Biomethane as a road transport fuel: the Biomaster project experience

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WORKSHOP FOR THE PROMOTION OF BIOMETHANE IN IRELAND

Wednesday, 22 May

Teagasc, Oak Park, Carlow

CRF Trento Branch
Current Scenario and lines of action towards the reduction of CO2 emissions

Alternative fuels Road map

The Trentino case: a territorial opportunity

Biomaster Project experience
TRANSPORT SECTOR

ECONOMIC DEVELOPMENT

- The transport sector directly employs 10 million people, constituting 4.5% of total employment.
- The industry generates 4.6% of the gross domestic product (GDP).
- The production of transport equipment represents an additional 1.7% of GDP.

SAFETY

Road transport is considerably more dangerous than other mobility systems, even if the technologies for road safety (such as braking systems developed and / or other electronic control devices) are helping to reduce these figures.

TRAFFIC CONGESTION

The costs arising from traffic and traffic jams account for about 1% of gross domestic product (GDP) each year.

ENERGY and ENVIRONMENT

Emissions of greenhouse gases from transport (including international aviation and maritime) increased by about 34% between 1990 and 2008. During the same period, the energy sector has reduced emissions by 9%.

In the EU-27 demand for both passenger and goods will increase significantly: approx. +18% and +30% between 2010 and 2030

GpKm: Giga-passenger-kilometer, it measures the Passenger transport activity
GtKm: 10^9 gross tonne-kilometres, it measures the Goods transport activity

Source: http://www.fondazionesvilupposostenibile.org/f/Documenti/CO2+Trasporti/
CO2 EMISSIONS BY SECTOR (EU-27)

Changes 1990–2008

- Total GHG
- International shipping
- International aviation
- Waste
- Agriculture
- Industrial processes
- Fugitive emissions
- Households/services
- Transport
- Manufacturing/construction
- Energy production

Rocket

Total greenhouse gas emissions by sector in EU-27, 2008

- Agriculture 9.6%
- Transport 19.6%
- Manufacturing/ construction 12.4%
- Energy production 31.1%
- Industrial processes 8.3%
- Fugitive emissions 1.7%
- Households/ services 14.5%
- Waste 2.8%

* Excludes international aviation and shipping (6% of total GHG emissions)

- The CO2 emissions of the transport sector continues to grow while there is a decrease in relation to other sectors as agriculture or industry
- In 2008 there was a 25% increase compared to 1990
- In 2008, the transport sector produced about 20% of all the CO2 produced by man

Source: European Environment Agency (EEA)
System approach in order to identify the right mix of objectives between the various interventions in order to reach the best compromise in terms of performance / cost ratio.
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Biomaster Project experience
Available technology
- 23% of CO2 emissions than petrol
- 75% NOx

Technological opportunities for further improvement
METHANE

<table>
<thead>
<tr>
<th>Self-Service</th>
<th>Multi-dispenser</th>
<th>Home Filling System</th>
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</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Self-Service Image" /></td>
<td><img src="image2.png" alt="Multi-dispenser Image" /></td>
<td><img src="image3.png" alt="Home Filling System Image" /></td>
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Available technology
- 23% of CO2 emissions than petrol
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Technological opportunities for further improvement

METHANE

EU Mandatory: 10% of transport fuels from renewable energies within 2020

DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
**BIOGAS AND BIOMETHANE**  
(ANAEROBIC DIGESTION and UPGRADEING)

**Direct environmental benefits:** The progressive use of biomethane will provide an additional reduction in CO$_2$ equivalent emissions thanks to the CO$_2$ closed cycle and to the biogas direct emission avoided (e.g.: waste humid fraction; manure → negative GHG emissions)

**Indirect environmental benefits:** potentiality for producing an effective and easily handled fertilizer which can be incorporated in soil in precise amounts (better homogeneity of digested products; better agronomic efficiency); reduction of odour nuisances (social impact)

Biogas can be produced from a variety of feedstock, through anaerobic digestion: sewage sludge (waste water treatment), wet and dry animal manures, waste and by-products from forestry,…..

**GLOBAL WARMING INDEX (GWI) =**

\[
\text{GWI} = \text{CO}_2 + 21*\text{CH}_4 + 296*\text{N}_2\text{O}
\]

Source: JRC/EUCAR/CONCAWE
ALTERNATIVE FUEL COMPARISON

Emissions "well-to-wheels" in gCO₂ eq/km

- Gasoline: 164 gCO₂ eq/km
- LPG: 141 gCO₂ eq/km
- Methane: 124 gCO₂ eq/km
- Methane 40% bio-methane: 75 gCO₂ eq/km
- Bio-Methane 100%: 75 gCO₂ eq/km
- Electric Mix UE: 5 gCO₂ eq/km
- Electric (100% eolic): 5 gCO₂ eq/km

