NATURAL GAS AS A TRANSPORTATION FUEL
LNG is the best solution for long-distance transport

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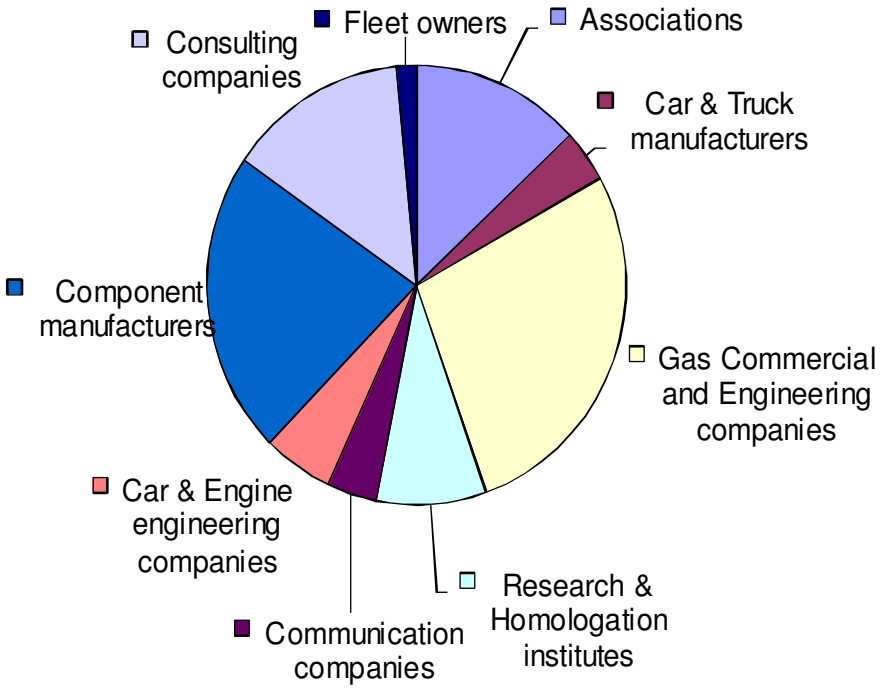
What is NGVA Europe?

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 140 members from 36 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.



World NG resources: increasing above expectations

- World's proven conventional NG resources (2008) = **180.000 Bm^3**, (60 years production at current rates: 3.065 billion m^3/year).
- Recent estimate for virtually recoverable NG = **850.000 Bm^3**, (280 years production at current rates).
- Unconventional resources, (e.g. coalbed methane, tight gas from low-permeability reservoirs, shale gas) = 45% of this amount. Increasingly affordable with rising crude price, and new technologies
- To date, only **66.000 Bm^3** of gas has been produced (or flared) [IEA Energy Outlook 2009].

Flared gas:

- It is still there, in different parts of the world (e.g. Nigeria, Russia, etc)
- A global estimation gives >**100 billion** m^3/year in the whole world

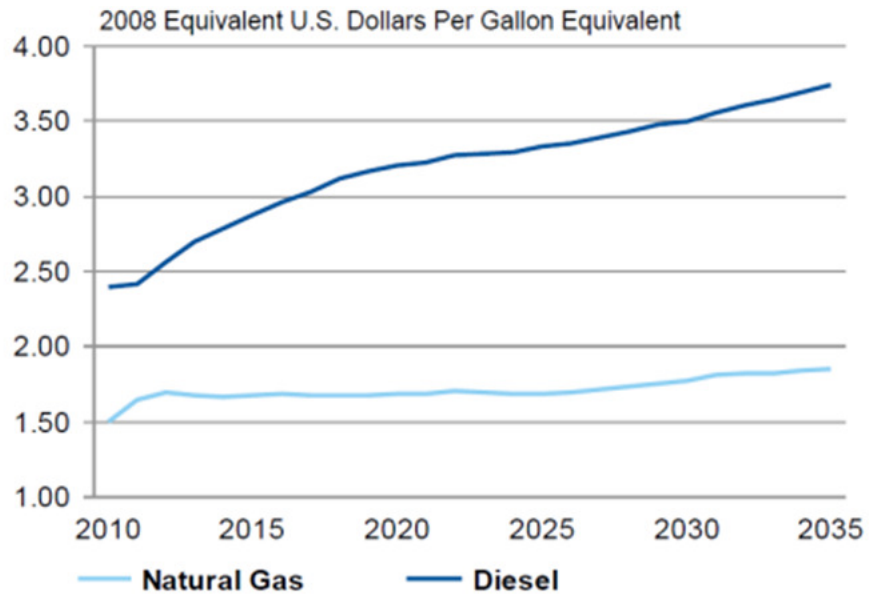
US, unconventional (shale) LNG exporter

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

Forecast: Delivered Energy Prices for Diesel & Natural Gas Transportation Fuels, 2010-2035



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.

The world NGV champions

Total NGV in the world: 13.2 million

PAKISTAN (in 10 years)
Total CNG vehicles:
3,500,000 i.e. ~ 80 % of the running park.

Refuelling stations: 3,300

IRAN (in 5 years)
Total CNG vehicles: 2,070,000
i.e. ~ 13.0 % of the running park.
Refuelling stations: 1,540

ARGENTINA
Total CNG vehicles: 1,900,000
i.e. ~ 23.0 % of the running park.
Refuelling stations: 1,880

BRAZIL
Total CNG vehicles:
1,640,000 i.e. ~ 5.0 % of the running park.

