The Impact and Potential Repercussions of Unconventional Hydrocarbons in the UK Market.

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What are unconventional hydrocarbons?

Shale Gas

Tight Oil

Coal Bed Methane

What are unconventional hydrocarbons?

Shale Oil

Tar Sands

Deep natural gas

Geopressurized zones

Methane Hydrates

Do (unconventional) hydrocarbons have a future?

"The Stone Age didn't end for lack of stone, and the oil age will end long before the world runs out of oil.“

- Sheik Ahmed Zaki Yamani (Saudi Oil Minister)

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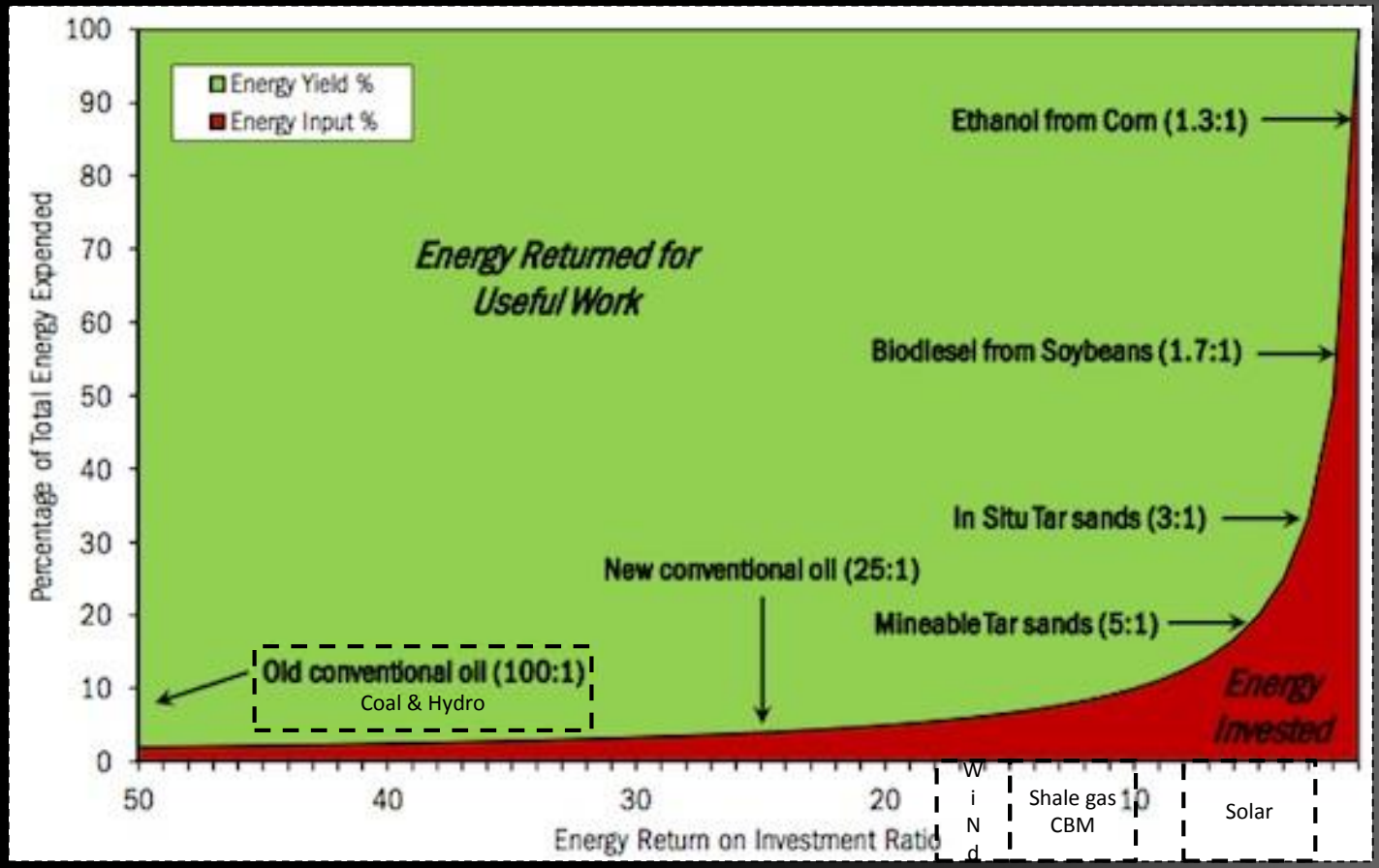
Energy returned on energy invested. (EROEI)



Reference: Drill, Baby, Drill J David Hughes Post Carbon Institute 2013.

Wind Power.