(*) Ref. Vehicle: Gasoline - emissions CO₂ (Tank-to-Wheel): 140 g/km

NGV System Italia su dati DENA - Agenzia Governativa Tedesca per l'Energia
BIOMETHANE IN ITALY

- Italy is the fourth largest producer of biogas in Europe
- In Italy the biogas is now used exclusively for the production of electrical energy combined with heat
- Biomethane is not yet incentivated in Italy

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### The biogas production in Europe in 2010 was equal to 10943 ktoe (= t. Of oil equivalent), (+42% vs. 2007)

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**Table: Biogas Plant Numbers for Various European Countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Biogas plants feeding the grid</th>
<th>Biogas plants total (approx.)</th>
<th>Agricultural</th>
<th>Biowaste (incl. organic MSW)</th>
<th>Sewage</th>
<th>LFG</th>
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<tbody>
<tr>
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<td>10</td>
<td>503</td>
<td>approx. 300</td>
<td>55</td>
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<td>14</td>
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<td>1</td>
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<td>8.792</td>
<td>approx. 7,000</td>
<td>92</td>
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<tr>
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<td>58</td>
<td>36</td>
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<td>14</td>
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<tr>
<td>Italy</td>
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<td>667</td>
<td>approx. 300</td>
<td>32</td>
<td>135</td>
<td>200</td>
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<tr>
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<td>13</td>
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</tr>
<tr>
<td>Poland</td>
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<td>17</td>
<td>2</td>
<td>approx. 200</td>
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</tr>
<tr>
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<td>-</td>
<td>24</td>
<td>12</td>
<td>-</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>UK</td>
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<td>360</td>
<td>60</td>
<td>100</td>
<td>&gt; 200</td>
<td></td>
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<td>229</td>
<td>14</td>
<td>23</td>
<td>135</td>
<td>57</td>
</tr>
<tr>
<td>Switzerland</td>
<td>17</td>
<td>15</td>
<td>600</td>
<td>140</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>177</strong></td>
<td><strong>128</strong></td>
<td><strong>11,869</strong></td>
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*http://www.greengasgrids.eu/?q=node/114
Biogas/Biometano in Italia: situazione e prospettive – Claudio Fabbri CRPA –2011*
BIOGAS PRODUCTION POTENTIAL

The potential of biogas in Italy has a total amount of about 20 TWh/year of EE corresponding about to 6.5 billion m$^3$ of bioCH$_4$/year.

If we suppose to use 1/3 of biomethane produced for vehicle fuel we would have a total amount of 1.5 billion m$^3$ of bioCH$_4$/year.

The up-graded biomethane would allow to run 1.1 millions of Fiat Panda/year (average range of 30’000 km) (~ 322,000 by 1/3 of actual production)

(*): La produzione di biogas/biometano in Italia – Sergio Piccinini CRPA – BiogasExpo 2009

Methane vehicle in Italy: ~615000 units
**EU Mandatory:** 10% of transport fuels from renewable energies within 2020

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Hydro – Methane Blends

Adding a fraction of GREEN hydrogen to CNG we obtain an advantageous technology in several aspects: it is possible to take advantage of some properties of hydrogen for enhancing the already excellent "green" natural gas minimizing the associated criticism using only hydrogen.

It is a technology "bridge", enabling investment in hydrogen infrastructure.

**FLEX-FUEL**

H₂ from 0 to 30%

Environmental Benefits:

- Fraction of 30% of H₂ reduces the CO₂ emissions by 11% compared to natural gas, 31% gasoline and 15% compared to diesel
- Reduction of polluting emissions (THC, CO and NOₓ) achieves EEV and approaches to future Euro VI standard
- Zero PM emissions
- Low noise compared to diesel vehicles

- Equivalent to the same natural gas vehicle
- Potentially applicable on all methane platforms using specific measures to adapt
Current Scenario and lines of action towards the reduction of CO2 emissions

Alternative fuels Road map

The Trentino case: a territorial opportunity

Biomaster Project experience
Through the creation of local partnerships between the worlds of research, industry and the public sector, the Province of Trento promotes an integrated system that enables the territorial development through the implementation of innovative solutions with a positive impact for citizens and at the same time for the creation of industrial opportunities.
SYSTEM APPROACH
Province of Trento - Italy

Renewable fuels

Electricity  Hydrogen  Bio-NG

Storage systems and distribution

Ecological fleets

Info-Telematic for the management of fleets of vehicles and the development of innovative services
Overview NGV Vehicles
Trentino Province

- Italy is the leading country in Europe with the largest number of filling stations (more than 900 compressed natural gas refuelling points)
- Increasing the number of filling stations is a response to the growing passenger car using natural gas despite a certain fragmentation in the territory country and the lack of self-service

- In Trentino there are more than 3'000 vehicles running on natural gas
- In the last 20 years the region has shown a considerable increase of the CNG cars passing from only 178 vehicles in 1990 to 3'303 at the end of 2011 (+1755%) and triplicating the number of CNG vehicles during the period 2001-2005.

