

Shale Gas development in the UK: Reserve estimates and potential impact on security of supply status

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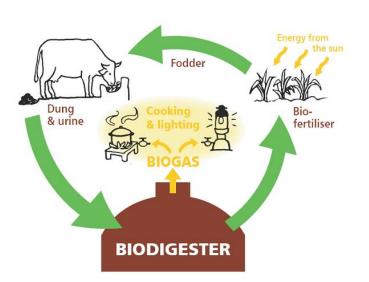
Where does natural gas come from?



There are two types of natural gas:

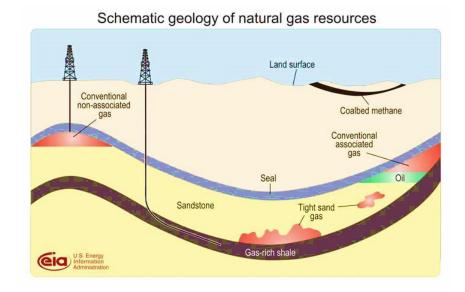
BIOGENIC

Methanogenic organisms formed by the assistance of bacteria in marshes, landfills and shallow sediments



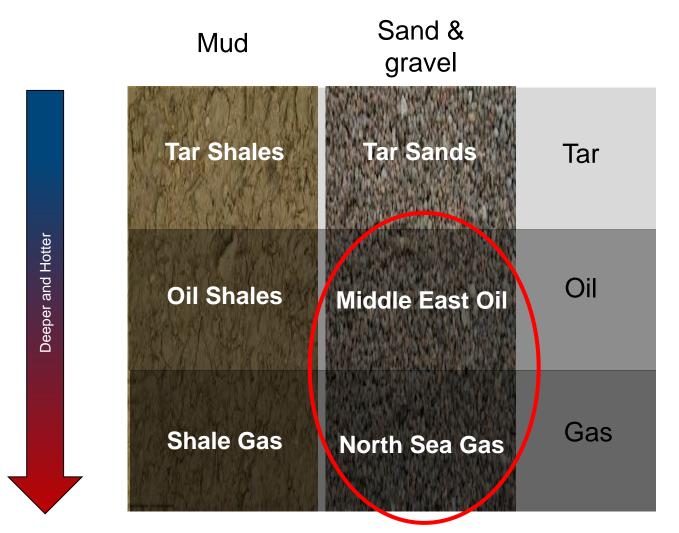
THERMOGENIC

Buried organic material deeper into the earth at greater temperature & pressure



Where does natural gas come from?

