

High Pressure Grid CNG: The low CO₂ option for HGVs

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Summary

- Dual fuel diesel-CNG offers around 15% 'tank to wheel' CO₂ saving over diesel
- Using UK extensive high pressure gas grid reduces 'well to tank' compared to low pressure gas and both are better than diesel
- Using biomethane instead of natural gas in a dual fuel truck gives saving of around 60% in 'Well to Wheels' compared to diesel
- Using UK produced shale gas instead of imported LNG likely to give around 20% lower Well to Tank CO₂

Move to CNG aimed at Heavy and Medium Goods Vehicles with high mileage and emissions

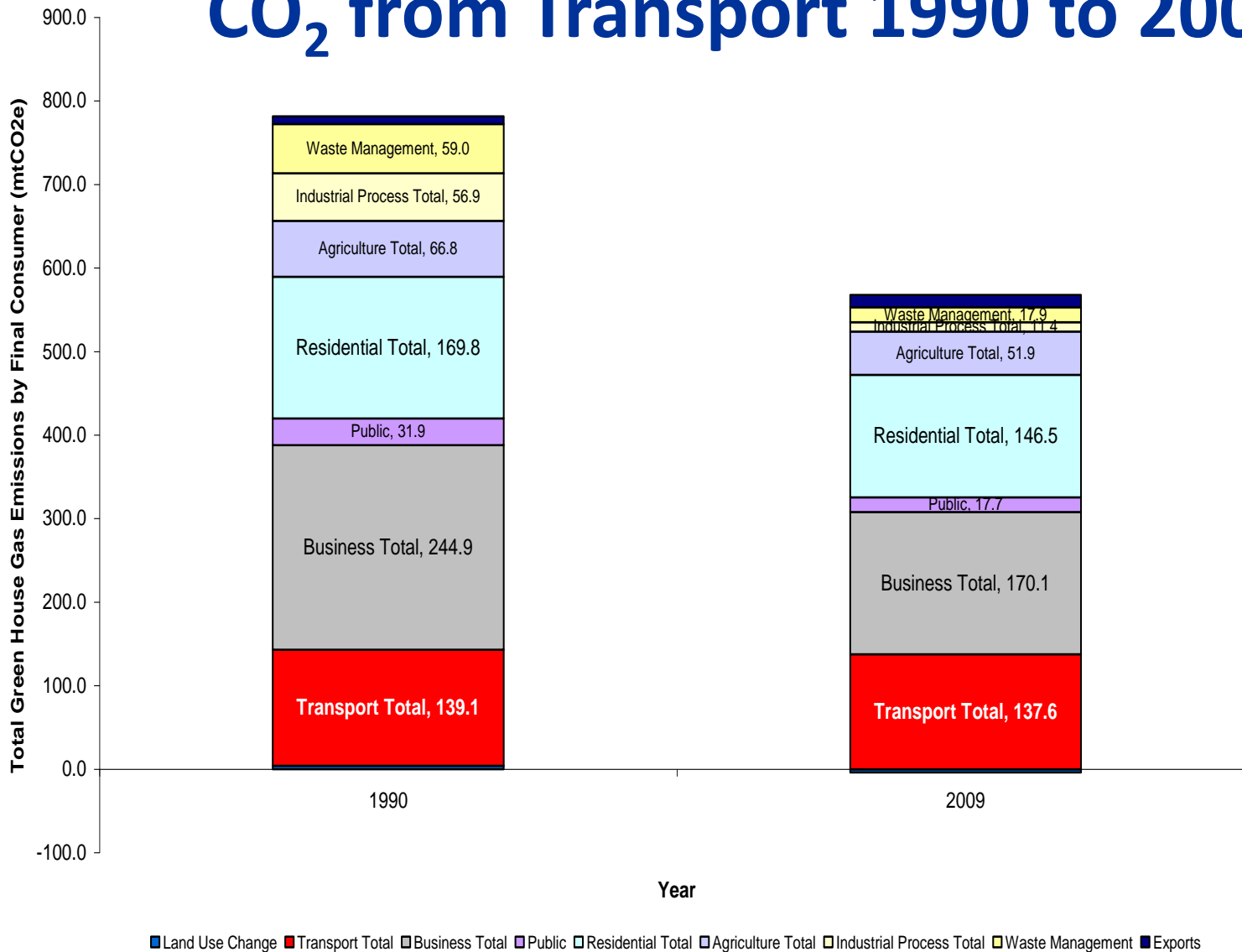
UK TRANSPORT – CO₂ EMISSIONS

UK Transport Emissions

- Transport accounts for 22.5% of the UK's GHG emissions with each sector producing:
 - Cars – 14.1%
 - HGVs – 4.1%
 - MGVs – 3.0%
 - Buses – 1.0%

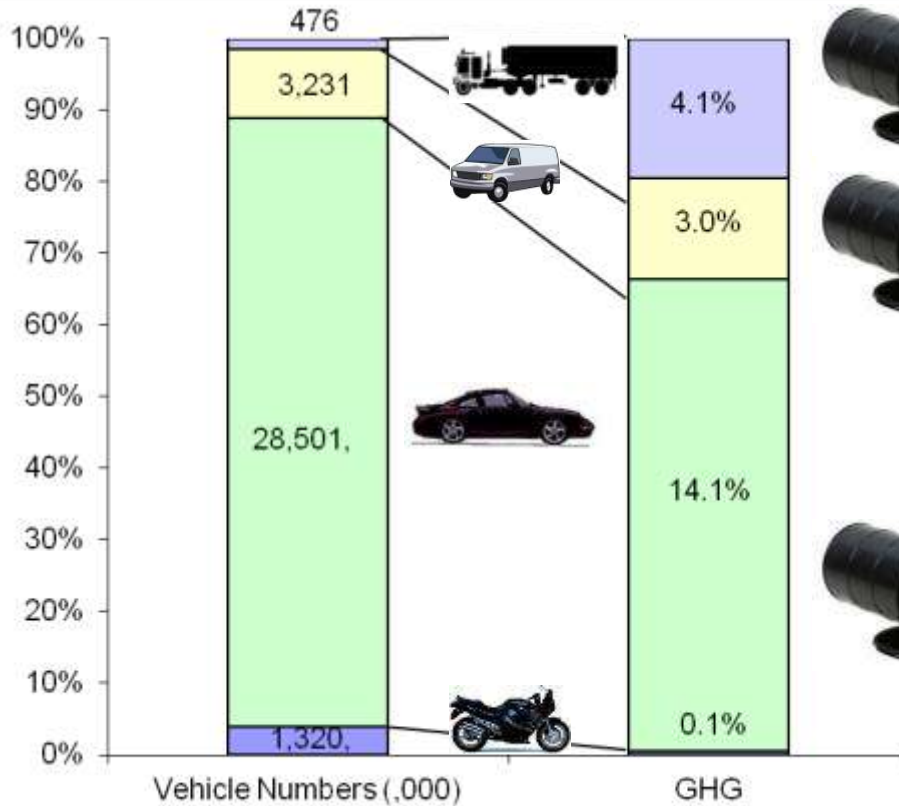
So how are we doing in relation to reducing it?

