Energy-Redefined

Unconventional Gas in Europe. Where is it going?

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"Unconventional gas—specifically shale gas—is a revolution in the making. "This discovery will change the course of world history" McClendon CEO Chesapeake Energy Dec 2009 - United Nations climate conference Copenhagen.

Forward Looking Views

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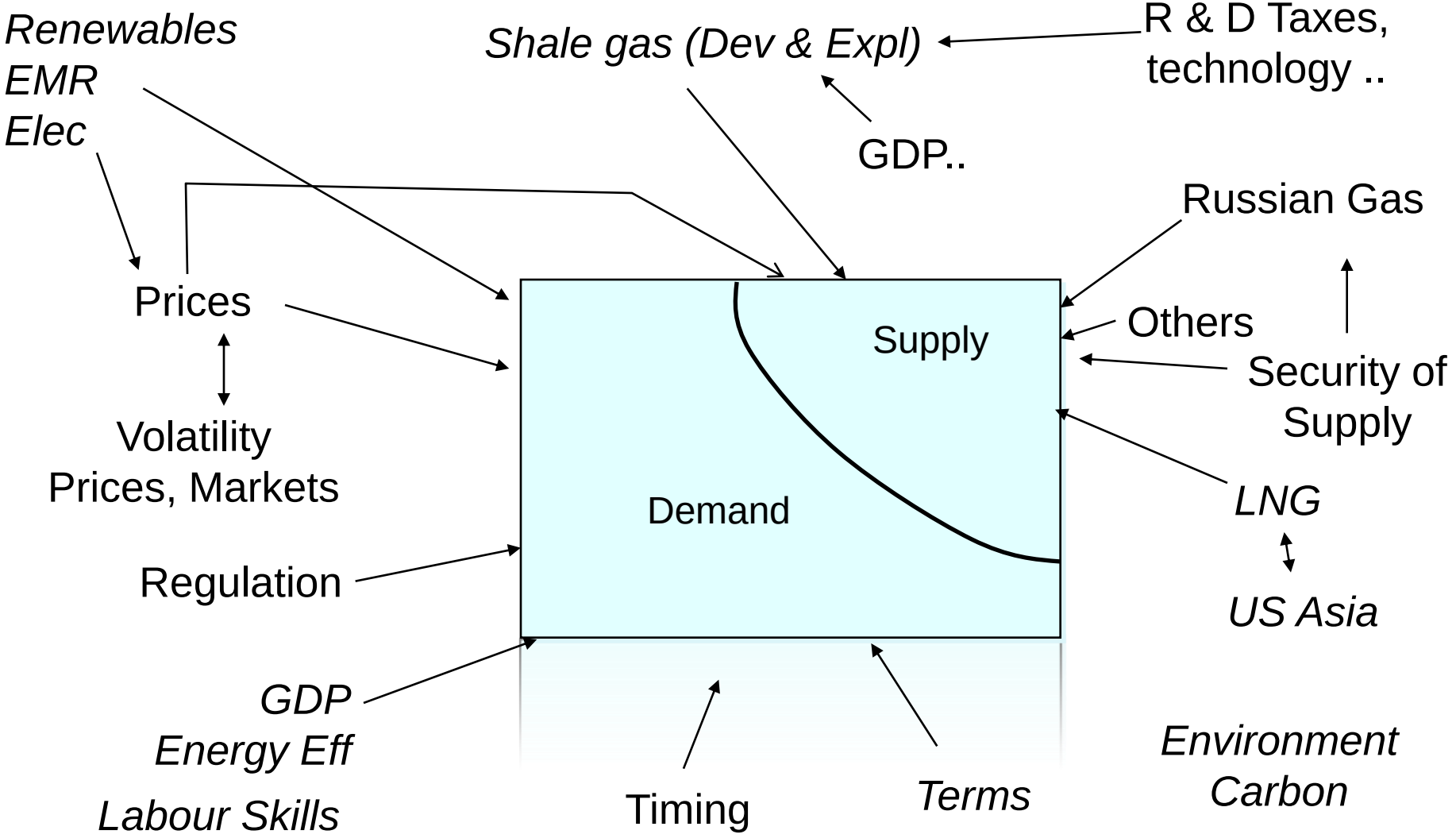
Many Intricate Parts to this Debate



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Introduction

- What is Unconventional gas
- The size of the resource
- The US Experience – and does it apply here?
- US shale gas and Exports
- Unconventional gas - Myths and legends
- Its impact on the environment
- What might future technology do for its deployment
- Our view on price and development impacts

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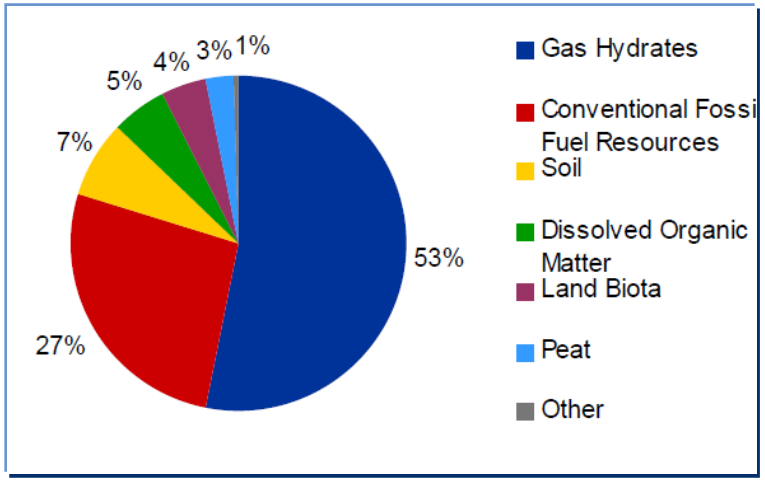
So what's Unconventional Gas

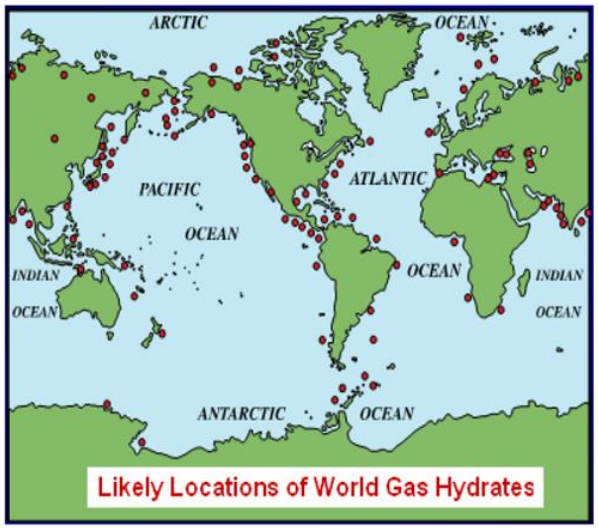
- Natural gas produced from shale is often referred to as 'unconventional' - type of rock type in which it is found.
- Tight sands, shale or coal (CBM) are now the focus of unconventional exploration.
- Conventional' oil and gas refers to hydrocarbons sourced in sandstone or limestone
- Techniques used to extract hydrocarbons are essentially the same.
- Horizontal drilling and fracture stimulation technology can enhance the natural fractures and recover gas from rocks
- Can frac in CBM
- Onshore but also offshore

Hydrates

- Gas hydrates are viewed by some as *the* energy source of the future. These commonly occurring formations have more energy content than the rest of the world's fossil fuel resources combined. Furthermore, they are distributed in every oceanic basin with proximity to nearly every major gas-consuming market of the world.