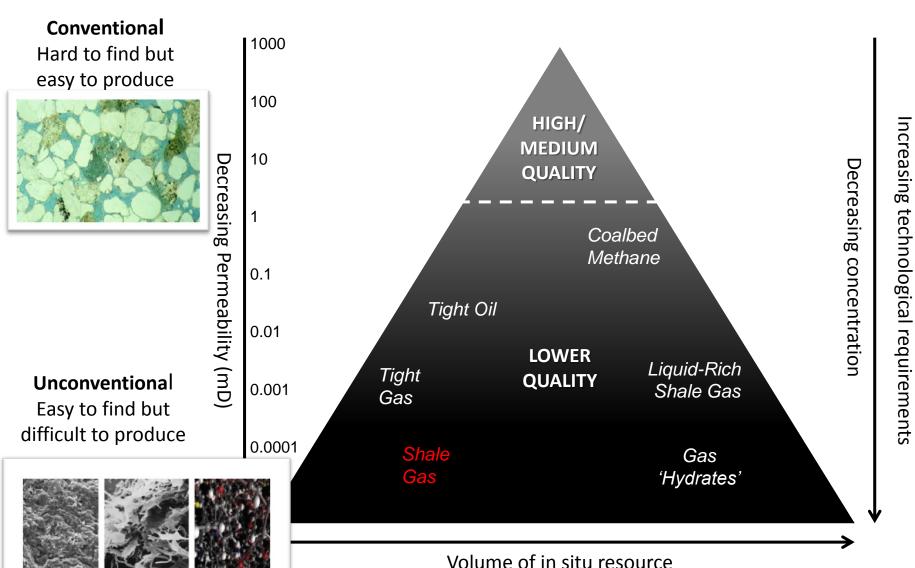




Conventional

Viability of extraction

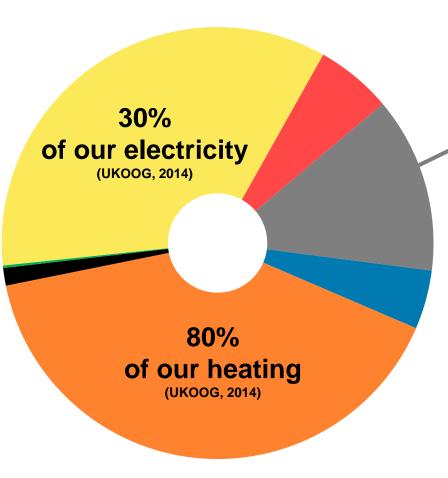


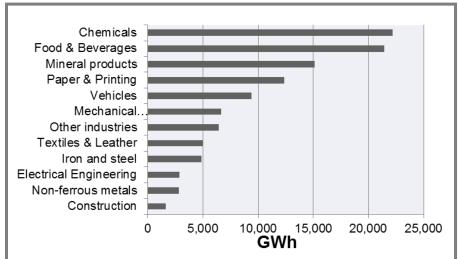


Natural Gas



Gas use by sector



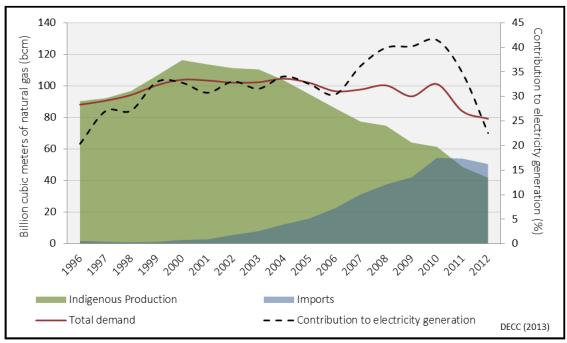


- Energy Sector
- Public Administration inc. Schools and Hospitals
- Industry
- Commercial inc. Retail and Hotels
- Domestic
- Miscellaneous
- Agriculture

UK Natural Gas Demand



2011 was a turning point as we **imported more** natural gas than **native production**



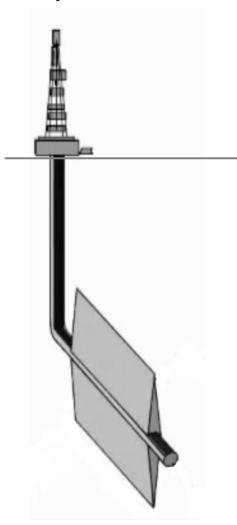
Imports, especially Liquid Natural Gas (LNG):

- More expensive
- Higher carbon footprint
- May originate from politically unstable countries

As a result, the government aspires to **improve our NG security of supply status** by extracting **shale gas**



Early 2000s Adapted from vertical wells



 Conventional wells have been 'fracked' historically

 Tried to adapt technology to 'frack' horizontal wells but wells did not produce



From mid-2000s Staged 'fracks' developed



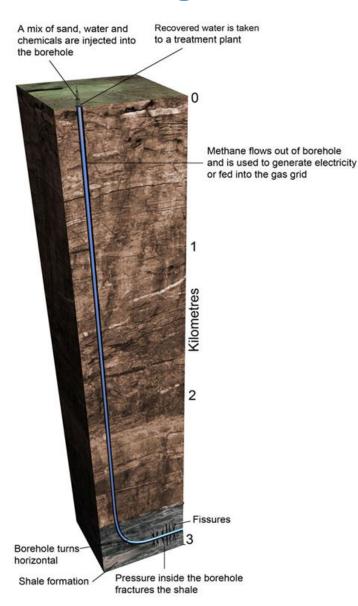
Then, a combination of three technologies came together:

- 1. Drilling horizontal wells
- 2. Fracking
- 3. Fracking in stages

Result:

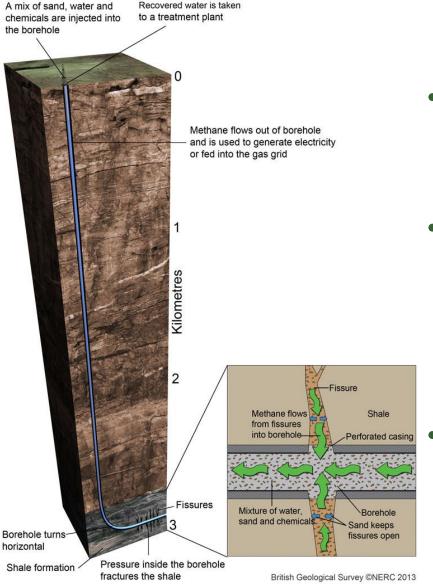
Shale gas is made economically viable in the US





- A vertical well is drilled and lined with steel casing and cement (>2900m deep)
- Water and chemicals are used to cool the drilling bids and reduce corrosion
- The well proceeds horizontally into the shale formation (1-2km length)





- The horizontal well is perforated in sections
- A water-based fracking fluid is injected at a pressure of ~15,000psi to fracture the designated section
- Sand particles prop open fissures to allow gas to flow

Shale gas extraction: The surface



- No commercial extraction in the UK
- Site of 1.5ha required
- Impermeable membrane



- 'Temporary' site, therefore resources and equipment brought onto site on trucks
- Unlike the US, waste pits are not used waste is 'contained'

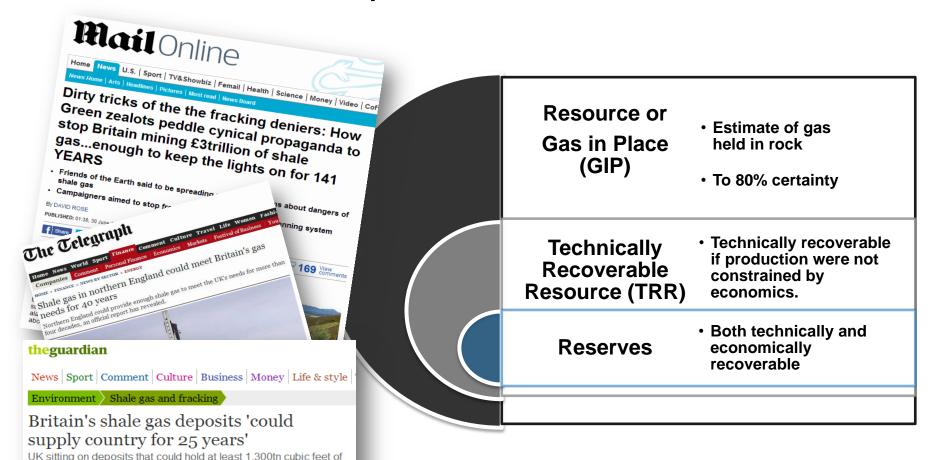
Resource vs. Reserves

gas, much more than previous estimates, British Geological

Survey report says



Estimates can be misinterpreted in the media....

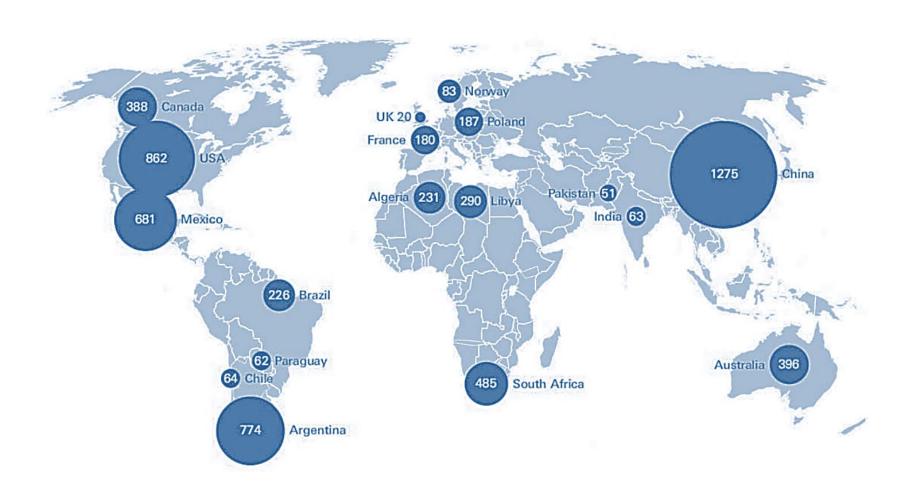


1 billion cubic meters (bcm) = 28.3 trillion cubic feet (tcf)

