Shale Gas and Oil: Reality, Hope or Hype?

Andrew Aplin
Department of Earth Sciences
Durham Energy Institute
a.c.aplin@durham.ac.uk

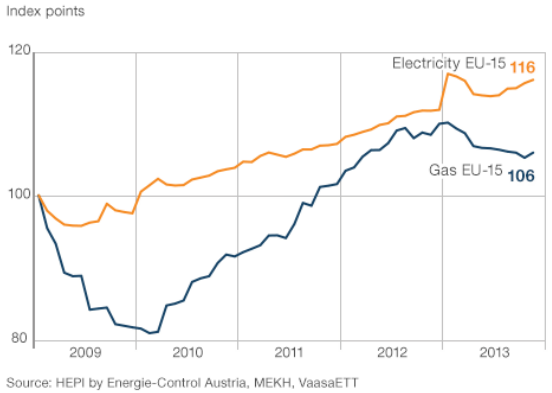
Durham University

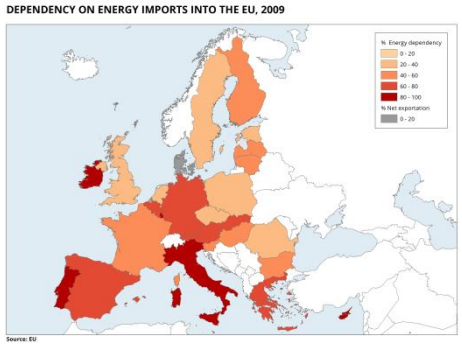
Durham Energy Institute
Science and Society

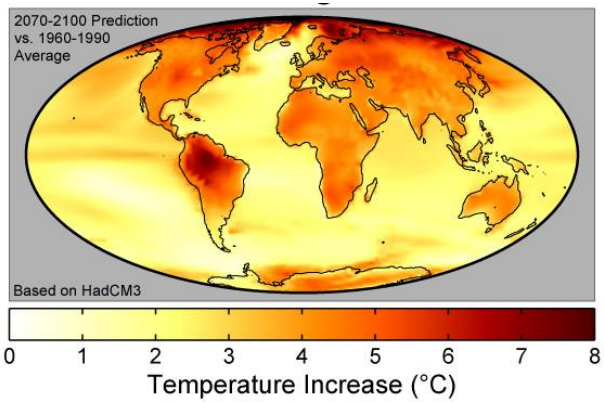
CONTEXT

The Energy Mantra

- Affordable
- Secure
- Sustainable



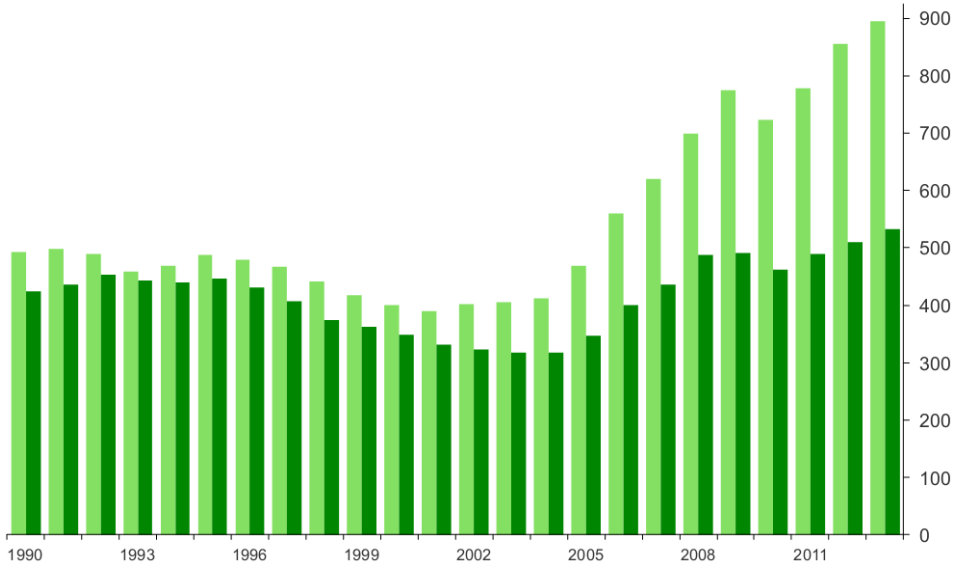




Durham University

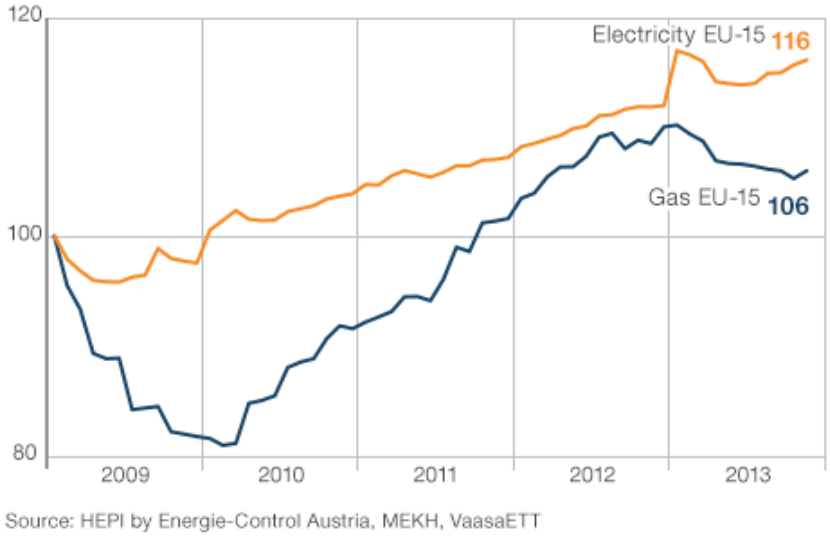
Affordability: Prices Increasing
10% Europeans are in “Fuel Poverty”

UK Household Gas and Electricity Costs



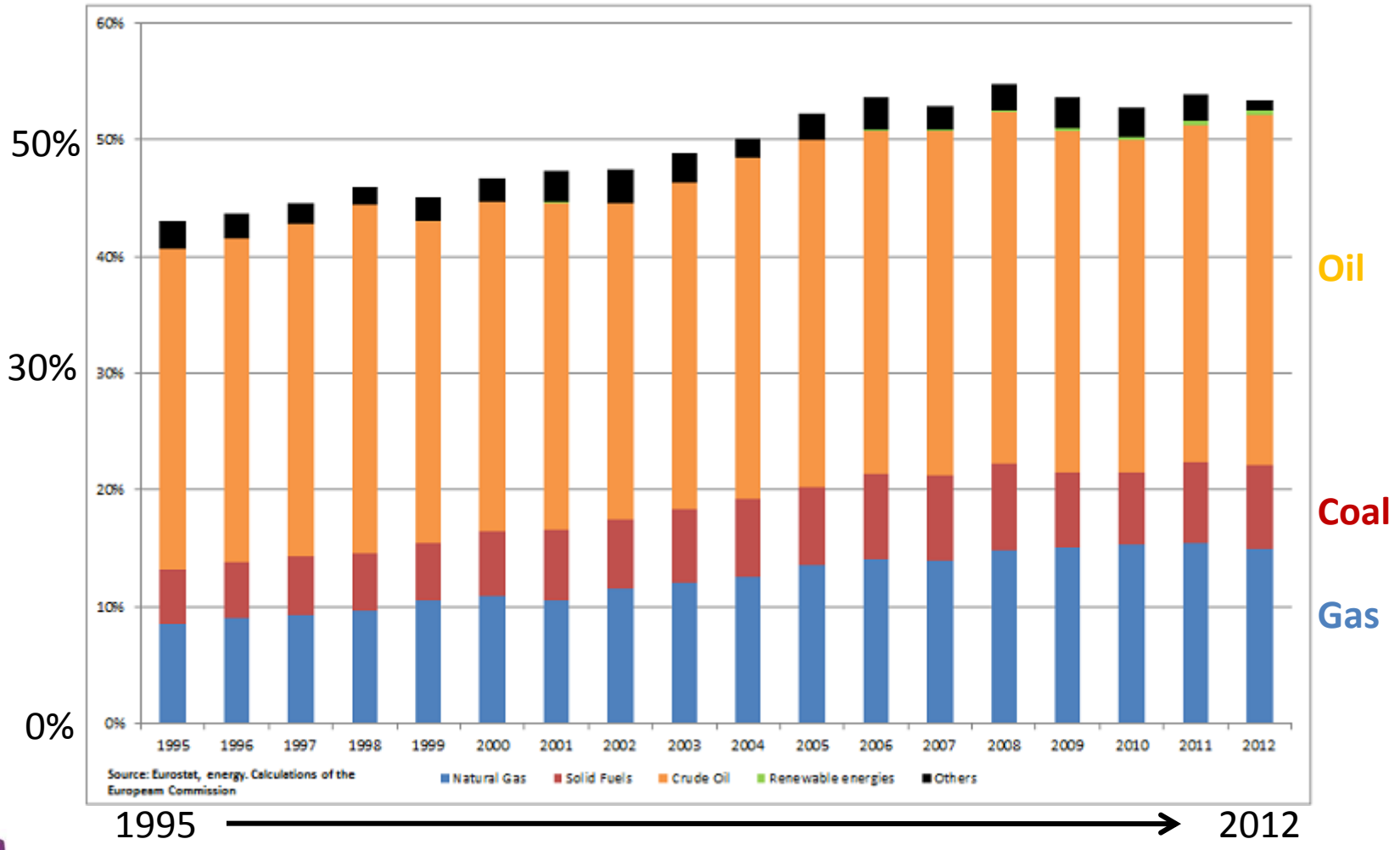
1990 → 2013

EU-15 Household Gas and Electricity Costs



2009 → 2013

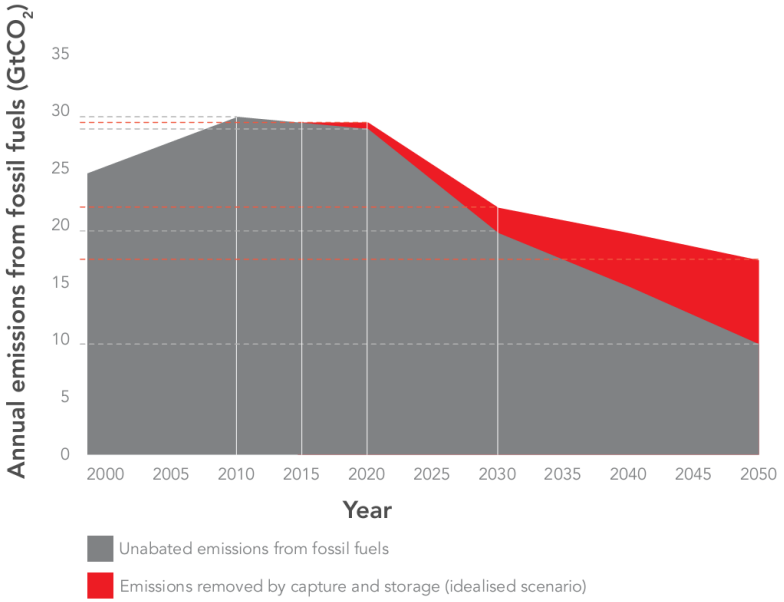
Security: 75% EU Energy is Fossil Fuel
EU Net Energy Imports > 50%