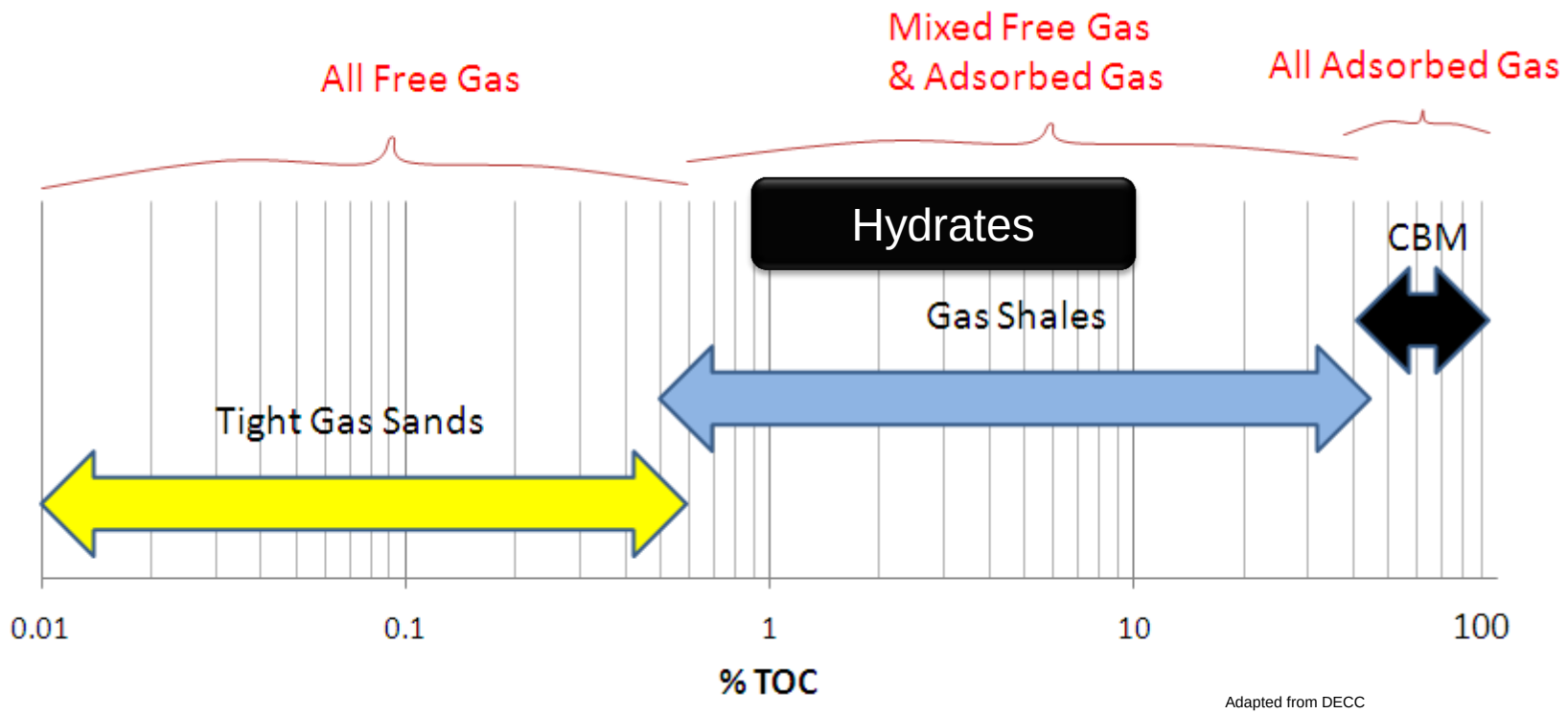
- Hydrates are essentially blocks of ice with methane trapped inside. Conventional drilling techniques have so far proved ineffective due to the physical crystalline structure and relatively shallow exposed areas in which hydrates are often found





Source: USGS

Unconventional Gas Reserves – A wide spectrum



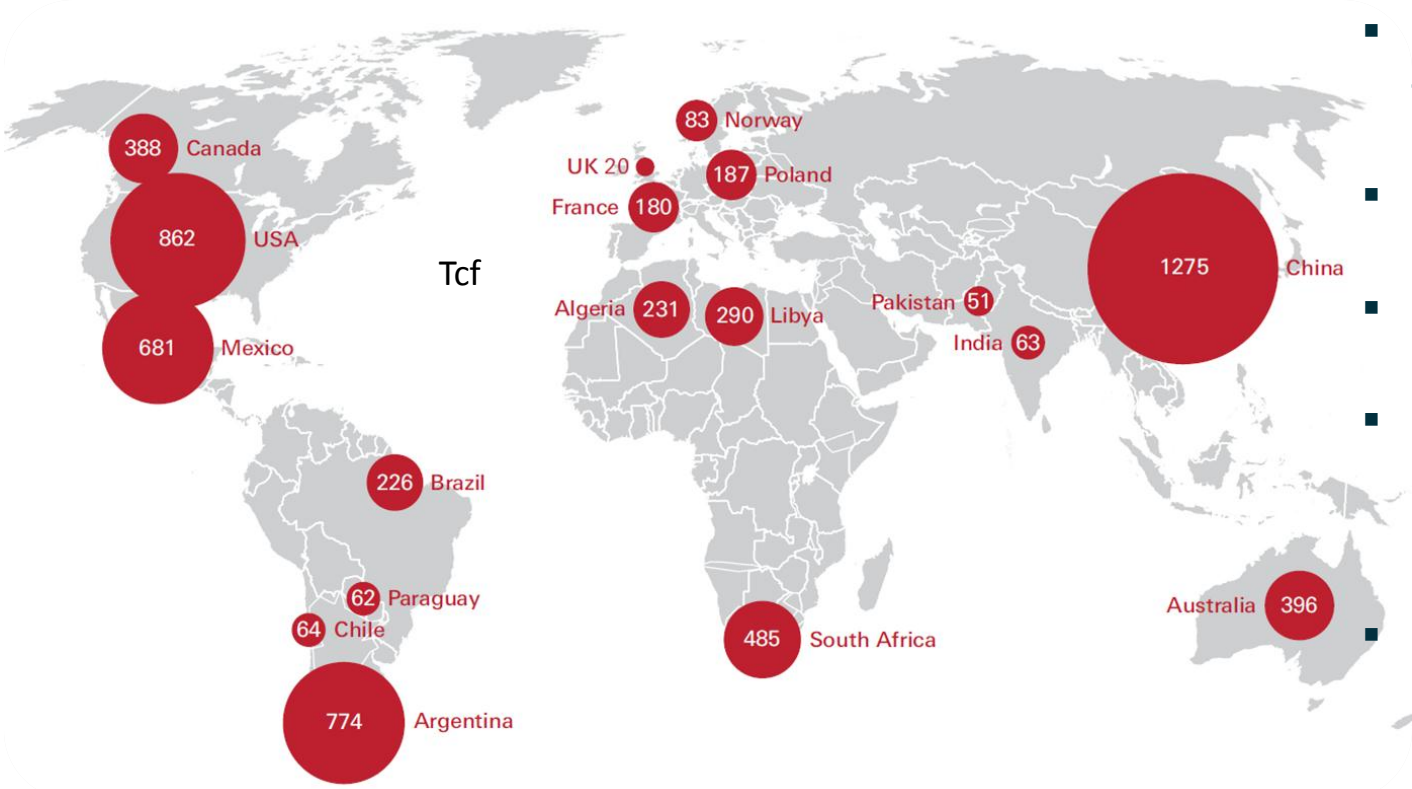
Adapted from DECC

Definitions

- A tight-gas reservoir is commonly defined as is a rock with matrix porosity of 10% or less and permeability of 0.1 milli Darcy or less, exclusive of fracture permeability.
- Unconventional wells produce from low-porosity sandstones and carbonate reservoirs
- Effective bulk permeability in gas shale is typically much less than 0.1 milli darcies (md), although exceptions exist where the rock is naturally fractured. Porosity 0.2-10%*
- Fracture porosity 2-7% effective fracture permeability's 7-35# md

* high end not typical # by experiment

World Resources



- Europe (with Algeria) – similar reserves to USA.
- So could replicate US production profile ?
- Cost structure different
- Shale gas production eyed in 2020 or later in many European areas
- Credible resource estimates in 3-4 years

- Source EIA 2011
- Technically Recoverable

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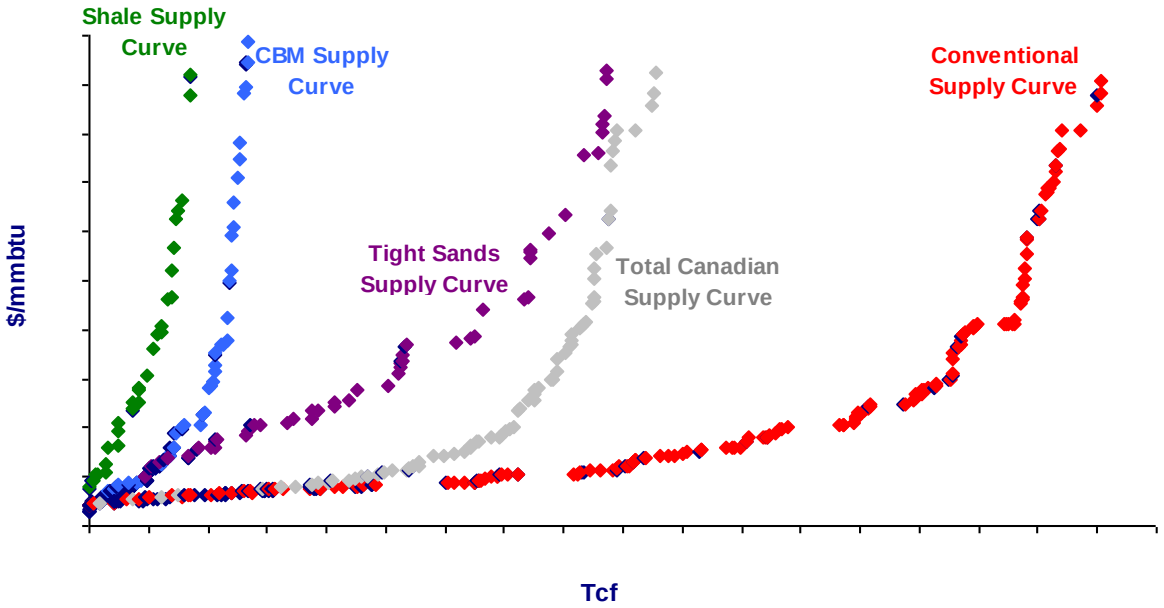
Onshore Non-Conventional Supply