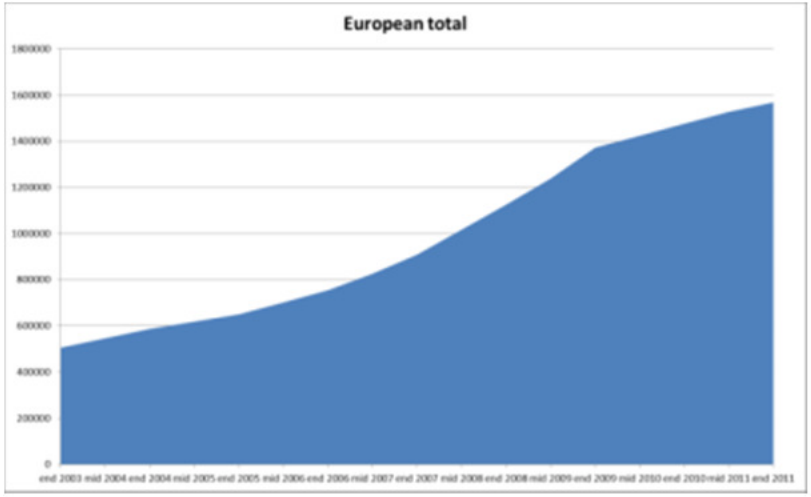
Refuelling stations: 1,780

INDIA
Total CNG vehicles: 1,100,000
i.e. ~ 8.0 % of the running park.
Refuelling stations: 600

ITALY
Total CNG vehicles: 740,000
i.e. ~ 2.0 % of the running park.
Public refuelling stations:
>850 (as of June 2011)

Source: The GVR – Gas Vehicles Report (February 2011)

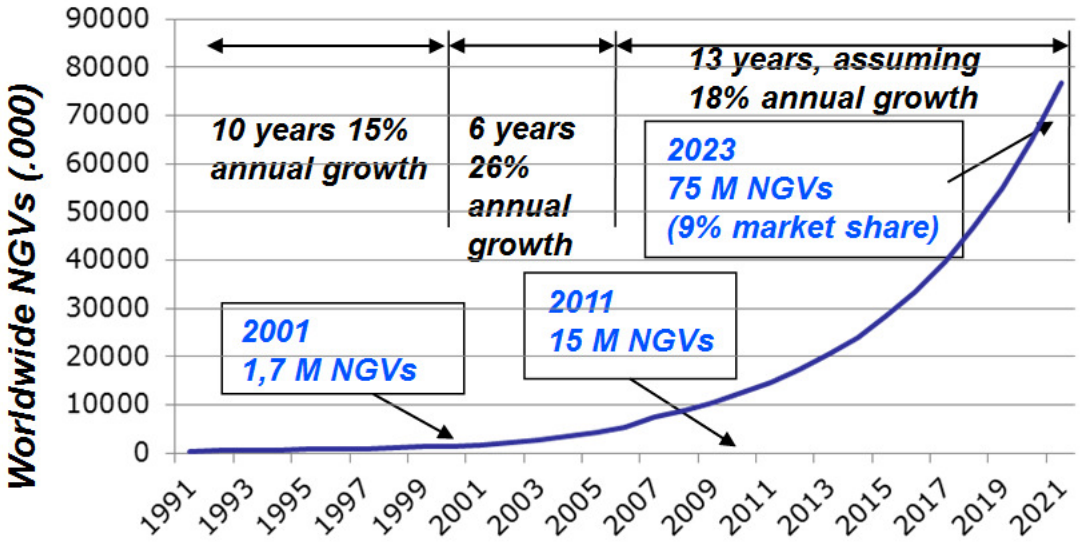
NGVs in the world
1991 to 2020 growth and forecast



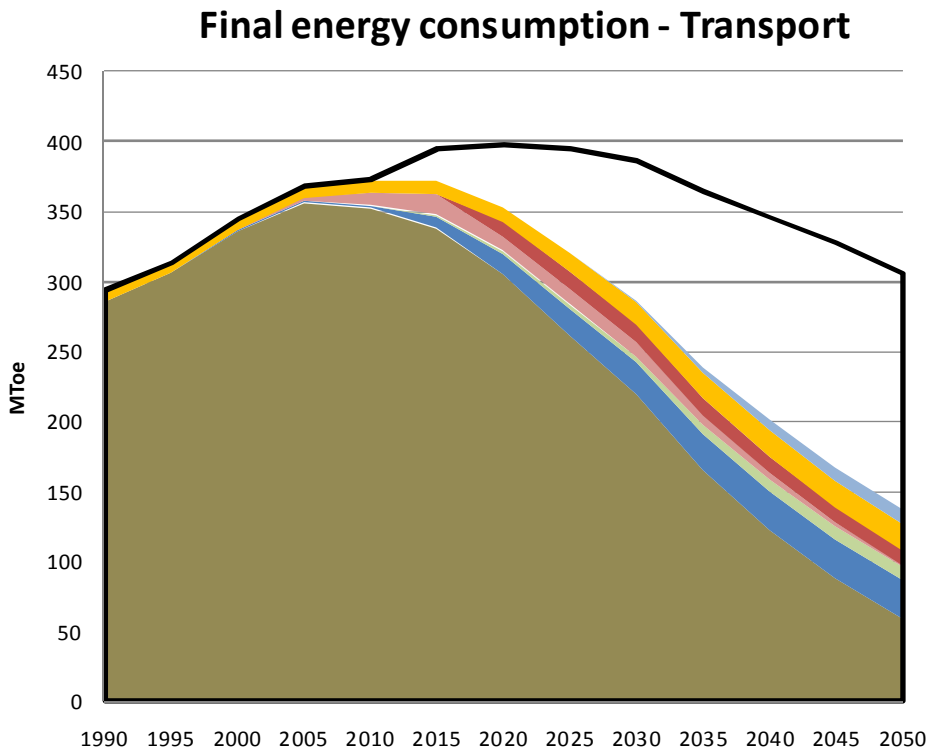
Europe:
16% growth (2006-2011)

World:
70+ M NGVs in 2020!