CO₂ from Transport 1990 to 2009



28% reduction in CO₂ emissions overall but Transport flat

HGV Sector Provides Best Opportunity for CNG



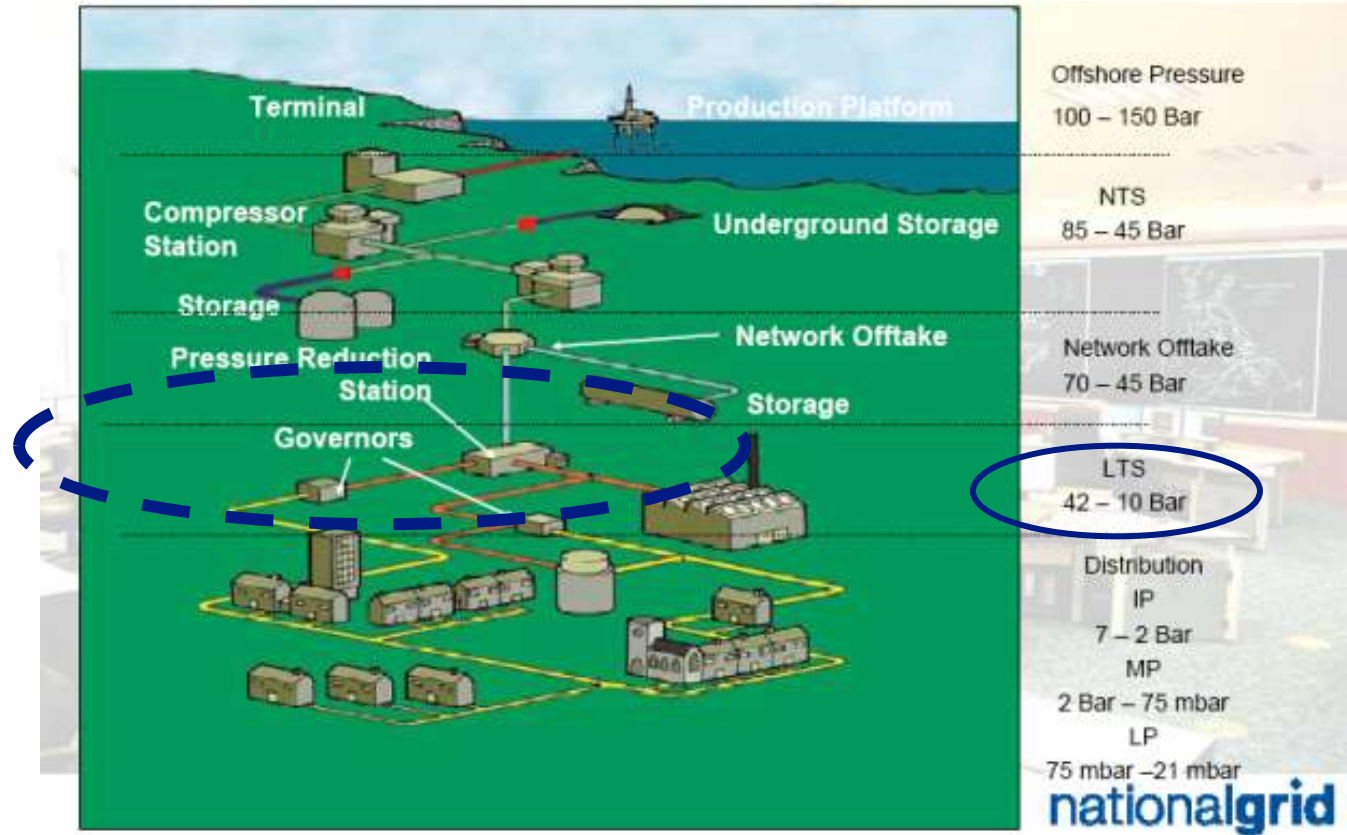
Fuel options in each sector

Cars are not the target for natural gas – trucks relatively few in number, limited other options, use a lot of diesel and cause significant GHG emissions

UK HIGH PRESSURE GRID – THE £15 BILLION LEGACY FOR TRANSPORT

UK Gas System

Local Transmission System



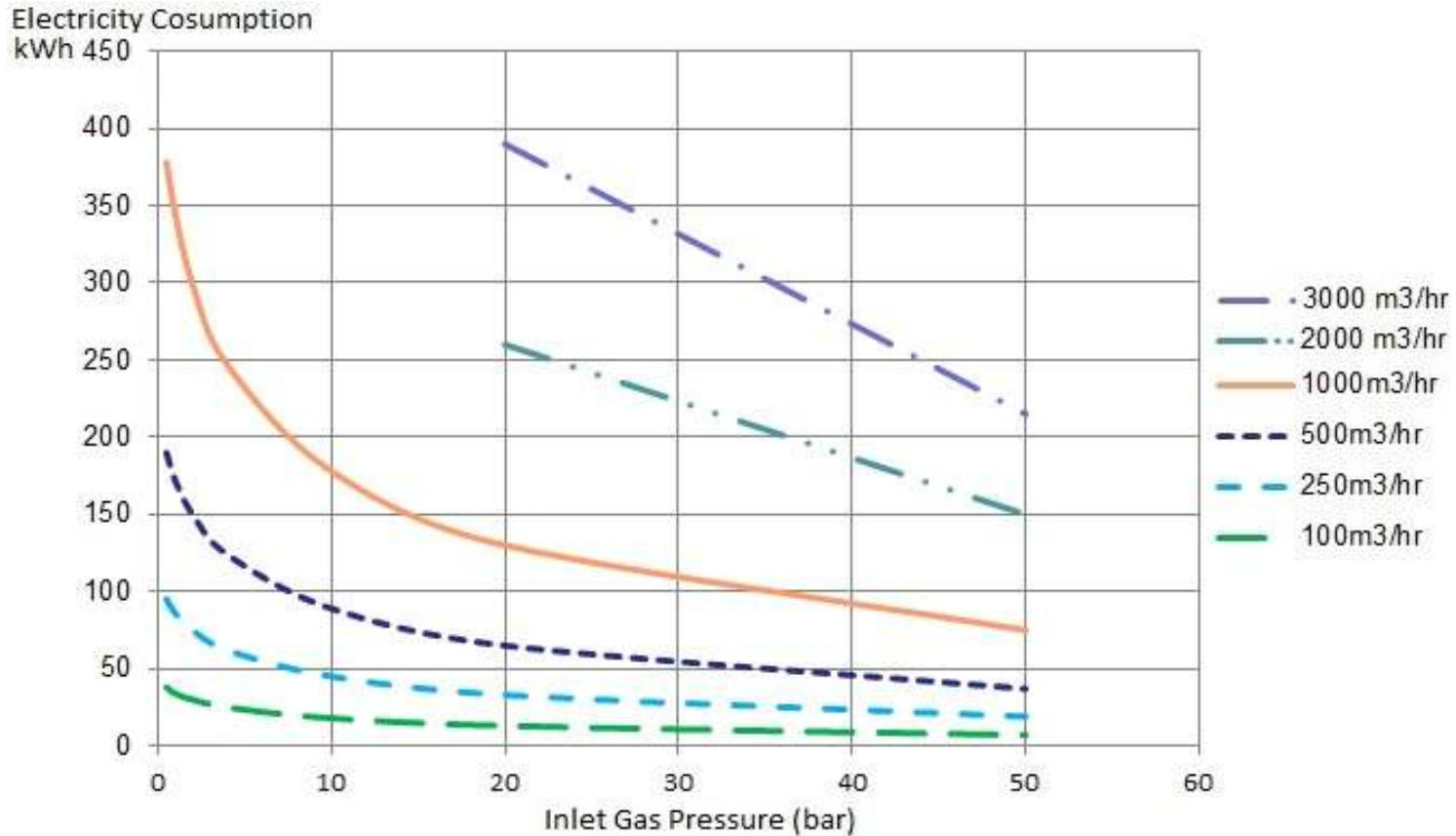
LTS is a vital national asset - ideal for CNG – it would cost >£15 billion to build NTS/LTS – these assets can help reduce diesel demand and reduce CO₂ from trucks

