

Development of infrastructure for biomethane used as a vehicle fuel in Germany and Europe

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Main arguments against use of methane as a vehicle fuel



- Reduced operating range with full tanks (but now 420 km in new Passat)
- Refuelling infrastructure not yet on par with conventional liquid fuels
- Vehicle price higher than for petrol car (but now on par with diesel car)
- Spare wheel usually sacrificed to make space for gas cylinders
- Until recently usually only offered with base line performance engines
- Age old perceptions that gas is dangerous (NGVs probably safer than other cars)

Main arguments for use of methane as a vehicle fuel



- Much lower fuelling costs
 - In practise 20-25 % tailpipe CO2 reduction
 - Virtually zero PM emissions
 - Extremely low NMHC emissions
 - Much lower NOx emissions
 - Considering the above much reduced contributions to ozone formation
 - Reduction of oil dependence
-
- When replacing natural gas with biomethane a dramatic reduction of fossil based CO2 , for biomethane from liquid manure even negative GHG emissions

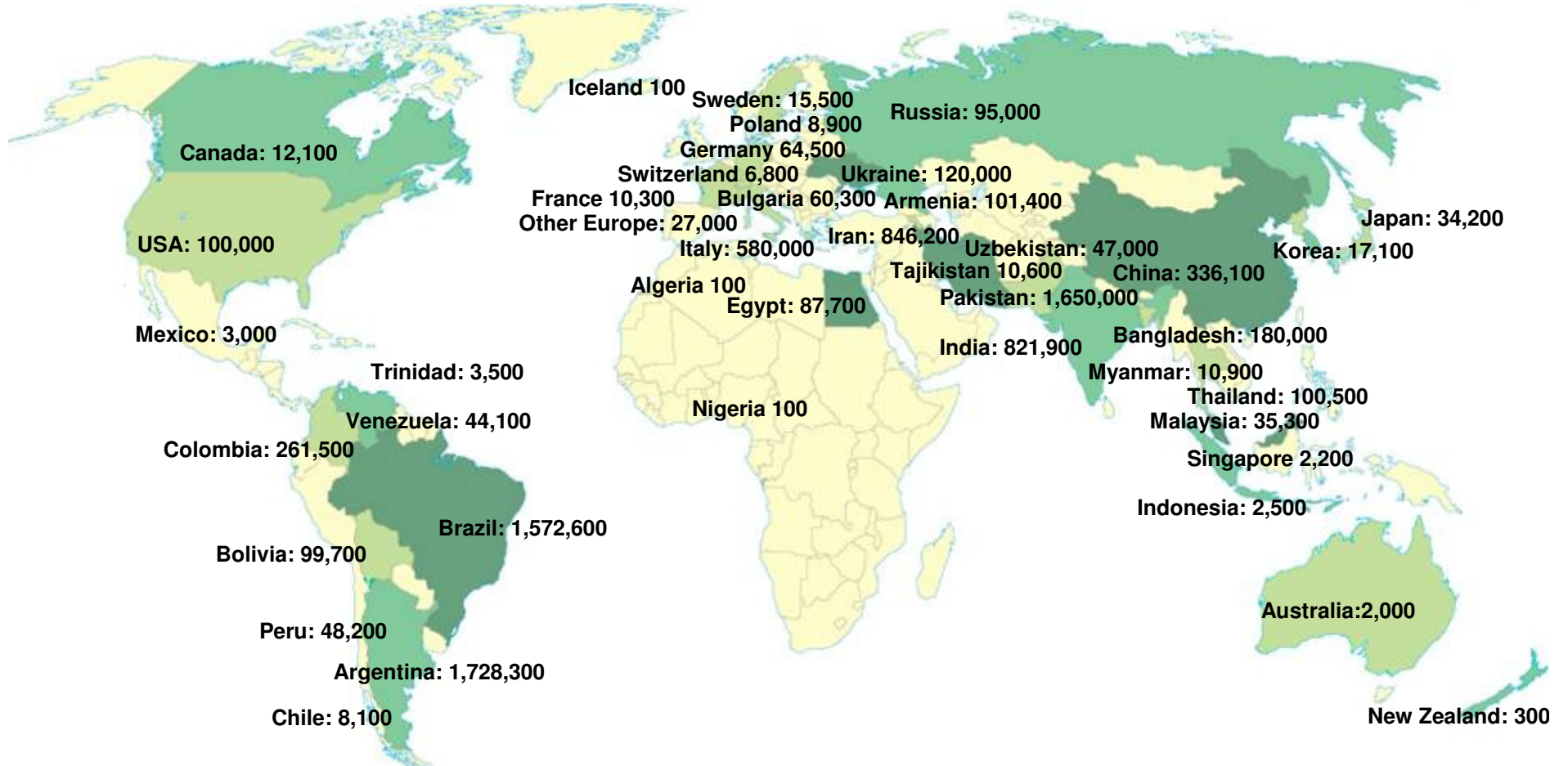
Changing market conditions



The new mandatory EU tailpipe CO₂ emission limits of 130 g/km (final proposal not yet decided) will force the car industry to introduce cost effective means of reducing these emissions. A rapidly increasing share of NGVs, improved downsized supercharged NG engines, new valve steering to reduce throttling losses, modified cylinder heads, electric stop and go functions, and regenerative braking, are some of the options closest at hand.

Hybridisation of NGVs would give even better pay off than in conventionally fuelled vehicles as it will help to provide additional range. The first NG hybrid car (Toyota Camry) launched two weeks ago in Los Angeles.

9.2 Million NGVs worldwide in the autumn of 2008 (4 million at the end of 2004)



7,826,000 cars, 185,000 buses, 144,000 trucks, and 1,011,000 other vehicles now running on natural gas and biomethane, using 25,8 billion Nm³ of methane annually (22.2 Mtoe). A total of 13,000 filling stations worldwide.

Source: The GVR, Nov 2008, adjusted

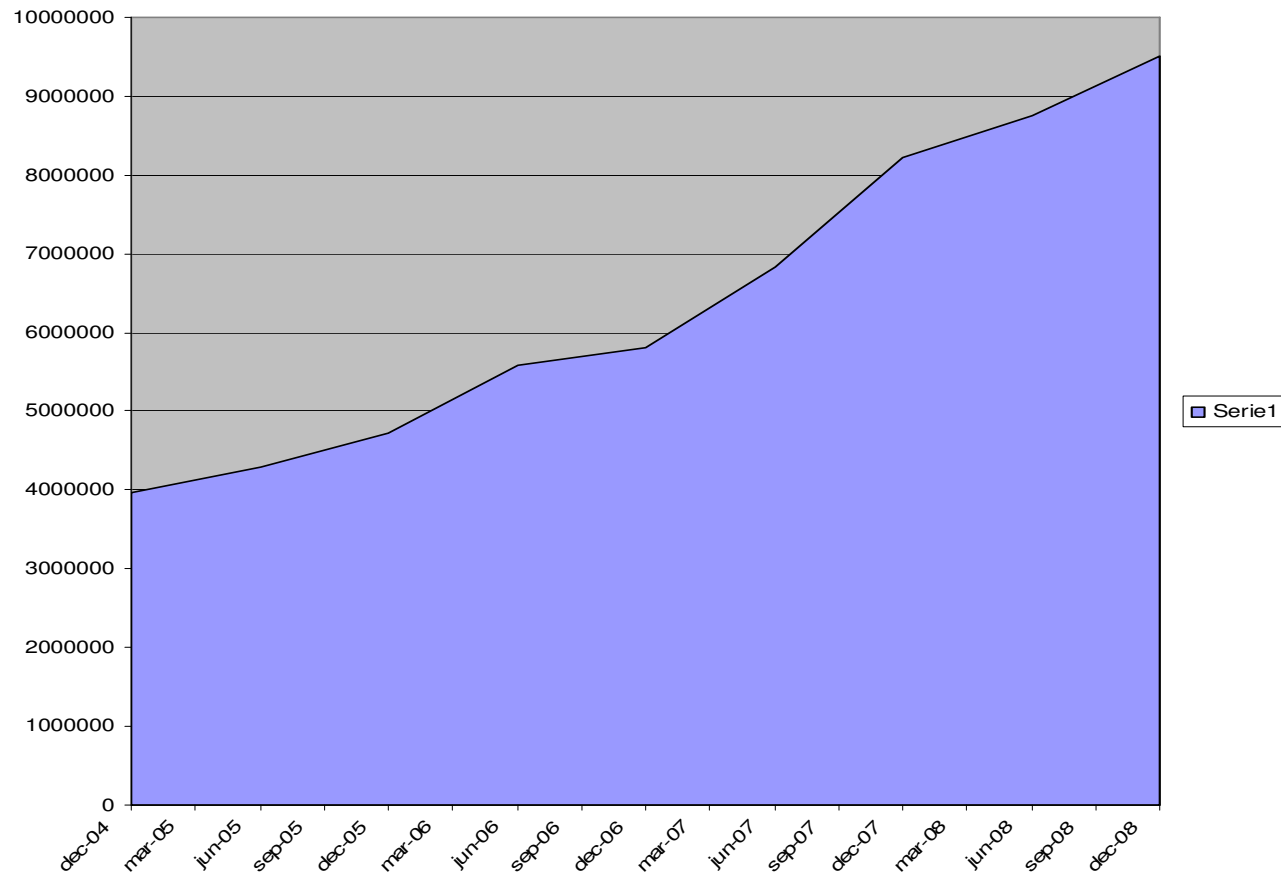
NGVs as % of all cars, trucks, and buses



