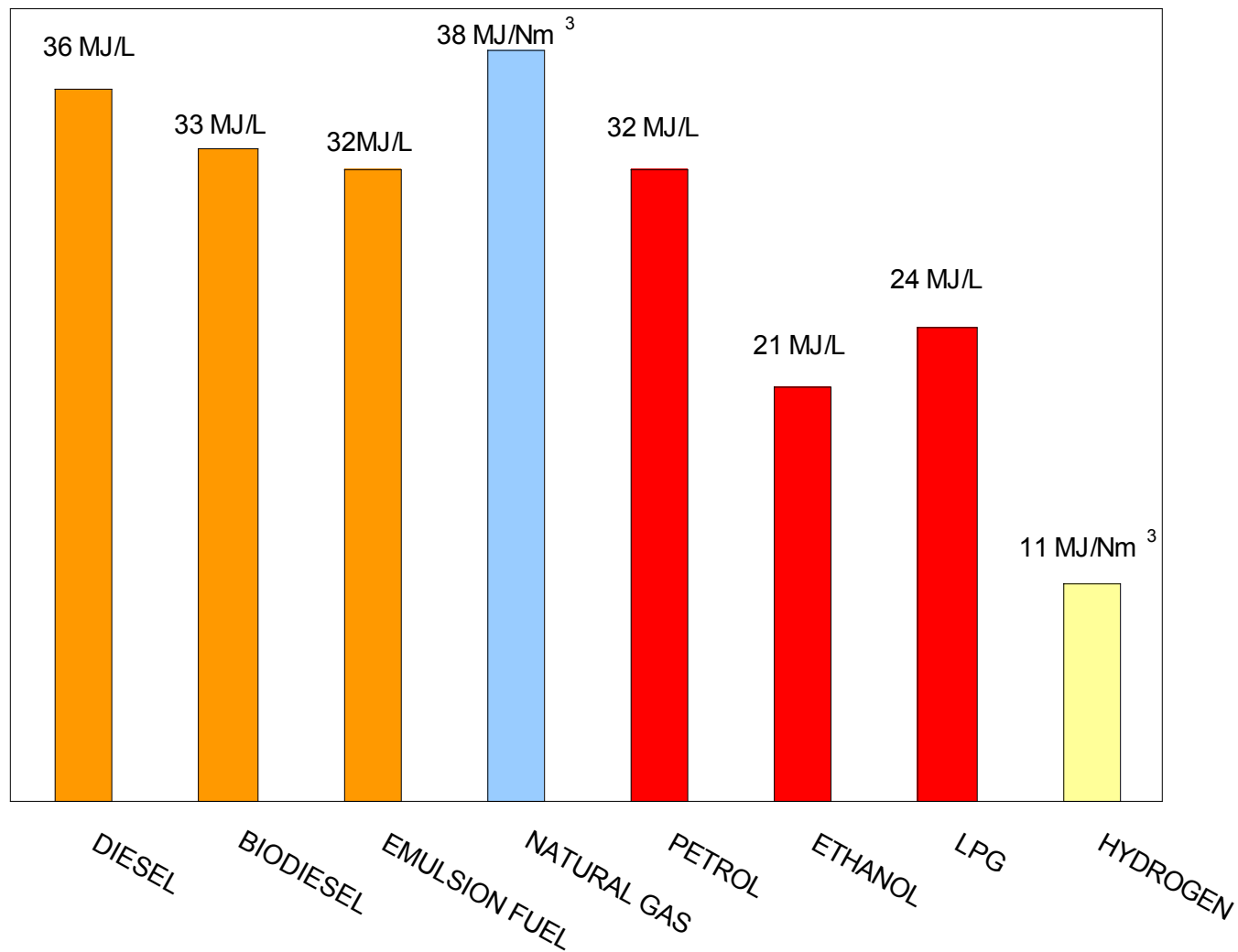


# Bio-natural-gas for cleaner urban transport

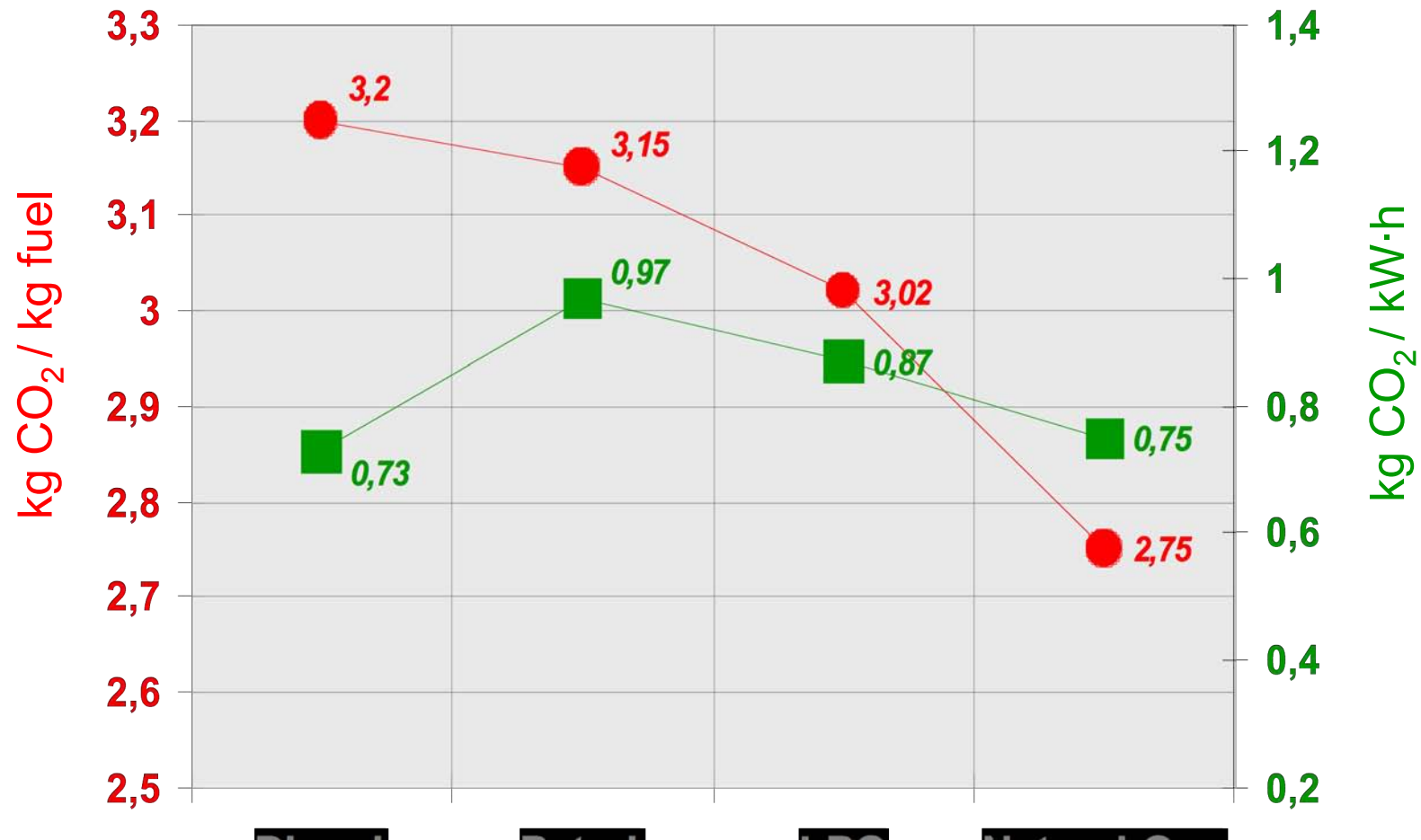
International Bus & Coach Expo  
**Greener Cities Expo Forum & Seminar**  
Verona. November 18-21, 2009

Manuel Lage, Dr. Eng.  
General Manager

# Energy content of different fuels



# CNG. CO2 emission



## Advantages of bio natural gas



- Natural gas is an alternative fuel coming from natural wells. It is mainly methane (CH<sub>4</sub>)
