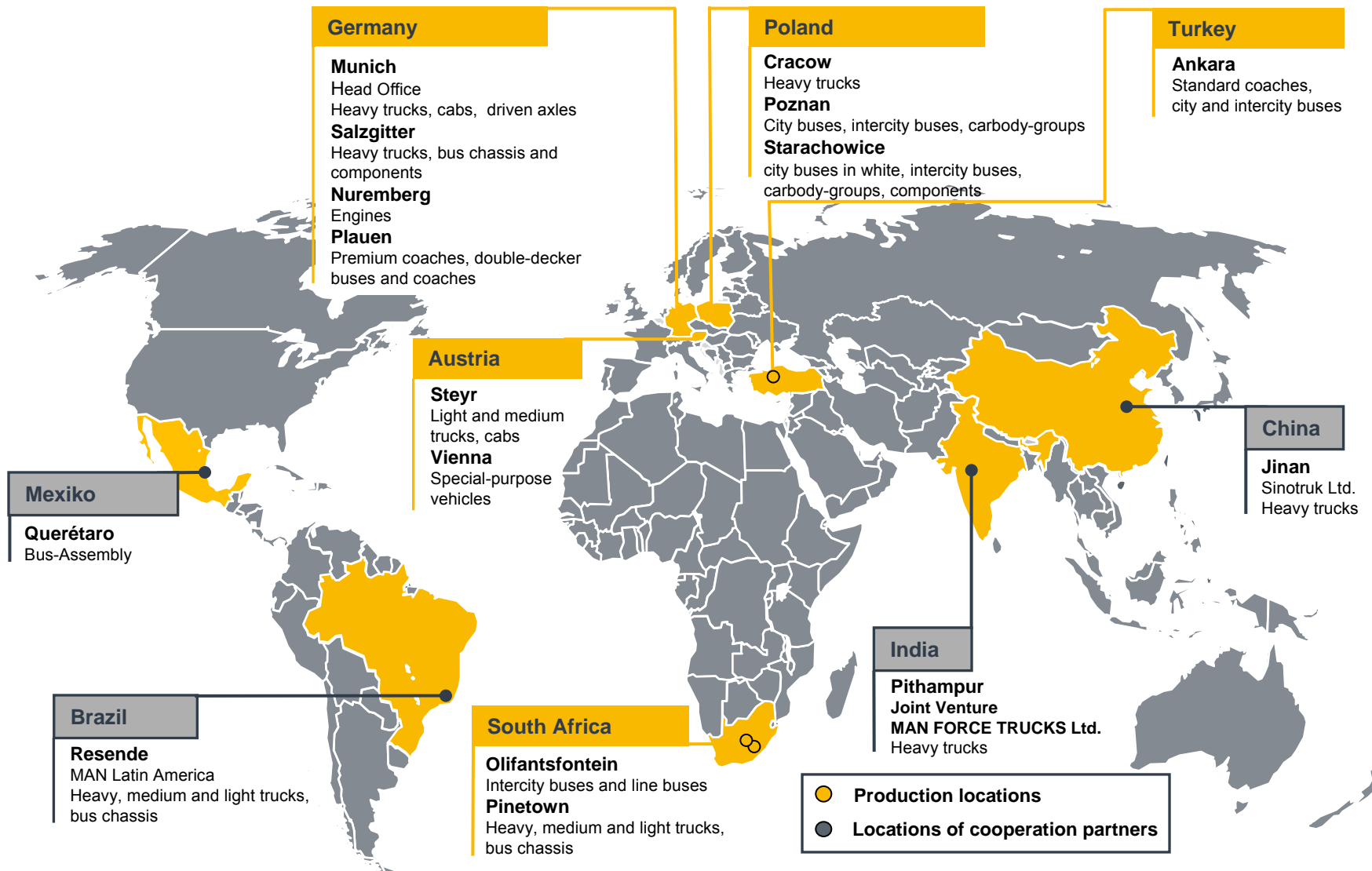




The MAN Lion's City Hybrid
Development from experimentation to mass-production



The MAN Lion's City Hybrid



The MAN Lion's City Hybrid Requirements



■ Reducing fuel consumption

- means reducing CO₂ emissions
(burning 1 litre of diesel generates 2.63 kg of CO₂)

