

# Expanding use of Biomethane in Europe and beyond: The policies driving this trend

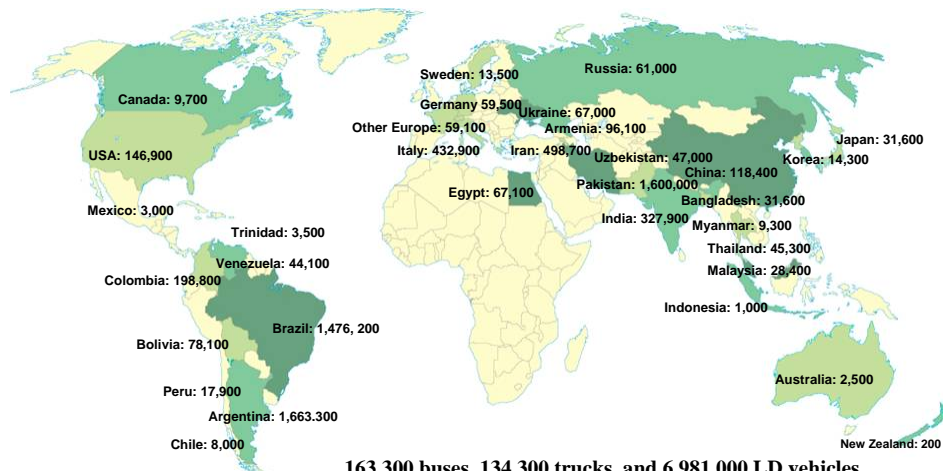
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## 7.3 MILLION NGVs WORLDWIDE



163,300 buses, 134,300 trucks, and 6,981,000 LD vehicles now running on natural gas and biomethane, using 22,2 billion Nm<sup>3</sup> of methane annually (19,1 Mtoe). Another 320,000 motor bikes and offroad NGVs also in use.

Source: The GVR, Nov 2007 adjusted

## **NGV Market share**

- **Worldwide still only 0.85 %, but**
- **Pakistan 58.7 %**
- **Iran 45.2 %**
- **Armenia 29.4 %**
- **Argentina 21.9 %**
- **Bolivia 16.4 %**
- **Colombia 16.1 %**
- **Bangladesh 10.8 %**
- **Malaysia 7.8 %**
- **Tajikistan 6.5 %**
- **Brazil 4.2 %**

## **Consequences of new strategies in the oil producing countries**

- **Iran, very cleverly, has embarked on a strategy where all domestic vehicles within a few years will be running on natural gas. Other major crude oil producers may very well follow.**
- **Reducing the crude oil output the producers can actually via increased prices improve and extend their total annual income while securing a longer period of production.**
- **Conservative forces protecting the status quo of conventional fuels are fighting a losing battle**
- **Governments should support the market development for NGVs via an adequate LNG and CNG refuelling infrastructure, and via dedicated efforts to quickly expand the share of renewable methane gas (biomethane). The German government at the turn of the century set a good example by coercing the oil companies to participate in the build up of an adequate CNG refuelling infrastructure.**
- **Putting all the eggs in one basket is seldom a smart move. H2/FC vehicles may come to play an important role in some vehicles segments several decades ahead, but methane offers immediate relief.**

## 'BIG OIL' ATTITUDES

Oil companies in general respond to the demand for biofuel production by proposing the use of liquid biofuels admixed to gasoline or diesel. Going this route they need not invest in a methane refuelling infrastructure, and they also keep their market control.

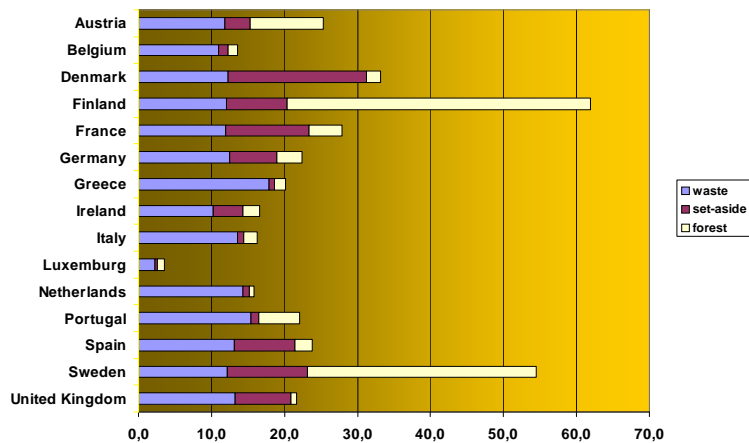
Biomethane production, however, offers far higher biomass conversion efficiencies than the liquid biofuels, and thus an increased contribution to the demand for sustainable fuel production.