- 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<sub>2</sub> are particularly favourable in the engines running on natural gas.

**Both CNG engine combustion technologies used in trucks and buses: Lean Burn and Stoichiometric, offer very significant advantages:**

- Much lower gaseous emissions
- Much lower noise
- Reduced CO<sub>2</sub> emission

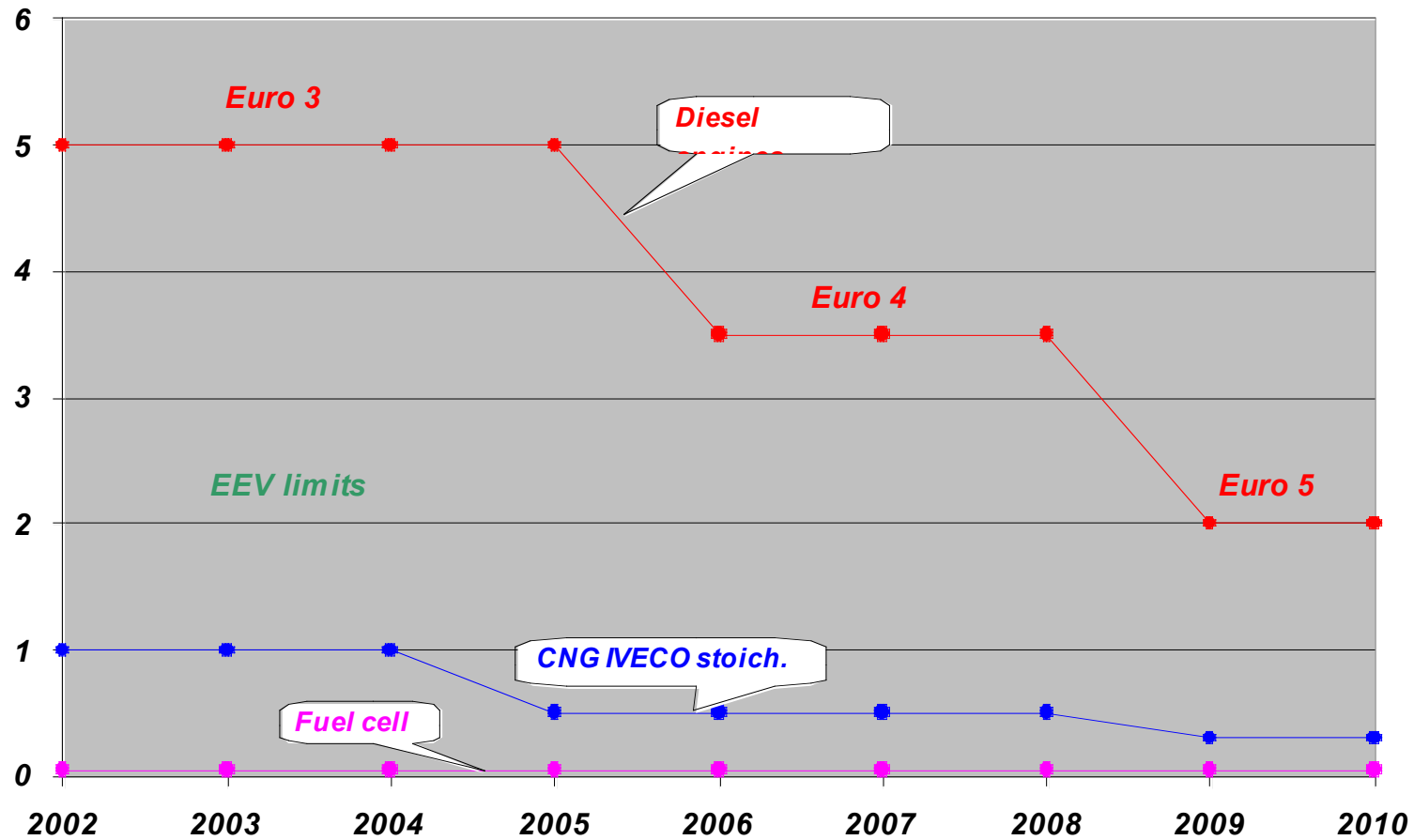
**In the case of the stoichiometric mixture combustion, exhaust pollutants are very near the fuel cell level**

