



Hybrid Drive Systems for Buses

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Overview

- Goal
- Retrospect
- Serial and Parallel Hybrid Systems
- Practical Experiences
- German Funded Project Electric Mobility
- Starting Points for a Further Development
- Conclusion

Hybrid Drive Systems for Buses

Our Goal:

- Reduction of fuel consumption and emissions
 - More value for the environment

Our Approach:

- We develop solutions for hybrid drives in citybuses:
 - DIWAhybrid (parallel) – applications for buses with higher average speeds
 - ElvoDrive (serial) – applications for buses with lower average speeds
- Both hybrid systems have their justification and are based on our competency in bus applications.

Hybrid Drive Systems for Buses Retrospect



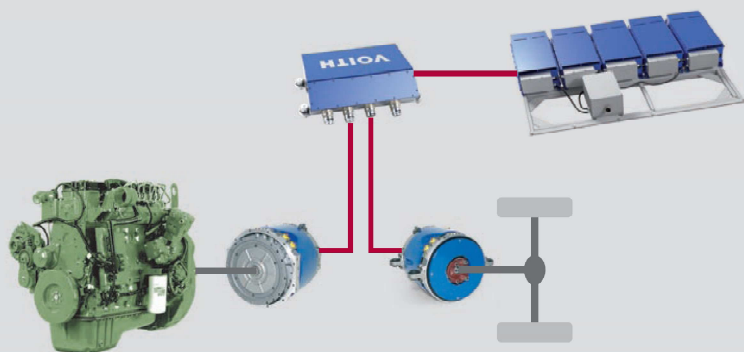
- Serial diesel-electric drive system based on the Voith-TFM technology;
- drive motors located close to the wheels;
- presented on the IAA 1994 and also in Luzern 1996

Hybrid Drive Systems for Buses Retrospect



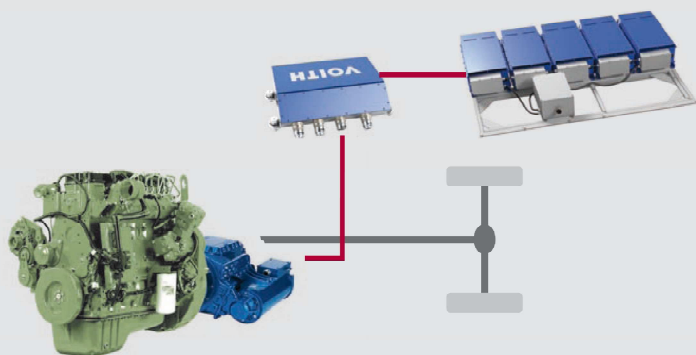
- Serial diesel-electric drive line, presented on the UITP 1997 in Stuttgart
- Diesel engine 162 kW with Voith-TFM-generator;
- two asynchronous motors as central motor unit
- in daily operation in Nuremberg from 1998 on, about 40.000 - 50.000 km p.a.

Overview Voith Hybrid Systems



Voith ElvoDrive – serial hybrid

- Flexible integration in bus structure
- High fuel saving potentials at inner city cycles



Voith DIWAhybrid – parallel hybrid

- Easy integration in existing bus structure
- High fuel saving potentials in city cycles with higher average speed

Hybrid Drive Systems for Buses ElvoDrive (serial)



- Required output is transmitted fully electrically
- ElvoDrive is based on Voith TFM Technology (TFM: Transversal flux machine)
- High torque at compact design and high efficiency
- TFM suitable both as drive motor and as generator

Hybrid Drive Systems for Buses ElvoDrive (serial)

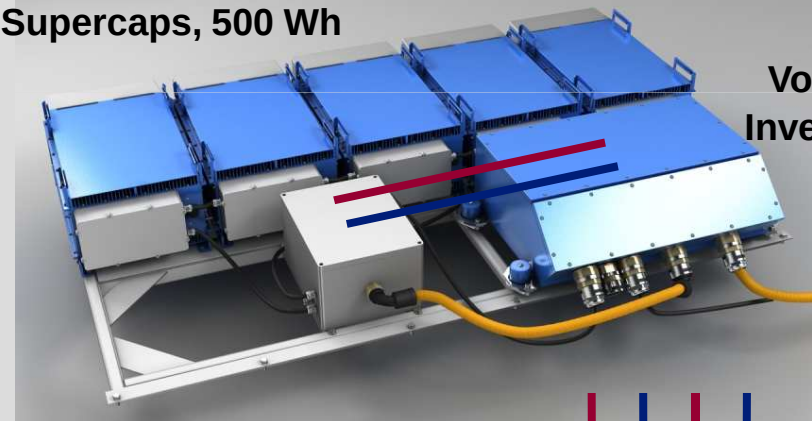


TFM as
drive motor



TFM as
generator

Energy storage unit
Supercaps, 500 Wh



Voith
Inverter

Power cable

Control cable

Electric Drives ElvoDrive (serial)

