

Bio-natural-gas for cleaner urban transport

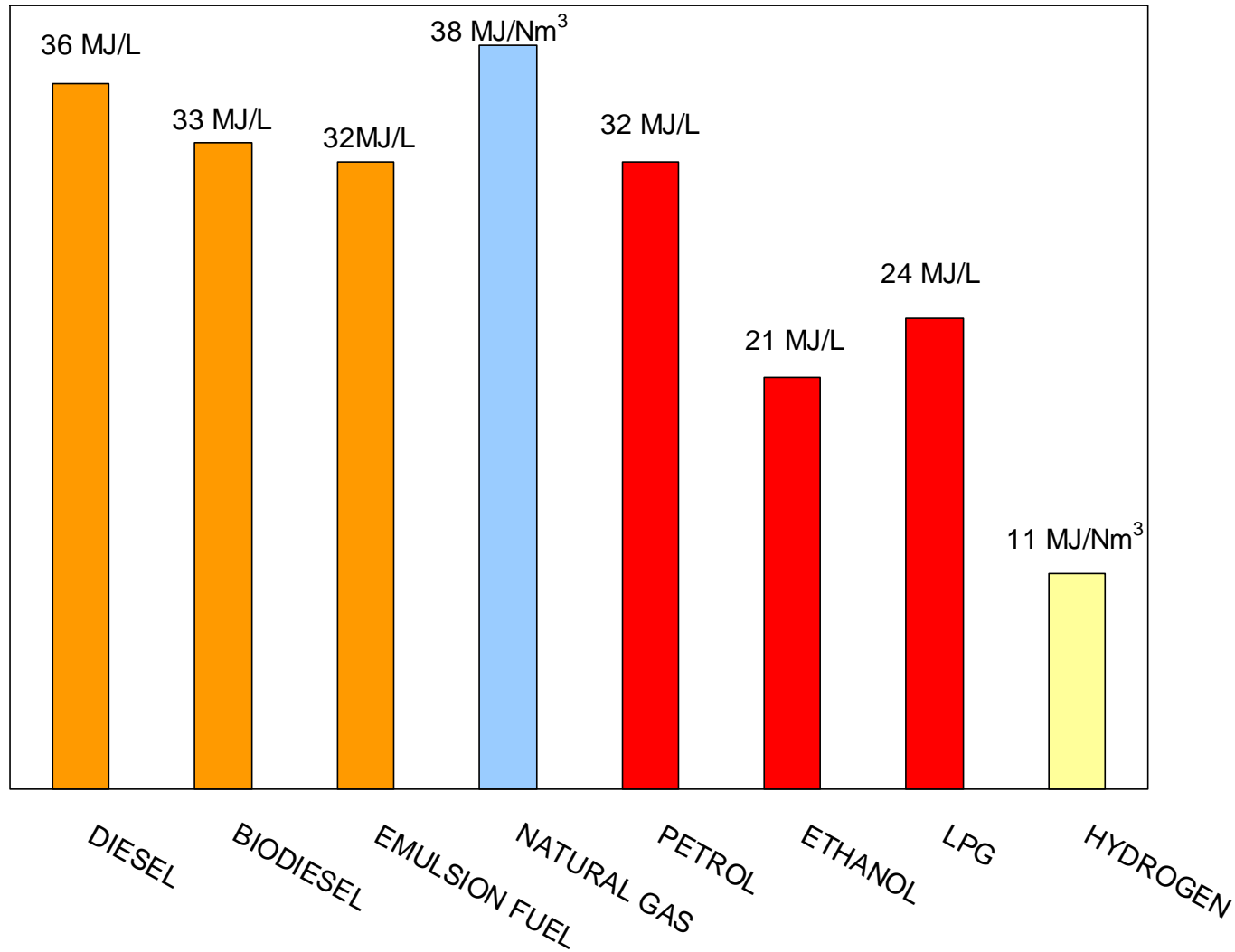
BIOGASMAX

European Biomethane Fuel Conference

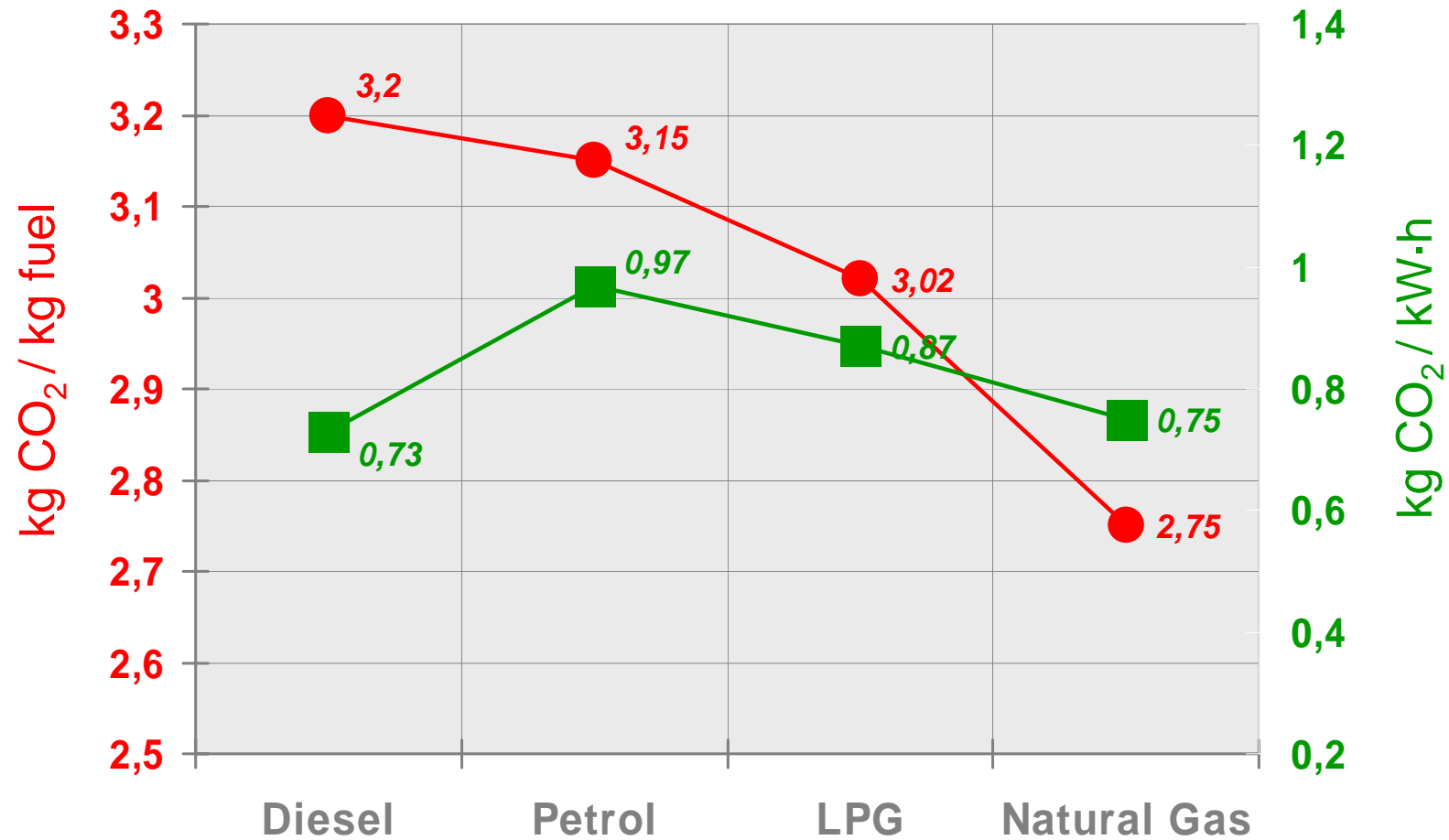
Göteborg. September 7-9th, 2009

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 (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.

