

Evaluating Development Opportunities for Liquid Biomethane as Transport Fuel

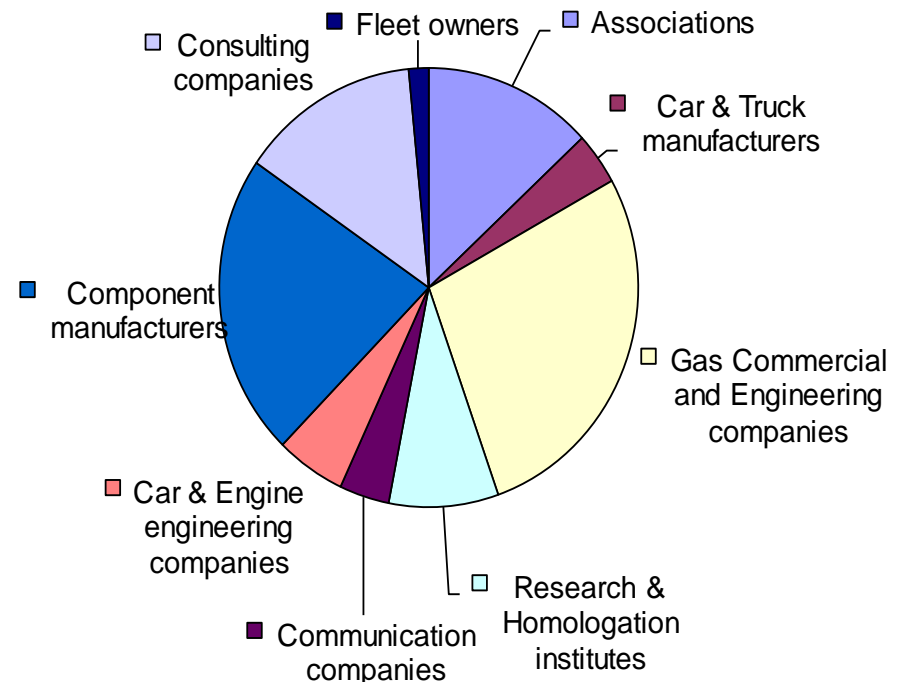
Global Biomethane Congress 2012
9th October 2012. Brussels

Manuel Lage, Dr. Eng.
General Manager

What is NGVA Europe?

NGVA Europe is the only European Association defending the interests of the NGV related industry.

- It was founded in 2008. We have now more than 150 members from 38 different countries, representing all the activities around NGVs and bio/natural gas production and distribution
- NGVA Europe has the main office in Madrid and a permanent representation in Brussels, being in close contact with DG Move, DG Ener, DG Taxud, TEN-T and CTS, being also member of the Future Transport Fuels Expert Group.
- We have an intense technical activity, being present in all the ISO, CEN and UNECE working groups, dealing with legislations and standardization
- NGVA Europe has several lines of communication with their members, which receive in a regular basis Case Studies, Technical Communications, Position Papers, etc.



Advantages of bio natural gas

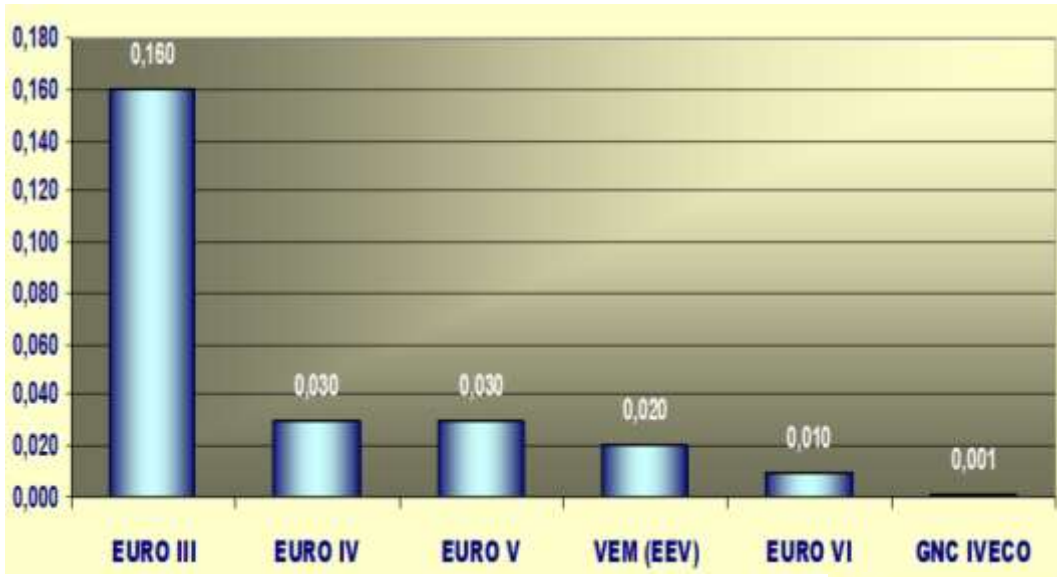
- Natural gas is an alternative fuel coming from natural wells. It is mainly methane (CH₄)
- Biogas is also a methane rich gas, produced by the fermentation of the biomass, it is then a renewable fuel.
- **Methane contents 25% H and 75% C, in weight**

As a comparison,

- Petrol contents 13,5% H and 86,5% C
- Diesel oil contents 13,5% H and 86,5% C
- LPG contents 17,4% H and 82,6% C

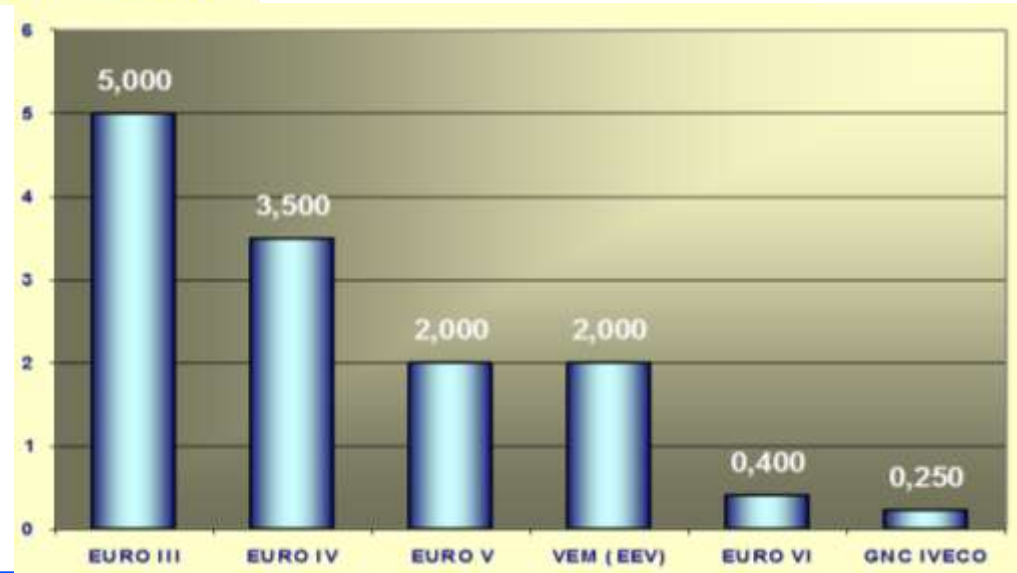
Due to its molecular advantage, regulated exhaust emissions and CO₂ are particularly favourable in the engines running on natural gas.