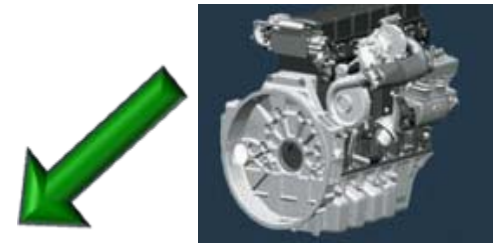


■ Reducing pollutant emissions

- including particulate matter (PM) and oxides of nitrogen (NO_x)
- enshrined in law in the form of the European emission standards



■ Reducing noise emissions



The MAN Lion's City Hybrid

History



1975

Gyro-capacitor with approx. 1.5 t flywheel



1979

Hydraulic capacitor with hydraulic pump and pressure accumulator



1987

Magneto-dynamic capacitor (fast-moving flywheel with motor generator)



2000

NiMH rechargeable batteries



2001

Ultracapacitors



2004

NiMH rechargeable batteries (also used in conjunction with hydrogen fuel cells)



2007

Ultracapacitors



2010

Ultracapacitors

The MAN Lion's City Hybrid

Framework conditions



Framework conditions conducive to the use of hybrid technology:

Constant driving cycle

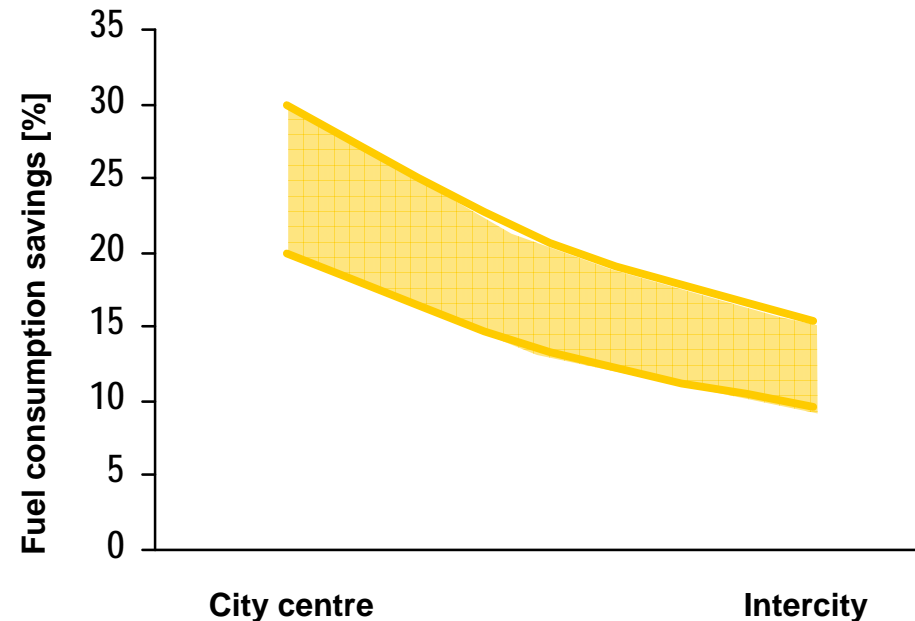
Regular acceleration

Frequent deceleration to a standstill

Recuperation:

Distance between stops in "heavy city traffic" of approx. 150 m to 200 m

- at an annual mileage of 60,000 km
= braking 400,000 times at stops
- = 400,000 recuperation periods during which energy can be stored, which is converted into useless heat during "normal braking"
- Topography: optimum precondition = flat terrain
- Influencing variables:
 - Number of passengers
 - Traffic flow and traffic routing



The MAN Lion's City Hybrid

USP - Automatic start/stop system



Automatic start/stop system

☞ The idea behind it is simple: whenever the diesel engine is not running, it consumes no fuel, emits no exhaust gases and produces no noise.