Durham University

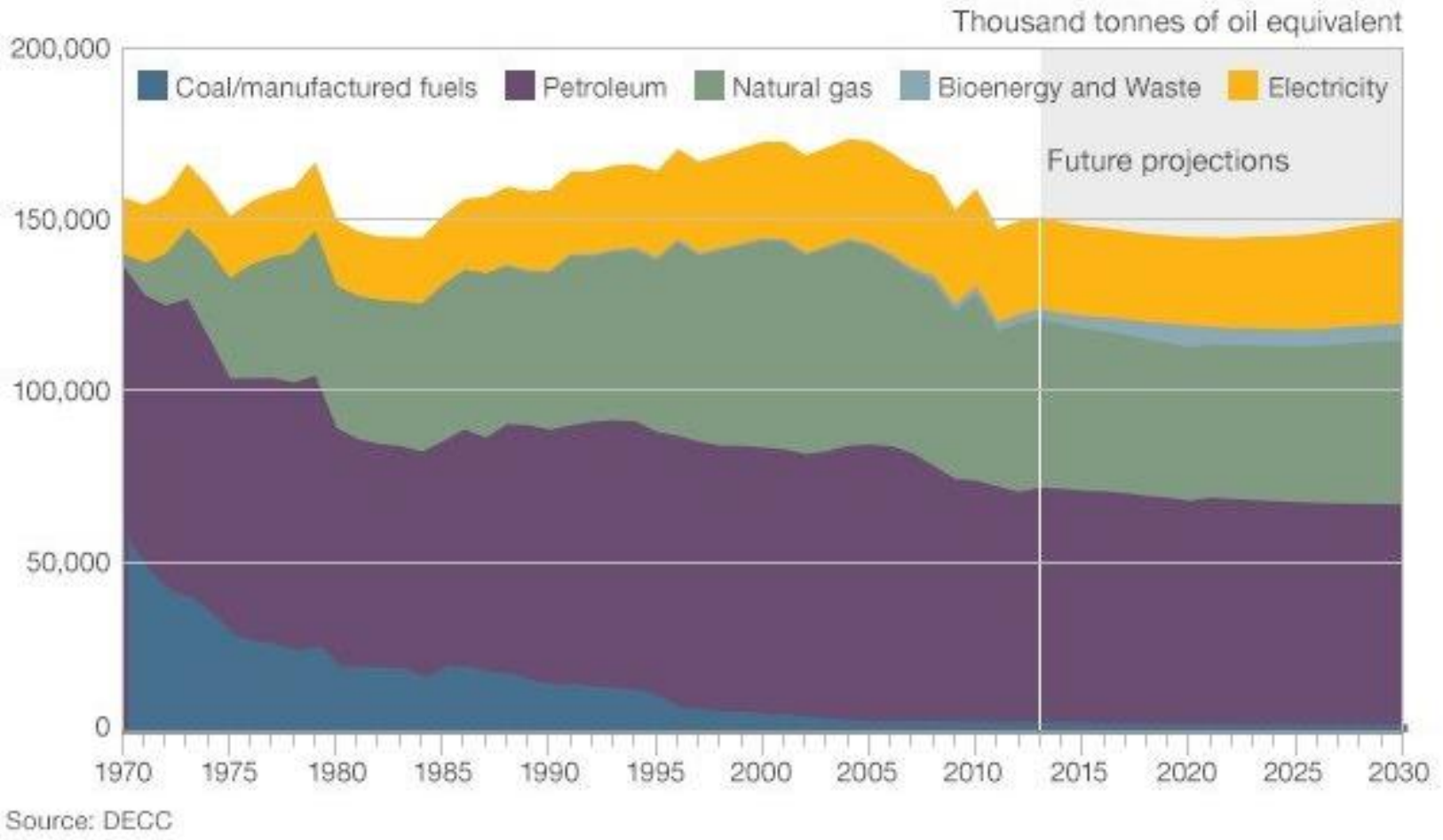
Sustainability

- EU: 40% CO_2 reduction 2030; 80% 2050



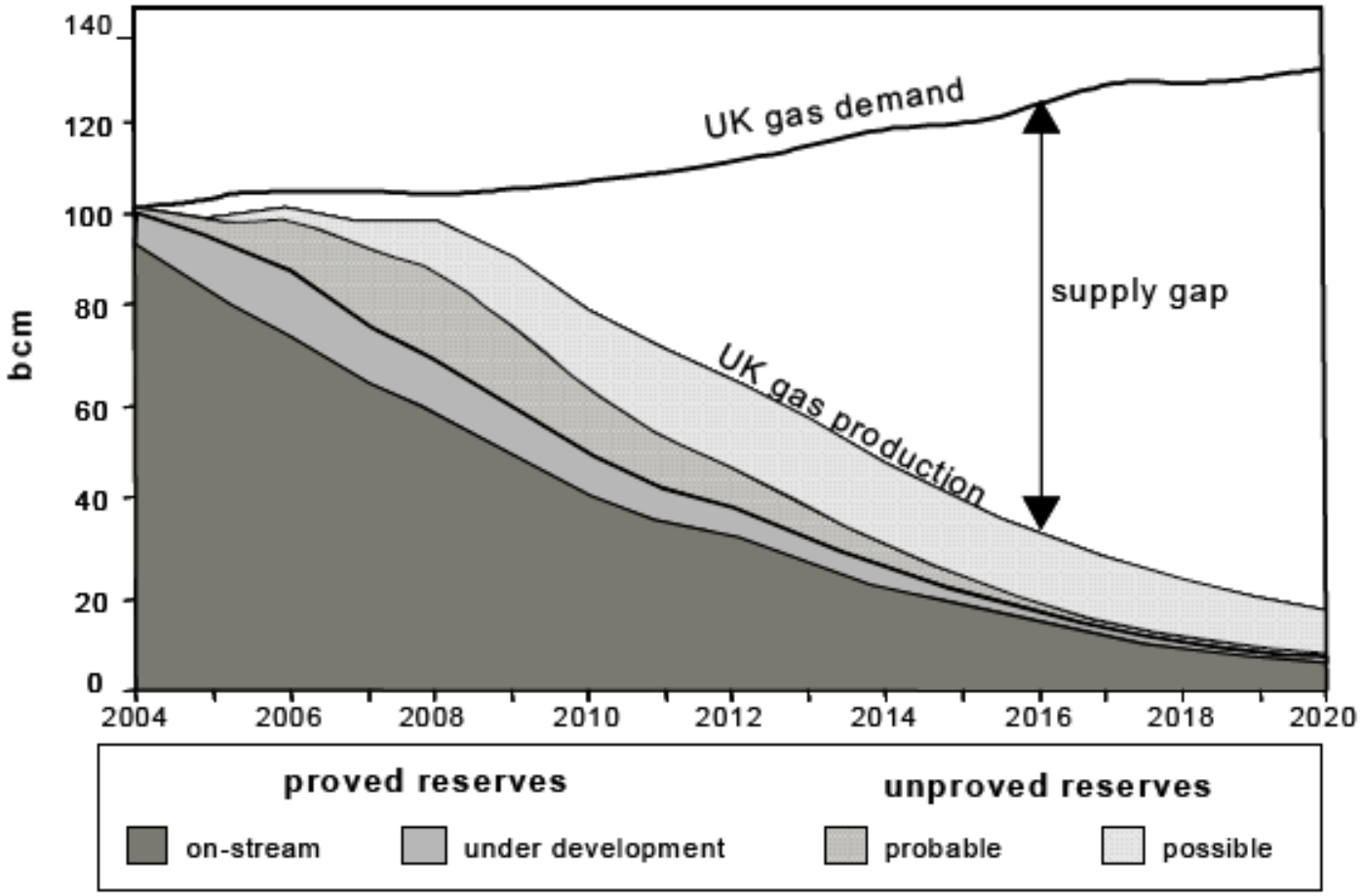
- China: Air Pollution; Peak CO_2 Emissions 2030

Breakdown of UK Energy Consumption: 1970-2013 with Projections to 2030



Durham University

UK Gas Supply Gap: 2004 Prediction……



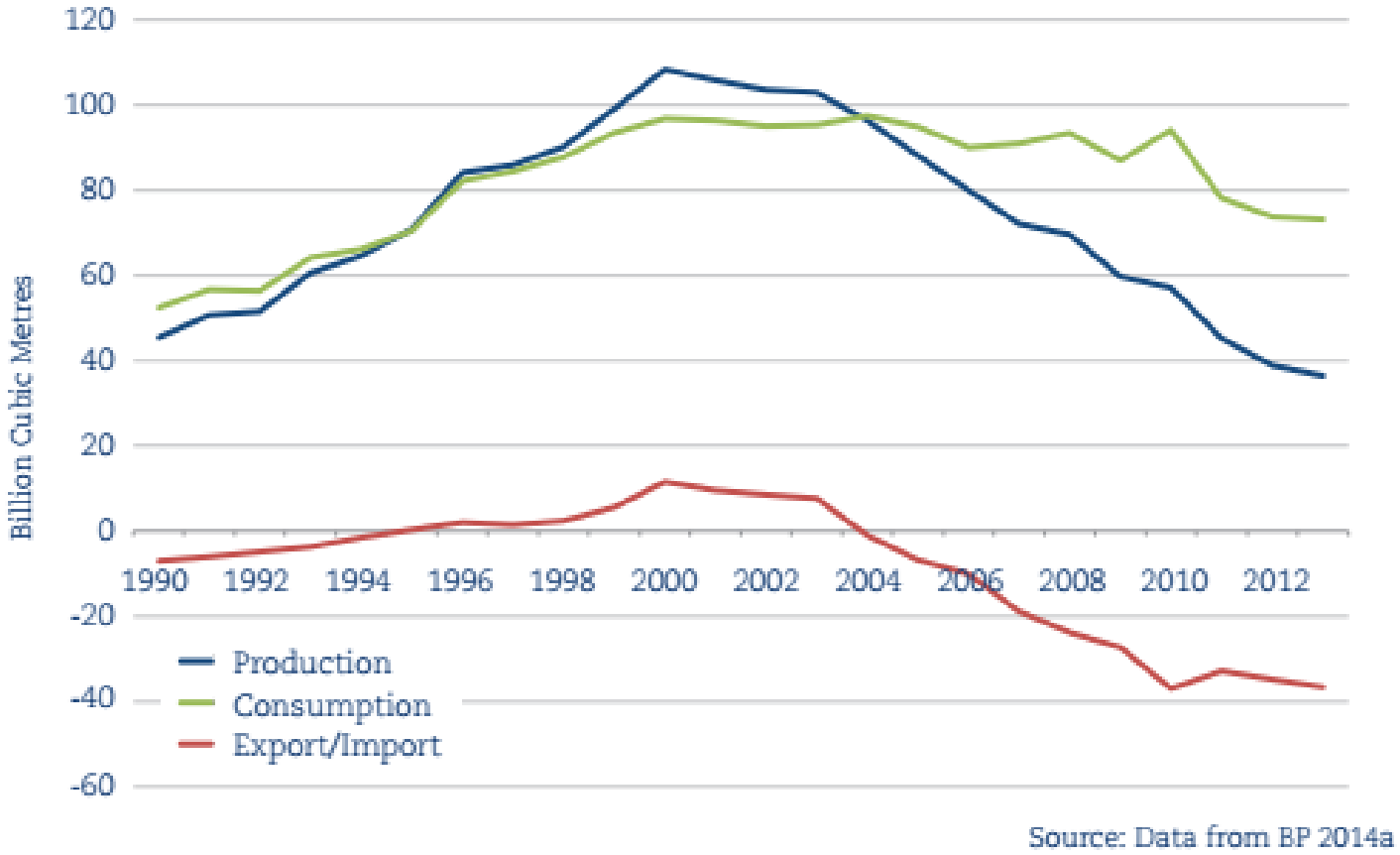
Source: Modified from WoodMackenzie 2004, 'From surplus to shortage'

- 35% UK Energy from Gas
- 80% UK Homes heated by Gas

….and 12 days storage

Durham University

.....Correct!



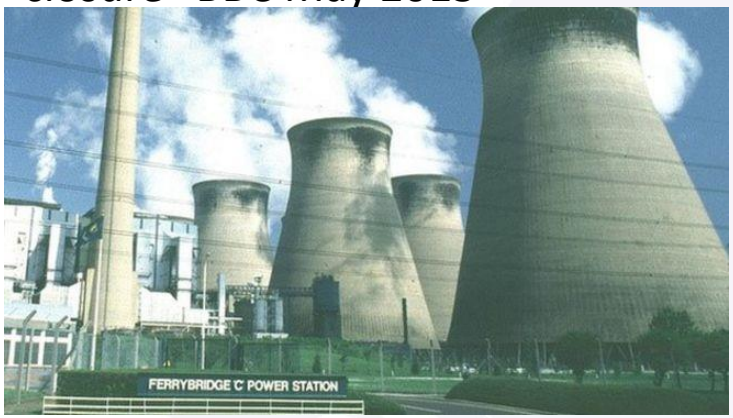
Source: Data from BP 2014a

Durham University

Durham Energy Institute

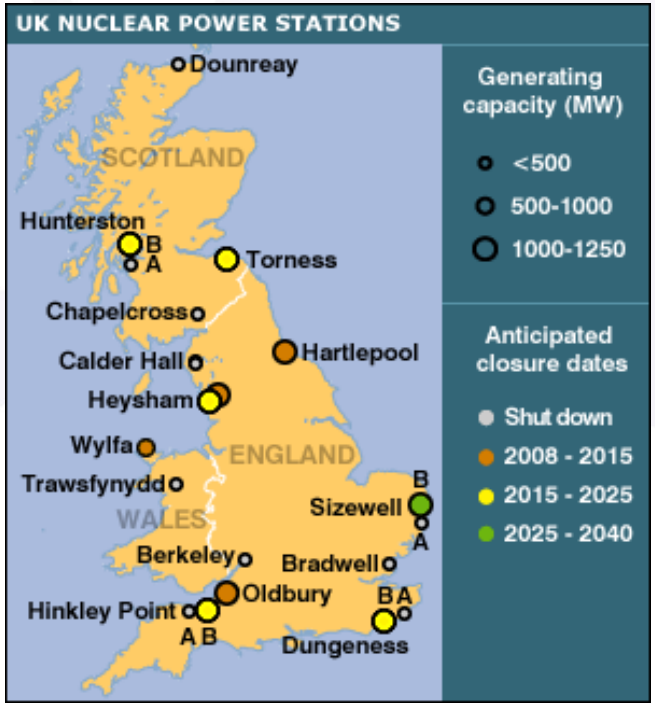
SCIENCE AND SOCIETY

"Energy company SSE confirms Ferrybridge power station closure" BBC May 2015



"North Sea oil revenues fall by 75% in the first three months of 2015" BBC August 2015

"UK North Sea oil drilling work lowest in 15 years" Reuters January 2015



All but one nuclear power stations to close by 2025


We're all doomed!
DOOMED!

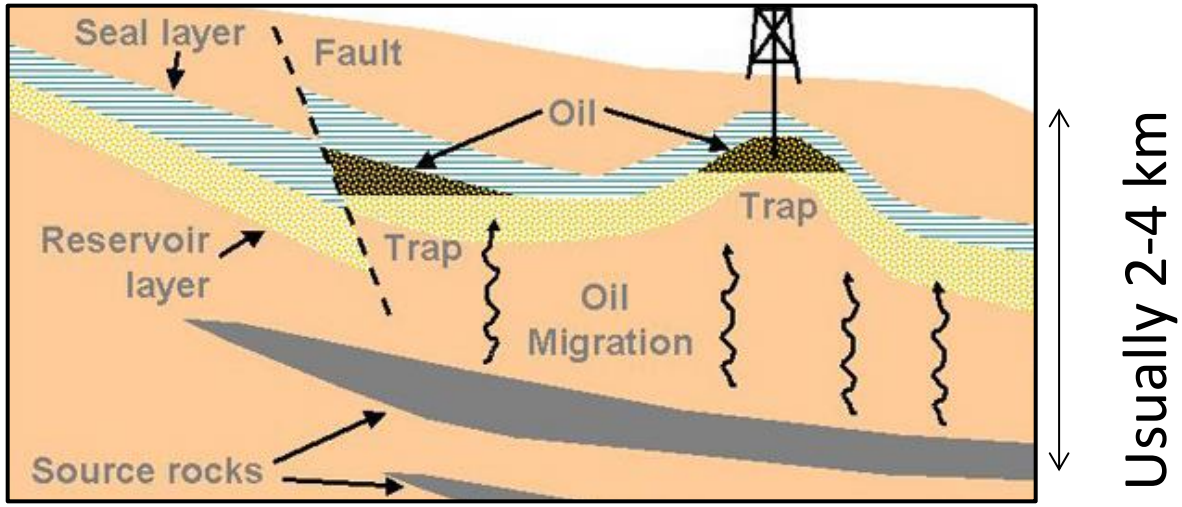
SHALE OIL/GAS

What is an Oil/Gas Shale?

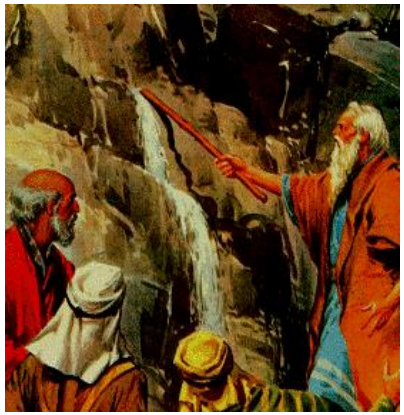
- Petroleum source rock
- Rich (> 10 vol %) in organic matter
- Buried over geological time to > 150C (5 km)
- Uplifted to e.g. 1-3km
- Non-expelled petroleum

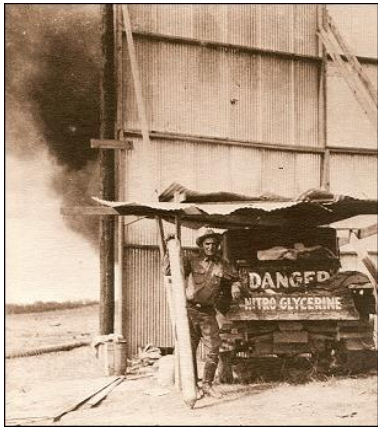
Shale Oil and Gas: "Unconventional Hydrocarbons"

- Conventional resources – Oil and gas that migrated from the shale source rock to more permeable sandstone and limestone formations
- Unconventional shale resources – Oil and gas that remains trapped in the petroleum source rock (shale)



Production Requires ‘Fracking’……..