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 CO₂ emission

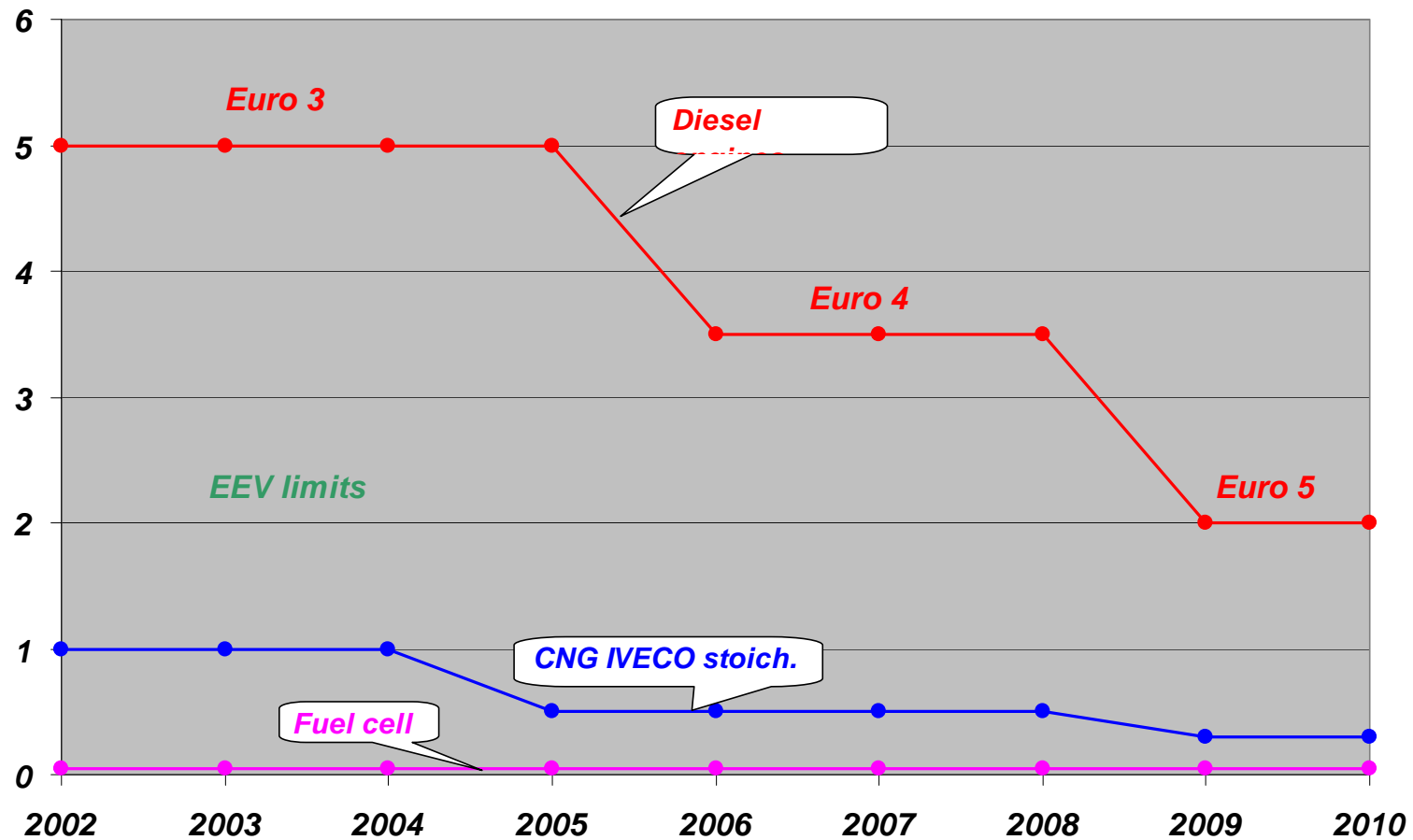
In the case of the stoichiometric mixture combustion, exhaust pollutants are very near the fuel cell level

CNG. NOx comparative emissions



Compared NOx emissions: Diesel vs CNG and Fuel Cell

(Source: IVECO)

