MAN Lion’s City Hybrid
Through city traffic – efficiently and with low emissions
Transport efficiency
Excellence in all areas

- More freight per truck, more payload for buses
  Low dead weight = higher payload = less energy per tonne-kilometre / person-kilometre

- More kilometres per litre diesel
  Low fuel costs and less CO2 output; less energy per tonne-kilometre / person-kilometre

- Greater safety in traffic
  Electronic assistance systems prevent accidents; new traffic information systems reduce traffic jams

- Maximum reliability
  Passengers and freight arrive reliably and punctually at their destinations; service contracts ensure high vehicle availability and calculable costs

  Greater comfort for the driver
  Sophisticated ergonomics = high concentration and alertness

- More service and flexibility
  Transport efficiency ensured by expert advice at purchase, flexible rental facilities and fleet management

MAN offers an all-embracing efficiency programme for cutting the total cost of ownership (TCO) wherever it can be attacked.
Sustainability and Environmental Protection

Social / Political Demands

- reduction of fuel consumption
- reduction of emissions (exhaust gases, noise)
- reduction of greenhouse gases (CO\(_2\))
- substitution of fossil fuels

Development Focuses

- improving efficiency of transport system

Measures

- improved driveline efficiency
- use of fuels with potential of CO\(_2\) reduction
- BTL (Biomass-to-Liquid) technology
- reduction of tractive resistances and vehicle weight
- consumption-oriented driving
- transport logistics, traffic management, improvement of infrastructure
- driver training to gain an energy-efficient driving style
- use of brake energy (recuperation)
MAN – Roadmap
Fuels and Drives

- Regenerative liquid hydrocarbons, hybrid as well on long distances
- Battery vehicles for short and medium distances (together with further optimization of batteries and regenerative fed energy supply)

- BTL for long distances
- Plug-in hybrid for short distances & ICE as range-extender

- Internal combustion engines plus
  - increased XTL – blend of diesel fuel
  - hybrid technology for city traffic
  - plug-in hybrid for short distances

- Internal combustion engines using
  - conv. diesel with bio – blends (HVO, FAME) and CNG
  - hybrid technology for city traffic

- Conventional diesel (based on crude oil) with bio – blends
- CNG
Hybrid concepts in comparison

**Parallel hybrid**
- ICE
- PE
- Energy storage
- Gearbox
- D

**Serial hybrid**
- ICE
- PE
- Energy storage
- EM
- D

**Power split hybrid**
- ICE
- P
- PE
- PE
- EM
- EM
- D

Legend:
- **ICE**: Internal combustion engine
- **EM**: Electric motor
- **PE**: Power electronics
- **D**: Differential gear
- **P**: Planetary gear

The diagram illustrates the different hybrid concepts, highlighting the energy flow and components involved in each type.
Overview Energy Storage Devices

UC-Technology
- high power density
- low energy density
- best efficiency
- best life cycle
- lifetime of the vehicle
- low system costs
- high safety level
- easy to maintain
- Zero emission mode for mid length period

NiMH-Batteries
- medium power density
- energy density ~90 Wh/kg
- medium efficiency
- medium cycle life
- lifetime approx. 4 ... 6 years
- high system cost
- high safety level
- proven technology
- Zero emission mode for longer periods

Li-Ion-Batteries
- high power density
- energy density ~110 Wh/kg
- good efficiency
- high cycle life
- lifetime approx. 6 ... 8 years
- high system cost
- relatively high safety level
- technology of high potential
- Zero emission mode for longer periods
History of development of MAN hybrid bus
Decades of competence and experience

**Trolley hybrid**
2000

**DE hybrid (NiMH battery)**
2001

**Fuel-cell hybrid (NiMH battery)**
2004

**Serial hybrid**
MAN Lion's City Hybrid
UITP 2009

**DE hybrid (MD flywheel)**
1978

**DG hybrid (gyro storage)**
1975

**DH hybrid (hydr. accumulator)**
1985

**DE hybrid (Ultracap storage)**
2001

**DE hybrid, optimised (Ultracap storage)**
2005

Manz 2010
Hybrid Prototype IDEAS project
Successfully tested in Europe
MAN Lion’s City Hybrid
Series Version at the UITP Congress 2009
MAN Lion’s City Hybrid
Through city traffic – efficiently and with low emissions