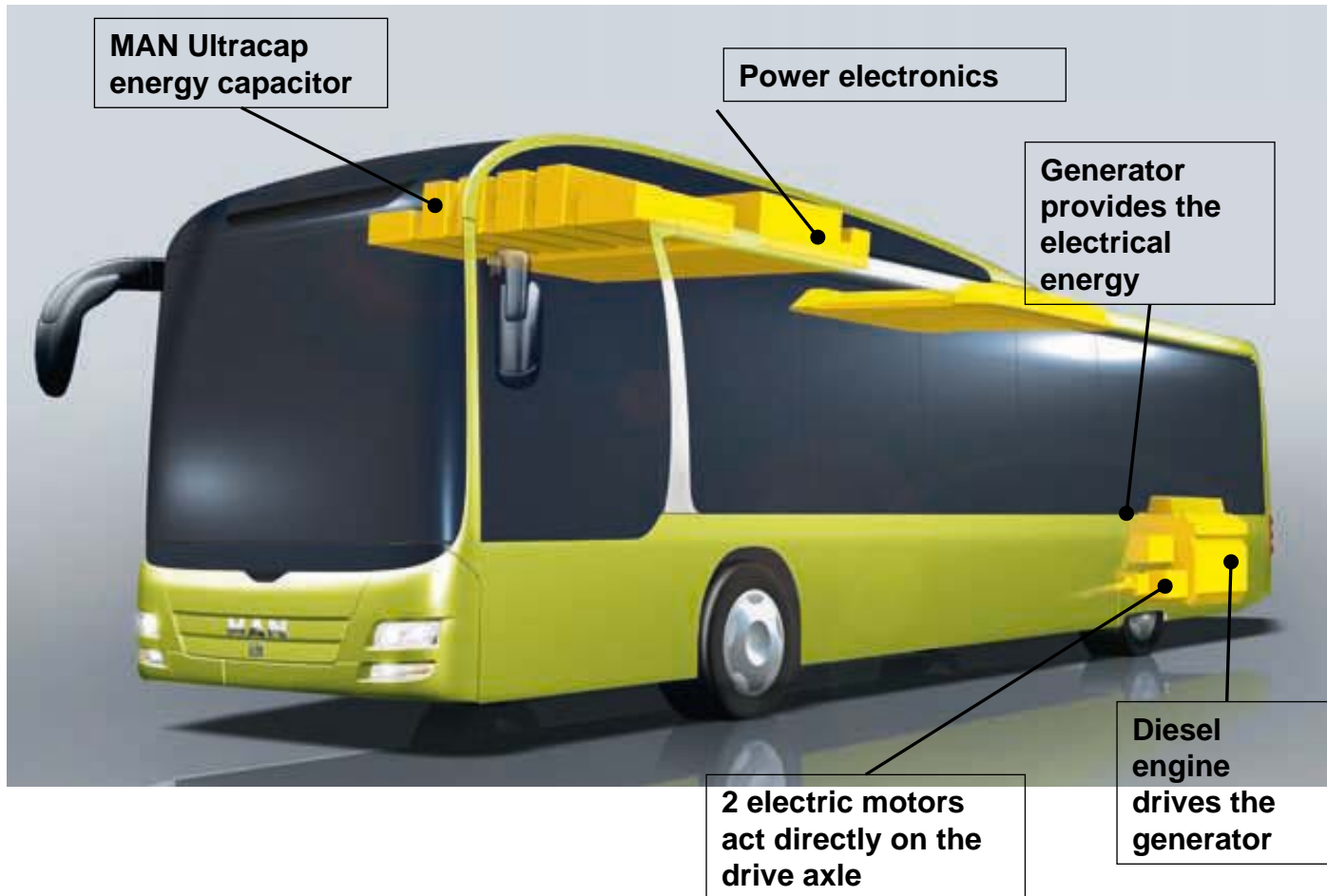
The automatic start/stop system ensures that the diesel engine is switched off as often and for as long as possible during normal driving operations. It functions automatically as soon as the vehicle comes to a standstill – e.g. at a traffic light or bus stop. The diesel engine also restarts automatically, controlled by the intelligent MAN Energy Management system.



In city operations, the diesel engine is switched off for up to 40% of the time. The automatic start/stop system thus saves on enormously valuable fuel and noise !

The MAN Lion's City Hybrid

The details





MAN
Ultracap technology
Life cycle ~vehicle lifetime

- ✓ Low system costs
- ✓ Life expectancy over 1,000,000 charge/discharge cycles*
- ✓ High power density
- ✓ Very high levels of efficiency
- ✓ High level of safety
- ✓ Recyclable as per **WEEE** Directive (*Waste Electrical and Electronic Equipment*)



NiMH batteries
Nickel-metal hybrid

- Life cycle approx. 4-6 years
- High system costs
- Life expectancy approx. 600-1,500 charge/discharge cycles*
- Not suitable for high currents
- Only partially recyclable

Li-ion batteries

- Life cycle approx. 6-8 years
- High system costs
- Life expectancy approx. 400-1,200 charge/discharge cycles*

* a recuperation period is **not** the same as a charge/discharge cycle!