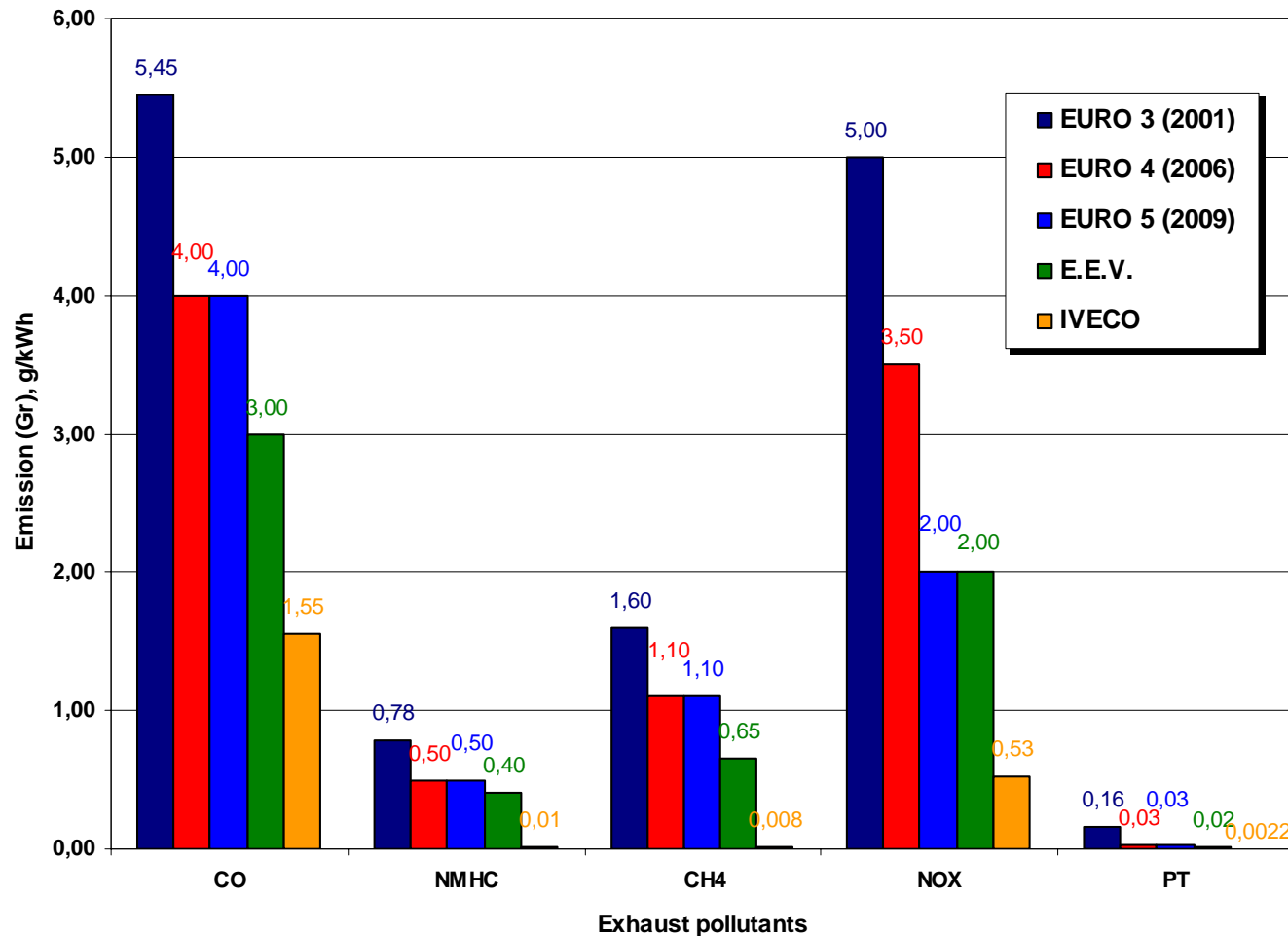


CNG. Other Emissions Comparison

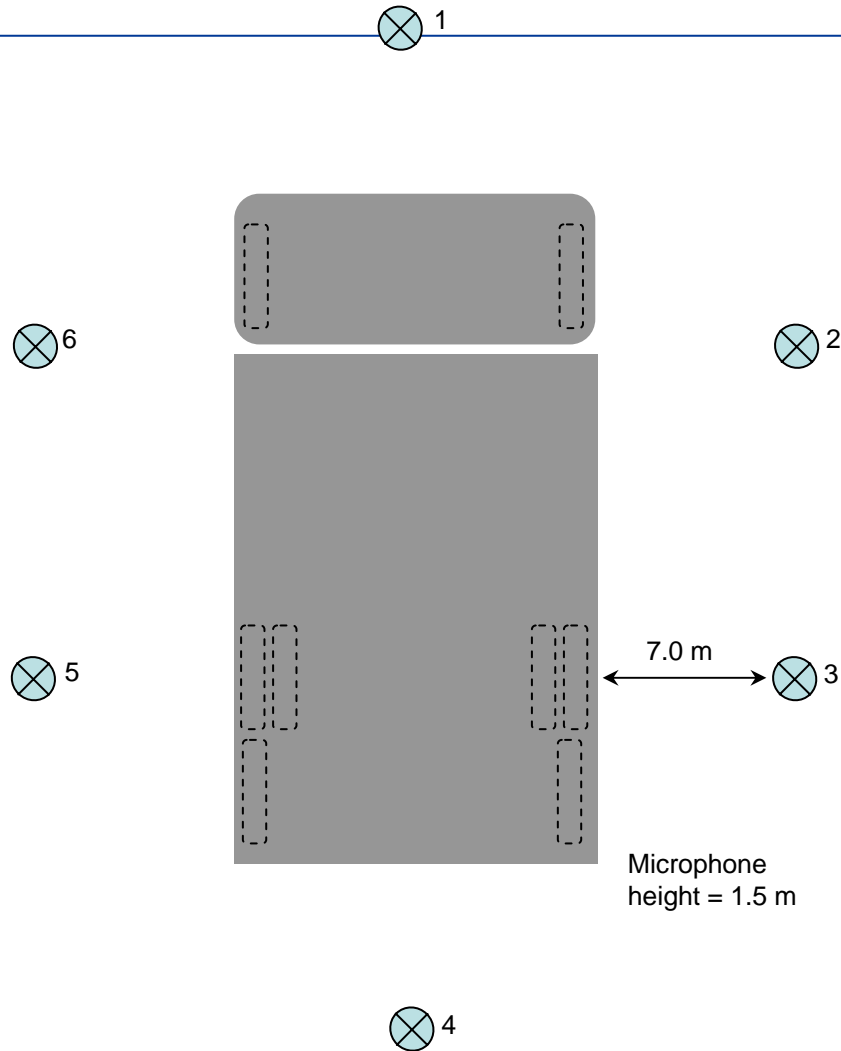


Emissions IVECO CURSOR 8 CNG engine vs present and future Euro limits

(Source: IVECO)