Global Resources



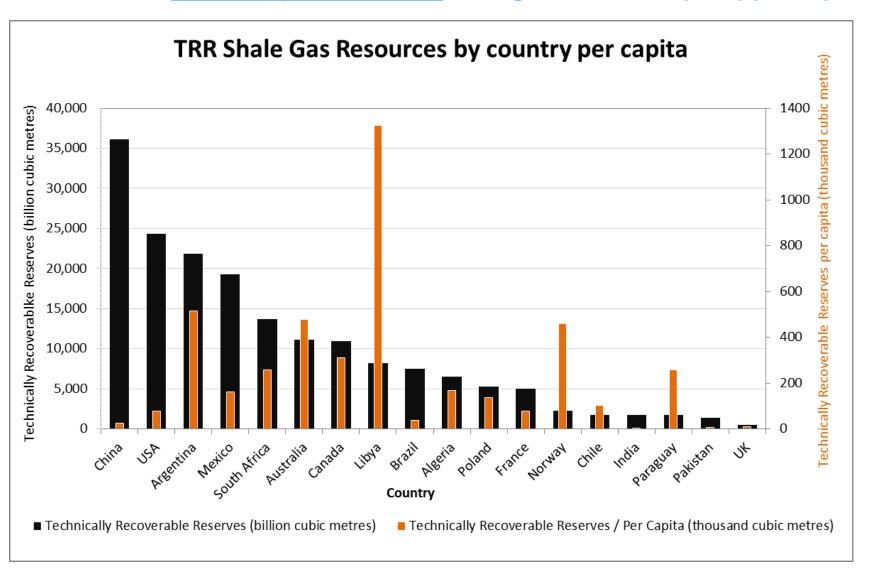
Estimates of <u>technically recoverable</u> shale gas resources (tcf) for selected shale formations in 32 countries (EIA, 2013)



Global Resources



Estimates of technically recoverable shale gas resources (bcm) per capita



Resource vs. Reserves

UK Shale gas assessments



United Kingdom (2011)

TRR: 566bcm



(2012)

"...the UK shale gas reserve potential could be as large as 150bcm



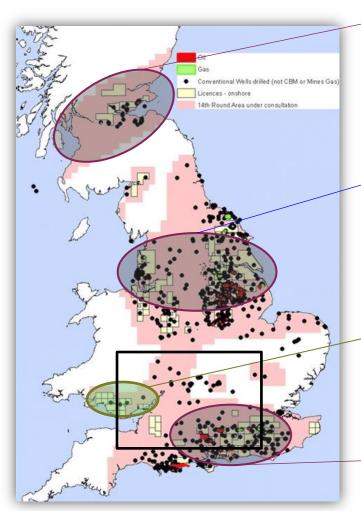
United Kingdom Revised (2013)

TRR: 732bcm

Reserves

Technically Recoverable

Resource / GIP





Proposed assessment >2014





International Water Security Network

The Bowland-Hodder (GIP)

Cuadrilla (2011): <u>5,663bcm</u> BGS (2013): <u>37,633bcm</u> Cuadrilla (2014): <u>9,344bcm</u>



South Wales and West (GIP)

968bcm (2011)

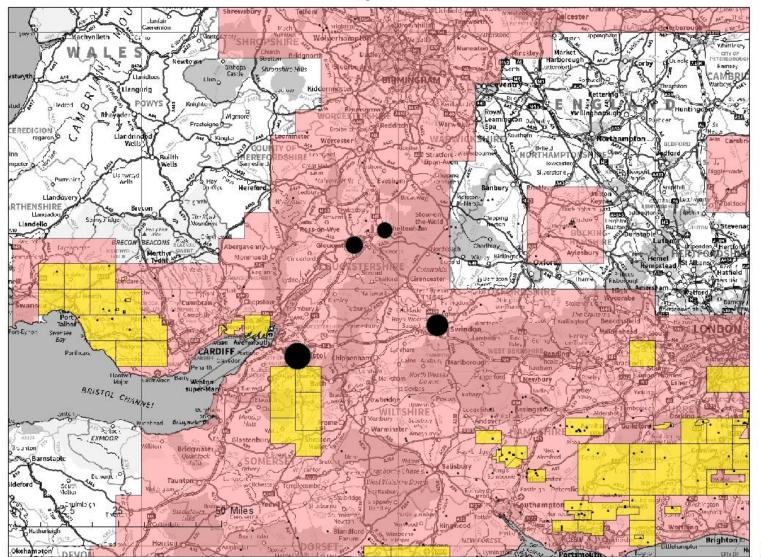


The Weald Basin Shale OIL not gas (May 2014)