NGV market development must on very good grounds be supported by national governments – starting with natural gas, but gradually also introducing biomethane.

The oil industry has a formidable lobby, but must nevertheless in many countries be convinced by government to give up its resistance to the use of methane.

## Biomethane potentials - % of all vehicle fuel

(conventional organic waste, use of currently set-aside land, assumed 8 % of annual forest growth)



Forecast presented in May 2003 – still relevant

## 2005

The Austrian environmental ministry released a report stating that biomethane in the longer term could cover 27 % of the Austrian automotive fuel needs.

The study states that biomethane produced from crops will yield 2-4 times more energy than alternatives like bioethanol or biodiesel.

A pilot plant in Güssing demonstrates that biomethane produced after gasification of forest industry residues will provide far higher yields of fuel than if instead opting for production of liquid biofuels.

## 2006

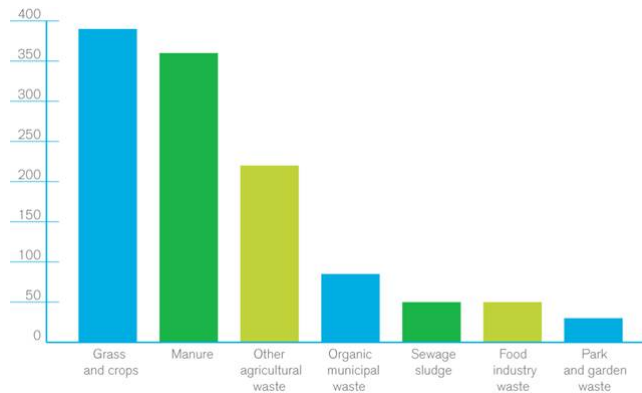
The German Wuppertal institute states that 20 % of all German demands for vehicle fuels could be covered by biomethane.

The German gas industry commits itself to the target that 20 % of all methane supplied for use in vehicles by 2020 should be made up of biomethane.

The Austrian government and the OMV company agree on a similar target.

In Sweden biomethane now accounts for 53 % of all methane gas used for vehicle propulsion, in Switzerland some 35 %.

**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.**

**GHG SAVINGS VIA THE USE OF BIOMETHANE  
Grammes of CO2 tailpipe emissions per 10 kWh LHV  
(lower heating value) energy content**

- Methane 1980
- Propane 2368
- DME 2460
- Methanol 2538
- Diesel 2675
- Gasoline 2723
- Ethanol 2755

**The use of gaseous, instead of liquid, fuels offers large CO2 savings  
Methane outperforms all other hydrocarbon fuels concerning CO2  
Methane gives 27 % lower tailpipe CO2 emissions than liquid fuels**

**On a well-to-wheels basis biomethane on average will have close to zero  
GWP impact. Manure based biomethane, due to avoided methane and  
laughing gas leakage, will instead of adding say 300g/mile to the total GHG  
emissions reduce the overall GWP impact by an even higher number!**

## EU support of biomethane

**The European Parliament via the Morgan report in December 2006 highlighted that gaseous biofuels (like biomethane) must not be seen only as a fuel for heat and power generation, but also as a biofuel option in the road transportation sector.**

**The European Commission via DG Agriculture in November 2007 proposed doubled CO<sub>2</sub> credits for waste based biofuels to stimulate a shift of focus from crops to waste. There is now also a clear realization that the true GHG savings achieved via biofuels differ very considerably. In the worst case (deforestation) *increased* net GHG emissions.**

## Biomethane economics

- Biomethane is in most markets free of fuel tax. This means that a fuel distributor is prepared to pay for biomethane the natural gas price plus the NG fuel tax.
- Future mandates concerning increasing shares of biofuels as a percentage of the total fuel mix could lead to an added value for certificates showing that the distributor has purchased a renewable fuel.
- Do not make the mistake of believing that the income from sales of biomethane and fertilizer will fully cover all waste handling costs.