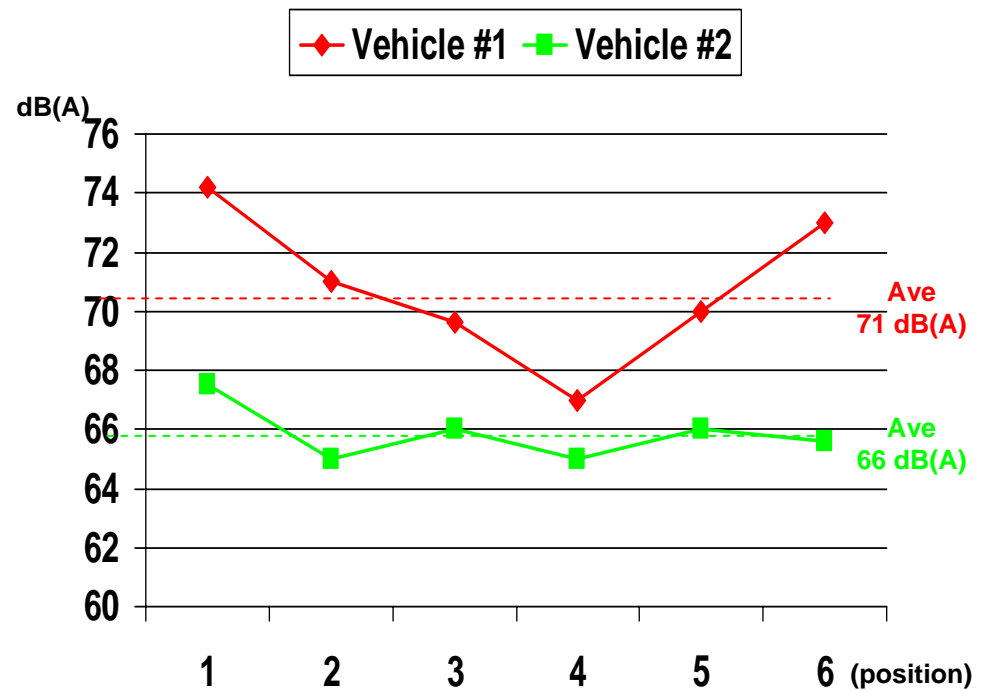


Noise emitted by the truck



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

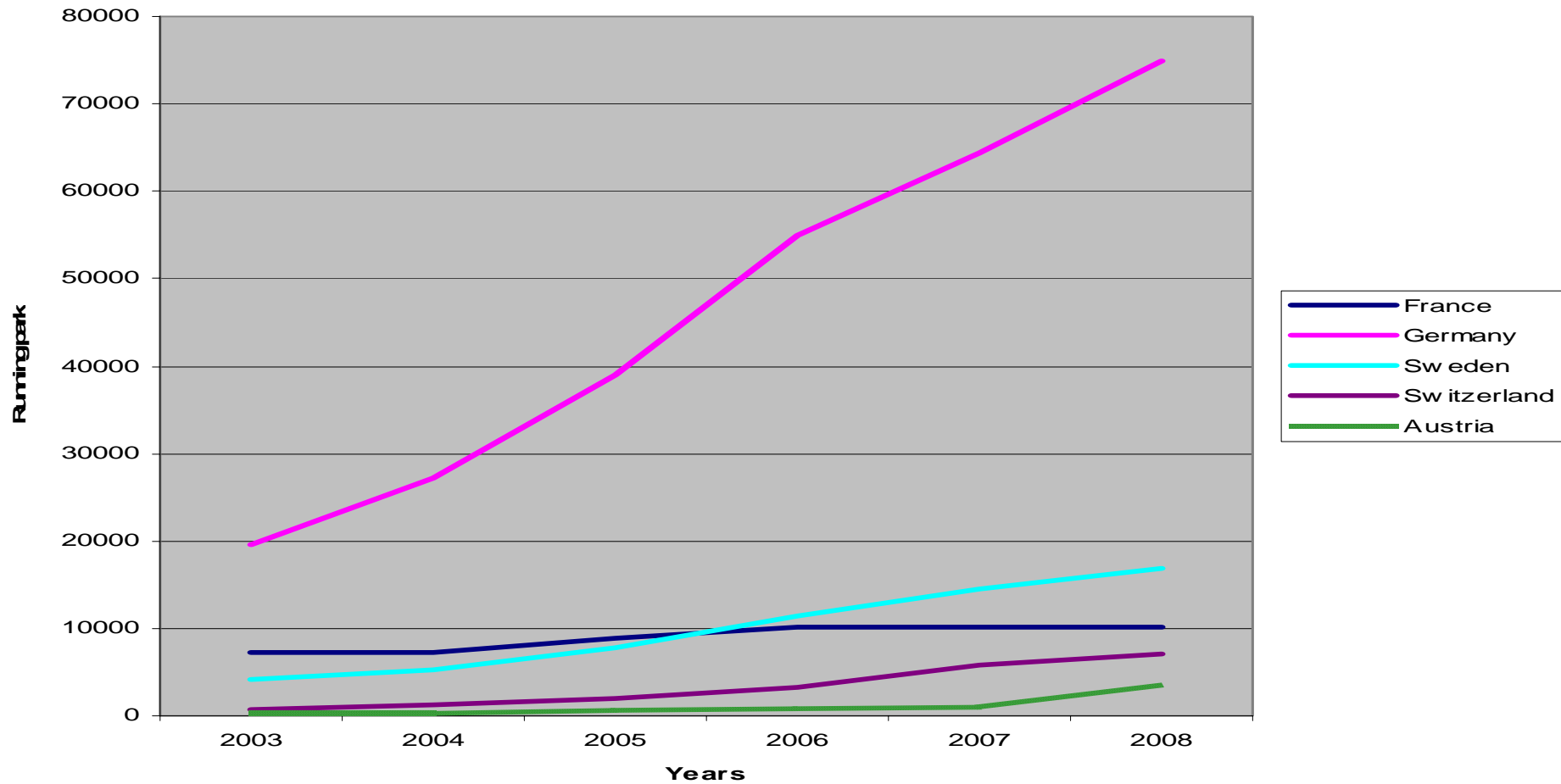
Refuse collection chassis cab with body
Vehicles laden and compacting
Vehicles stationary



European market development (1)



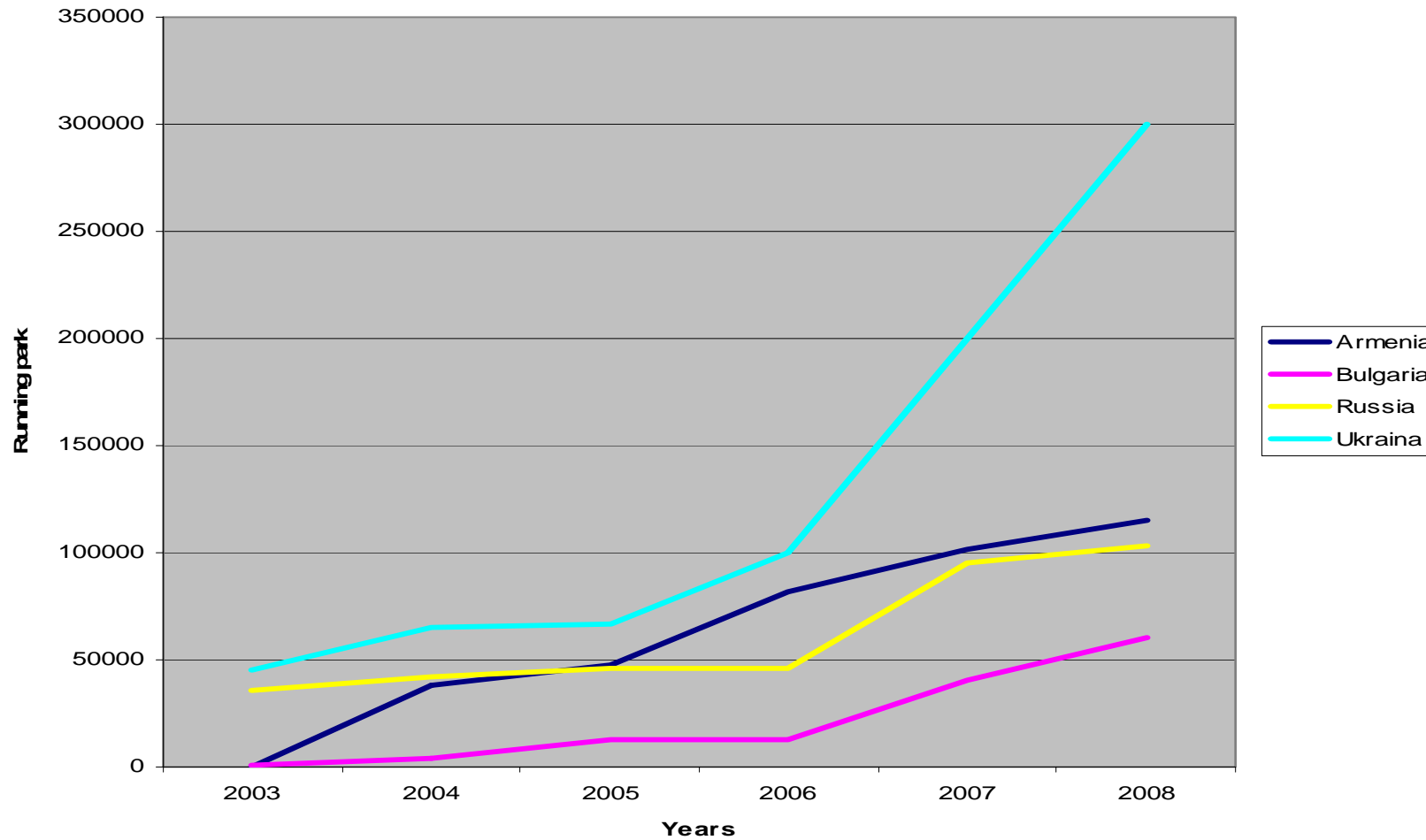
Europe (without Italy)



European market development (2)