Exhaust pollutants limits



PM limits

NOx limits NO₂ is not measured

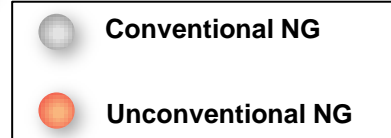
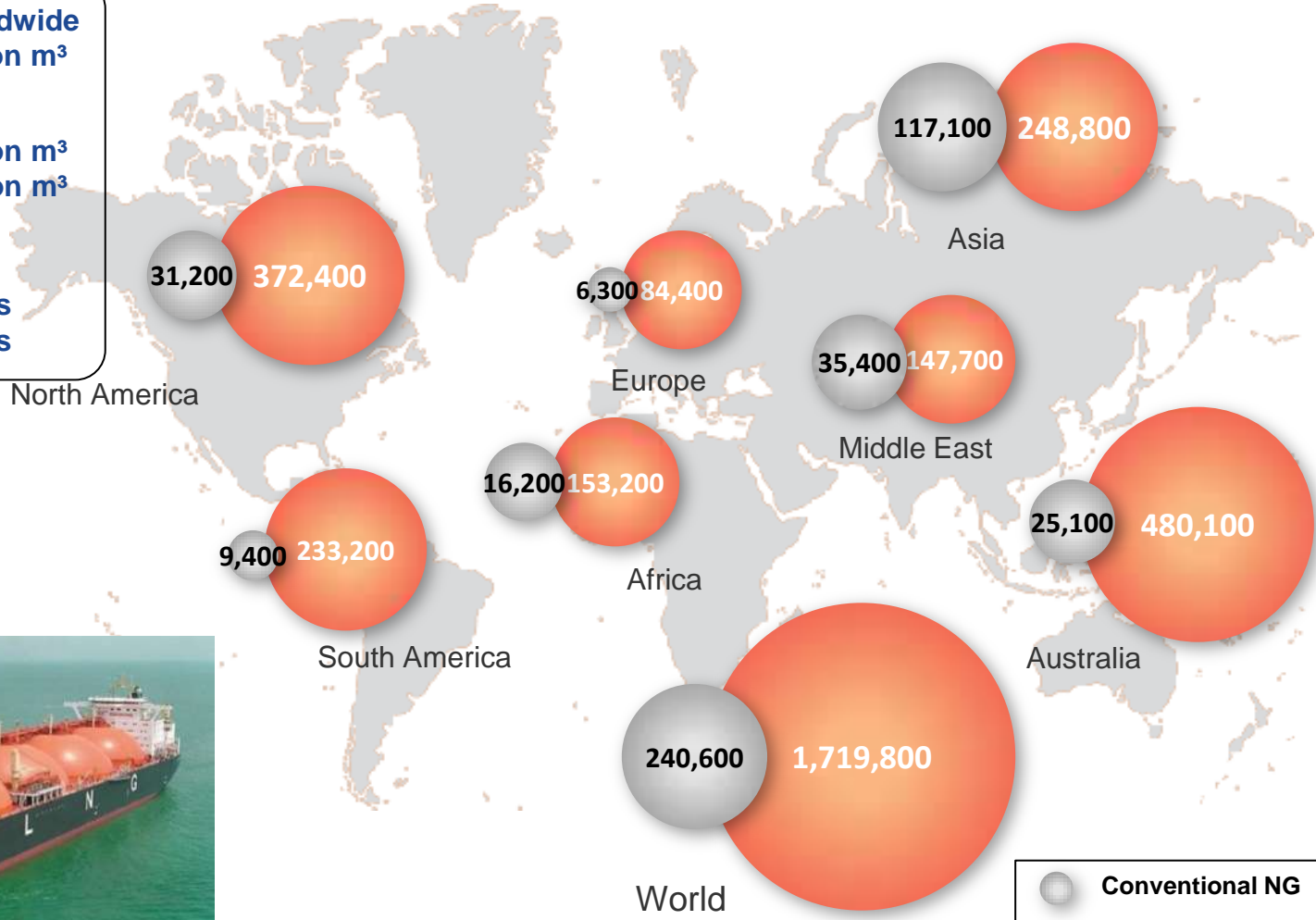


Worldwide gas reserves (unit= 10^9 m³)

Gas consumption worldwide
 (2010): 3.200 billion m³

Europe:
 Total 522 billion m³
 NGVs 1,8 billion m³

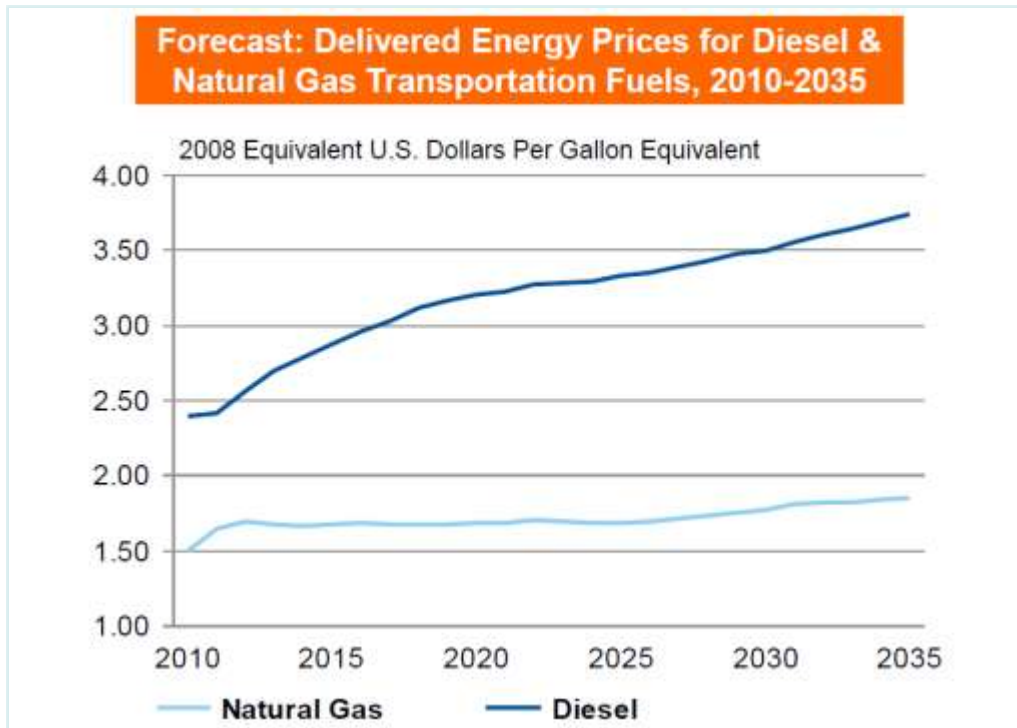
Reserves:
 World: 537 years
 Europe: 161 years



