



Modern e-bus propulsion systems

4. International E-Bus-Conference in Hamburg

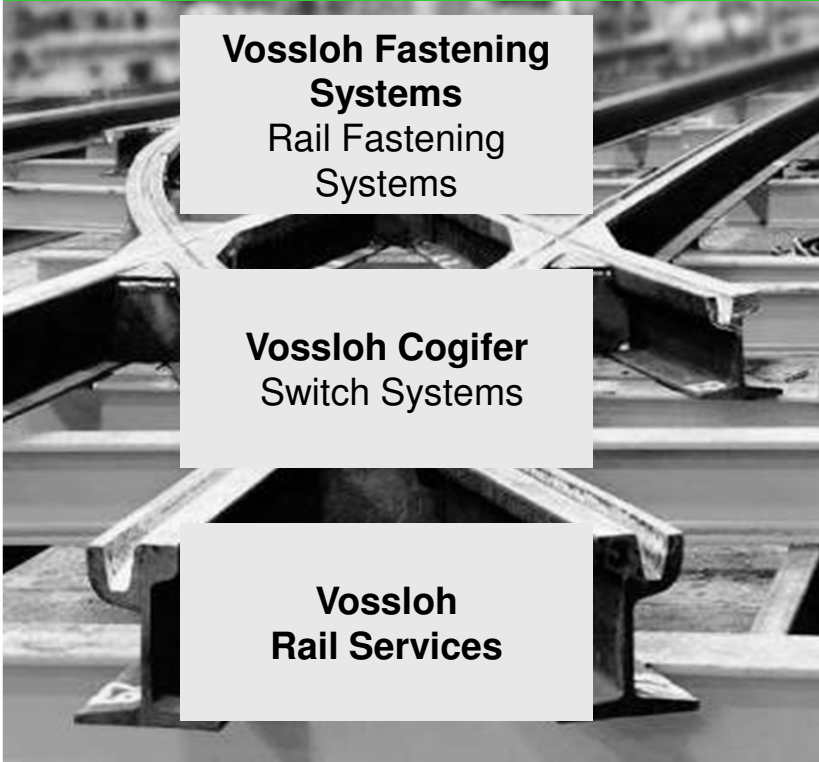
Erik Lenz 17.11.2014



Vossloh Kiepe
Kiepe in the Vossloh Group

Vossloh AG

Rail Infrastructure

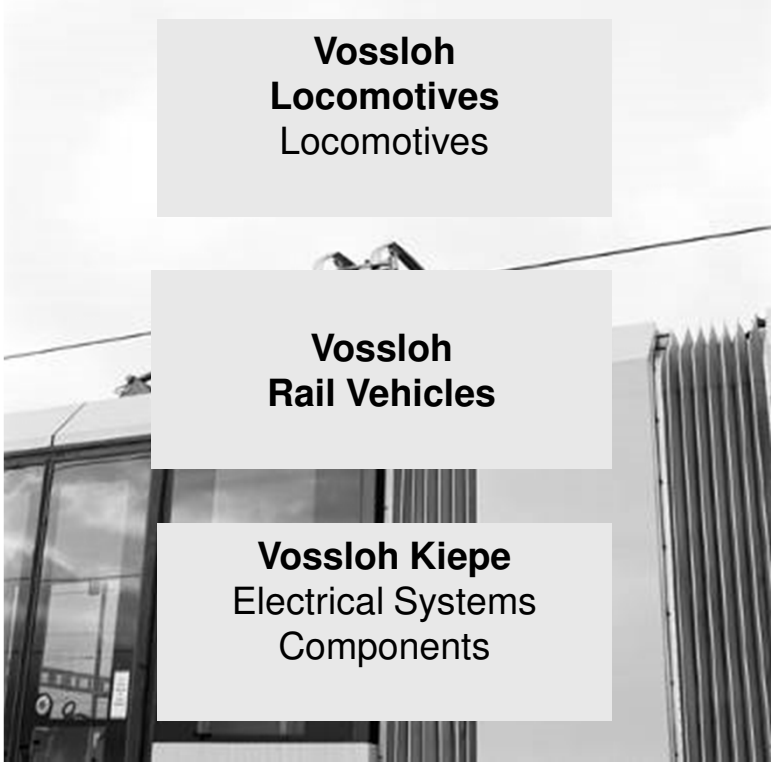


**Vossloh Fastening
Systems**
Rail Fastening
Systems

Vossloh Cogifer
Switch Systems

**Vossloh
Rail Services**

Transportation



**Vossloh
Locomotives**
Locomotives

**Vossloh
Rail Vehicles**

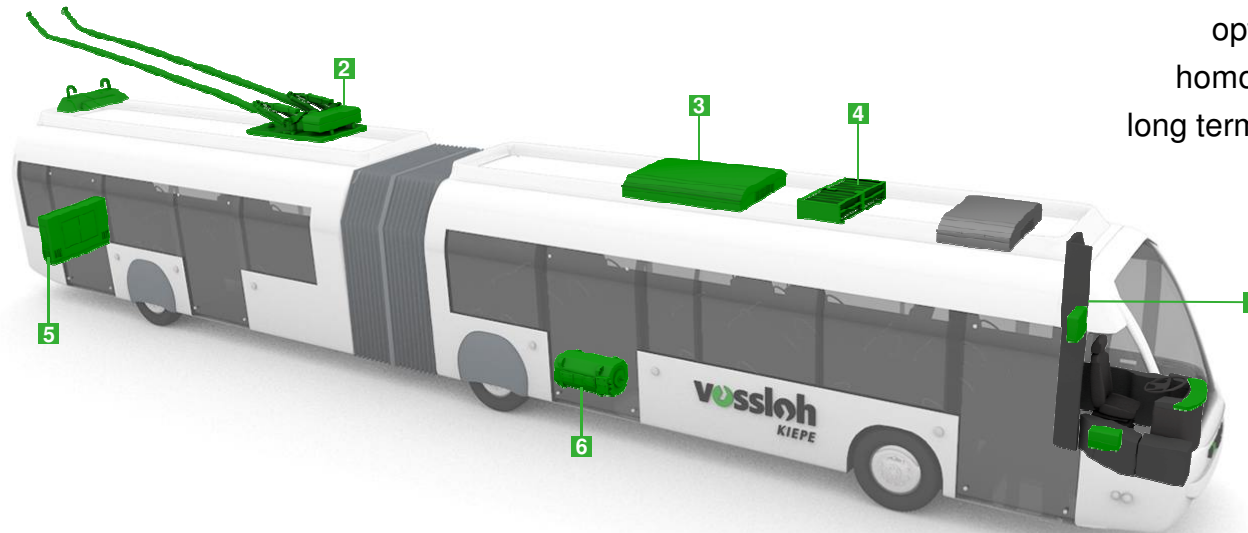
Vossloh Kiepe
Electrical Systems
Components