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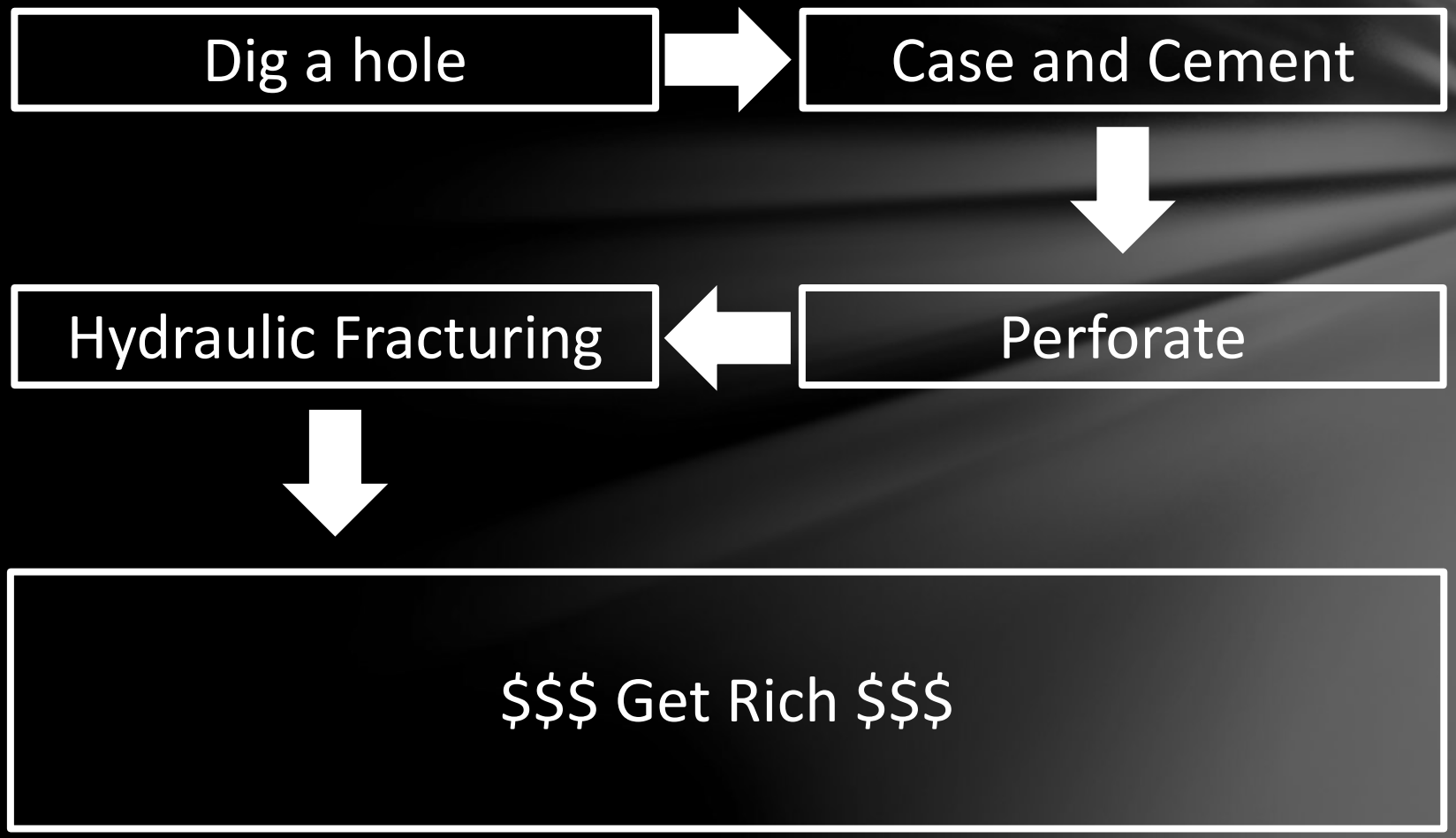
Solar power.

The shale gas ‘revolution’.



Where are shale gas and tight oil?

Numbers are in Tcf

Reference: *USEIA 2011a; Bickle et al. 2012*

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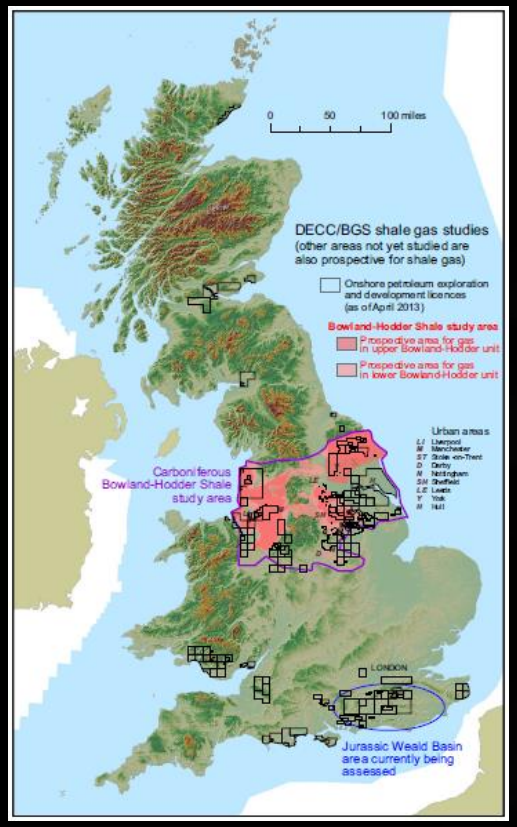
Where are shale gas and tight oil?



	Total Resources	Technically Recoverable
Bowland Gas study	822 < 1329 < 2281 Tcf	N/A
USEIA June 2013	623 Tcf	26Tcf
Tight Oil USEIA June 2013	54Bbbl	0.7Bbbl

Reference: Andrews, I.J. 2013. *The Carboniferous Bowland Shale gas study: geology and resource estimation*. British Geological Survey for Department of Energy and Climate Change, London, UK.

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Shale gas and tight oil Extraction.

Low permeability formation

Requires hydraulic fracturing

- Long established – historical overview
  - 1947 – Halliburton, first hydraulic fracturing
  - 1949 – Halliburton patent granted
  - 1952 – First hydraulic fracturing in soviet union
  - 1955 – First hydraulic fracturing in Europe (Schleswig-Holstein, Germany)
  - 1982 – First hydraulic fracturing in UK