Source: data BGR, graph works NGVA Europe

Gas Natural firma un contrato para abastecerse en EE UU por 20 años

Cheniere suministrará cada año el equivalente al 15% del consumo de España.
El País, 23rd November 2011



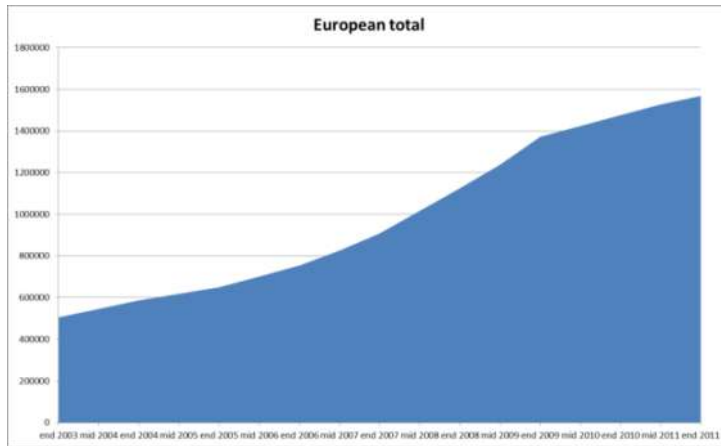
Source: U.S. Energy Information Administration, Annual Energy Outlook 2010

In 2008, non conventional gas meant 8% of the total US gas consumption.

In 2035 EIA estimates unconventional gas could reach 57%!

US EIA forecasts prices for diesel and gas will continue being decoupled.

NGVs in the world 1991 to 2020 growth and forecast



Europe:
16% growth (2006-2011)

World:
70+ M NGVs in 2020!

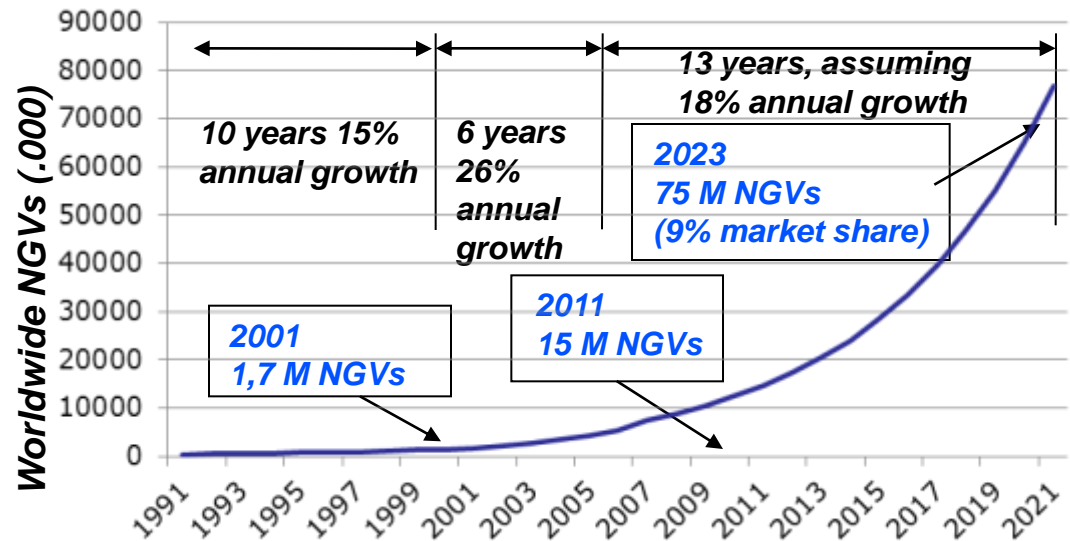
Source: NGVA Europe

Global market for NG trucks is expected to grow at a Compound Annual Growth Rate of 14% between 2012 and 2019, while NG buses are expected to grow at 19% during the same period.

This growth is being fueled by:

- economic growth following the global slowdown of the last few years
- increased vehicle availability
- environmental benefits
- and the desire for increased energy security.

Pike Research, September 2012

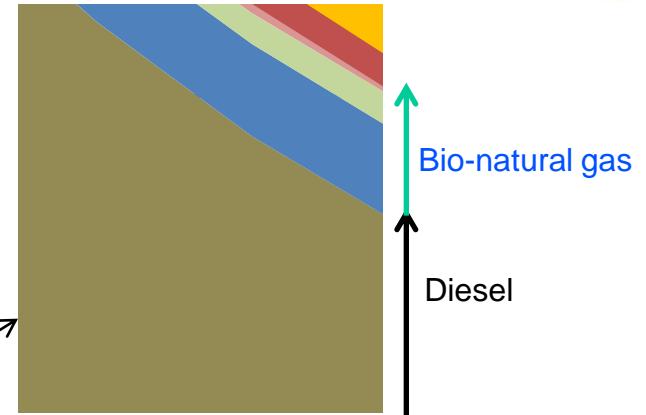
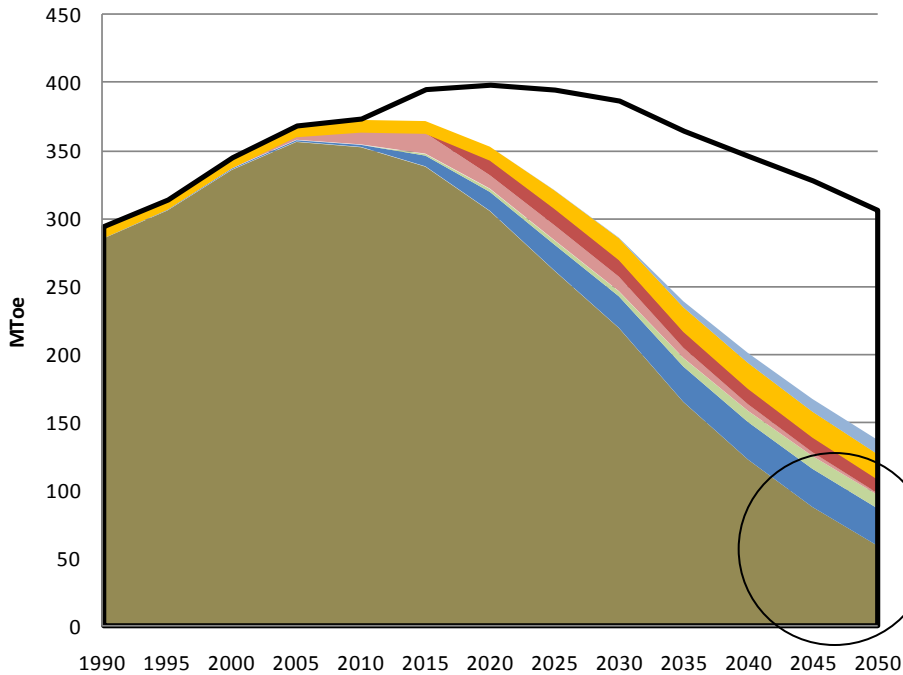