The MAN Lion's City Hybrid

MAN Ultracap energy storage and power electronics

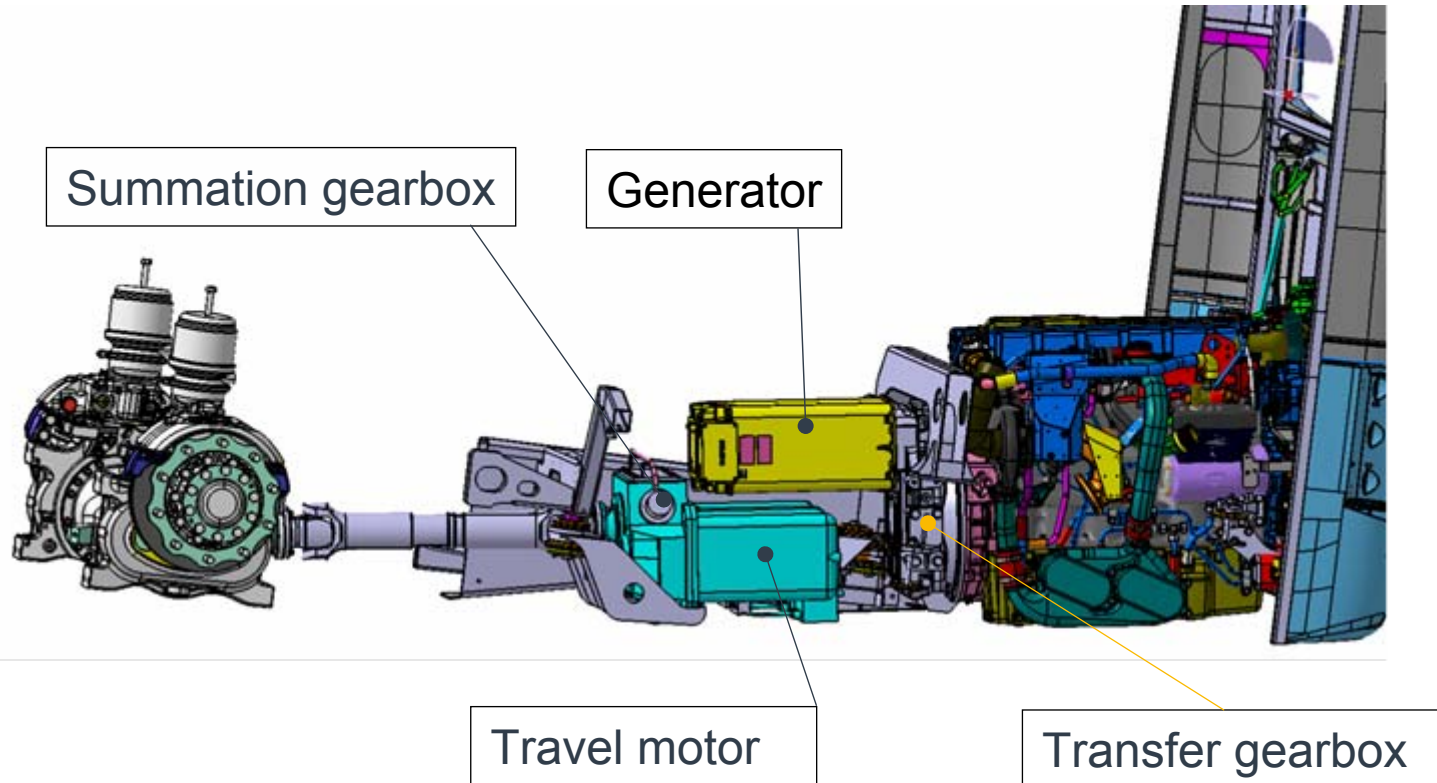


MAN Ultracap energy capacitor

Power electronics



MAN Ultracap energy capacitor	
Maximum charging/ discharging capacity	200 kW
Maximum current	500 A
Voltage range	400 V – 750 V
Energy content approx.	0.4 kWh
Total weight approx.	500 kg