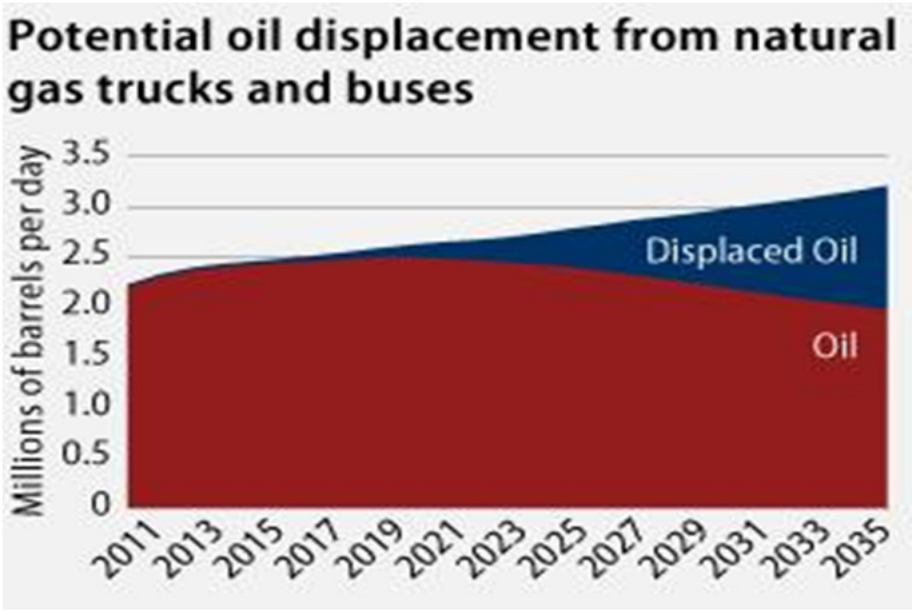
Source: NGVA Europe



Eurogas Roadmap 2050 (13th Oct. 2011)
9% market share passenger, 33% freight



Eurogas roadmap: 33%



North American forecast: 37%

Advantages of bio natural gas

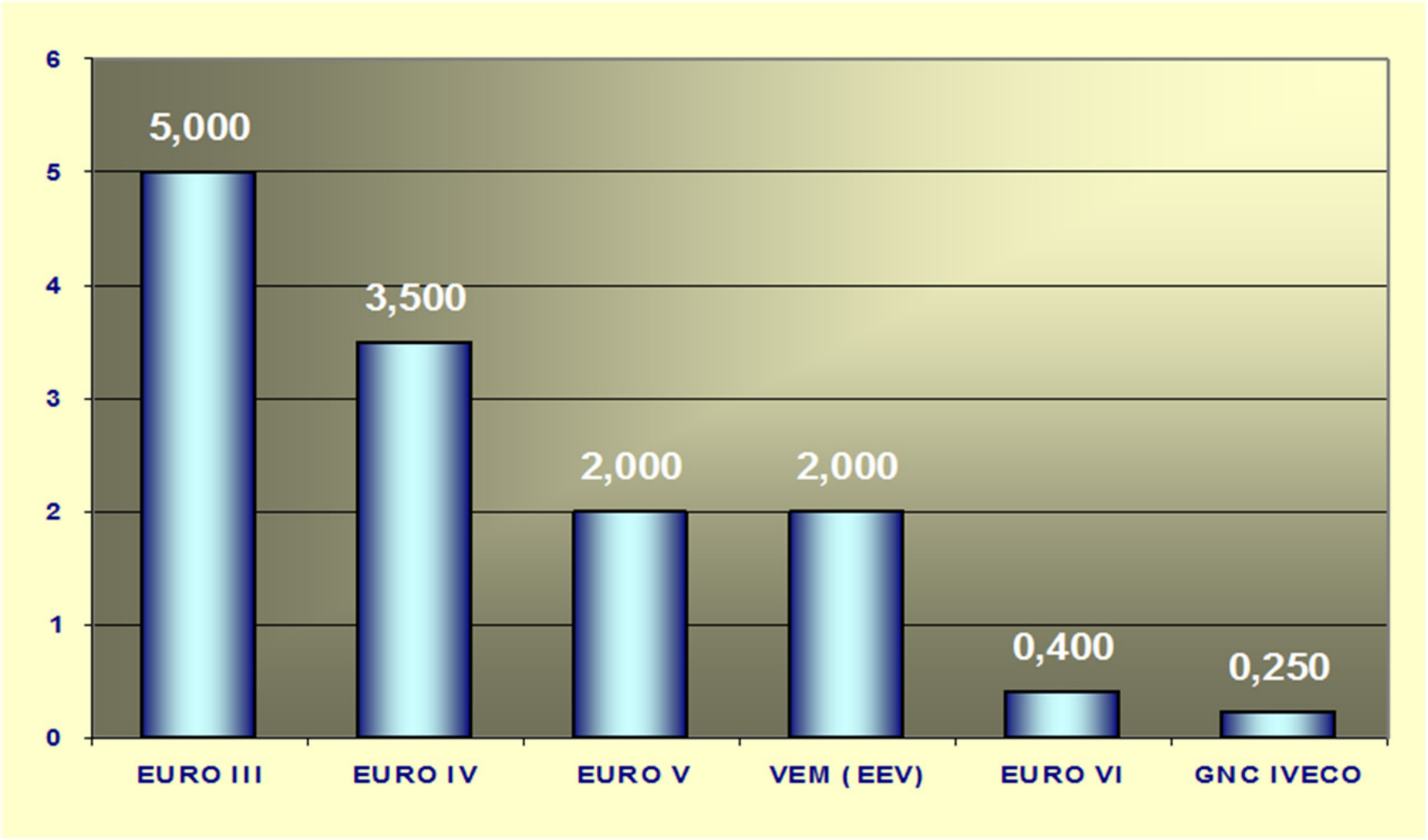
- Natural gas is an alternative fuel coming from natural wells. It is mainly methane (CH4)
- Biogas is also a methane rich gas, produced by the fermentation of the biomass, it is then a renewable fuel.
- **Methane contents 25% H and 75% C, in weight**