Modern e-bus propulsion systems

Trolley Bus Propulsion System

System Integrator

make it work reliable
optimize
homologation
long term availability

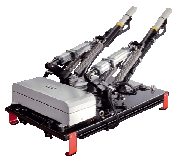


1 Energy Management

Controlling Units, Diagnostics



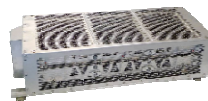
2 Current Collector



3 Power Electronics



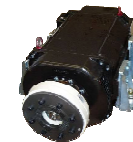
4 Brake Resistor



5 Auxiliary Power Unit (APU)

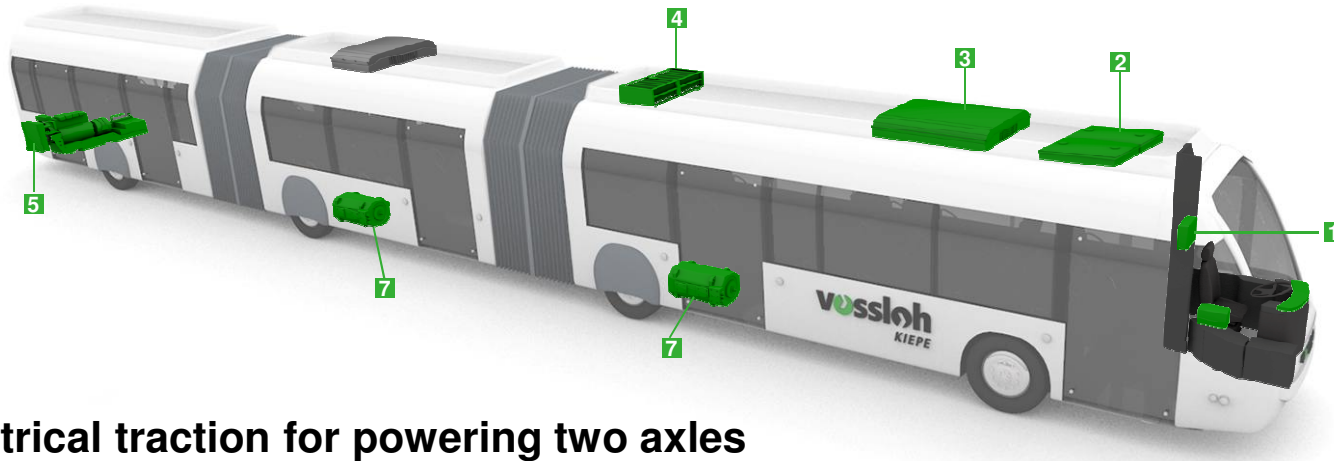


6 Traction Motor



Modern e-bus propulsion systems

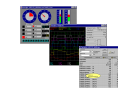
e-Bus Variations: Serial Diesel Electric Hybrid



Electrical traction for powering two axles

1 Energy Management

Controlling Units, Diagnostics



2 Energy Storage



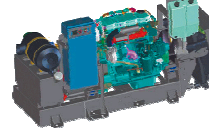
3 Power Electronics



4 Brake Resistor



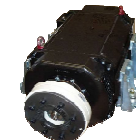
5 Main Power Unit (MPU)



6 Pantograph



7 Traction Motor



Concepts

Overnight charging Battery Bus

Project Rheinbahn



Max. charging power:

90 kW

Installed energy:

200 kWh

Range:

app. 110km

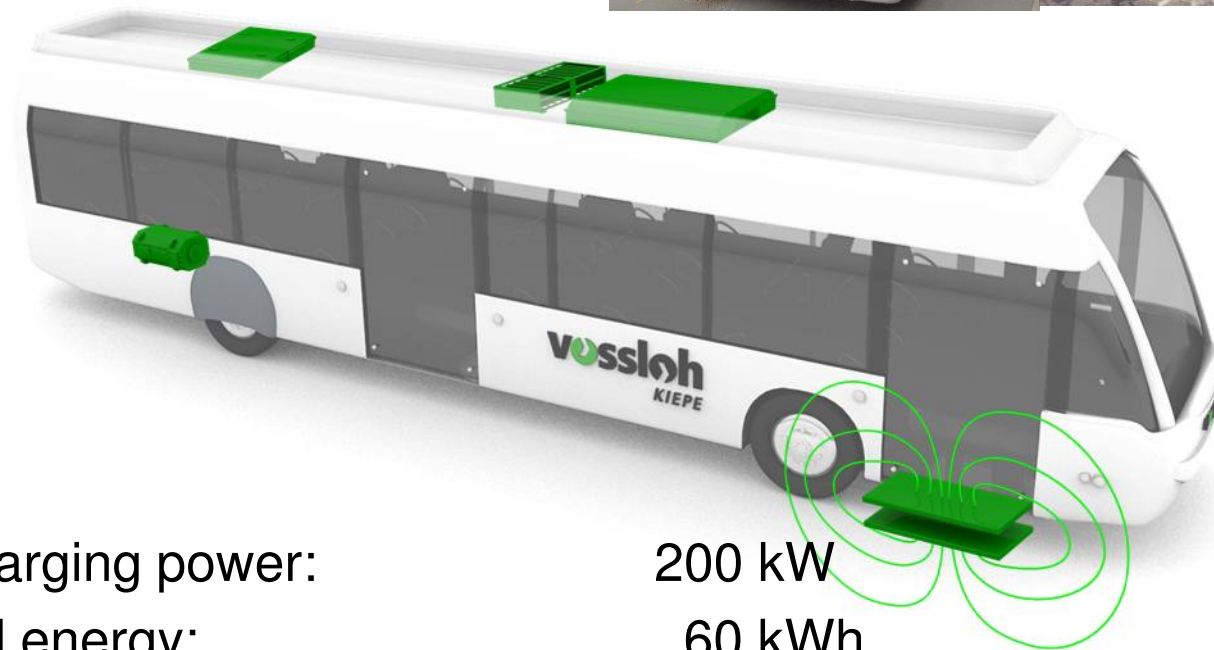
Charging time per day:

2,5h night + 0,5 h during breaks

Project Braunschweig

Concepts

Battery Bus inductive charging



Max. charging power:

200 kW

Installed energy:

60 kWh

Average charging time per hour:

8min + coupling

Project SEB Dresden

Concepts

Battery Bus fast charging via pantograph

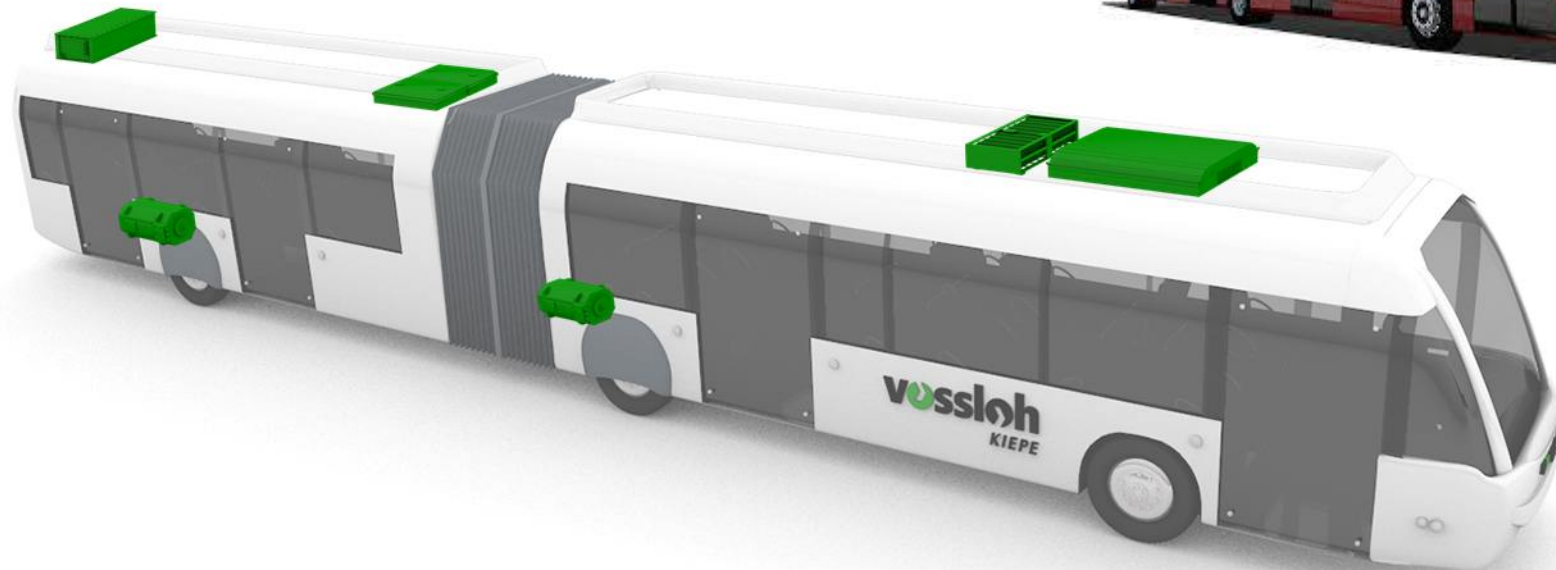


Max. charging power:	500 kW
Installed energy:	86 kWh
Average charging time per hour:	3min + coupling