Resource vs. Reserves



Scope of the Shale Gas Strategic Environmental Assessment by DECC 2013







How could shale gas potentially affect our natural gas security of supply status?

Bowland- Hodder BGS Estimate Scenario (bcm)	Gas in Place (GIP)	Technically Recoverable Resource (TRR) = 25% GIP	Possible = 43% TRR	Probable = 32% TRR	Speculative = 25% TRR	Potential Reserves = 50% Speculative TRR
Low	23,279	5,834	2,492	1,869	1,444	736
Most Likely	37,637	9,402	4,050	3,002	2,351	1,189
High	64,598	16,142	6,938	5,154	4,050	2,011

To contextualize this figure:

- The UK's remaining recoverable conventional gas reserves are
 493bcm (17.4tcf) (DECC, 2013)
- Annual UK gas consumption is 80 85bcm (2.8 3tcf)

Shale gas extraction of the Bowland-Hodder contains the equivalent of >15 years' UK natural gas consumption



How could shale gas potentially affect our natural gas security of supply status?

Continued uncertainties in the estimation of shale gas' contribution to ur SoS status as a result of:

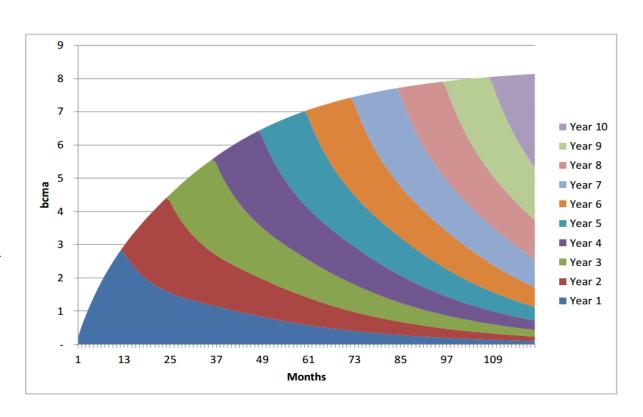
- Limitations to extrapolation from US case studies
- Updated resource estimates
- Projected natural gas demand
- Wells / laterals / well pad figures
- Public opinion



Gas production rates decrease from 1st year

Illustrative shale gas production profile based on average Barnett shale gas well production

Ref: (Rogers (2013); Berman (2012)



To meet 10% UK of gas demand in 10 years requires
 300 wells to be drilled annually / 25 well pads



Would the UK see development to the scale of the US?

"...exploiting the Bowland shale, based on the example of the US, might require

33,000 wells."

Prof. Andy Aplin

Former adviser to oil giant BP and now at Durham University

ShaleUK Conference (March 2014):

