Biomethane as a vehicle fuel made from upgraded biogas

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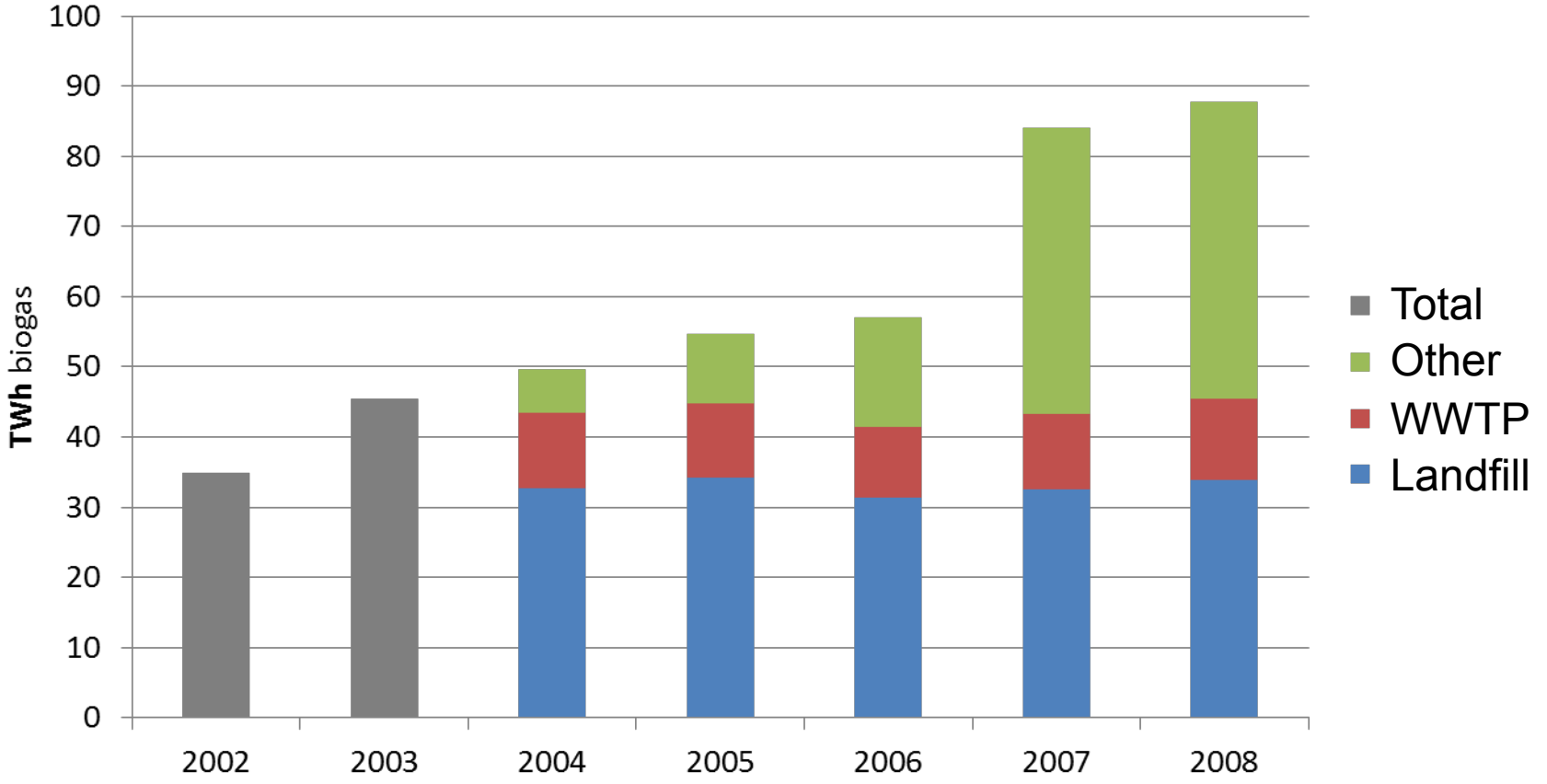
Outline

- Biogas production and utilisation as vehicle fuel in Europe
- Biogas upgrading
- Standardisation of vehicle gas (CNG + biomethane)
- The lower emissions of gas vehicles
- Natural gas vehicles of today and tomorrow
- Conclusions