Hydraulic Fracturing Job Circa 1950

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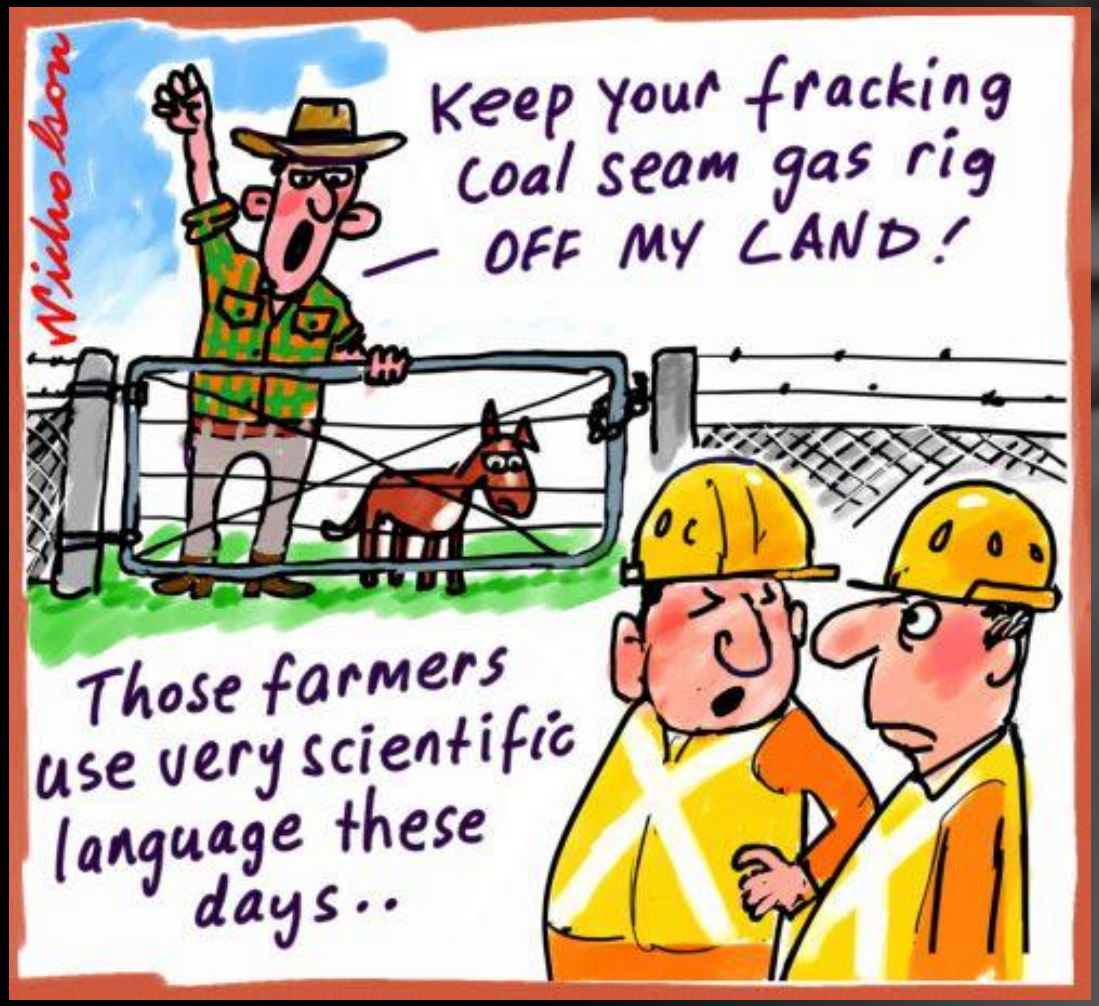
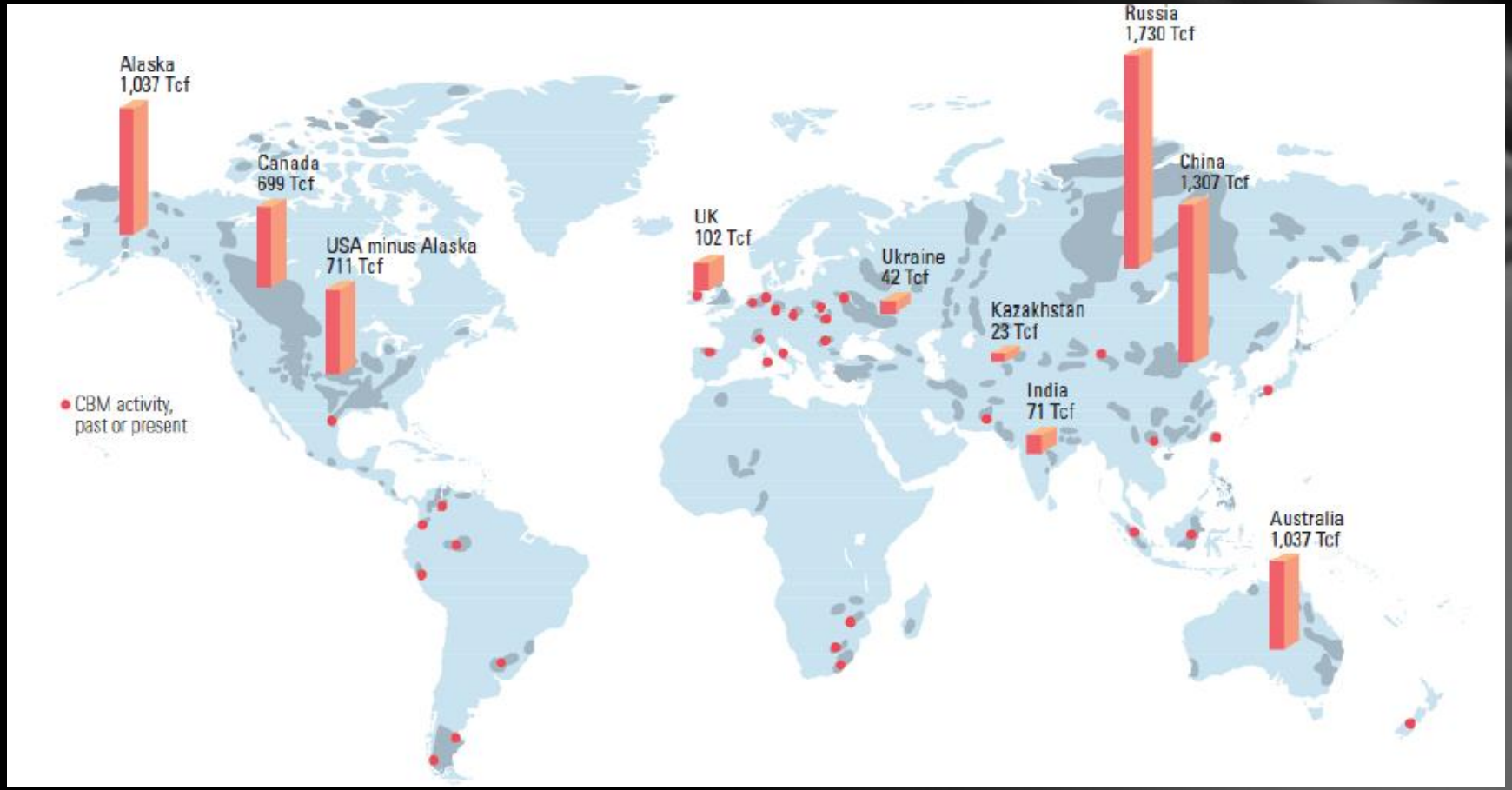
Hydraulic fracturing.

