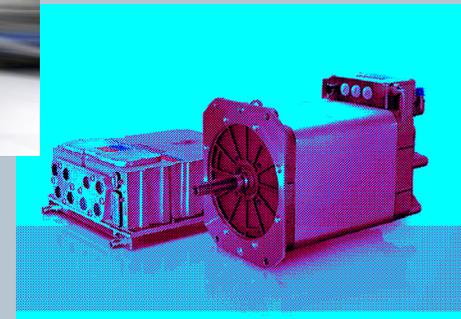


Economical, ecological and efficient:

The intelligent response to
increasing demands, the ELFA®
Hybrid Drive



July 2009

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New perspectives for public transport companies: ELFA® the leading-edge hybrid drive

Based on more than 100 years of experience in electric drives and the concentrated force of innovation in our company, we realize solutions for all heavy duty applications in harsh environment.

In the competence center of Siemens Large Drives, our experts develop and manufacture side by side drive systems for industrial, marine, mining, train and road applications.

These synergies incorporate directly into the ELFA Hybrid Drive System.



Siemens Electric Traction

Rail



Road



Off - Road



Others



Siemens Hybrid Drives - Product Portfolio



Focused competence from the global market leader: ELFA® from Siemens

Perspective & Competence

With regional divisions in almost every country and 18 own facilities throughout the world we are always close to our customers.

More than 30 hybrid bus projects in Europe, North- and South America as well as in Asia demonstrate our global presence.

Hybrid Applications for city buses, delivery, port & garbage trucks, cranes, boats and construction machines demonstrate the flexibility and modularity of our ELFA Hybrid Drive System.



Increased degree of cost effectiveness and flexibility: The Serial Hybrid

The majority of the OEMs and suppliers concentrate on serial hybrid solutions for city buses. This decision is based on following key advantages of the serial hybrid system:

- **Standardization, i.e. the same drive system can be used in diesel- and fuel cell hybrids**
This system has no direct, mechanical connection to the diesel engine, which offers:
 - **Increased degree of freedom in the design**
 - **Less noise due to gear-less drive**
 - **Flexibility, i.e. the serial hybrid drive is independent from the optimized diesel engine. The energy storage will improve in the years to come by the change to the Li-Ion technology, which requests a „downsizing“ of the diesel engine for achieving optimal results. The parallel system does not support this development schedule in an acceptable way, since they have a close relationship between the output torque of the diesel engine and the drive shaft torque.**
 - **Profitability, the serial hybrid is the most cost effective solution for city buses that is based on the high fuel reduction results**

ELFA® Hybrid Drives for City Bus Applications Products

Motor / Generator



Drive Motors and Generators from 30 kW to 180 kW

Inverter / Control



Inverters and interface components with flexible usability of inverter phases, i.e. controls for

- ASM motors
- PEM motors
- Braking resistances
- DC-DC operations
- 3phase and single phase hotel power
- DC decoupling of energy storages

Mechanical Integration



Axle and gearbox solutions for the mechanical integration

System Configurations & Functions

- 30 ft drive systems
- 40 ft drive systems
- 60 ft drive systems
- braking resistors
- Various different battery types and ultra-capacitors
- coupling to DC power sources, i.e. energy storages and fuel cells with up to two individual DC-DC converters
- DC decoupling of energy storages with IGBT's

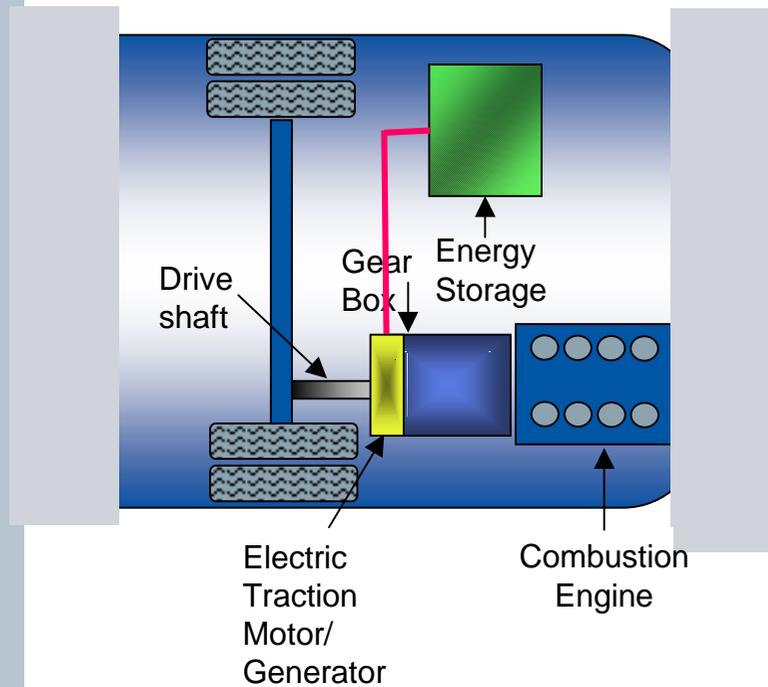
Functions

- Drive Control Unit
- Energy Management
- Engine Control
- BMU Interface
- LOS-Modes
- Safety Controller
- System Diagnostic by SAE-CAN bus