# CNG. NOx comparative emissions



## Compared NOx emissions: Diesel vs CNG and Fuel Cell

(Source: IVECO)

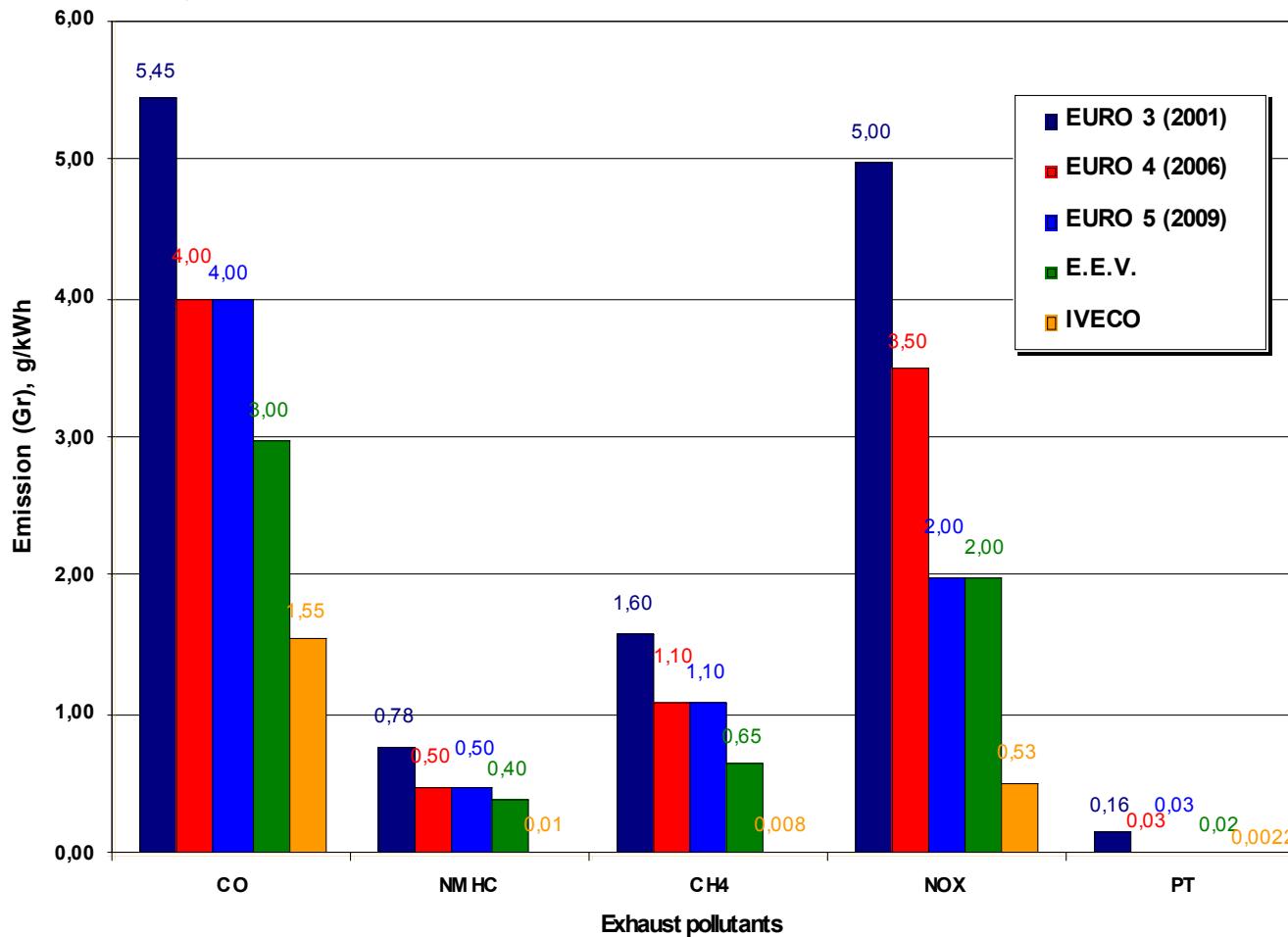


# CNG. Other Emissions Comparison

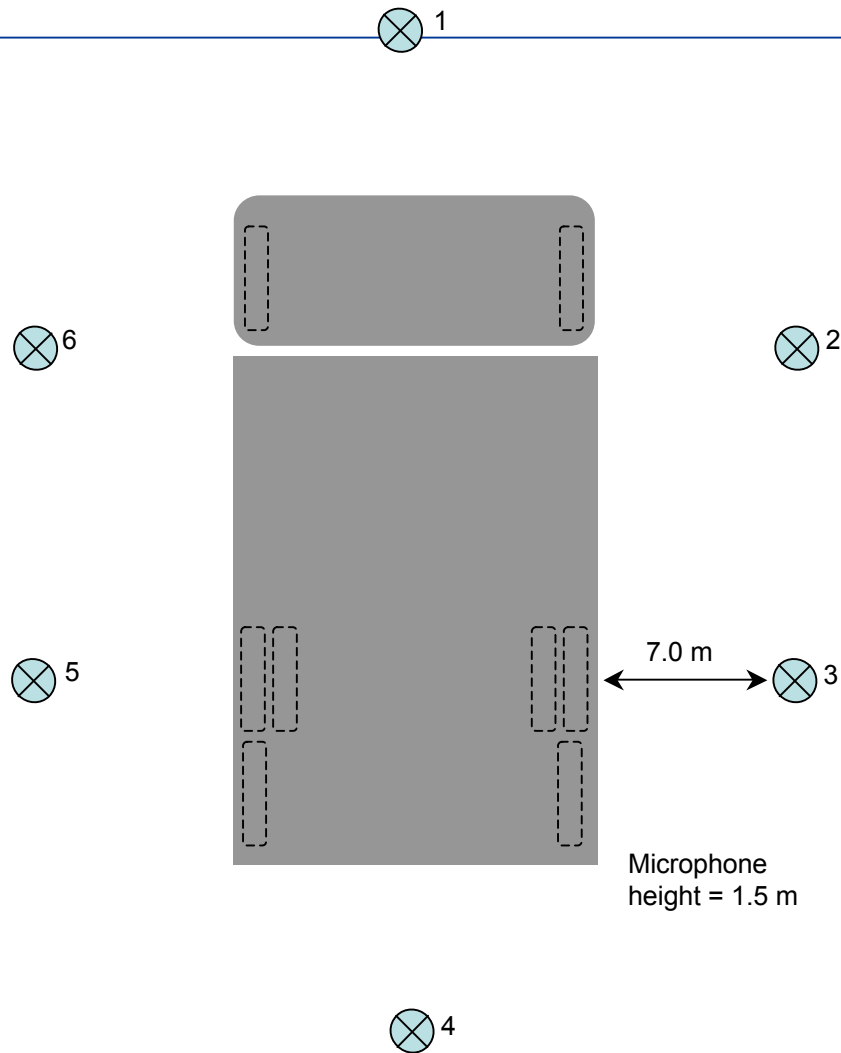


Emissions IVECO CURSOR 8 CNG engine vs present and future Euro limits

(Source: IVECO)