Project Hamburg

Concepts

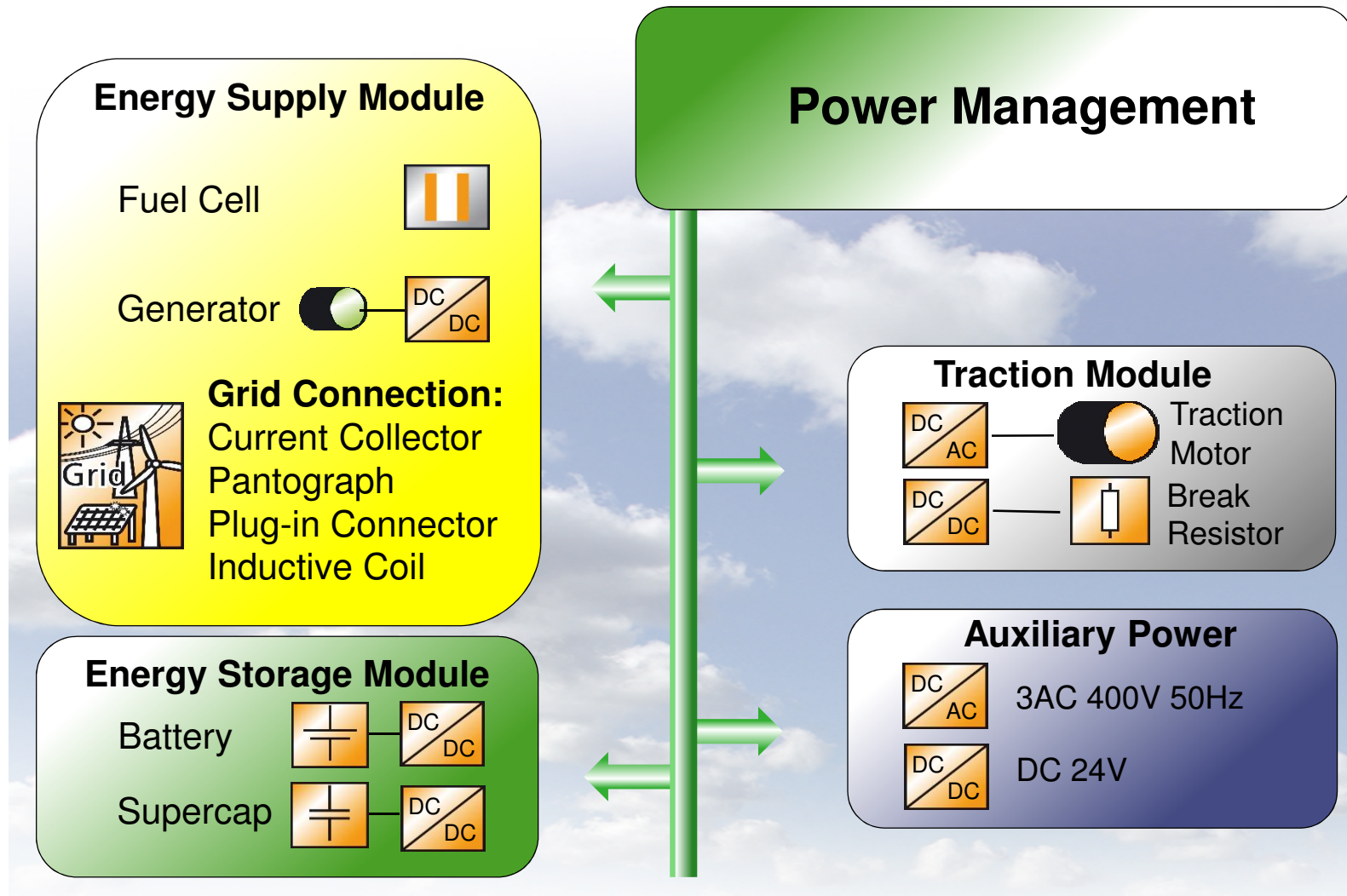
Battery Bus with Fuel Cell as Range Extender