(source ACI website)
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Biomaster Project experience
The Biomaster Project

CRF leads WP5 “Biomethane use as transport fuel” aims to expand in the partner regions the use of biomethane as renewable fuel, sharing this information more broadly in Europe.

It addresses the following topics:

- Biomethane and vehicle **engine performance** (gas composition, quality, emissions, efficiency, standards for use in vehicles);
- Innovative technologies to improve vehicle **storage** systems;
- Assess and promote use of biomethane in different **typologies of fleets**;
- **Policies** to boost the vehicle market
CNG vehicles could be divided into the following 3 categories:

- **Mono Fuel**: Dedicated natural gas vehicles designed to run on natural gas/biomethane only;
- **Bi-fuel vehicles**: Running on natural gas/biomethane or gasoline: since natural gas is stored in high-pressure fuel tanks, bi-fuel vehicles require two separate fueling systems;
- **Dual-fuel vehicles**: Running on biomethane/natural gas but using diesel for ignition assist. They allow users to take advantage of the efficiency of the diesel engine but without the risk of running out of gas because of the wide-spread availability of diesel. When biomethane/natural gas is available, the dual fuel vehicle can use a cleaner, more economical alternative.

Light-duty vehicles typically operate in mono-fuel or bi-fuel modes, whereas heavy duty vehicles operate in mono-fuel or dual-fuel modes. Conventionally vehicles in which an auxiliary tank for a different fuel is incorporated, but where this fuel has a capacity not exceeding 15 litres, are also considered to be mono-fuel.
The Biomaster Project
NGV Vehicles overview
According to the ECE R110, the CNG System:

“means an assembly of components (container(s) or cylinder(s), valves, flexible fuel lines, etc.) and connecting parts (rigid fuel lines, pipes fitting, etc.) fitted on motor vehicles using CNG in their propulsion system”.
The Biomaster Project
Storage Systems

• In general there is a common categorization of NGV cylinders used across the major NGV safety standards and 4 basic types of tank designs

• This choice depends on the weight reduction and cost target

• Safety level is the same for all systems, as they meet the standard requirements
The Biomaster Project
Storage Systems

Type I Cylinders:
They are the generally the cheapest option, but they are also the heaviest.

Type II Cylinders:
They provide a compromise between the low cost of Type 1 cylinders and the lightest weight Type 3 and 4 cylinders.

Type III Cylinders:
These cylinders are used in a wide range of applications where weight reduction is important, for example in transit buses and delivery trucks.

Type IV Cylinders:
These are the lightest tanks. A Type IV tank will weigh about 70% less than a Type I tank of equivalent size.
The Biomaster Project

Survey on current CNG Users

- The survey done in Biomaster aims to compare the situation in the four different BIOMASTER regions regarding the perception of gas as vehicle fuel.
- In particular this survey aims to evaluate the degree of awareness and acceptance of natural gas and biomethane in the vehicle market interviewing selected target groups of potential private and public users.
- Nowadays the situation in the BIOMASTER regions is heterogeneous and can vary as much from one site to another one.
The gas vehicle market is more developed in Italy and Sweden than in UK and Poland.

On the other hand, Italy does not produce biomethane yet (despite the large number of biogas plants) as opposed to Sweden where biomethane is already in use.

UK and Poland have only 70 distributors of methane for cars: in these countries the gas vehicle market is at an initial stage and need to be further developed.
The Biomaster Project
Survey of current CNG Users

- The perception of NGV’s is generally good and users are satisfied
- The main reason for purchasing a NG/Biomethane vehicles is fuel saving
- The environmental aspect of NG/Biomethane is a very important driver for choosing NGV’s
- NG/biomethane is considered by the users not more dangerous than the standard fuels
- There seems to be a good general knowledge of alternative fuels such as biomethane, although in some cases, people still get confusion with name.
- A consistent part of the people look at biomethane as an additional motivation to buy a CNG vehicle.
CONCLUSIONS

• The transport sector is responsible for 23% of CO2 emissions and the continued demand for mobility determines that a continuous increase must be balanced and reduced by continuous improvements in vehicle efficiency;

• Alternative fuels, and in particular natural gas, which is already a reality in many countries, can contribute significantly to reduce CO2 emissions, (it is essential to aim for a strong infrastructure development);

• Fuels from renewable sources such as BIOMETHANE have great opportunities for development and will play an important role in the transport near future (target of 10% by 2020), but also for agriculture sector;

• To enable and promote the development and application of fuels from renewable sources is extremely important to move towards a system approach and supply chain approach involving all necessary stakeholders (public administration, companies, research world,…).
Centro Ricerche Fiat

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