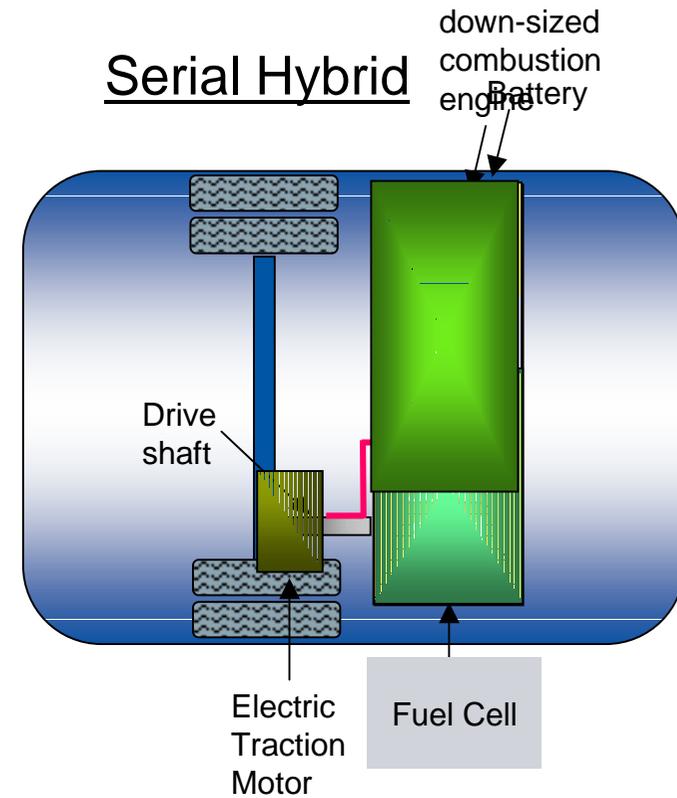
Hybrid Concepts

There are two major types of electric hybrid systems available for city buses:

Parallel Hybrid



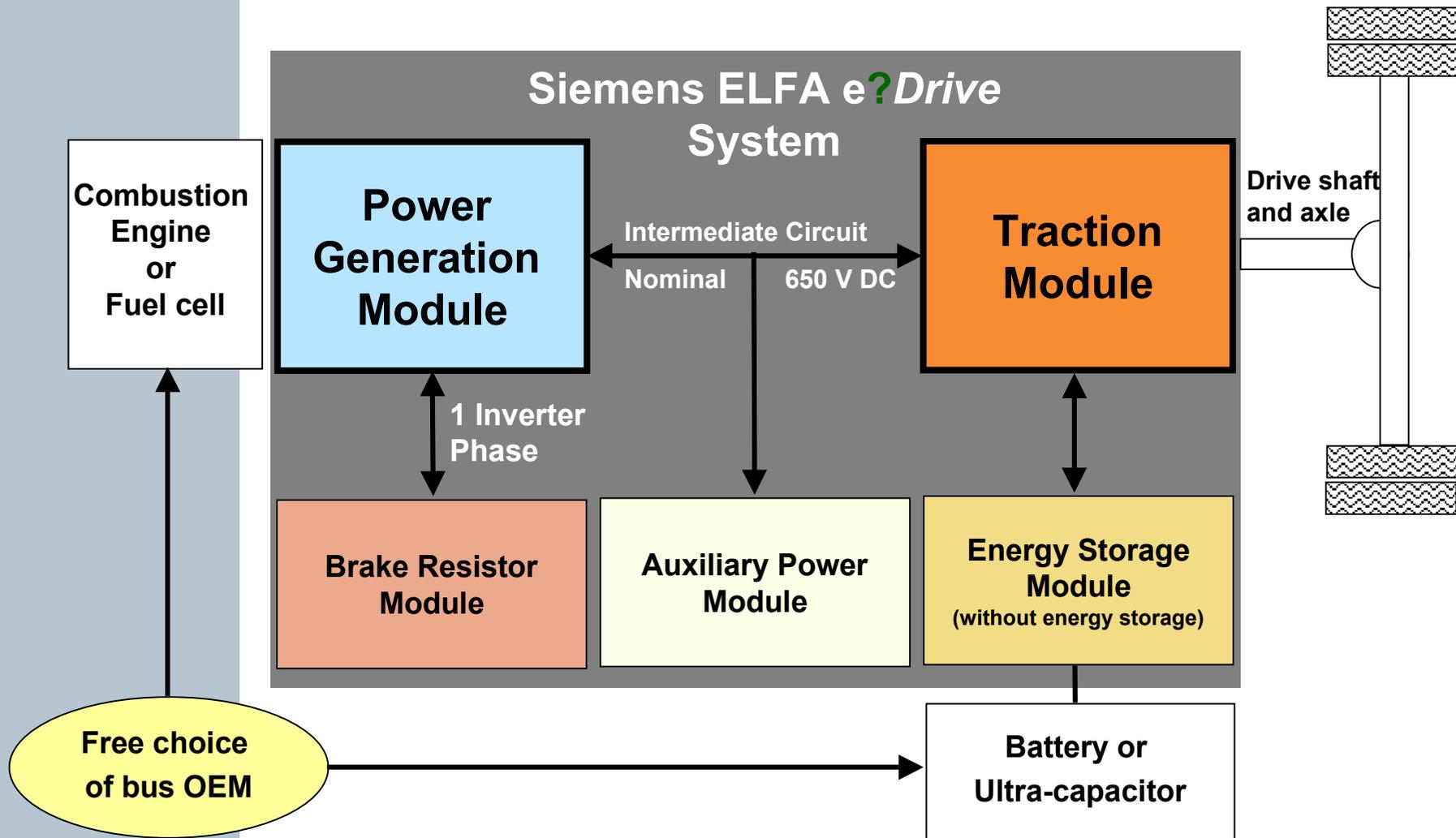
Serial Hybrid



ELFA Hybrid Drive Modules provide **Flexibility**

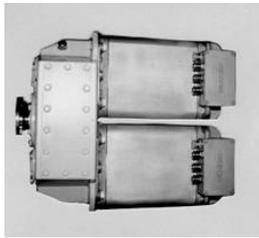
**ELFA =
Flexibility !**

ELFA Hybrid Drive Modules provide **Flexibility**

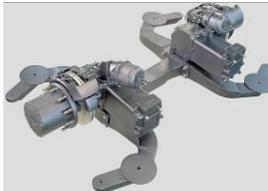


ELFA Hybrid Drive Modules provide **Flexibility**

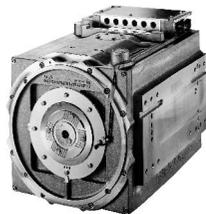
Flexibility in Integration



ASM (asynchronous motor) and gearbox drive solution for 12m buses with standard performance. Today the most cost efficient solution for volume production available