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

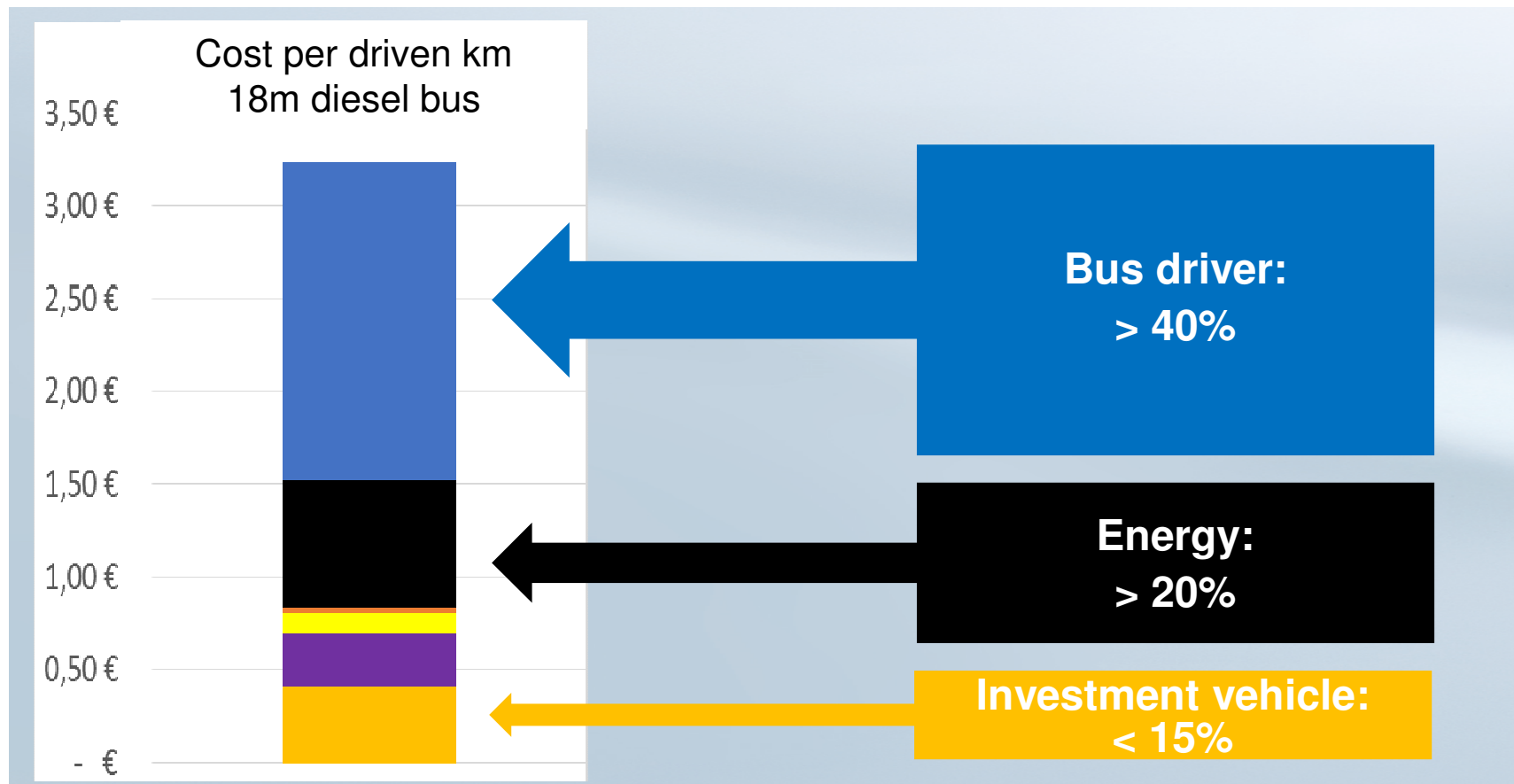


Facts and Figures



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)

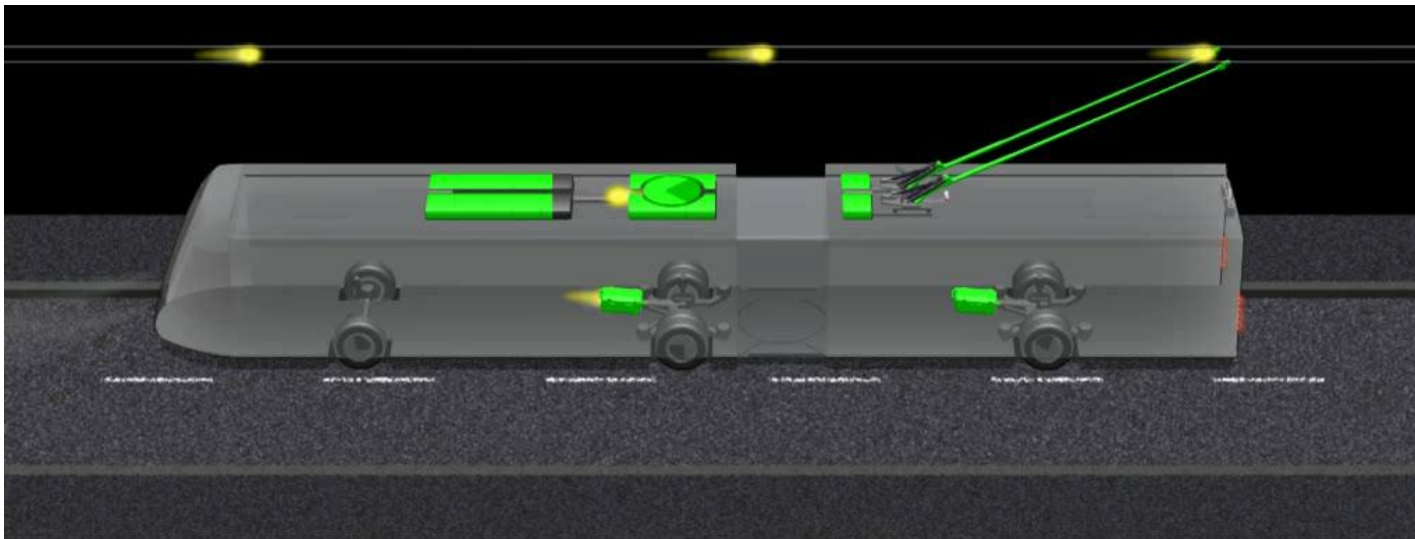
Advantages:

50% wireless sections

Lower infrastructure costs

Reliable e-bus operation

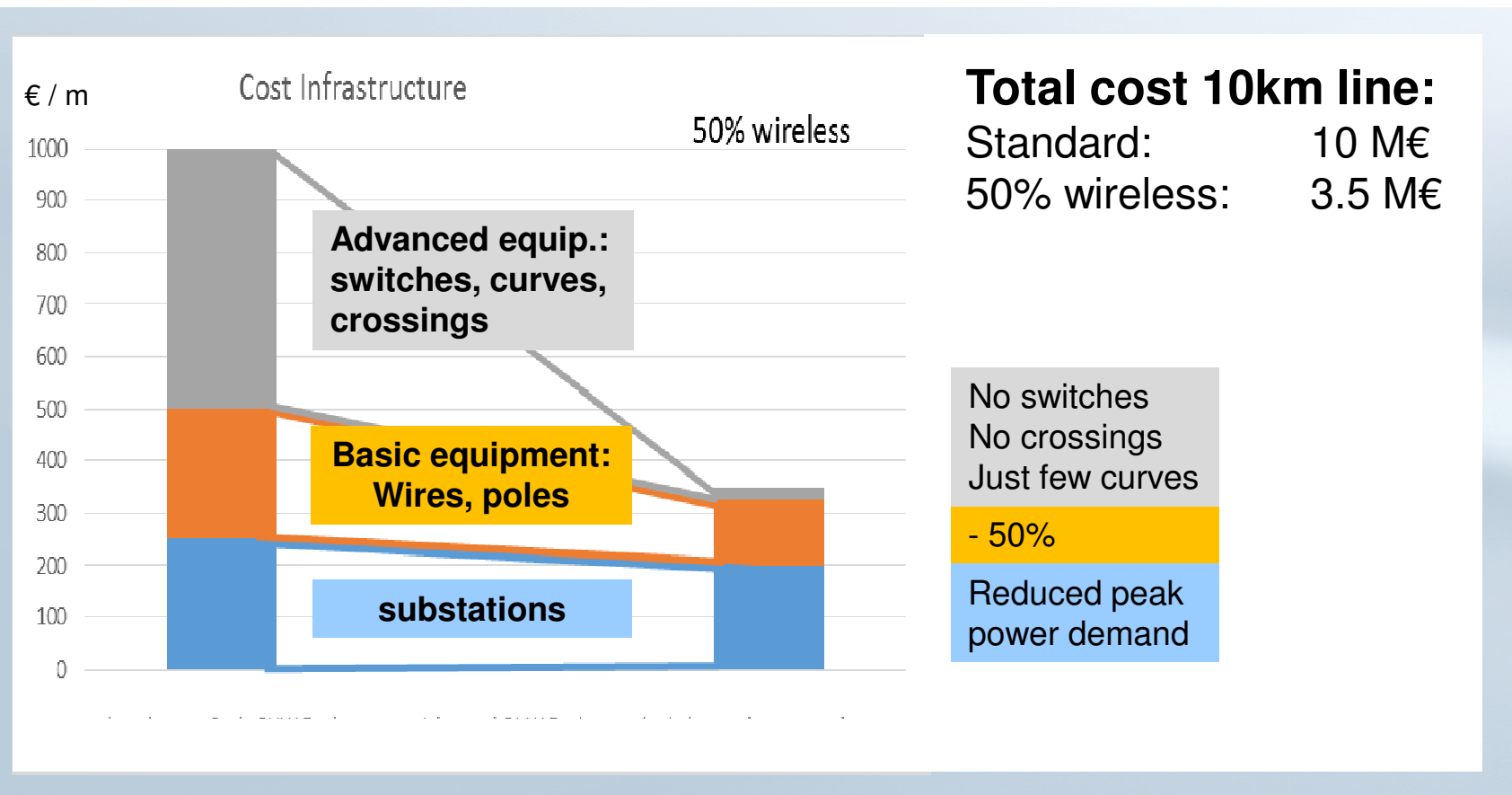
**Proven Technology
in combination
with high-tech batteries**