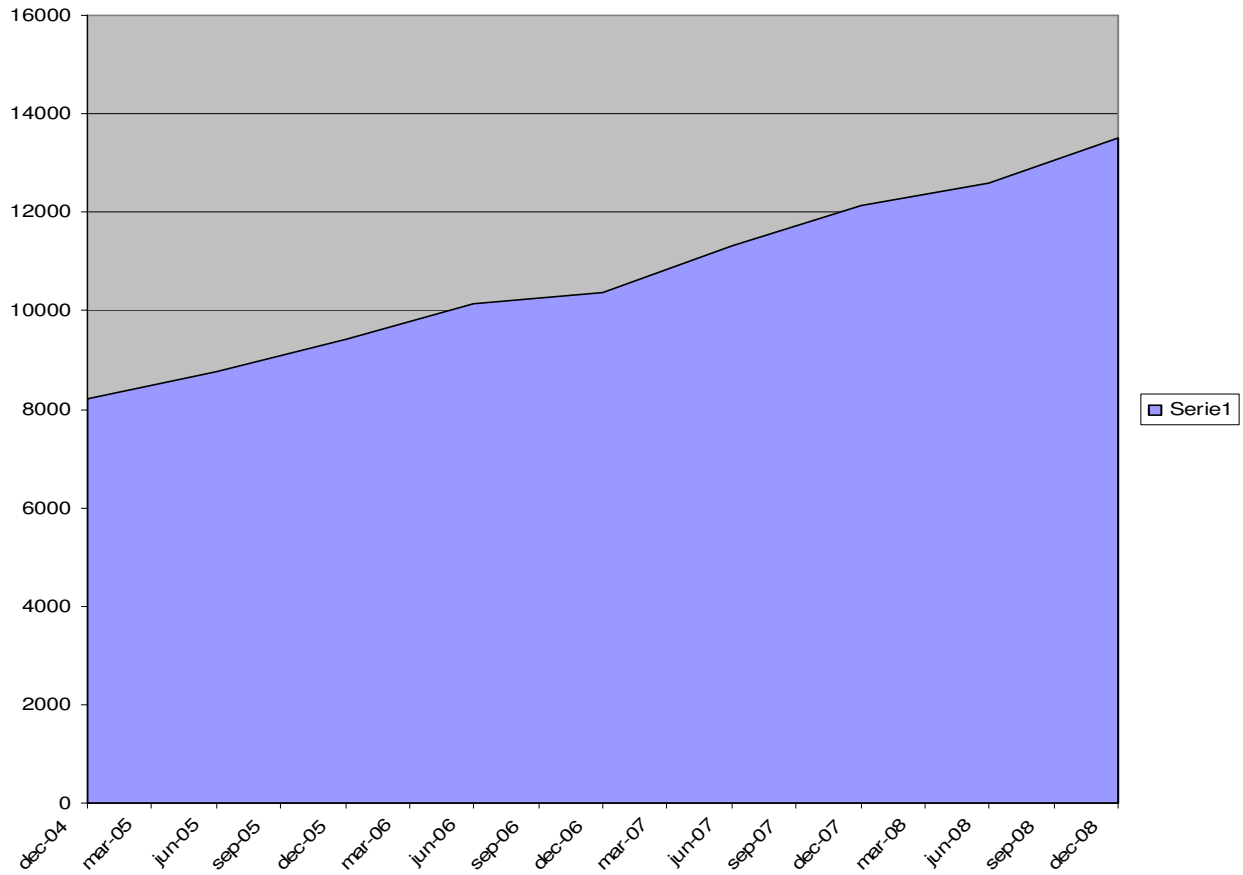
- **Iran 76.7 %** (no NGVs five years ago!)
- **Pakistan 58.7 %**
- **Armenia 30.4 %**
- **Argentina 22.7 %**
- **Bolivia 21.0 %**
- **Bangladesh 19.3 %**
- **Colombia 16.4 %**
- **Malaysia 9.3 %**
- **Tajikistan 6.5 %**
- **Brazil 4.5 %**
- **Peru 4.0 %**
- **Myanmar 3.1 %**
- **Kyrgyzstan 2.9 %**
- **Bulgaria 2.9 %**
- **Egypt 2.8 %**
- **Uzbekistan 2.8 %**
- **India 2.3 %**
- **Moldova 2.1 %**
- **Venezuela 1.56 %**
- **Italy 1.48 %**
- **Ukraine 1.35 %**
- **Trinidad & Tobago 1.22 %**
- **Georgia 0.60 %**
- **Belarus 0.44 %**
- **Thailand 0.40 %**
- **China 0.39 %**
- **Chile 0.35 %**
- **Sweden 0.33 %**
- **Singapore 0.28 %**
- **Lichtenstein 0.20 %**
- **Russia 0.19 %**
- **Switzerland 0.15 %**
- **Korea 0.14 %**
- **Germany 0.13 %**