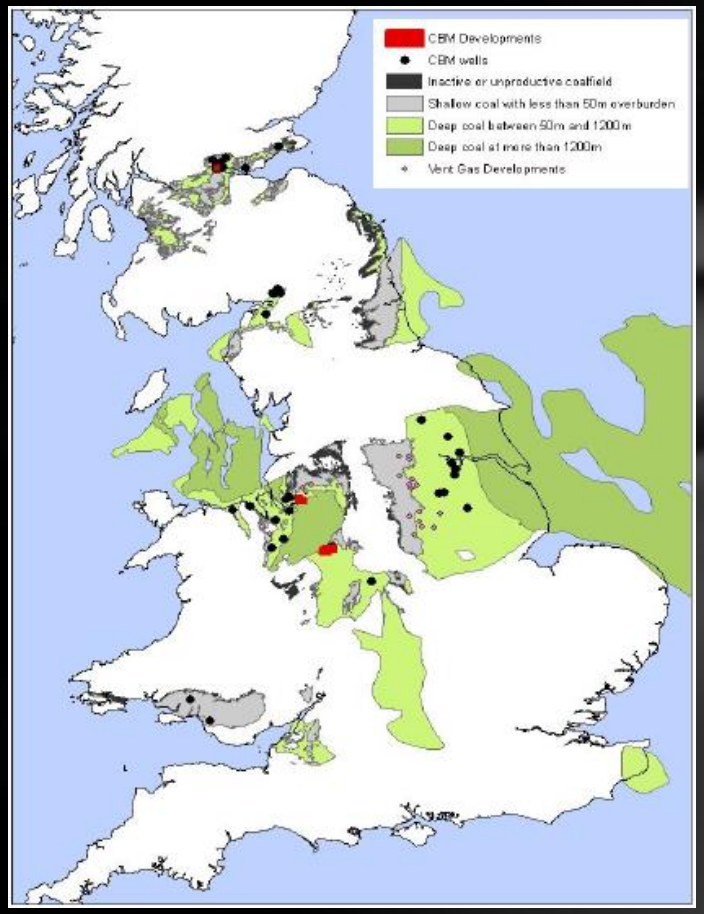


Where is coal bed methane?



Reference: US DOE, reference 3, and BP Statistical Review, reference 5.

Where is coal bed methane?



Reference: Department of Energy and Climate Change 2012

Coal bed methane extraction.

Methane is adsorbed to coal, held in micro-pores

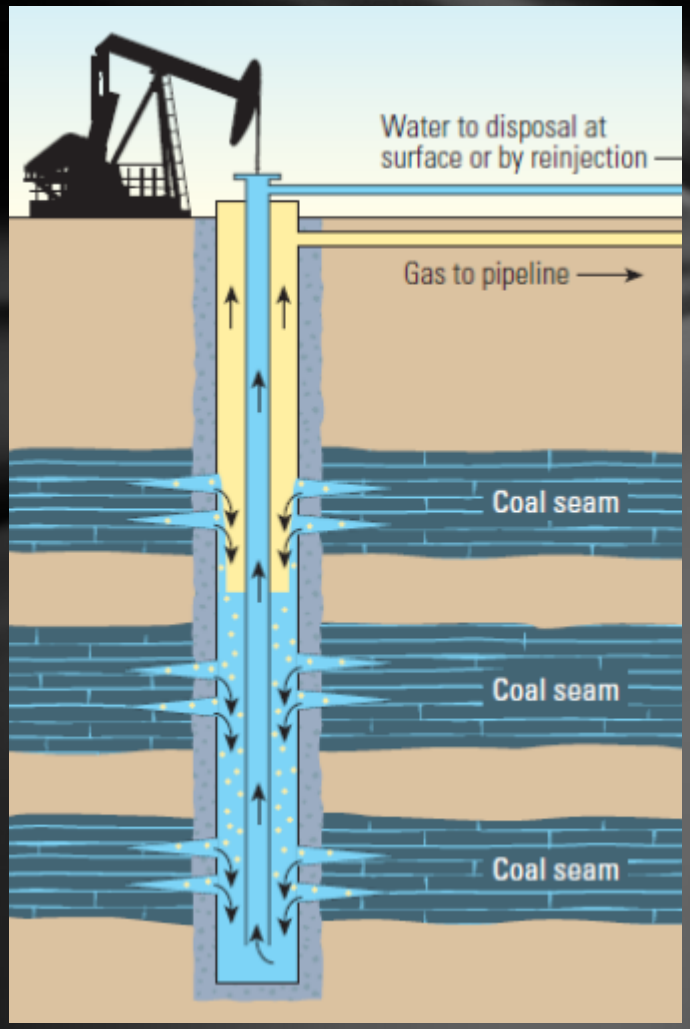
CBM reserves typically exhibits low permeability

Can be highly fractured already.