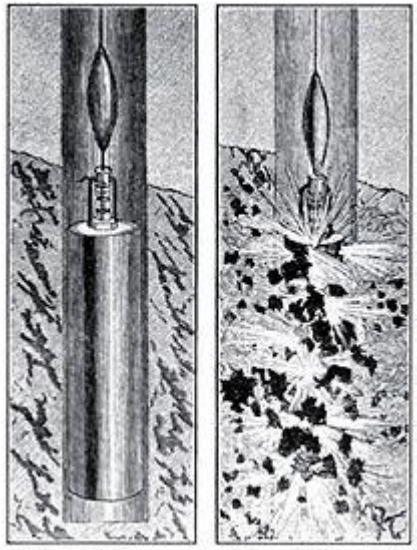
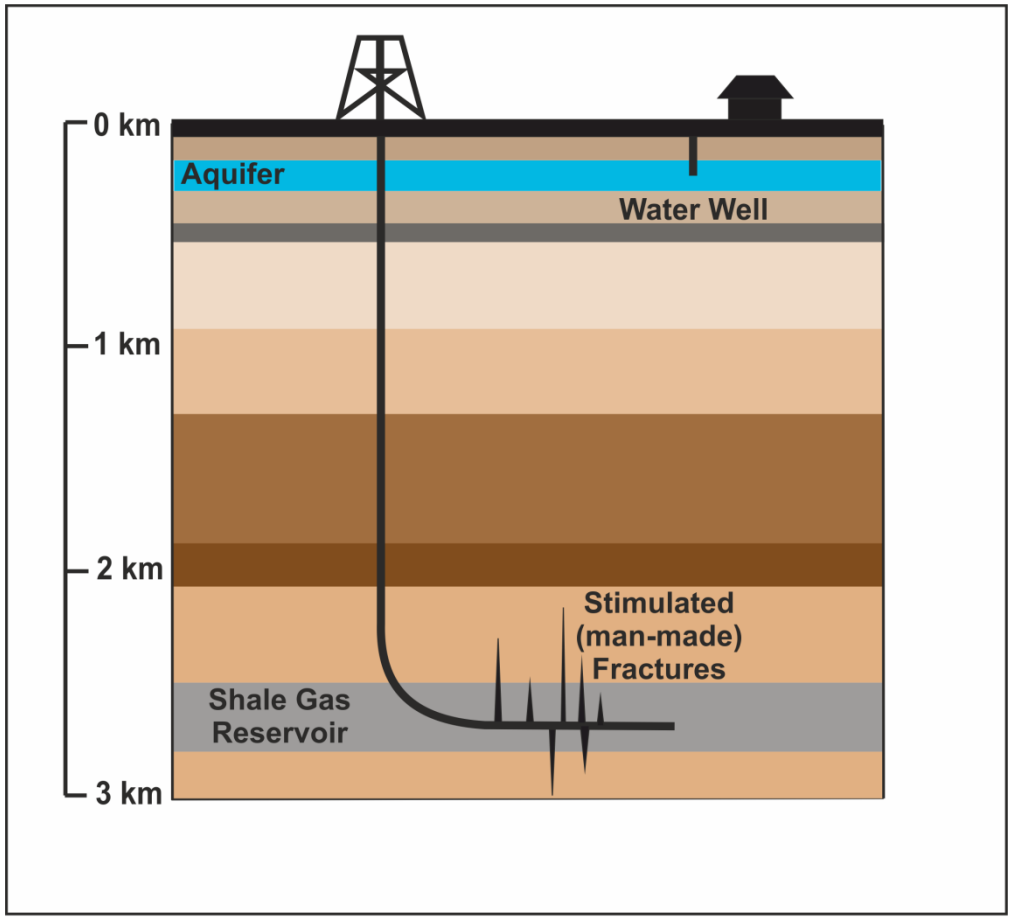


Fig. 134.—The Roberts torpedo, before and during explosion.