Electric low-floor axles with ELFA induction ASM-Motors offer wide aisles at very low floor heights



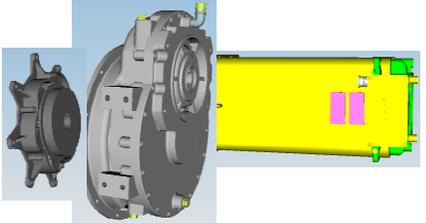
Innovative PEM (permanent magnet) motor technology for high powered buses from 12m up to double-articulated buses with high performance requirements

ELFA Hybrid Drive Modules provide **Flexibility**

Power Generation Module

Flexibility in Bus Size

Power Generation Module (PGM)			Combustion Engine Power (kW)
P1	1FV5135 + Damping Coupling	1 Mono Inverter	90
P2	1FV5139 + Damping Coupling	1 Mono Inverter	125
P3	1FV5139 + Damping Coupling + Step-up Gear	1 Mono Inverter	160
P4	1FV5168 + Damping Coupling	1 Mono Inverter	160
P5	1FV5168 + Damping Coupling + Step-up Gear	1 Mono Inverter	240
P6	1DB2007 + Damping Coupling	1 Mono Inverter	200
P7	2 Inductance Boxes	1 Mono Inverter	120 kW ^{*)} <small>*)= Fuell Cell</small>

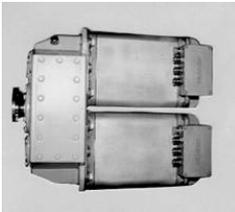
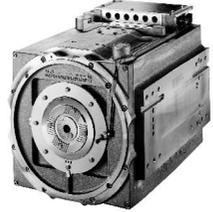
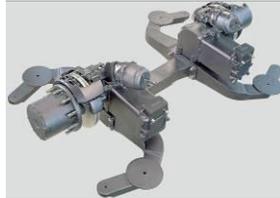