Benefits of Using LTS

- Lower pressure lift
 - Reducing electricity used in compression
 - Reduces number of stages of compression from 5 to 2
- Higher flow rates
 - Compressors run for less time, lower maintenance
 - Very high capacity per CNG station
- No leakage of gas in LTS
 - Higher pressure grids made with Carbon Steel pipes
- Dry Gas
 - No gas drier needed

The 6,000 km of 20 – 35 bar LTS means that 95% of major UK distribution centres are within 2 km of the ideal energy source is a vital national asset

Energy Used in Compression



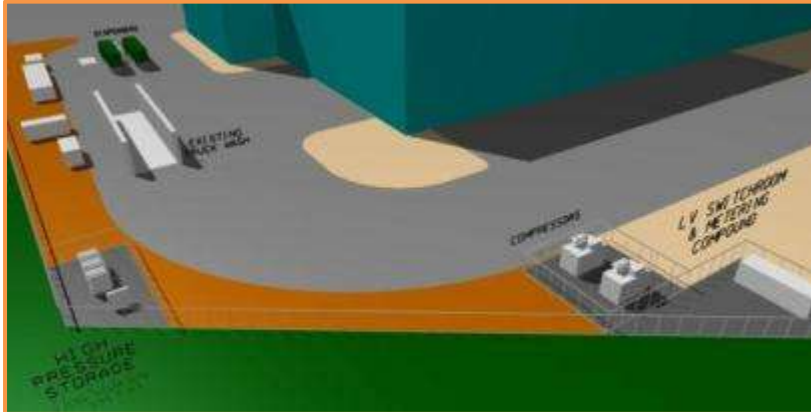
As the grid (inlet) pressure increases the electricity used in compression decreases and higher flow rates of above 2,000m³/hr are possible which reduces the running hours of compressor and/or provides very high capacity

Estimated CO₂ savings from LTS CNG

- Well-to-Tank savings from LTS compared to Low Pressure grid are significant
 - No leakage of methane to get gas to the supply point = 11.5%
 - 80% less electricity for compression = 6%
 - No drier = 1%
- Compared to diesel, the Well to Tank for LTS CNG is around 10% lower
- Tank-to-Wheel CO₂ savings are 15% CO₂
 - This is based on 60% CNG, 40% Diesel in dual fuel HGVs
 - Assumes diesel efficiency maintained
- Total CO₂ reduction from Dual Fuel trucks supplied via LTS is around 20% compared to diesel

Then there is biomethane on top

Private Host and Satellite Public Station



- The station's main components are:
 - LTS Gas Connection
 - Compressors
 - High Pressure (300bar) storage banks
 - CNG Dispensers

2 CNG compressors at the Host Station taking gas out of the 30 bar grid and compressing to 300 bar

Two 25 mm dia stainless steel pipelines of 500 m length that will connect the storage on the Host CNG Station to the Storage on the Public CNG Station



This model can be applied across UK

How Many Trucks can be Filled with CNG at an LTS Station?

- Flow-rates of 2,500 m³/hr from a single compressor
 - 1,900 kg/hr
- 1 truck doing 100,000 miles per annum will use around 50 kg of CNG per day (around 20,000 kg/annum)
- So 1 hour compression = 38 trucks per compressor
 - 1,824 trucks per day (assuming 4 compressors running for 50% each), say 1,500 trucks at each station
 - 8 per dispenser per hour
- 25 CNG stations can supply gas for around 40,000 trucks

The LTS provides the gas capacity – each CNG station costs around £1.5 - £2 million. So for £40n million can have 40% of UK large trucks on CNG-diesel

How Much Saving in Oil Imports?

- For 1 CNG Station, 1,500 trucks, annual CNG = 30 million KG
 - 15 million therms
 - Cost of LNG around £9 Million at 60p/therm for gas
 - This money goes to fund the Air Conditioned World Cup
- Equivalent to around 40 million litres of diesel
 - Cost around £24 million at 60 p/litre (duty free)
 - This money goes to Saudi Arabia (or Russia – main diesel supplier to UK)
- 1 CNG station will save around £15 M per annum from gas replacing oil
- But if the gas is from Lancashire then of the £9M, around £6M comes back to UK as tax
 - We can use this money to insulate homes and build renewable generation

**25% CO₂ saving is great but money is key – UK plc has to switch trucks to gas
(like we have heating and 50% of electricity)**

25 CNG stations can save 1 billion litres of oil imports

DUAL FUEL TRUCKS

Dual Fuel Trucks

- A 40% diesel- 60% CNG tractor will save 17% CO₂ on a 'tank to wheels' basis compared to diesel alone
 - Because CH₄ contains less carbon than C12 diesel
- 3 UK companies are world leaders in dual fuel technology:
 - Hardstaff Group – Mercedes Benz
 - Clean Air Power - Volvo
 - G-Volution - working on DAF and MAN
- Also Prins active in UK with DAF dual fuel conversions
- See next slides

Dual fuel trucks provide a pathway to natural gas trucks, available now

Dual Fuel Technology – Key Components

250 bar CNG storage



Hardstaff OIGI system exhaust including methane catalyst



Westport
HPDI injector



Clean Air Power
'Genesis' ECU

There is a worldwide dash for dual fuel technology underway driven by abundant world-wide gas resources

CNG Trucks Using Crewe CNG Station

- Filling CNG dual fuel trucks for GIST/M&S, John Lewis/Waitrose and Tesco
- UK's largest CNG station



Largest grid supplied CNG station in UK – takes gas from 4 bar grid and so uses 20% less electricity compared to 0.2 bar grid

Dual Fuel Tractors – Volvo

VOLVO TRUCKS



Press release, published: 31/05/2011

Volvo Trucks first to market gas-powered truck for long-haul operations

Volvo Trucks is enhancing its focus on alternative fuels with the launch of the new Volvo FM MethaneDiesel. This truck is powered by up to 75 percent gas. Thanks to its fuel-efficient technology – which extends the vehicle's operating range – it can considerably reduce CO₂ emissions from heavy and long-distance transport operations.

