Automotive World Conference
Innovation and Growth in the UK Automotive Industry:
The Next Ten Years

The renewable CNG option for carbon neutral transport

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Agenda

- CNG Services Ltd
- Aims for the presentation
- The fuel – renewable CNG/LNG
- World tour report 2006-2007
- Lille bio-methane buses video
- Natural gas vehicle availability
- Making bio-gas
- Making bio-methane CNG
- Bio-gas potential
- Summary
CNG Services Ltd

• Owns the UK’s highest capacity CNG filling station and is developing a number of innovative low carbon transport and electricity generation projects including:
  – Trialling home-fill CNG device with the VW Eco-fuel Caddy (CNG)
  – Clean-up of bio-gas and injection of bio-methane into the gas grid
  – Generation of electricity from gas pressure energy
  – Use of CNG ‘virtual pipeline’ to extend gas networks and displace higher carbon heating fuels
Aims for the presentation

• Show what biomethane CNG is
• Show that there are major developments world-wide in relation to OEM produced NGVs
  – Especially Germany and German OEMs
• Show that biomethane CNG can be a transformational low carbon, low emission fuel
  – Leadership from Lille
• Show the bio-gas resource available in the UK and the way it can easily be converted into a pure, high quality vehicle fuel
  – No impact on food or rain-forests or gorillas
What is bio-methane CNG?

• Bio-gas contains typically 65% methane, 35% CO2
  – Lager shandy
• Natural gas contains around 90% methane, with ethane, propane, butane, CO2 and nitrogen making up the rest
  – Blended whisky
• Bio-methane is bio-gas without the CO2, containing around 98% methane
  – Malt whisky
  – The elixir of life
  – Vehicles love it
    • Clean gas in, clean gas out
• Compress biomethane to 200 bar or liquefy it and you have biomethane CNG or biomethane LNG
  – A lot of whisky
  – Remarkably simple to brew
The fuel – renewable CNG/LNG

- Renewable CNG/LNG
- Biomethane from an anaerobic digester or from landfill
- Offers carbon neutral transport option:
  - Lowest ‘Well to Wheel’ CO2 of any fuel
  - Reduction of around 80% compared to petrol if biomethane from municipal waste
  - If from liquid manure then has a GLOBAL COOLING effect
JB’s CNG World Tour

Los Angeles
Zurich
Abu Dhabi
New Delhi
Singapore
JB’s World Tour

• Singapore (2007)
  – Right hand drive CNG E Class
  – Air quality
    • Very low Nox and particulates
  – Global warming
    • Bio-gas capture and conversion to biomethane
    • Waste is a valuable resource
JB’s World Tour

- India (2006)
  - Delhi switched all buses and taxis to CNG
  - Great improvement in air quality
  - Being repeated across India as gas network grows
  - Biomethane CNG being developed to use CNG infrastructure
JB’s World Tour

- Abu Dhabi (2006)
  - Gas available
  - Diesel/petrol imported
  - Air quality
  - Quality of life
    - 12 CNG stations being built
    - E Class etc

16 CNG Stations to be Installed Around the UAE

Significant progress has been made regarding the implementation of Compressed Natural Gas (CNG) as an alternative fuel in cars in the UAE. This was announced during the most recent meeting of the Technical Committee responsible for implementing CNG as a cleaner alternative. According to the Technical Committee, with this project underway, significant improvements in the UAE’s air quality can be expected, particularly in the urban areas, if more of the community moves towards using cleaner alternatives such as CNG.
JB’s World Tour

• Switzerland (2007)
  – Domestic and industrial ‘green’ waste is a resource
  – Anaerobic digestion followed by composting
  – Bio-gas cleaned to biomethane and injected to grid or used directly for vehicles
JB’s World Tour

• Los Angeles (2007)
  – Air quality – buses
  – LNG vehicles at the Port
  – CNG Honda Civic
    • Cleanest production vehicle in the world
  – CNG taxis
JB’s World Tour

- UK
  - Warburtons/Co-op
  - Tesco
  - VW Caddy Eco-fuel
  - Dual fuel trucks
  - Refuse trucks
The Oil Supply Crunch

TIMESONLINE
From The Times
July 10, 2007

World facing oil ‘supply crunch’ as demand soars, agency warns

Carl Mortished, International Business Editor

The world faces an energy squeeze as soaring demand for fuel exceeds the rate of growth in the supply of crude oil, the West's leading energy forecaster has predicted.