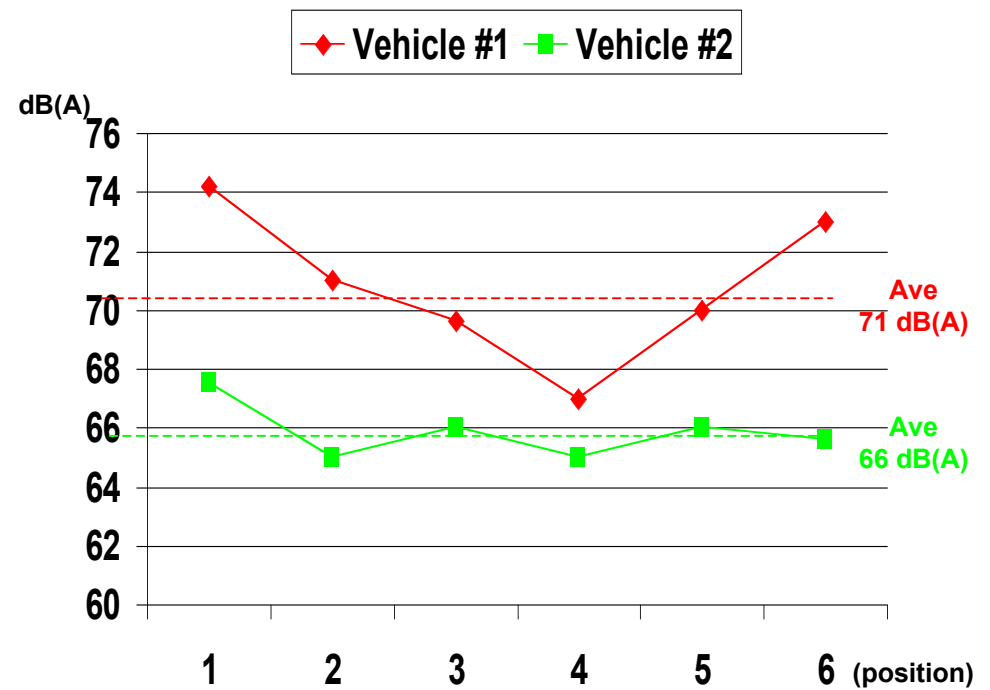


# Noise emitted by the truck



**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**



# Madrid CNG Refuse collection fleet



# FCC NATURAL GAS FLEET (TOTAL 445 UNITS)



FCC NATURAL GAS FLEET CONSUMPTION 10,500,000 m<sup>3</sup>

## Yearly emission savings

Iveco CNG (EEV) vs. Diesel Euro 3 limits

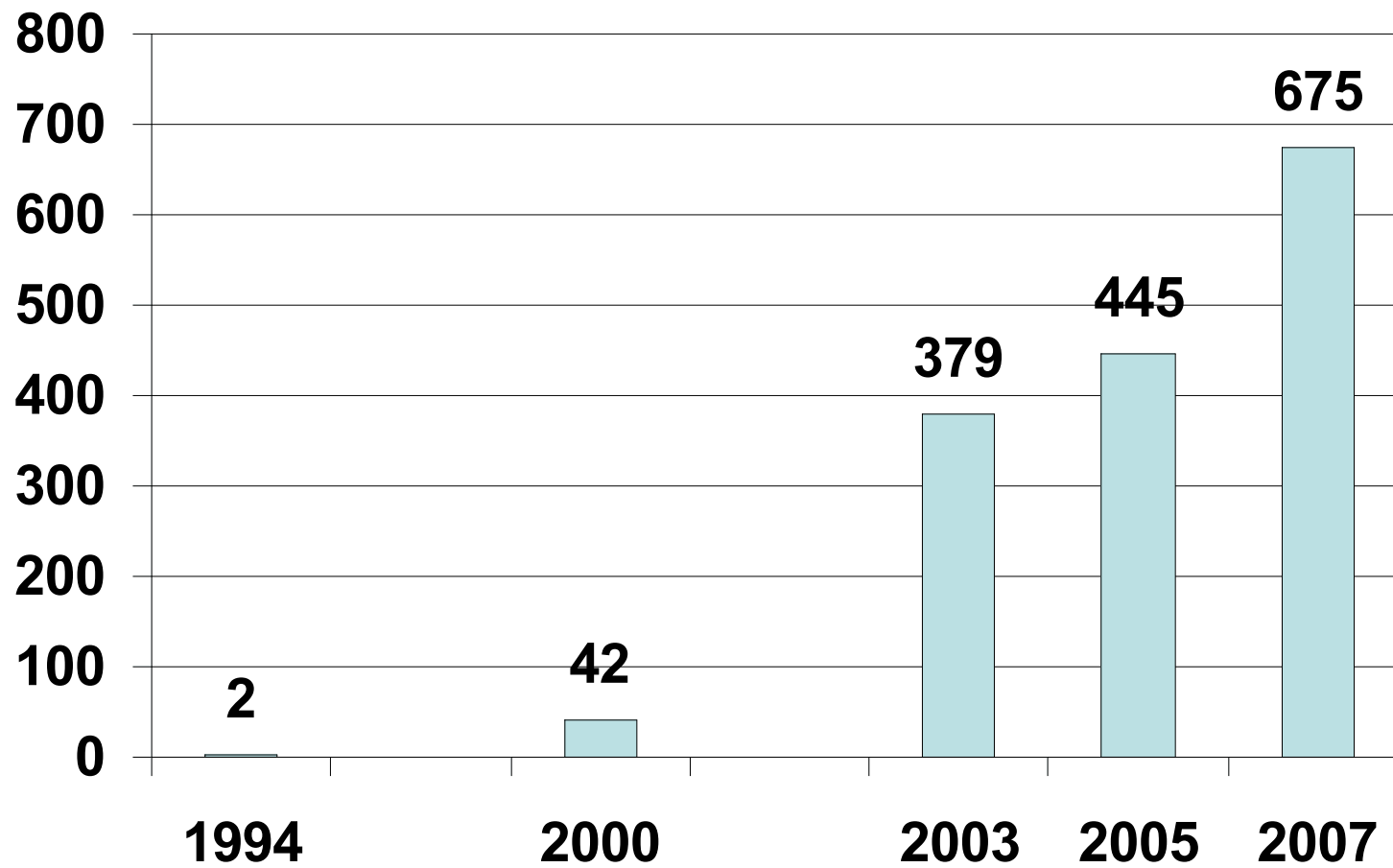