The MAN Lion's City Hybrid

Combustion engine



- **Specially designed for use in a hybrid system**
- **Type:** MAN D0836 LOH
- **Build:** 6-cylinder in-line engine
- **Installation position:** vertical; back left
(tower construction)
- **Displacement:** 6.9 litres
- **Output:** 184 kW (250 hp) at 2,300 rpm
- **Torque:** 1,050 Nm at 1,200-1,750 rpm
- **Turbocharging:** 2 exhaust gas turbochargers
- **Injection:** Common Rail
- **Exhaust gas treatment:** closed CRTec[®] particulate filter
- **Emission standard:** EEV





The MAN Lion's City Hybrid

Reducing fuel consumption



- Depending on the product line, a MAN Lion's City Hybrid consumes up to **30% less fuel** than a city bus fitted with a conventional drive.
- Assuming an annual mileage of 60,000 km, the MAN Lion's City Hybrid **can save up to 10,000 litres of fuel** per year.
- **Every year**, therefore, a MAN Lion's City Hybrid thus saves up to **45 full tanks of fuel** (220-litre tank)!



The MAN Lion's City Hybrid

Reducing pollutant emissions



- Reducing fuel consumption also cuts CO₂ and NO_x emissions
- Assuming an annual mileage of 60,000 km, this equates to up to **26 tons less CO₂** each year or **71 kg each day!**
- A MAN Lion's City Hybrid can thus save as much CO₂ in a year as can be bound by approx. **26,000 m² of forest or 3.5 football pitches!**

The MAN Lion's City Hybrid



Reducing noise and exhaust gas emissions

- In purely electrical operation, the diesel engine in a MAN Lion's City Hybrid does not run, producing neither noise nor exhaust gases – and thus no pollutants either.

= start/stop function and zero-emission mode

- **Government funding:** ultra-low emissions, maximum cost-efficiency – not least the winning, pioneering concept has attracted government funding for the purchasing of MAN Lion's City Hybrid buses.



- e.g.



The MAN Lion's City Hybrid

Optimum support for the driver



Acceleration



Environmentally friendly acceleration

During acceleration, the indicator moves to the right. If the indicator is in the green area, this signifies energy-saving and thus environmentally friendly acceleration.

Braking



Environmentally friendly braking

During braking, the indicator moves to the left. If the indicator is in the green area, this signifies that purely electrical braking is being used and that the high-voltage traction energy accumulator is being charged. If the indicator is in the red area (Eco min), this signifies a level of deceleration that is not ideal for the hybrid system, because the mechanical brake is also being applied.

The MAN Lion's City Hybrid IDEAS 1 Trials in Paris



The MAN Lion's City Hybrid

Test at RATP Paris: 03-04/2009



Tests on different lines:

2 x inner city line

1 x suburb line

1x separate bus track

Line	Type	Length	v_medium	Stop time	Stop's distances
L21	Inner City	8,1 km	10,4 km/h	31 %	6,9 stops/km
L91	Inner City	5,5 km	11,6 km/h	27 %	5,5 stops/km
L147	Suburb	10,3 km	14,8 km/h	23 %	3,7 stops/km
L-TVM	Bus Track	10,7 km	19,4 km/h	25 %	3,0 stops/km

The MAN Lion's City Hybrid
Prototype IDEAS 1 in Trials



Paris	March – April 2009
Logrono / Valladolid	October 2009
Madrid	November 2009
Porto / Lissabon	November 2009
Cadiz / Sevilla	December 2009
Lubijana	December 2009 – January 2010
Veolia Nice	April / May 2010



Mailand



LANO

Barcelona

Testing program with





Vienna

Testing program with



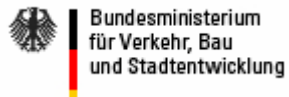
Research programm with Graz University of Technology





Hagen

Research program with





Munich



Testing program with



The MAN Lion's City Hybrid

Full range of technical and driver's training



Service	Responsibility	Training given by
	Member of staff responsible for hybrid systems: master mechanic has responsibility	MAN Academy
	Repair	
	e.g. vehicle electrician or mechanic services and repairs the high-voltage hybrid system	MAN Academy
Vehicle operator	Handling	
	Personnel in charge of hybrid vehicles: staff who, in addition to the driver, work with hybrid vehicles to ensure their daily operational readiness	Operator, documentation from MAN
	Driver	
	Driver training	