Please note that the fuel market share is often larger than the vehicle market share
NGVs can no longer be dismissed as niche vehicles only

Worldwide growth of NGV fleets 2005-2008



Worldwide filling station network 2005-2008



European market growth somewhat slower than in Asia and Latin America because:



- Most customers want no compromise factory built vehicles, not after market conversions
- Only 6-7 % of the vehicle fleets can be replaced annually
- CNG refuelling network not yet on par with conventional fuels

In Sweden, Germany, the Czech Republic, Bulgaria, Austria, Switzerland, and Italy CNG refuelling is no longer a major problem (but improvements are required along the motorways). In most other European countries large improvements are required.

On islands, in mountain regions, or in countries without an area covering NG grid, pipeline gas supply may have to be replaced by liquefied gas moved via tankers or tank trucks. The technology is available.

Local production of biomethane from all kinds of organic waste (also approved use of crops) presents an opportunity to create gas supply for local fleets.

Until the oil companies open their forecourts in all European countries for biomethane/natural refuelling, gas filling stations may look as follows

A modern gas car (MB B-class 170 NGT), a modern filling station, a modern fuel - biomethane

picture supplied by Fordonsgas Sverige AB) – photography Nils-Olof Sjödén

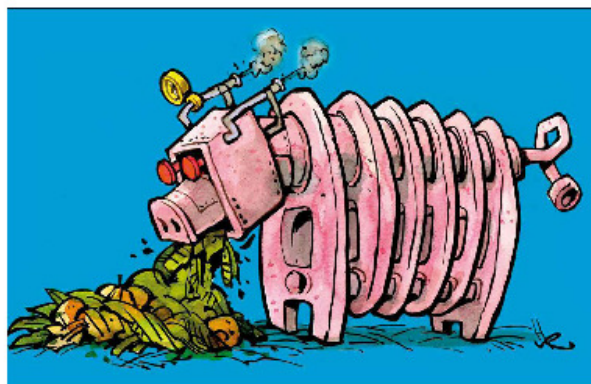


Lidköping



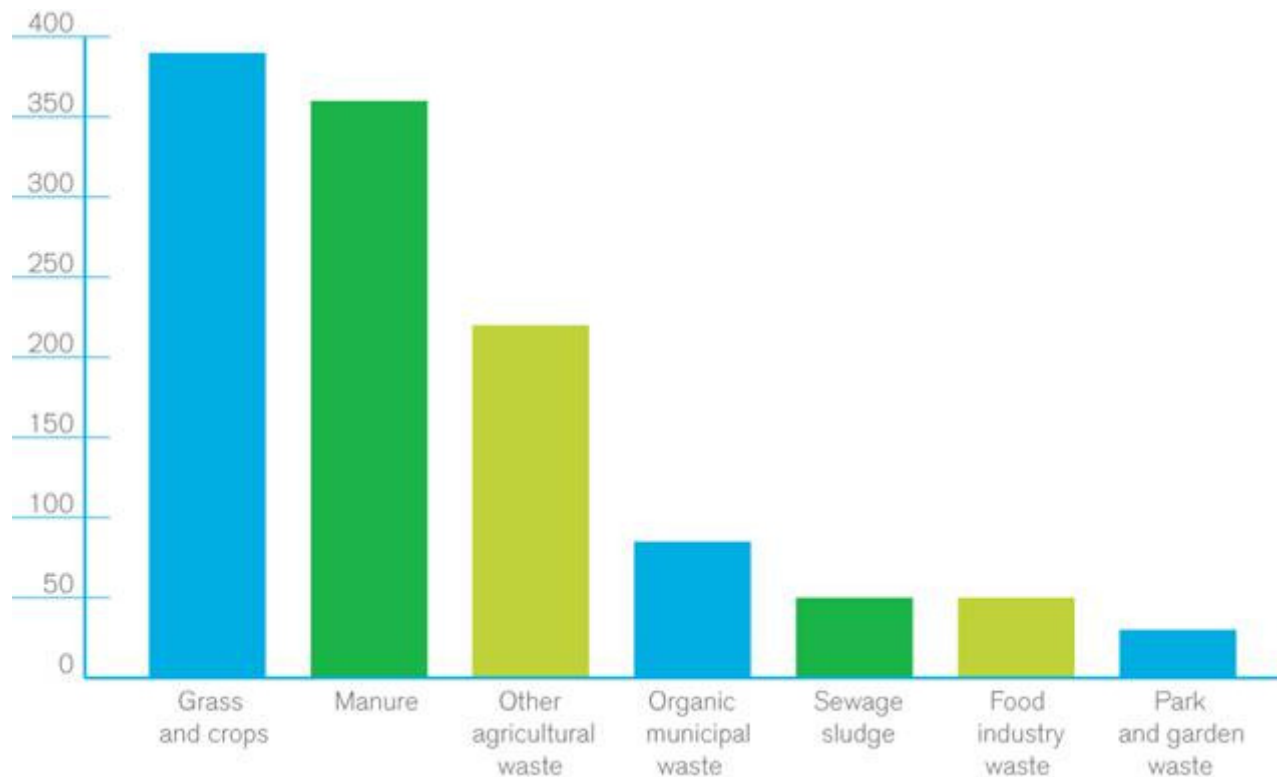
Anaerobic digestion - the mechanical cow –eats what it can chew and digest

Thank you for the attention
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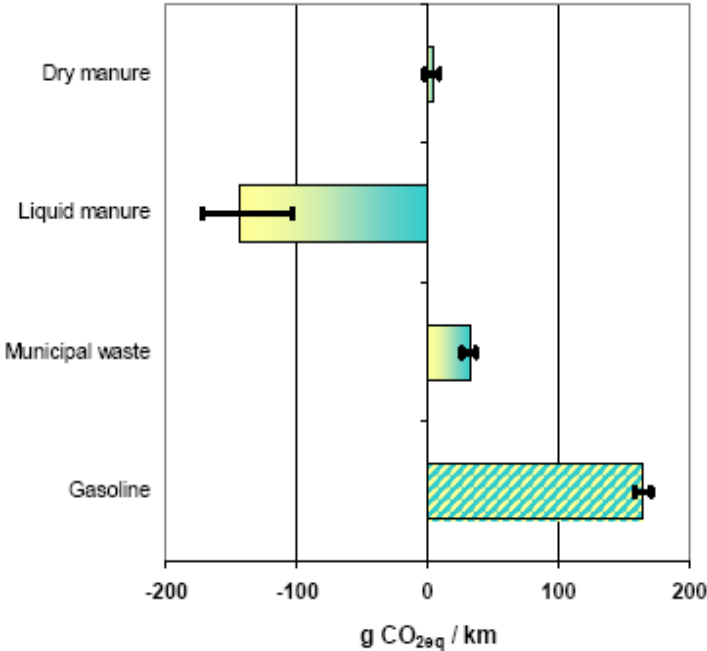
Picture borrowed from a Dutch Senter Novem presentation. The cow sets a very high standard concerning the speed for conversion of biomass into methane, Man has not yet been able to match this efficiency, but we are getting closer.