As a comparison,

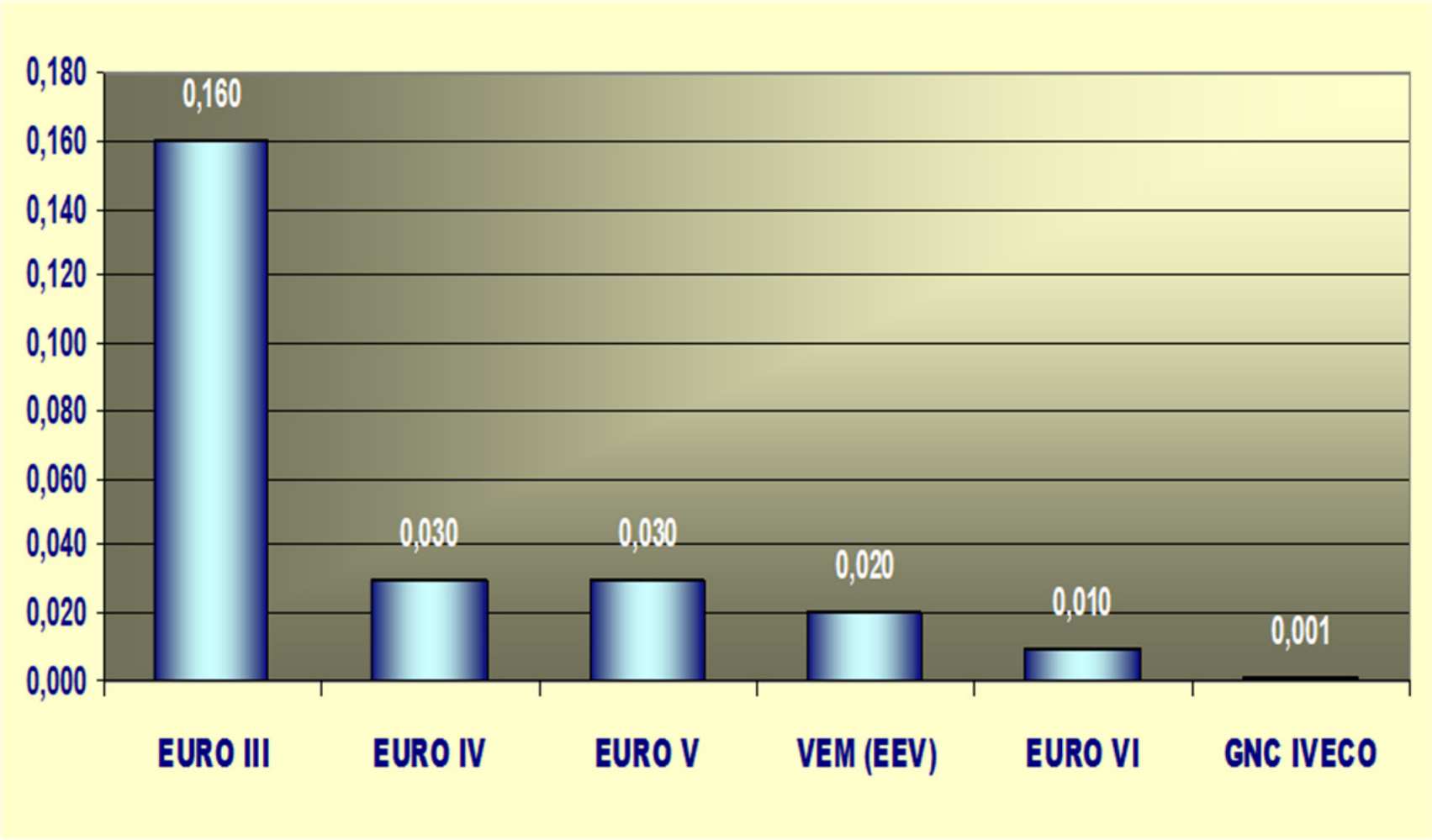
- Petrol contents 13,5% H and 86,5% C
- Diesel oil contents 13,5% H and 86,5% C
- LPG contents 17,4% H and 82,6% C

Due to its molecular advantage, regulated exhaust emissions and CO_2 are particularly favourable in the engines running on natural gas.