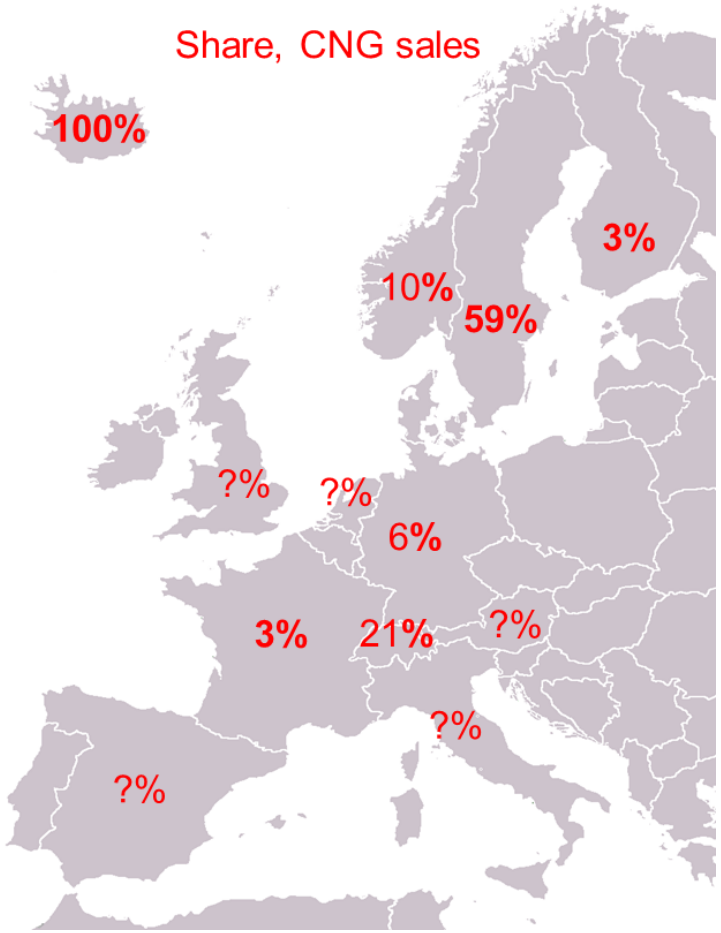
Biogas production in Europe

88 TWh in total (2008)



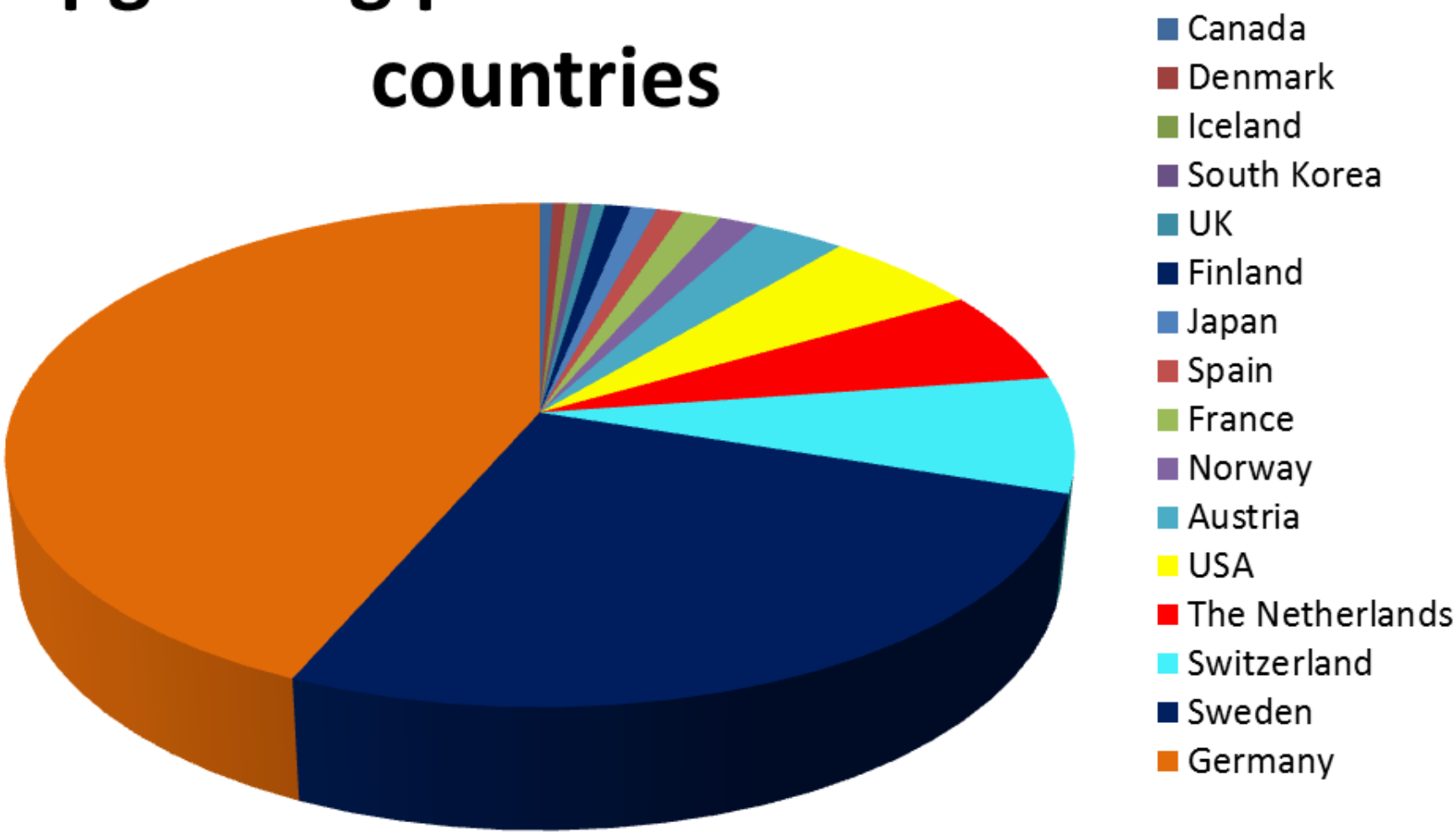
Source: EurObserv'ER 2009. 2008 is an estimation