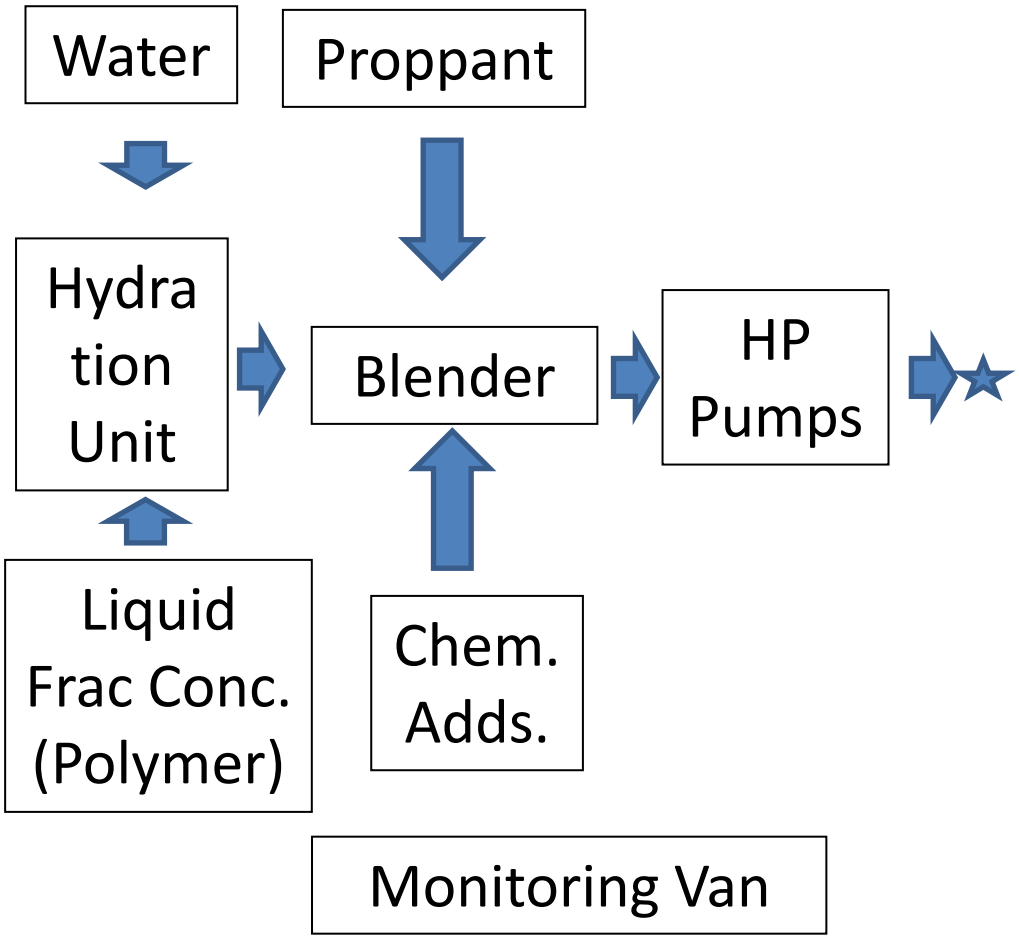


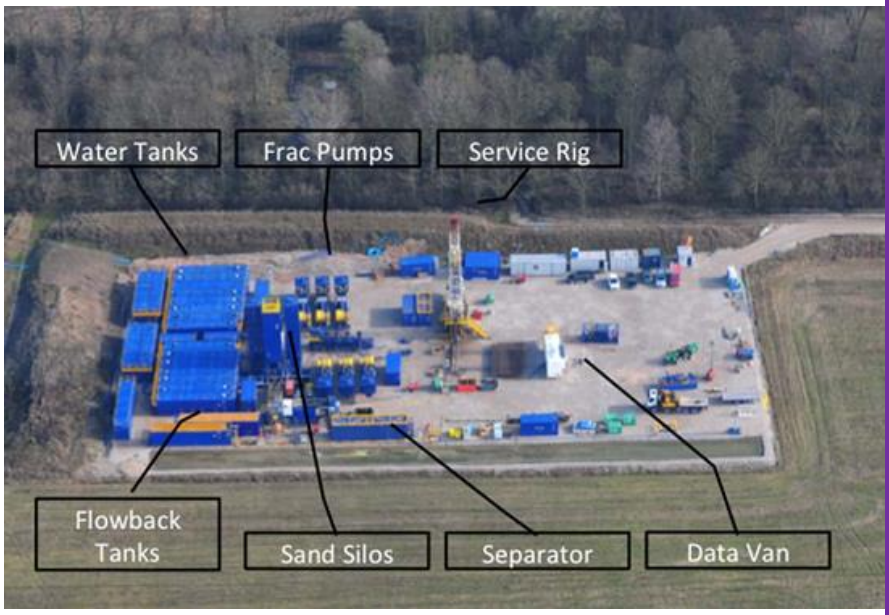
Hydraulic fracturing common since 1940

Applied with horizontal wells from mainly 2000

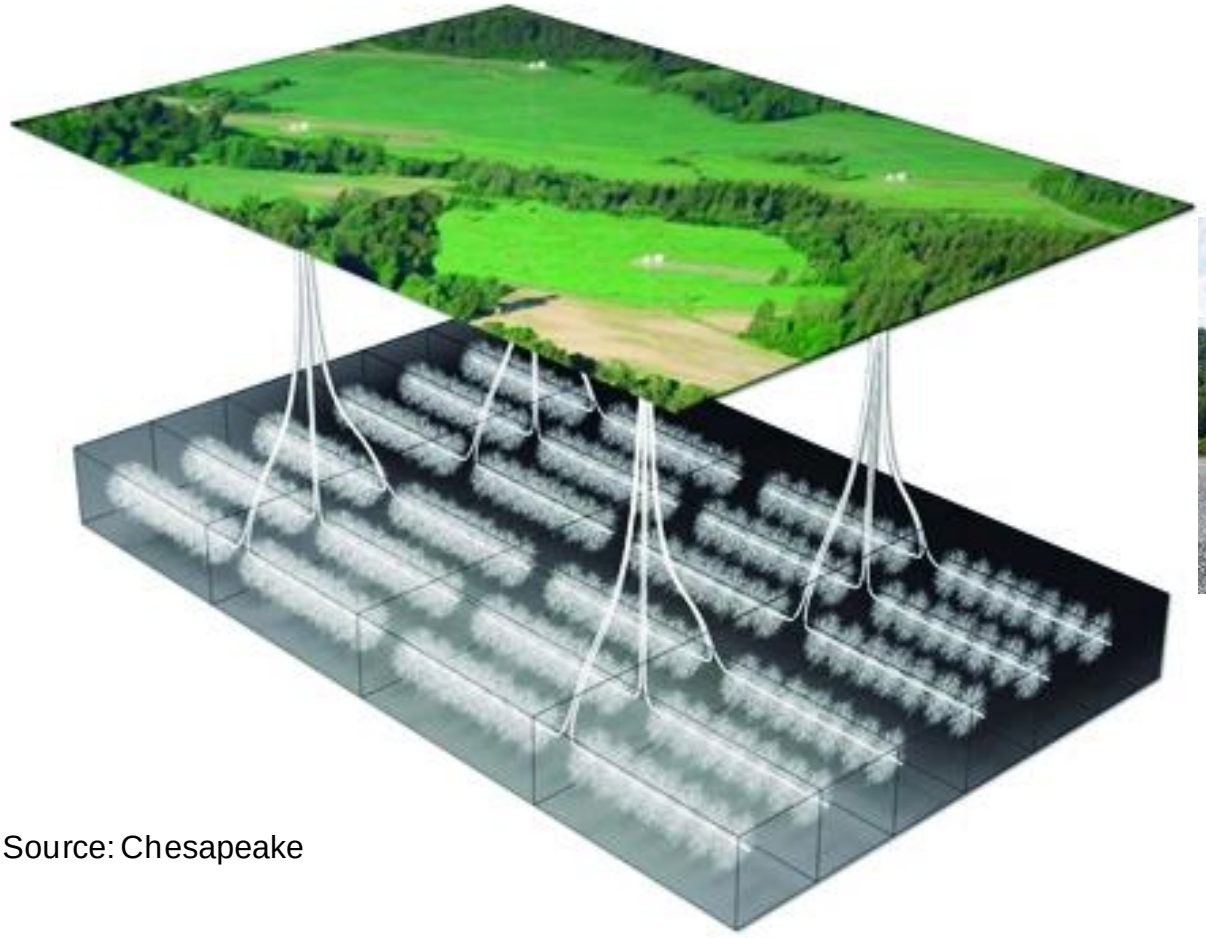
Durham University

Fracking Operation



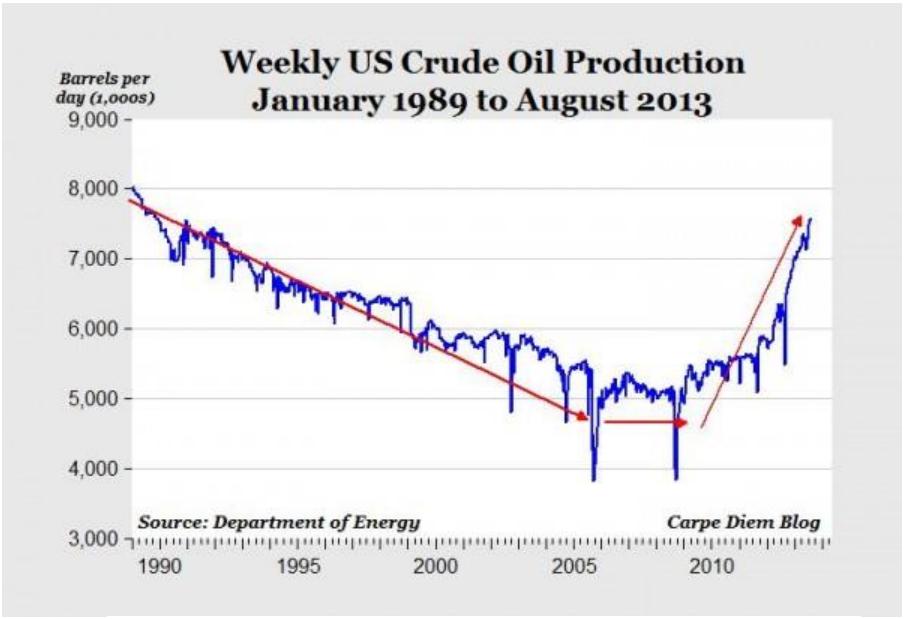


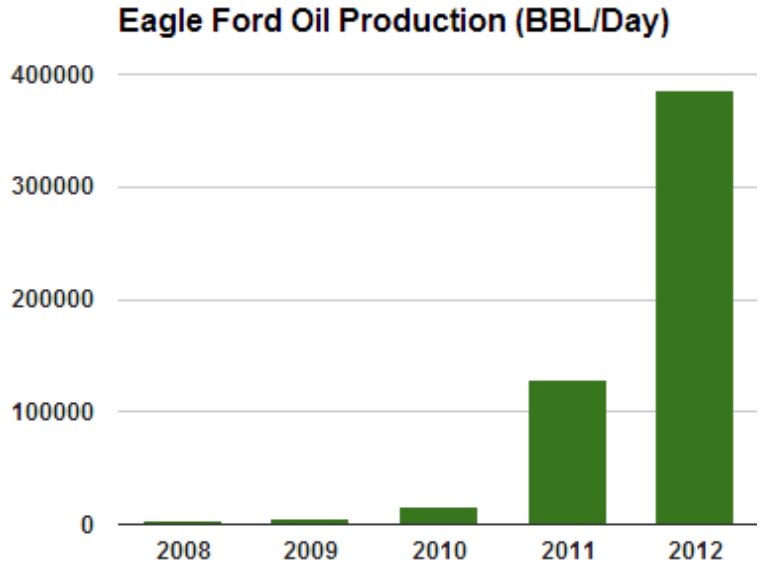
Multilateral and Multistage Fracs



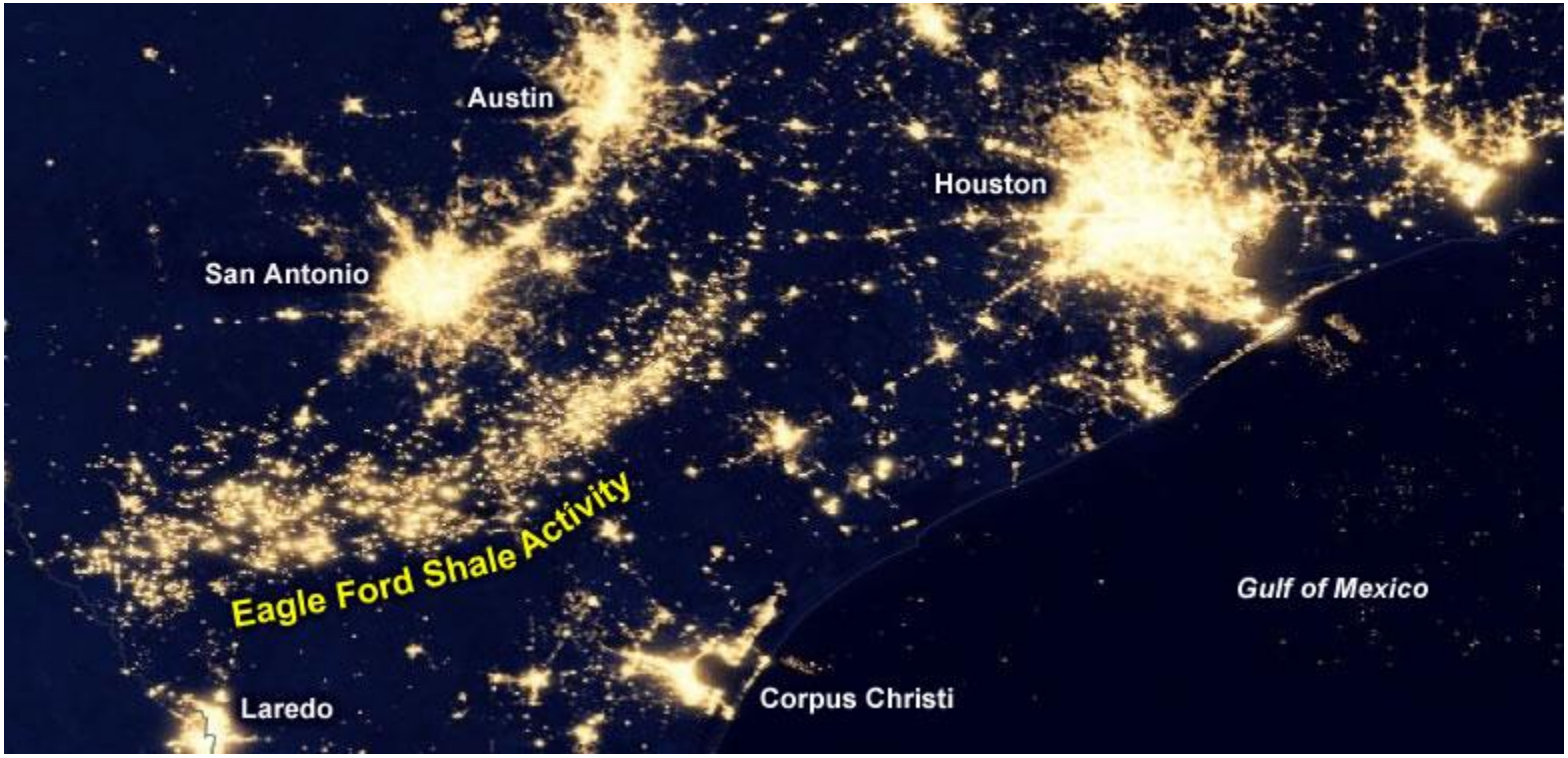
Source: Chesapeake

US Oil Upturn Driven by Bakken and Eagle Ford



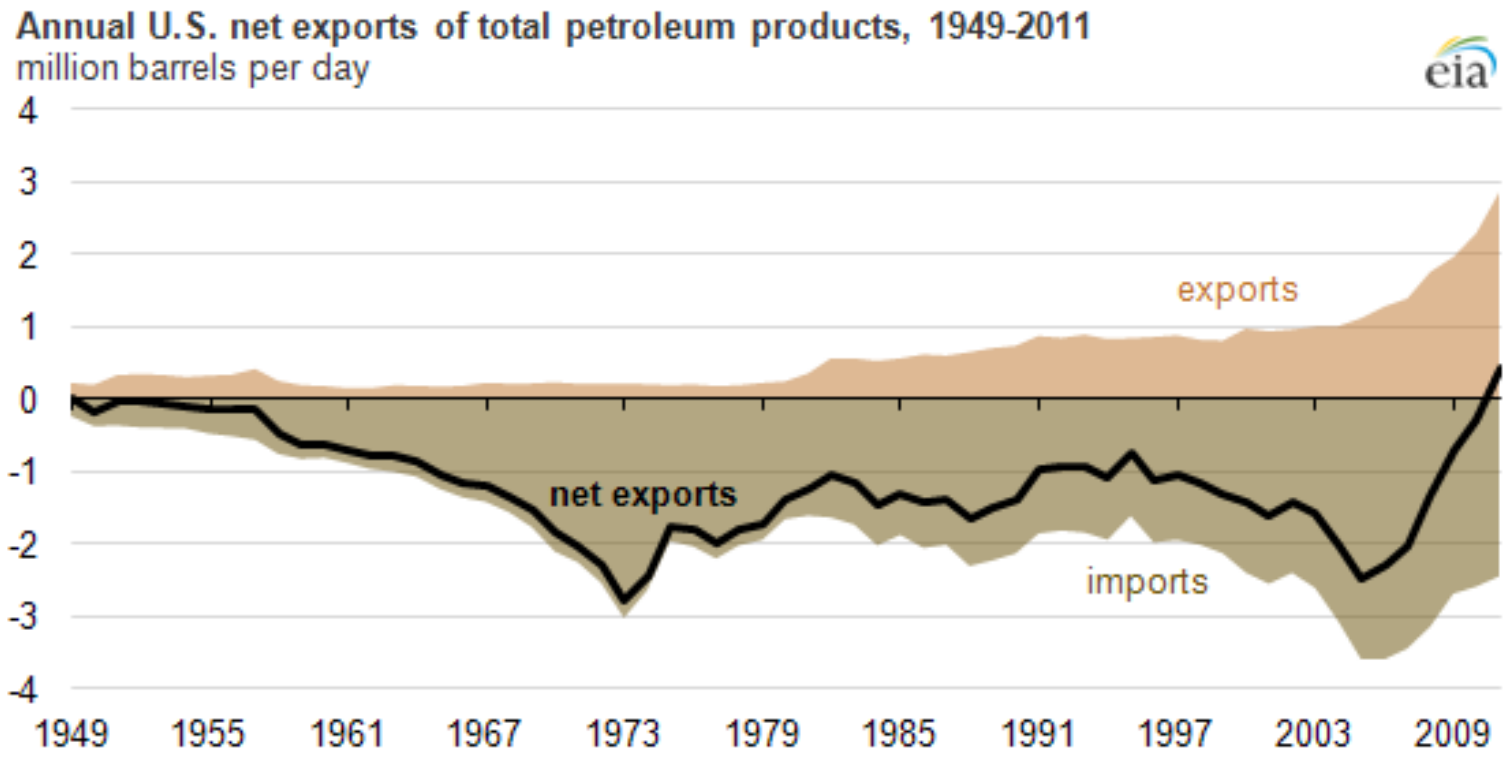


Nighttime Satellite Image, SW Texas



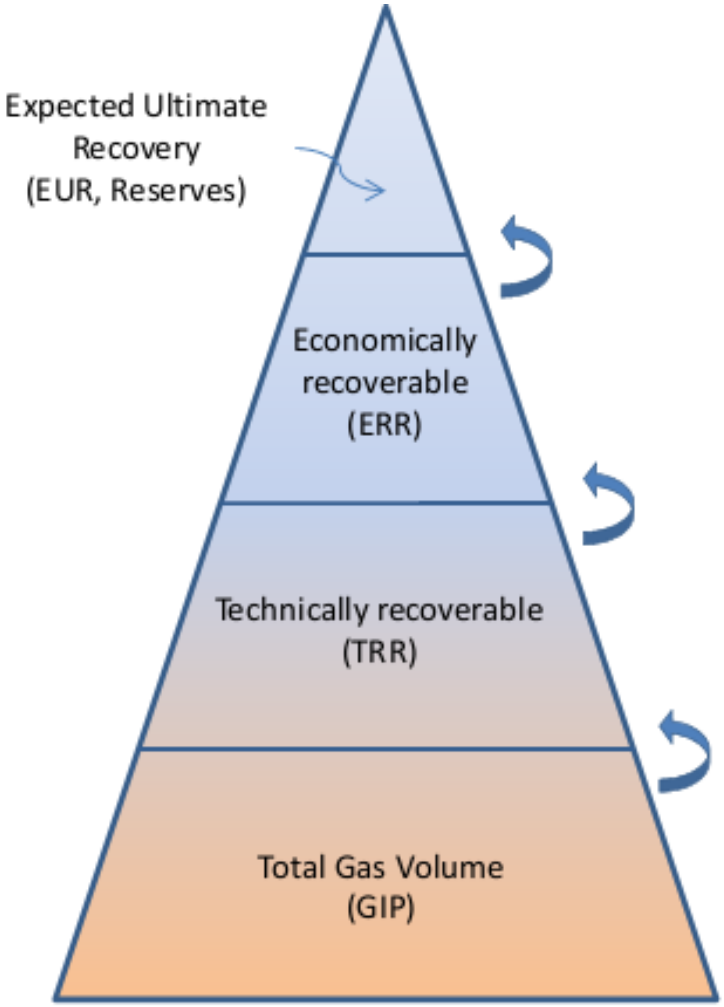
10000 wells since 2008
4000 more wells approved

US Now Net Exporter of Petroleum Products



HOW BIG IS THE RESOURCE AND RESERVE?

Resource and Reserve



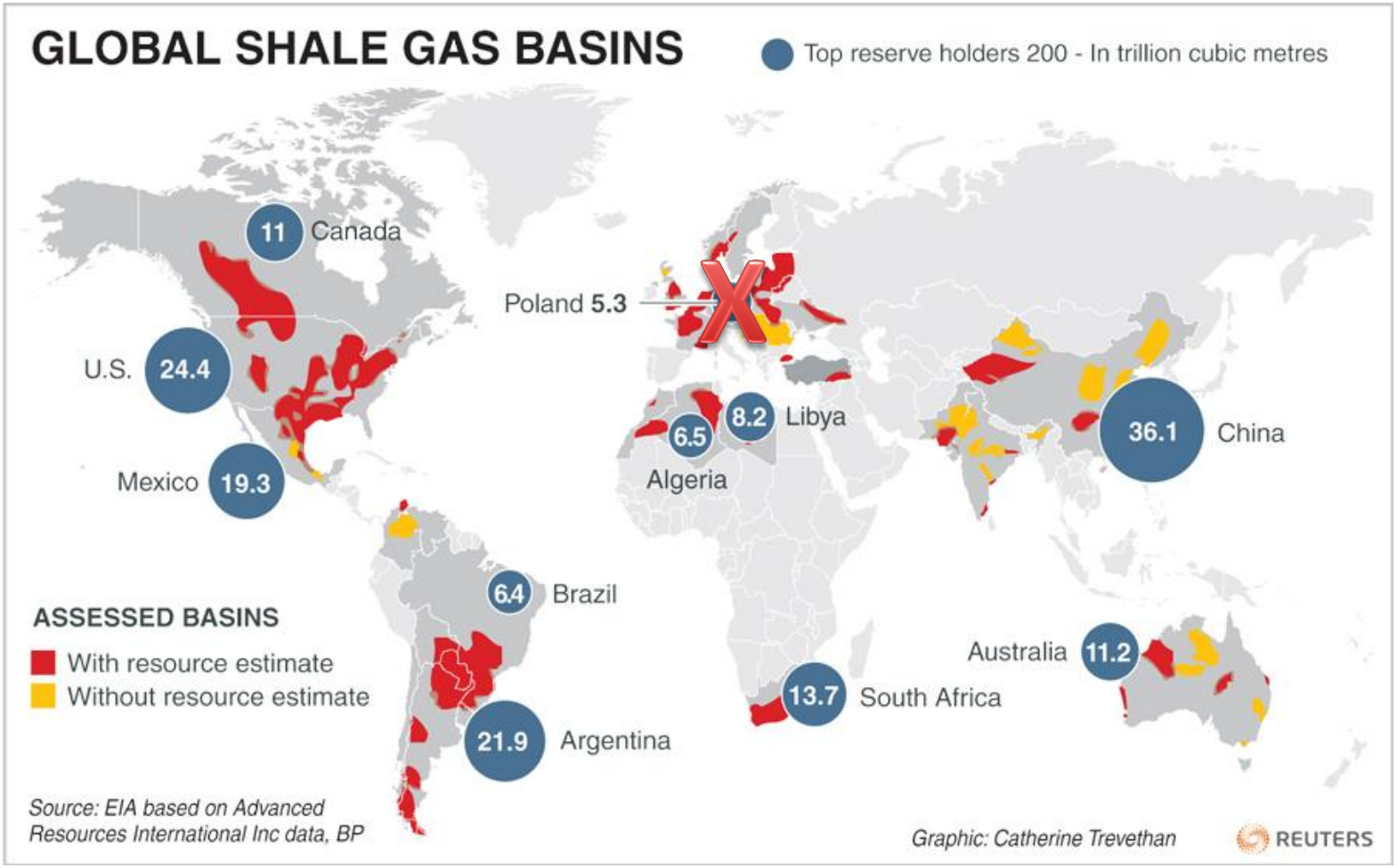
Play maturation, spatial planning, legislation

Shale gas development plans

Exploration drilling

Geological analysis

Technically Recoverable Gas Shale Resource

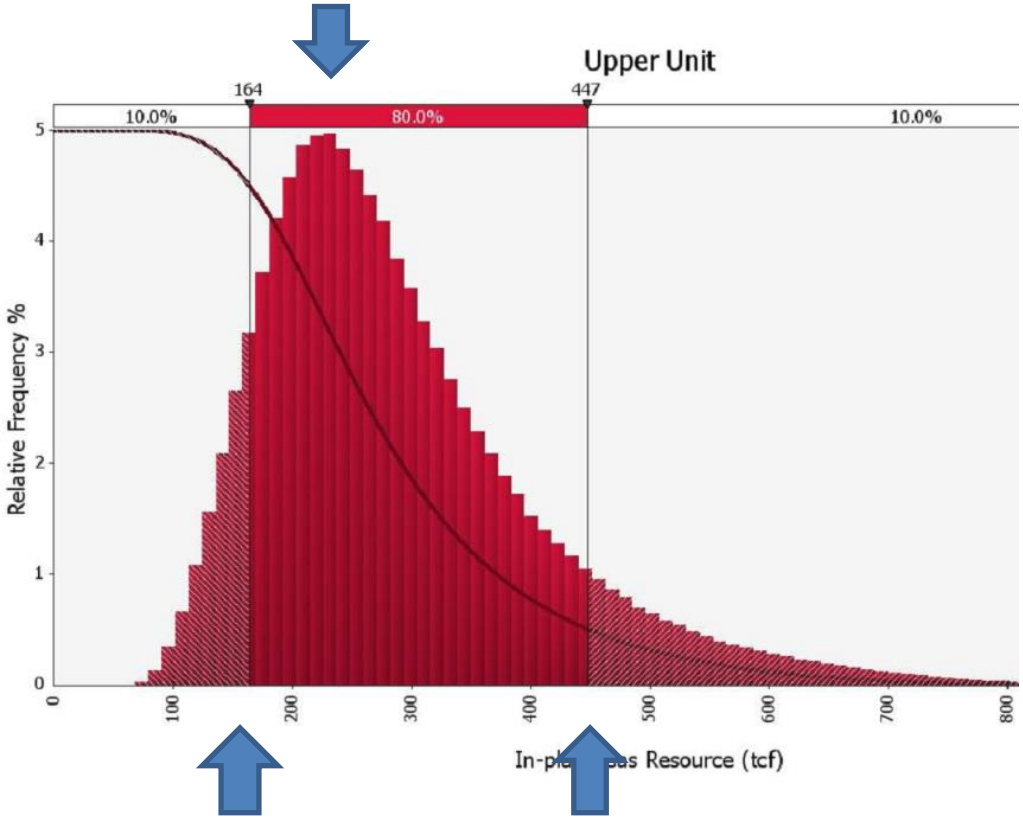


Total Gas Shale Recoverable Resource = 190 tcm (source: EIA)

Total Conventional = 190 tcm (source: BP)

We Don’t Know How Much is There: UK Bowland Shale RESOURCE (NOT RESERVE)