ELFA Hybrid Drive Modules provide **Flexibility**

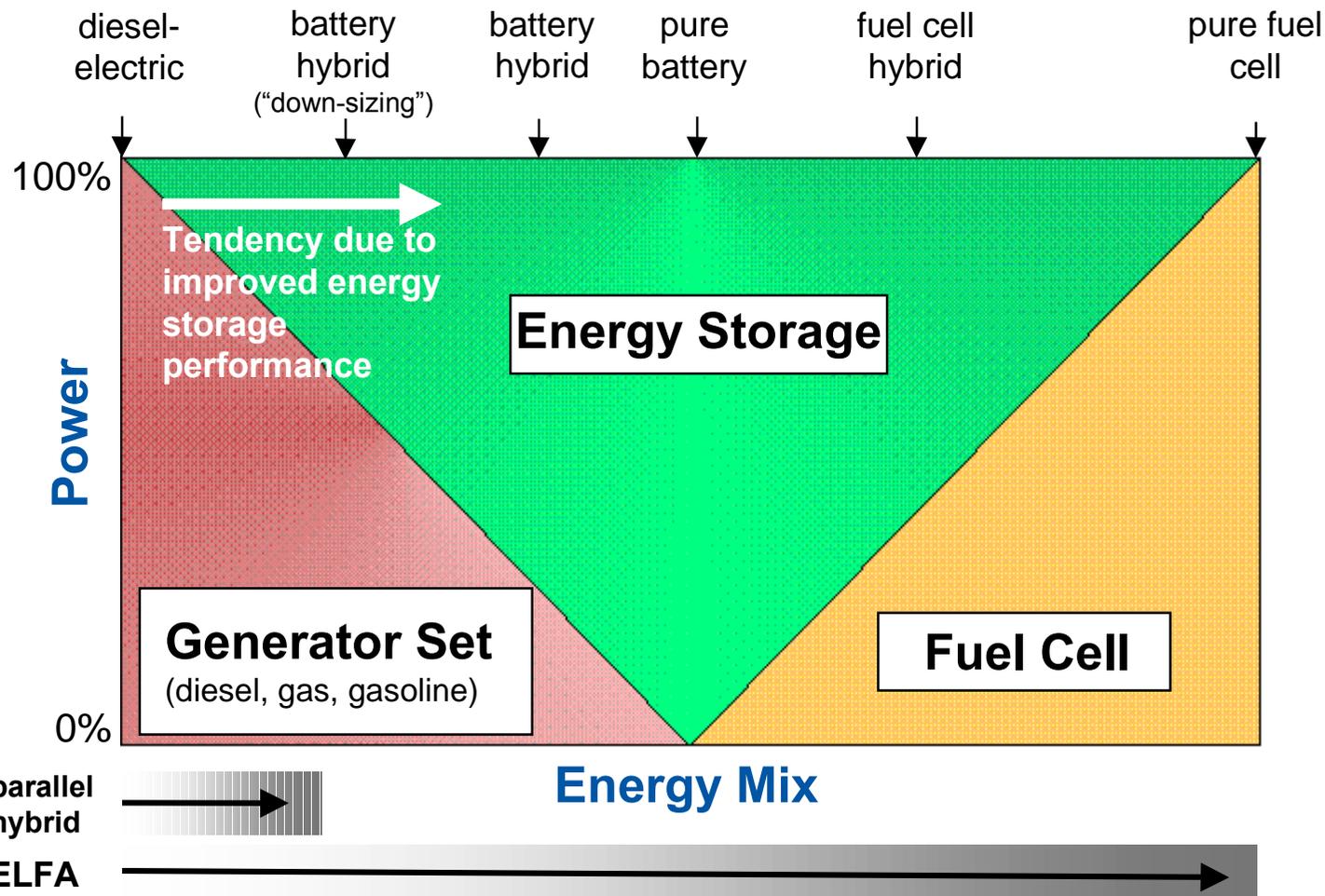
Flexibility in Bus Size

Traction Module incl. DICO (TMD)			Bus Type (length in m)
T1	2 x 1PV5135 + Summation Gear	2 Mono Inverter	12
T2	2 x 1PV5138 + Summation Gear	2 Mono Inverter	12, 15, (18*) * = flat topography
T3	1DB2016 + VPM	1 Mono Inverter	12
T4	1DB2016 + VPM (6 ph)	2 Mono Inverter	15, 18
T5	1DB2024 + VPM (6 ph)	2 Mono Inverter	24
T6	2 x 1PV5135 + ARM axle	2 Mono Inverter	12 ,18 (2 axles)
T7	ZF axle including 2 motors	2 Mono Inverter	12,18 (2 axles)

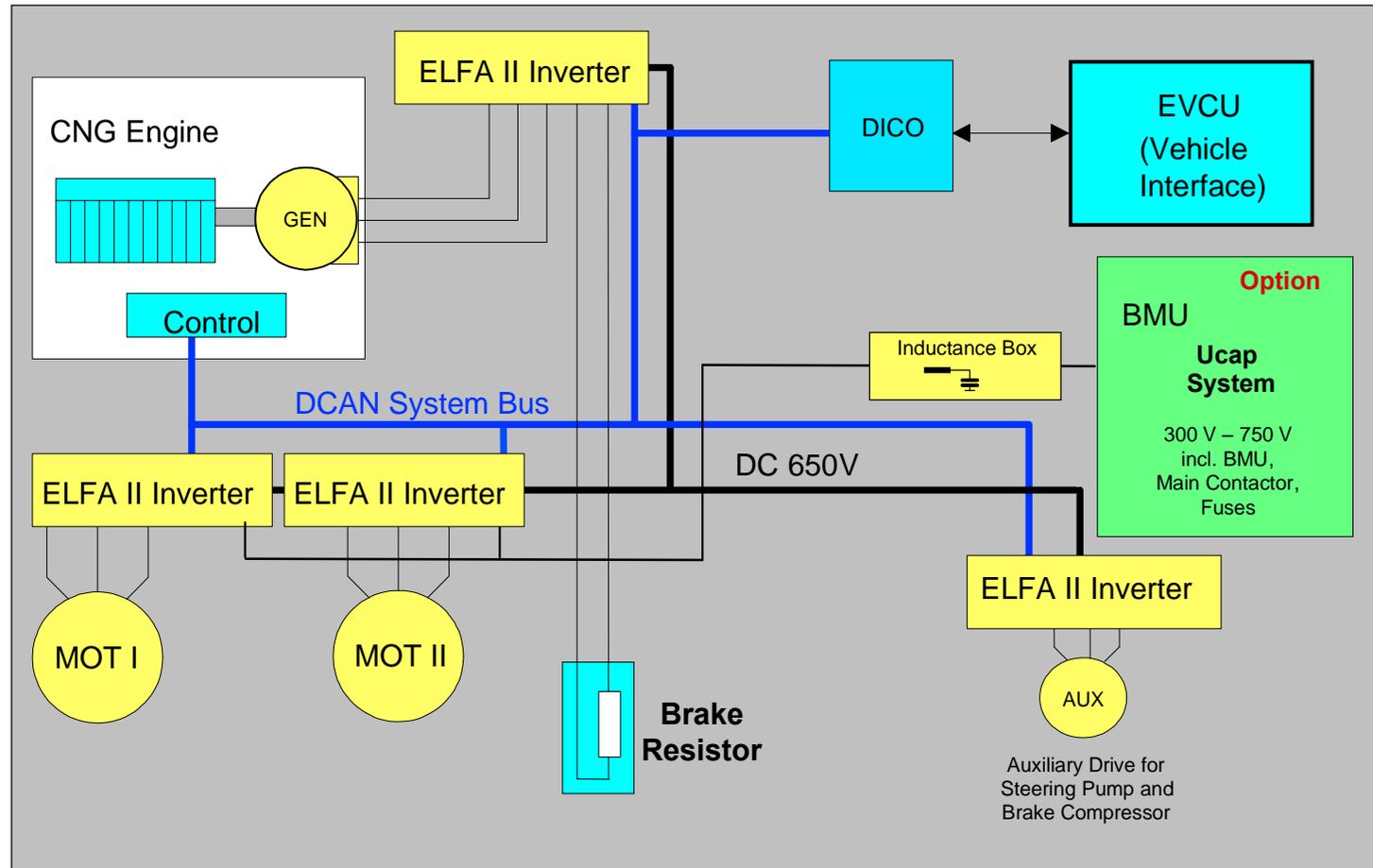

ELFA Hybrid Drive Modules provide Flexibility

Flexibility in Energy Mix



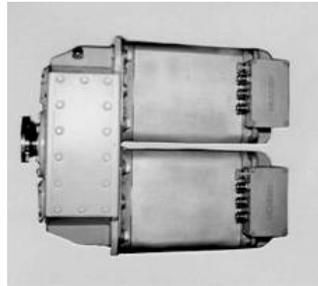
Operating Range

ELFA® Hybrid Drive System for 12m City Bus with Ultra-capacitor



Required ELFA® Components for a 12m City Bus

2 ELFA drive motors on a summation gear



ELFA Gateway Unit – drive control, hybrid control, safety control and communication with the CAN-bus system of the vehicle