Utlisation of biomethane as vehicle fuel

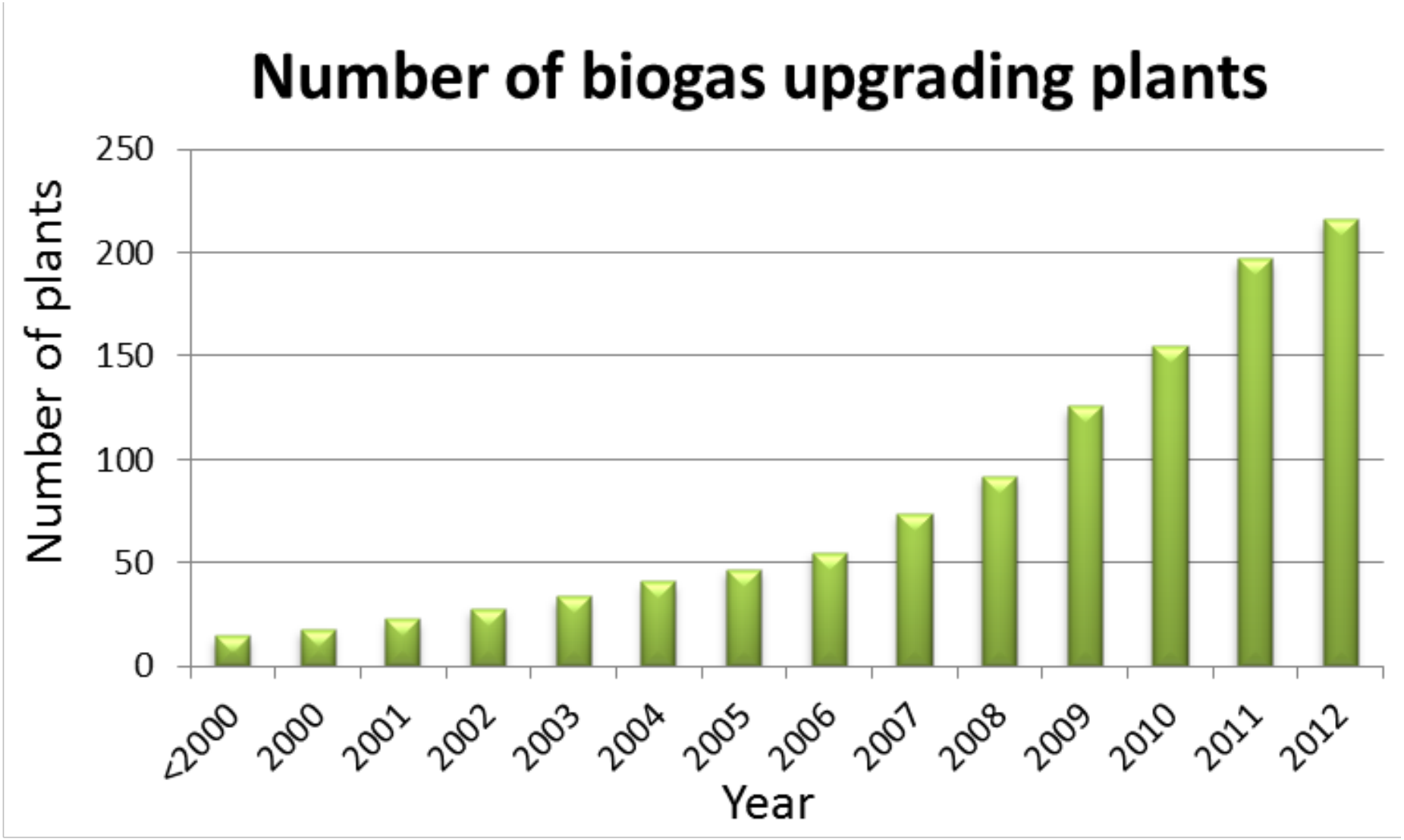


- Small but growing market
  - Estimation: 1.5-3 TWh (Sweden ~0.7 TWh Germany ~0.2 TWh)
- New projects happening
  - India, Canada, Thailand, Estonia, China, New Zealand, South Korea, South Africa, Brazil