Better exhaust filtration technology and lower emissions

Compared with conventional gas-powered spark-plug engines, Volvo's gas technology offers 30 to 40 percent higher efficiency, and this in turn cuts fuel consumption by 25 percent. This means that if a Volvo gas-powered truck is run on biogas, emissions of carbon dioxide would be able to be cut by up to 70 percent compared with a conventional diesel engine.

Since the price of natural gas is often significantly lower than that of diesel, financial savings are also possible; this is often a necessary precondition for widespread acceptance of new technology.



GREEN GAS CERTIFICATES

REAL Green Gas Certificate Scheme

- Designed to allow ‘tracking of biomethane from injection point to customer’
 - Integrity - no ‘double counting’
- Allows a haulier to ‘make’ its own gas from organic waste and use this to fuel its trucks
 - Replacing high CO₂ imported LNG

GGCS Launch Members

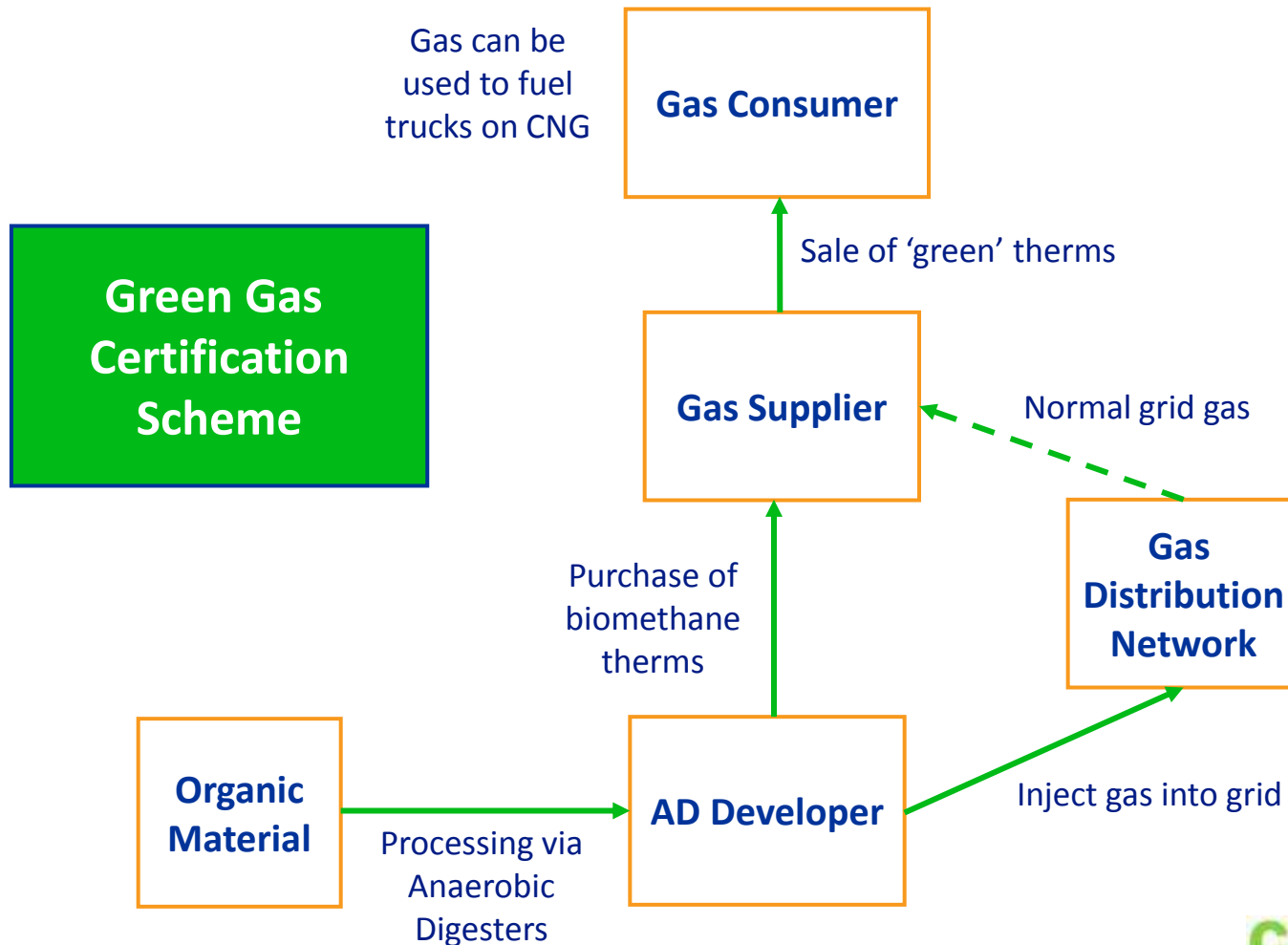
- National Grid
- British Gas
- E.ON
- Thames Water (Didcot)
- Adnams Biogroup (Adnams)
- Milton Keynes City Council
- CNG Services Ltd

<http://www.greengas.org.uk>

8 biomethane projects going ahead in 2012/13 using the REAL Green Gas Certificate Scheme