In a gloomy appraisal of the global oil balance, the International Energy Agency yesterday predicted a world of increasing market tightness beyond 2010. The world faces a “supply crunch” by 2012, according to the agency's Medium-Term Oil Market Report, with weak increases in oil output from non-Opec countries colliding with strong demand and diminished spare capacity within the cartel of oil producers.

The oil price bounced higher yesterday in reaction to the IEA's stark warning about the erosion of Opec spare capacity beyond 2010. Brent crude rose almost a dollar to $76.34 a barrel, its highest level for almost a year and $2 shy of its peak.

Oil analysts said that the IEA's strong demand growth projections, if they proved to be correct, would lead to upward spikes in the price of crude.

Underlying the agency's expectation of a supply crunch is its forecast that demand for crude will rise strongly over the five years, driven by global economic growth of 4.5 per cent a year. More cars and white goods in Asia and the Middle East will create oil demand growth three times faster than that of OECD countries.
Bio-methane for NGVs in Germany

Eon Ruhrgas concentrates biomethane activities

Eon Ruhrgas is planning in a higher dimension. The Essen-based transnational energy giant intends to invest up to €120 million in the next few years in building six plants and processing biomethane. Each fermentation power station is to feed at least 1,000 m3 of biomethane per hour into the company’s own pipe grid. Those dimensions equate to a biogas plant with a power capacity of five megawatts.

The company has built such plants through its subsidiary Eon Sverige in Sweden, where they have been feeding biomethane into the grid for years. That experience is now to be put to use in Germany. “We’re flat out looking for locations. We offer biomass suppliers financial participation in the plants,” explains Helmut Roloff, spokesman of Eon Ruhrgas. In early February the energy corporation set up Eon Bioergas GmbH in Essen to run its biogas activities. Led by Friedrich Wolf, its staff is to grow to 25 in the mid-term.

In addition, Eon Ruhrgas plans to invest in the distribution of biomethane as a motor fuel, says Matthias Hansch, head of the corporation’s gas acquisition division. In the next two years €36 million is to be spent to build 150 natural gas fuel stations. Presently some 750 fuel stations sell natural gas in Germany. Hansch’s clear preference is biomethane, which he sees as the most effective and most cost-efficient use of biomass. He says enough biomethane could be available by 2020 to fuel more than four million German natural gas vehicles.

Eon subsidiaries are also active. For example Eon Avacon in Hanover. The regional supplier told us last summer they weren’t even thinking about biogas. While officially the company is still holding its cards close to its chest, others in the industry in the region have a different impression. They report that Eon Avacon is massively pushing into the biogas business and is even trying to buy biogas from plants to upgrade it itself and feed it into the grid. One hears that operators of new installations are getting problems connecting to the electricity grid because Eon Avacon preferred to take their biomethane.
Lille Video (1)

Biogas is made from organic waste, using naturally produced gas. That is then purified for use as a fuel for buses. At present, we have just over 200 buses, 214 to be exact. The aim is to make the entire fleet run on gas, and to only have gas-operated vehicles.
Weed the garden

Don’t eat the celery

Make bio-methane, Fill the buses

Lille Video (2)

Looks too good to be true – carbon neutral bus travel, with very low NOx and particulates

SHOULD HAVE THIS IN LONDON!!

But you’ll be delighted to ride on them

You won’t hear them (50% less noise than diesel)
You won’t smell them (close to zero NOX and particulates)
Lille

• My mother, aged 76, is not a transport specialist, nor an energy specialist, nor a vehicle manufacturer
  – However, she does recycle and she does turn off the standby button
• She watched the Lille video:
  – 226 buses running on bio-methane from domestic waste
  – Refuse lorries on bio-methane CNG being introduced
  – Very high recycling rates, consumer has direct link between cabbage leaf and road fuel
• She says “it’s obvious that every town in Britain should do that” and “we should stop messing around and do it?”
  – No vehicle issues, all OEM product, proven, reliable
  – No technical challenges
  – All it needs is a holistic approach between waste disposal and transport and we can have truly carbon neutral buses and refuse trucks
Catching on??