Technical Data

Input power (generator)	220 kW
Input torque (generator)	1350 Nm
Mech. output TFM drive motor	175 kW
Mech. output drive motor – max. torque	2750 Nm
Weight of system (compared to convent. traction system)	approx. 610 kg

Advantages and Customer Benefits:

- High systems efficiency
- Compact dimensions
- Low weight of system
- Fuel Saving up to 25% (in miles per gallon up to 30%)
- Systems competency from one single source

Hybrid Drive Systems for Buses ElvoDrive (serial)



- First presentation at UITP 2007 in Helsinki by Scania
- Presentation of ElvoDrive at IAA 2008
- Successful field test with 6 vehicles in Stockholm from May 2009 to June 2010

Scania Hybrid Citybus Project in Stockholm Results



Reference Bus (Benchmark)

- Engine DC9E02 Ethanol (1100 Nm) Euro 5
- Automatic transmission ZF 6HP 594C NBS
- Rear axle ratio 5,57

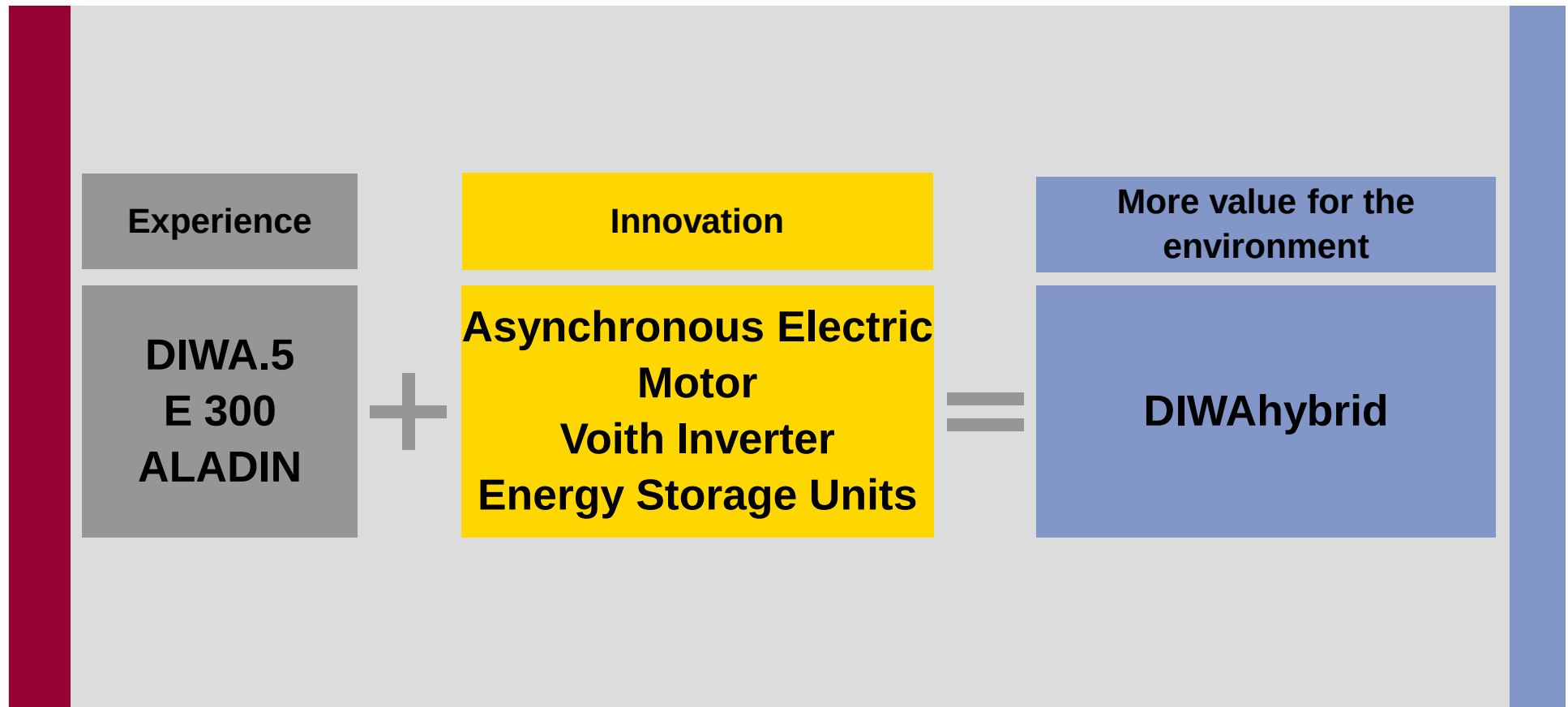
Hybrid Bus

- Engine DC9E02 Ethanol (1100 Nm) Euro 5
- TFM motor and Generator
- Rear axle ratio 5,57

Results – Fuel Savings:

- SORT 1: 24 %
- SORT 2: 20 %
- SORT 3: 10 %

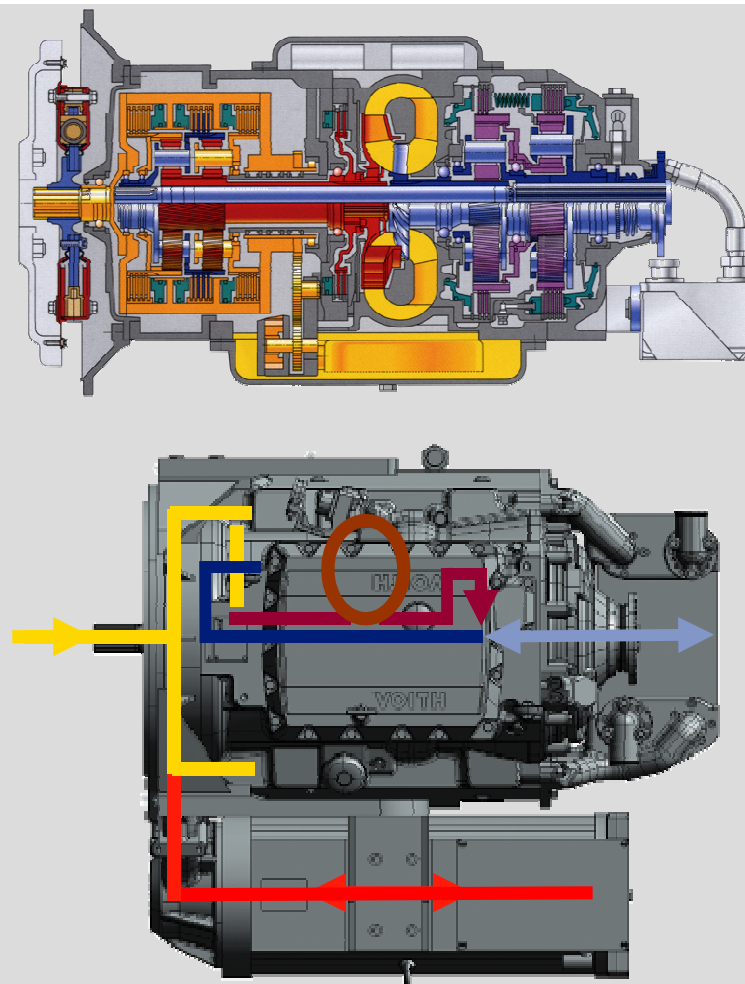
Hybrid Drive Systems for Buses DIWAhybrid (parallel)



Hybrid Drive Systems for Buses DIWAhybrid: Principle

The design of the DIWA transmission allows connection of the electrical machine directly to the input gear cage. The entire spread of the transmission (incl. converter) can be used both by the diesel engine and the electrical machine. The transmission of power in gear 2 to 4 is mechanically.

-  Input torque from diesel engine
-  Hydrodynamic power flow
-  Mechanical power flow
-  Electrical power flow
-  Output torque



Hybrid Drive Systems for Buses DIWAhybrid (parallel)