AD Developer → Gas Supplier → Gas Grid → Gas Consumer

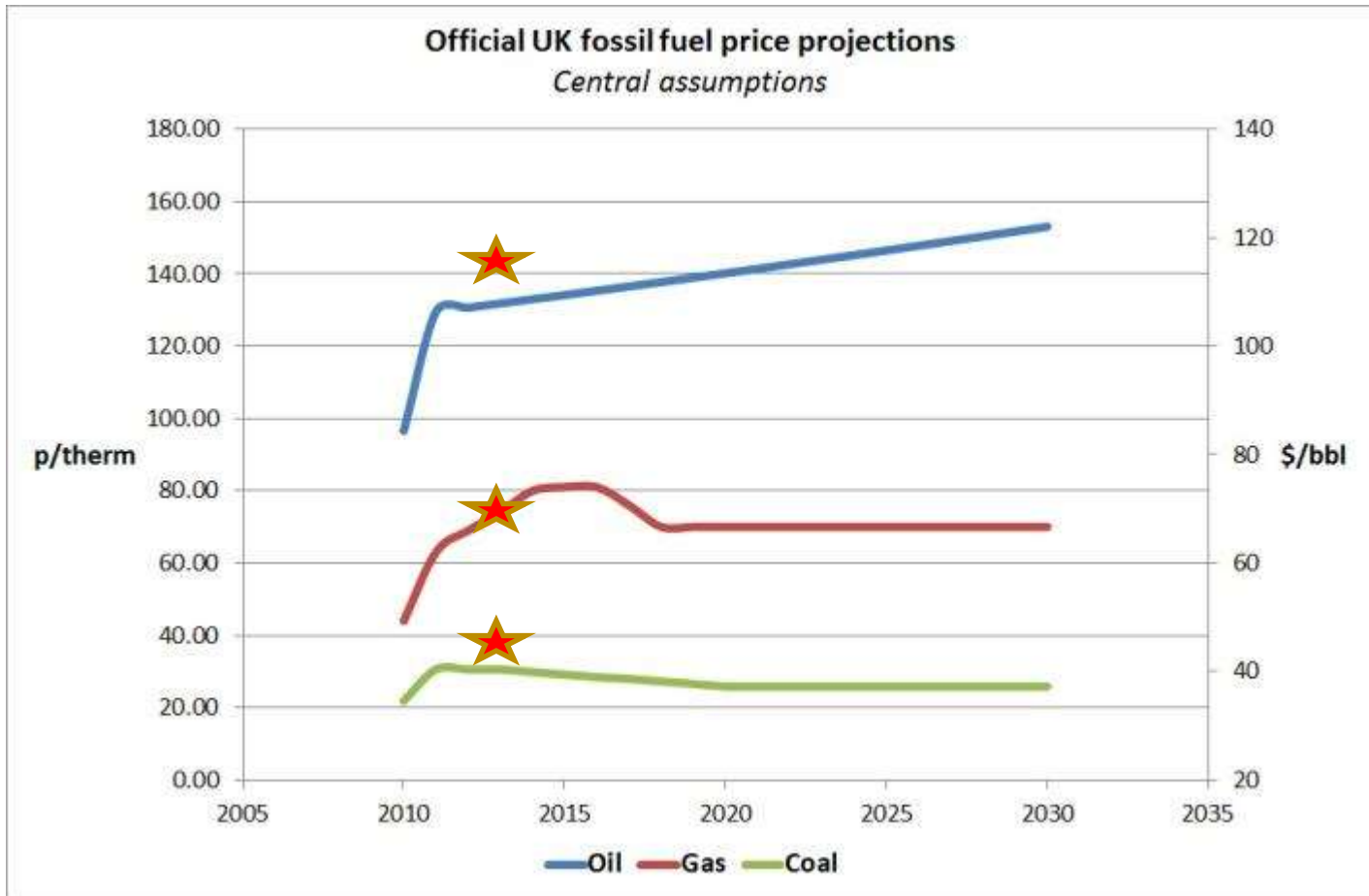


BENEFITS OF SHALE GAS

DECC Energy Price Forecasts



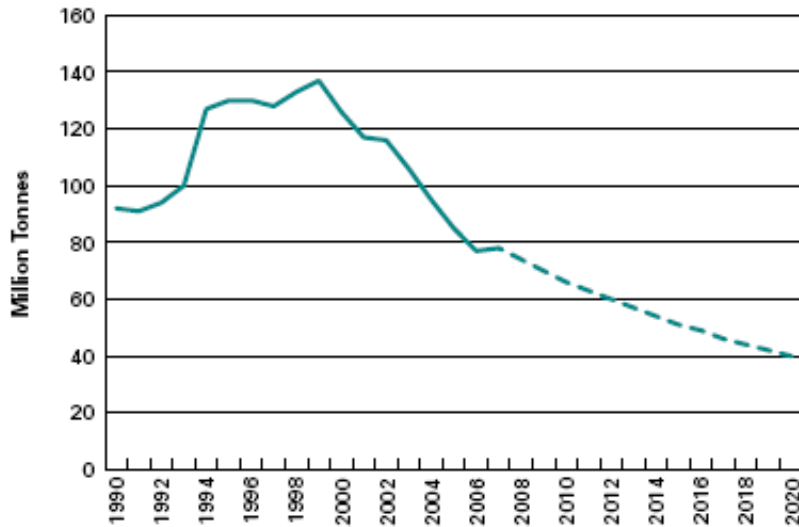
Prices
today



Key points - oil getting more expensive, coal cheap, gas flat

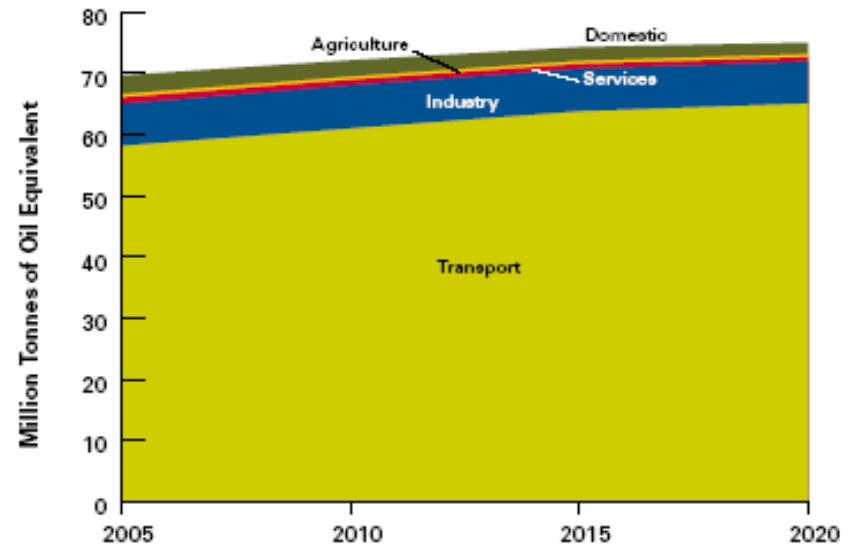
UK Oil Production and Demand 1990 - 2020

UK oil production



Source: BERR

UK oil demand



Source: BERR forecast model

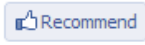

DECC forecasts that by 2025, UK will be importing around 1 million barrels of oil per day, almost all for road transport

This is the Elephant in the room.....Question - How does UK plc afford this extra import bill of around £40 billion/year

Answer – We Don't Import It!

- BGS working on estimate of UK shale gas resource...
- Announcement by DECC due before end 2012
- Cuadrilla already say that Bowland shale gas in place over 200 TCF
- Toni Harvey of DECC knows but cannot say.....

UK sees new shale gas resource estimate by end-2012

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LONDON | Tue Oct 16, 2012 11:56am BST

(Reuters) - Britain expects to issue a new estimate of its shale gas resources in the Bowland formation in the north before end-2012, followed by a more comprehensive figure for the whole of the country in 2013, the energy ministry said on Monday.