**Biomethane production will, however, minimize net municipal costs for fulfilling legal demands on the handling of organic waste, and at the same time offer many environmental advantages.**

## SWEDISH VISION AND INNOVATIONS, ALSO APPLICABLE IN OTHER COUNTRIES

- Refuelling sites offering LNG as well as CNG every 2-300 km along the major highways.
- Plants for biomethane production near all major urban centres.
- Increased use of existing natural gas grid. Natural gas, from all points of view, is a better fossil fuel alternative than oil or coal – reduced CO2 emissions, reduced pollution, and reduced oil dependence.
- Dual fuel technology for HD trucks used in long distance haulage will reduce diesel use by 80 % without any loss of energy efficiency, and will thus yield 20 % reduction of tailpipe CO2 emissions (some 80 % reduction if NG is replaced by biomethane).
- Cryogenic upgrading of biogas, and condensation of biomethane and carbon dioxide, provides new exciting opportunities, and potential overall cost reductions.
- Condensation of natural gas at pressure reduction stations could provide reduced gas distribution costs.
- Reduced costs, and an adequate nation wide refuelling station coverage, is necessary to ensure ambitious targets concerning a reduced oil dependence.

## Liquified biomethane



- Cryogenic technology used for purification and upgrading of biogas and landfill gas
- Two products, liquified biomethane and liquified CO2
- Cost and energy efficiency in transportation of liquified methane
- Refueling stations with both compressed and liquid methane, and 2/3 saving on maintenance and operational costs.

## CONNECTING THE BIOGAS ISLANDS

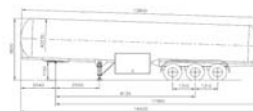
- Sweden, where NG is only available in the southwest, started the use of biomethane as a vehicle fuel in 1996, and now has some 20 cities producing biomethane for NG vehicles (totally some 40 plants with many more plants being built). The very limited NG grid has sparked innovations.
- Four regional distribution companies cooperate regarding new refuelling stations in 'white spots'
- To cover wide areas of Sweden yet without either biomethane or natural gas supplies, L-CNG filling stations are now proposed. These stations would supply LNG for dual fuel trucks in long distance traffic, but also be able to refuel conventional CNG vehicles.
- The L-CNG stations will be supplied by 21 tonne LNG trailers using imports, local liquefaction of high pressure pipeline gas at pressure reduction stations, or cryogenic purification and condensation of biogas.
- Making LNG available for dual fuel HD vehicles also means a fast growth potential for this type of vehicle, and a very significant oil replacement potential.

## Transportation costs – CNG vs LNG

Costs included:

CNG swap body, or LNG trailer investments

Running costs for tractor unit, including fuel, driver, loading and unloading



One way distance	CNG 1.8 ton swapbody [\$/GGE]	LNG 21 ton trailer [\$/GGE]
<b>62.5 miles</b>	<b>0.78</b>	<b>0.11</b>
<b>125 miles</b>	<b>1.46</b>	<b>0.22</b>
<b>250 miles</b>	<b>2.91</b>	<b>0.34</b>

Cost level expected to be significantly lower in USA due to the much lower fuel taxation, but the relations would be the same. Swap body transports are only economically viable over very short distances.

## Technology for cryogenic upgrading of biogas

Cryostar/Prometheus technology available for flows in excess of 500 Nm<sup>3</sup>/hour

Capacity 1000 Nm <sup>3</sup> /hour raw biogas	Only LNG sales [\$/GGE LNG]	Also CO <sub>2</sub> sales [\$/GGE LNG]
<b>Investment costs</b>	<b>0.45</b>	<b>0.45</b>
<b>Operational costs</b>	<b>0.56</b>	<b>0.56</b>
<b>Maintenance costs</b>	<b>0.28</b>	<b>0.28</b>
<b>CO<sub>2</sub> income</b>	<b>-</b>	<b>- 0.67</b>
<b>Total net cost</b>	<b>1.29</b>	<b>0.62</b>

As a comparison European costs of conventional upgrading is around \$ 0.84/GGE for plants with an annual production of 1-1.5 million GGE