EU-15 **THEORETICAL** BIOGAS POTENTIAL 1200 TWH
(THE TOTAL USE OF ROAD FUELS IS ABOUT 3200 TWH OR 275 MTOE)



The German Wuppertal institute in January 2006 released an estimate that up to 20 % of all road fuels could be replaced by biomethane

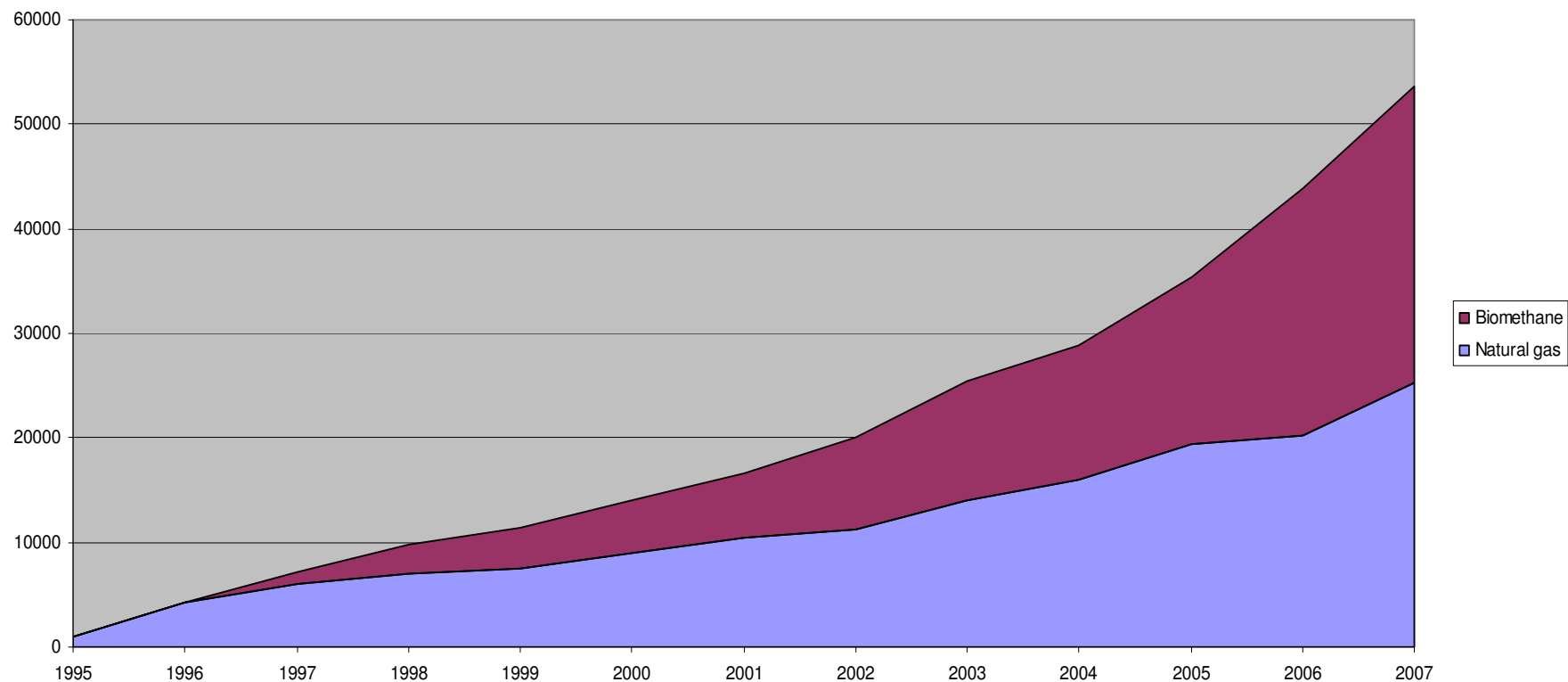
Biomethane GHG performance



Data from Concawe/Eucar/JRC study

BIOMETHANE MARKET GROWTH IN SWEDEN (kNm³)

(development supported via 30 % government funding of investments, new development – central upgrading of manure based farmscale raw biogas production)



Methane now accounts for 0,50 % of the Swedish road fuels. With an annual growth of 35 % the market share will reach 2 % by 2010. Biomethane already accounts for about 55 % of all Swedish use of methane in road transports. In Switzerland biomethane accounts for 18 %, Germany and Austria both have the target to reach a 10 % share by 2010, and 20 % in 2020.