Water is produced to lower formation pressure and de-adsorb methane.

Gas production rates initially increase over time

Productive life span can be decades



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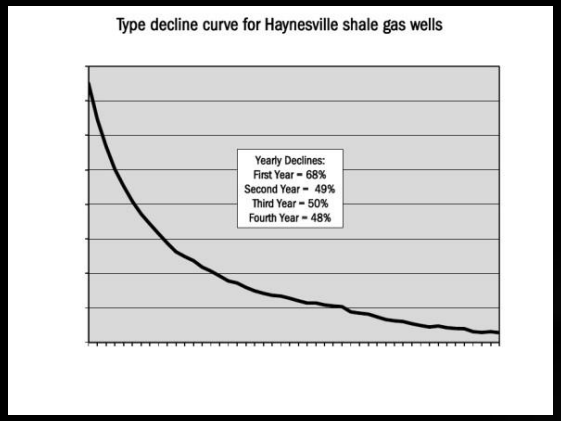
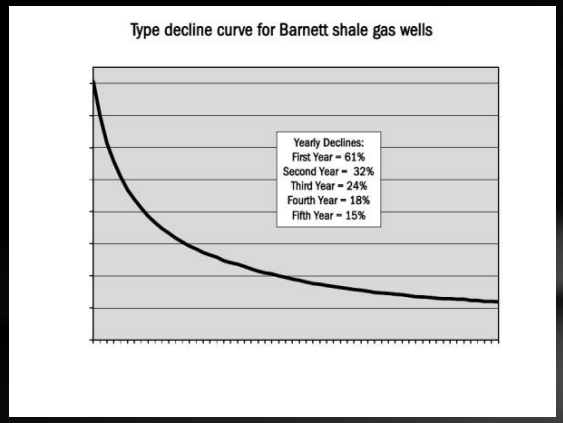
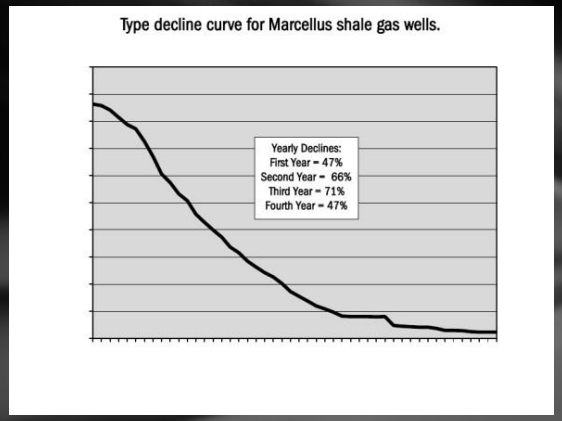
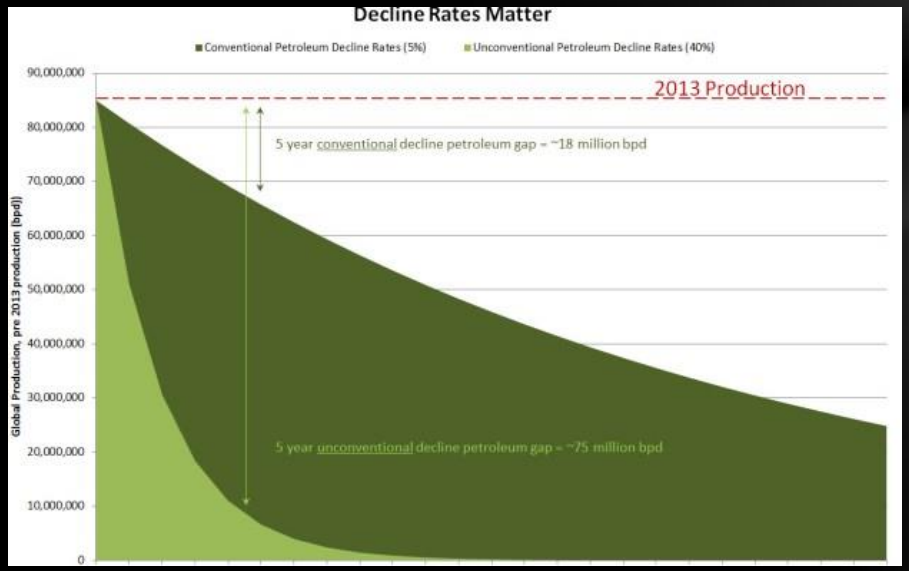
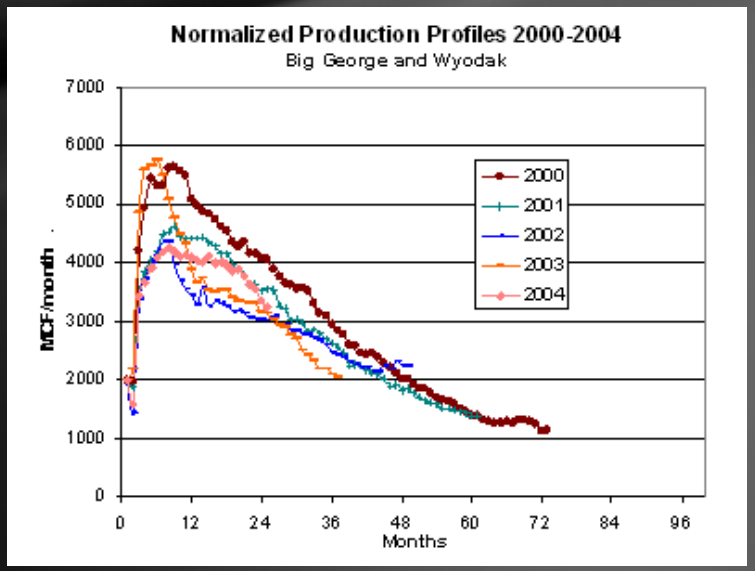
Shale gas vs CBM decline rates.