260 Tcf = 80 years UK consumption



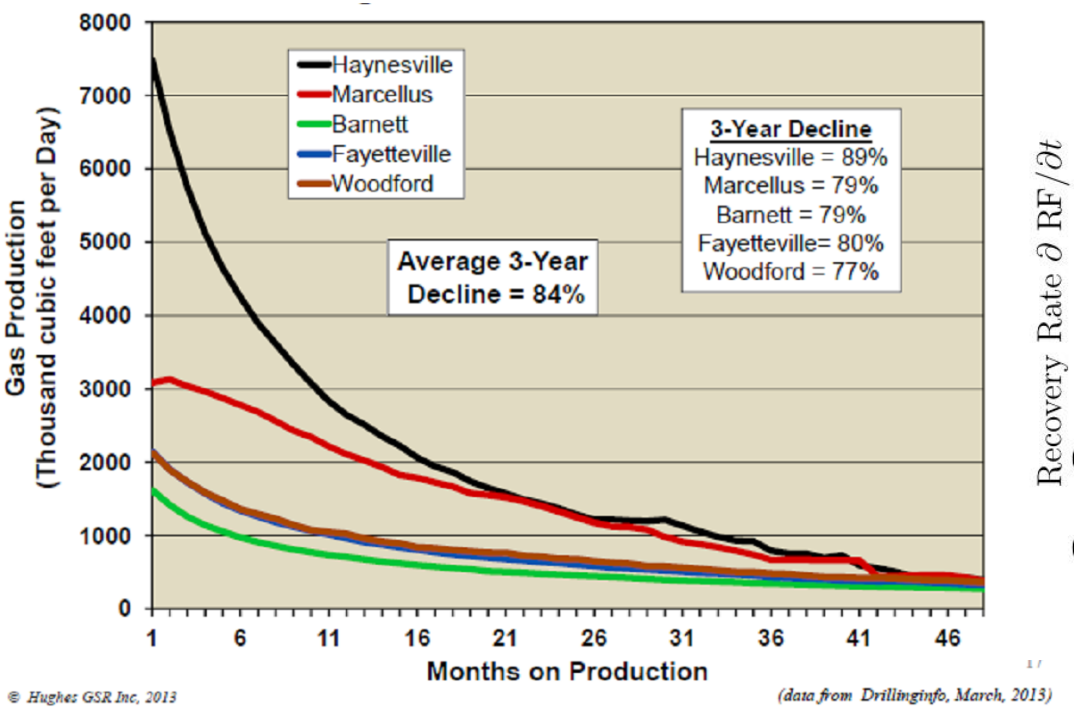
160 Tcf

450 Tcf

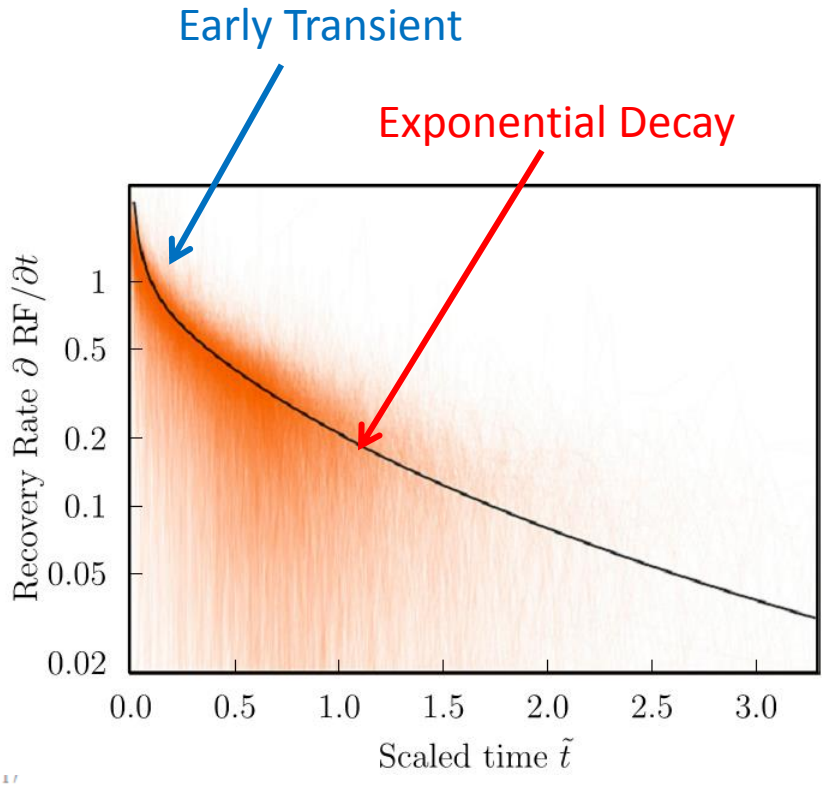
- Volume Gas Mature Shale
- Porosity
- Gas-filled Porosity
- Organic Matter Content
- Amount Adsorbed Gas
- Pressure

Durham University

Gas Production Data: Well Decline Curves Are Remarkably Similar

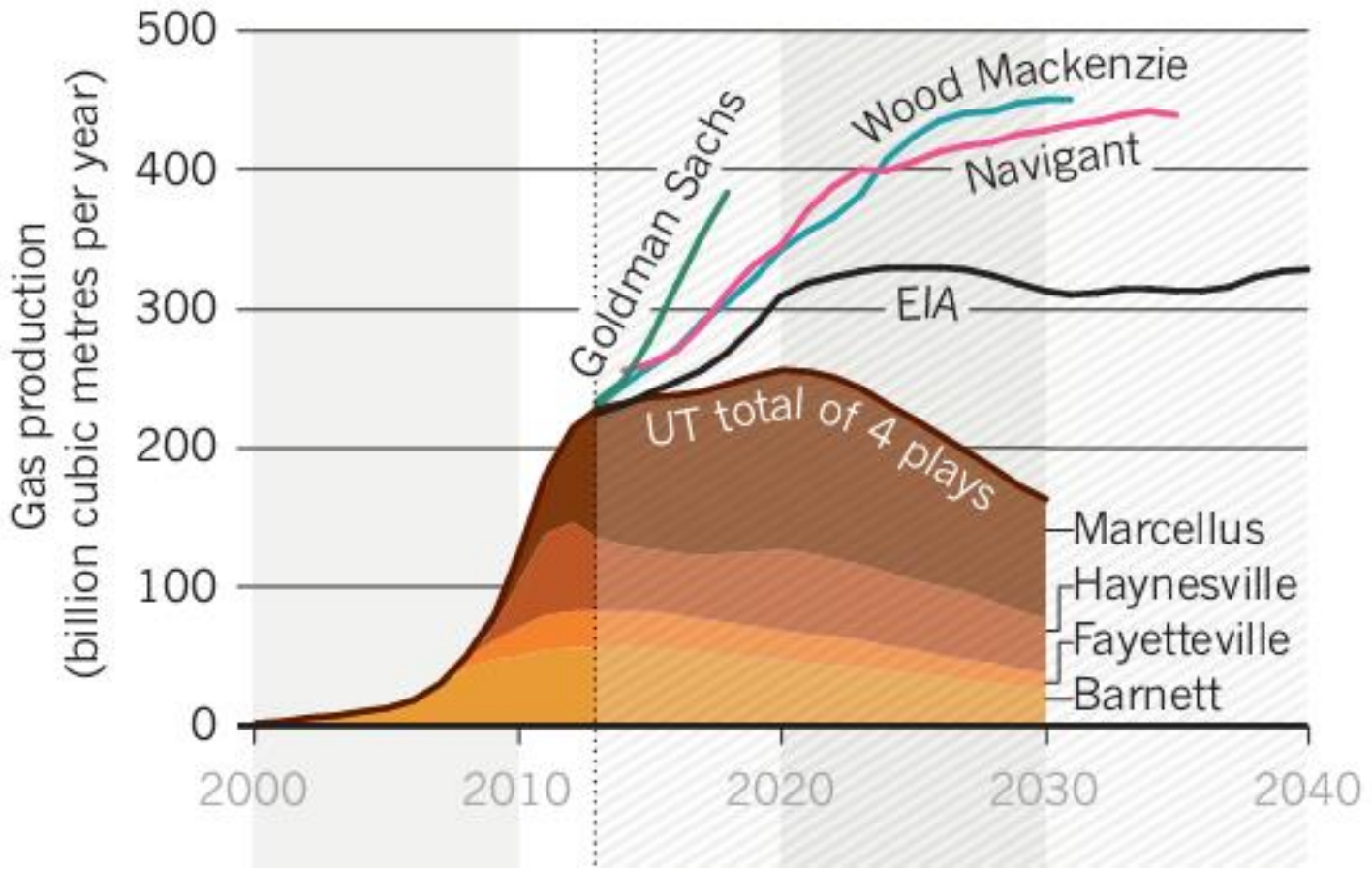


Individual Wells



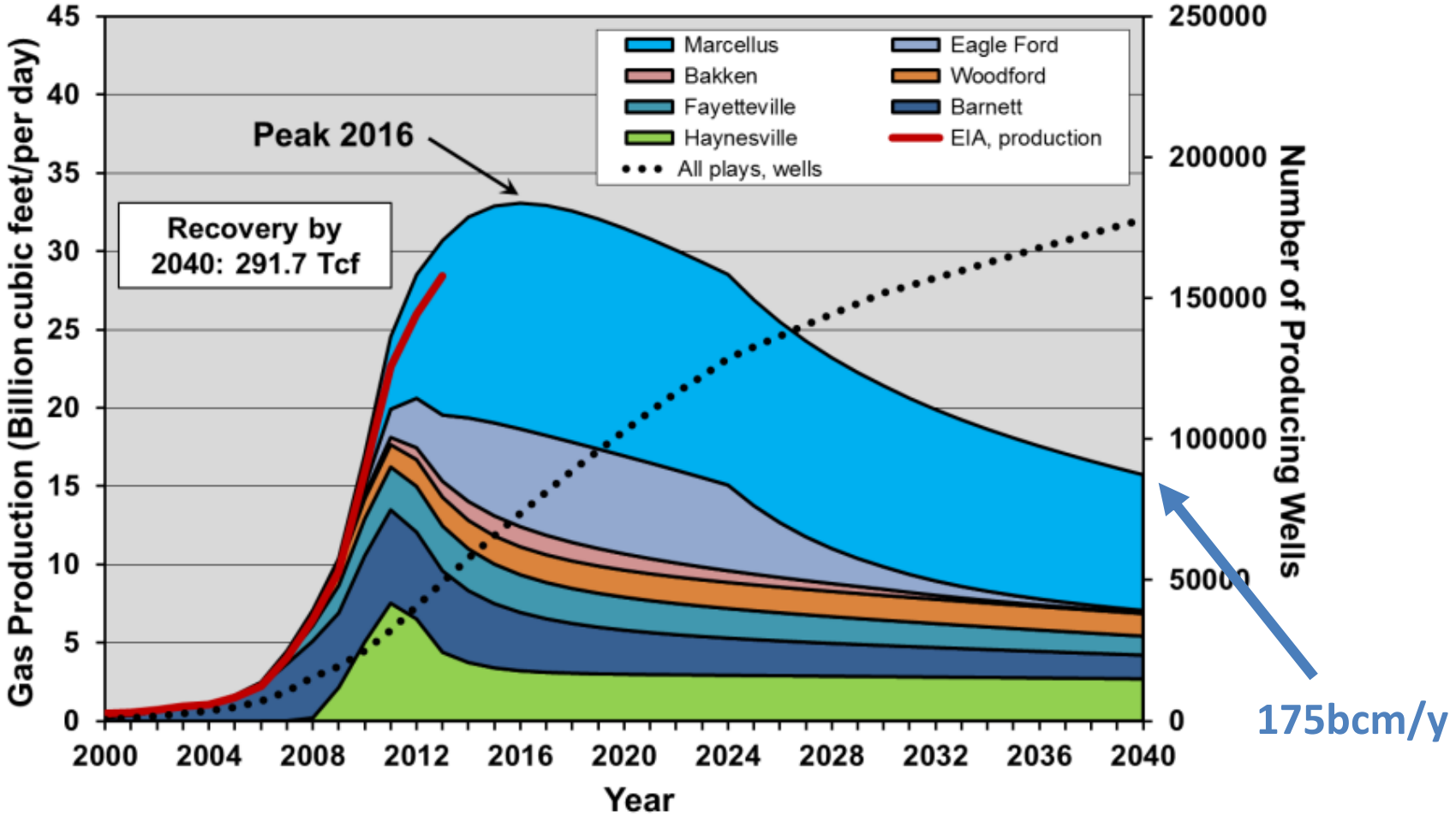
> 8000 Barnett Wells
Patzek et al. (2013)

US Production Forecasts



Inman (2014) Nature

Most Likely Production Rates, US Shale Gas Wells (EIA)



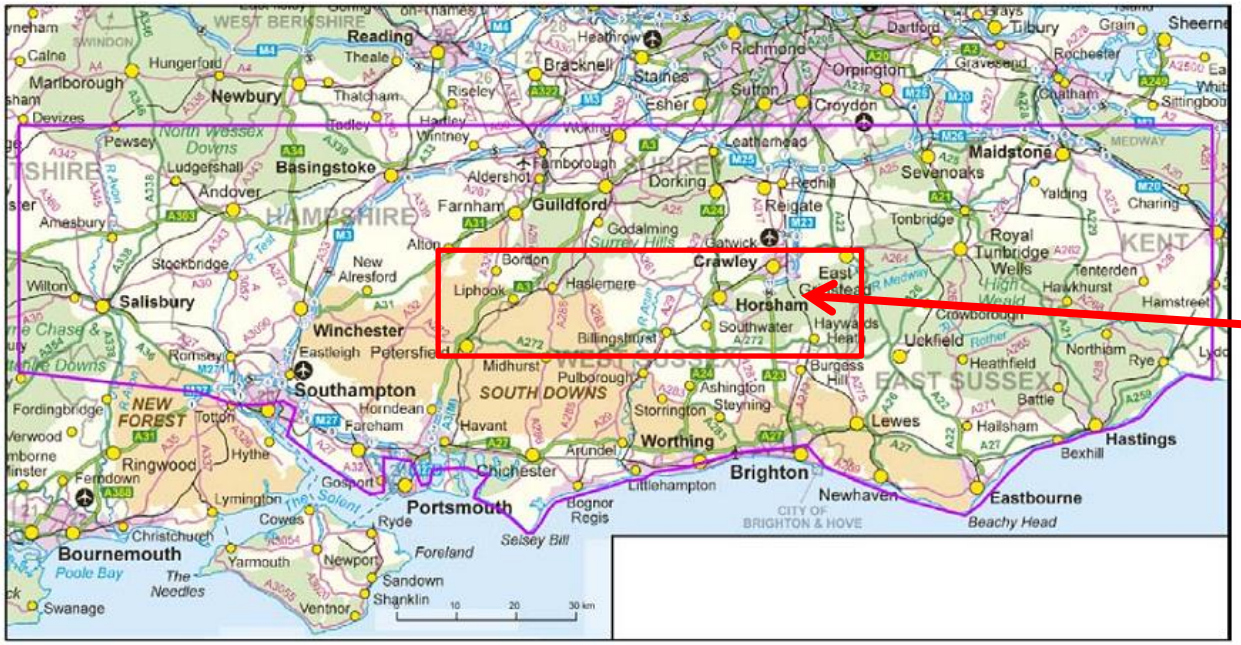
- 2016: 12 tcf/y production from 75,000 wells (US)
- UK consumption = 3tcf/y = 18,000 wells

Durham University

The European Challenge

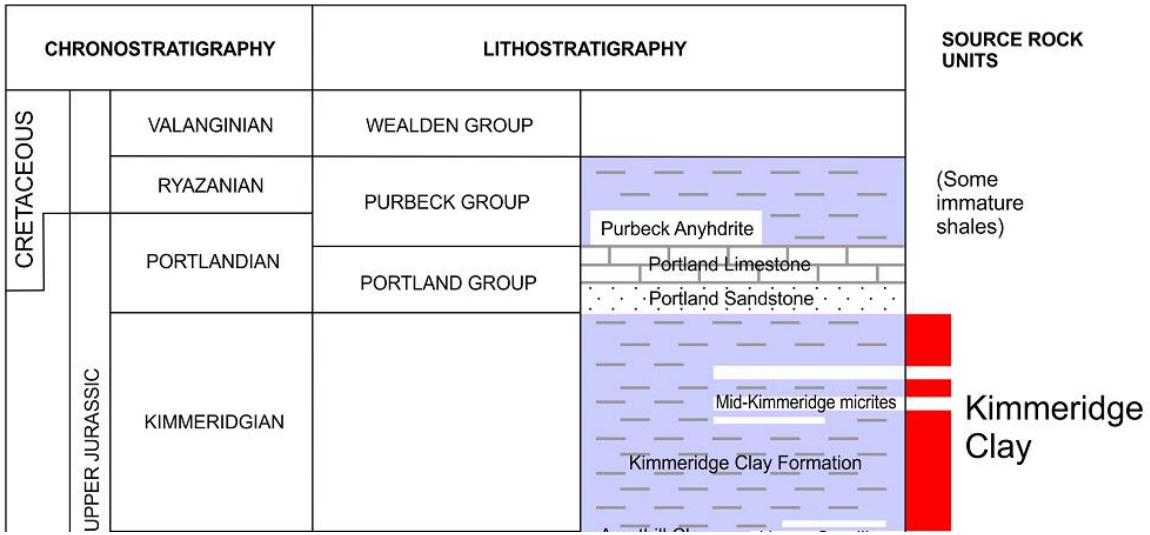
- Security: 60% gas, 80% oil imported
- Sustainability: 40% CO_2 reduction 2030; 80% 2050
- More complex geology
- High population density
- Low, unchanging level of societal acceptance

Weald Shale Oil: Is It Worth It?