Ruddock backs anaerobic digestion for food waste
17-10-2007

Minister Joan Ruddock has spoken of the forthcoming protocol for anaerobic digestion to be published next year, as she explained what is being done to bring more certainty for investors regarding the technology.

Mrs Ruddock was giving the keynote speech yesterday at the Environmental Services Association conference on anaerobic digestion in Westminster.

She revealed that "central government doesn't usually have a preference" when it came to waste treatment technologies, but said her Department considered anaerobic digestion as the "best process" for dealing with food waste.

However, the minister responsible for waste and recycling noted that as far as she knew, there were only three AD plants in the whole of the UK dealing with food waste on a commercial basis.
Vehicles that can run on bio-methane – these are the key to market transformation
VW Caddy Eco-fuel

- Best selling CNG vehicle in Germany, launched mid 2006
  - Built to run on CNG rather than a petrol conversion
  - Right hand drive is type approved for sale in UK
- UK trial underway:
  - With “Phill’ home-fill device
  - Range 350km on biomethane + 150 km on petrol
MB E-Class

- Very clean, low CO2
  - 168 g/km (petrol = 215 g/km)
- Run on bio-methane and have a carbon neutral vehicle

MB B-Class

- CNG version available in June 2008
- Perfect shape for CNG – tanks can go under floor, no loss of boot space
VW Passat and Touran

- 2008
  - OEM products, not conversions
  - Meet highest EU emissions standards
  - Great to drive
  - >400 km range

New Audi cars with TFSI technology

Alternative fuels are gaining in importance all around the world. In many countries for example, natural gas is being used more and more as a low-cost, low-CO2 energy source. Here, Audi has developed a concept for the use of CNG (compressed natural gas). It is based on the TFSI engine and retains the strengths of this engine, for example the great pulling power and spontaneous response, even in natural gas operation.

In other words, CNG operation allows you to enjoy a CO2 balance that is up to 20 percent better, without having to make compromises in driving pleasure. Moreover, the innovative package, despite the natural gas tank, allows full versatility and use of the luggage compartment.
MB Sprinter

- Mercedes Benz
  - Sprinter CNG in 2008
  - First time MB have designed a CNG Sprinter from first principles:
    - Very low emissions
    - 25% less CO2 than petrol on grid gas
    - Carbon neutral on bio-methane
  - Will also have small petrol tank
    - Total range of 1100 km
    - MB expect to sell in large numbers
      - UK Utilities want this van!!
Iveco Daily

Iveco presents new Daily CNG

At the European Road Transport Show 2007, Iveco will be exhibiting the new Daily CNG which was recently introduced in Italy. This van makes Iveco one of the few commercial vehicle manufacturers to sell a heavy van with a natural gas driven engine straight from the factory.

All Iveco Daily CNG versions are equipped with the 3.0 litre F1C CNG engine. This four-cylinder, 16 valve, turbo-charged engine provides 136 hp (100 kW) and 350 Nm of torque. The standard version comes with a manual, six-speed gearbox. As of early 2008, an automatic Agile gearbox will also be available.

Five tanks
The Daily CNG comes equipped with five tanks with a total capacity of 220 litres. An optional sixth tank can be installed to provide a total capacity of 250 litres. Iveco has not yet issued fuel consumption figures or a range.

Ecologically responsible vehicle
The Daily CNG's emission values are well under the limit prescribed by the Euro 4 and Euro 5 standards. The CNG engine equipped Daily is therefore regarded as an ecologically sound vehicle which qualifies for the EEV (Enhanced Environmental Vehicle) classification according to European environmental legislation. All the natural gas versions bear the CNG logo and the hummingbird symbol.

Being launched this month in Amsterdam, in UK from Jan 08
Very low emissions of NOX/particulates
Carbon neutral on bio-methane

cng services ltd
MB Econic - rigid

• **Tesco**
  - Tesco trialling RHD Econic CNG in London Tesco
  - Fuel saving of 10 p/km
  - No congestion charge
  - 50% of noise of diesel and can run 24 hours so need 30-40% less vehicles compared to diesel

• **A major Swiss supermarket is moving to carbon neutral transport by using bio-methane CNG**
  - Leadership

With chassis and body for Tesco deliveries into London.

