzerland

Straight overhead wire lines are almost not perceived
Without background: free sky



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Without background: free sky



Modern e-bus propulsion systems

System of overhead wires – Arnheim / Netherlands

Straight overhead wire lines are almost not perceived
Without background: free sky



Modern e-bus propulsion systems

System of overhead wires – Norway / Bergen

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here buildings



Modern e-bus propulsion systems

System of overhead wires – Norway / Bergen

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here buildings



Modern e-bus propulsion systems

System of overhead wires – Norway / Bergen

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here buildings



Modern e-bus propulsion systems

System of overhead wires – Norway / Bergen

Straight overhead wire lines are almost not perceived
Especially with backgrounds: here buildings



Modern e-bus propulsion systems

System of overhead wires – Fribourg / Switzerland



Modern e-bus propulsion systems

System of overhead wires – Fribourg / Switzerland



Modern e-bus propulsion systems

System of overhead wires – Fribourg / Switzerland



Modern e-bus propulsion systems

System of overhead wires – Fribourg / Switzerland



Modern e-bus propulsion systems

System of overhead wires – Lausanne / Switzerland

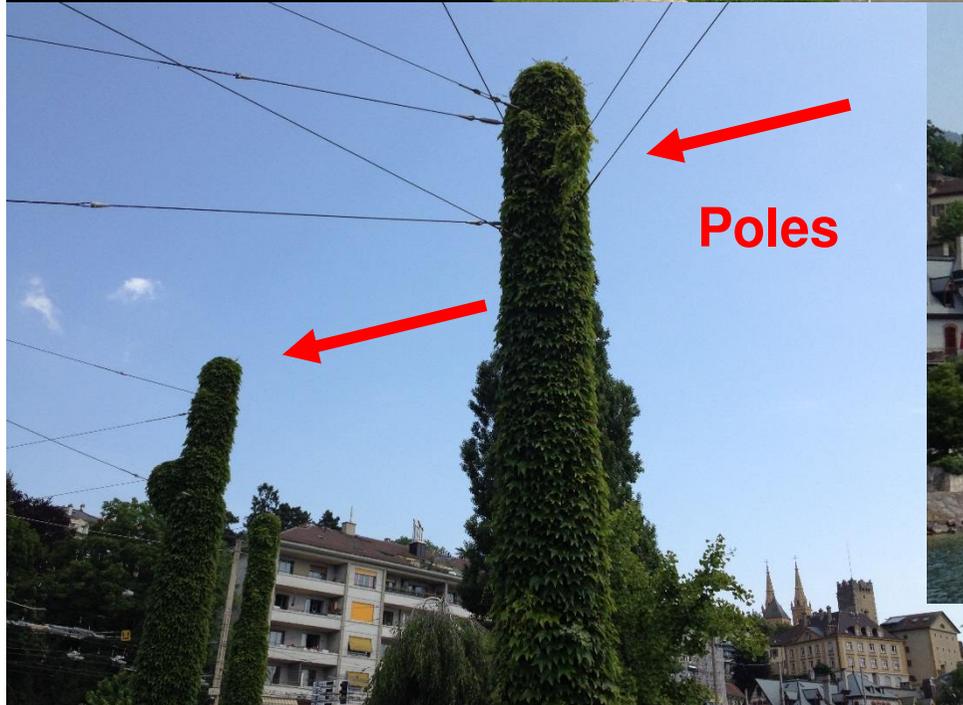
Street café at the water front (Lac Lemman)

„Café Zero Emission“ instead of „Café noxious fumes“



Modern e-bus propulsion systems

System of overhead wires – Fribourg / Switzerland



Modern e-bus propulsion systems

System of overhead wires - Landskrona / Sweden



Modern e-bus propulsion systems

System of overhead wire – Pescara / Italy



Modern e-bus propulsion systems

Catenary system – Malatya / Turkey



Modern e-bus propulsion systems

New systems since 2000 - (a selection)

▶ Landskrona	1 st	Sweden	09.2003
▶ Roma	13 th	Italy	03.2005
▶ Castellón	1 st	Spain	06.2008
▶ Chieti	14 th	Italy (re-activated)	09.2009
▶ Lecce	15 th	Italy	01.2012
▶ Riyadh	1 st	Saudi Arabia	10.2012



Modern e-bus propulsion systems

New systems – coming soon

Under construction / permission for official operation

- ▶ Pescara Italy
- ▶ Avellino Italy
- ▶ Bari Italy (re- activation)
- ▶ Malatya Turkey 1st in country

Planning phase

- ▶ Şanlıurfa Turkey 2nd in country
- ▶ 2 Riyadh + Jeddah Saudi Arabia
- ▶ Leeds UK 1st in country
- ▶ Bogota Colombia 1st* in country
- ▶ Several cities Italy



Modern e-bus propulsion systems

Summary: Why the wires?



