The renewable CNG option for carbon neutral transport

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John Baldwin
Managing Director, CNG Services Ltd
C Eng M I Mech E, M I Gas E, MA (Oxon)
Agenda

• CNG Services Ltd
• Aims for the presentation
• Supplies and uses for natural gas
• Price of carbon
• Renewable CNG/LNG
• Natural gas vehicle availability
• Making biomethane CNG
• Biomethane current use and potential vehicle fuel resource
• 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)
  - Cleaning bio-gas and injecting biomethane into the gas grid
  - Lobbying for Green Gas to be given equivalence with Green Electricity
  - Generation of electricity from gas pressure energy
  - Consultant in relation to LNG imports to UK

1 LNG tanker holds around 65,000 tonnes of gas.....enough to fuel 65,000 CNG Caddy’s each doing 20,000 km per annum!
Aims for the presentation

• The carbon price – key to economics for everyone
• UK energy – strategic view
• Latest UK gas supply-demand position
• Show what biomethane CNG is
• Show what the Germans are doing
• Show that biomethane CNG can be a transformational low carbon, low emission fuel
• Show the biomethane 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
  – Very low energy consumption in making the vehicle fuel
EU and UK NEED a high carbon price to support renewables and nuclear. Air transport being included, it is inevitable that it will cover road transport as well.....this is the key factor that underpins all alternative fuels for transport, for heating, for electricity....
At present, gas supplies 40% of electricity and almost 100% of heating for homes and business.

UK Govt strategy is for new **nuclear** stations, huge increase in **offshore wind**, new **clean coal**. Gas will provide the flexibility for when it's not windy....
Renewable natural gas is a premium fuel that is attractive to transport, heat and electricity...at present UK produces largest volume in Europe, but all used to make electricity at average efficiency of 30%....a bit like having Ronaldo but only playing him for half the game...the price of carbon sorts that out as the 70% waste is economically unacceptable.
UK gas supplies – dramatic growth from next winter

UK Gas Industry Import Developments

St Fergus
Tampen (2007) 24mcm
Vesterled 36mcm (commissioned)

Langeled
Currently delivering in excess of 50mcm
(Potential additional Norwegian gas deliveries scheduled 2010 onwards + 41 - 55mcm)

Bacton
IUK Upgrade to 64.4mcm/d commissioned December 2006
BBJ
Commissioned with 2 compressors in Dec 2006 (~28mcm/d)
March 2007 – 3rd compressor commissioned raising capacity to 42mcm/d

Milford Haven
South Hook LNG facility (2008)
29mcm rising to 56mcm
Dragon LNG facility (2008)
16mcm

Isle of Grain
18mcm increasing to 40mcm 2008 further increase to 60mcm 2010
UK gas supply and demand

There is a lot of new gas coming on stream.....Nigeria, in 1999 no LNG, by mid 2008 20 million tonnes per annum – all this was flared!
Worth $15 billion per annum. By 2012, will be 60 million tonnes!
What is biomethane 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
- Biomethane 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

- Biomethane is renewable CNG/LNG
  - From an anaerobic digester or from landfill or from gasification of biomass

- Offers carbon neutral transport option:
  - Lowest ‘Well to Wheel’ CO2 of any fuel
  - Reduction of around 80% compared to diesel if biomethane from municipal waste
Biomethane 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 not just looking for locations. We offer biomass suppliers financial participation in the plants," explains Helmut Rohr, spokesman of Eon Ruhrgas. In early February, the company started commercial operations of the first fermentation power station in Prerow.

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 that 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.

Biomethane Station Opens for German Public
Source - Oilgas
Wednesday, 30 August 2005
Germany

Germany's first public compressed natural gas (CNG) refuelling station to supply gas exclusively using biomethane has opened, servicing route 6048 between Dannenberg and Luchow. The station opened in June following a one-year construction period.

Feedstock for the methane is sourced from corn, grain, clover, supplied by a plant owned by RWG and fed directly to the RWG owned station. The station operates 24 hours per day.

A natural gas vehicle display of more than 30 vehicles was held in conjunction with the opening, as well as an overview by experts on renewable gas production.

RWG’s fermentation plant and a biogas powered Opel Zafira
Campaign to give biomethane equivalence with electricity so biomethane in = biomethane out
Amendment to Energy Bill drafted, offers significant CO2 benefits from allowing use of premium fuel
Were customers exist and not were the waste exists! As for electricity
Vehicles that can run on biomethane CNG – these are the key to market transformation
Vehicles that can run on biomethane CNG – these are the key to market transformation

Environmental performance

- Based on petrol
- Simple conversion
- Bi-fuel

2000

2005

2010

GOLDEN AGE FOR NGVs BIOMETHANE FUEL

We are here

These vehicles were not that good!

On gasoline or CNG

Some improvement, still runs

Designed for CNG alone, unbeatable in all respects!!
CNG Vehicles in Germany – OEM Product

Circled ones may be available in RHD in UK in 2008
Quick, what’s the most popular fleet car in Germany?