1 ELFA generator with step up gear



2 ELFA Mono inverters to operate the drive motors



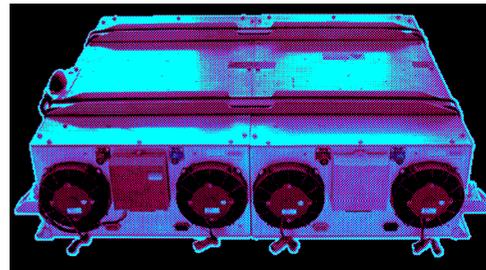
2 ELFA inductance boxes



1 ELFA MONO inverters to operate the generator



Ultra-cap unit (not Siemens, i.e. ISE)



ELFA Braking resistor

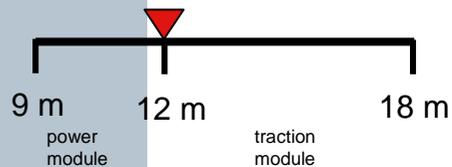
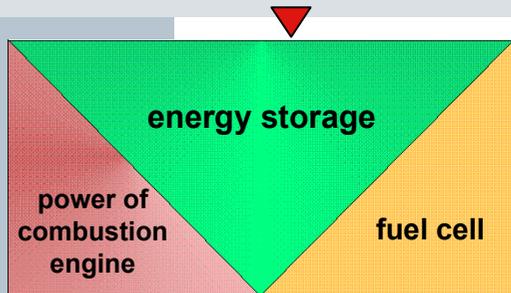


Additional: power and control cables, cooling system for the ELFA components (ca. 50 °C)

July -2009

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Industry Sector DT LD CoC

World-wide Hybrid Bus Projects – TUTTO Fuel Cell Hybrid (BRA)



power module		traction module	
P1		T1	
P2		T2	
P3		T3	
P4		T4	
P5		T5	
P6		T6	
P7		T7	

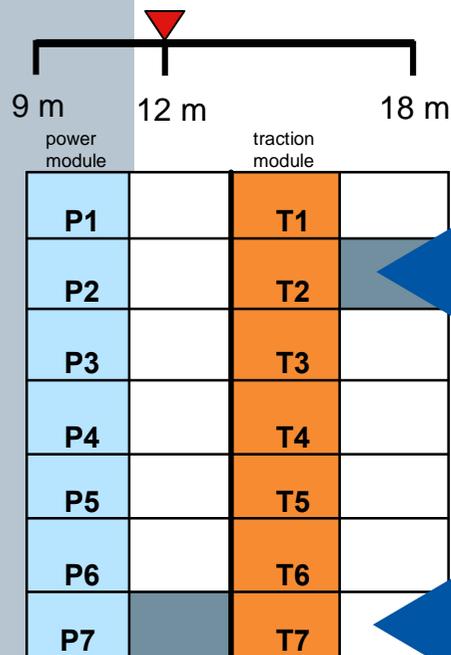
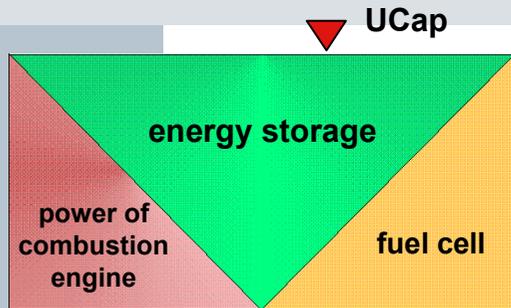


2 x 1PV5138 + Summation Gear
2 Mono Inverter

Prototype vehicles

2 Inductance Boxes
1 Mono Inverter

World-wide Hybrid Bus Projects – Wrightbus Fuel Cell Hybrid (UK)



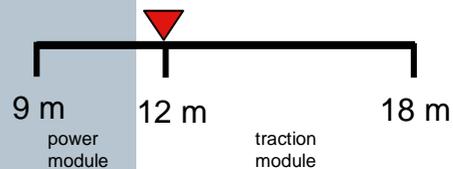
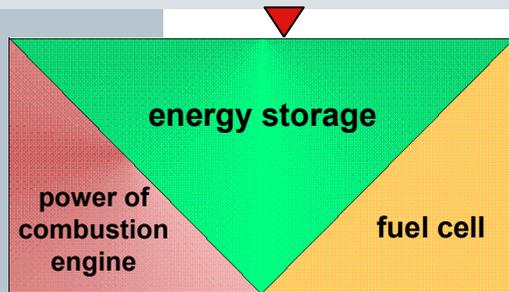
2 x 1PV5138 + Summation Gear
2 Mono Inverter

10 vehicles sold *)

2 Inductance Boxes
1 Mono Inverter

*) = via ISE Corp.

World-wide Hybrid Bus Projects – Mercedes Citaro Fuel Cell (GER)



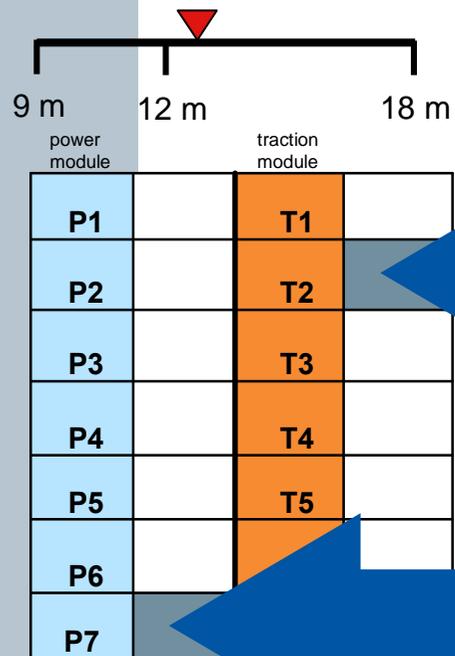
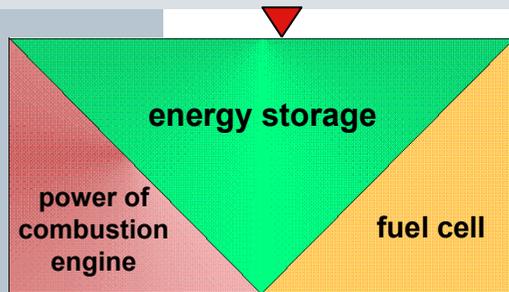
P1		T1	
P2		T2	
P3		T3	
P4		T4	
P5		T5	
P6		T6	
P7		T7	