## PROPOSED SWEDISH L-CNG INFRASTRUCTURE (150-200 miles between these stations)

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

<b>LNG production*</b>	<b>\$ 20 million</b>
<b>20 LNG trailers</b>	<b>\$ 10 million</b>
<b>24 L-CNG stations</b>	<b>\$ 17 million</b>
<b>Total investment</b>	<b>\$ 47 million</b>

Specific investment costs \$ 0,06/GGE

\*Both liquefied biomethane and liquefied NG



From a study made by Vattenfall Power Consultant

## Rough ideas from Sweden concerning biomethane production costs and investments

- Sewage sludge \$ 1.9/GGE
  - Slaughterhouse waste \$2.5/GGE
  - Crops \$ 2.8/GGE
  - Upgrading costs €0.8/GGE
  - Average total costs \$ 3.3/GGE
- 
- A European plant annually producing 1.2 million GGE of biomethane from crops would probably mean an investment of \$ 6.5 million. Amortized at 6 % over 15 years this means about \$ 0.55 CAPEX per GGE produced, for an MSW plant twice as much (also including waste sorting and pre-treatment facilities), or \$ 1.1 per GGE.
  - The commercial value of biomethane is set by the price of natural gas, adjusted for any differentiation of respective fuel taxes.
  - The European experience is that total waste handling costs, reduced by the income from gas sales, *makes biomethane production a financially more attractive choice than alternative methods for biological waste disposal.*

## SYSTEM EFFICIENCY COMPARISON biomethane production based on forest residues

Biomethane	Bioethanol
<b>70 %</b> biomethane	<b>21 %</b> bioethanol
20 % district heating	35 % district heating
<b>10 %</b> consumed in process	16 % electricity
	<b>28 %</b> consumed in process

District heating, or warm water supply, may have low value in warm climate zones

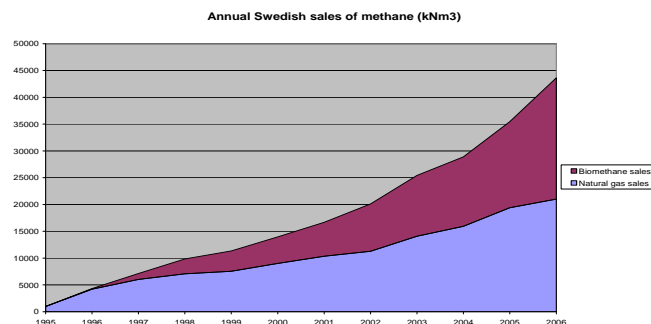
A gasification plant in Gothenburg , Sweden, with an annual biomethane output of 24 million GGE now planned to start up in 2012 (investment around \$ 250 million)

## RECENT CONCERNS ABOUT BIOFUELS

- WWF report April 2007 proposing a differentiation between sustainable and **non sustainable use of biomass**. The report also supports increased mid term use of natural gas to help fight global warming.
- Dutch Cramer report April 2007 suggesting a certification of all specially grown biofuel feedstocks
- Ongoing concerns about rapidly increasing food and fodder prices

Waste based biomethane a winner on all counts!

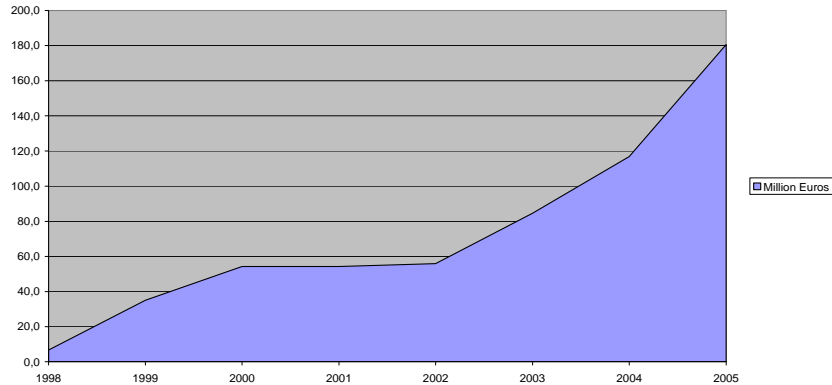
## BIOMETHANE MARKET GROWTH IN SWEDEN (kNm<sup>3</sup>)



**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 more than 50 % of all methane sold.**

## ACCUMULATED SWEDISH INVESTMENTS IN SUPPORT OF NGVs AND BIOMETHANE

Available details concerning Swedish investments in biomethane developments, decided 1998-2005, and supported by national grants (up to 30 %). Details for the years 1992-1997 not readily available. Investments have also been made without grants.