Future Meets Experience

Facts and Figures - Infrastructure

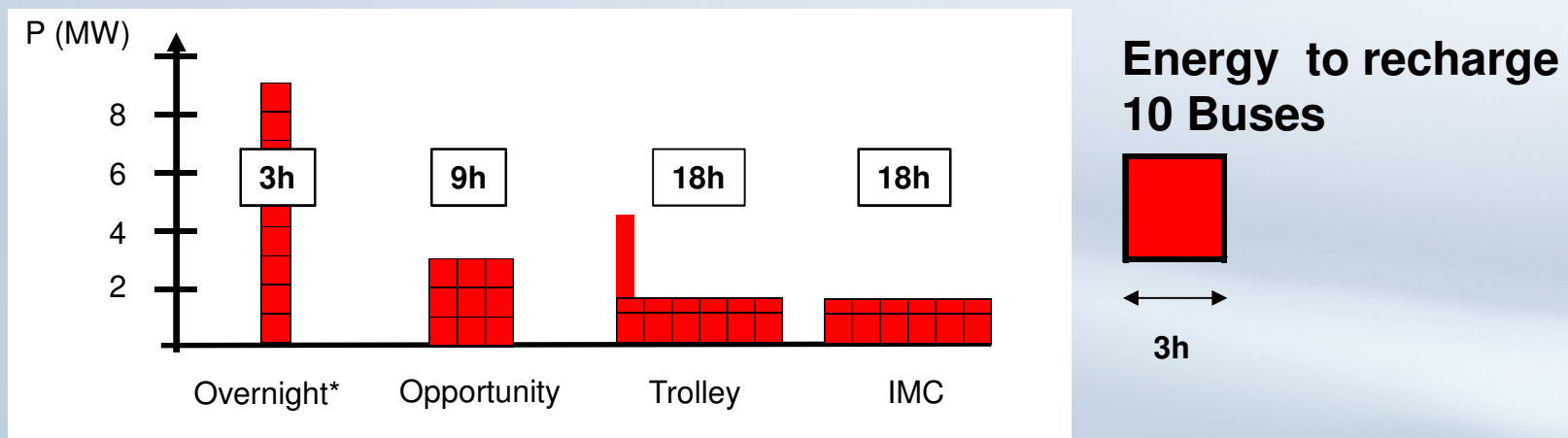
Infra structure cost reduction due to partly wireless operation



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”

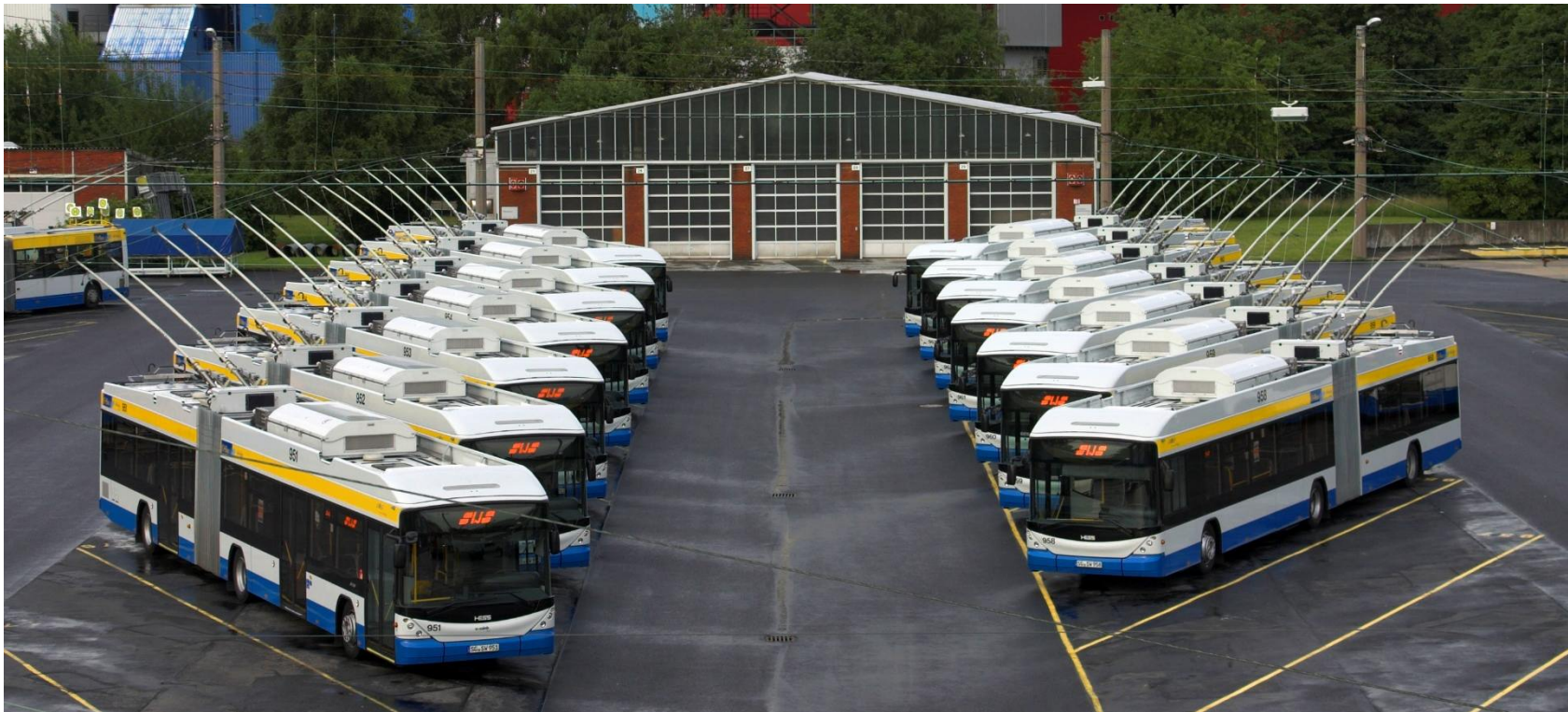


Foto: Marcus Fey (Obus Museum Solingen)