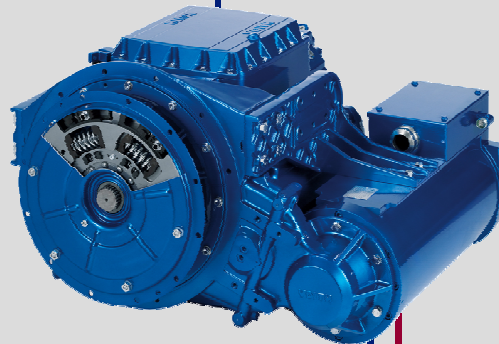
ALADIN
Diagnosis



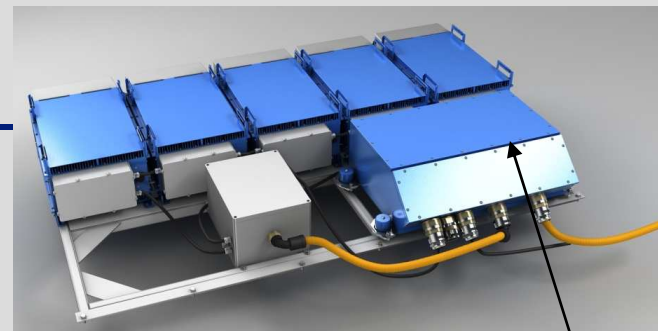
E300.1 Control



Control cable

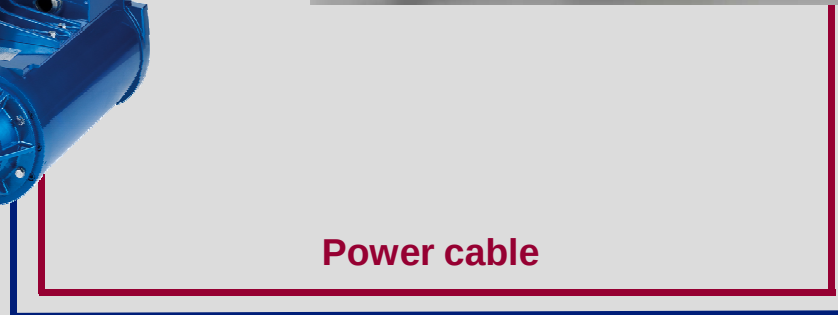


Energy storage with supercaps

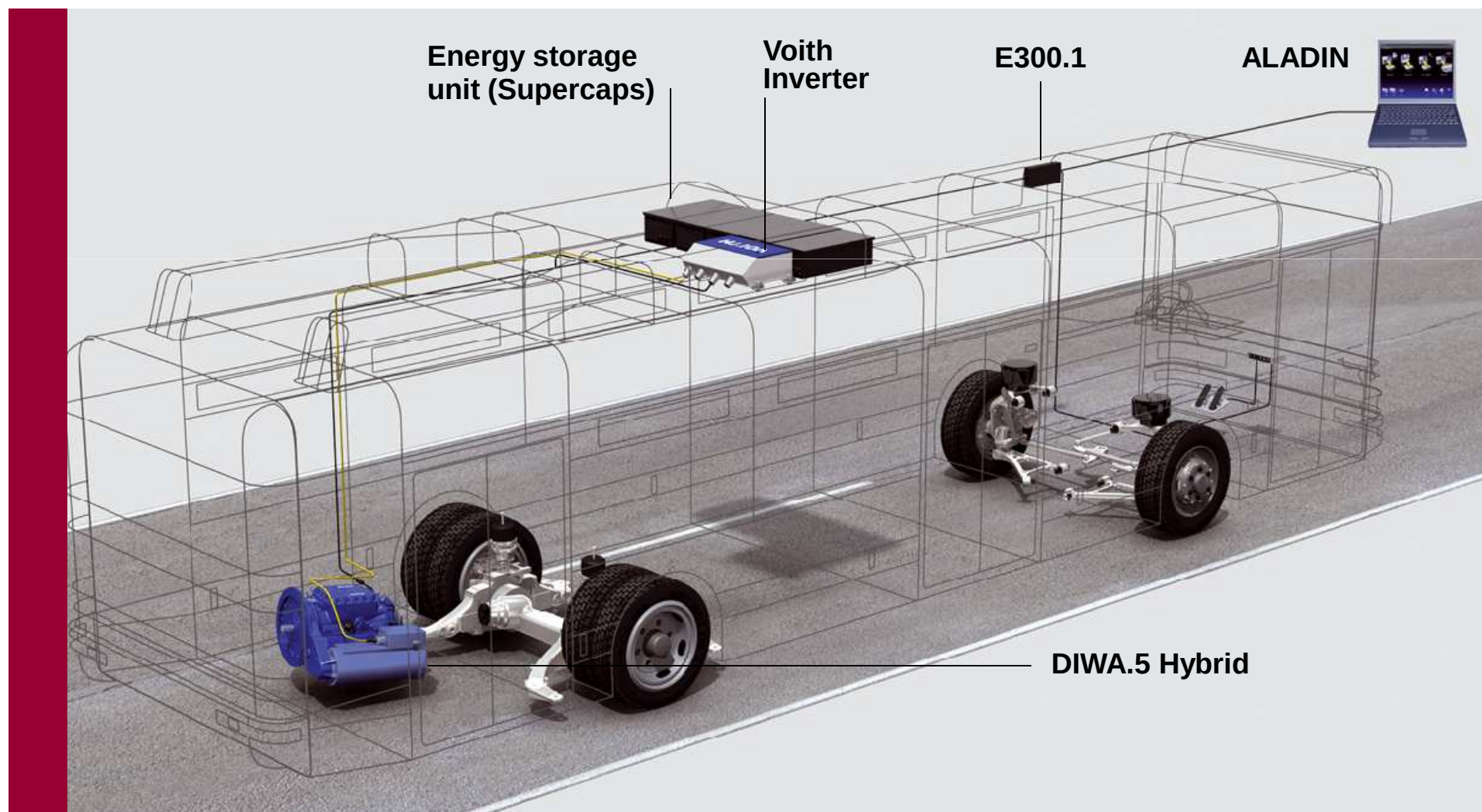


Voith inverter
with system
software

Power cable



Hybrid Drive Systems for Buses DIWAhybrid (parallel)



Hybrid Drive Systems for Buses

DIWAhybrid (parallel)

Technical Data:

Input power	290 kW
Input torque	1600 Nm
Motor/Generator, electric output	150 kW
Weight of system (compared to convent. traction system)	approx. 640 kg