Eurogas Roadmap 2050 (10/2011)

Expected market share: 9% in passenger, 33% freight



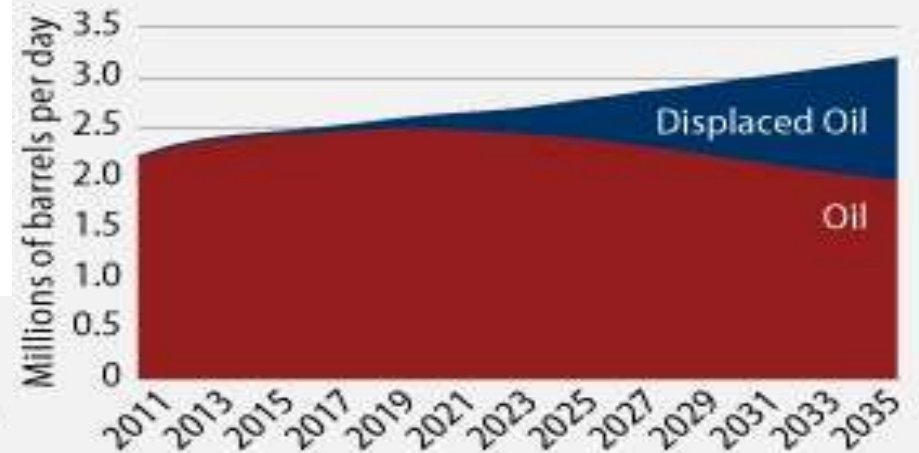
Final energy consumption - Transport



North American forecast: 37%

Sources: Energy Information Administration, Annual Energy Outlook 2010, Supplementary Tables 46 and 67, available at: http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C170 and http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C2275

Potential oil displacement from natural gas trucks and buses



CNG urban trucks and buses in Europe

70.000 urban buses give service in the main European cities (Italy, France, Germany, Spain, Sweden, Greece, Portugal, Netherlands)

9.000 (13%) are CNG.

20.000 garbage trucks in service in Europe

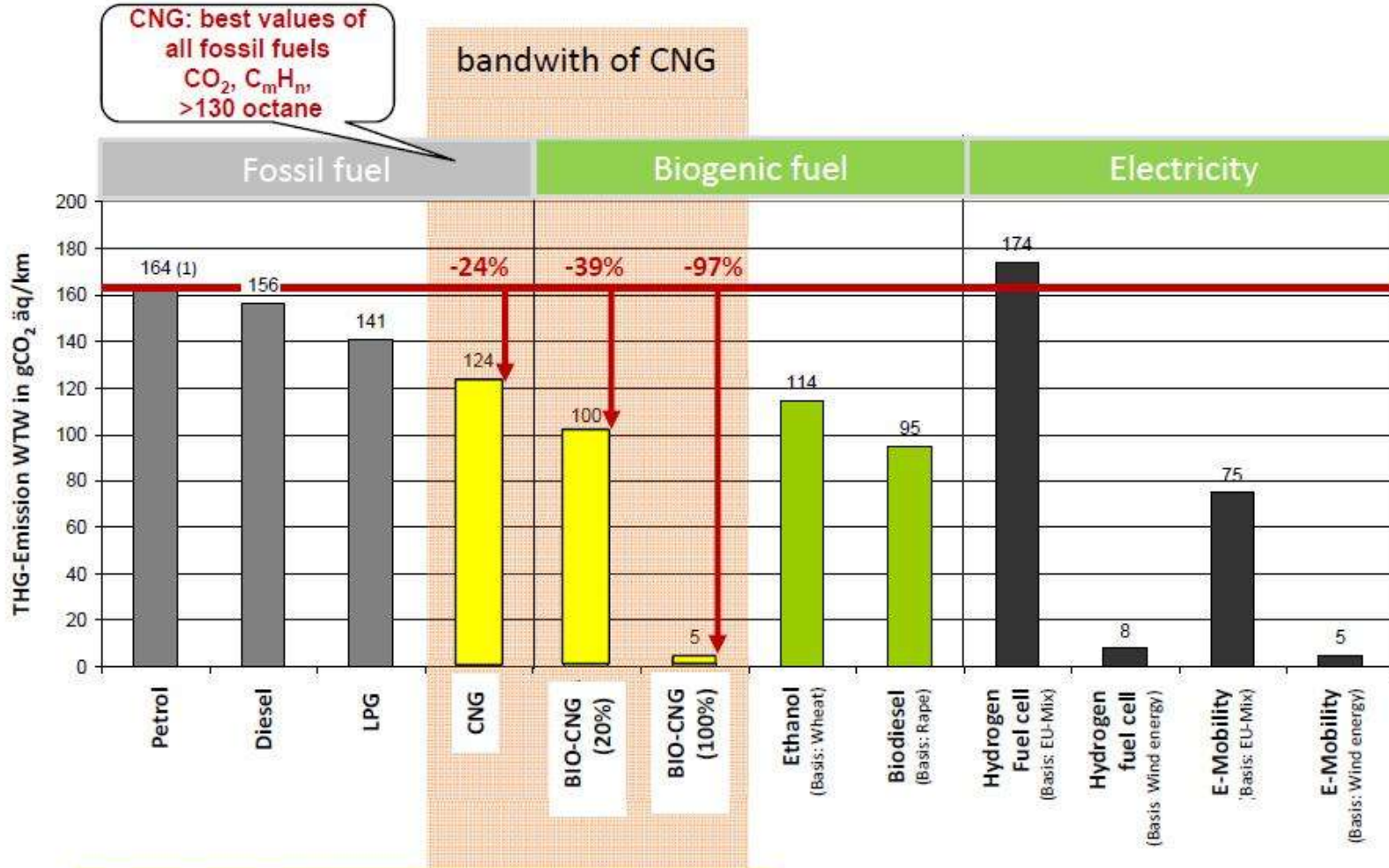
(France, Spain, Italy, Greece)

3.000 (15 %) are CNG.

On top of the great advantages in exhaust emissions, Natural Gas vehicles offer a very silent operation, much appreciated in urban centres.