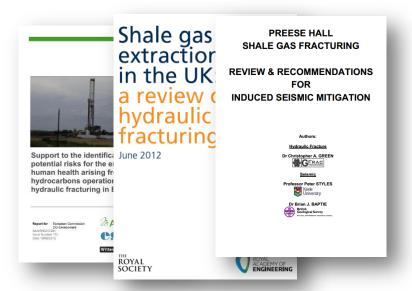


Regulation



Private and Public Sector Research

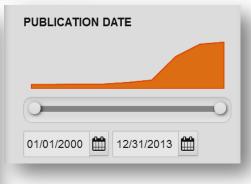












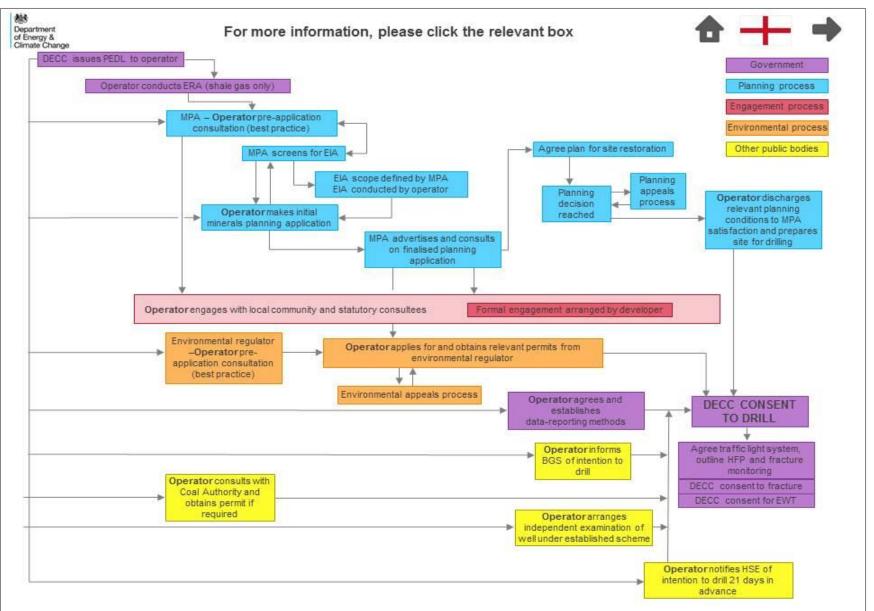
Regulatory Controls



Risk to:	Regulatory Controls
Groundwater	 Water Framework Directive Groundwater Daughter Directive Chemicals used much be in accordance to REACH regulations Abstraction permits (EPR) Borehole integrity checked by HSE
Surface water	 Water Framework Directive Abstraction Permit (EPR) Mining Waste Directive Site design and construction standards regulated by LPA and HSE
Air Quality	 Air Quality Directive Mining Waste Directive Borehole checked by HSE Flaring and Venting authorised by Petroleum Licences (DECC)
Habitats	 Habitats Directive Natura 2000 Environmental Impact Assessment (LPA)

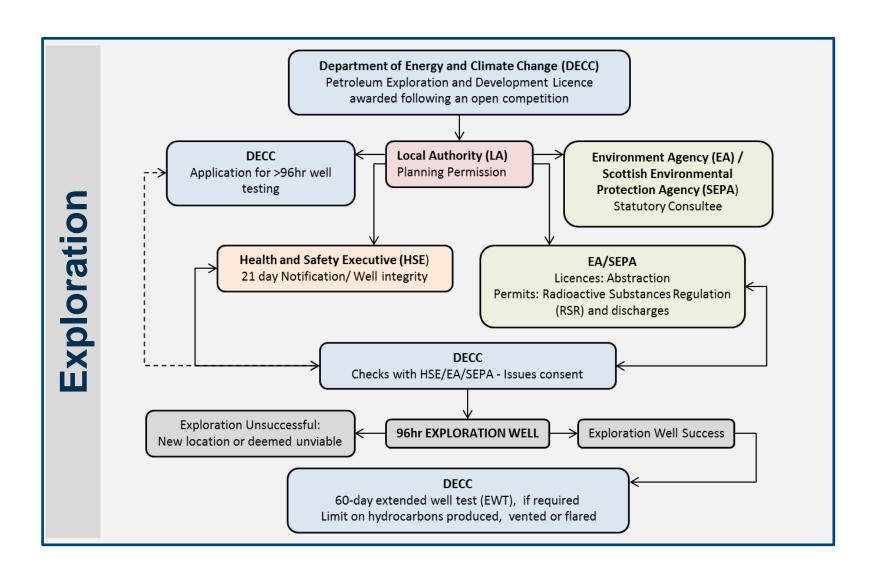
Regulatory Roadmap





Regulatory Network





Summary



 BGS continue to evaluate UK reserves with the Midlands Valley report due to be published in Summer 2014

- Based on annual demand of 8bcm, shale gas reserves from the Bowland-Hodder alone to meet at least 15 years of NG demand
 - However land use, population density, economic viability (and to a degree public support) act as limiting factors to development
 - Considerable variation in wells required and well pad density

 Regulation is adapted from established on onshore conventional gas extraction or deals with issues not isolated to unconventional gas exploration. This continues to be enhanced.





Thank you, I welcome your questions

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