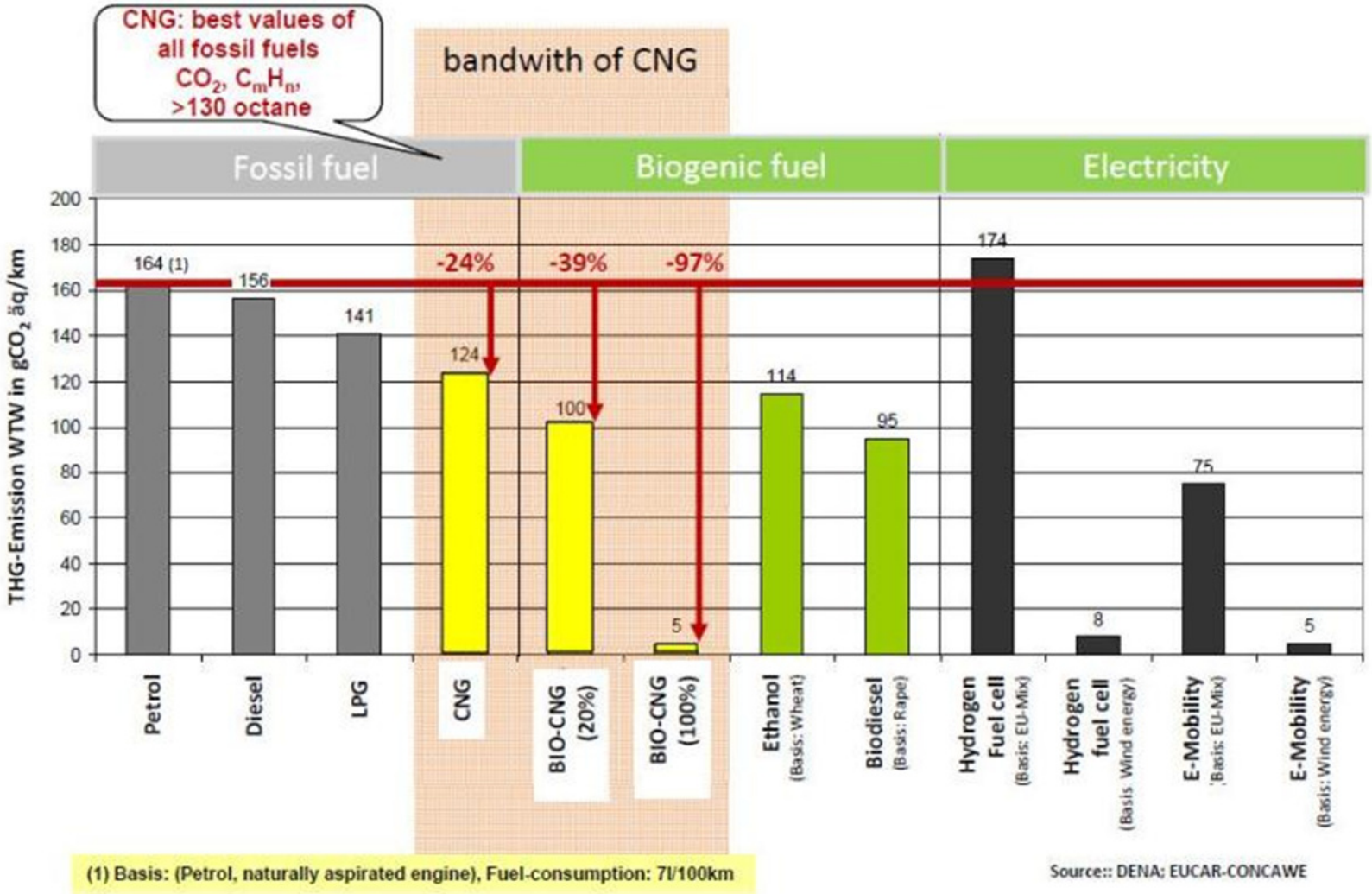
Evolución límites de NOx



Evolución límites de partículas

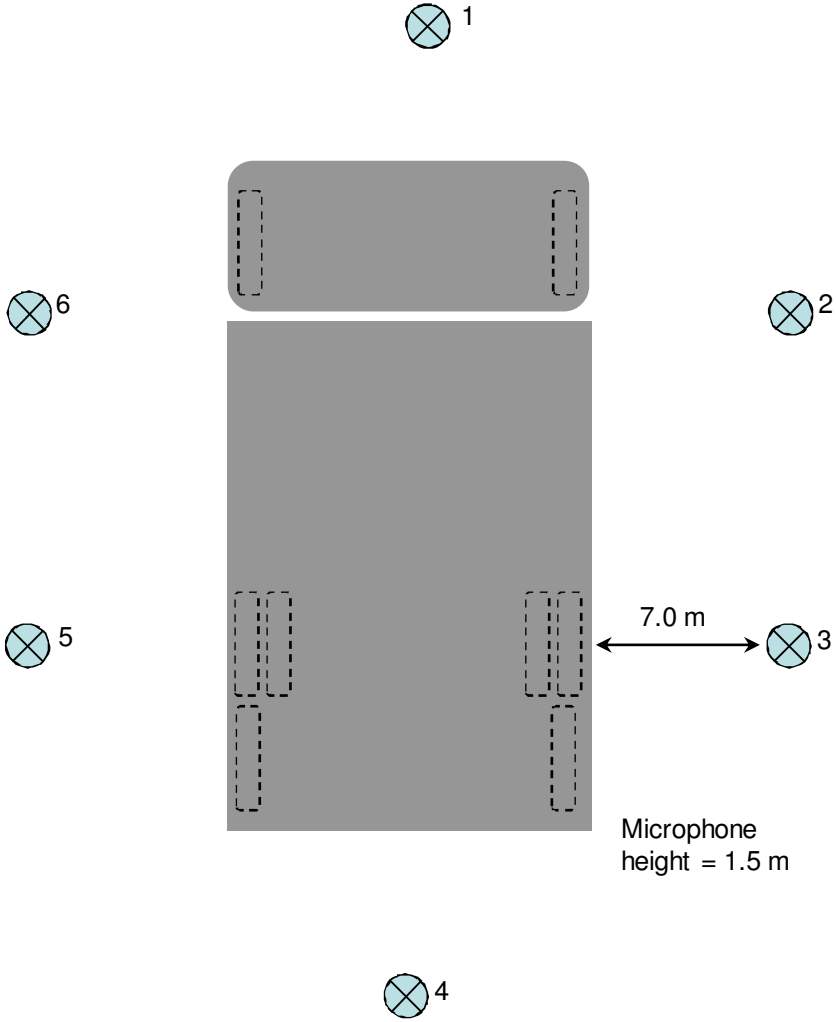


Well-to-Wheel balance of vehicle fuels



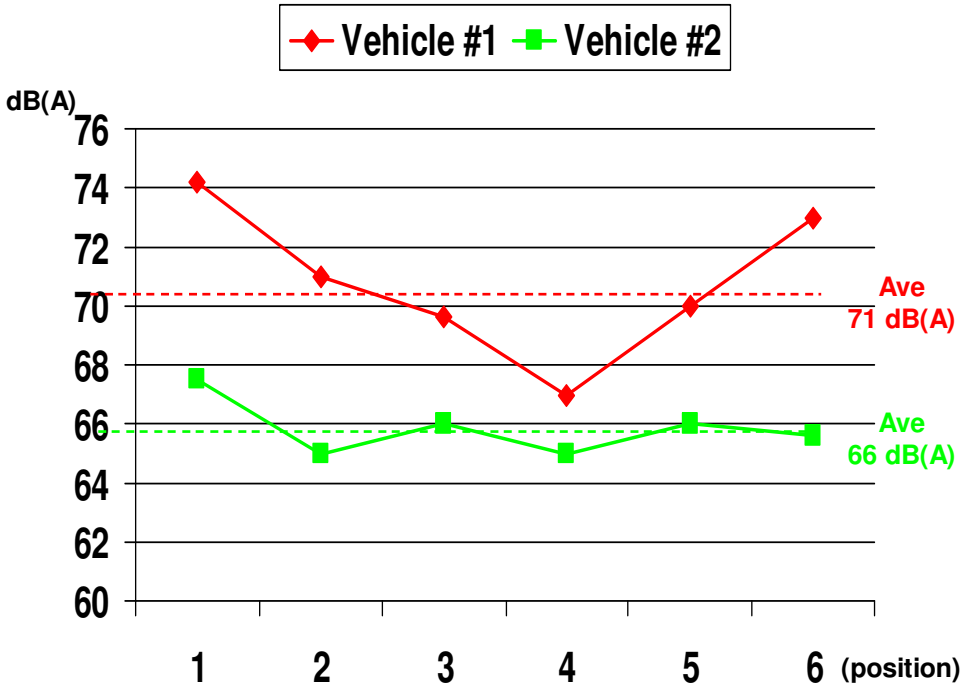
Source: German Energy Agency (DENA) Study 2010

Noise emitted by the truck



Vehicle #1: IVECO 240E25 6x2 RSU
Vehicle #2: IVECO 240E26 6x2 RSU CNG (EEV)

Refuse collection chassis cab with body
Vehicles laden and compacting
Vehicles stationary

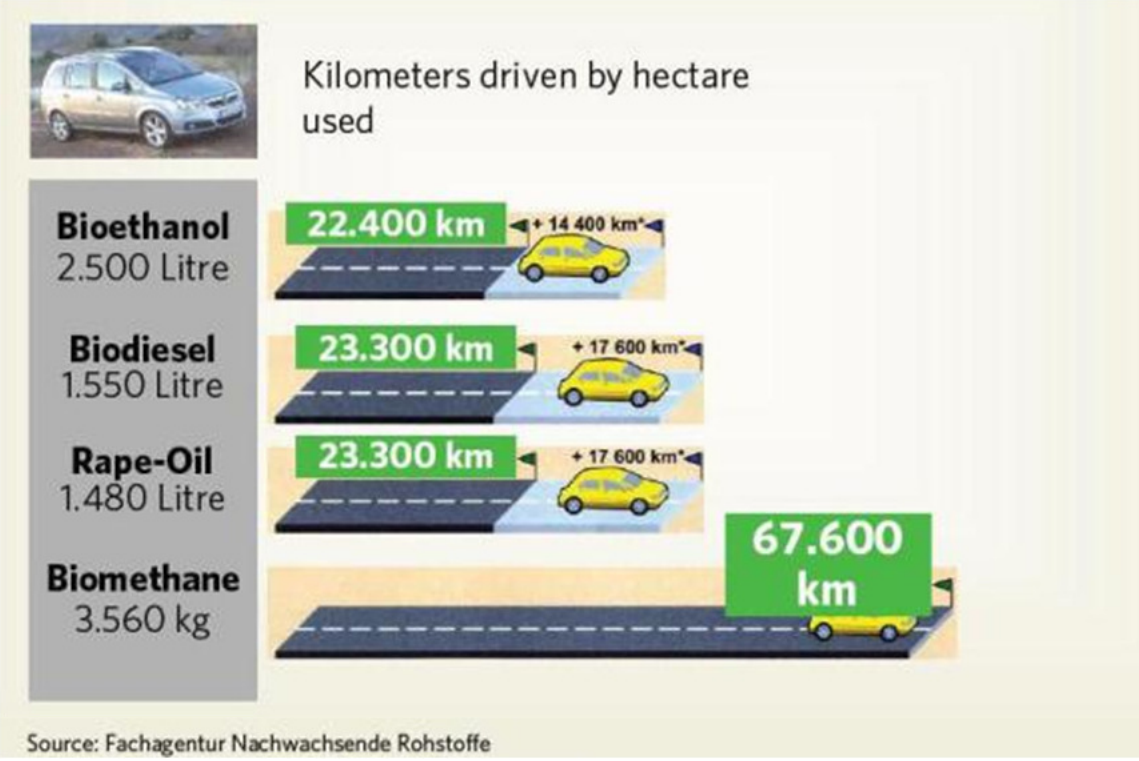


CNG urban trucks and buses in Europe

70.000 urban buses give service in the main European cities
9.000 (13%) are CNG.
(Italy, France, Germany, Spain, Sweden, Greece, Portugal, Netherlands)

20.000 garbage trucks in service in Europe
3.000 (15 %) are CNG.
(France, Spain, Italy, Greece)

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 loose 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).

Strong municipal decisions on alternative fuels

In February 2010 EMT (*Empresa Municipal de Transportes, Madrid*) declared its intention to stop buying diesel buses.

Purchases done in 2010 for deliveries in 2011, 2012 and 2013 are all CNG, except for some special units not yet available with CNG engine.

EMT is the third largest bus company in Europe, with more than 2.000 units in service.