The Bowland formation covers a huge area with potentially significant recoverable reserves, extending beyond current shale [gas drilling](#) locations in Lancashire by companies such as Cuadrilla Resources to the Isle of Man, north Wales, south Cumbria and the East Midlands.


"The Bowland Shale estimate will be released by year end," a spokesman for Department of Energy and Climate Change (DECC) said. "There will be a more comprehensive estimate of UK shale resources in 2013," he added.


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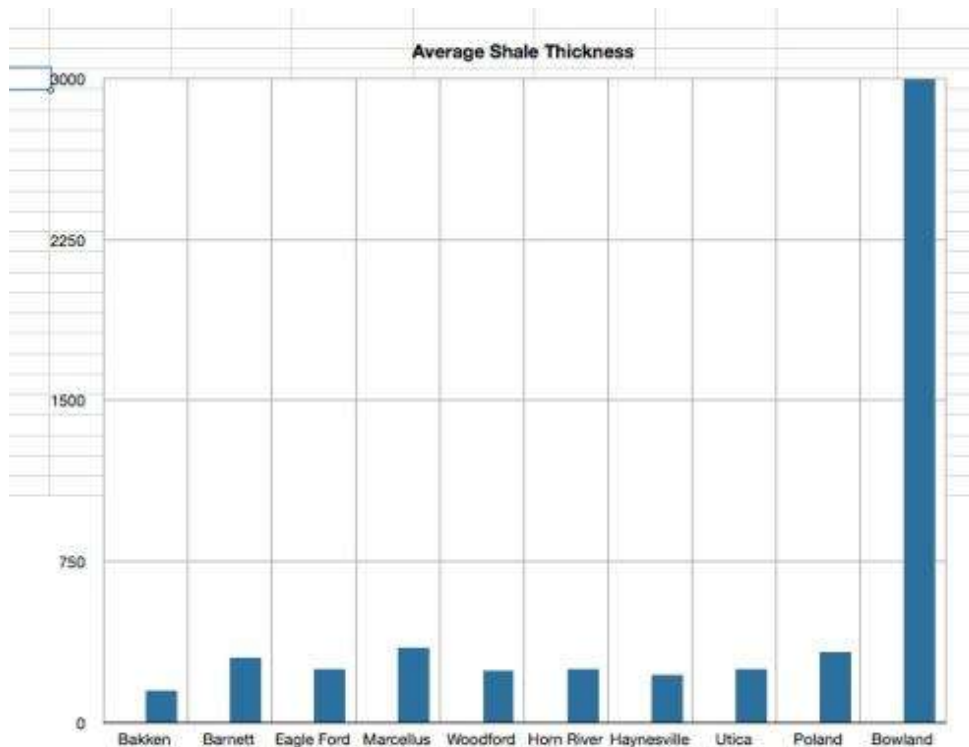
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Possible that UK shale gas resources could be > 1,000 TCF - assume 30% recoverable = 3 TCF (84 BCM)/annum for 100 years (UK annual demand around 80 BCM)

Lancashire 350 million years ago



Bowland shale at 4,000 feet thick

Most US shale at 300 feet thick



Imagine an inland sea where Preston is today..... is this going to be one of the top 10 largest gas fields on planet earth?
A bit of the gas leaked out and was captured in a different stratawe call this gas “South Morecambe” – our largest gas field to date, mostly produced

Morecambe Gas

- In 1973, Gulf (now part of Chevron) drilled through the South Morecambe gas field
 - They said it was dry....
- John Bains of British Gas looked at the logs and identified 600 feet of pay!
 - Clever chap
- Probably the single most important event in the history of Centrica, BG Group and National Grid
- 172 BCM of gas = 69 billion therms
- Worth £50 Billion at today's gas prices
- Key to UK energy from 1985 - 2000

I was graduate trainee on South Morecambe commissioning...with hindsight the whole of Morecambe was just an early indication of the shale gas available in Lancashire.....

Largest Gas Fields

Largest non-associated gas fields

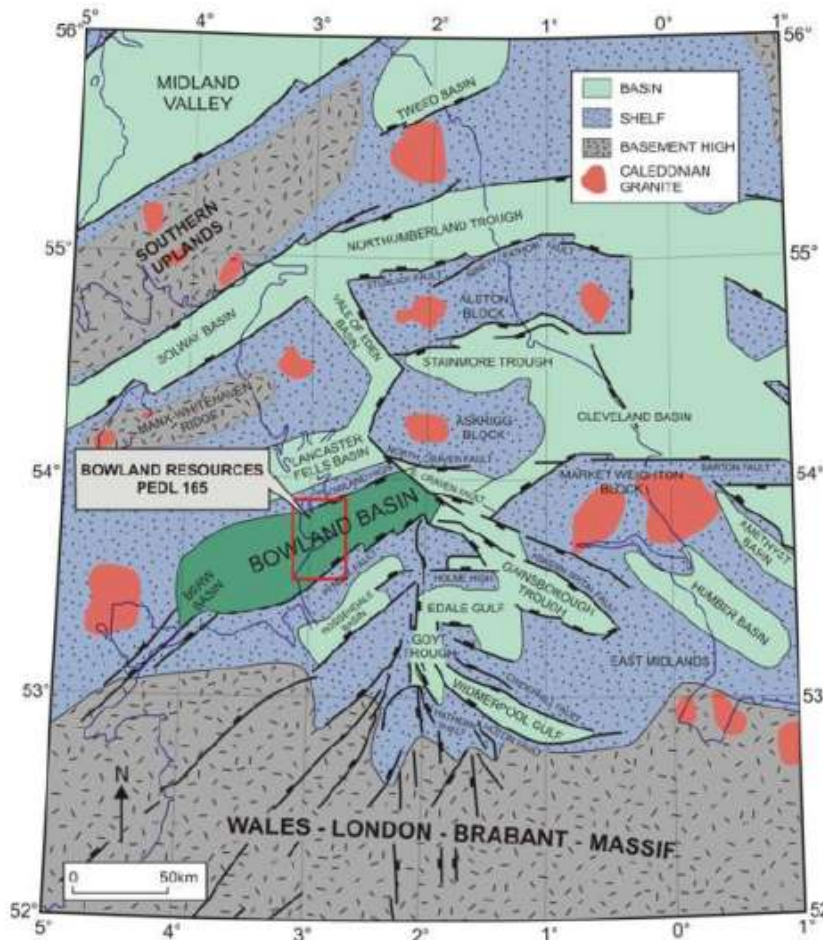
No	Field name	Country	Recoverable reserves ^[1]
1	South Pars/North Dome	 Iran and Qatar	1235×10 ¹² cu ft (35,000 km ³)
2	Urengoy	 Russia	222×10 ¹² cu ft (6,300 km ³)
3	Yamburg	 Russia	138×10 ¹² cu ft (3,900 km ³)
4	Hassi R'Mel	 Algeria	123×10 ¹² cu ft (3,500 km ³)
5	Shtokman	 Russia	110×10 ¹² cu ft (3,100 km ³)
6	South Iolotan–Osman	 Turkmenistan	98×10 ¹² cu ft (2,800 km ³)
7	Zapolyaroye	 Russia	95×10 ¹² cu ft (2,700 km ³)
8	Hugoton	 USA (TX-OK-KS)	81×10 ¹² cu ft (2,300 km ³)
9	Groningen	 Netherlands	73×10 ¹² cu ft (2,100 km ³)
10	Bovanenko	 Russia	70×10 ¹² cu ft (2,000 km ³)
11	Medvezhye	 Russia	68×10 ¹² cu ft (1,900 km ³)
12	North Pars	 Iran	48×10 ¹² cu ft (1,400 km ³)
13	Dauletabad-Donmez	 Turkmenistan	47×10 ¹² cu ft (1,300 km ³)
14	Karachaganak	 Kazakhstan	46×10 ¹² cu ft (1,300 km ³)
15	Kish	 Iran	45×10 ¹² cu ft (1,300 km ³)
16	Orenburg	 Russia	45×10 ¹² cu ft (1,300 km ³)
17	Kharsavey	 Russia	42×10 ¹² cu ft (1,200 km ³)
18	Shah Deniz	 Azerbaijan	42×10 ¹² cu ft (1,200 km ³)
19	Golshan	 Iran	30×10 ¹² cu ft (850 km ³)