Biomethane potentials



Waste based fuels

- Some 15 % of the European fuel needs in the transportation sector could in the long term be covered by biomethane derived from *anerobic digestion* of all kinds of biodegradable waste
- In countries with an established forest industry the lignocellulosic residuals and waste products can be processed via *gasification* to produce biomethane. The potential, of course, varies from one country to another. In Sweden a recent estimate states a potential corresponding with not less than 75-100 % of the present total Swedish demand of fuels for road transports.

Crop based fuels

- To the extent that crops will be used for production of agrofuels, biomethane offers much higher fuel yields per hectare of land than other alternatives.

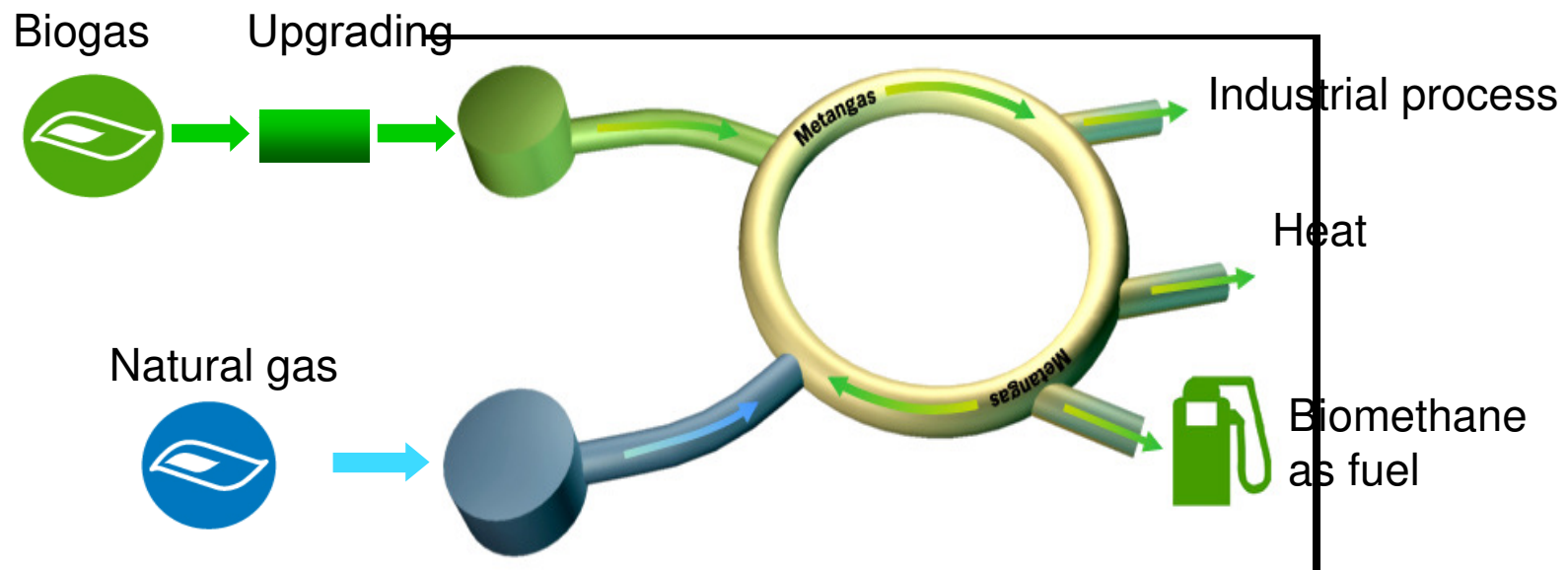
Synthetic fuel potentials



- Using forest industry waste to make biomethane net energy conversion yields of 56-65 % have been demonstrated, and 70 % targeted
- For various competing wood based options like FT diesel net yields of 50-55 % are targeted, for ethanol only 35-40 %. Why settle for 40 or 55 %, if you could get 70%?
- Göteborg Energi, supported by E.ON (20 % stake), will in 2011 open the first large scale facility for production of biomethane via gasification of lignocellulosic waste. The final production capacity will for this plant be about 80 million Nm³ of biomethane (or enough to fuel some 80,000 cars).