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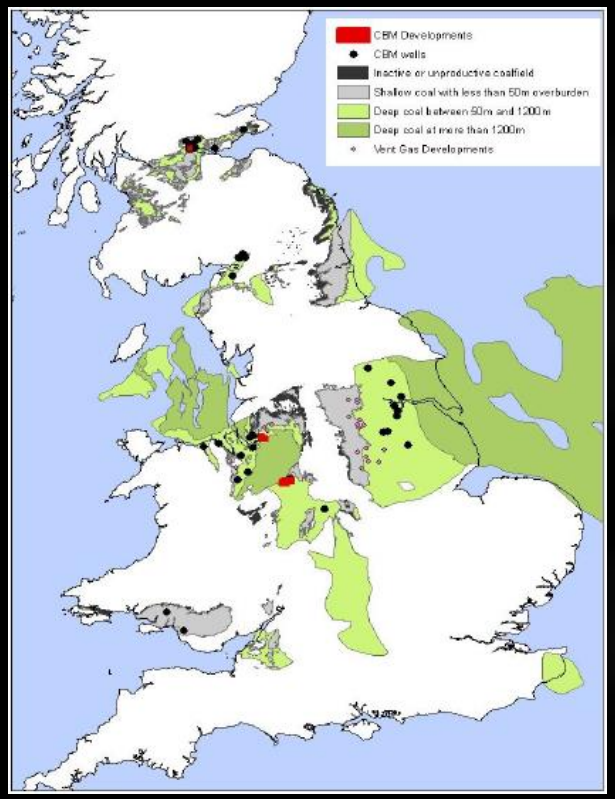
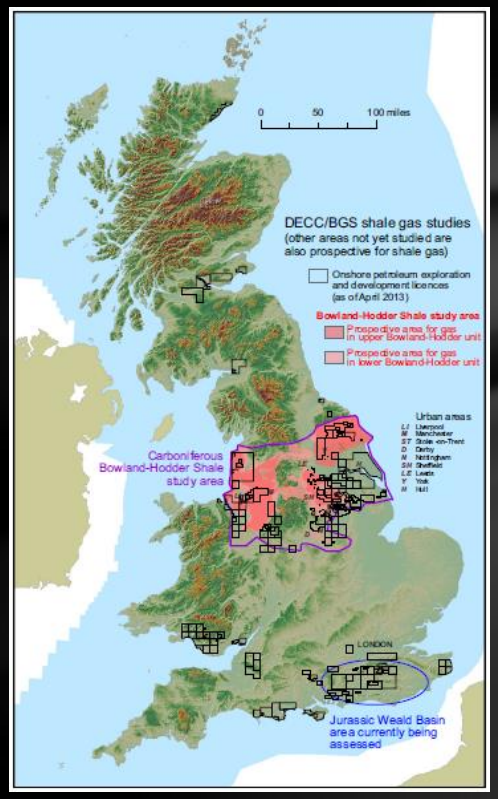
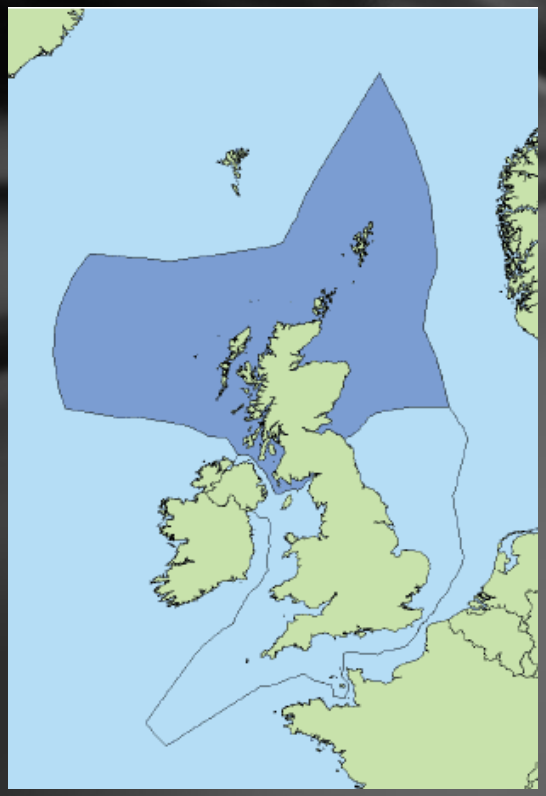
Reserves overview







Reference: BBC April 2013

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The US shale gas ‘revolution’.

How did it come about?

- Combination of horizontal drilling and
- Hydraulic fracturing

US became net hydrocarbon exporter July 2013

- Coal
- LNG

Is this case study transferable to the UK market?

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UK US key differences.

Mines and mineral rights

UK

- Petroleum (Production) Act 1934
- 1994 Coal Authority
- 1998 Petroleum Act

US Lease system

Star Energy UK Onshore Ltd vs Bocardo SA (2010)

Star Energy UK Onshore Ltd vs Bocardo SA.

Star drilled three wells into the Palmers Wood field crossing the Bocardo estate.

Minimum depth 800ft

Initial incursion in 1990

Trespass case raised in 2006 after 1,000,000bbl produced

High Court awards damages of £621,180

Appeal reduced award to £1000

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The case against unconventional hydrocarbons in the UK.