You are very smart to guess the Volkswagen Passat. And according to an article in *Automotive News Europe*, Volkswagen is being very smart by planning to offer a version of the Passat that will run on either gasoline or compressed natural gas (CNG). CNG is currently selling at .90 euro a liter while gasoline is priced at 1.35 euro a liter.

The Passat will offer the world’s first turbocharged engine that will run on either gasoline or CNG. The engine is reputed to be a version of VW’s 1.4 liter turbocharged engine and is expected to produce a minimum of 150 hp.

*Fiat, Opel and Peugeot are reportedly all working on similar powerplants.*
VW Caddy Eco-fuel

- Best selling CNG van 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 bio-methane + 150 km on petrol
MB Sprinter

• Mercedes Benz
  – Sprinter CNG in UK in Q3 2008
  – First time MB have designed a CNG Sprinter from ‘first principles’ (rather than petrol conversion):
    – 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
    – Ideal for supermarket home delivery, quiet, clean, long range, fast refuelling

In Germany, it is expected that this vehicle will become the vehicle of choice for Utilities looking both at their CO2 footprint and at their bottom line…
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.

Launched in Q4 2007, in UK from Jan 08
Very low emissions of NOX/particulates
Carbon neutral on bio-methane
MB Econic - rigid

- 20% lower CO2
- Very low emissions, EEV
- No congestion charge at present
- 50% of noise of diesel and expected to be approved for night running (avoiding traffic and congestion charge)

Decreasing CO2 impact

Diesel

CNG

biomethane
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
  – Launched in Oct 07
  – In UK in Q4 2008
MB Econic - refuse trucks

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

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

- NGVs for own fleet use, converted Euro 3 diesel trucks

**Tractor Unit**

300 miles (480 kms) approx

**Main Storage on Trailer**

620 water litres (two CNG tanks) = 320 miles (515 kms)

**Total Range**

620 miles (1,000 kms) approx

(Independent upon substitution ratio)

cng services ltd
Daimler Trucks (1)

FURTHER TECHNOLOGIES IN ORDER TO REDUCE EMISSIONS IN OUR TRUCKS

Yesterday

Conventional Engines

Today

Biofuels

HEV Technology

Fuel Cell

CNG-Engine

Conventional Engines with SCR

Tomorrow

Each technology has its specific market & use!
ALTERNATIVE FUELS BECOME INTERESTING FOR COMMERCIAL USE

Bio Diesel
Blends
CNG
Ethanol
Dual-Fuel
Methanol
Vegetable Oil

Test for Suitability

Bio Diesel
EU-engines: B100 released
Blends
NAFTA-engines: B5 released

Application in products

CNG
CNG-Econic available

Commercialization

Requirements
- Standardization of fuels
- Broad Availability

Commitment of all stakeholders necessary
Audi – T-CNG

- Designed for maximum range on natural gas (> 400 km range on CNG)
- Superior functionality of luggage compartment
- Consistent use of conceptual advantages of front-wheel drive
- Adapted rear end with 4 lightweight pressure tanks
- 2.0-liter TFSI (163 hp, 260 Nm) with CNG-optimized engine concept

Carbon neutral on biomethane! Why wouldn’t you buy this if you could fill up at 1000 CNG stations (and it also runs on petrol!)
Buses

- Rome
  - 470 Iveco buses
- Barcelona
  - CNG bus olympics
- Sidney
  - CNG bus olympics
- Paris
  - 50% of new buses now CNG
- Beijing
  - Buses for olympics

None in UK due to duty free diesel for buses

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

20 May 2007

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

Compressed Natural Gas Buses in Barcelona

New CNG buses have 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 biomethane
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 biomethane to biomethane CNG

Or can go direct to CNG compressor and vehicles from here
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>
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<tbody>
<tr>
<td>Sewage sludge</td>
<td>1,260,000</td>
<td>195</td>
<td>245,700,000</td>
<td>8,747</td>
<td>208,260</td>
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<td>Wet animal slurries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<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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<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>107,375,625</td>
<td>3,823</td>
<td>91,014</td>
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<tr>
<td>Farm yard manure</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Cattle</td>
<td>625,314</td>
<td>160</td>
<td>100,050,240</td>
<td>3,562</td>
<td>84,804</td>
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<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>
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<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>12,377,641</td>
<td></td>
<td>3,609,377,745</td>
<td>128,494</td>
<td>3,059,377</td>
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- 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

<table>
<thead>
<tr>
<th>Country</th>
<th>TWh</th>
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</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>

- Highly inefficient use – burnt to make electricity:
  - Landfill gas, only 25% efficiency, no use for waste heat
  - Sewage gas, limited use for waste heat, 30 – 35% efficient

- This is the energy and environmental equivalent of taking a 10 Year Old Malt whiskey and selling it as blended
  - Biomethane will earn RTFO certificates when used in vehicles
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 CNG vehicles developed for German market
  - Really good vehicles, turbo-charged!
- 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
  - Biomethane will earn RTFO certificates from 1 April 2008
- Biomethane is an unbeatable environmental fuel
  - EU Renewable Fuel Directive says that biomethane should earn 2 X ROCs
- UK has a huge potential resource
  - We can have hundreds of Lille’s
  - Can stop wasteful use of biogas