Upgrading plants in different countries

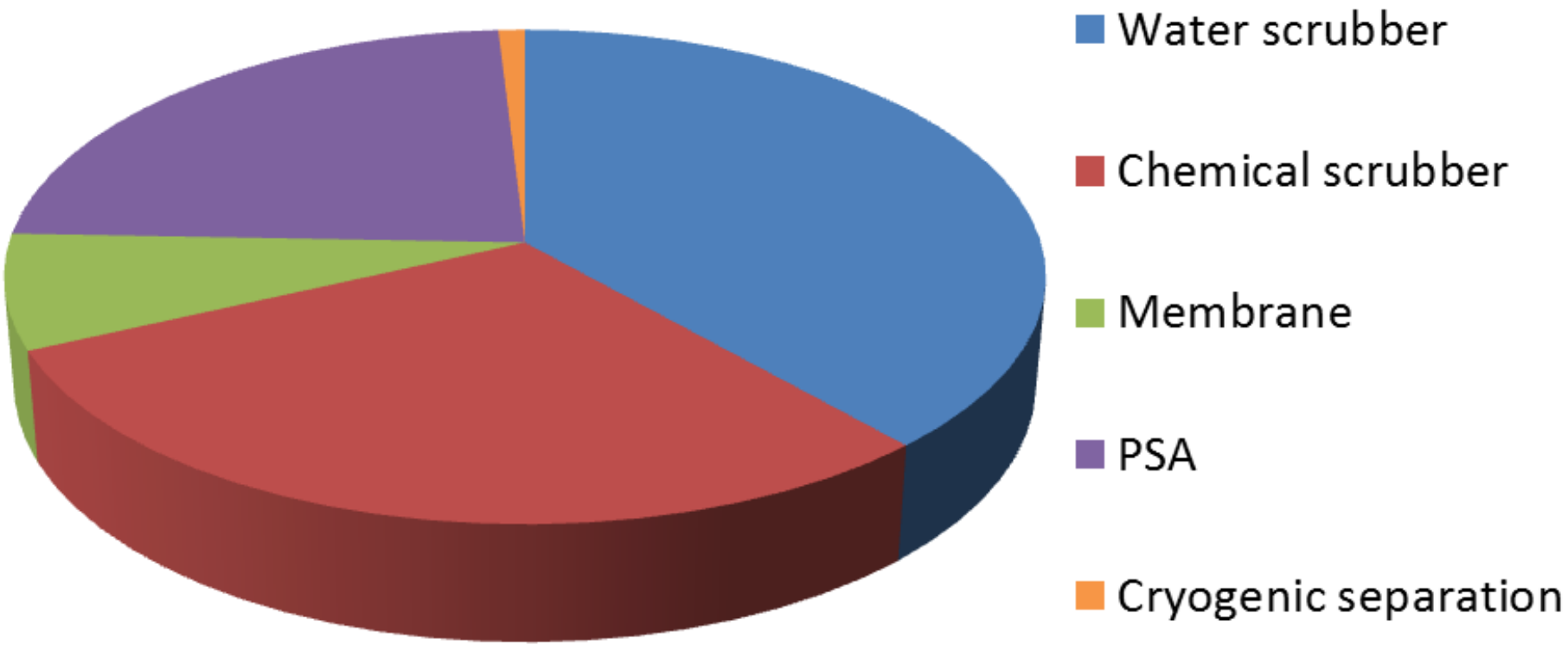


Source: IEA Bioenergy Task 37



Source: IEA Bioenergy Task 37

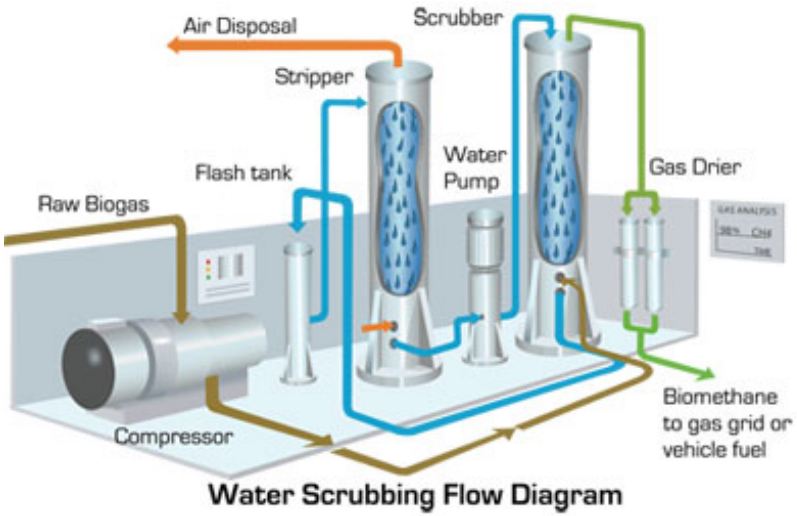
Upgrading technologies



Source: IEA Bioenergy Task 37

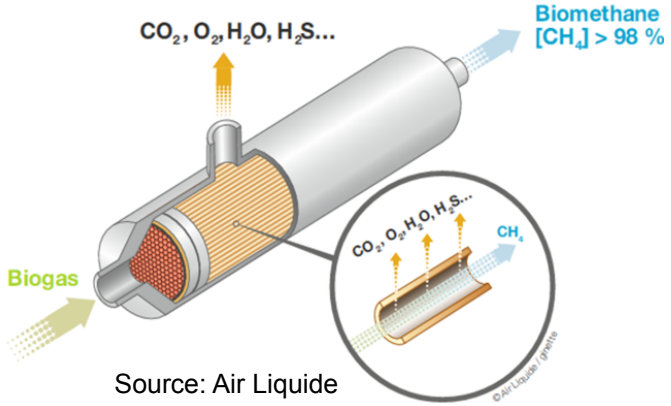
Biogas upgrading

Water/chemical scrubber



Source: Greenlane Biogas

Membrane

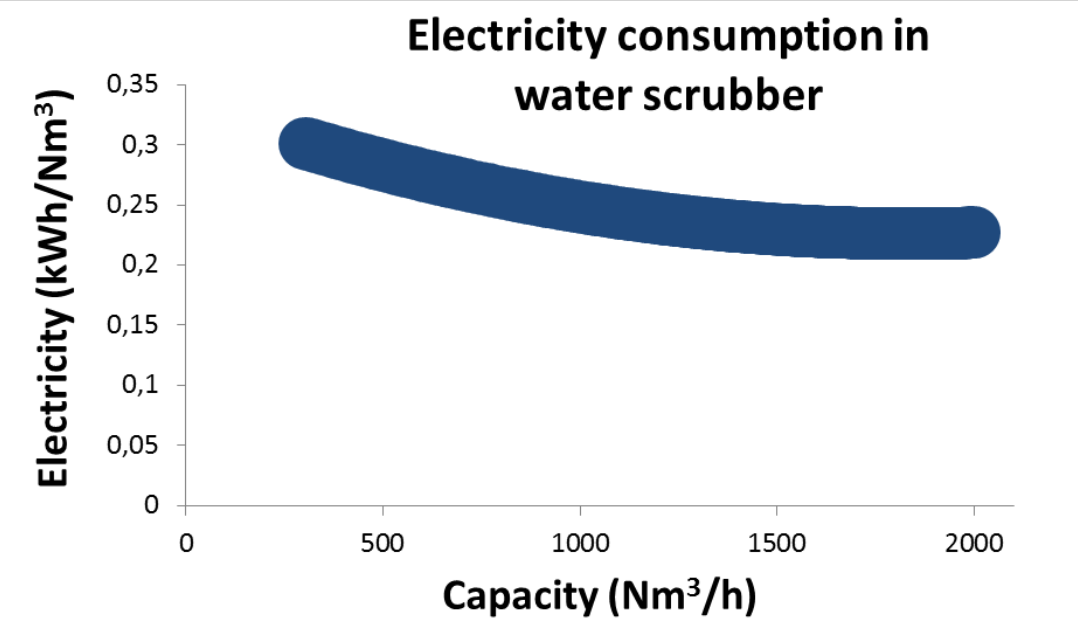


Source: Air Liquide

PSA

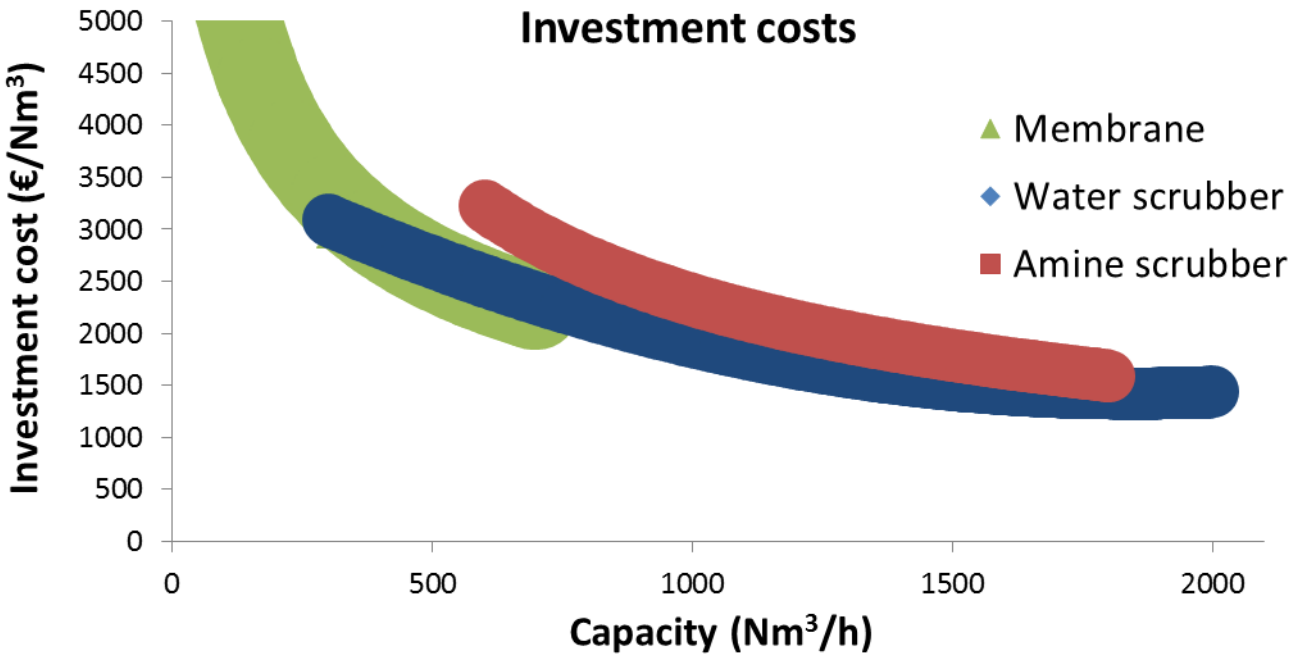
Energy consumption

- Amine scrubber: 0.12-0.14 kWh/Nm^3 (4 barg) (0.55 kWh/Nm^3 heat)
- Membrane: 0.20-0.30 kWh/Nm^3 (5-20 barg)
