New ways to mobility.

Hydrogen buses with internal combustion engines.

Hydrogen – the fuel of the future

Hydrogen – the oldest, lightest and most frequently found element in the universe is also the simplest chemical element. This small molecule could be the solution to a major problem – the dependence on fossil fuel and global warming caused by emissions of carbon dioxide. The substance with the molecular formula H2 can be produced from renewable resources, has no impact on the environment and in principle is available in infinite quantities. With these attributes hydrogen certainly fulfils the requirements of a fuel to ensure mobility in the future. MAN and Neoplan, with their great commitment to the development of buses with hydrogen drives, demonstrate that the H2 future is rapidly becoming reality.

Boundless energy.

As a part of the biological cycle, hydrogen can be found in numerous organic compounds and it is a component of water. The fact that about 71 % of the surface of the earth consists of water just goes to show what an inexhaustible energy source hydrogen is. Today the most promising method of producing it is electrolysis, the splitting of water into hydrogen and oxygen with the aid of electricity. It makes good ecological sense to generate the energy necessary to achieve this from renewable sources such as the sun, wind or hydroelectric or geothermal power.

NEOMAN Bus gases up.

As a pioneer of gas drives the NEOMAN Bus Group puts its great expertise in this field to good effect in the systematic ongoing development of environmentally acceptable drive concepts. Today MAN is the leader in Europe in natural-gas buses with CNG and LPG engines and is the first manufacturer to offer a complete range of natural-gas low-floor buses. Back in 1996 MAN presented the first hydrogen bus with an internal combustion engine worldwide to the public and then carried out two years of trials of the hydrogen engine in customer service. By deploying this bus in regular service it was possible to give an impressive demonstration of the suitability of the hydrogen engine for day-to-day use. Spurred on by this success, the second generation of low-floor buses with hydrogen-fuelled internal combustion engines came onto the road in 1999.

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The hydrogen bus with internal combustion engine: en route towards series production.

Experience leads the way.

Since mid 1999 three low-floor articulated buses with hydrogen drives have been in service transporting passengers at Munich Airport – two MAN Lion's City buses and a Neoplan Centroliner. Together they have already covered a distance of over 350,000 km. At the end of the five-year project period of this joint venture, known as the ARGEMUC project, the partners will continue their collaboration. In April 2004 another MAN hydrogen bus started demonstration service for the BVG public transport company in Berlin. All these buses have hydrogen combustion engines. Parallel to this the NEOMAN Bus Group is also developing and evaluating the use of hydrogen in forward-looking fuel-cell drives.

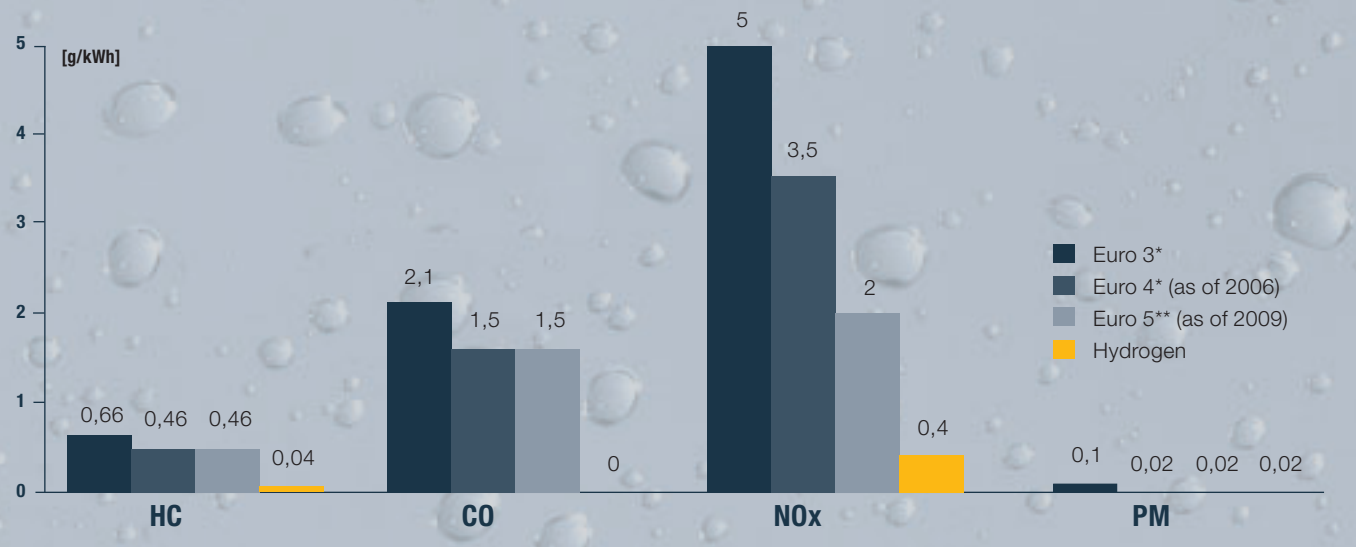
The environmental engine of progress.