- Price sensitivity is extremely important to un-conventional sources
  - With sustained US gas prices above $4-6/mmbtu, economic gas reserves available in NA could be as high as 400 Tcf (Technical reserves higher)
  - US Shale gas costs in US $5-6/mmbtu – European reserves likely to be much higher because of labor and other costs. Some estimates suggest 8-12$/mmbtu. This is expensive! Maybe higher. Shale is not cheap
  - Euro well $6-14/mmbtu

Hydrates



- Current UK/European gas prices around $9/mmbtu

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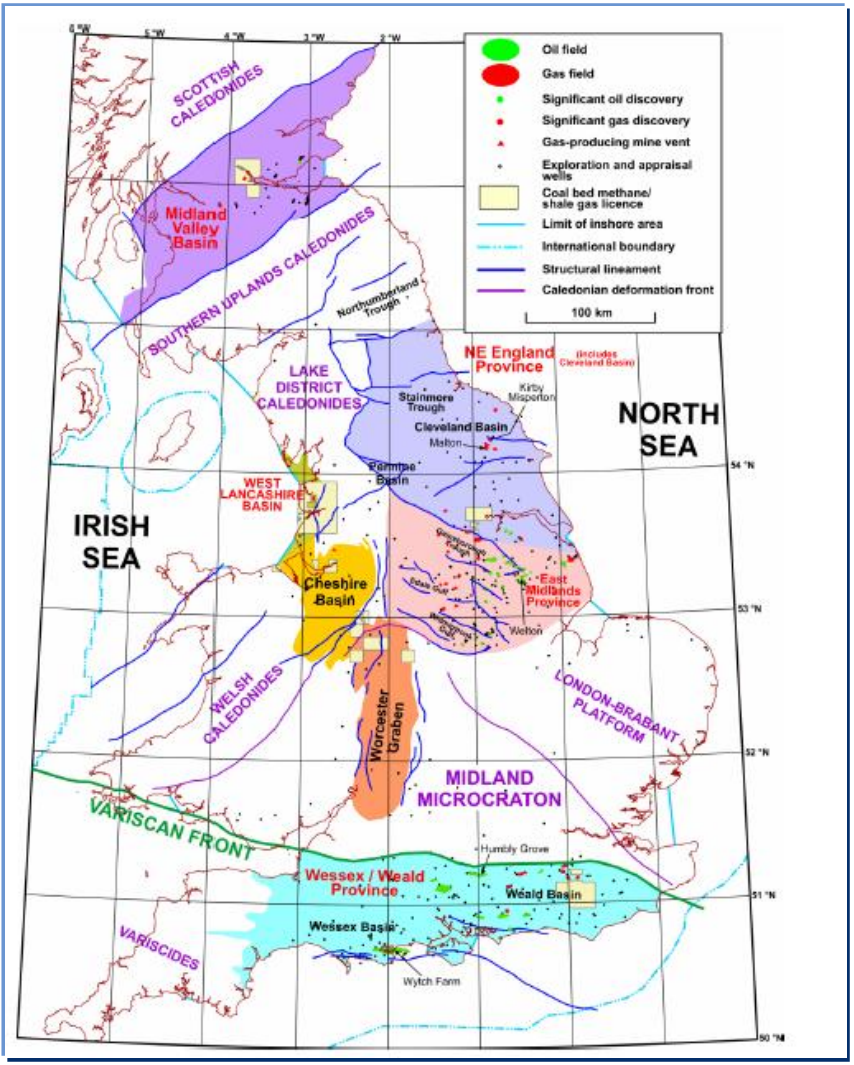
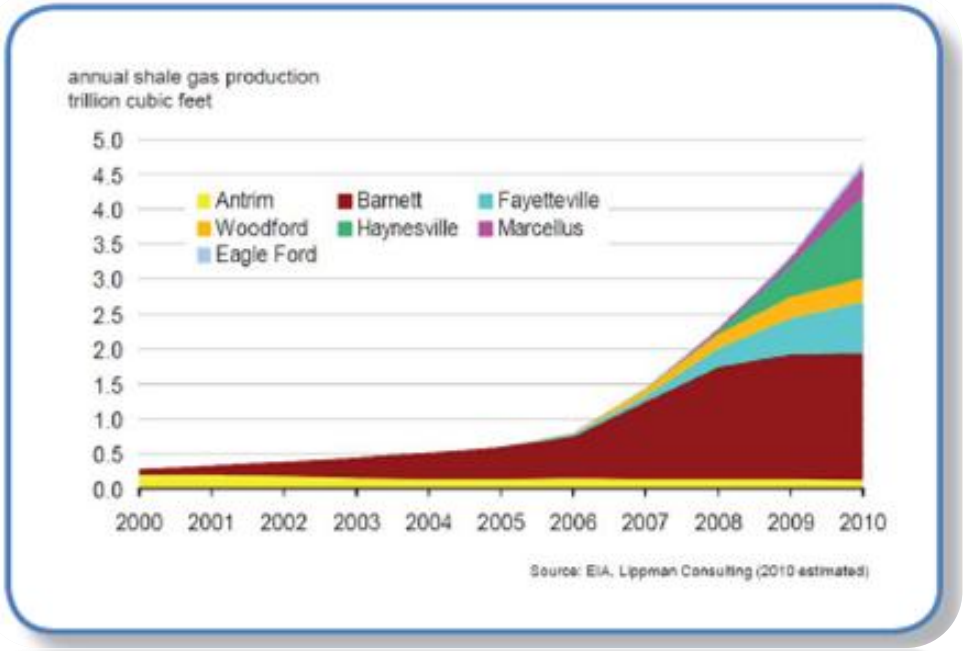
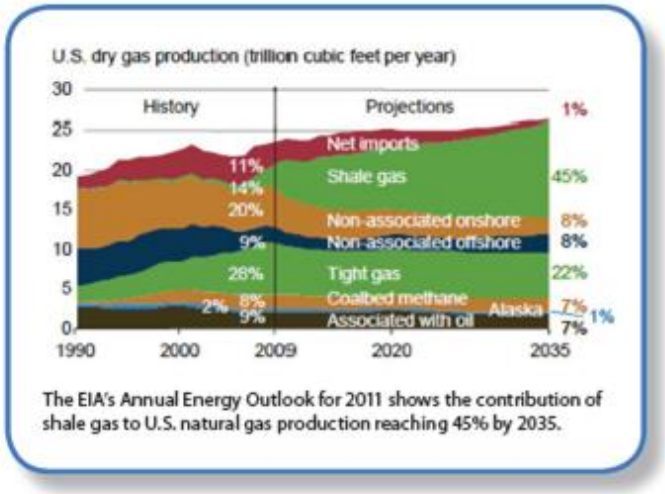
UK Studies – But many other places at same stage



- The lowest risk shale gas exploration is where shale gas prospects are associated with conventional hydrocarbon fields/Exploration
- Used analogies to estimate shale gas reserves – good start but …
- Barnett Shale is probably not a good analogue for the UK
- Wells in the Conasauga Shale play (AL, GA) produce 80-100 mcfd, and are hence not as prolific as in the Barnett or younger shales in the USA.
- While US shale seams are quite thick and relatively easy to access, those in Europe are thin and fractured, making it more difficult to extract the embedded gas.
- Scotland about 10% of 21 Tcf

US Shale Gas Production





EIA Unconventional US production 74%

Shale gas 60% of Unconventional -2035

- 18 times increase in decade
- 12,328 mmscfd (4.5 tcf/yr) 40% more than UK Demand
- 127 Bcm per year

- Might expect it to get to 1100 mmscfd UK if UK ramped up in the same way but
- Circa 11000 -15000 wells

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Key Success Factors for Uncoventionals – Lessons from US