Its CNG fleet composition is:

2011: 430 CNG buses (27 %)
2012: 700 CNG buses (35 %)
Medium term: 1.000 CNG buses (50 %)

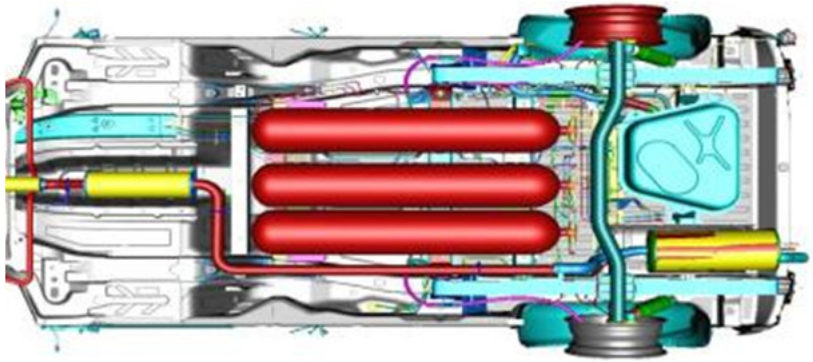
Barcelona's TMB (1.000 buses) is following the same scheme of CNG share in its fleet.

New EMT bus depot in Madrid

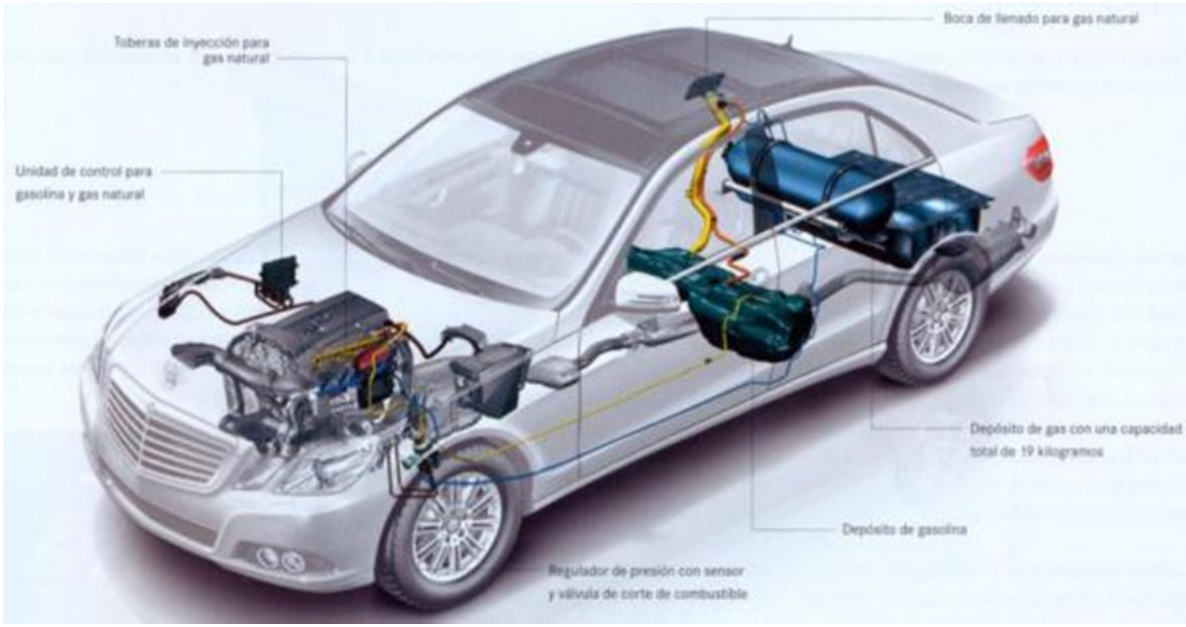
Design capacity: 400 CNG buses
CNG tank capacity per vehicle: 150 kg
Maximum allowable time for refuelling: 3 minutes.

The filling station building has an external access for other customers.

Underfloor tanks save space



Modern cars have CNG tanks installed underneath the floor, offering the same internal space for passengers and luggage than the petrol or diesel equivalents.

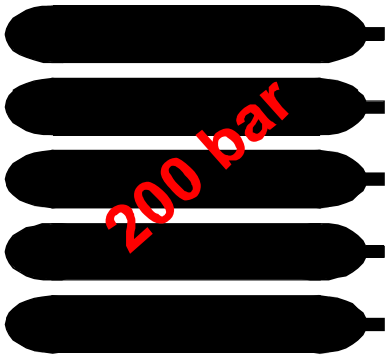


Types of vehicles and alternative fuels

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 trucks for long distance transport

Diesel vs CNG & LNG.
Autonomy equivalence



CNG
5 litre

1 liter Diesel oil

-162ºC at 1 bar
-125ºC 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

North American and Australian LNG trucks

Autocar
International
Freightliner
Peterbilt
White
…

6.000 LNG heavy trucks running in USA

Chinese NG trucks

Foton

Shaanxi

Sinotruk

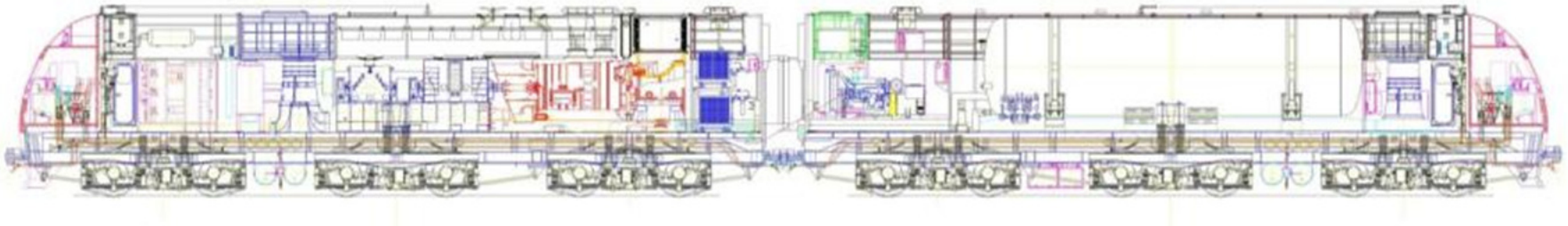
Dong Feng

More than 4.000 LNG heavy trucks already running in China!

LNG in railways

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

In daily service since 2009.