The H 2876 UH hydrogen engine is a naturally aspirated 6-cylinder in-line engine installed horizontally which operates according to the four-stroke Otto principle. The monovalent engine, i.e. designed exclusively for operation with hydrogen, with a capacity of 12.8 litres develops an output of 150 kW (204 hp) and a maximum torque of 760 Nm. A considerably more powerful engine with exhaust-gas supercharging and an output of 200 kW (272 hp) is expected to be ready for vehicle trials in 2006.

The typical features of hydrogen engines are the external fuel preparation and the ignition by means of spark plugs. Since hydrogen ignites more easily and combusts more rapidly than petrol, measures must be taken to prevent spontaneous ignition, backfiring in the intake duct and knocking. MAN's hydrogen engine therefore has a lower compression ratio of 8.5 : 1, sequential multi-point hydrogen injection by means of electromagnetic valves and a map-controlled injection system with special spark plugs with platinum electrodes.

A slightly oversaturated hydrogen/air mixture is ignited. A secondary catalyst minimises the nitrogen oxide emissions (NOx) by over 95 %. MAN's hydrogen engine falls well within all the fixed future EU exhaust-gas limits through to Euro 5 and even achieves considerably better emission values than those laid down in today's most demanding exhaust-gas standard, EEV (Enhanced Environmentally Friendly Vehicle).

Exhaust emissions of the hydrogen engine
H2866UH01



*ESC 13-stage test for diesel engines (including diesel engines with oxidising catalytic converter)

**ESC 13-stage test

Hydrogen on board.

Unlike electrical energy, hydrogen can be stored in large quantities. There are two alternative methods: One is the storage of liquid hydrogen at minus 253°C. A high energy density can be achieved in this way, but it requires more elaborate thermal insulation.

The other method – the one used by MAN and Neoplan - is the storage of gaseous hydrogen in pressurised tanks at a pressure of 350 bar. On buses there is enough room on the roof for a storage system which gives them a wide enough operating range. Depending on the task of the vehicle an operating range of 150 – 250 km can be assured.

Filling up made easy.

Filling up with gaseous hydrogen is as easy as with diesel fuel. The main difference is the pressure-tight, low-temperature resistant coupling instead of a fuel nozzle. To fill the vehicle up the coupling is attached to the tank neck and locked in place with a lever; then the hydrogen can flow. It takes just 10 minutes to fill a bus up manually. By the way, if necessary the compressed hydrogen can be produced from liquid hydrogen.

Looking ahead.

Hydrogen has a future. We at MAN and Neoplan are working hard to continue development of the environmentally friendly technology of hydrogen drives and to make it ready for series production. We have successfully demonstrated just how serviceable this fuel is for buses. We are convinced that hydrogen will permit us to open up a new era in local passenger transport. Now it is our task to pave the way and inspire the general public with enthusiasm for this fascinating form of lasting mobility.

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