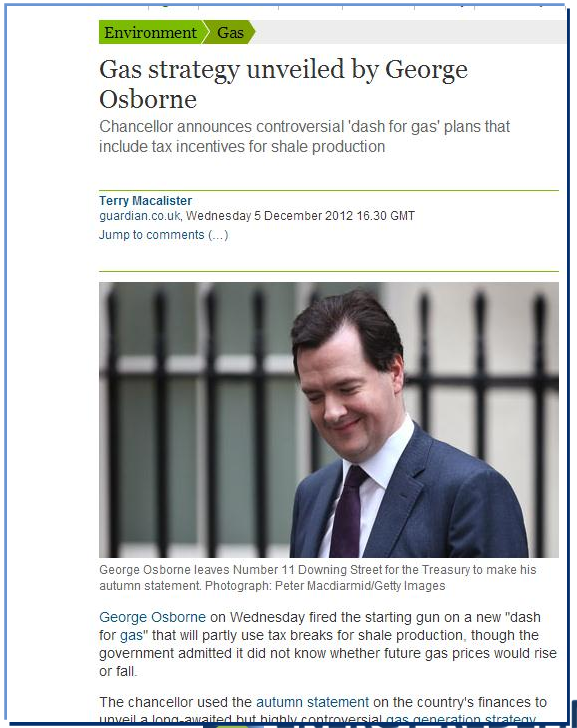
- Relentless search for better technology
- Reduction in operating Costs, Drill times
- R&D commitment
- Tight Spacing's – improves economics
- “Good Reservoir characteristic – high initial flows
- Market access (Prices)
- Water Management (In Europe and more so in the future in US)
- In early years – Govt Support – subsidy – but for how long and at what cost?

- Unlike the US, in most of Europe mineral rights do not belong to private land owners but to the state
- US has a lot of small independent energy companies that are used to taking a risk on these projects

Tax Breaks

- George Osborne has fired the starting gun on a new "dash for gas" that will partly use tax breaks for shale production, though the government admitted it did not know whether future gas prices would rise or fall.

- But what impact?
- Depends on what he does?



Environment › Gas

Gas strategy unveiled by George Osborne

Chancellor announces controversial 'dash for gas' plans that include tax incentives for shale production

Terry Macalister
guardian.co.uk, Wednesday 5 December 2012 16.30 GMT
Jump to comments (…)

George Osborne leaves Number 11 Downing Street for the Treasury to make his autumn statement. Photograph: Peter Macdiarmid/Getty Images

George Osborne on Wednesday fired the starting gun on a new "dash for gas" that will partly use tax breaks for shale production, though the government admitted it did not know whether future gas prices would rise or fall.

The chancellor used the autumn statement on the country's finances to unveil a long-awaited but highly controversial gas generation strategy

US Government Backing. Years of Research

1947: Hydraulic fracturing first used to extract natural gas from limestone.

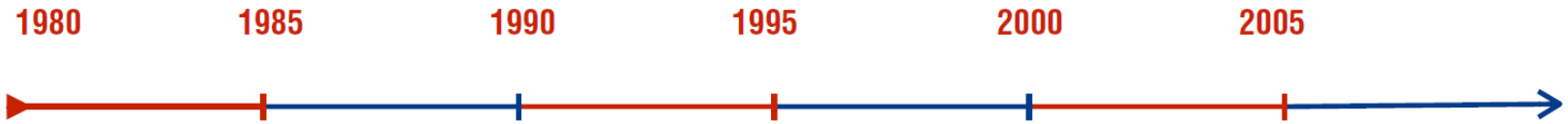
1976: Two MERC engineers patent early technique for directional drilling in shale.

1977: DOE successfully demonstrates massive hydraulic fracturing in shale (MHF).

1980: Congress creates Section 29 production tax credit for unconventional gas (lasts until 2002).

1991: GRI subsidizes Mitchell Energy's first successful horizontal well in the Texas Barnett shale.

2000s: Natural gas generation grows faster than any other energy source; shale gas boom pushes prices to record lows.



1986: First successful multi-fracture horizontal well drilled by joint DOE-private venture in Wayne County, West Virginia.

1998: Mitchell Energy engineers achieve commercial shale gas extraction.

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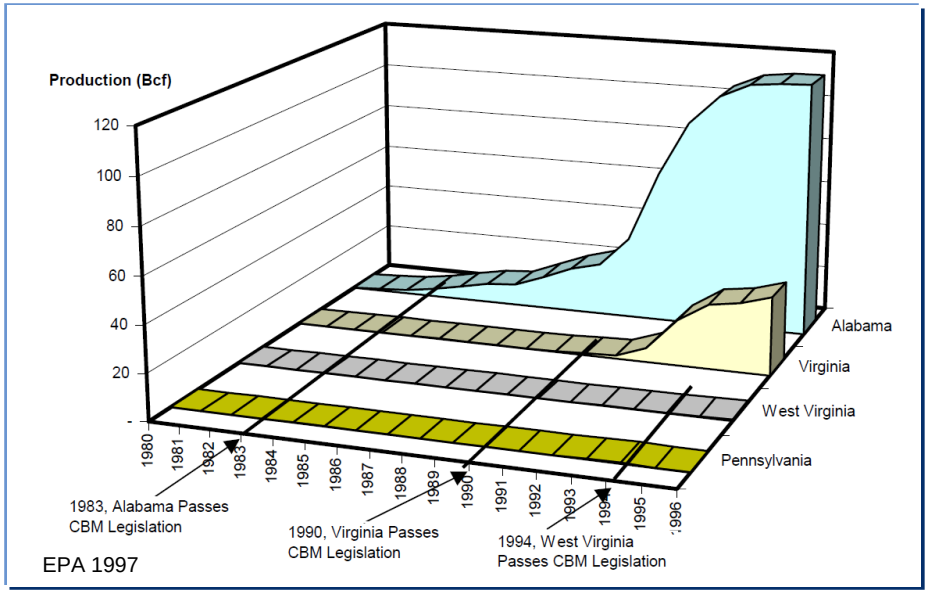
US Tax Breaks

- In 1980, Congress passed the Windfall Profits Tax Act, which among other things created the Section 29 production tax credit for unconventional gas, providing an incentive of $0.50 per thousand cubic feet (Mcf) of natural gas produced from unconventional resources to claim a tax credit equal $3 (in 1978 dollars) per barrel or Btu oil barrel equivalent. Equivalent to $1.50/mmbtu today

- For almost 100 years, two very important tax incentives have been available for businesses that explore for and produce oil and gas: (1) the percentage depletion allowance and (2) the deduction for intangible drilling costs the costs associated with a nonproductive well or “dry hole” (which make up about 80 percent of all wills drilled) are deductible when incurred and can offset other sources of income

Others Experience (NA CBM)

- CBM production began in the early 1980s, fueled primarily by Section 29 of the Federal Windfall Profits Act of 1980 (Non-conventional Fuels Tax Credit) for wells drilled between 1980 and 1992.
- In 1997, the act provided a tax credit of $1.02/mmbtu of CBM recovered, almost half the price of gas at that time.
- In the United States, CBM accounts for almost 10% of total domestic production. In Queensland Australia, it accounts for 30% of production.



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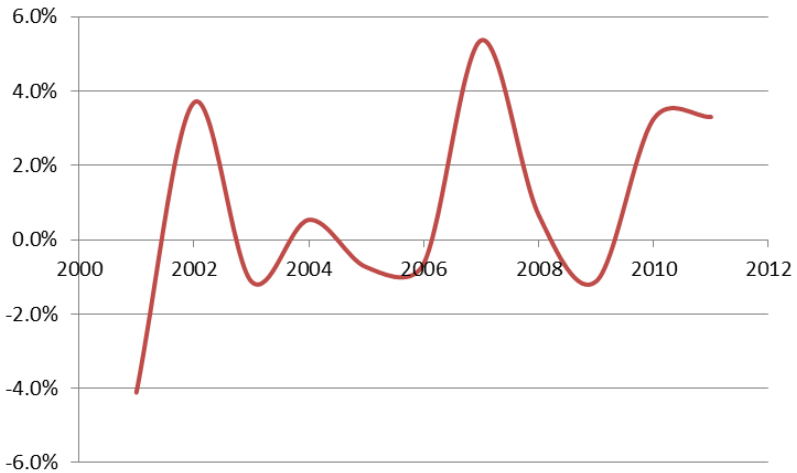
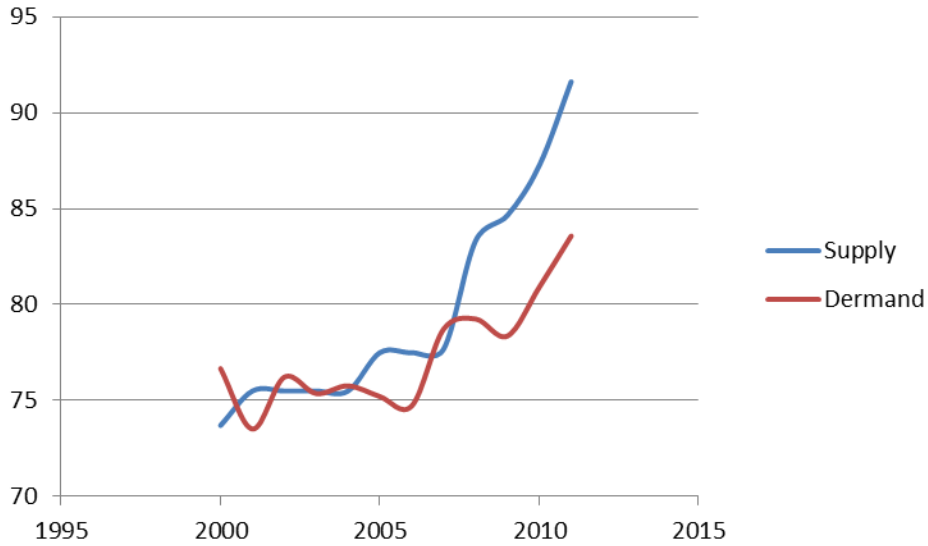
US Supply Demand