Pre-series 2009, Fleet Test 2010

**ZF axle including 2 motors
2 Mono Inverter**

World-wide Hybrid Bus Projects – Van Hool Fuel Cell Hybrid (B)

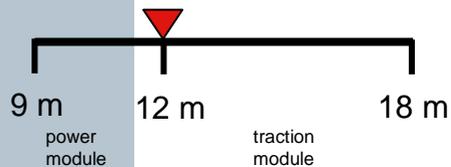
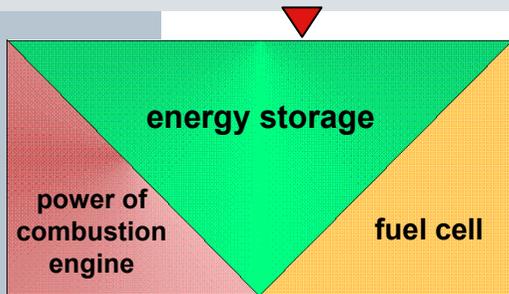


2 x 1PV5138 + Summation Gear
2 Mono Inverter

approx. 15 vehicles sold

2 Inductance Boxes
1 Mono Inverter

World-wide Hybrid Bus Projects – New Flyer*) Fuel Cell Hybrid (USA)



power module		traction module	
P1		T1	
P2		T2	
P3		T3	
P4		T4	
P5		T5	
P6		T6	
P7		T7	

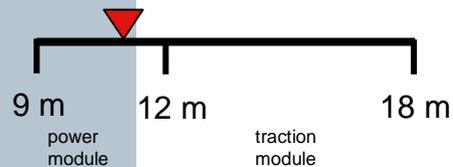
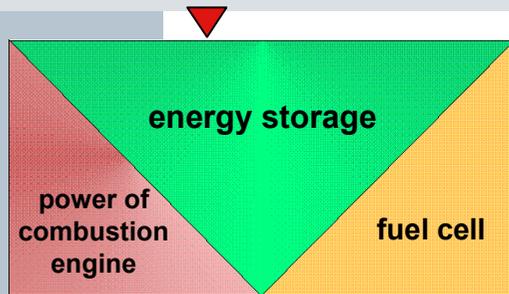
2 x 1PV5138 + Summation Gear
2 Mono Inverter

20 vehicles sold *)

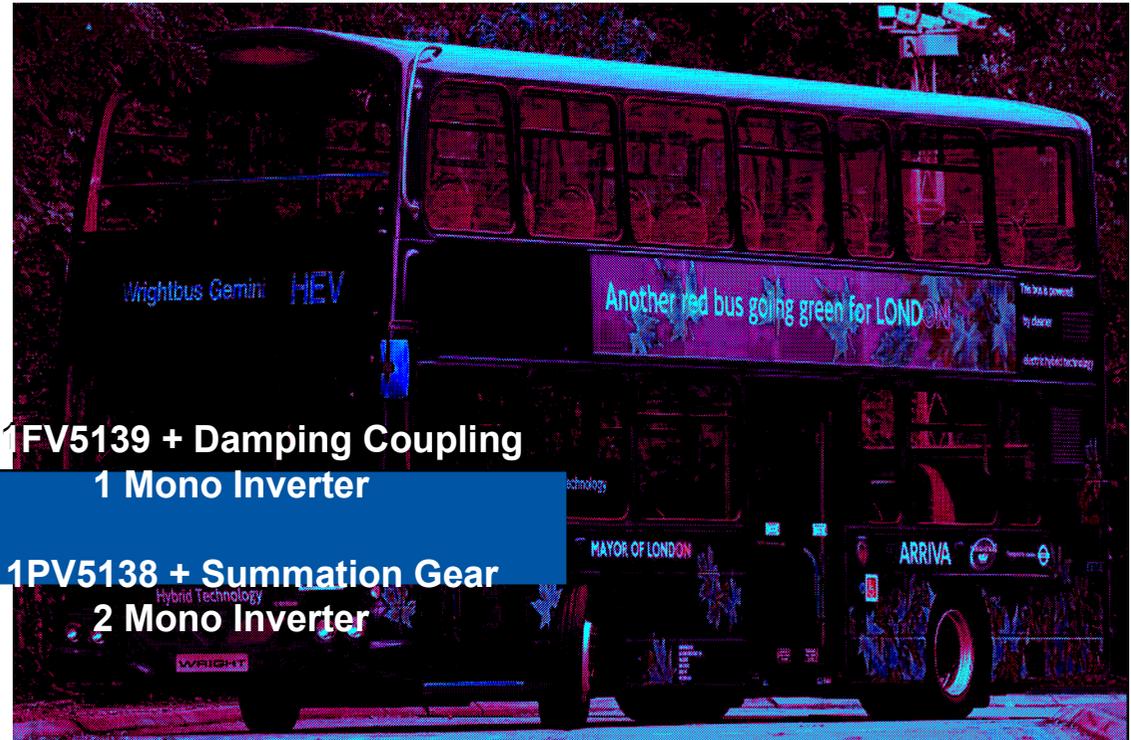
2 Inductance Boxes
1 Mono Inverter

*) = via ISE Corp.