- PSA: 0.20-0.30 kWh/Nm^3 (4-8 barg)
- Water scrubber: 0.20-0.30 kWh/Nm^3 (5-9 barg)



Investment cost (500 Nm3/h raw gas)

- Amine scrubber: 3000-3500 €/Nm^3 raw gas
- Membrane: 2200-3100 €/Nm^3 raw gas
- PSA: 2200-2800 €/Nm^3 raw gas
- Water scrubber: 2500-3000 €/Nm^3 raw gas



Standardisation of vehicle gas

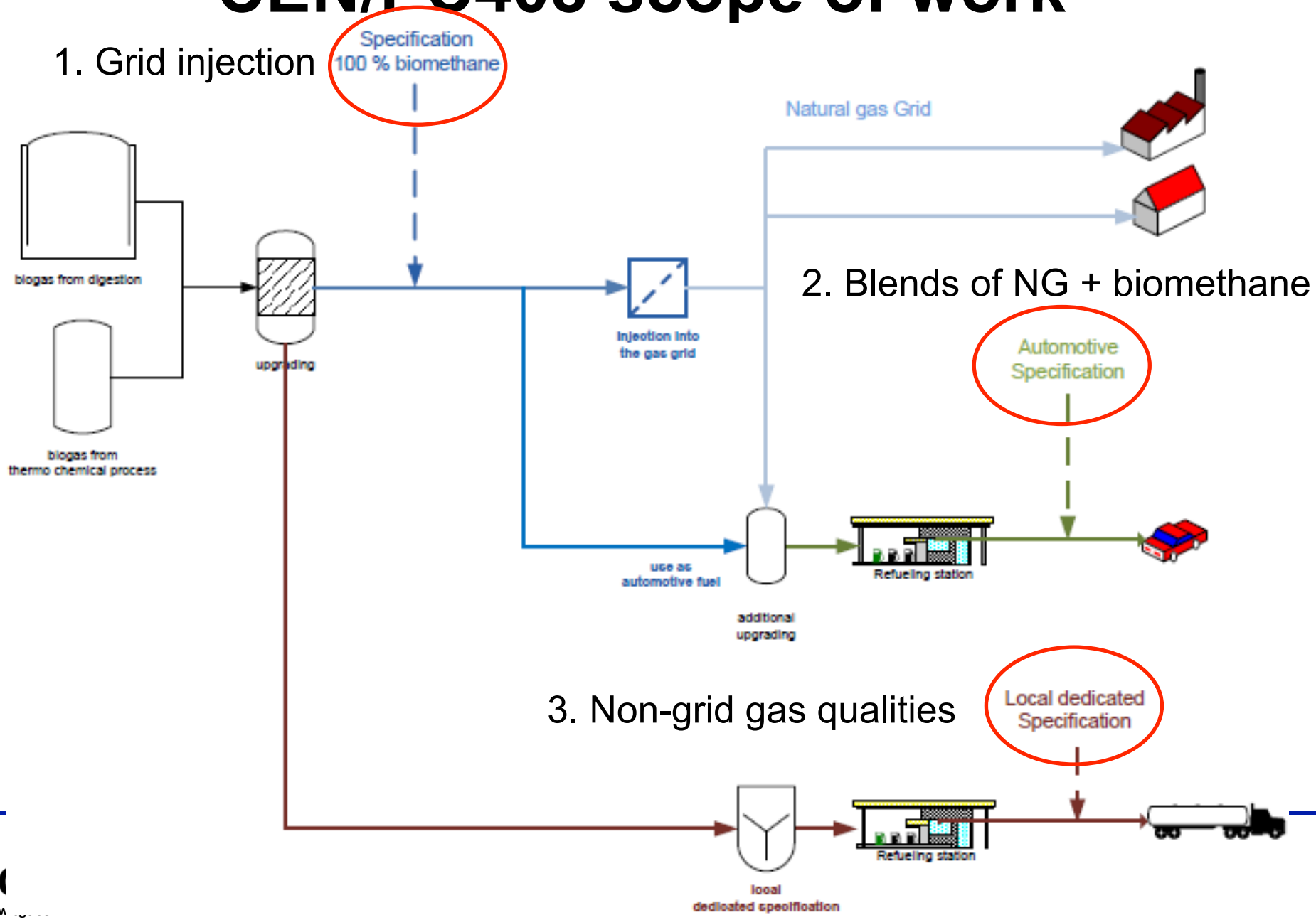
- A few national standards with quantitative limits (DIN 51624 for CNG, SS 155438 for biomethane)
- Many national standards for grid injection
- 2011-2015: Int'l standard: Project committee CEN/PC408* in charge of EC mandate M/475**