- 124BBO P50 (Nutech 21 Oct 2015)
- 42BBO total produced oil N Sea

Weald Oil: Is It Worth It?



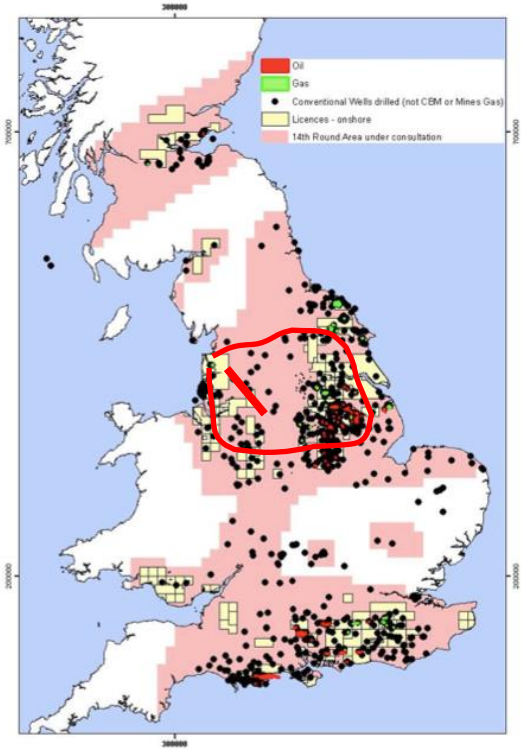
15% of section = tight carbonates: 19 BBO

5% recovery = 0.9 BBO = 2 years UK consumption = 6000 wells

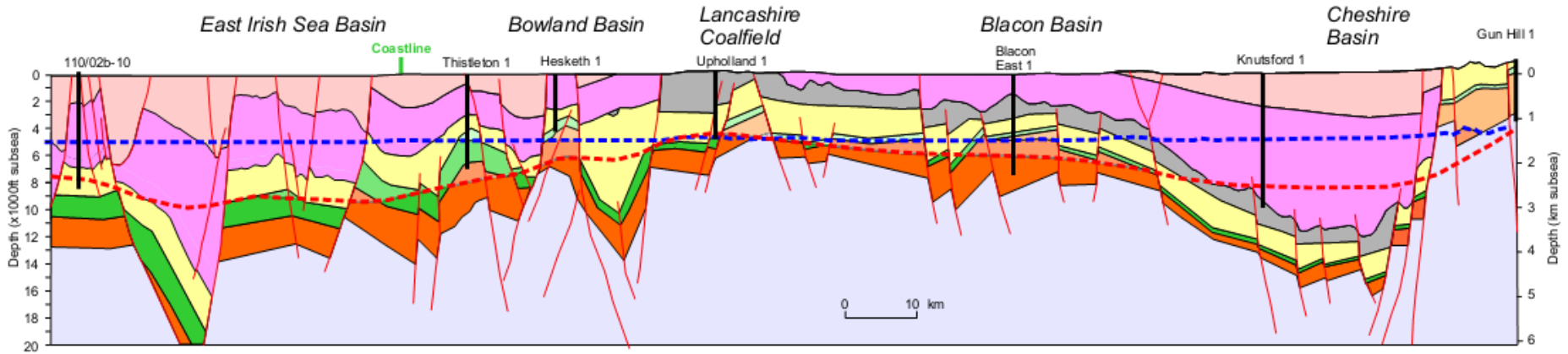
2% recovery = 0.4 BBO = 1 year UK consumption

Durham University

Bowland Shale Gas Example



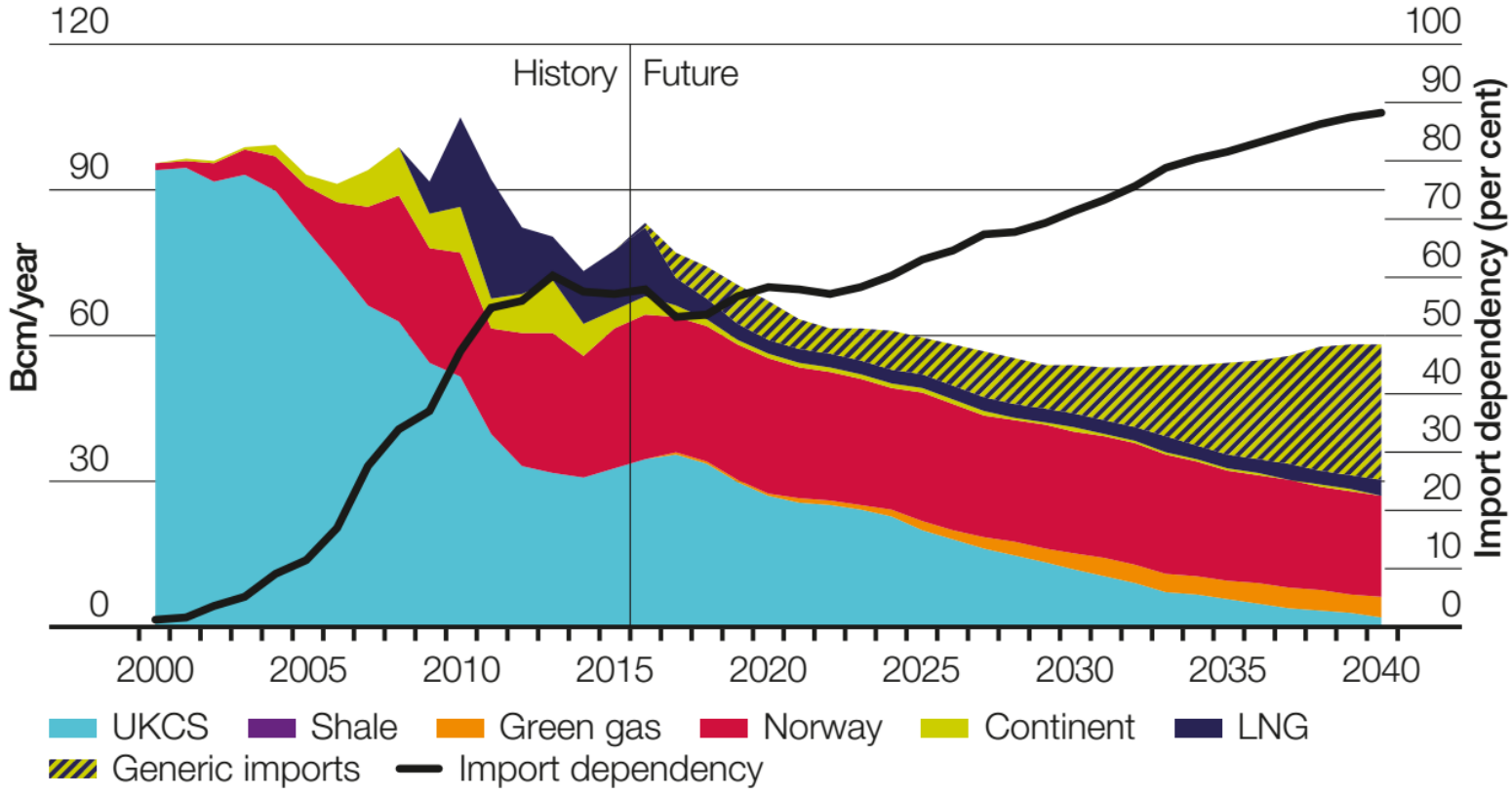
- Up to 20,000 wells or 2000 pads to recover 40 tcf in northern England
- 13y UK consumption so NOT a game changer
- UK drilled 20 onshore wells per year 1902-2013
- Population of 8 million



Durham University

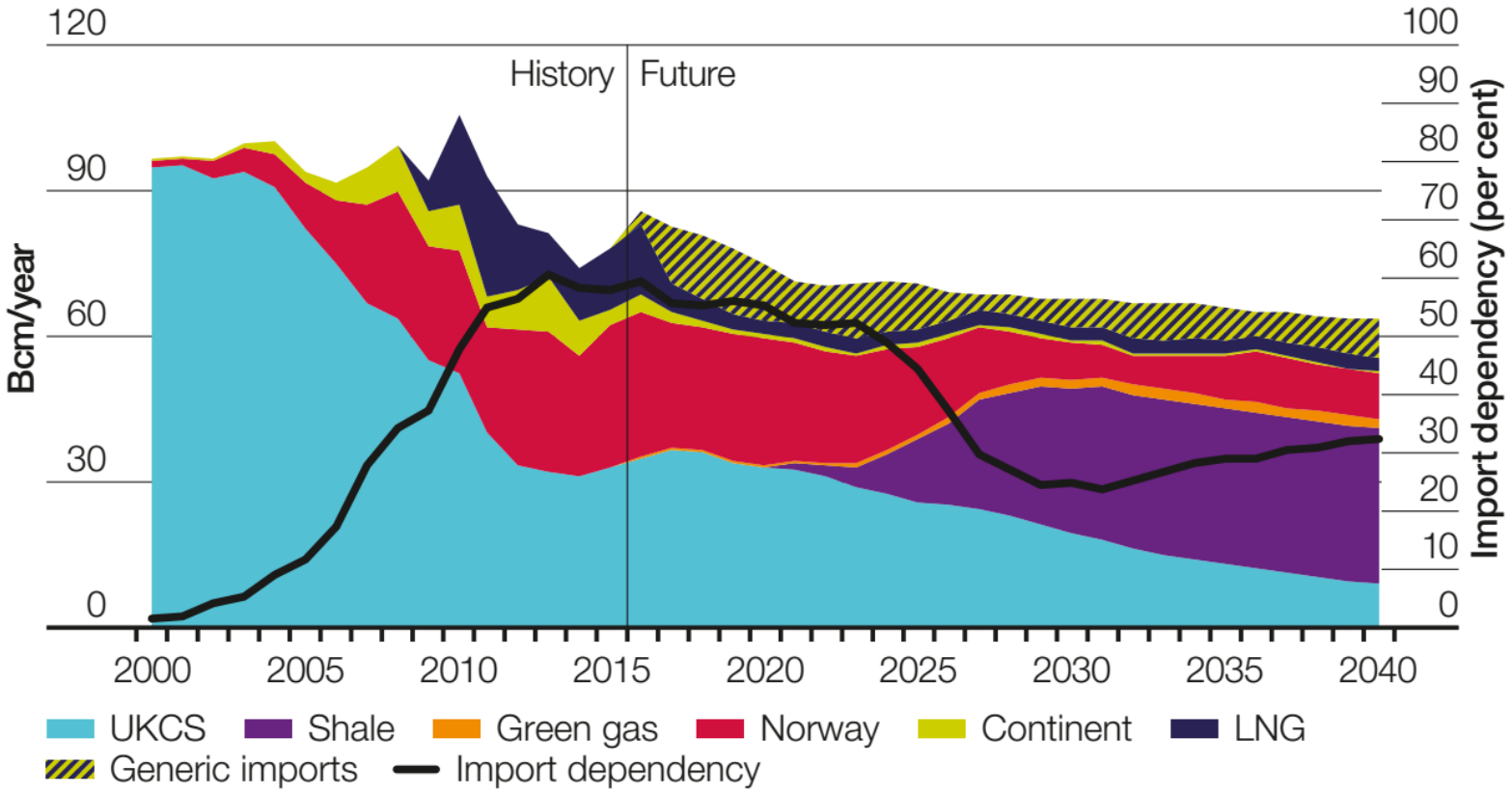
National Grid's Future Energy Scenarios: Gone Green = No Shale

Figure 4.4.1
Annual supply pattern in Gone Green



National Grid's Future Energy Scenarios: Consumer Power = Max Shale

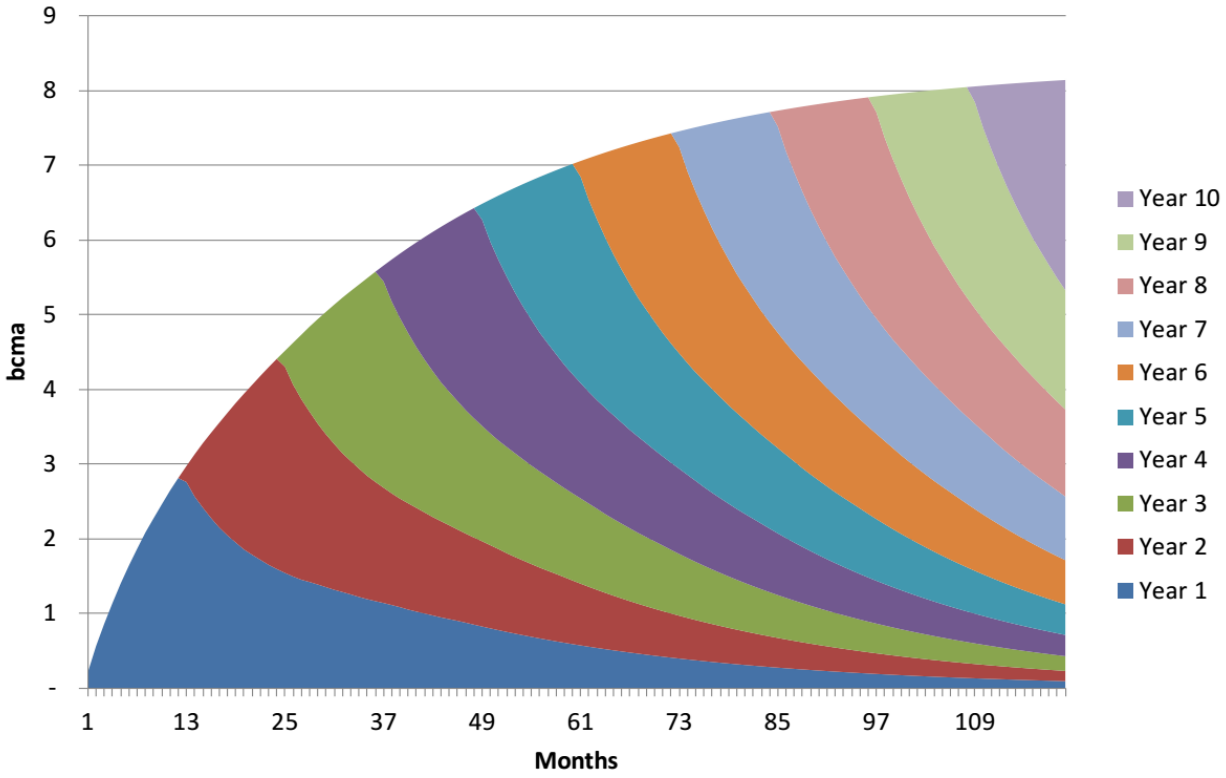
Figure 4.4.4
Annual supply pattern in Consumer Power