## Inspiring examples

- **Madrid, Spain** - more than 500 gas powered garbage trucks, soon on biomethane
- **Lille, France** – 300 city buses running on gas, the majority already on biomethane
- **Sweden** – 760 city buses in sixteen cities running on gas. In twelve cities (Boden, Borås, Eskilstuna, Eslöv, Helsingborg, Kristianstad, Linköping, Norrköping, Stockholm, Trollhättan, Uppsala, and Västerås) exclusively on biomethane, and in Göteborg, Landskrona, Lund, and Malmö on a mix of natural gas and biomethane. In these cities most of the garbage trucks are also using biomethane.
- The Swiss cities of Bern and Basel have some 100 buses running on biomethane
- The Dutch city of Harlem runs close to 100 buses on a mixture of natural gas and biomethane.
- In Germany the large energy company E.ON has started a special daughter company with the purpose of quickly building up biomethane production capacity. The gas will normally be injected into the NG grid and withdrawn from the grid at the fuelling stations.

### Madrid 2003. Delivery of 330 Iveco CNG trucks



World Environment Day - CNG vehicles for road transport

**IVECO**

Natural Gas Vehicle Development

Data classification: Public  
October 2006

**33**

**NGVs are available now. Large scale use will offer immediate relief (oil and GHG) and will pave the way for future H2/FC vehicles.**

- The large potential for domestic supply of renewable biomethane, and the synergies with already existing supply of natural gas, offer a credible long term solution to the dilemma caused by the imbalance between crude oil supply and demand.
- The paradigm shift from liquid to gaseous fuels will initially mainly support methane powered vehicles, but eventually also H2/FC vehicles (similar components and potential for shared distribution system).
- The WWF supports increased mid term use of natural gas as a vehicle fuel (numerous advantages compared to oil). We should be grateful for the role that natural gas can play in the gradual transition from fossil fuels to truly sustainable fuels.

## THE WAY AHEAD

Oil production has already peaked in many oil producing countries, but the world demand just keeps growing. According to the laws of supply and demand the oil prices are skyrocketing. Natural gas production will also peak, but most likely twenty years later. These twenty years could be used to start a gradual replacement of natural gas with biomethane.

Biomethane produced from waste offers a more favourable greenhouse gas balance than any other fuel - including hydrogen produced with renewable power. Gas produced from manure is not only CO<sub>2</sub> neutral, but actually reducing the overall GHG impact due to avoided natural leakages of methane and laughing gas. The residuals from the gas production can replace artificial fertilizers, thus further reducing CO<sub>2</sub> emissions, and avoiding eutrophication problems.

Methane, whether natural gas or biomethane, is the cleanest of all hydrocarbon fuels, and thus helping to combat air pollution.

Finally, even if we found a lot more oil, we cannot continue to increase the global greenhouse gas emissions. Wind, waves, tides, photovoltaics, geothermal energy etc can be used to provide electric power and heating, but *the biomass resources should, to the extent possible, be conserved for use in the transportation sector*. No other biofuel can compete with biomethane concerning fuel yield per ton of waste, or per hectare of arable land.

## 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

Production of raw biogas which is flared, used to generate electric power and/or heat, already occurs in most countries. Biogas production technologies are thus well known, but upgrading of the gas to a quality on par with, or better than pipeline gas, and the use in vehicles, is new. Production processes can also be much improved.

## **Biomethane from waste**

- **One million people will directly or indirectly generate enough organic waste to annually produce about 30 million GGE of methane gas, and simultaneously large volumes of good fertilizer.**
- **30 million GGE would by 2020 cover the annual fuel needs in 100,000 American cars. The required investment would be around \$ 150 million.**
- **Each AD plant would typically produce between 0.5 and 1.5 million GGE annually - say 30 plants for every 1 million human population. The capital costs would be in the order of \$ 0.50 per GGE delivered gas.**
- **Gas from old landfills can be purified with cryogenic technology to produce pure LNG which can be distributed using tank trucks. Such gas could be supplied at a cost below today's natural gas price.**

**Thanks for your attention!**