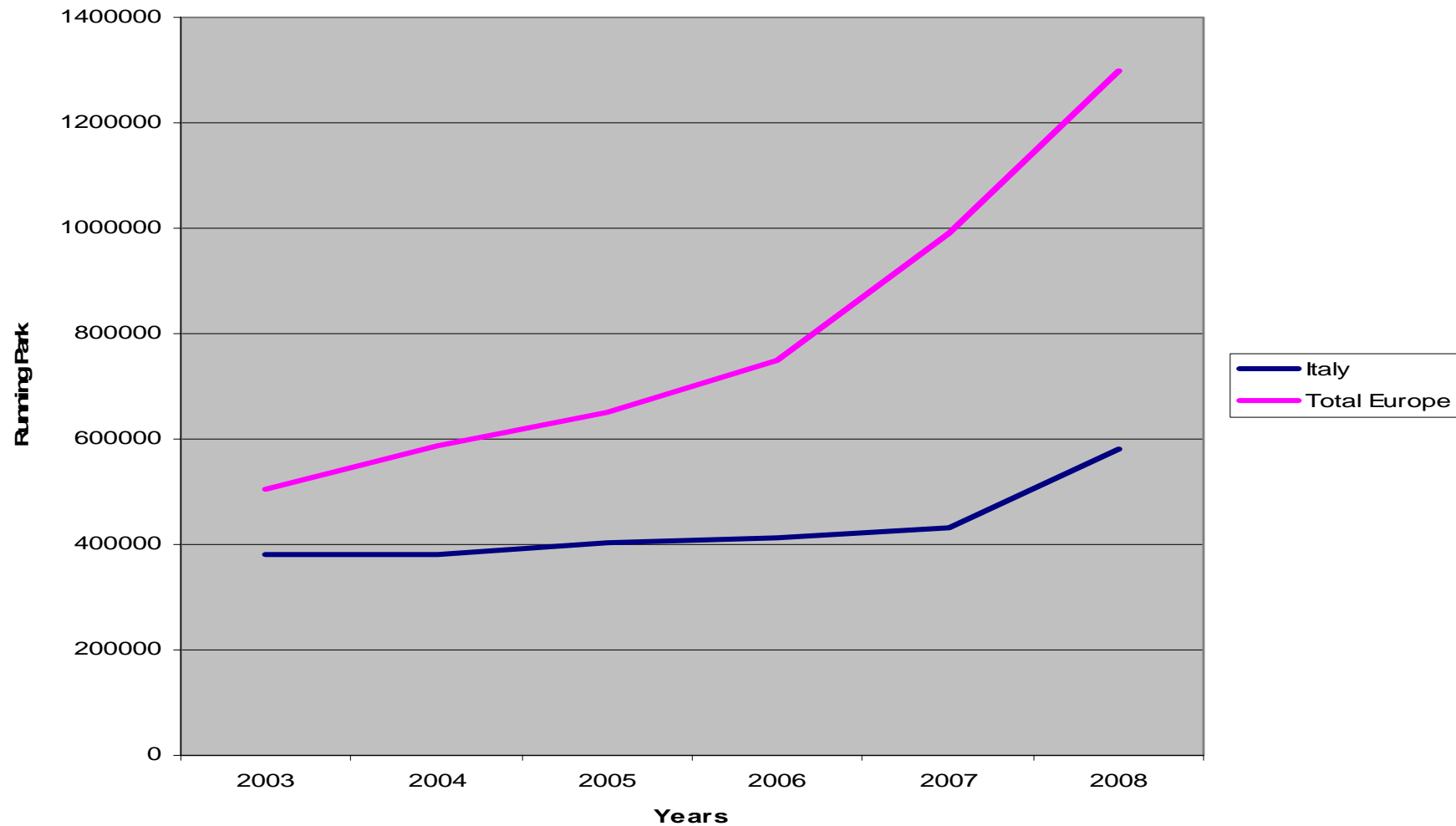
Europe. Eastern countries



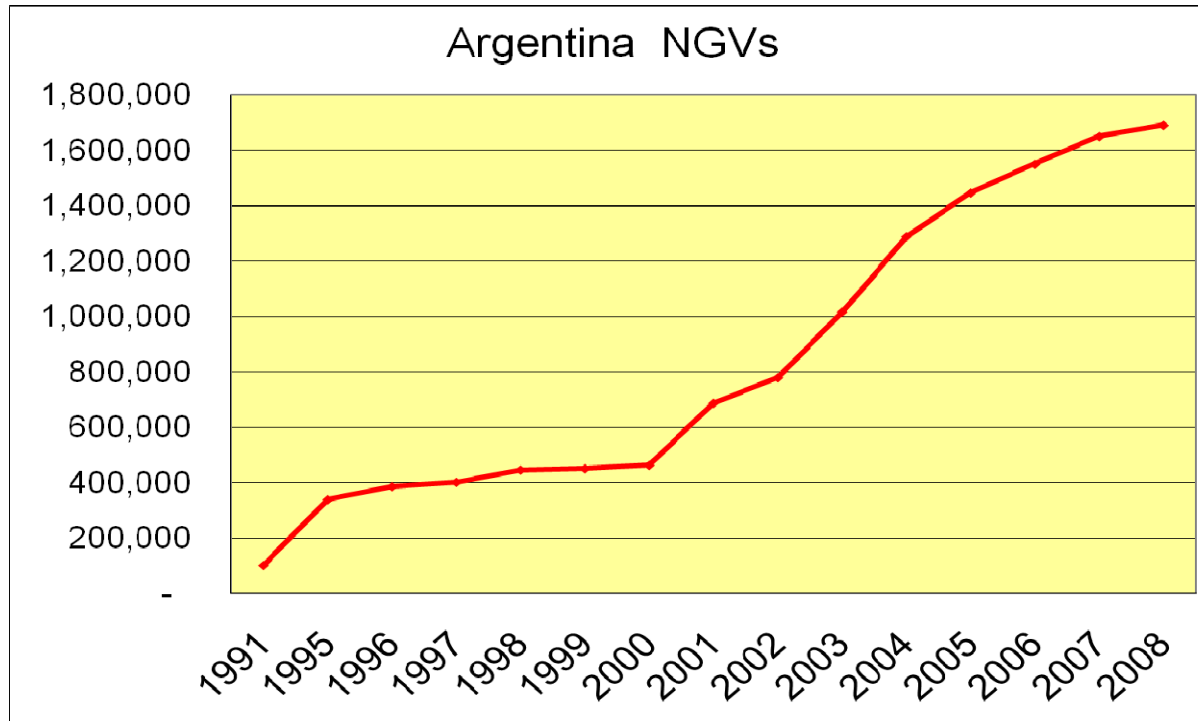
European market development (3)