**NOx** 132.391 kg

**CO + HC + PM** 703.000 kg

**CO2** 2.069.440 kg

**Plus a 30% less fuel cost per kilometre!**

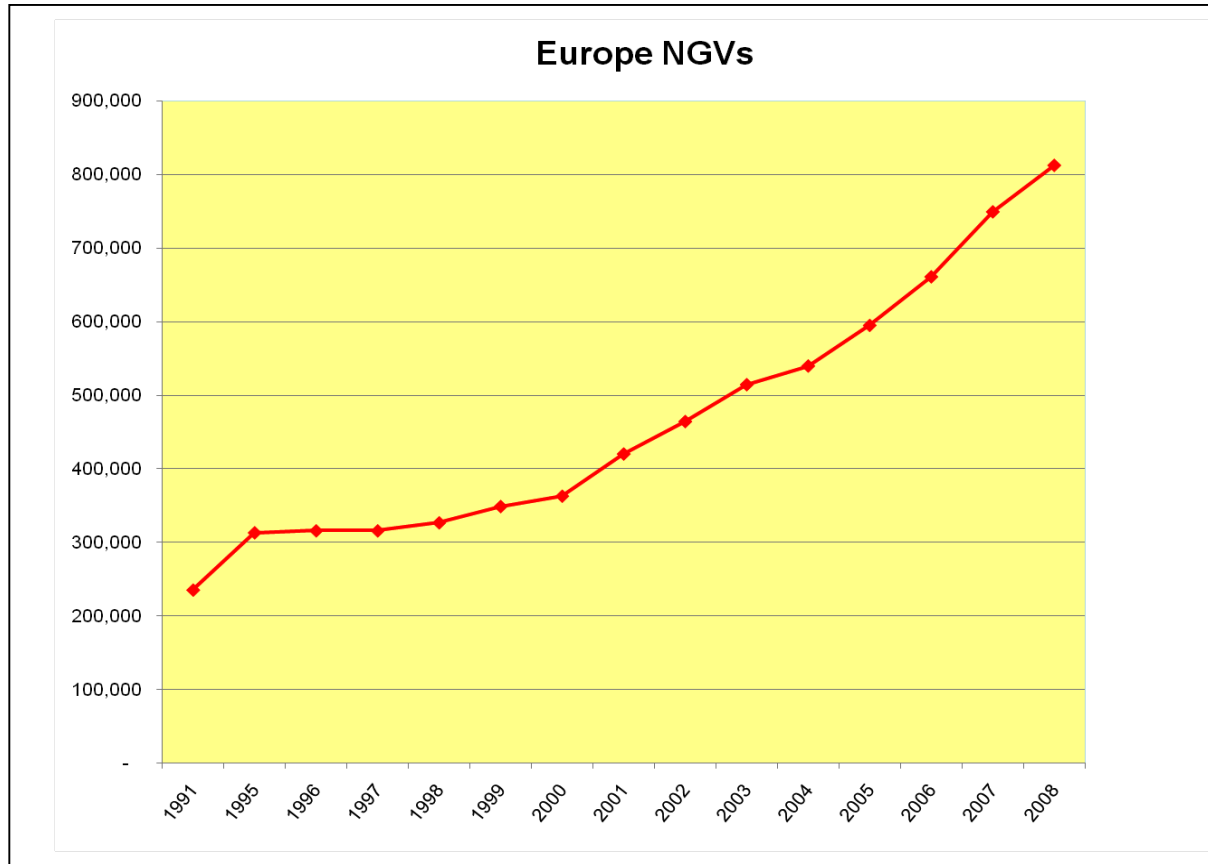
# Madrid CNG Refuse collection fleet



# CNG truck for food distribution



# Western Europe. Market Growth



The steady Western European growth is driven by the cleaner emissions of NGVs

# CNG Urban buses



Irisbus Iveco EUROPOLIS CNG



Irisbus Iveco CITYCLASS CNG 12 m

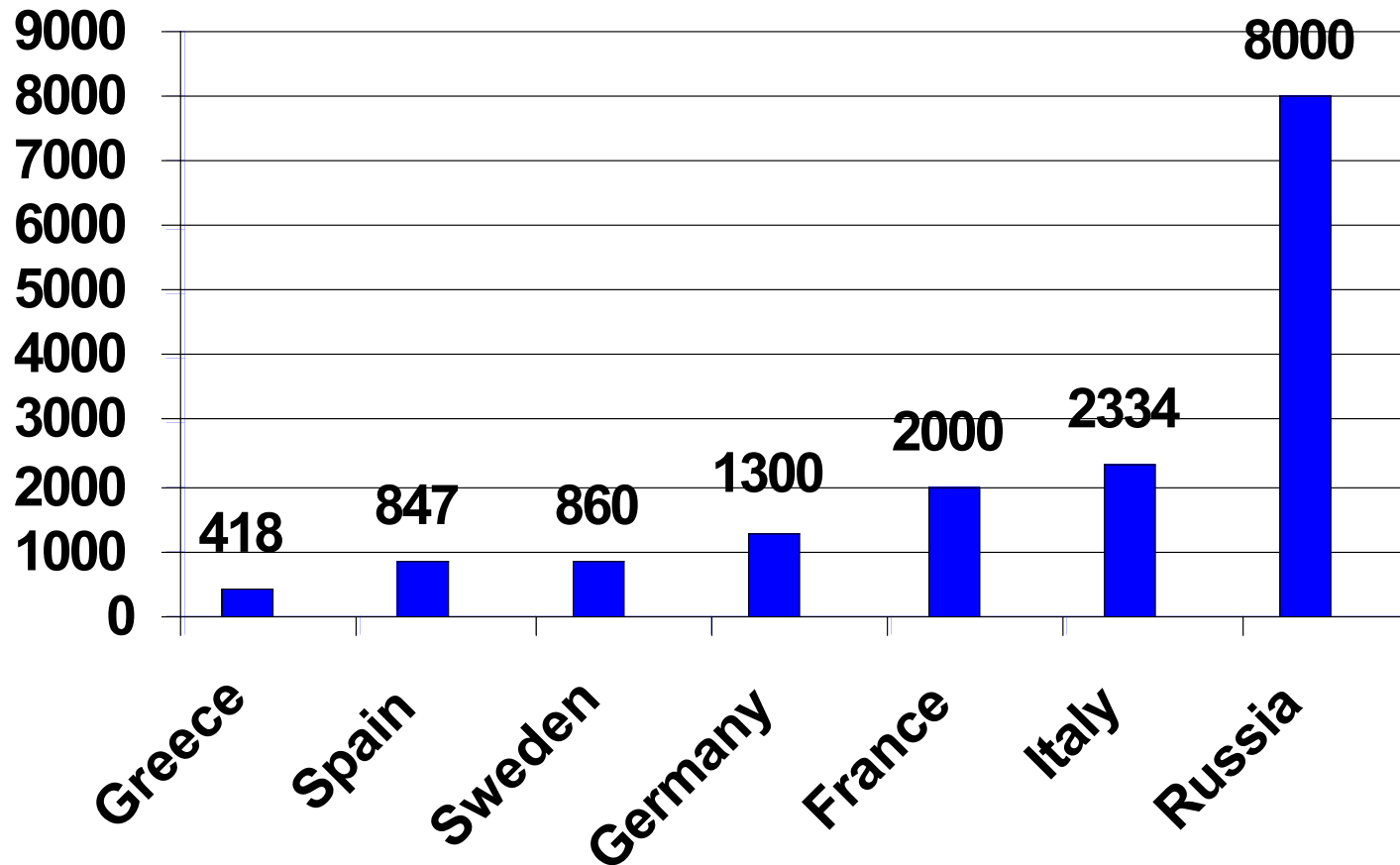