World-wide Hybrid Bus Projects – Wrightbus DD (UK)



P1	T1
P2	T2
P3	T3
P4	T4
P5	T5
P6	T6
P7	T7



1 FV5139 + Damping Coupling
1 Mono Inverter

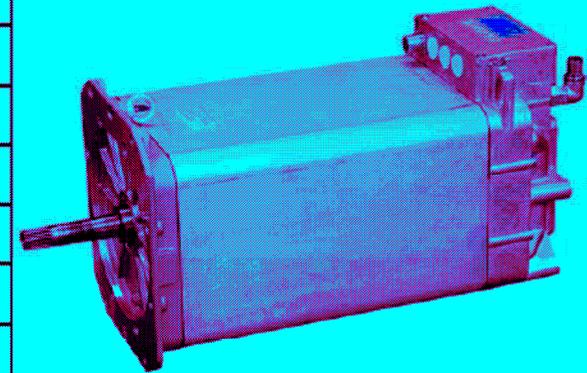
2 x 1PV5138 + Summation Gear
2 Mono Inverter

approx. 20 vehicles sold

Traction Motor

Drive Motor 1PV5138-4WS24-W12

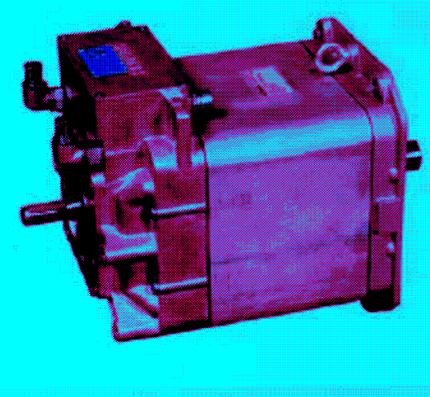
Type	AC Induction Motor
Cooling Media	Water-Glycol
Rated Voltage DC	650 V
Rated Power	85 KW
Rated Torque	220 Nm
Max. Torque	530 Nm @ 300A
Rated Current	142 A
Max. Speed	10,000 rpm
Weight	120 kg
Dim. (LxWxH)	510 x 245 x 245 mm
Ambient Temperature	- 30 °C to 70 °C
Degree of Protection	IP 65 / 9k