Well-to-Wheel balance of vehicle fuels

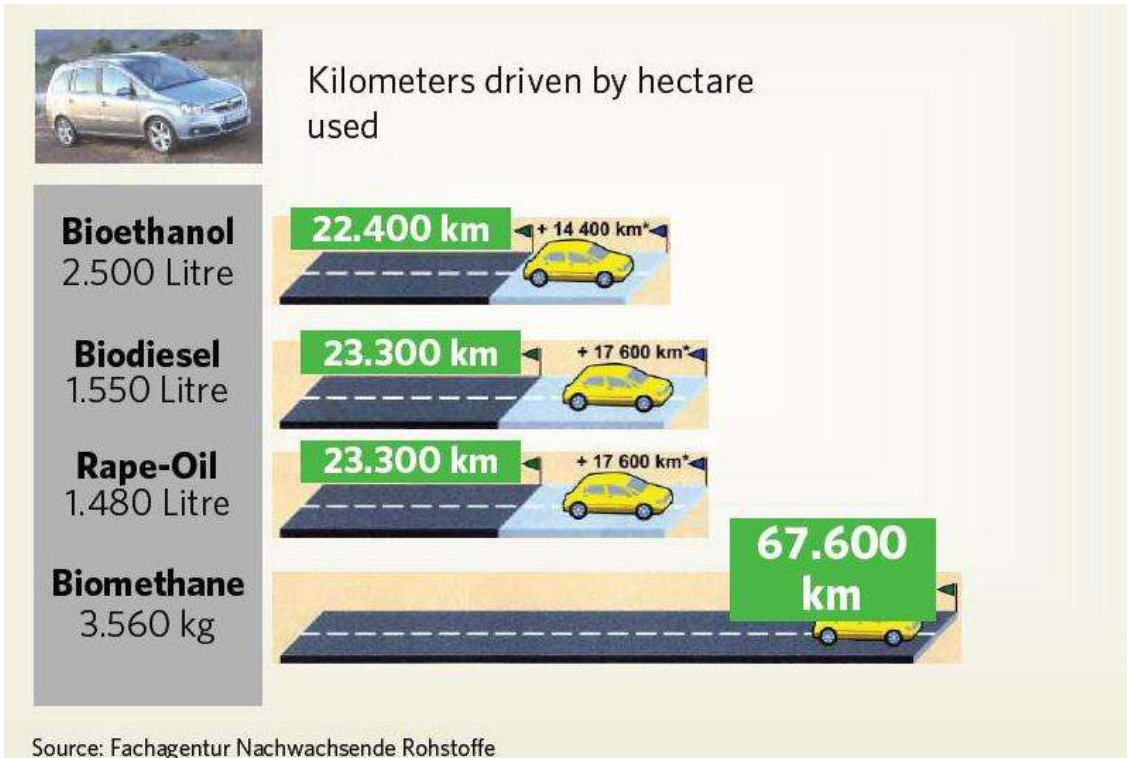


(1) Basis: (Petrol, naturally aspirated engine), Fuel-consumption: 7l/100km

Source:: DENA; EUCAR-CONCAWE

Source: German Energy Agency (DENA) Study 2010

Biogas (also LBG) production potential



Among different options of biofuels, biomethane presents the highest efficiency per hectare of land.

A global European estimation shows a potential of:

2.750 TWh (9,9 EJ=238 Mtoe), made out of:

1.500 TWh (5,4 EJ=130 Mtoe) coming from crops, plus another **1.250TWh (4,5 EJ=1.108 Mtoe)**

coming from other sources: sewage, manure, landfills, etc.

If we choose bioethanol instead of biogas we would lose the potential of the waste, sewages, etc (1.250TWh, 4,5EJ=108Mtoe) and we would also reduce the efficiency of the land by 47%.

In other words we would obtain:

800TWh (2,9 EJ=70 Mtoe) instead of 2.750TWh (9,9 EJ=238 Mtoe).

Biogas is the perfect fuel for food distribution and other urban activities



Deliveries of Coca Cola UK in London for the Olympic Games will be done exclusively with CBG trucks.

Some garbage collection companies in Switzerland are also using biogas.



CBG buses in Nijmegen (NL)



CNG Net, a subsidiary of the NGVA Europe member Ballast Nedam, is set to deliver 12 million m³ of biomethane for all 225 city buses of Connexxion in the city area of Arnhem/Nijmegen in the Netherlands, from the end of 2012. This will be the largest public transport concession for biomethane in the Netherlands and unique in Europe.

European biogas projects: GasHighWay



The **GasHighWay** project: Promoting the Uptake of Gaseous Vehicle Fuels, Biogas and Natural Gas in Europe

Status: The project has finished last May 2012. Now we are submitting the last reports and financial statements for evaluation by the EC officer.
NGVA Europe contribution has been very positive, specially due the success of the two Seminar that we have organized (Final Seminar last 1st March 2012 in Brussels)

Main achievements:

[CNG/BioMethane network map](#) as GPS application. Now available in GasHighWay website and will also be available in the NGVA Europe website in 2013

[National reports](#) on current status of biogas production

[Best practices reports](#)

[Feasibility studies](#) and business plans for the realization of the filling stations

[Techno-economical analysis](#) for the gas vehicle infrastructure

[EcoFleet Scan tool](#), to activate gas vehicle fuel consumption

This project has triggered the interest of different EU countries in the production and use of the biogas as another source of natural gas for vehicle use. Best practices from some countries served as an example for other, now starting its own biogas development.

European biogas projects: BioWALK4Biofuels



BioWALK4Biofuels. Bio waste and algae knowledge for the production of 2nd generation biofuels.
Last meeting held in Grenaa (Danmark) in April 2012
Next meeting in Augusta (Italy) in October 2012

NGVA Europe assists with promotion, marketing and dissemination of project results (work shops and site visits).
The project website www.biowalk4biofuels.eu has been developed by NGVA Europe, opened in July 2010

This is the first European experience in the production of 2nd generation biogas from algae.

Current status: Assembling biogas plant in Augusta
Definition of the main legislation barriers for the production on LBG/CBG
Contacting the local fleets for the use of CNG vehicles

The choice of the more gas productive algae has been carried out in different laboratories from India, Jordan, Denmark and Italy, under different conditions of water salinity and temperature.

European biogas projects: BioWALK4Biofuels

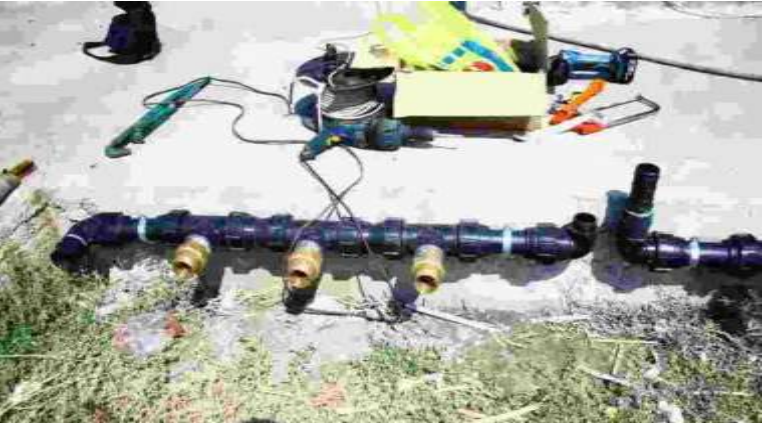


Single open pond preparation.

Augusta, Sicily (Italy). July 2012



Pond installation. July 2012



Main trunk for pumping out/in water-algae from open ponds



Anaerobic digester tank

European projects: GreenGasGrids



This IEE (Intelligent Energy Europe) project try to encourage biogas injection into gas grids or use as a transport fuel, including streamlining procedures for grid connection and quality monitoring. NGVA Europe participates actively in the elaboration of guidelines for biogas market actors and roadmaps.