- Currently low prices circa $3/mmbtu
- 2014-2015 Supply/Demand back into balance - maybe
- But depends on GDP growth
- Prices Low – not because of cheap shale gas, but oversupply





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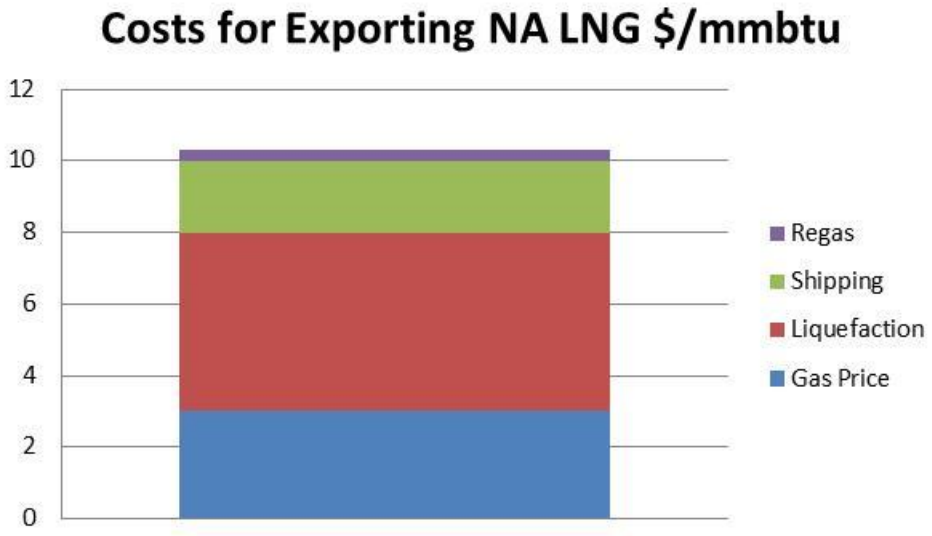
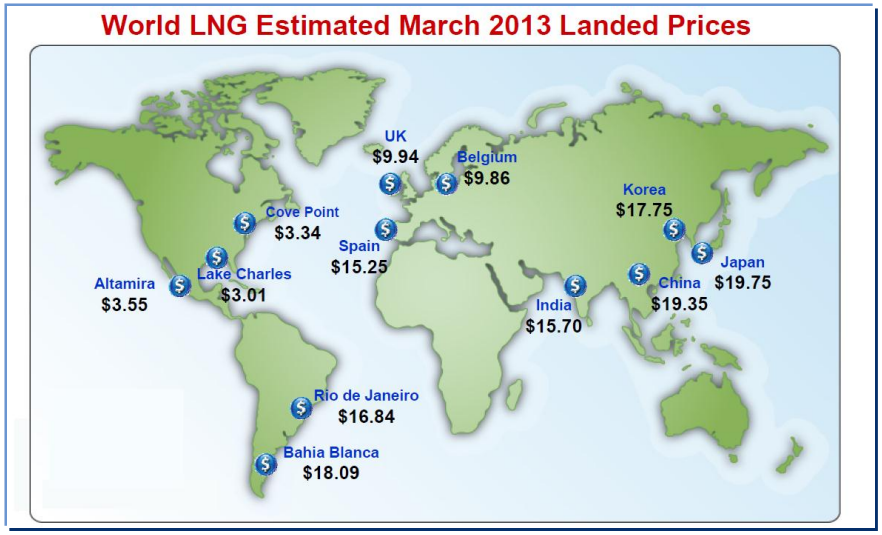
US LNG Exports

- LNG exports would reduce oversupply and raise prices
- Contentious debate in US – not a done deal – need Govt approval
- Exports will improve US prices by $1/mmbtu
- Costs for export are high
- With current Asia prices – Exporters would prefer





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More Myth than Fact ?

- A small U.S. oil co (KS) performed the first commercial frac job on a conventional gas well using 1,000 gallons of napalm as well as sand from the Arkansas River.
- Practice of pumping small volumes (1,000 to 10,000 gallons) of toxic fluid into vertical wells (2,400 feet) using about 600 horsepower of pressure is indeed 60 years old. But …now the Industry:
- Injects millions of gallons of water into wellbores two miles deep
- Uses Horizontal wells
- Pumps to 40,000 hp

Recent Advances

- Only in the last two decades have four different technologies made it possible to fracture deep shale rock formations one to two kilometres underground. They include
  - directional drilling :
  - fracturing fluids including sand, water and toxic chemicals;
  - slick water (the use of gels and high fluid volumes)
  - multi-well pad and cluster drilling (the drilling of six to nine wells from one industrial platform).
- The first horizontal shale gas well was drilled in 1991; the first slick water fracture took place in 1996; and the use of cluster drilling from one pad didn't happen until 2007.

Shale gas fracturing is at best a decade old - based on four new technologies that are still being refined.

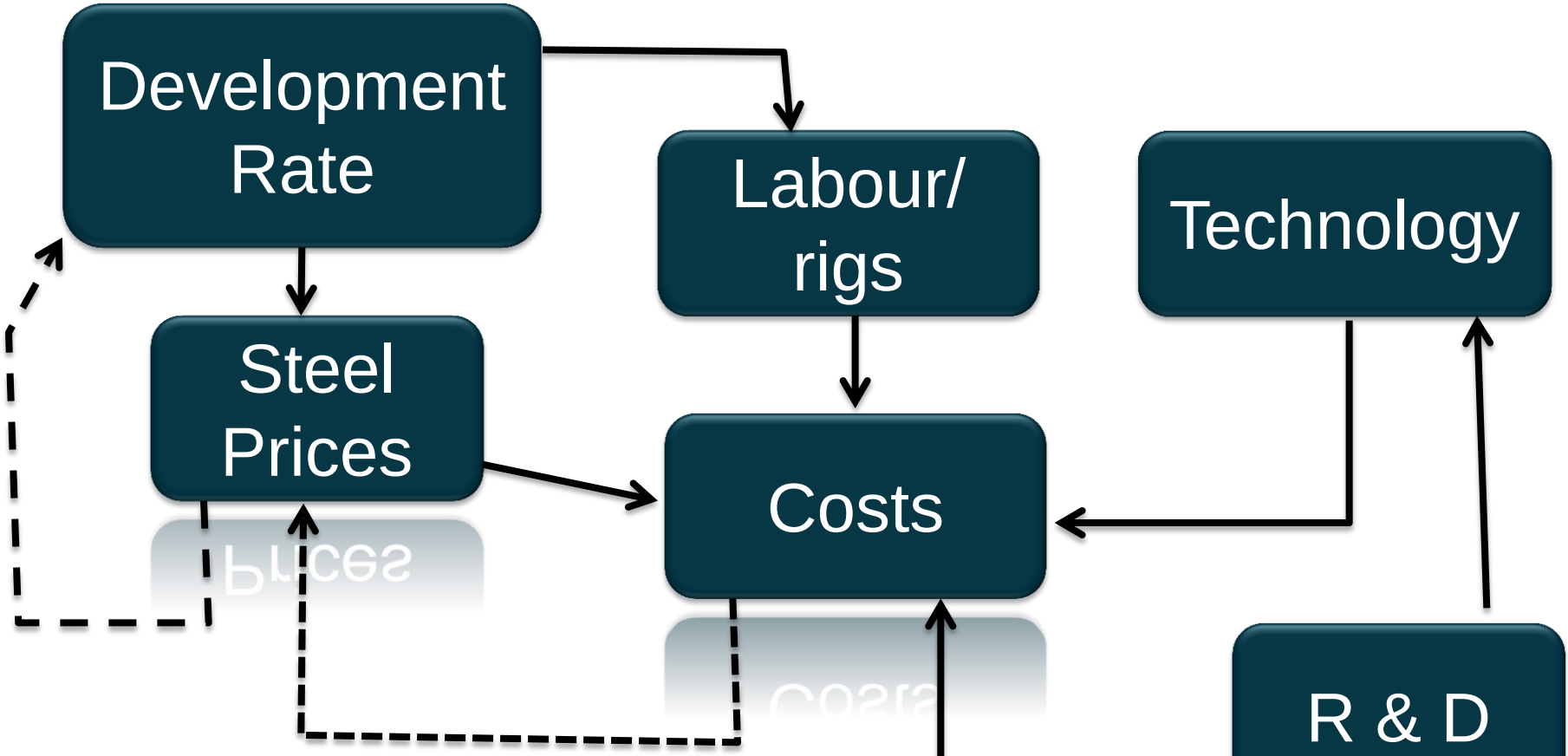
- Until a decade ago it just wasn't possible to open fractures in walls of shale rock 20 metres thick a kilometre under the ground.
- Of 75-100 oil and gas firms in US, only 6-12 had any experience combining all four technologies.
- Research on its impacts is scant. Nor is there a standard operating practice due to its cost
- Given the relative newness of the multi-faceted technology, its health impacts have not been adequately explored either.
- EPA (US) has only just recently started the compilation of a comprehensive fraccing chemical database
- Some of these fluids are proprietary and companies may have an excuse not to disclose