- Reduction of CO₂
- Recuperation of brake energy
- Modular design based on series diesel bus
- Reduced consumption
- Performance like diesel bus
- Electric PTOs controlled as required
- Motor downsizing
- Drive system optimised for vehicle
- Greater ride comfort thanks to smooth moving off
- Driving solely under electric power possible
- Goal: In long term LCC below those of conventional diesel bus

Goal:
In long term LCC below those of conventional diesel bus
Innovative and attractive **Efficiency Design** – streamlined and weight-optimised

**MAN series six-cylinder diesel engine (EEV)** with CRTec® and **MAN PURE DIESEL®** technology for smooth running and high reliability

**MAN-developed, intelligent energy management system**

**Start-Stop-System** for pulling away from stops under electric power without exhaust gases

**Two Series-E-Drives** with 75 kW each at 3.000 Nm max. torque on rear axle

**Neither loss of seats** nor restrictions in interior compared to conventional diesel bus

**High economy** thanks to durable, low-cost ultracap system
MAN Lion’s City Hybrid

The main components

1. Ultracap Storage-system
2. Power electronics
3. Generator
4. EEV-Diesel-Engine
5. E-Drives
MAN Lion’s City Hybrid

The main components

Energy store / capacitors (1)
- 6 air-cooled ultracap modules, each of 24 cells,
- Max. charging/discharging power: 200 kW
- Energy content: approx. 0.5 kWh
- Voltage: 400-750 V

Power electronics (2)
- IGBT pulse inverter

Generator (3)
- High-speed, permanently excited synchronous generator
- Output: 150 kW
The main components

Diesel engine (4)

- **Type:** MAN D0836 LOH CR
- **Design:** 6-cylinder in-line
- **Installation position:** vertical, rear left (tower design)
- **Capacity:** 6.9 litres
- **Output:** 184 kW (250 hp) at 2,300 rpm
- **Torque:** 1,050 Nm at 1,200-1,750 rpm
- **Turbocharging:** two exhaust-gas turbochargers
- **Injection:** common rail
- **Exhaust-gas after-treatment:** closed particulate filter CRTec®
- **Emission standard:** EEV

Electric motors (5)

- **Two asynchronous machines arranged in parallel**
- **Output of 75 kW each**
- **Coupled by means of a summation gearbox**
Highly mature system

Proven components for public transport applications (rail and bus transport)

Modular integration in existing vehicle concept

Basis for "electro-mobility" in conjunction with more powerful energy storage systems in future

VM Int. combustion engine (D0836LOH/EEV-184kW)
LE Power electronics
EM Electric motor (generator / drive motors)
D Differential with hypoid gear stage

Energiespeicher = Energy storage unit
MAN Lion’s City Hybrid
Fuel consumption – main influences

Long-distance touring
- Drag
- Rolling resistance

Touring
- Drag
- Rolling resistance

Intercity traffic
- Acceleration/retardation
- Idling

Urban traffic
- Acceleration/retardation
- Idling
MAN Lion’s City Hybrid
Fuel consumption – attainable potential savings

Fuel savings depend on route profile

Other influences:
- Hybrid concept
- Topography
- Energy consumption share of auxiliary units
- Driver's experience
- Number of passengers
- Traffic flow/guidance
Many components located in front roof area for **favourable weight distribution**

**Air inlets** for UC storage system designed to **improve airflow**

**Visually harmonious integration of roof hood**

**AeroLine** in matt anodised aluminium as cladding and distinguishing feature

**Discreet rear spoiler** as defined air breakaway edge and visual conclusion
Aerodynamic optimisation compared to conventional hoods up to ten per cent
From mid-2010: delivery of first vehicles to customers in Europe (pre-series production vehicles):
- Munich, Germany
- Hagen, Germany
- Vienna, Austria
- Paris, France
- Barcelona, Spain
- Milan, Italy
- Vehicles in the Netherlands

Sale from IAA Nutzfahrzeuge 2010 in Hanover onwards

From 2011 onwards: delivery of first series-production vehicles
Engineering the Future – since 1758.