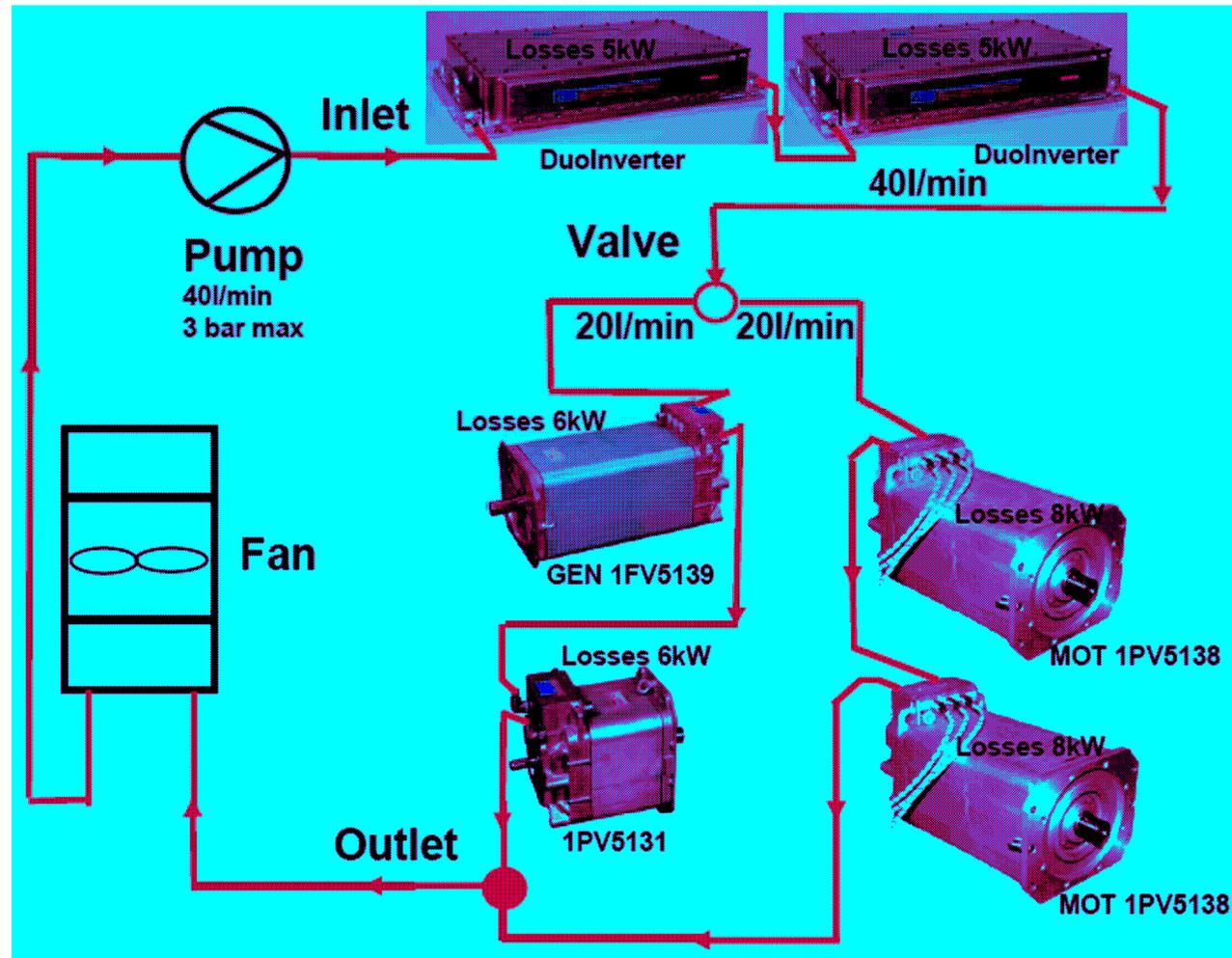
Auxiliary Motor

Auxiliary Drive Motor 1PV5131-4WS52

Type	AC Induction Motor
Cooling Media	Water-Glycol (8 l/min)
Rated Voltage DC	450 - 650 V
Rated Power	20 KW / 3.000 rpm
Rated Torque	65 Nm (< 3.000 rpm)
Max. Torque	120 Nm @ 90A
Rated Current	54 A
Max. Speed	5,000 rpm
Weight	54 kg
Dim. (LxWxH)	320 x 245 x 245 mm
Ambient Temperature	- 30 °C to 70 °C
Degree of Protection	IP 54



Example Cooling Circuit



Future in E-Traction > Gear-less Drive: i.e. PEM-Motor 1DB2024

Type	PM Synch. Motor
Cooling Media	Water-Glycol
Rated Voltage DC	750 V
Rated Power	260 KW @ 1500 rpm
Rated Torque	2700 Nm @ 360 A
Max. Torque	4500 Nm @ 600A
Rated Current	360 A
Max. Speed	3.500 rpm
Weight	500 kg
Dim. (L x W x H)	660 x 510 x 500 mm
Ambient Temperature	- 30 °C to 70 °C
Degree of Protection	IP 65 / 9k



- Successful market introduction (Las Vegas Project)
- Performance targets verified
- Series development started (weight and cost optimization)
- Series production 2010

ELFA® Operating Experience (1)

Status April 2008



MAN diesel-electric



Gillig Hybrid



Mercedes diesel-electric



Iveco Hybrid



Hino Hybrid



Iveco diesel-elctric



MAN Fuel Cell



BMB 12m Hybrid



Mitsubishi Hybrid



MAN Ultra Cap Hybrid



Battery School Bus



OCC Hybrid



ISE, Fuel Cell Hybrid Bus II



SBETI, 30ft Battery Bus



BMB 10m Hybrid Bus



ISE, 40ft Hybrid Bus

ELFA® Operating Experience (2)

Status April 2008



ISE, 40ft Gasoline Hybrid Bus



CEV, 40ft Hybrid Bus



MAN, Fuel Cell Hybridbus



FCC, Hybrid Garbage Truck



ISE, 40ft HICE Hybrid Bus



ISE, 40ft Fuel Cell Hybrid Bus



ISE, 40ft Diesel Hybrid Bus



ISE, 30ft Diesel Hybrid Bus



ISE, Hybrid Shuttle Bus



Tutto, 40ft Fuel Cell Hybrid Bus



Wrightbus, Doubledeck Diesel Hybrid Bus



ISE / Wrightbus 60ft Diesel Hybrid Bus



Azure Hybrid Shuttle Bus



MAN Hybrid Bus



Iveco Hybrid Bus



Van Hool 13m Fuel Cell Hybrid

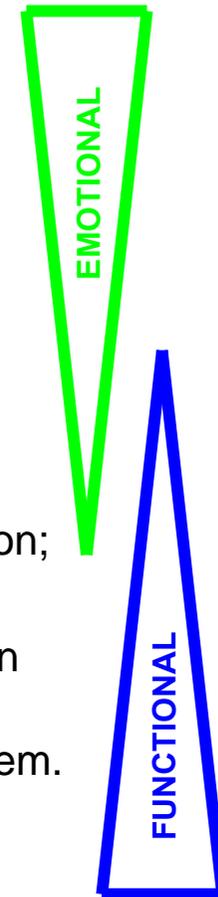
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Industry Sector DT LD CoC

Reasons to buy hybrid buses

- The hybrid bus needs to be obviously different from the standard diesel bus
 - pure electric operation into and from the bus stop (constant behavior at all conditions/inclines)
 - prevention of excessive diesel engine noise → peak power always from the energy storage
 - absolute jerk-free acceleration („tram-feeling“)
 - modern design – e.g. more low-floor area
- The hybrid bus must clearly save fuel and emissions, i.e. technically → highest possible braking energy recuperation; in a standard 12m bus this is approx. 150 kW
- the electric drive (components) must remain unchanged in future when new, more powerful energy storages and smaller diesel engines will dominate the hybrid drive system. (easy retrofit will be possible). Long-term the small diesel engine can be replaced by a small fuel cell

will decrease in future



will increase in future

ELFA® - Advantages at a Glance

- Up to 40 percent less energy consumption and exhaust emission
- Emission-free operation possible in inner city areas and at bus stops
- Noticeably more quiet
- Higher degree of comfort for passengers as the bus accelerates a lot more smoothly
- Extremely reliable and low-maintenance traction systems
- All components from a single source – motor, generator, traction converter and control
- Serial hybrid system concept for maximum degree of flexibility and cost effectiveness
- Can be adapted to all city bus types as a result of the modular design
- Proven thousands of times over



WHY SIEMENS?

- Electric Traction is core competence of since more than 100 years
- The ELFA® Hybrid System made specifically for road application is already more than 12 years successfully in operation
- All major drive components are produced in-house
- Sales & Service is available around the globe
- Capable to create volume production through synergies in other business areas with ELFA system, i.e. off-road, special machinery and boats. → volume will lead to scale effects with positive effect on pricing
- Capable of working with all vehicle OEMs as well as system integrators around the world
- Financially sound company – will stay with its customers in “good and in bad times”



Thank you!

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E-Mail:

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