EU LIFE+ Mhybus

HYDROMETHANE FOR PUBLIC CITY TRANSPORT BUS

LAYMAN'S REPORT

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ENEA
START
SOL
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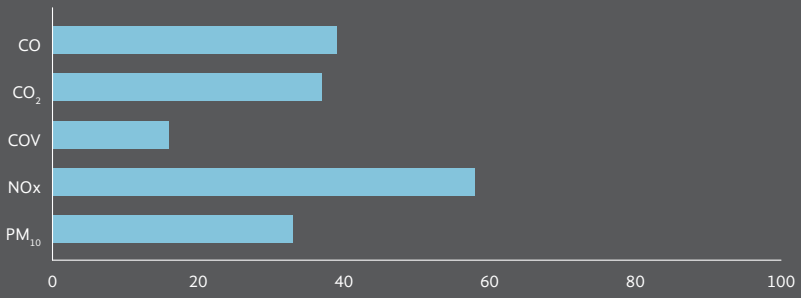
AIR QUALITY: THE ROLE OF TRANSPORT

Carbon dioxide is the main responsible for global warming and climate change, other atmospheric pollutants such as ozone, fine particulate matter (PM) and nitrogen oxides (NOx) contribute as well to this process. Transport has a strong impact on air quality (see box), but not only. The impact of the transport sector is relevant also on the energy consumption patterns: in Italy, this sector consumes the 23% of national energy consumption. Reducing the environmental impact of transport decreases citizen's exposure to pollutants, and contrast climate change by lowering CO_2 emissions and energy demand. One of the possible ways to reach these goals is the use of non-fossil alternative fuels. This is the path towards sustainability that Mhybus chose to follow.

Contribution of transport to atmospheric pollutants emissions in Emilia-Romagna as %



Source: ARPA, 2013. Air quality in Emilia-Romagna, 2013 Edition. CO: carbon monoxide, CO_2: carbon dioxide, COV: volatile organic compounds, NOx: nitrogen oxides, PM10: atmospheric particulate matter smaller than 10 μm.

HYDROMETHANE

Hydromethane is a blend of hydrogen and methane. Research by ENEA in 2006 has shown that low percentages of hydrogen in methane, thanks to the enhanced efficiency of combustion, reduce fuel consumption and CO_2 emissions. This is because the combustion of hydrogen produces water vapor and is energetically very favorable. In order to identify the optimal hydrogen content, different hydromethane blend compositions were tested, varying from 5% to 25% volume of hydrogen in methane, as well as the air/fuel ratio. For the use in public transport vehicles, the optimal blend composition was found to be 15% of hydrogen in volume, roughly equal to 2.2% in mass. The main advantages of hydromethane are:

- reduction of atmospheric pollutants emissions
- reduction of fuel consumption
- direct use in methane fuelled vehicles without mechanical modifications
- safety aspects similar to methane
- possibility of integration with the methane distribution grid.

MHYBUS PROJECT

Mhybus has accomplished the necessary technical and administrative steps to bring the first hydromethane fuelled bus to circulate on public roads with the aim of playing a pioneering role for further spreading of this technology. Furthermore, Mhybus aimed at providing a sound knowledge basis for the regional air quality policy and increasing the citizen's awareness with respect to climate change and air quality. Work phases were the bench tests and the development of the prototype vehicle, the construction of an "ad hoc" fuelling station, and the road tests without and with passengers. Technical guidelines, directed to local transport agencies were produced, as well as a roadmap for introducing hydromethane as alternative fuel. Organizations, companies, professionals and technical experts from the field were updated in all project phases by dedicated workshops and seminars, and also by means of the Hydromethane Community, where all produced documents are available.

BENCH TESTS AND PROTOTYPE DEVELOPMENT

The hydromethane bus prototype has been developed through different steps:

1. The bench and all the necessary technical equipment have been prepared according to the technical requirements defined by ENEA
2. The engine has been optimized for functioning with hydromethane: the only modification was a different setting of the electronic control unit consisting of a delay of the ignition
3. The final bench tests results have been transferred on the vehicle during the preparation of the hdyromethane fuelled prototype.

FUELLING STATION

A dedicated fuelling station for the hydromethane blend has been designed and constructed within the premises of an hydrogen production plant in Ravenna of SOL SpA. A specific mixing unit has been designed to provide the bus daily with the necessary fuel. During refueling, hydrogen and methane are mixed according to the fixed ratio (15% H2 in volume with a tolerance of ± 2%) within a mixing unit tailor-made for the project by SOL.

ROAD TESTS

Road tests were performed according to a protocol agreed with the Ministry of Transport. In December 2012, after having successfully completed the first 5000 km without passengers on board on a defined test route, the bus was authorized to perform road tests with passengers on board.

From January to September 2013, the hydromethane bus ran on normal service along line 8 in Ravenna. It ran on average 212 km per day, for a total of 45.000 km transporting more than 10,000 passengers. Passengers were informed about the characteristics of the vehicle by dedicated informative material hanging in the bus. During this phase, the absence of technical problems and the monitoring data about the engine's performance demonstrated that the use of the hydromethane blend does not hinder the vehicle's performances.