Italy and Total Europe



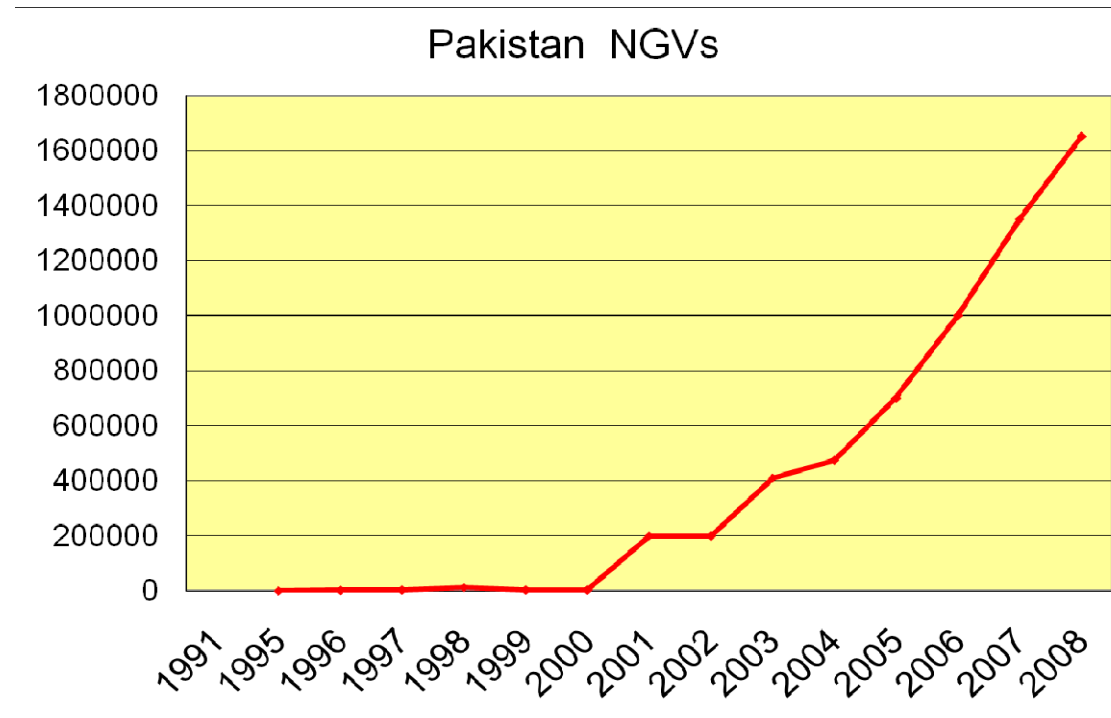
World markets: Argentina



The driver for this development has been economic. Most of the NGVs are conversions from petrol cars.

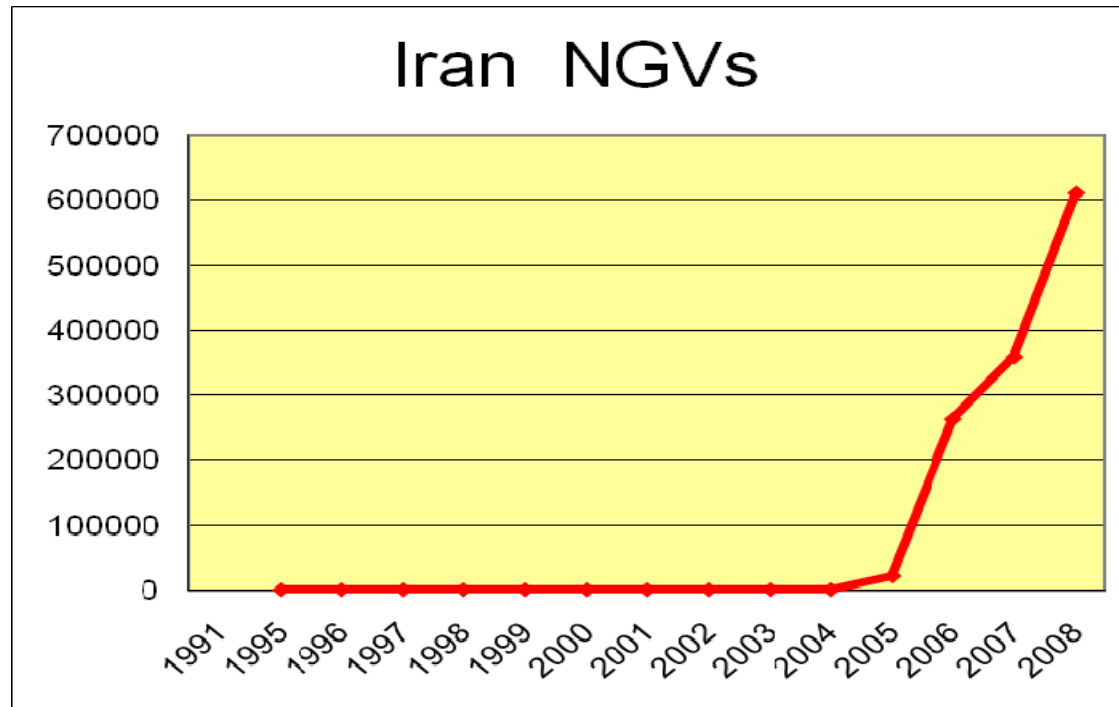
The minor cost difference today smoothes the growth

World markets: Pakistan



The driver for this development has also been economic. NGVs are both conversions from petrol and new cars, now available.

World markets: Iran



The driver has been the Government Strategy. Iran strategy is to export all the oil produced and have NG as the domestic fuel.

All new cars produced in the country have to be necessarily NGV.

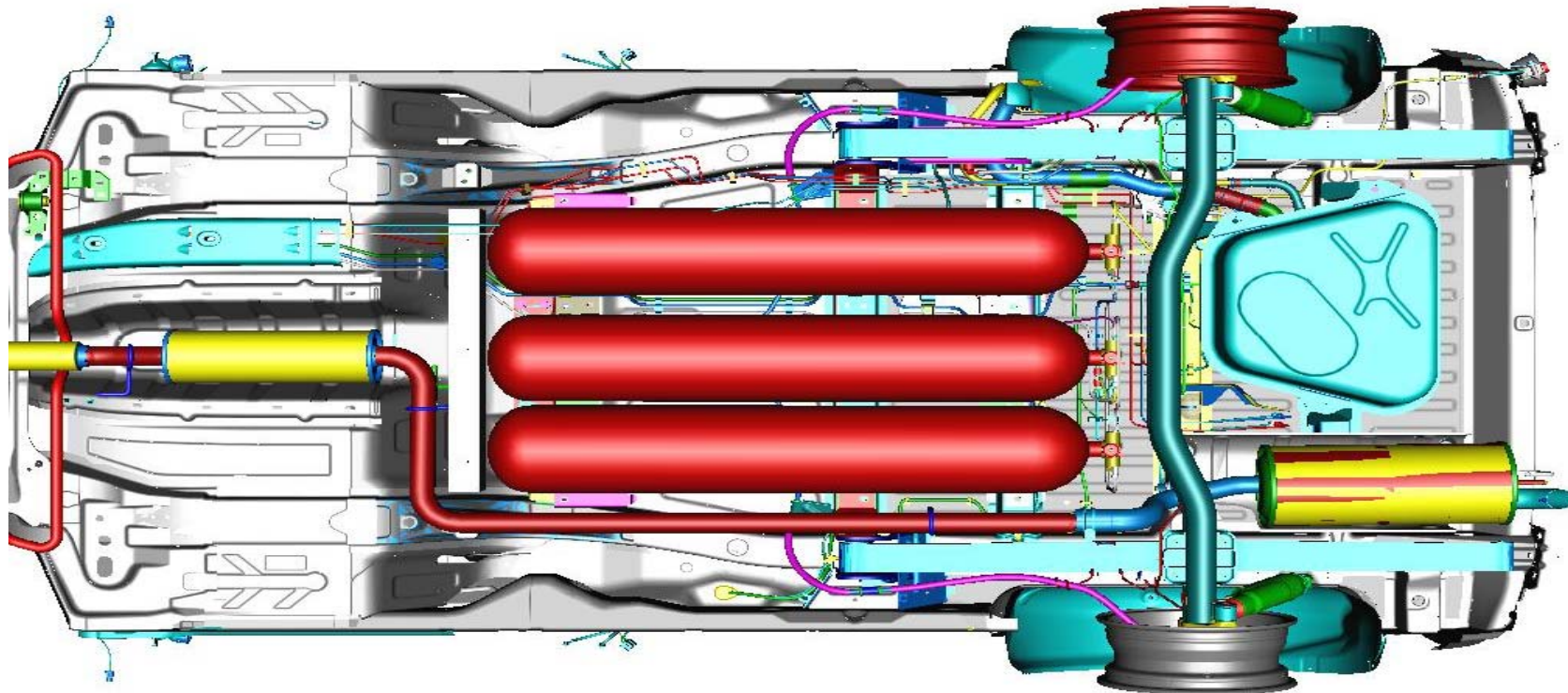
Series production CNG cars (1)