32bcm/y = 1.1 tcf/y = 40% UK gas in 2031, production starting 2021
Would need ca. 1000 wells per year

Durham University

Modelled Shale Gas Production over 10 Years



- 3000 wells = 300 wells per year
- Average Barnett Production per well
- 10% UK gas consumption after 10 years

Durham University

Rogers (2013)

GEOLOGICAL AND ENVIRONMENTAL CONCERNS

Important Issues

- Transport Disruption
- Water Use and Disposal
- Aquifer Contamination
- Induced Seismicity
- Leakage through Boreholes
- Climate Change

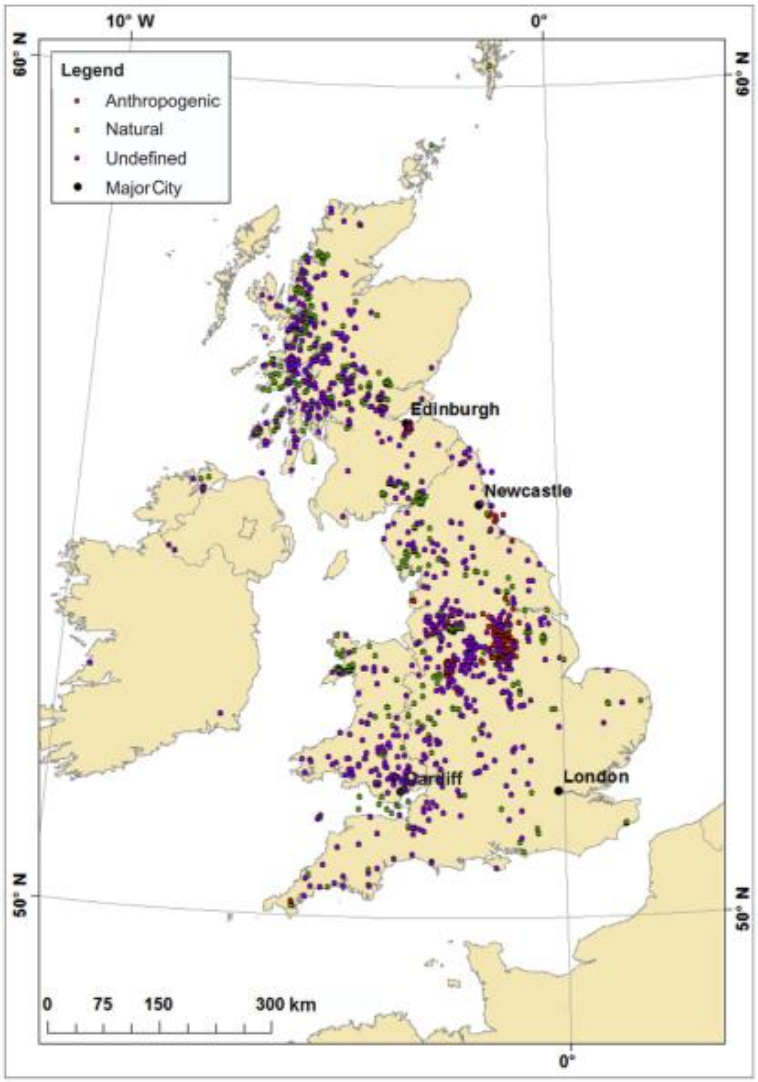
Water Use: Substantial but Incremental

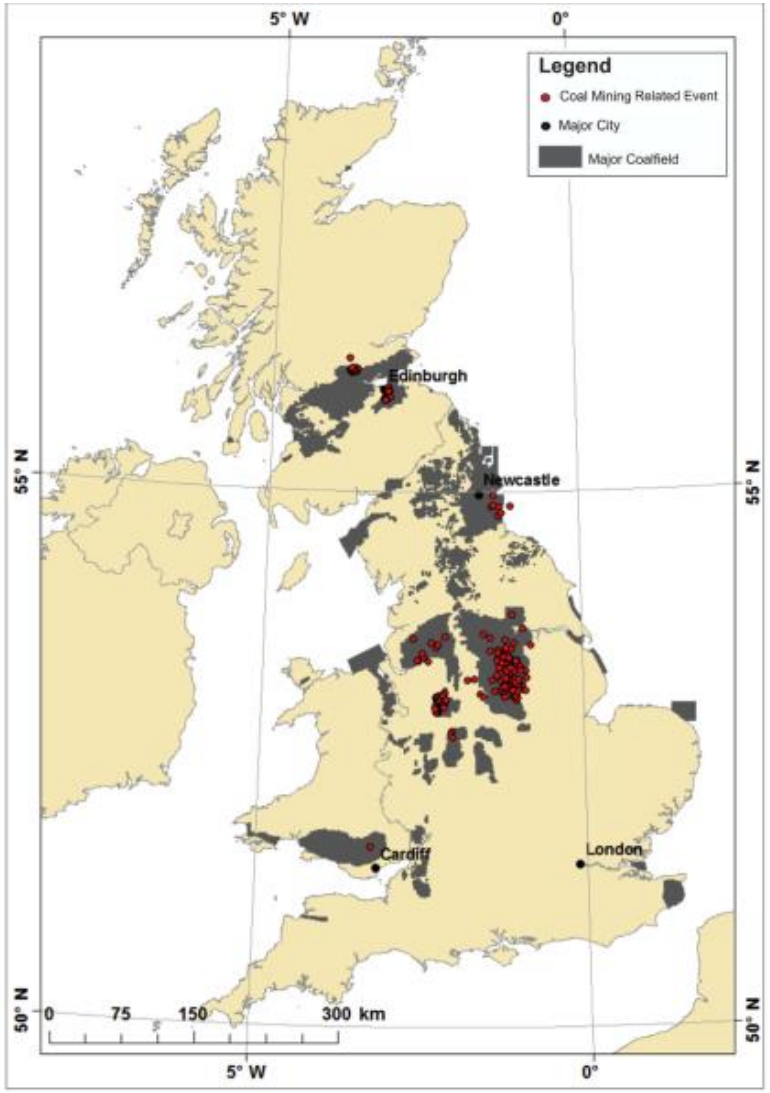
Shale Play	Public Supply	Industrial and Mining	Power Generation	Irrigation	Livestock	Shale Gas	Total Water Use (Bbbl/yr)
Barnett	82.70%	4.50%	3.70%	6.30%	2.30%	0.40%	11.15
Fayetteville	2.30%	1.10%	33.30%	62.90%	0.30%	0.10%	31.9
Haynesville	45.90%	27.20%	13.50%	8.50%	4.00%	0.80%	2.15
Marcellus	11.97%	16.13%	71.70%	0.12%	0.01%	0.06%	85

But flowback water is often saline and must be disposed of according to strict Environment Agency rules (already in place)

ALL Consulting (2009)

UK Earthquakes > M_L 1.5

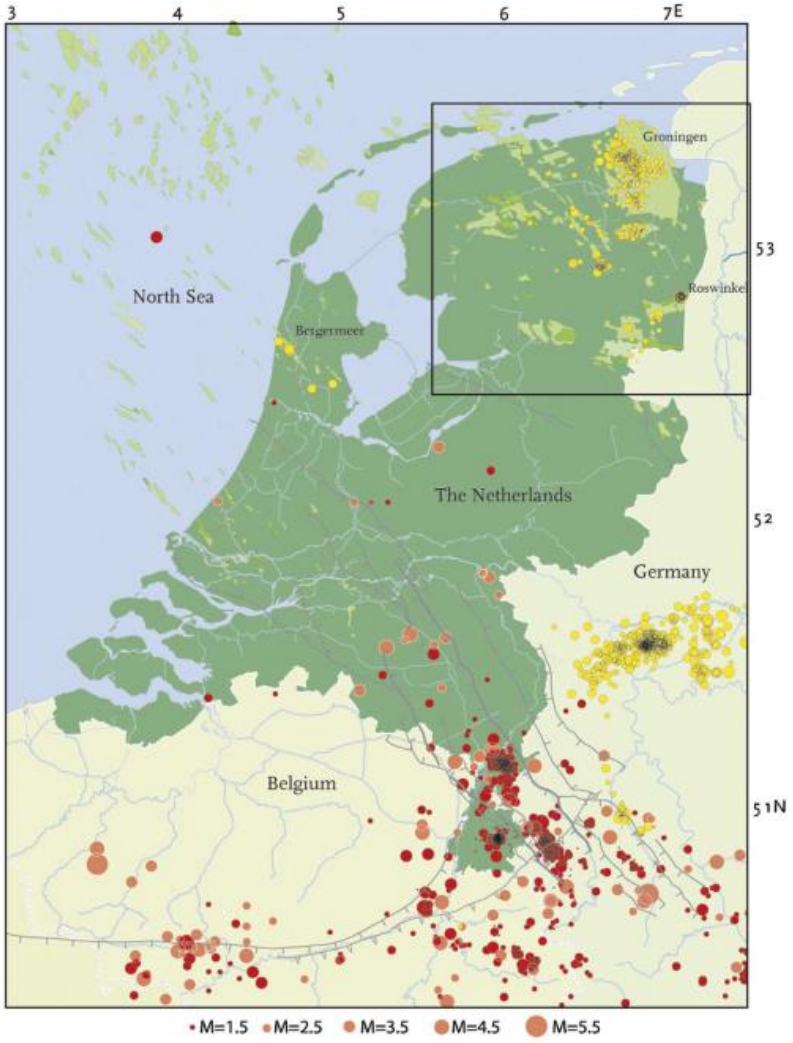


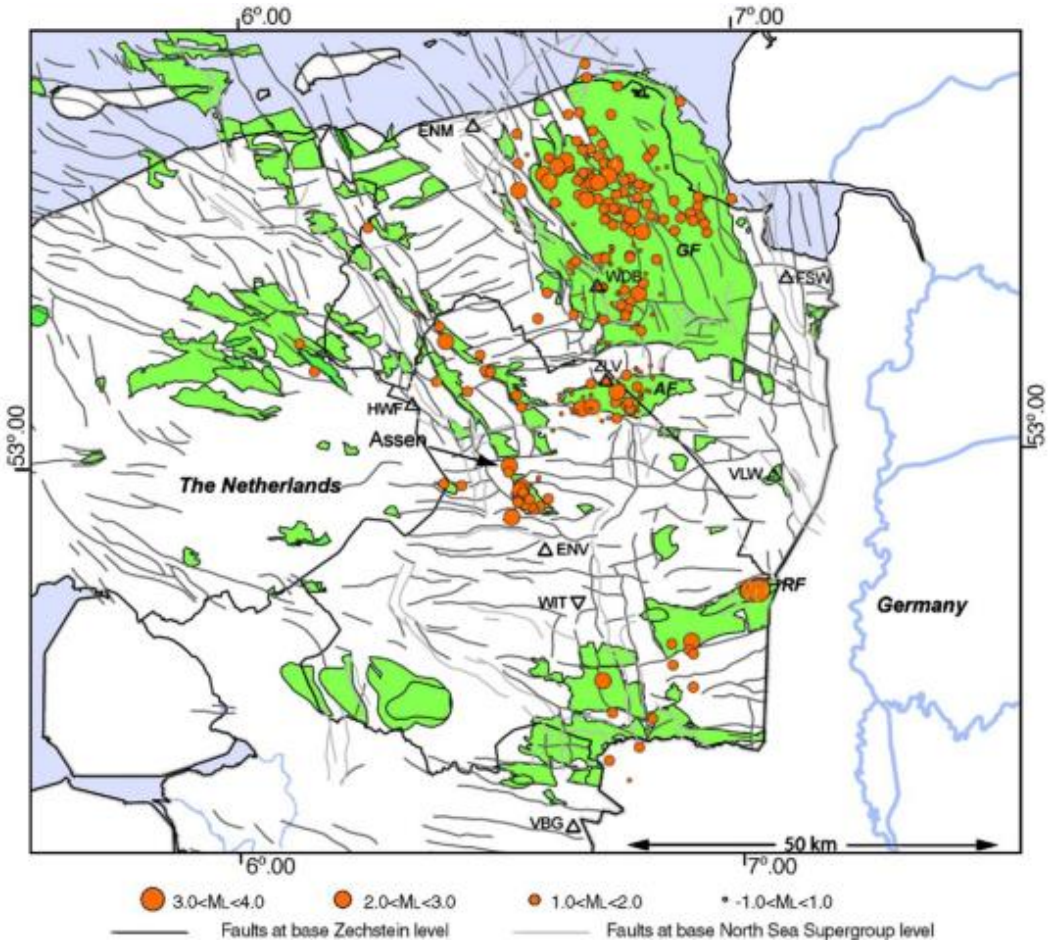


Durham University

Wilson et al. (2015)