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

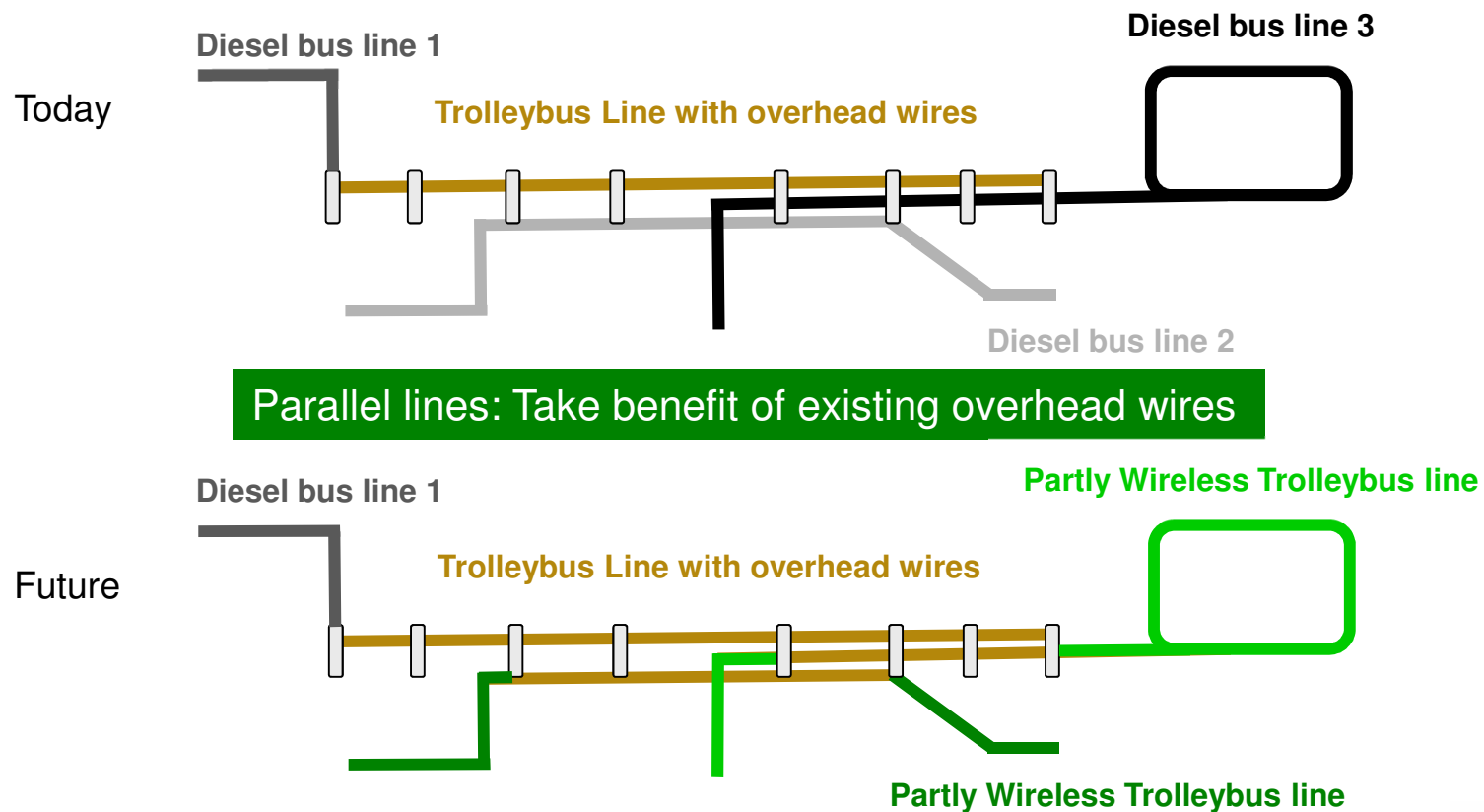
- Steep roads

Inexpensive installation

- Straight roads

The future of Electro-Mobility with Vossloh Kiepe

Transforming Diesel bus lines into partly wireless Trolley bus lines

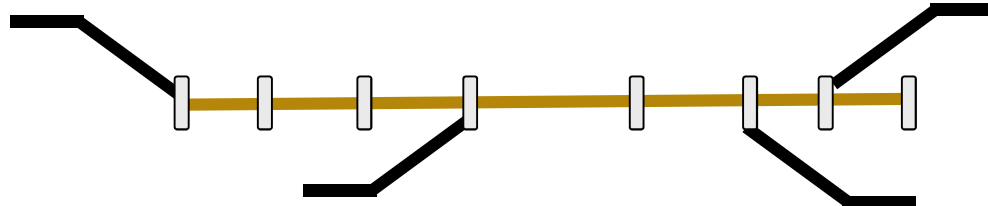


The future of Electro-Mobility with Vossloh Kiepe

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

Feeder lines
with diesel bus

e-BRT Line
with overhead wires

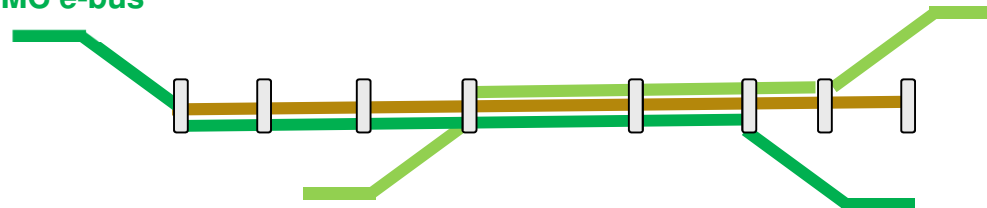


Passengers change bus from feeder bus to e-BRT bus

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

Wireless feeder lines
could merge with e-BRT
by IMC e-bus

e-BRT Line
with overhead wires



Modern e-bus propulsion systems

Time for new branding name

Once upon a time....(1882)

a trolley (wagon)

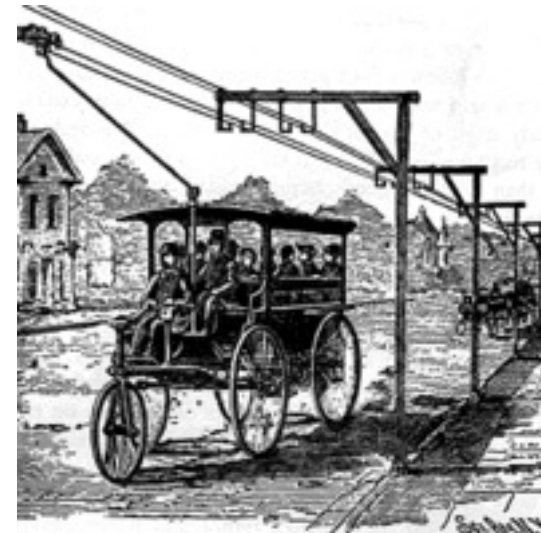
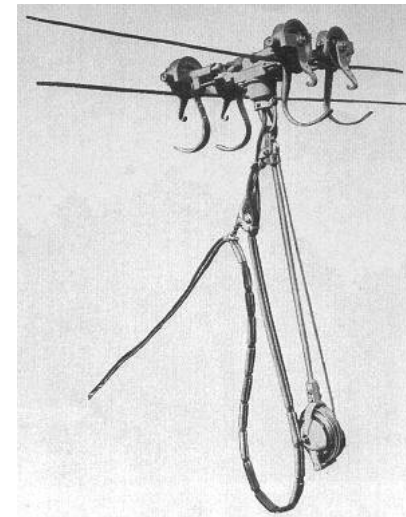
on the over head wire

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, ...)