Who knows where
Bowland shale will
fit? Find out on 5th
Dec 2012

Who needs to buy
Shockman gas from Russia
when we may have this
gas under Lancashire?

Location of Bowland Shale

Slides courtesy of Cuadrilla

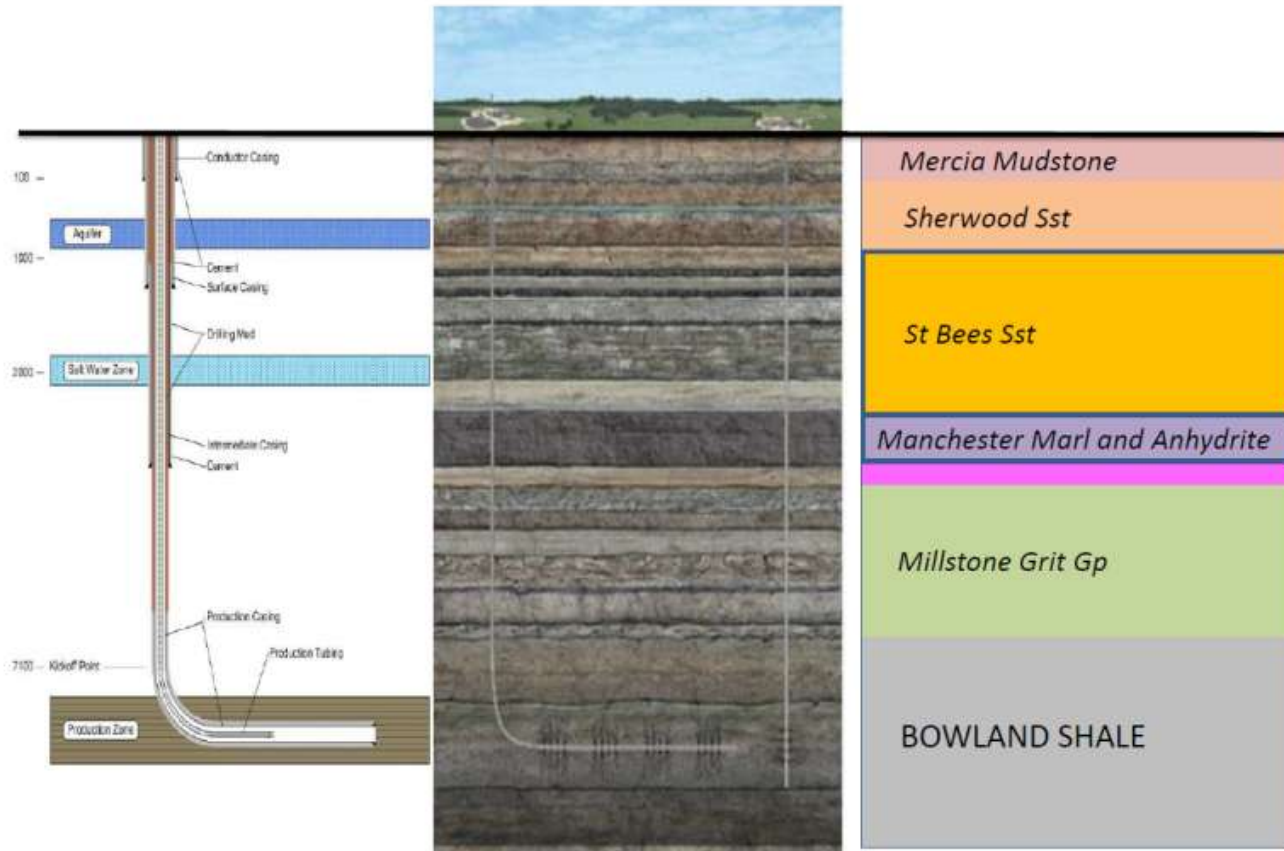


NTS Map



200 tcf in the Cuadrilla Licence area implies a huge total resource of Bowland Shale gas in place.....

Gas Extraction



In UK there are no material risks to the environment from shale gas development - CH₄ leaks, contamination of aquifers, earthquakes etc (note – the aquifer above Bowland shale is salt water not drinking water)



Bowland Shale Development

Drilling site and indicative development showing multi-well pads several km apart