Geological Unknowns and Uncertainties including:

- How Deeply they Penetrate;
- Their Vertical Extents;
- Their Symmetries About the Wellbore;
- Their Geometries At the Perimeter;
- Which Directions They Go;
- What their Conductivities Are.

Makes optimal reservoir engineering difficult

Technology Impact –Other Issues



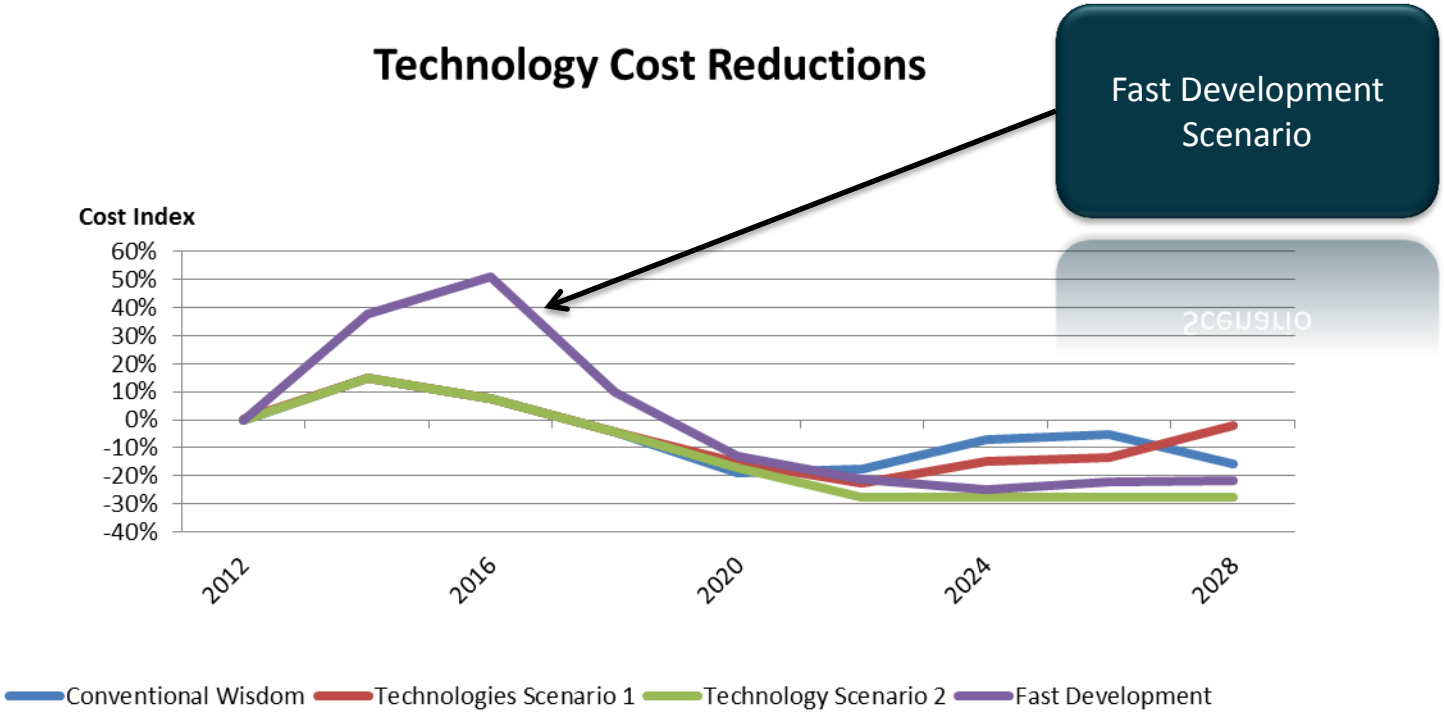
- Technology has reduced drill times and costs dramatically
- But other factors at play could counteract these gains

Technology Focus USA

- Micro generation
- process to convert ethane to petrochemicals
- process for converting natural gas to Dimethyl Ether(DME) as a transportation fuel
- Flowback water filter press treatment system for shale wastewater
- hydrocarbon and cement integrity detection for groundwater and the freshwater casing
- dust control technology for existing sand equipment
- Microchannel Fischer Tropsh natural gas to liquid fuel well head application
- Rotary compressor that allows natural gas & NGL to be piped together from the well head
- Sequential precipitation and fractional crystallization treatment of shale wastewater
- Mobile real-time site monitoring and security

Note: Focus on access issues

So What Could Technology Do. (With Steel and Rig Price Adjustments)



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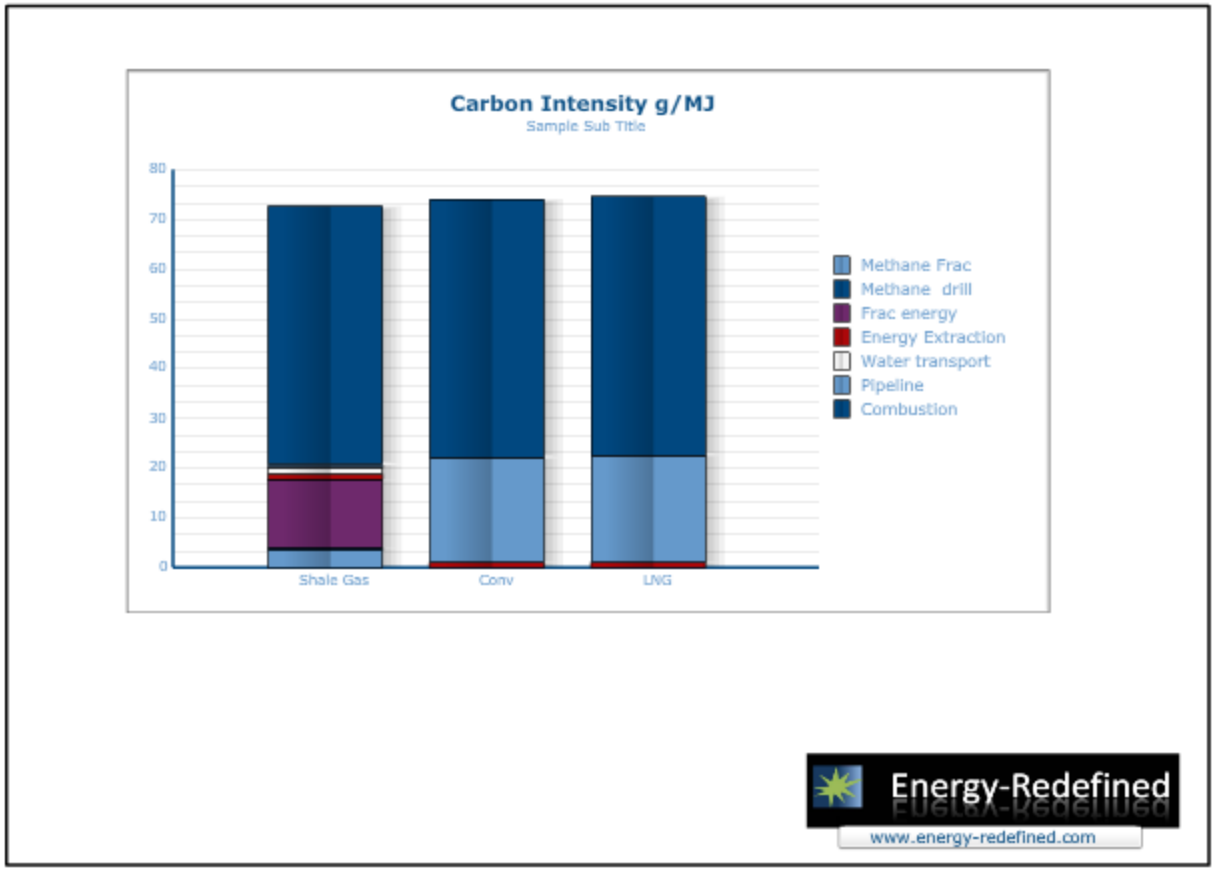
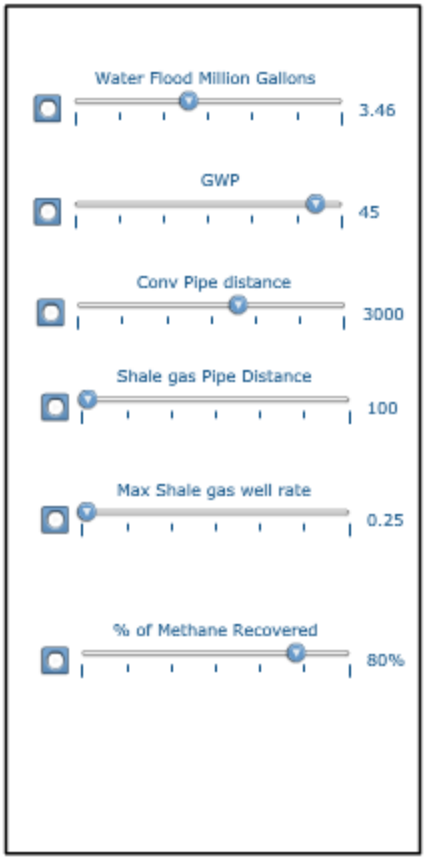
Environmental