Duration: 36 months

Last meeting took place in Zagreb past September 2012

Updating: The report with the overview of biomethane markets and regulations can be found on the project website: www.greengasgrids.eu

NGVA Europe's main implication is the development of Gas Quality procedures in the CEN PC-408 Working Group.

We are also acting as the European platform in charge of collecting the experiences from different countries not directly involved in the project.

BIOGAS FROM FOOD AND MUNICIPAL WASTE PROMOTION (WASTETOGAS)

WASTEtoGAS project proposal has been submitted last May to CIP-IEE-2012.

The global aim of WASTEtoGAS proposal is to foster the transformation of European food and municipal waste to renewable energy through biogas production, using anaerobic co-digestion (AncoD) in Europe. Four target regions/countries have been chosen for the experience: Spain, Greece, Portugal and The Netherlands

NGVA Europe will participate as a partner giving advice to the best biogas utilization guidelines and disseminating the main achievements of the project

Landfill for biogas production Valdemingómez (Madrid)



Yearly biogas production: 40.000.000 cm/year

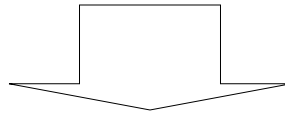
Big city Gas consumption vs biogas production

The yearly consumption of natural gas of the garbage collection fleet (450 trucks) is:

10,5 mio m³

The yearly biogas production of the city is of about 40 mio m³, that once refined would mean:

22 mio m³ of biomethane



This volume is enough to fuel the full fleet of garbage collection (450 units) plus a similar figure of urban buses (25% of the total fleet of 2.000 units)

Gasrec Technology & IPR



A Gasrec plant can clean, purify and liquefy landfill gas and other waste methane streams.

The process removes contaminants to produce biomethane which is ~ 96% methane and 4% nitrogen.

Gasrec owns IPR relating to the front-end clean-up technology and the overall process for separating and liquefying waste gas.

No other company outside the US has technology to clean, upgrade and liquefy biogas.

Gasrec has committed 8 years and £20m to technology development



The Gasrec Business Plan



Through the plan Gasrec will support the major adopters of liquid gas road fuel - HGV Logistics.

The model needs to provide fuel security and availability.

As well as having supplies of Liquid Natural Gas (LNG), Gasrec will expand its unique capability to convert bio sources of liquid gas fuels through multi million pound investments in new facilities in the next three years.

The major adopters of Gasrec's offer want their fuel provider to deliver:

- **Access to regional refuelling Infrastructure**
 - Supporting their multi location logistics business
- **Resilience in the supply chain**
 - Replacing the unreliable and ineffective existing logistics and refuelling market offer
 - Continued access to bio product as a key enabler for decarbonisation of their operations
 - Ensuring strategic access to LNG as a driver for volume and resilience in the supply chain



The new Lidköping Biogas Plant

Lidköping Biogas is one of the world's first production plants for Liquefied Biogas. The plant produces annually 60 GWh, equaling 6 million liters of petrol.

Official inauguration: October 19th 2012

http://www.youtube.com/watch?v=Vsk6Anillfs&list=PL40008AC070F834CC&index=2&feature=plpp_video

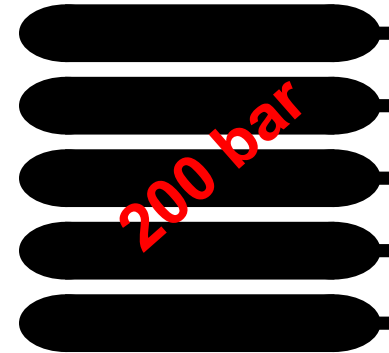


LNG trucks for long distance transport



**Diesel vs CNG & LNG.
Autonomy equivalence**

1 liter Diesel oil



CNG
5 litre

-162°C at 1 bar
-125°C at 10 bar

LNG/LBG
1,8 litre



Two engine technologies are available for heavy engines:

- Dedicated, using 100% natural gas
- Dual fuel, using diesel injection for ignition and natural gas as the main fuel

LNG opened the way for the medium and long distance road transport

LNG truck refueling process



Single hose filling,
low working pressure, 7-10 bar (**Chart**)



Double hose for filling and venting,
high working pressure, 18 bar (**Indox**)
(MB to adopt 7-10 bar shortly)

European LNG heavy duty tractors



European LNG park:

200 LNG vehicles
25 filling stations (end 2012)



Soluciones en Gas Natural en Camiones: Tecnología dual-fuel



- Acuerdo de colaboración con Hardstaff para dualización de Actros/Axor
- Homologación en España en proceso
- 150 unidades en funcionamiento dualizadas
- Funcionamiento con GNC/GNL
- Sustitución 40-70%
- Ahorro hasta 25% del coste de combustible

North American and Australian LNG trucks



**Autocar
International
Freightliner
Peterbilt
White**

...



More than 6.000 LNG heavy trucks already running in USA!

Chinese NG trucks



Foton
Sinotruk



Shaanxi

Dong Feng



Today: 19.000 LNG heavy trucks & buses in service and 300 LNG fuel stations!
2015 (5-year-plan target): 200.000 LNG vehicles and 1.500 fuel stations!!

Types of vehicles and alternative fuels

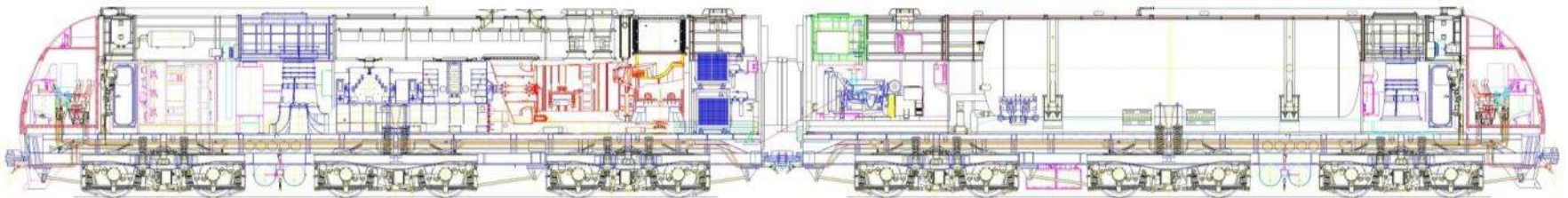
Vehicle type	Present fuel	LPG	Liquid biofuels	Full electric	Hybrids (energy recuperation)	Bio-natural gas (CNG & LNG)
Three wheelers	Petrol	Yes (mostly converted)	Yes (%)	No	No	Yes (CNG)
Cars	Petrol & diesel	Yes (mostly converted)	Yes (%)	Yes (city cars)	Yes	Yes (CNG)
Vans & delivery trucks	Diesel	Yes (vans), mostly converted	Yes (%)	Yes (city use only)	Yes	Yes (CNG)
Heavy urban trucks	Diesel	No	Yes (%)	No	Yes	Yes (CNG)
Suburban & urban buses	Diesel	No	Yes (%)	Yes, small Yes (wired)	Yes	Yes (CNG/LNG)
Coaches	Diesel	No	Yes (%)	No	No	Yes (LNG)
Heavy on road trucks	Diesel	No	Yes (%)	No	No	Yes (LNG)
Heavy off road trucks	Diesel	No	Yes (%)	No	No	Yes (CNG/LNG)
Railway locomotives	Diesel & electric	No	Yes (%)	Yes (wired)	No	Yes (LNG)
Ships	Diesel	Short sea (converted)	Yes (%)	No	No	Yes (LNG)
Aircraft	Diesel Jet A-1	No	Yes (%)	No	No	Yes (LNG)

LNG in railways



Russian locomotive with 8.300 kW gas turbine engine running on LNG.

