Hybrid Drive Systems for Buses

- Walter Rau
  General Manager Business Development
  Electric Drive Systems

- Dr. Robert Mueller MBA
  General Manager After Market Business

Voith Turbo GmbH & Co. KG
Produkt Group Bus Drive Systems
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

Power cable

Control cable
Electric Drives
ElvoDrive (serial)

Technical Data

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<table>
<thead>
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<th></th>
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<tbody>
<tr>
<td>Input power (generator)</td>
<td>220 kW</td>
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<tr>
<td>Input torque (generator)</td>
<td>1350 Nm</td>
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<td>Mech. output TFM drive motor</td>
<td>175 kW</td>
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<td>Mech. output drive motor – max. torque</td>
<td>2750 Nm</td>
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<tr>
<td>Weight of system</td>
<td>approx. 610 kg</td>
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<td>(compared to convent. traction system)</td>
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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)

Experience
DIWA.5
E 300
ALADIN

Innovation
Asynchronous Electric
Motor
Voith Inverter
Energy Storage Units

More value for the environment

DIWAhybrid
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)

- Energy storage unit (Supercaps)
- Voith Inverter
- E300.1
- ALADIN
- DIWA.5 Hybrid
Hybrid Drive Systems for Buses
DIWAhybrid (parallel)

**Technical Data:**

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<th>Value</th>
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<td>Input torque</td>
<td>1600 Nm</td>
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<td>Motor/Generator, electric output</td>
<td>150 kW</td>
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<tr>
<td>Weight of system</td>
<td>approx. 640 kg</td>
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<td>(compared to convent. traction system)</td>
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**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)
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
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 CO$_2$-emissions.
- In combination with alternative fuels the CO$_2$-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.