[cng services ltd]
MB Econic - tractor

• Distribution logistics
  – This vehicle is a CNG Econic tractor, operating in Germany
  – Gross combination weight rating was 40 tonne
  – EEV emissions, 20% lower CO2 than diesel
  – On bio-methane, carbon neutral

• MB prepared to bring to UK in right hand drive form
  – Discussions underway with customers wanting to reduce their environmental impact
MB Econic - refuse trucks

• Refuse Trucks
  – MB Econic (see below in Malmo, running on bio-methane)
  – Renault
  – Dennis Eagle

• UK Waste Companies
  – French and Spanish owned
  – Bio-methane focus
  – Best Practice for Waste is separation of green material at source

cng services ltd
Clean Air Power dual fuel

- Clean Air Power – 400 bhp Mercedes Axor (Euro 3), duel fuel
  - Reduction of around 20 tonnes of carbon per vehicle per year on grid gas
  - Biomethane (CNG or LNG) offers a very low CO2 outcome
Hardstaff Group duel fuel

- Daf and Volvo (FH12) tractors
  and with launch of duel fuel 18 tonne DAF in Q4 2007
Buses

- **Rome**
  - 470 Iveco buses

- **Barcelona**
  - CNG bus olympics

- **Sidney**
  - CNG bus olympics

- **Paris**
  - 50% of new buses now CNG

- **Beijing**
  - Buses for olympics

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**Beijing Public Transport Co. Orders 250 CNG Bus Engines from Cummins Westport**

29 May 2007

Beijing Public Transport Holdings, Ltd. (BPT) has ordered 250 Cummins Westport B Gas Plus engines to power Beijing Jinhua Coach Co. buses.

These buses will be in addition to the current fleet of CNG-powered buses to showcase next year’s 2008 Beijing Summer Olympic Games. More than 3,000 Cummins Westport natural gas engines are in operation in China today.

The Cummins Westport B Gas Plus is a 5.9-liter six-cylinder natural gas engine that builds on the design of Cummins diesel and natural gas engines. The B Gas Plus delivers power from 195 to 230 hp with low emissions and proven reliability. It features enhanced controls, plus full-authority electronics that include a programmable Electronic Control Module (ECM) that sets engine operating parameters and provides for road speed governing, engine protection and complete self-diagnostics.

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**Compressed Natural Gas Buses in Barcelona**

New CNG buses has been integrated in the urban transport fleet. Besides the reduction in pollutant emissions, reductions in smell, vibrations and noise have been measured by different surveys of passengers and drivers. Barcelona Metropolitan Transport has become the pioneer CNG bus operator in Spain and has obtained ISO 14,001 certification.
Making Bio-gas and bio-methane
Making bio-gas

Big, ugly looking red bacteria turns the green matter into methane
That’s it
Same guys that did this with dinosaur poo all those years ago....
Takes 15 days not 100 million years, that’s a slow annual increase
in bacteria productivity (and compound interest!)
Bio-gas to bio-methane to bio-methane CNG

Or can go direct to CNG compressor and Vehicles from here

Biogas Processing Scheme

cng services ltd
Bio-gas resource

• A small stream of 100 m³/hr of biogas would give 65 m³/hr of biomethane
• This will produce 415,000 kg of biomethane CNG (570,000 m³/annum)
• This will fuel 300 CNG Caddy’s, each doing 20,000 km

NSCA Report on potential UK resource, 2006:

<table>
<thead>
<tr>
<th>Material</th>
<th>Dry tonnes per year</th>
<th>Gas factor</th>
<th>Total CH₄, m³</th>
<th>Energy value, TJ</th>
<th>Tonnes of oil Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage sludge</td>
<td>1,250,000</td>
<td>195</td>
<td>245,790,000</td>
<td>8,747</td>
<td>290,260</td>
</tr>
<tr>
<td>Wet animal slurries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy cattle</td>
<td>604,800</td>
<td>130</td>
<td>78,624,000</td>
<td>2,799</td>
<td>66,643</td>
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<tr>
<td>Pig manure</td>
<td>160,500</td>
<td>195</td>
<td>31,297,500</td>
<td>1,114</td>
<td>26,528</td>
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<tr>
<td>All poultry</td>
<td>454,500</td>
<td>236</td>
<td>107,375,825</td>
<td>3,023</td>
<td>91,014</td>
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<tr>
<td>Farm yard manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle</td>
<td>625,314</td>
<td>160</td>
<td>100,050,240</td>
<td>3,562</td>
<td>94,804</td>
</tr>
<tr>
<td>Pig</td>
<td>453,241</td>
<td>180</td>
<td>81,583,452</td>
<td>2,904</td>
<td>69,152</td>
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<tr>
<td>Horses</td>
<td>45,817</td>
<td>75</td>
<td>3,436,290</td>
<td>122</td>
<td>2,913</td>
</tr>
<tr>
<td>Commercial food waste</td>
<td>4,091,750</td>
<td>330</td>
<td>1,350,277,500</td>
<td>48,070</td>
<td>1,144,521</td>
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<tr>
<td>Domestic food waste</td>
<td>4,881,919</td>
<td>330</td>
<td>1,611,033,138</td>
<td>57,353</td>
<td>1,365,542</td>
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<tr>
<td>Total</td>
<td>12,577,841</td>
<td></td>
<td>3,690,377,745</td>
<td>128,494</td>
<td>3,059,377</td>
</tr>
</tbody>
</table>

• This is enough gas to fuel 1.9 million CNG Caddy’s
• That’s a lot of gas
Current use of bio-gas

• UK produces largest amount of biogas in Europe

• Highly inefficient use – burnt to make electricity:
  – Landfill gas, only 30 – 35% efficiency, no use for waste heat
  – Sewage gas, limited use for waste heat, 45 – 50% efficient

• This is the energy and environmental equivalent of taking a 10 Year Old Malt whiskey and selling it as blended
  – Thanks goodness its days are numbered
  – Biomethane will earn RTFO certs when used in vehicles

Table 1: Biogas production in some European countries 2005 [1], [18]

<table>
<thead>
<tr>
<th>Country</th>
<th>TWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>18.6</td>
</tr>
<tr>
<td>Germany</td>
<td>18.6</td>
</tr>
<tr>
<td>Italy</td>
<td>4.4</td>
</tr>
<tr>
<td>Spain</td>
<td>3.7</td>
</tr>
<tr>
<td>France</td>
<td>2.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.3</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.68</td>
</tr>
</tbody>
</table>
Best use of biomethane: Vehicle fuel? Heat? Electricity?


This study, ordered by Agence de l’Environnement et de la Maîtrise de l’Energie (French environmental and energy control agency) and Gaz de France, was carried out by RDC-Environnement according standards ISO 14040 and 14044.

This study deals with two questions: what is the best biogas recovery process from methanisation: vehicle fuel? heat? electricity? what is the best organic wastes treatment from selective collection? methanisation? industrial composting? This LCA (Life Cycle Analysis) took four classes of impact (indicators): non renewable primary energy use, greenhouse effect within 100 years, atmosphere acidification, waterways eutrophication. Among all its conclusions, biogas valorization as fuel for buses and household wastes collection vehicles is the best process.

Presentation - Analyse du Cycle de Vie des modes de valorisation de biogaz - sept 2007
Synthèse - Analyse du Cycle de Vie des modes de valorisation de biogaz - sept 2007
Summary

Market forces converging to set the stage for significant growth in biomethane CNG/LNG in UK

- Vehicles becoming available
  - UK benefiting from vehicles developed for German market
  - Dual fuel ‘natural gas/diesel’ has 25% lower CO2 than 100% diesel
    - UK a world leader in this technology
- CO2 and greenhouse gas reductions becoming major driver
  - Very efficient means of delivering 2nd Generation bio-fuel benefit early, with no ‘food crop’/gorilla/rainforest issues
  - Minimal transportation costs associated with ‘local’ biomethane
  - Biomethane will earn RTFO certificates from 1 April 2008
- Bio-methane is an unbeatable environmental fuel
  - Ask my mother. Show your mother the Lille video and ask her!
- UK has a huge potential resource
  - We can have hundreds of Lille’s
  - Can stop wasteful use of biogas