- ▶ Reliable e-bus concept with very high availability → Low vehicle reserve needed
- ▶ Highest energy efficiency
- ▶ “Unlimited” energy available “just in time”
 - convenient for heating & air conditioning, infotainment
- ▶ High passenger capacity possible up to 220 pers/bus (with few personnel)
- ▶ Fast with powerful climbing characteristics
- ▶ Range of Zero Emission operation is “unlimited”
- ▶ IMC battery charging is easy on battery and therefore on battery live time
- ▶ Universal interface for battery charging (not tying up to an unique provider with monopole)
- ▶ Bus driver doesn't have to wait for battery recharging (TCO)
- ▶ Low peak power requirement for substations (= battery charging)
- ▶ Most economical zero emission bus operation for medium too high traffic

Vossloh Kiepe – One Source for Your eBus System

IMC e-bus is a strong trend



2015 Esslingen (4)



2014/2015 Seattle (141)



2014/2015 San Francisco (60)



2014 Lucerne (9)



2013/2014 Geneva (33)



Zürich (35) **2012**



2005 Vancouver (262)

Modern e-bus propulsion systems

Trolleybus References (a selection)

- ▶ **Germany:** Esslingen, Solingen, Eberswalde
- ▶ **France:** Lyon, Limoges
- ▶ **Ecuador:** Quito
- ▶ **Greece:** Athens
- ▶ **Italy:** La Spezia, Parma, Bologna, Avelino, ...
- ▶ **Canada:** Vancouver
- ▶ **Latvia:** Riga
- ▶ **Austria:** Linz, Salzburg, Innsbruck
- ▶ **Switzerland:** Fribourg, Geneva, Bern, Lucerne, Zurich, ...
- ▶ **Venezuela:** Mérida
- ▶ **Turkey:** Malatya*
- ▶ **Norway:** Bergen
- ▶ **USA:** Philadelphia, (San Francisco*, Seattle*)
- ▶ **Saudi Arabia:** Riyadh



Modern e-bus propulsion systems

Diesel-Hybrid bus References

- ▶ **Netherlands:** Enschede, Groningen
- ▶ **Luxembourg:** Luxembourg
- ▶ **Switzerland:** Basel
- ▶ **Germany:** Darmstadt, Dortmund, Dresden, Düsseldorf, Ennepetal, Hagen, Leipzig, Hagen, Leipzig, Lübeck, Wuppertal, Hamburg
- ▶ **Poland:** Co. Solaris