TC234 Gas infrastructure → PC408 ← (TC019 Petroleum products)

- Priority lane: Natural gas quality standardisation in CEN/TC234/WG11 according to EC M/400***

*CEN/TC408 "Project Committee - Biomethane for use in transport and injection in natural gas pipelines"
**M/475 08/11/2010, "Mandate to CEN for standards for biomethane for use in transport and injection in natural gas pipelines"
***"M/400 16/01/2007, "Mandate to CEN for standardisation in the field of gas qualities"

CEN/PC408 scope of work



Parameters chosen, what limits are discussed?

	TC234/WG11	PC408 -grid	PC408-fuel
Sulphur (mg/Nm^3)	5-30, excl. odoriz.	←	7-13, incl. odoriz.
Methane No. (AVL)	65	←	75-90*
O_2 (%)	1 (0.01, storage)	←	-
H_2 (%)	- (0.1-10, no limit better)	←	2
Water (mg/Nm^3)	32 (corrosion)	←	Lower, climate**
Siloxanes (mg Si/Nm^3)	-	1-10	0.5-1***
Compr. oil (mg/Nm^3)	-	-	10-20?#

*Euro6: Emission guarantee not only for reference fuel, but for **all** fuels used

**Driveability issue (methane hydrates). In Sweden as low as 1-5mg/Nm^3

*** abrasive silica sand formation, fouling λ-sensors, faster aging of catalysts

#Pending current validation of new sampling and test method, spring 2013

Microorganisms: Only information, micron filtering. Low hazard assessment

Vinnerås et al 2006 ”Identification of the microbiological community in biogas systems and evaluation of microbial risks from gas usage”

Euro6: no problem for NGV's

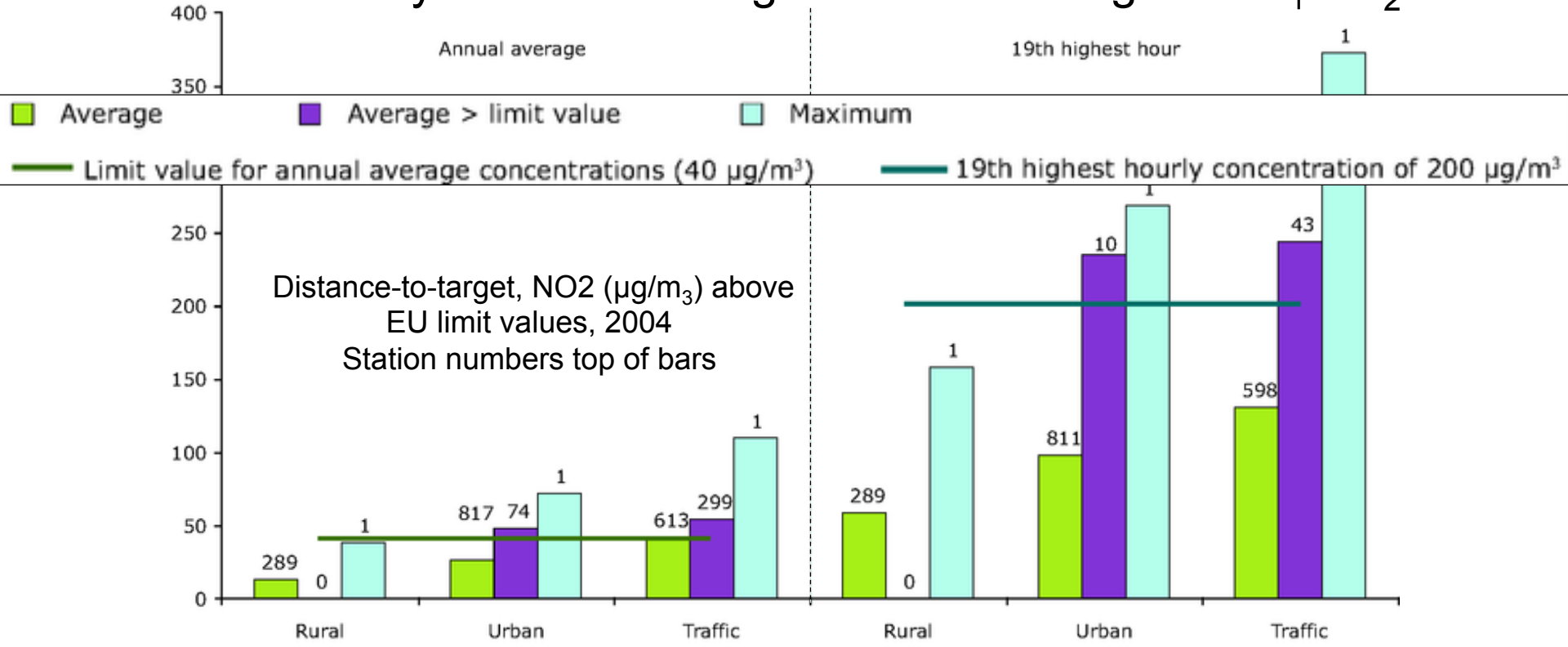
MAN E2876 LUH03, 320hp engine, launched in 2010 (autoflesz.pl)