- Methane Capture
- Water Treatment
  - Infrastructure major problem in US
- Well Spacing - Rockies
- Is shale more Carbon intensive than other
- Earthquakes
- Robert Howarth Cornell Methane Leakage at Shale

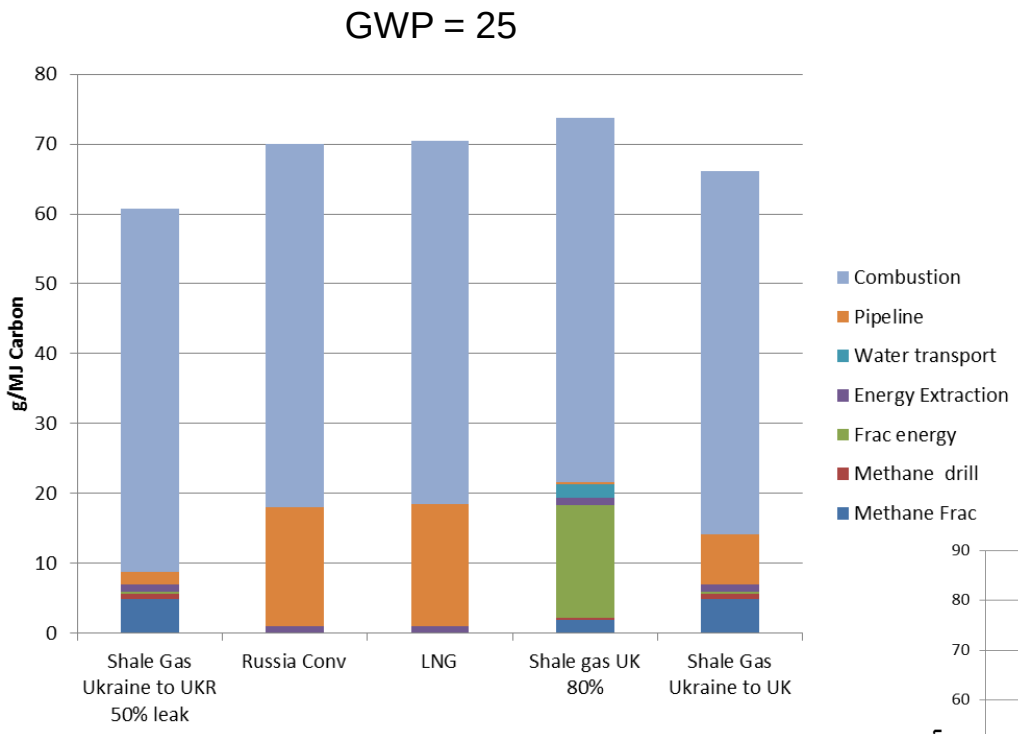
Shale Vs Conventional Gas



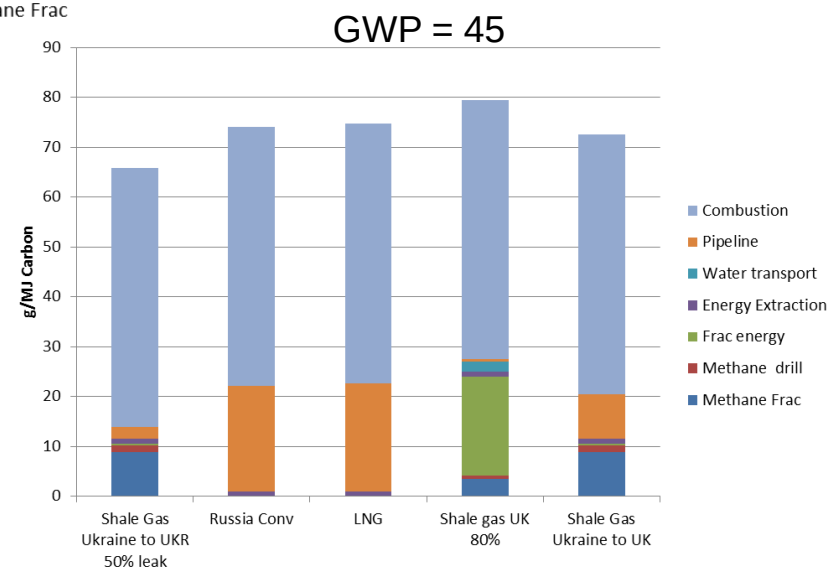


Move Sliders to change assumptions
Full screen view required

Shale Vs Conventional Gas



- Well productivity Key
- Might be better environmentally to take gas from Ukraine
- Shale UK Upstream emissions up to 33% higher



Seems that from an Environmental point of view that shale gas from Ukraine to the UK would be better than local shale gas. Of course this does not consider the economics of the fields

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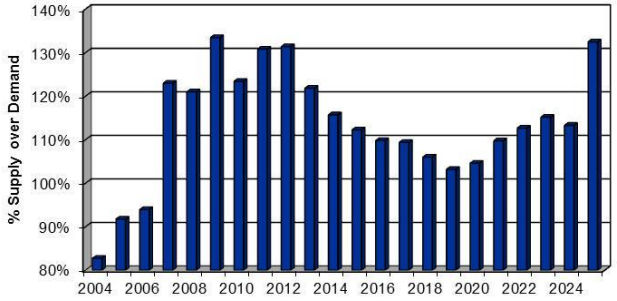
European Gas Prices – higher European gas demand Scenario

- All depend on your views about shale gas costs, European demand and oil prices. At one extreme costs could be significantly higher than LNG prices
- Pricing to Oil index helps Shale



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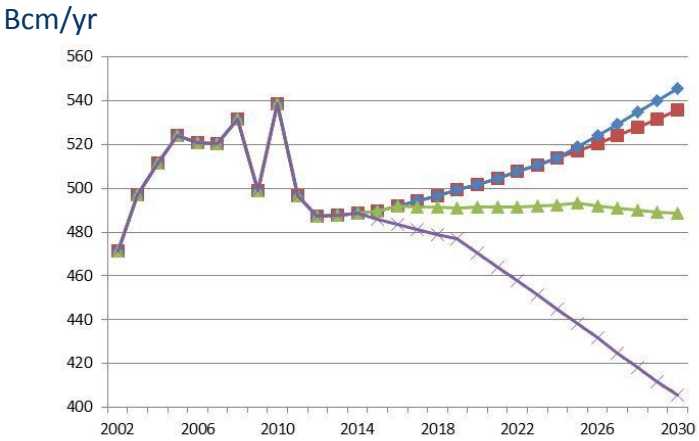
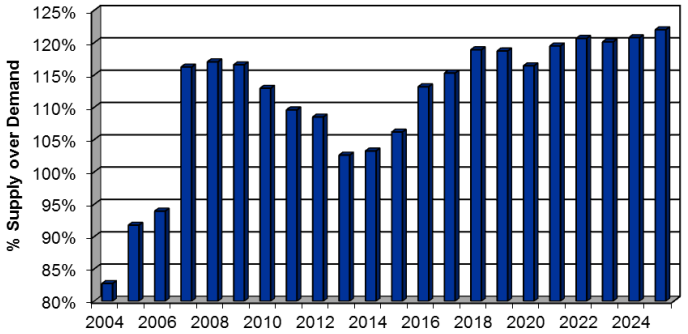
European Gas Scenario – Low demand Scenario