Irisbus Iveco CITYCLASS CNG 18 m



BEIJING BUS, IVECO TECTOR CNG engine

# CNG urban buses in Europe



## Future developments of NGV's

---



NGVA Europe sees the development of NGV's in the medium term future following three main lines:

- **Biogas**
- **LNG for trucks and buses**
- **Methane-Hydrogen mixtures**

# Biogas

## Another source of Natural Gas

---



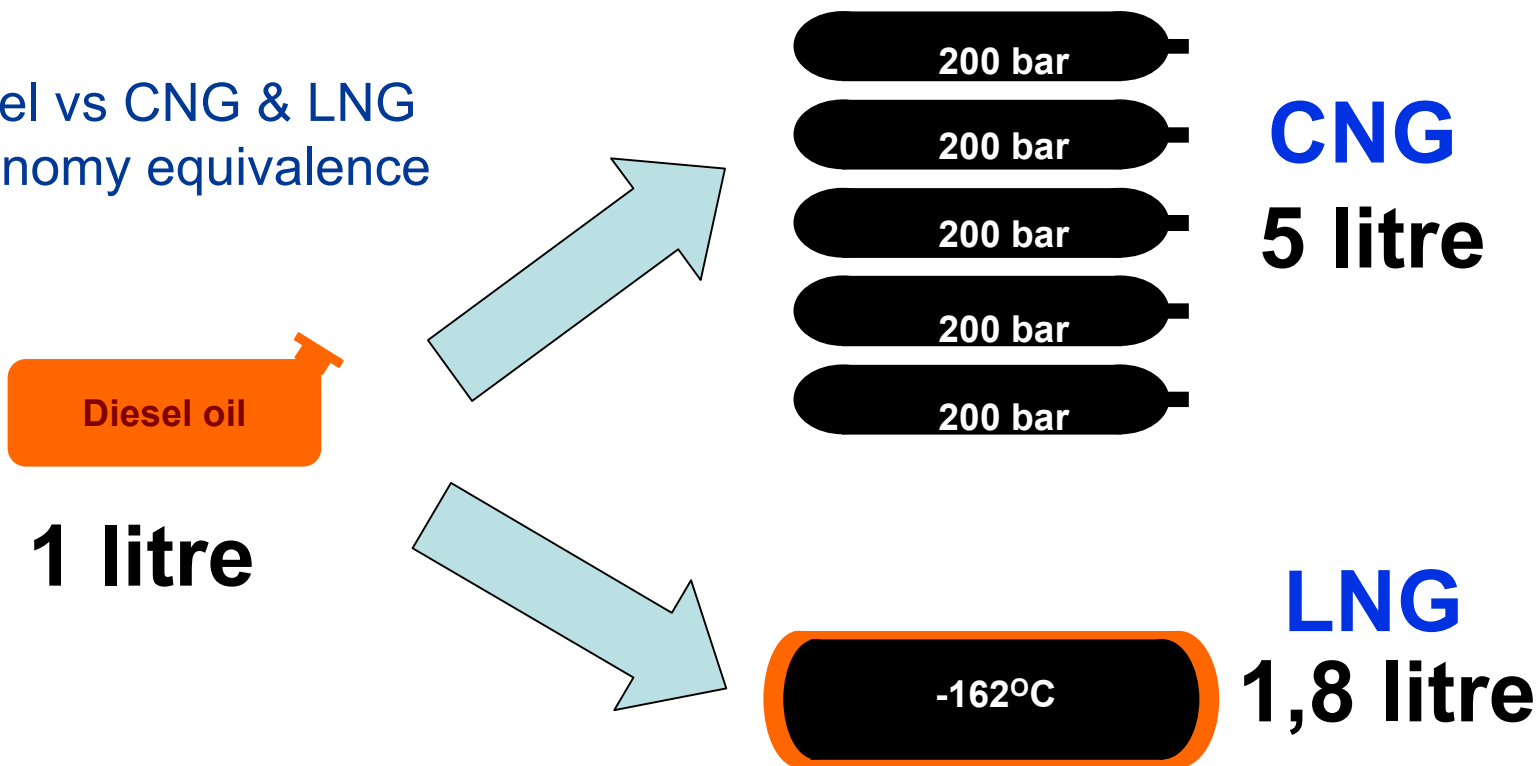
- Biogas comes from fermentation processes of biomass (organic waste, landfills, vegetable and animal feedstock), which produces methane rich gases.
- Biogas brings together the advantages of natural gas with the environmental benefits of renewable energy sources.
- Due to the wide different types of sources: forestry, landfills, agricultural; there is a large and wide potential for biogas production in Europe, where it is expected to grow significantly in the coming years.