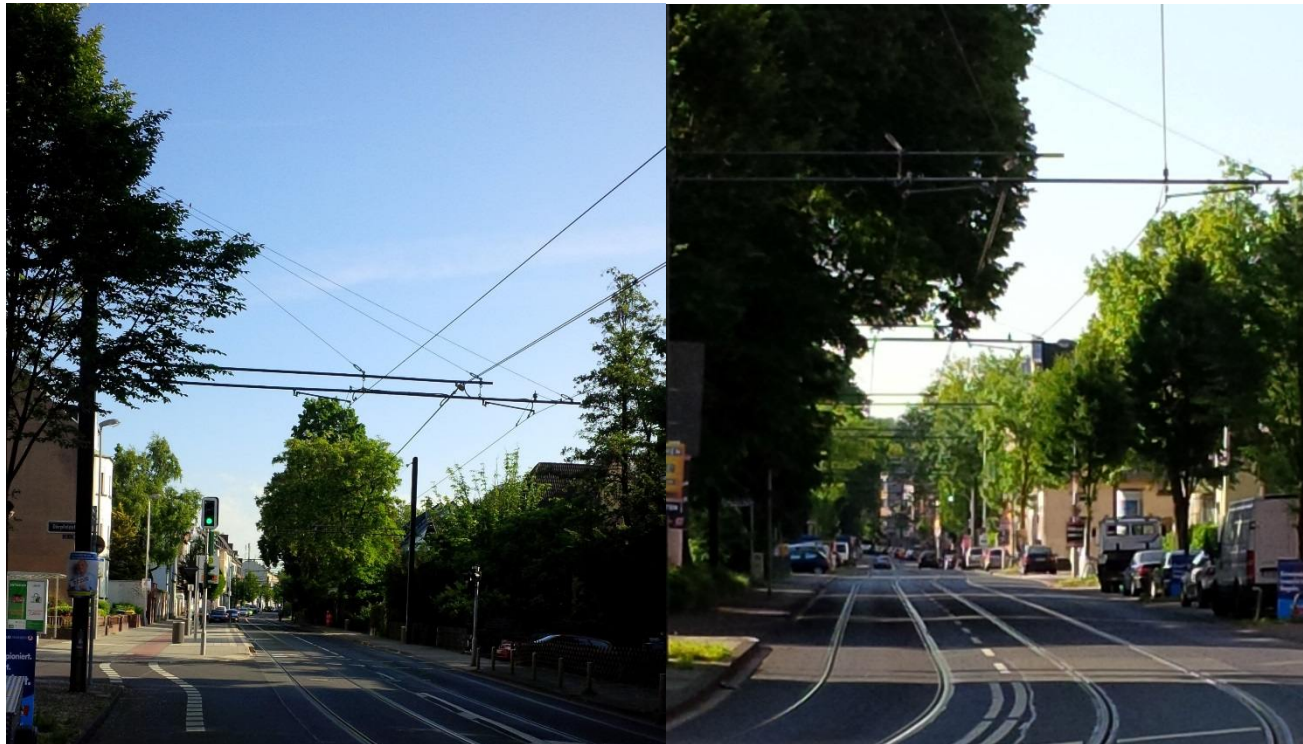
Modern e-bus propulsion systems

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



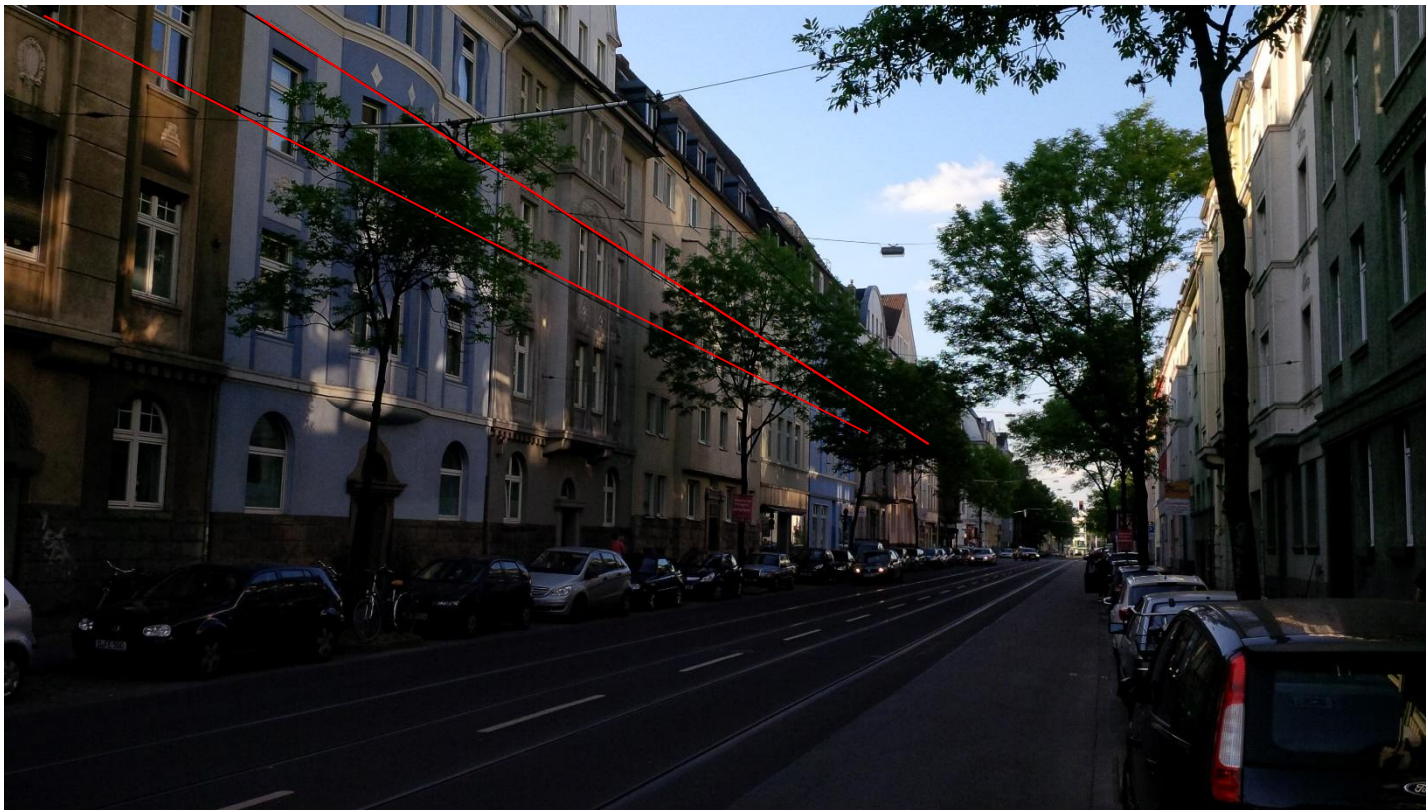
Modern e-bus propulsion systems

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

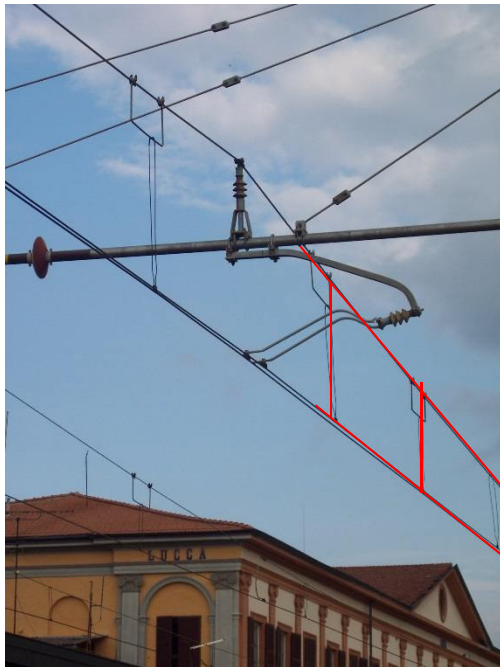


Customers just don't perceive the ceiling / the "sky"

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



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Modern e-bus propulsion systems

System of overhead wires – Montreux / Switzerland

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



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System of overhead wires – Montreux / Switzerland

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



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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



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Modern e-bus propulsion systems

System of overhead wires – Fribourg / Switzerland



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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