NGV's have lower unregulated emissions

- NO_X – Nitrogen oxides
  - NO_2, higher ozone and photochemical smog forming capacity than NO
  - N_2O, GWP_{100}-factor 298 (CH_4 25)
- HC – hydrocarbons
  - Harmless ones (methane, ethanol)…
  - Real health hazards such as aldehydes, benzene (aromatic, the B in BTX) and polyaromatics (PAH)
- Particulates
  - Solids with vastly different biogenic impact (reactivity, size)

Diesel aftertreatment increase NO_2?

- NO_X trend decreasing in Europe and Japan, while NO_2 lags behind*
  - Ox. catalysis and DPF regeneration strategies → ↑NO_2



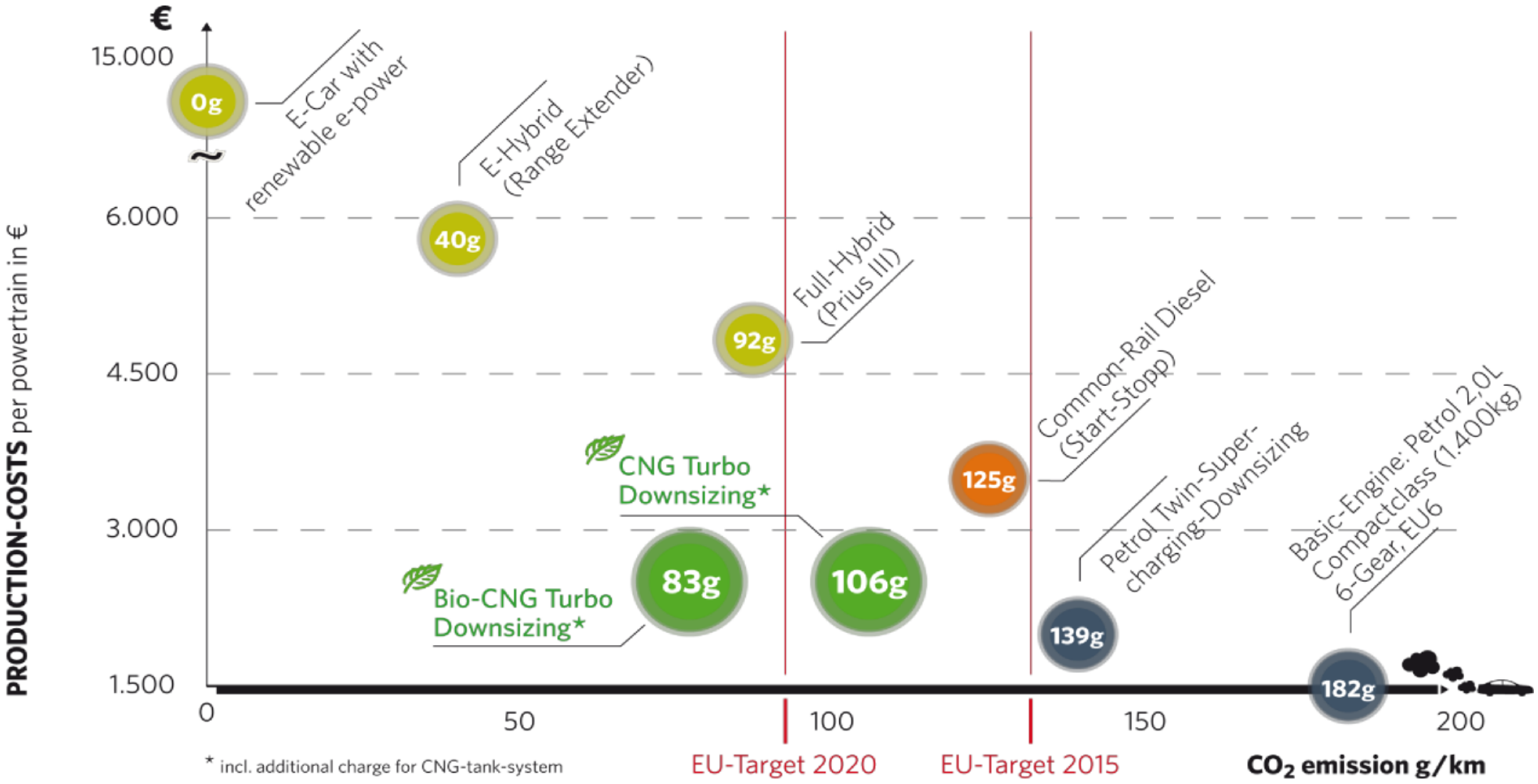
Graph: AirBase, the European Air quality dataBase, 2006 URL: http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=949