# LNG (Liquefied Natural Gas)

The solution for medium-long distance



Diesel vs CNG & LNG  
Autonomy equivalence



**LNG opens the way for the medium-long distance road transport**

## CNG vs LNG. Tank configuration



**8 tanks of 80 lt. 640 lt. CNG**  
eq. to 128 lit. diesel



**1 single LNG 360 lt. tank**  
eq. to 200 lt. diesel (56% more)

# Methane/Hydrogen mixtures

A bridge towards the hydrogen fuelled transport



Methane/Hydrogen mixture (*Hythane, Idrometano*) offers a number of significant advantages as a bridge solution for a future possible hydrogen fuelled transport:

- It can be used in the existing NGV engines and vehicles with minor engine resetting
- The inboard fuel storage uses the same type of tanks and fittings, with some specification changes in materials
- The H<sub>2</sub> content considered (~20%) does not alter the autonomy of the vehicles
- There is an immediate impact as CO<sub>2</sub> emission reduction
- The use of compressed H<sub>2</sub> in a “large” basis will push ahead the development of the hydrogen production and logistics

## Biogas. Another source of Natural Gas (2)

---



- The raw biogas composition is variable depending upon different factors like garbage origin, humidity, temperature, etc., but it normally contains 50-55% of methane (CH<sub>4</sub>) and 40-42% of carbon dioxide (CO<sub>2</sub>).
- The depuration of this gas means:
  - avoiding the emission of CO<sub>2</sub> to the atmosphere
  - reusing the CO<sub>2</sub> as a commercial product
  - eliminating other pollutants like Cl<sub>2</sub>, F<sub>2</sub>, SH<sub>2</sub>
  - the purified biogas will have a 90-95% methane content
- In terms of use in vehicles, the advantages of natural gas are increased with a much better balance of total CO<sub>2</sub> due to the renewable origin of biogas.

## **Big cities. Gas use vs biogas potential**

---

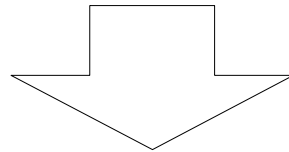


The yearly consumption of natural gas of the complete fleet of 445 garbage collection trucks is:

- **10.5 MM cubic meter**

The yearly biogas production of the city is of about 40 MM cubic meter, that once refined would mean:

- **22 MM cubic meter of biomethane**



**This volume is enough to fuel the full fleet of garbage collection (445 units) plus a similar figure of urban buses (25% of the total fleet of 2.000 units)**

## 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 GPL
- Natural gas can be used in the existing internal combustion engines, with minor additional investments, taking advantage of a well known and mature car & commercial vehicle technology
- Natural gas has been used so far as CNG mainly for urban applications. The availability of LNG will spread its use for medium distances road transport
- The increasing production of biomethane, both from urban waste and from agricultural sources, is giving natural gas the new and valuable consideration of a renewable fuel
- Methane/Hydrogen mixtures to be used in today's NG vehicles, will pave the way for a potential future of hydrogen as a fuel
- **NG vehicles constitute an economic, up-to-date and dependable alternative to oil derived fuels and to improve acoustic and gaseous emissions simultaneously**



[manuel.lage@ngvaeurope.eu](mailto:manuel.lage@ngvaeurope.eu)

[www.ngvaeurope.eu](http://www.ngvaeurope.eu)