The prototype vehicle

Vehicle
VivaCity BredaMenarinibus 7,90 m

Engine
DAIMLER CHRYSLER - MERCEDES M 906 LAG

Emission Class
EEV

Maximum power
170 kW (231 CV) at 2.200 rpm

Maximum copy
808 Nm (82 Kgm) at 1.400 rpm

FUEL CONSUMPTIONS AND CO_2 EMISSIONS

During road test, at prescribed intervals, CO_2, CO, HC and NOx emissions were monitored by means of dedicated instruments installed on board. At the same time, hydromethane consumption was calculated from measured gas pressure in the vehicle tanks before and after each refueling, before and after reading of the number of kilometers.

To obtain consistent data, fuel consumption as well as pollutants emissions were compared with an identical methane fuelled vehicle used as reference. Results shown in the table clearly demonstrate that hydromethane leads to significant reductions of fuel consumption and CO_2 emissions.

Environmental benefits of hydromethane in figures*

	Methane bus	Mhybus	Difference as percentage
Fuel consumption Kg/km	0.32	0.28	13
CO_2 emissions g CO_2/km	0.87	0.74	14.96

* data obtained from monitoring activities of Mhybus experimentation and compared with an identical methane fuelled vehicle on the same itinerary.

THE ADDED VALUE OF MHYBUS

Mhybus has demonstrated that using the hydromethane blend in public transport significantly increases its sustainability. This is due to a 15% reduction of CO_2 emissions and to a 13% decrease of fuel consumption. During the road test phase, 5.98 tons of CO_2 emissions were saved on 45.000 km. The project has a pioneering aspect, besides the technical aspects, for the definition of the procedures to be applied for the homologation of a public transport vehicle. Mhybus is only one of the strategies that the Emilia-Romagna region has adopted for a more sustainable transport. This strategy has proven to be successful in Ravenna, where a high efficient hydrogen production plant is present, which can be used for the blend. The project is an example of an "ad-hoc" solution to contrast climate change and to improve air quality. Thanks to the positive results of the project, the vehicle is used as well as demonstrative mean of transport for events related with sustainable mobility.

MHYBUS IN FIGURES

1 hydromethane autobus realized
1 dedicated hydromethane fuelling station built
45.898 km run on road
More than **10.000** transported passengers
5,98 tons of CO_2 emissions saved
12,6 tons of produced hydromethane
1,8 tons of saved methane
15 dedicated networking events of national and international interests
33 articles, scientific publications, videos and interviews
37 presentations at technical events and participation to dissemination events
12 dedicated events
62 technical experts and professionals participating to the Hydromethane Community

HYDROMETHANE'S SUSTAINABILITY AND FUTURE

For the area of Ravenna, under the tested conditions, it was estimated that the maximum annual fuel costs for an hydromethane fuelled bus are 800-1000 €/vehicle, net of necessary costs for the infrastructure. This estimate takes into account fuel consumptions and costs for hydrogen production. However, while fuel costs are borne by the local transport agency, CO_2 emissions involve costs for the whole society, thus are expressed as indirect costs. According to the most recent estimates, every ton of CO_2 emitted by the transport sector has an external cost of 70 € (Maibach et al., 2008). Based on emissions avoided thanks to the use of hydromethane, which are beneficial for the entire urban system, a saving of 419 €/vehicle on external costs of CO_2 emissisons can be obtained. Thus, the higher yearly costs could be partially balanced by local or regional policy incentives as part of an overall strategy to increase the sustainability of transport. Considering the limited costs and the ease of its practical application, demonstrated thanks to the Mhybus project, hydromethane is surely interesting compared to other emerging technologies which reduce urban trasport's environmental impacts. The extension of the technology to other methane fuelled fleets is thus already a feasible solution.

Hydromethane: what are the costs?

Annual fuel costs per vehicle (45.000 km)	800 - 1.000 € /vehicle
Tons of avoided CO_2 emissions	5,98 ton CO_2
Reduction of external costs of transport thanks to the use of hydromethane	419 € /vehicle

MHYBUS TEAM

Emilia-Romagna Region, Directorate-General Infrastructural Networks, Logistics, and Mobility Systems, Mhybus project's coordinator, has put efforts in reducing atmospheric pollution also by promoting since 2007 the sixth "Agreement on air quality" among cities with more than 50.000 inhabitants in the region.
http://mobilita.regione.emilia-romagna.it/

ASTER S.cons.p.a. is the consortium for innovation in Emilia-Romagna. It coordinates and develops the High Technology Network, formed by regional laboratories for industrial research and innovation centers, organized into thematic platforms. Aster also promotes higher education initiatives for human capital valorization to foster employment in the R&D departments of companies.
www.aster.it

ENEA, the National Agency for New Technologies, Energy and Sustainable Economic Developmetn, is a public body operating in the field of Energy, environment supporting competitiveness and sustainable development.
www.enea.it

START Romagna Spa is the public transport company of the Romagna region, in which the three public transport companies of the area have merged, namely AVM (Forlì-Cesena area), ATM (Ravenna area, including busses and ferries on the Ravenna channel), and TRAM (Rimini area). The new company, with a fleet of 700 vehicles and more than 900 employees, provides public transport for a territory of about 5.100 Km2 and 1.100.000 inhabitants.
www.startromagna.it

SOL Spa is a multinational italian group which operates in Europe, Turkey and India in two different market sectors: production, applied research and commercialization of technical and medical gasses (Technical Gasses Area), and home care (Home Care area). Sol is active in Emilia-Romagna since 1973 with three plants, of which one located in Ravenna.
www.sol.it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