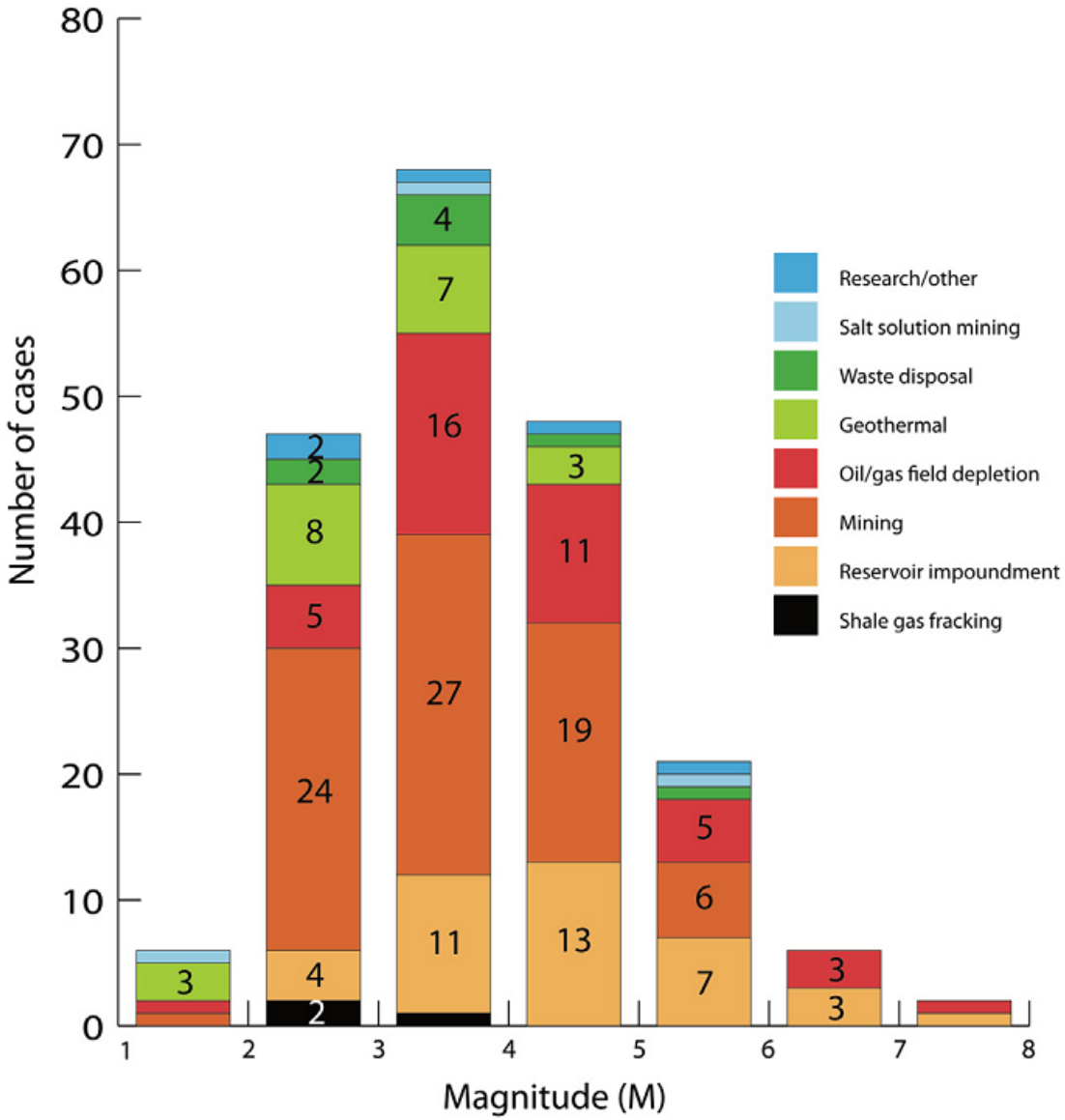
Seismicity Since 1990, Netherlands





Durham University

Subsurface Water Disposal Does Induce Seismicity

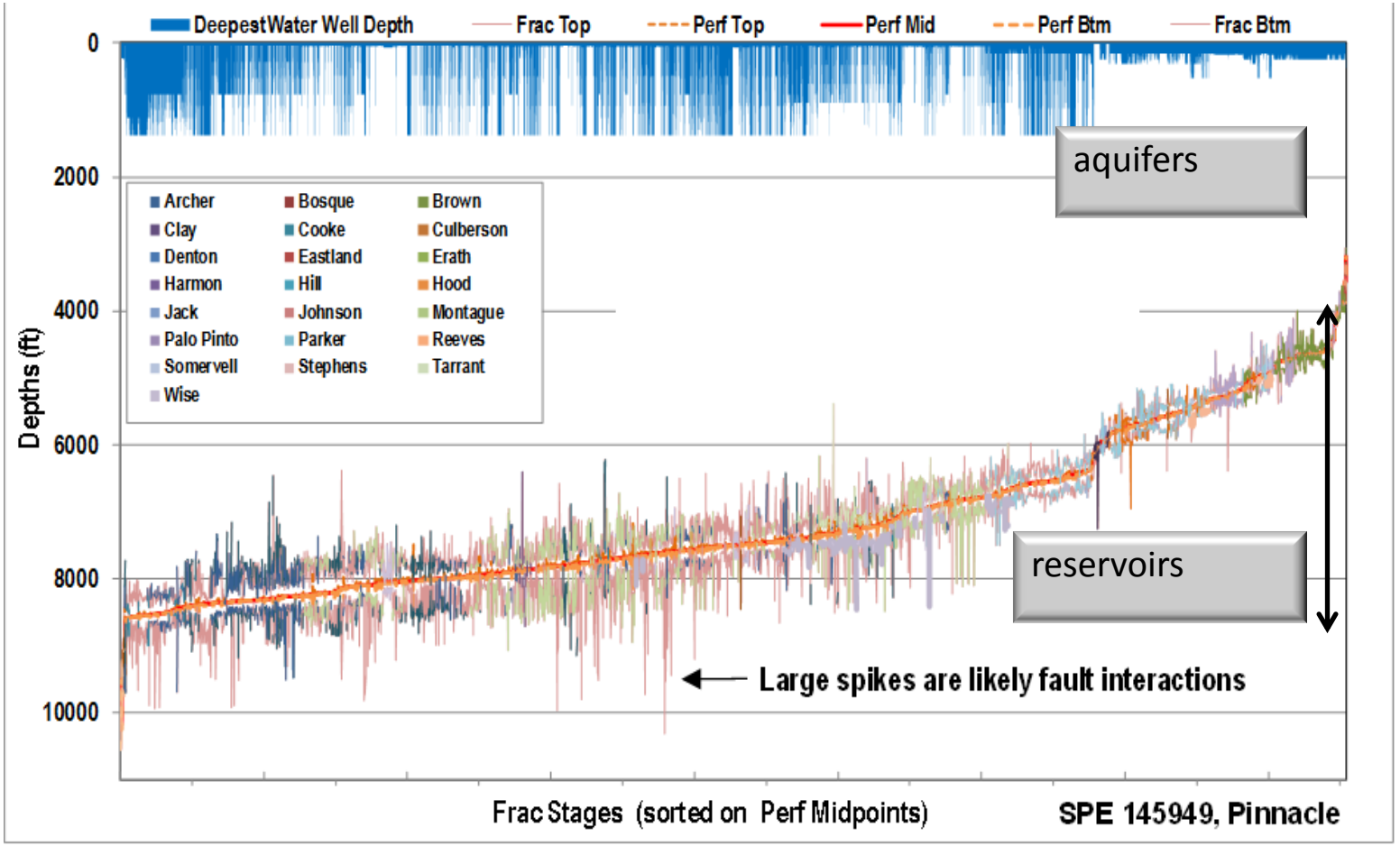


ReFINE
RESEARCHING FRACKING IN EUROPE

Durham University

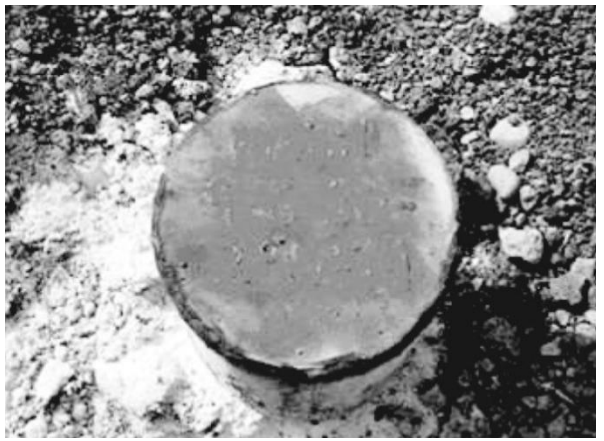
Davies et al. (2013)

US Data: Fractures Very Unlikely to Intersect Aquifers



New and Old Wells Can Leak

- During Production: strict UK rules about double/triple casings through drinking/saline aquifers
- Pennsylvania and Alberta data suggest 5% wells have leaked – rate is key here



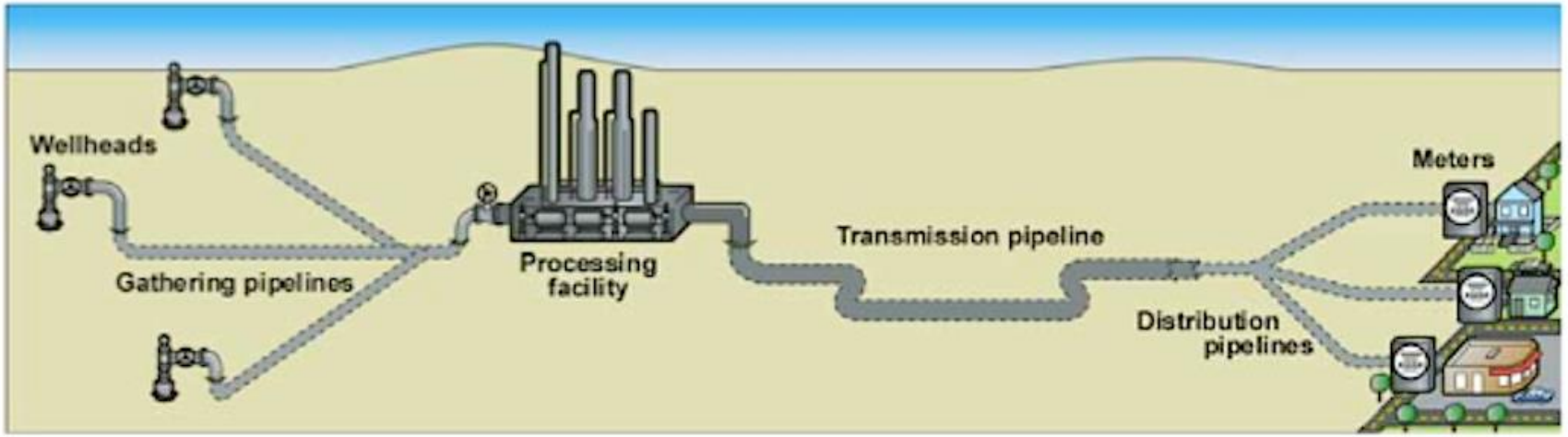
CH_4 Flux from Decommissioned UK Wells

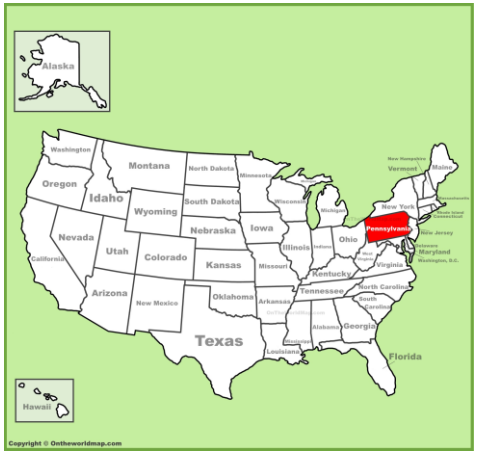
- 30% of well sites had CH_4 at the soil surface that was significantly larger than their respective control
- 39% of well sites significantly lower

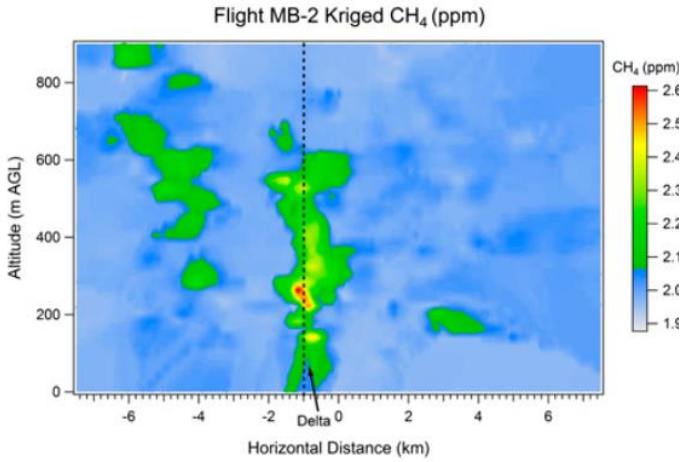
"Flux low relative to the activity commonly used on decommissioned well sites (e.g. sheep grazing)"

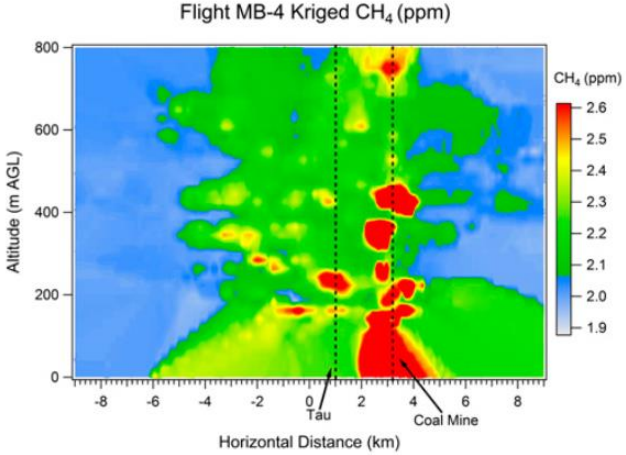
(Boothroyd et al., 2015)

Fugitive Emissions: Drilling, Production, Transportation



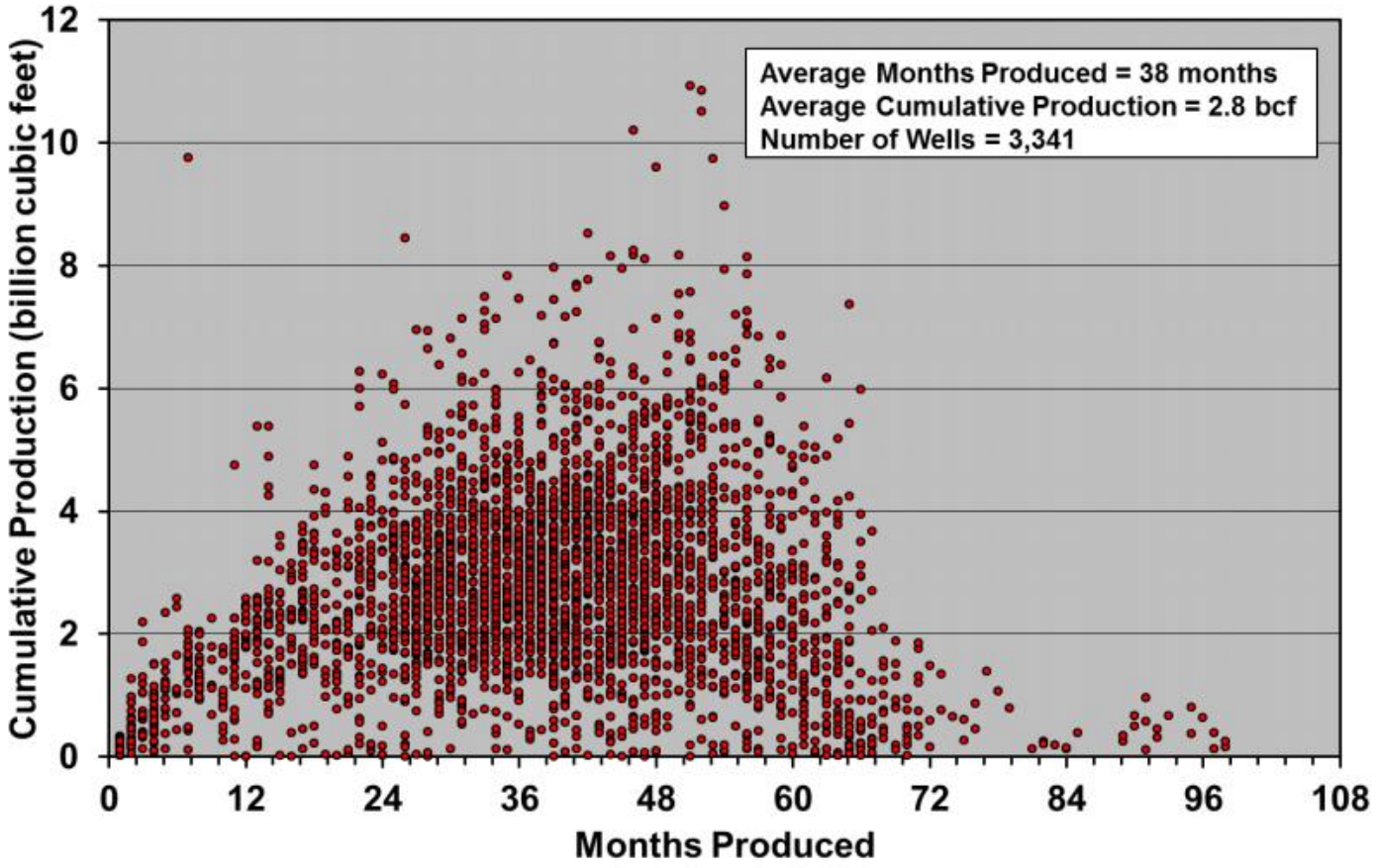






Durham University

Doing it Better: Haynesville Production



EIA

- <1-6 bcf/well EUR
- 30% wells and fracks fail: $100 billion annual waste in US

Concluding Comments

- Globally large volumes of shale oil/gas – and tight gas
- Shale not a game changer in the UK
- US shale success will be harder elsewhere
- Transparent, strong and effective regulation and monitoring
- Social licence to operate: public engagement essential but may be insufficient
- Doing it better: water management, geology and engineering