Fiat Doblò Panorama



Fiat Doblò. CNG tanks positioning



Madrid CNG Refuse collection fleet



FCC NATURAL GAS FLEET (TOTAL 445 UNITS)



FCC NATURAL GAS FLEET CONSUMPTION 10,500,000 m³

Yearly emission savings

Iveco CNG (EEV) vs. Diesel Euro 3 limits

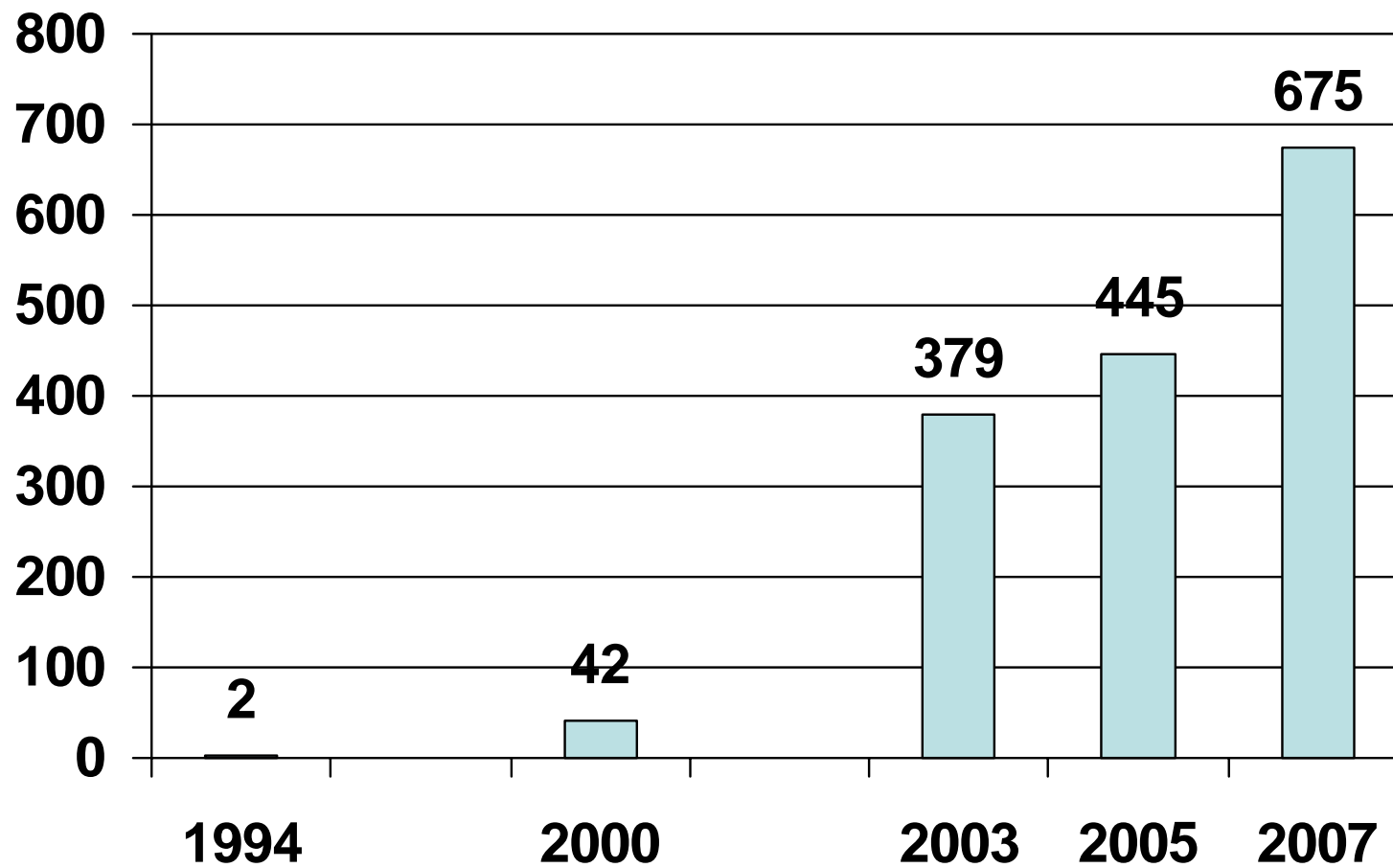
NOx 132.391 kg

CO + HC + PM 703.000 kg

CO2 2.069.440 kg

Plus a 30% less fuel cost per kilometre!