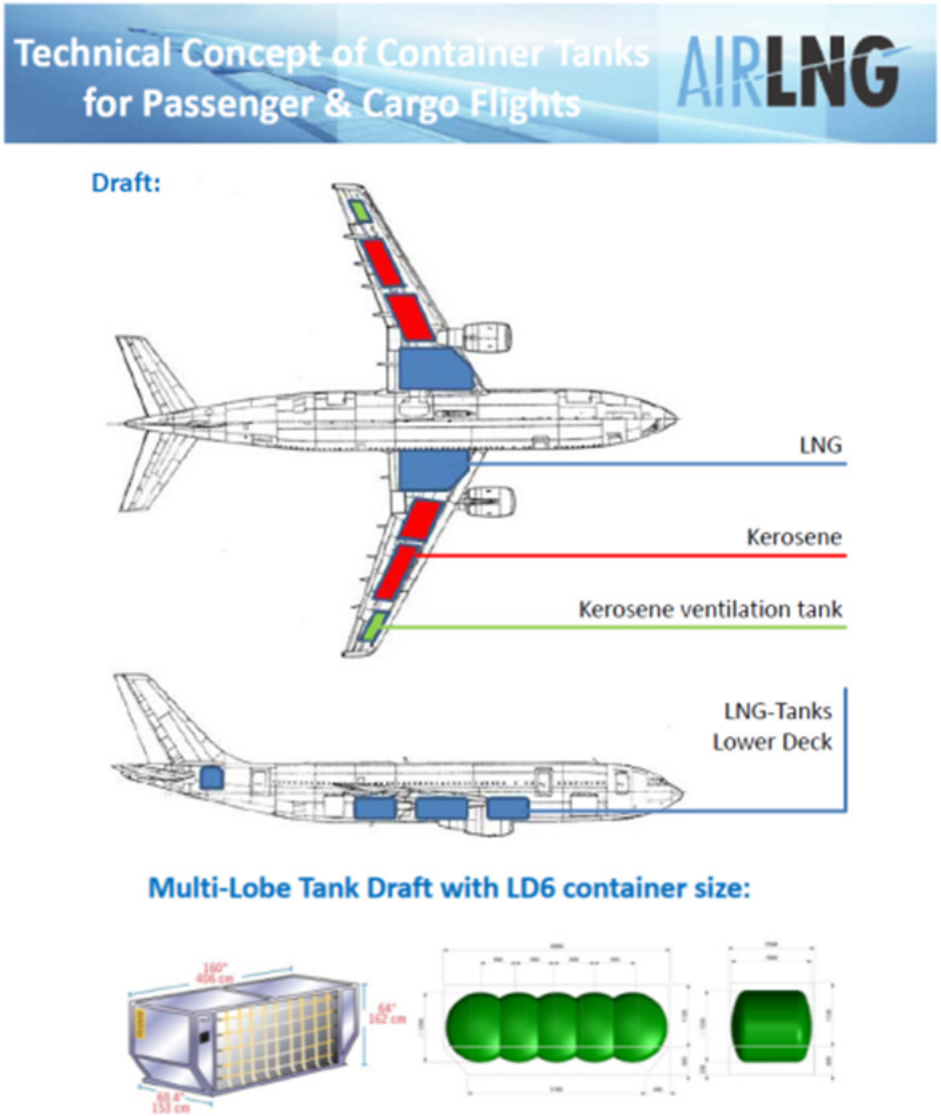
LNG fuelled ships are growing rapidly

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.**

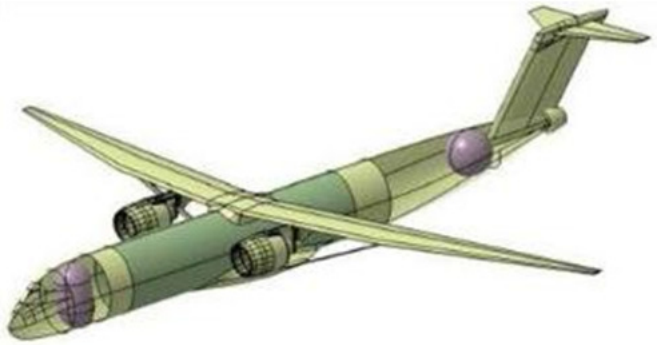
November 29, 2011 | Norway: **"We believe 500 LNG fuelled ships will be on order by 2015, several thousands by 2020,"** Mr. Remi Eriksen, COO of Det Norske Veritas Asia Pacific & Middle East

LNG in aircraft



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.



The EU "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 Viena
- AGRI (Azerbaijan-Georgia-Romania-Interconnection) project to transport LNG from Azerbaijan to the EU through Georgia and Romania.

NGVA Europe has presented a proposal to the "**European LNG Blue Corridors**", ***FP-7 TRANSPORT-2012-MOVE-1*** *project:*
Demonstration of heavy duty vehicles running with liquefied methane

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.

L-CNG infrastructure in Europe

L-CNG filling station in Göteborg (Sweden)

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.

L-CNG filling station in Lleida (Spain)

Conclusions

- Natural gas (methane) is an **excellent energy vector**, with the lowest Carbon to Hydrogen ratio of all the hydrocarbons. Additionally **natural gas is an alternative fuel**, having a different origin from the traditional oil derived diesel, petrol and LPG

- Natural gas is used in **existing internal combustion engines**, with minor additional investments, taking advantage of a well known and mature car & commercial vehicle technology.
  Dual Fuel technology offers the possibility of conversion for existing engines

- The increasing production of **biomethane**, both from urban waste and from agricultural stuff is giving natural gas the new and valuable consideration of a **renewable fuel**

- Natural gas has been used so far as CNG mainly for urban applications. The availability of **LNG will spread its use for medium and long distances** road transport

- **Methane/Hydrogen mixtures,** that could be used the existing NGVs will become the bridge to a potential hydrogen fuelled transport

- NG vehicles are today the best and most economic alternative to oil derived fuels, also improving gaseous and acoustic emissions.

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