The Green Gas principle

- A huge market is opened for biogas.
- The reliability of the biogas supply improves



This principle e.g. allows injection of biomethane into the low pressure NG grid, and the withdrawal of a similar energy volume from the high pressure NG grid, also in the form of LMG.

PROPOSED SWEDISH L-CMG INFRASTRUCTURE (2- 300 km between stations)

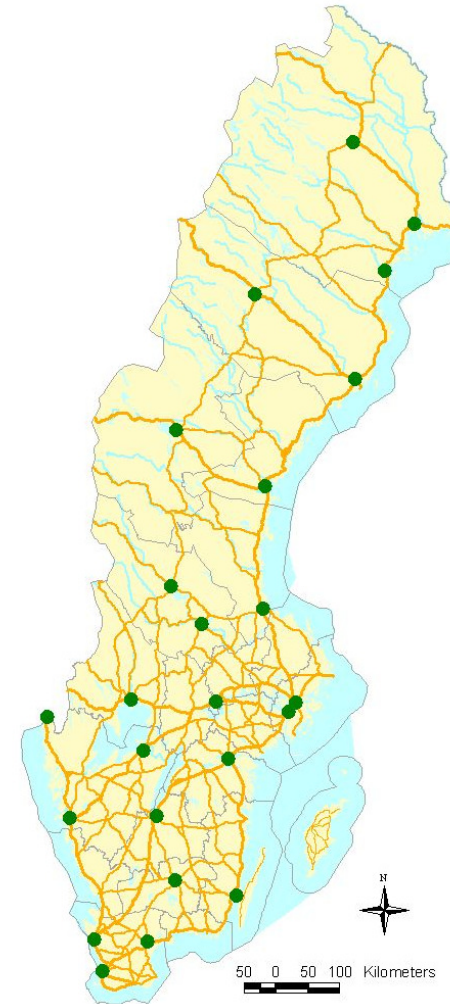


Infrastructure for 200,000 ton annual diesel substitution (3 % of Sweden's transportation fuel requirements)

LMG production*	€ 12 million
20 LMG trailers	€ 6 million
24 L-CMG stations	€ 10 million
Total investment	€ 28 million

Specific investment costs € 0,01/Nm³

*Both liquefied biomethane and liquefied NG



From a study made by Vattenfall Power Consultants

Countries with ongoing commercial projects for supply of biomethane as a vehicle fuel



- Korea
- China
- India
- Pakistan
- Spain
- France
- Switzerland
- Austria
- Germany
- The UK
- The Netherlands
- Sweden
- Norway
- Iceland
- Brazil
- The USA

The European Parliament (EP) on March 12, 2008, voted in favour of a proposal for the adoption of a directive on biogas. The European Commission was asked to prepare a proposal supporting injection of biomethane into the NG grid, and suggested that 'green gas' should enjoy similar benefits as those applicable for 'green electricity'. The EP also stressed the need for R & D funding, and highlighted that biomethane could be used not only for heat and power generation, but also as a fuel for use in the transport sector.

HD potential in all of Europe



- About one million HD buses and five million HD trucks annually use up to 250 million tonnes of diesel oil, corresponding with close to 800 million tonnes of CO₂ emissions.
- Dual fuel vehicles using natural gas could save some 160 million tonnes of CO₂ emissions, or more than 600 million tonnes if instead using biomethane.

Really important issues



To really secure future high volume sales of NGVs it is essential that the EU should introduce legislation demanding that the member states secure an adequate NG/biomethane refuelling infrastructure. This could e.g. mean that multi-fuel stations above a certain size, or with a certain market share, should be required to provide refuelling.

The future



Even if it would be possible to maintain crude oils supplies, meeting the world demand at a reasonable price, we cannot continue to increase the CO2 emissions.

No other biofuel can compete with biomethane in terms of fuel per tonne of waste, per hectare of cultivated land, or per tonne of algae produced.

Sunshine, wind, and water can be used to generate electric power, but not fuels. Let us prioritize the use of available biomass resources for use as fuels, and let us choose the biofuel alternatives that will maximize oil substitution.

Thanks for your attention!



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