In daily service since 2009.



LNG fuelled ships are growing rapidly



Nov. 1st, 2011. Japan's Ministry of Land, Infrastructure, Transport and Tourism had indicated its intention to develop safety standards for vessels powered by **liquefied natural gas (LNG)** which it expects will **largely supersede oil-fueled marine transportation**, reports L-News.

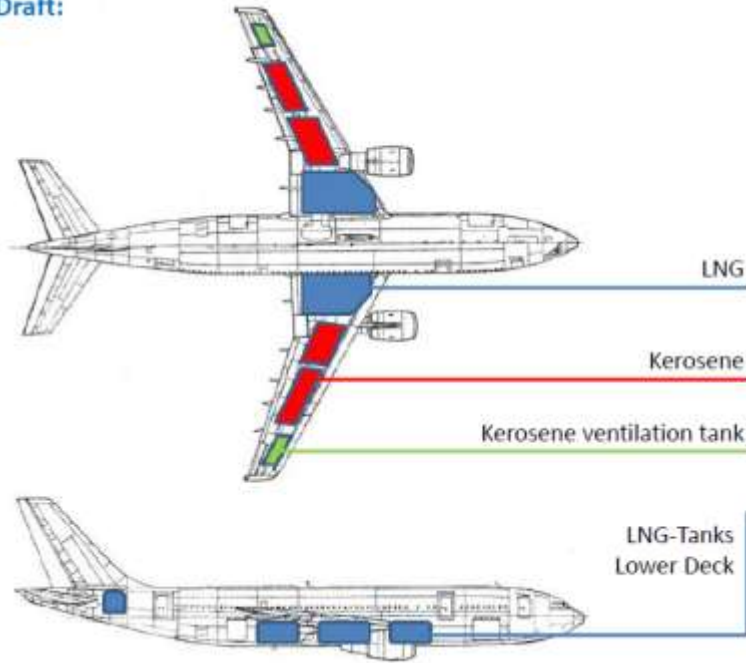
JPY 647 M (€ 6,2 M) has been set aside in the 2012 budget for **the creation of comprehensive safety measures pertaining to marine renewable energy**.

November 29, 2011 | Norway: **"We believe 500 LNG fuelled ships will be on order by 2015, several thousands by 2020,"** Mr. Remi Eriksen, COO of Det Norske Veritas Asia Pacific & Middle East

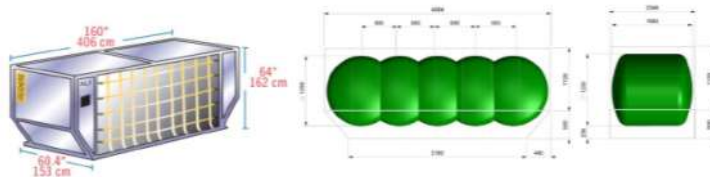
LNG in aircraft

Technical Concept of Container Tanks for Passenger & Cargo Flights **AIRLNG**

Draft:

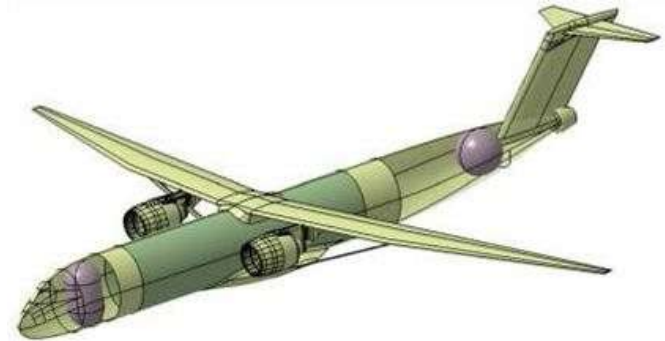


Multi-Lobe Tank Draft with LD6 container size:



Boeing's proposal is an efficient airliner design, LNG fuelled, the company submitted to NASA in 2010 as part of the **Subsonic Ultra Green Aircraft Research project** (SUGAR Freeze).

The company says it could reduce fuel burn by 60 percent compared to a typical 737-800 used today.



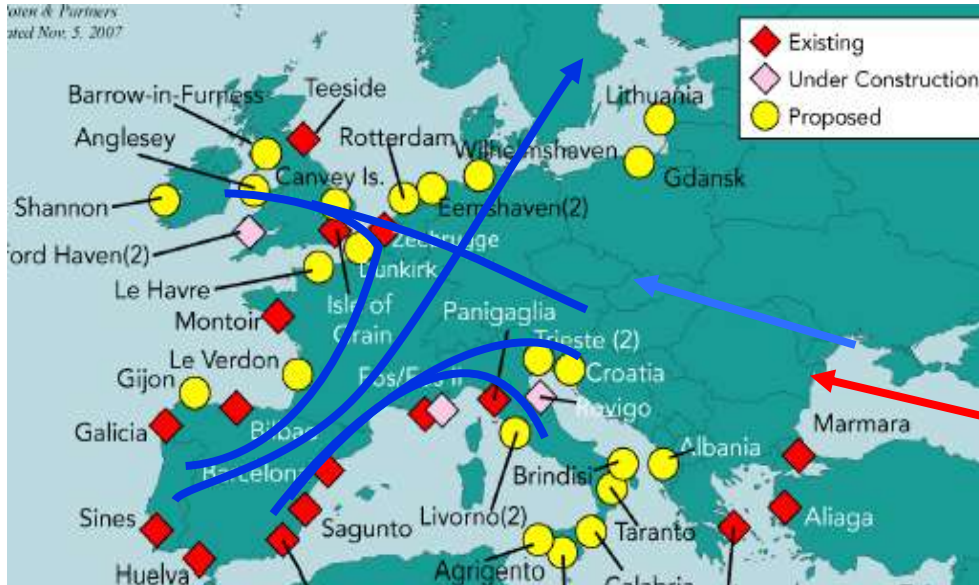
NGVA Europe Technical Committee is following very actively the meetings regarding LNG:

- Gaseous Fuelled Vehicles (GFV)
- Dual Fuel Task Force
- LNG Task Force
- ISO/PC 252. WG-2. L-CNG Filling Stations
- **Dual Fuel legislative developments:** In 2010 work started at UNECE level to develop standards that will allow to type approve Dual Fuel engines.
The group is meeting practically once a month. Technical specifications on emissions and tests for new dual fuel vehicles (Euro VI) presented in the June 2011 session of GRPE.