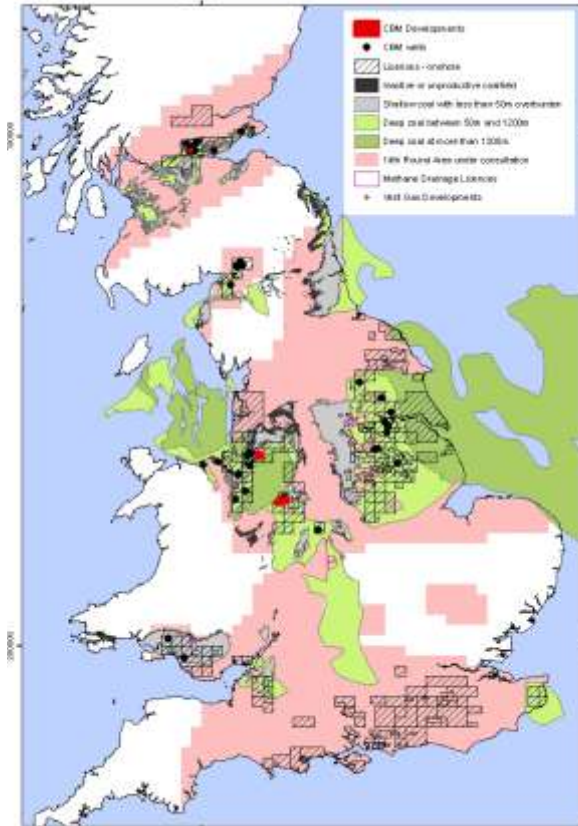
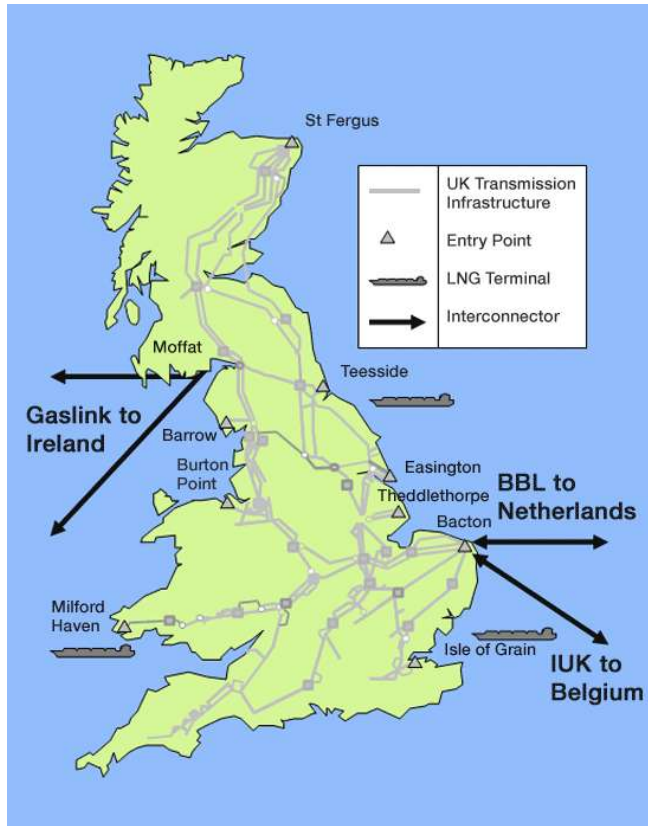
-no difficulty in Lancashire

- see www.ryedalegasproject.co.uk)



UK Planning Reforms to support nuclear power stations will support the development of shale gas though the impact is much less

Shale Gas Locations and the UK Gas Grid



The National Transmission System appears to be wherever there is shale gas which is a stroke of luck (and saves UK around £10 billion!)

PUBLISHED 23 MARCH 2012

Nigel Keen, Director of the John Lewis
Partnership's Carbon Plan

CONCLUSIONS



Post Date: 10 October 2012

Imagine an attractive and genuinely viable alternative to using fossil fuels; a source of power for vehicles, businesses and homes that is truly sustainable, less carbon intensive, more economical and brings with it the added benefits of job creation and an injection of capital into British industry. With a supportive fiscal and regulatory framework, we believe there is huge potential for bio fuels to fulfil this aspiration.

The "green" arguments for making greater use of bio fuels are highly persuasive and the economics, compelling. The primary argument for replacing fossil fuels with bio fuels is of course the significant reduction in carbon emissions.

Dual fuel vehicles - those that use diesel and an alternative fuel such as natural gas - emit far less carbon than their solely diesel-fuelled counterparts. A standard heavy truck that uses £50,000 of fuel in a year and emits 100 tonnes of CO₂ can see a reduction in CO₂ emissions of between 10 and 15 per cent through conversion to dual fuel. Using bio-methane as a road fuel has the potential to reduce CO₂ emissions even further. Taken from the national gas grid, compressed and used in "dual-fuel" heavy vehicles, bio-methane can boost the carbon reducing effect of dual fuel to around 60 per cent, and that's without counting the other environmental benefits.

Conclusions (1)

- Very high growth driven by the oil – gas price differential
 - Gas grid = gas for heating (UK 1970-90)
 - Gas = gas for electricity (UK 1992 - 2012, 50% switch)
- OEMs now making trucks that run on natural gas
 - This is the key development
 - Supported by UK engineering (Hardstaff, Clean Air Power, G-Volution)
- Reduce haulage costs to UK truckers
 - Foreign lorry loaded with diesel issue
- CNG is ideal fuel for UK
 - Small country
 - Extensive Local Transmission System
 - Back to base operations

The development of trucks that can run on gas-diesel dual fuel is transformational

Conclusions (2)

- LTS CNG and dual fuel trucks can save 1 billion litres of diesel per annum by getting around 40% of trucks off 100% diesel
- Needs 25 CNG stations, around £40 Million capex
- Premium per vehicle in short term of £15- £25K but can be expected to fall towards cost of tanks (£5k)
- Reduce CO₂ from large trucks by 20 – 30%
- Biomethane is ideal way for hauliers to reduce their carbon footprint by making their own gas from waste – 60% CO₂ reduction
- Shale gas offers CO₂ reduction compared to fossil natural gas/imported LNG
 - Jobs and more wealth that can remain in UK
 - Taxes to fund insulation and renewables

Shale gas and LTS CNG can provide huge benefit to UK

And finally....Home-fill CNG

German Transport Association Names VW eco up! for Environmental Car Award

August 23, 2012 | Germany



The annual evaluation of climate-friendly cars in Germany has once again yielded a natural gas vehicle as best car. The Verkehrsclub Deutschland (VCD) — Transport Association Germany — awarded five stars and overall first place for 2012/2013 to the VW eco up!, even though the vehicle is yet to reach suppliers. It will be available to order from autumn 2012.

In the category of Best Air, where focus is on greenhouse gas emissions and noise, the VW eco up! shares first place with the Toyota Yaris. Both cars emit just 79g CO₂ / km and show that a CO₂ limit of 60g CO₂ / km, as called for by the VCD and other environmental organizations for 2020, is feasible. Gerd Lüttsiepen, transport spokesman of VCD, said, "Another reduction to 60g/km is ambitious but technically feasible, necessary for climate policy and desirable for consumers."

The CO₂ emissions has a direct correlation to consumption; at a fuel price of EUR 2.60 (USD 2.56) per liter the eco up! can save around EUR 5.00 (USD 6.36) per 100 kilometers compared to average new car.



AUTOS | Updated November 13, 2012, 9:14 a.m. ET

Natural-Gas Cars to Get Home Fueling

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BY BEN LEFEBURE AND JEFF BENNETT

Chesapeake Energy Corp. said it is working with General Electric Co. and Whirlpool Corp. to develop a \$500 appliance that will allow natural-gas powered cars to be refueled at their owners' homes.

The effort would be Oklahoma City-based Chesapeake's latest push to promote compressed natural gas as a mainstream fuel and boost its own sales. It is the first attempt at overcoming one of the biggest challenges in putting natural-gas powered cars on the road—convenient refueling.

Chesapeake and other natural gas producers have felt a cash crunch as a technology-led increase in natural gas production has led to a supply

The VW CNG Up! And home-fill CNG using UK shale gas and renewable electricity is unbeatable in Well to Wheel CO₂ terms