‘Fracking’ safe?

Water contamination

Water Usage

Earthquakes

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Hydraulic fracturing chemicals – is it safe?

Product	Purpose	Downhole Use	Other common uses
Acid	Helps dissolve minerals and initiate cracks in the rock	Reacts with minerals present in the formation to create salts, water and carbon dioxide (neutralized).	Swimming pool chemical and cleaner
Corrosion inhibitor	Prevents the corrosion of the pipe	Bonds to metal surfaces (pipe) downhole. Any remaining product not bonded is broken down by micro-organisms and consumed or returned in produced water.	Used in pharmaceuticals, acrylic fibers and plastics
Iron control	Prevents precipitation of metal (in pipe)	Reacts with minerals in the formation to create simple salts, carbon dioxide and water all of which are returned in produced water.	Food additive; food and beverages; and lemon juice
Antibacterial agent	Eliminates bacteria in the water that produces corrosive by-products	Reacts with micro-organisms that may be present in the treatment fluid and formation. These micro-organisms break down the product with a small amount of the product returning in produced water.	Disinfectant; Sterilizer for medical and dental equipment
Scale inhibitor	Prevents scale deposits downhole and in surface equipment	Product attaches to the formation downhole. The majority of product returns with produced water while remaining reacts with micro-organisms that break down and consume the product.	Used in household cleansers, de-icer, paints and caulk
Clay stabilizer	Prevents formation clays from swelling	Reacts with clays in the formation through a sodium-potassium ion exchange. Reaction results in sodium chloride (table salt) which is returned in produced water.	Used in low-sodium table salt substitute, medicines and IV fluids
Friction reducer	"Slicks" the water to minimize friction	Remains in the formation where temperature and exposure to the "breaker" allows it to be broken down and consumed by naturally occurring micro-organisms. A small amount returns with produced water. Generally returned with produced water, but in some formations may enter the gas stream and return in the produced natural gas.	Used in cosmetics including hair, make-up, nail and skin products
Surfactant	Used to increase the viscosity of the fracture fluid		Used in glass cleaner, multi-surface cleansers, antiperspirant, deodorants and hair-color
Gelling agent	Thickens the water in order to suspend the sand	Combines with the "breaker" in the formation, thus making it much easier for the fluid to flow to the borehole and return in produced water.	Cosmetics, baked goods, ice cream, toothpaste, sauces and salad dressings
Breaker	Allows a delayed break down of the gel	Reacts with the "crosslinker" and "gel" once in the formation, making it easier for the fluid to flow to the borehole. Reaction produces ammonia and sulfate salts which are returned in produced water.	Used in hair coloring, as a disinfectant and in the manufacture of common household plastics
Crosslinker	Maintains fluid viscosity as temperature increases	Combines with the "breaker" in the formation to create salts that are returned in produced water.	Used in laundry detergents, hand soaps and cosmetics
pH Adjusting Agent	Maintains the effectiveness of other components, such as crosslinkers	Reacts with acidic agents in the treatment fluid to maintain a neutral (non-acidic, non-alkaline) pH. Reaction results in mineral salts, water and carbon dioxide which is returned in produced water.	Used in laundry detergents, soap, water softener and dishwasher detergents

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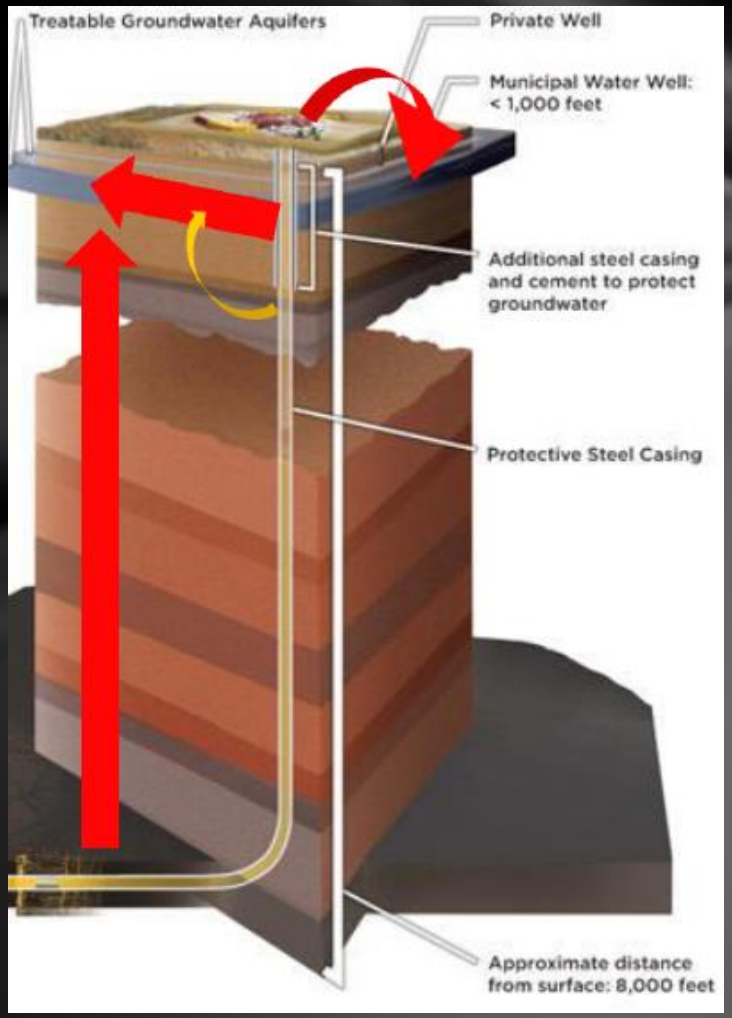
Groundwater methane contamination.