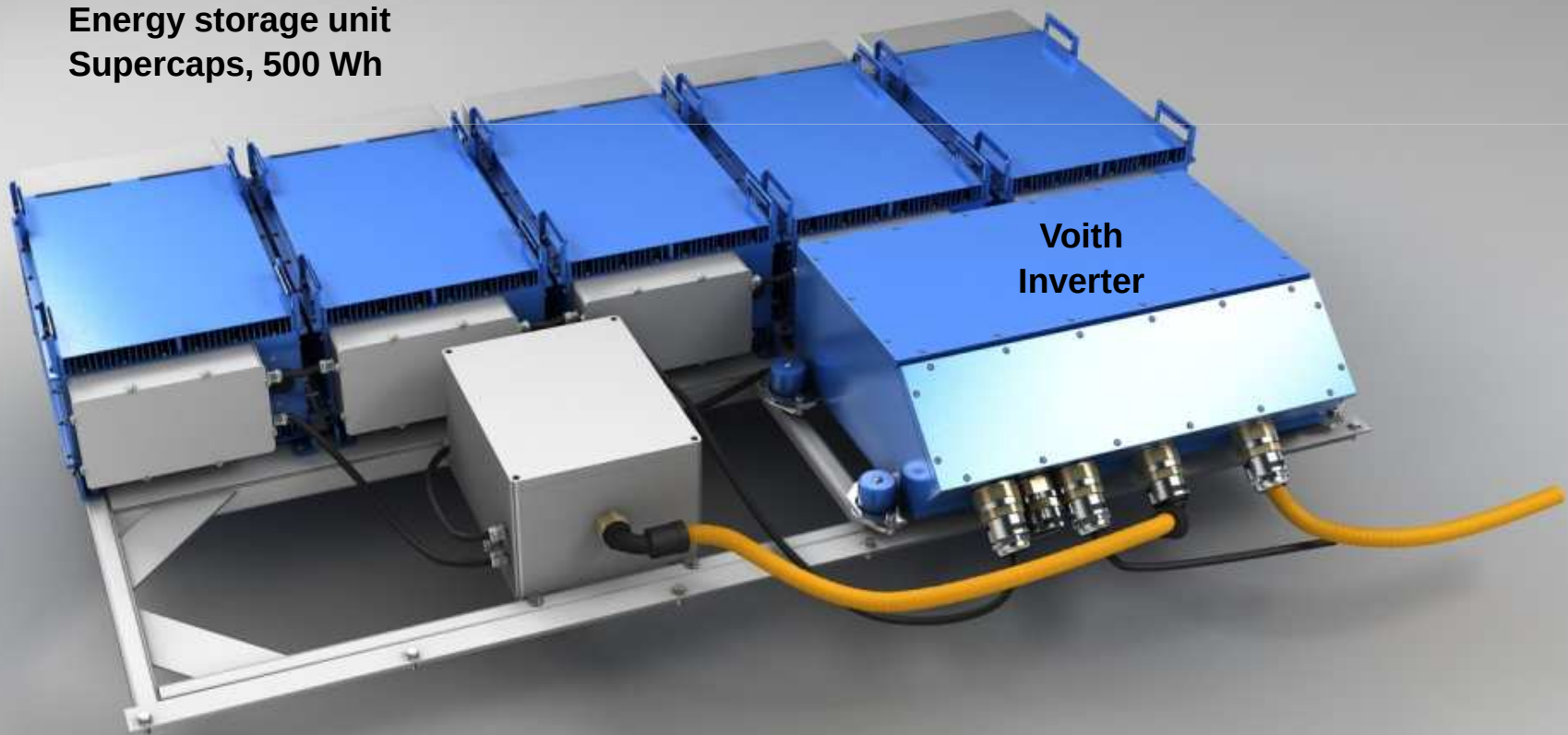
Advantages

- Independent of engine
- During braking, the electric motor works as a generator
→ maximum service life of brake, reduced braking dust particle emission
- Fuel Saving up to 20% (miles per gallon up to 25%)
- Systems competency from one single source

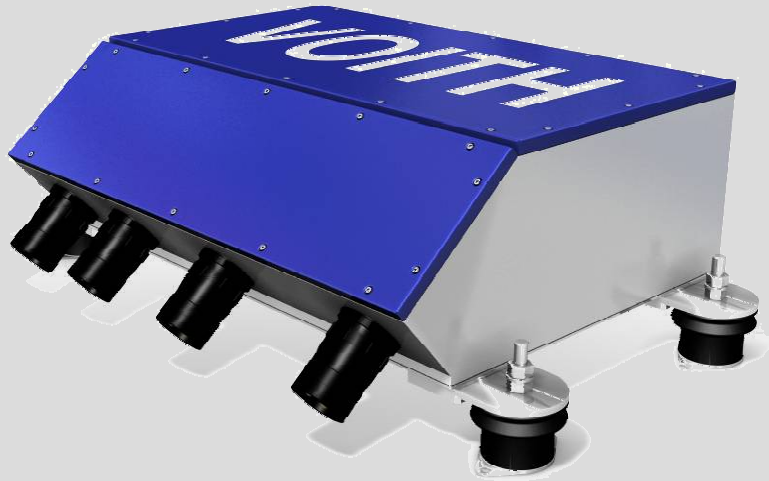
Energy Storage Unit with Supercaps DIWAhybrid (parallel) and ElvoDrive (serial)

Energy storage unit
Supercaps, 500 Wh

Voith
Inverter



Hybrid Drive Systems for Buses Voith Inverter



Both Hybrid Systems are based on the Voith Inverter Technology:

- Optimization of overall system to suit citybus applications
- Ensuring stability of energy supplies up to complete energy management
- Flexibility when selecting energy storage system

Hybrid Drive Systems for Buses DIWAhybrid (parallel)



- Presentation of DIWAhybrid at IAA 2008 and APTA 2008
- First bus with DIWAhybrid passed the Altoona-Test in USA End of 2009
- Second bus verification test in Heidenheim 2009 to April 2010
- Summer 2010: 22 buses in operation in the USA
- Pilot Project “Electric Mobility” of the German Ministry of Transport: Solaris Urbino 18 DIWAhybrid



German Funded Project Electric Mobility Solaris Urbino 18 DIWAhybrid

- Definition of 8 demonstrator regions to test different buses with different drive systems under daily operating conditions
- Starting with one pre-serial bus with DIWAhybrid for certification, up to 50 buses to be put on the road in the first half of 2011



Conclusion

Starting Points for a Further Development Stop-Start Facility



- Tests at GTT Torino with two buses with a Stop-Start facility: DIWA transmission with diesel engine driven, not hybrid;
- First experiences show reduction in fuel consumption of 8%
- Not yet used e.g. in the Hybrid buses tested in Stockholm!

Hybrid Drive Systems for Buses

Conclusion

- With DIWAhybrid and ElvoDrive Voith offers two hybrid drive systems for buses, suitable to different operating conditions
- Both systems are already proven in daily operation
- The use of hybrid drive systems allows a significant reduction in fuel consumption and therefore also a reduction in CO₂-emissions
- In combination with alternative fuels the CO₂-emissions can be reduced up to 90%
- The reduction of fuel consumption and emissions can be increased further by optimization of the drive line as with stop-start facility etc.



VOITH

Engineered reliability.