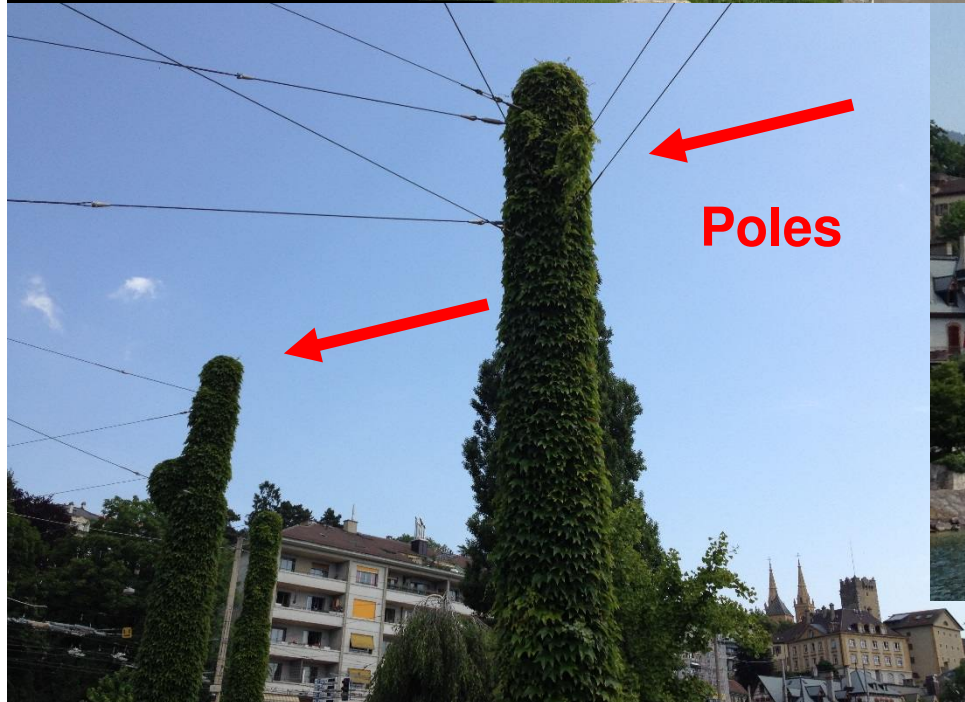
Street café at the water front (Lac Lemman)

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



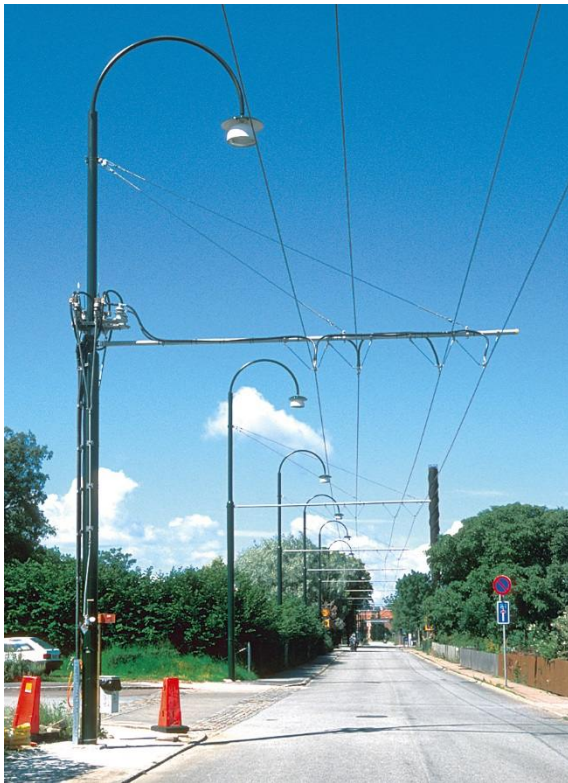
Modern e-bus propulsion systems

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

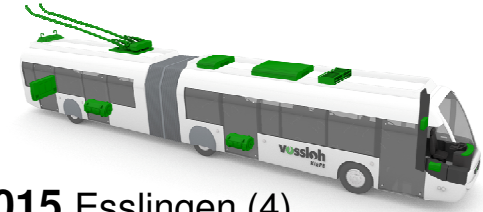
Summary: Why the wires?



- ▶ 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 monopoly)
- ▶ 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 San Francisco (60)



2014/2015 Seattle (141)



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

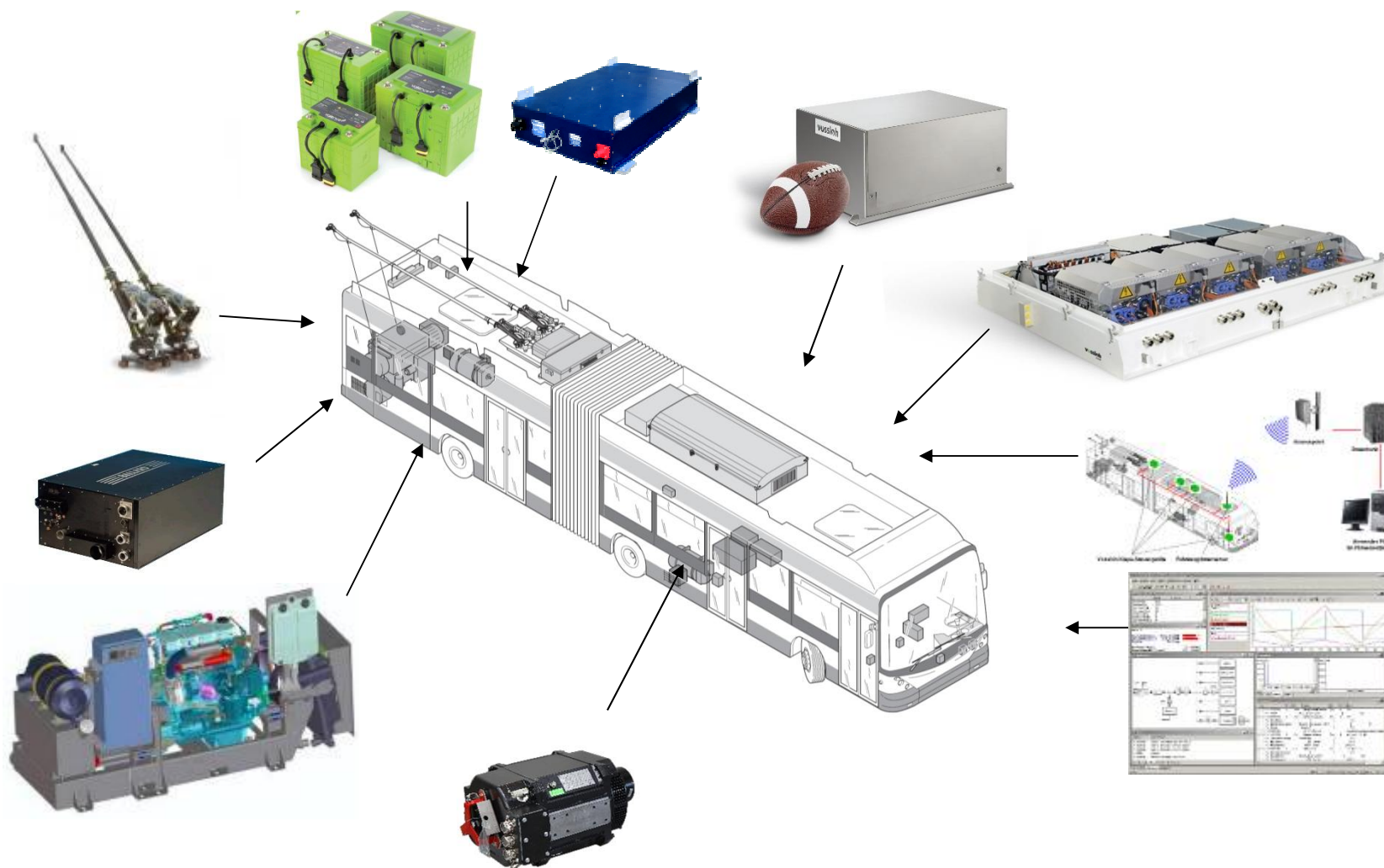
Fuel-Cell & Battery Bus References

- **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

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