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Hydraulic fracturing – water usage.

- 1000MW Coal Power Station — 12 Hours
- Golf course — 1 Month
- St Lawrence River — 1 Second

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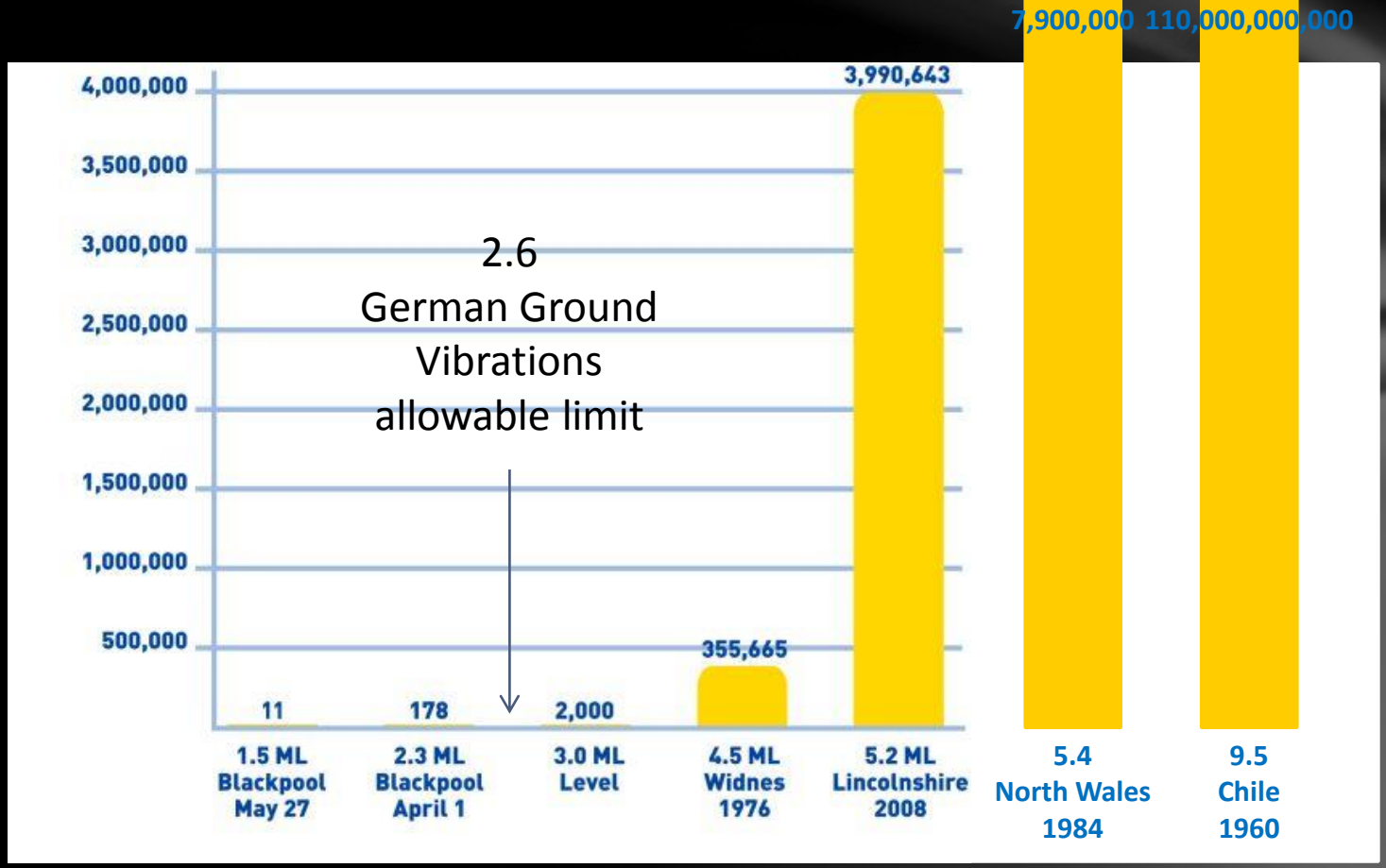
Earthquakes.

March to May 2010 Lancashire experiences a total of 50 seismic events. Strongest were 2.3 and 1.5

Cuadrilla blamed.

- Hydraulic Fracturing operations paused.
- Report commissioned by Department of Energy and Climate Change (DECC)
- Procedures implemented to mitigate risks

Earthquakes – energy released.



TNT (tons)				85	950	1,900	2.7 x 10^9
TNT (kg)	2.7	42	470				
		(120)					

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Earthquakes – induced seismicity.

Also observed in

- Conventional oil and gas
  - Gas fields in Groningen observed 688 seismic events since 1986 greatest magnitude 3.5 ML
- Hydro
  - Reservoir Induced Seismicity (RIS)
  - First recorded 1932 Algeria Oued Fodda Dam
  - Sichuan 12 May 2008, 7.9ML
- Enhanced Geothermal Systems
  - First observed hot rocks, Cornwall
  - Heat sources place EGS closer to faults
  - Also observed in…

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Earthquakes – induced seismicity.

- Tourism
  - Lady Knox Geyser New Zealand induced to erupt 10:15 every day.

Potential impacts and repercussions.

Impacts:

1. Energy independence.
2. Renewables effected.
3. Public awareness of energy generation.
4. Significance of Aberdeen.
5. Energy costs.

Repercussions:

1. Protects against global fluctuations.
   What if reserves not recoverable.
2. Increases likelihood of renewable sources being fully developed and viable.
   Finite resources.
3. Industry and community able to benefit each other (see US change in media representation).
   Public backlash already based on lack of technical foundations.
4. Increased talent pool, more competition.
   Increased operating costs.
5. Initially likely to increase.
   Money invested locally.

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Questions?