As a consequence of the Dual Fuel task force it has been decided to create a new Task Force to deal specifically with **LNG on board systems**

Regulations needed for series production LNG vehicles are being developed rapidly!

The LNG Blue Corridors Project



These initially proposed Blue Corridors will also develop with connection to other LNG distribution initiatives as:

- Danube Inland Waters Blue Corridor, from Romania to Vienna
- AGRI (Azerbaijan-Georgia-Romania-Interconnection) project to transport LNG from Azerbaijan to the EU through Georgia and Romania.

NGVA Europe has presented a project to the FP-7, to develop the concept of **European LNG Blue Corridors**

The intention is to define four initial pan European routes with strategically placed LNG filling stations that would allow the heavy, long distance truck transport throughout Europe:

- Portugal-Spain to France, Netherlands, UK and Ireland
- Portugal-Spain to France, Germany, Denmark, Sweden
- Mediterranean arch to Italy and with another branch to Croatia
- Ireland-UK to Austria

GC.SST.2012.2-3. Demonstration of heavy duty vehicles running with liquefied methane

Call: FP7-TRANSPORT-2012-MOVE-1

Content and scope:

- The overall objective is to perform **large-scale demonstration** in order to facilitate a broad market development for heavy duty trucks running with liquefied methane. The specific objectives for the project should be:
 - To **optimize the complete powertrain and storage system of LNG heavy duty vehicles** with respect to energy efficiency and pollutant emission, by fully utilizing the technical potential of liquefied methane in an optimized fuel-engine system.

Existing and proposed LNG filling stations (March 2012)



- ▼ Existing LNG stations:
- Spain:** Abrera (Barcelona), Olaberria (Guipúzcoa), Lleida, Castellón, Guadalajara, Guadalajara (2012), Madrid, Zaragoza (2012), La Jonquera (Girona, 2012), Tarragona, Valencia (2012).
 - Portugal:** Mirandela, Maia (2012)
 - Italy:** Poirino (Torino)
 - Holland:** Oss
 - Sweden:** Goteborg, Järna, Malmo (2012), Jönköping (2012)
- ▽ Proposed:
- Lisbon (Portugal)
 - Sines (Portugal)
 - Irún (Guipúzcoa), Spain
 - Lyon (France)
 - Paris (France)
 - La Crèche (France)
 - Metz (France)
 - Antwerpen (Belgium)
 - Ventimiglia (Italy)
 - Piacenza (Italy)
 - Palmanova (Italy)
 - Roma (Italy)
 - Karlsruhe (Germany)
 - Berlin/Postdam (Germany)
 - Hannover (Germany)
 - Munich (Germany)
 - Split (Croatia)
 - Örebro (Sweden)
 - Sundsvall (Sweden)
 - London Orbital M25 (UK)
 - South Wales M4 (UK)
 - Manchester M6 (UK)
 - Watford Gap (UK)
 - Dublin (Ireland)

Existing LNG filling stations in Europe

LNG public stations in Spain

Name	Owner	Address	Town	Province	Fuel delivered
HAM	HAM	N-II. Km. 582	Abrera	Barcelona	LNG/CNG
TRANS. MONFORT	MONFORT	C/ Dinamarca. Ciudad del Transporte	Castellón de la P.	Castellón	LNG/CNG
HAM	HAM	N-II, Km. 117. E.S. Petromiralles	Torremocha del C.	Guadalajara	LNG/CNG
GN TRUCK	VICUÑA	N-I, Km. 419	Olaberria	Guipuzcoa	LNG/CNG
GNF	GNF	Pol. Ind. El Segre	Lleida	Lleida	LNG/CNG
BIONET	HAM	C/ Sofre nº 3. Políg Ind Riu Clar.	Tarragona	Tarragona	LNG/CNG
VIA AUGUSTA GAS	VIA AUGUSTA	N-II, km 328	Zaragoza	Zaragoza	LNG/CNG
GHC	GNF	N-III Km 11,8	Rivas	Madrid	LNG/CNG
J. SANTOS	GNF	N-II Km. 47,5	Alovera	Guadalajara	LNG/CNG
DISFRIMUR VALENCIA	GNF	Ribarroja	Valencia	Valencia	LNG/CNG
DISFRIMUR ALICANTE	GNF	San Isidro	Alicante	Alicante	LNG/CNG
EUROCAM	GNF	N-I	Vitoria	Alava	LNG/CNG

Biggest in Europe

LNG public stations in Portugal

Gold Energy			Mirandela	Tras os Montes	LNG/CNG	Opening end 2012
Gold Energy			Maia	Porto	LNG/CNG	Opening end 2012

LNG public stations in The Netherlands

	Vos Logistics		Oss	Noord Brabant	LNG	
Salland Ollie	LNG 24	Kleefstraat 7	Zwolle	Overijssel	LNG	Need special card
De Kock	Rolande/De Kock	Hescheweg 223	Oss	Noord Brabant	LNG/CNG	Oct. 2012. Need sp. card
Rolande LNG	Rolande LNG	Schepersvenweg 1	Tilburg	Noord Brabant	LNG/CNG	Oct. 2012. Need sp. card

LNG public stations in Italy

Concess. TotalErg (costr. Vanzetti)		Borgata Marocchi statale 29 km 24 + 570	Poirino	Torino	LNG/CNG	LNG refilling not yet available
Concess. Esso (costr. HAM Italia)		via Prati, 24/a	Calderara di Reno	Bologna	LNG/CNG	LNG refilling not yet available
Concess. ENI R&M (costr. Vanzetti)		via Circonvallazione Est, 18/a	Villafalletto	Cuneo	LNG/CNG	LNG refilling not yet available
Kostner GmbH (costr. Vanzetti)		via Brennero (SS 12) uscita autostr. Varna	Varna	Bolzano	LNG/CNG	LNG refilling not yet available
Concess. ENI R&M (costr. HAM Italia)		via della Borghesiana	Roma	Roma	LNG/CNG	LNG refilling not yet available
F.Ili Ratti (costr. Vanzetti)		Strada Statale per Voghera, 75	Tortona	Alessandria	LNG/CNG	LNG refilling not yet available

LNG public stations in Sweden

Fordonsgas			Göteborg	Göteborg	LNG/CNG
Statoil/AGA			Järna	Södertälje	LNG/CNG
Preem/E.ON			Malmö	Malmö	LNG

LNG public stations in UK

Hardstaff Group			Nottingham		LNG/CNG
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L-CNG infrastructure in Europe



L-CNG filling station in Göteborg (Sweden)



L-CNG filling station in Lleida (Spain)

From the North to the South, from the West to the East, we have to implement the European L-CNG infrastructure that will allow us to reduce the oil dependence.





manuel.lage@ngvaeurope.eu
www.ngvaeurope.eu

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