Madrid CNG Refuse collection fleet



Food distribution on CNG chassis



CNG urban buses



Irisbus Iveco CITYCLASS CNG 12 m



MB CITARO CNG 12 m

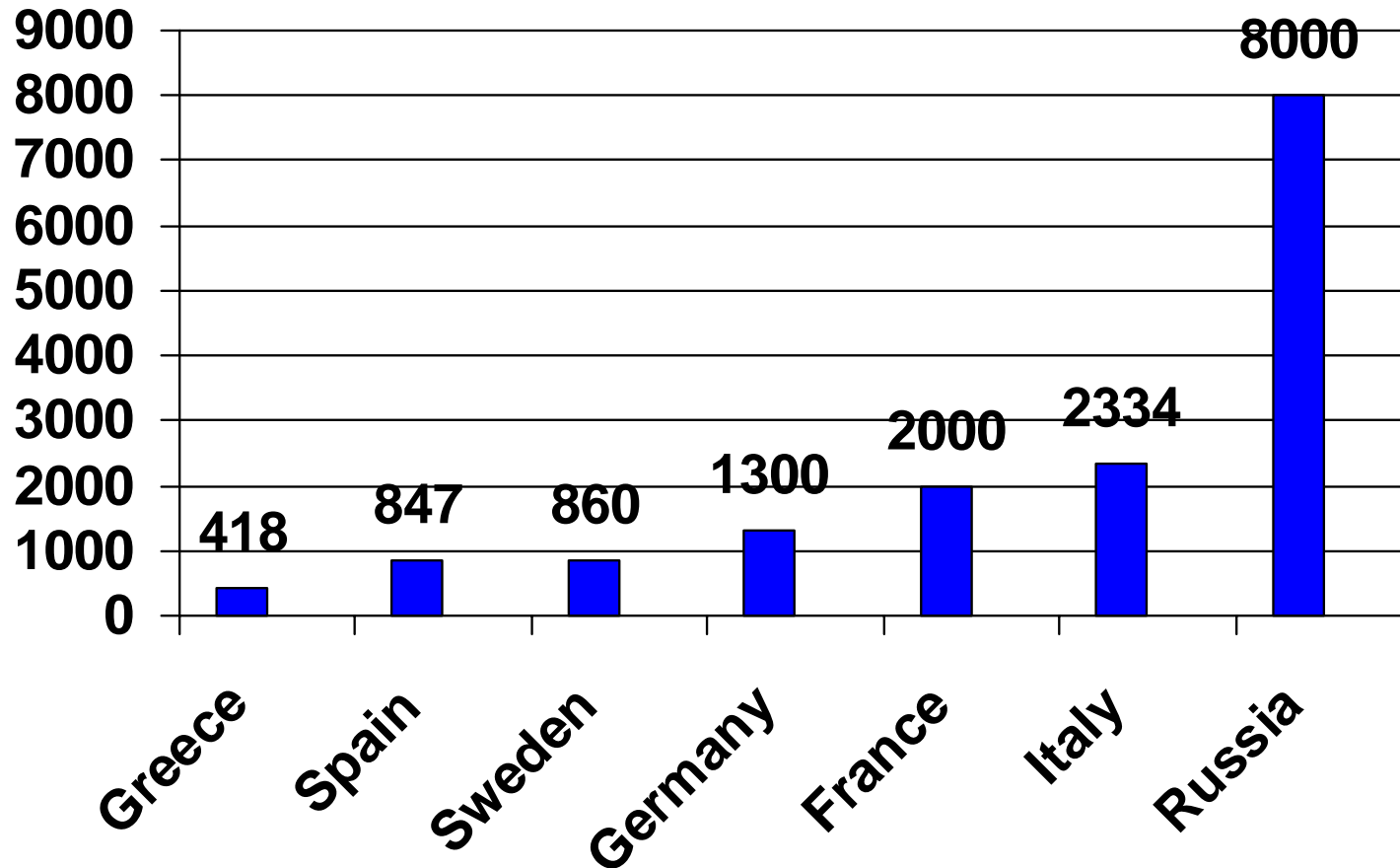


Irisbus Iveco CITYCLASS CNG 18 m



MB CITARO CNG 18 m

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 (1)



- 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.

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 (CH₄) and 40-42% of carbon dioxide (CO₂).
- The depuration of this gas means:
 - avoiding the emission of CO₂ to the atmosphere
 - reusing the CO₂ as a commercial product
 - eliminating other pollutants like Cl₂, F₂, SH₂
 - 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 CO₂ due to the renewable origin of biogas.

Big cities. Gas use vs biogas potential

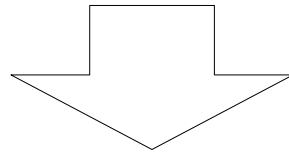


The yearly consumption of natural gas of the complete fleet of 445 garbage collection trucks is:

- **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**



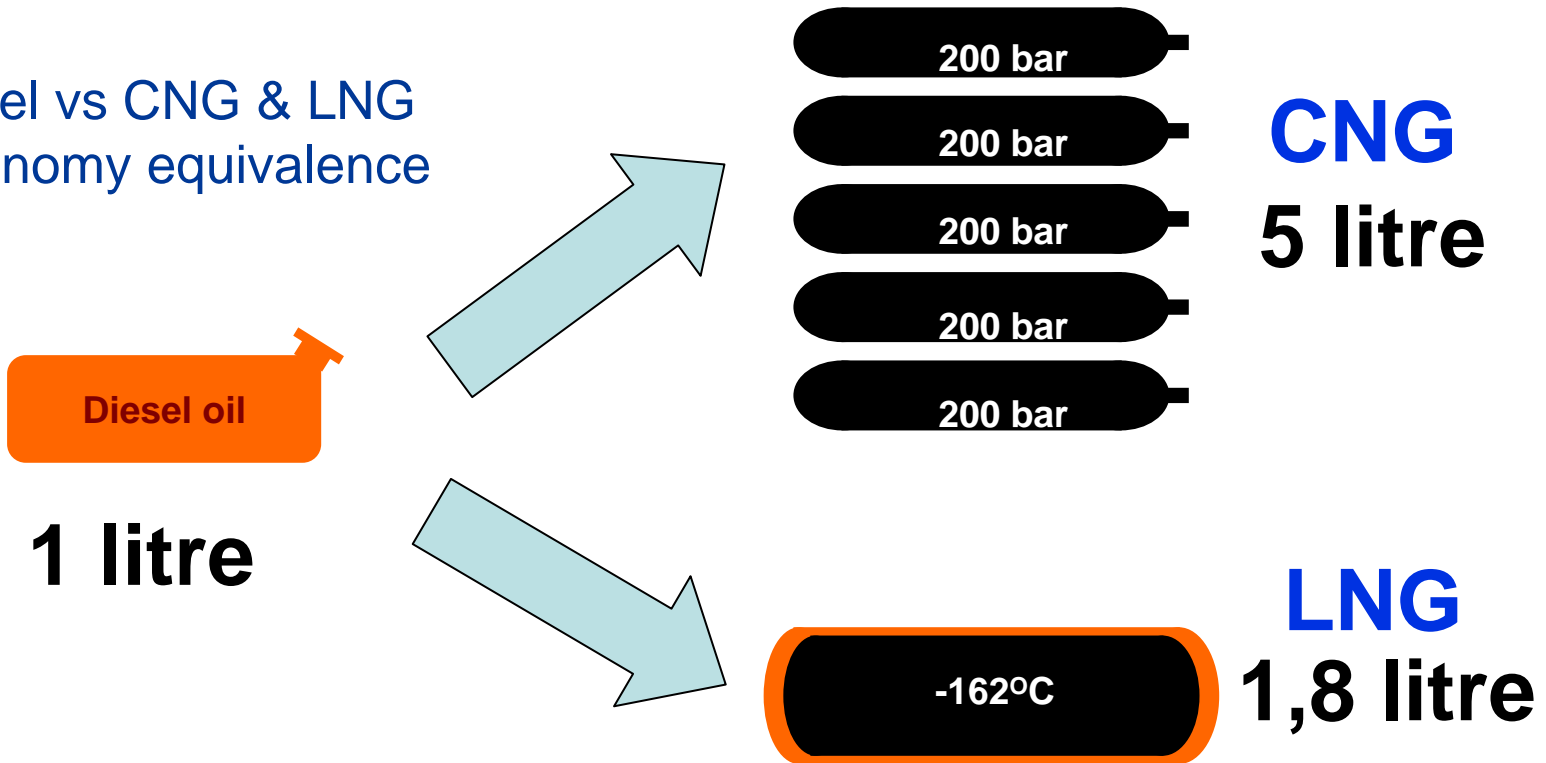
This volume is enough to fuel the full fleet of garbage collection (445 units) plus a similar figure of urban buses (25% of the total fleet of 2.000 units)

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)

LNG Prototype tractors MB and IVECO



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 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 H₂ content considered (~20%) does not alter the autonomy of the vehicles
- There is an immediate impact as CO₂ emission reduction
- The use of compressed H₂ in a “large” basis will push ahead the development of the hydrogen production and logistics

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 can be used in **existing internal combustion engines**, with minor additional investments, taking advantage of a well known and mature car & commercial vehicle technology
- 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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