*Further reading:

Bishop and Stedman 2008, Emissions of nitrogen dioxide from modern diesel vehicles. http://library.witpress.com/pages/PaperInfo.asp?PaperID=19653

Guerreiro et al 2010, Status and trends of NO2 ambient concentrations in Europe. http://acm.eionet.europa.eu/reports/ETCACC_TP_2010_19_NO2trends

NGV's: Cost competitive already today

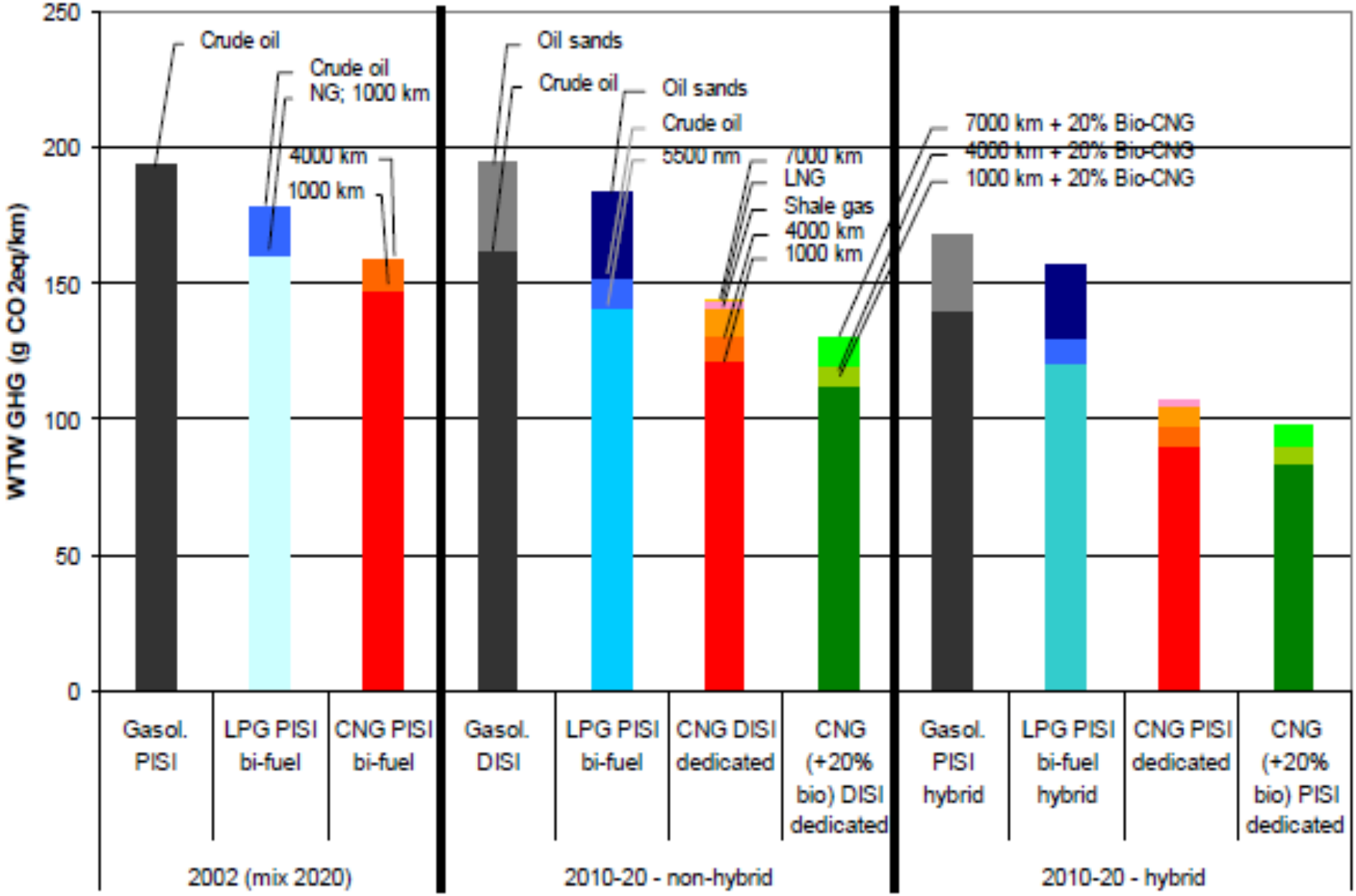


Future: Diesel efficiency in gas engines?

- High octane fuel → higher compression
  - Especially pronounced with hybridized powertrains
- Medium-term: lots of improvements possible
  - Enhanced engine control (new sensors gas quality detection)
  - Increased EGR improves low load performance
  - High energy ignition extends the dilution limit
- Short-term: dual-fuel HDV's
  - Fuel efficient methane-diesel tech and space efficient LNG tech gives diesel engine performance with lower fuel costs
  - The challenge: Euro6 possible?

Volvo FM 13-litre MDE Euro5

Future: Oil sands and hybridization



Conclusions

- Biogas upgrading: Well established and diversified technology, market is taking off
- Biomethane for NGV's is a small but quickly expanding market within the growing NGV market
- Int'l standardization of biomethane, and also CNG, hopefully by 2015. Non-grid specs possible?
- Euro6 NGV's and beyond: Yet untapped potentials for low cost and fuel efficient propulsion
- Hybridization and biomethane important!