Modern e-bus propulsion systems

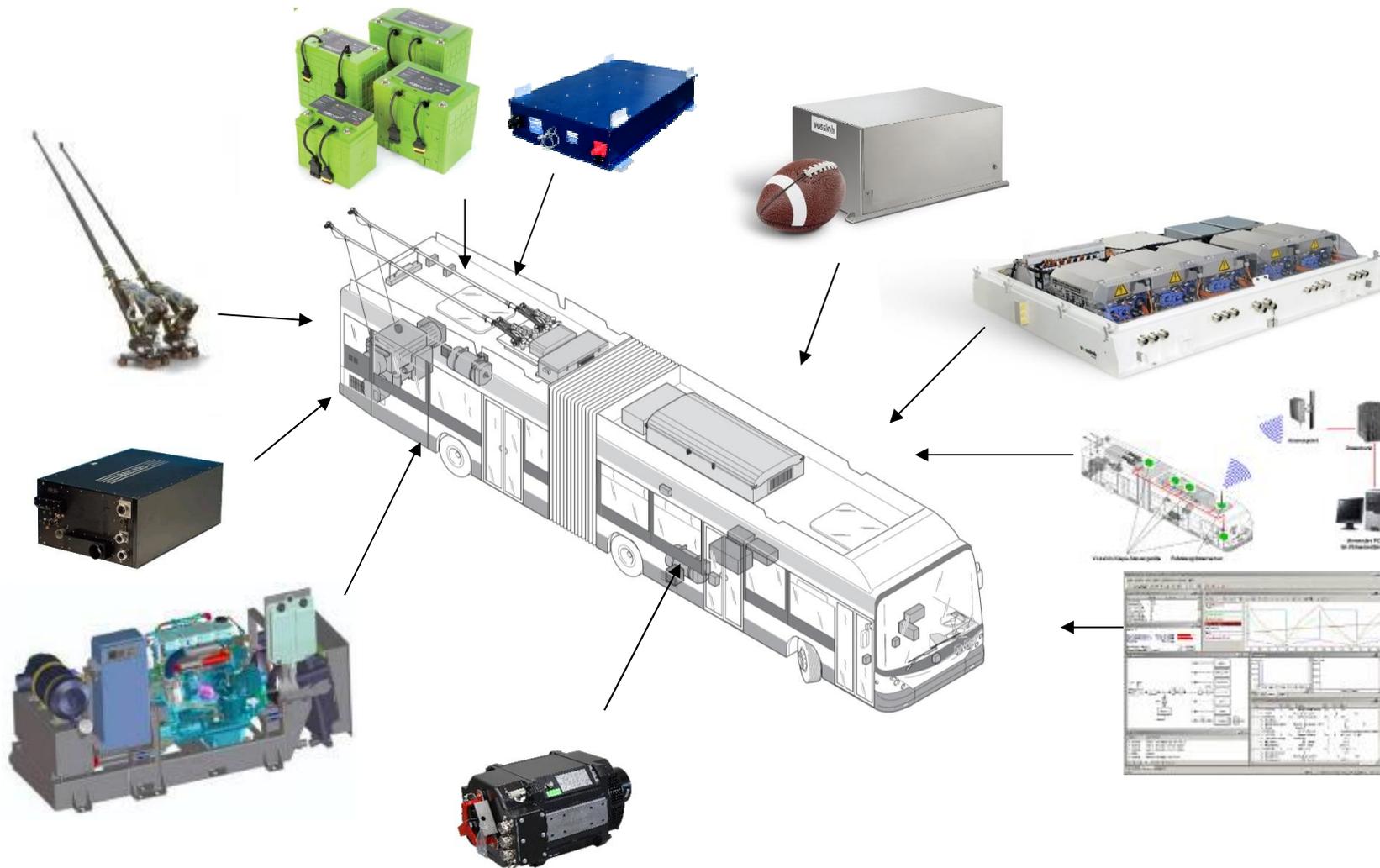
Fuel-Cell & Battery Bus References

- ▶ **Netherlands:** Amsterdam
- ▶ **Austria:** Klagenfurt
- ▶ **Poland:** Krakow, Co. Solaris
- ▶ **Germany:** Cologne, Düsseldorf, Braunschweig, Hamburg



Modern e-bus propulsion systems

One platform – plenty solutions



Vossloh Kiepe
How can we help you?

Tell us your needs ...

... and we can advice you the right e-bus concept



Erik Lenz
Vossloh Kiepe GmbH
Kiepe-Platz 1
D - 40599 Düsseldorf

Tel: + 49 211 7497 473
Fax: + 49 211 7497 1473
Mob: + 49 172 8563 411

E-Mail: E.Lenz@vkd.vossloh.com

Disclaimer

The presentation contains forward-looking statements that are based on current estimates and assumptions made by the management of VOSSLOH to the best of its knowledge. Such forward-looking statements are subject to risks and uncertainties, the non-occurrence or occurrence of which could cause a material difference in future results including changes in political, business, economic and competitive conditions, regulatory reforms, effects of future judicial decisions, foreign exchange rate fluctuations and the availability of financing. Neither VOSSLOH nor any of its affiliates, advisors or representatives shall have any liability whatsoever (in negligence or otherwise) for any loss arising from any use of this presentation or its content or otherwise arising in connection with this document. VOSSLOH does not undertake any responsibility to update the forward-looking statements contained in this presentation.

The information provided in this presentation does not represent an offer or invitation for the purchase of the stock of VOSSLOH AG or other companies, nor should it be considered as a call to purchase or otherwise trade stocks directly or indirectly.