- Difficult to justify Shale in scenario where demand falls – i.e. a green renewable scenario.
- Both price scenarios suggests shale will reach 20% of potential – That would mean the UK might reach 200 -400 mmscf. Circa 2-5% of demand
- Lock out game to be played

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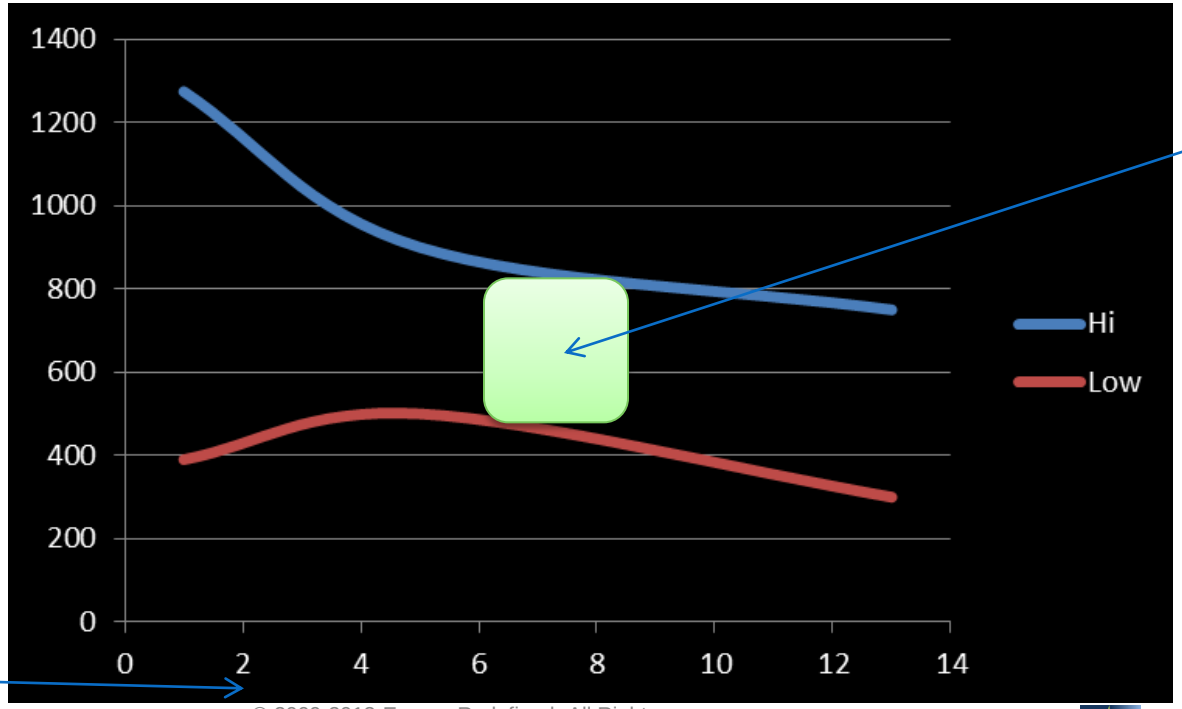
Jobs

- Lots of uncertainty in forecasts. Recent US forecasts seem high
- New jobs or redeploy – not all new jobs!!!
- 25-50,000 latent potential jobs in the UK Shale, many more in Europe
  .
- Scottish Companies well placed – if move first

000's jobs Direct and Indirect



Europe

Productivity of area

UK US UKR

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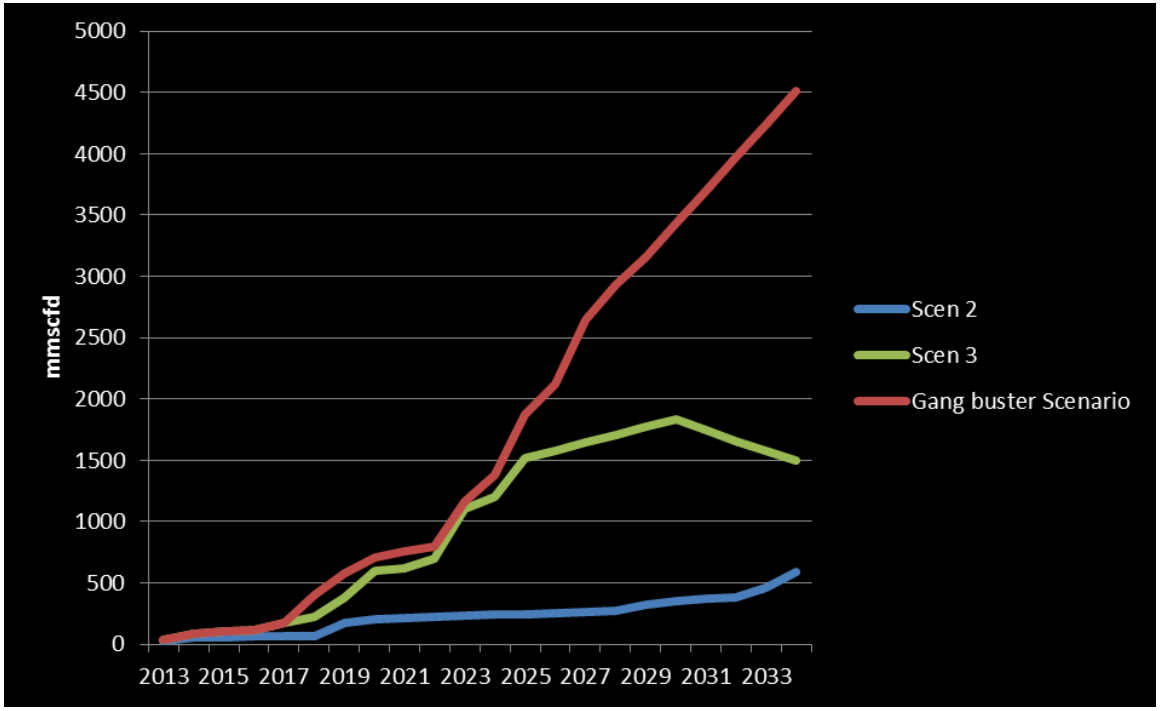
So what does this mean for Europe?

- Too early to tell – Need more well data
- Depends on assumptions such as the actual well productivities, oil indexation, Russian response, tax breaks etc… amongst other things
- Created three production scenarios based on a variety of assumptions as listed above:



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Summary

- In the short term shale gas is not going to be the saviour of UK or European gas
- Russia is not going to stand idle whilst shale is developed. Russia has Shale too, but its gas is comparatively cheap
- Skills an issue – A learning curve to climb
- Going to be complex but an opportunity. Need to start sooner rather than later but with care
- Too soon to make concrete predictions - Shale still not well understood
- Prices ie economics will be a big determinant of Shale gas development. It is not cheap gas.
- Water disposal and Environmental concerns need to be adequately addressed

Summary 2

- Governments should consider R & D funding not subsidizing small plays
- Theoretically Europe could produce some 30,000 mmscfd (~300 BCM) of shale gas by 2040/2050. But at what price? And will they be allowed to. Prices indicate that only 20% of the potential might be produced
- By that time Hydrates may be a more interesting contender – but its fate will depend on technology innovations and breakthroughs
- Focused on Onshore – Offshore would be interesting
- Shale's with higher flows will obviously be more competitive.
- Security of supply – not discussed – but may be a driver for Shale Development. What is the Value we should put on this

Thank You

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"Chesapeake Energy is the largest stakeholder in the Utica shale, with the company and its CEO McClendon betting the proverbial farm that Nat gas is about to become the nation's preferred source of energy. Chesapeake CEO Aubrey McClendon is no stranger to controversy
According to some estimates the Utica Shale may contain 38 trillion cubic feet of undiscovered gas."

From Riches to Rags?

"Chesapeake Energy Corp. disclosed Monday that it will not give CEO Aubrey McClendon a bonus for last year and it is limiting his use of company aircraft. Chesapeake has also been struggling financially, due in part to a plunge in natural-gas prices. It has cut jobs, sold assets and disclosed in a regulatory filing Monday that it is substantially reducing its executives' annual incentive compensation for 2012.