Conventional and Unconventional Oil and Gas

What is changing in the world?

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Discussion outline

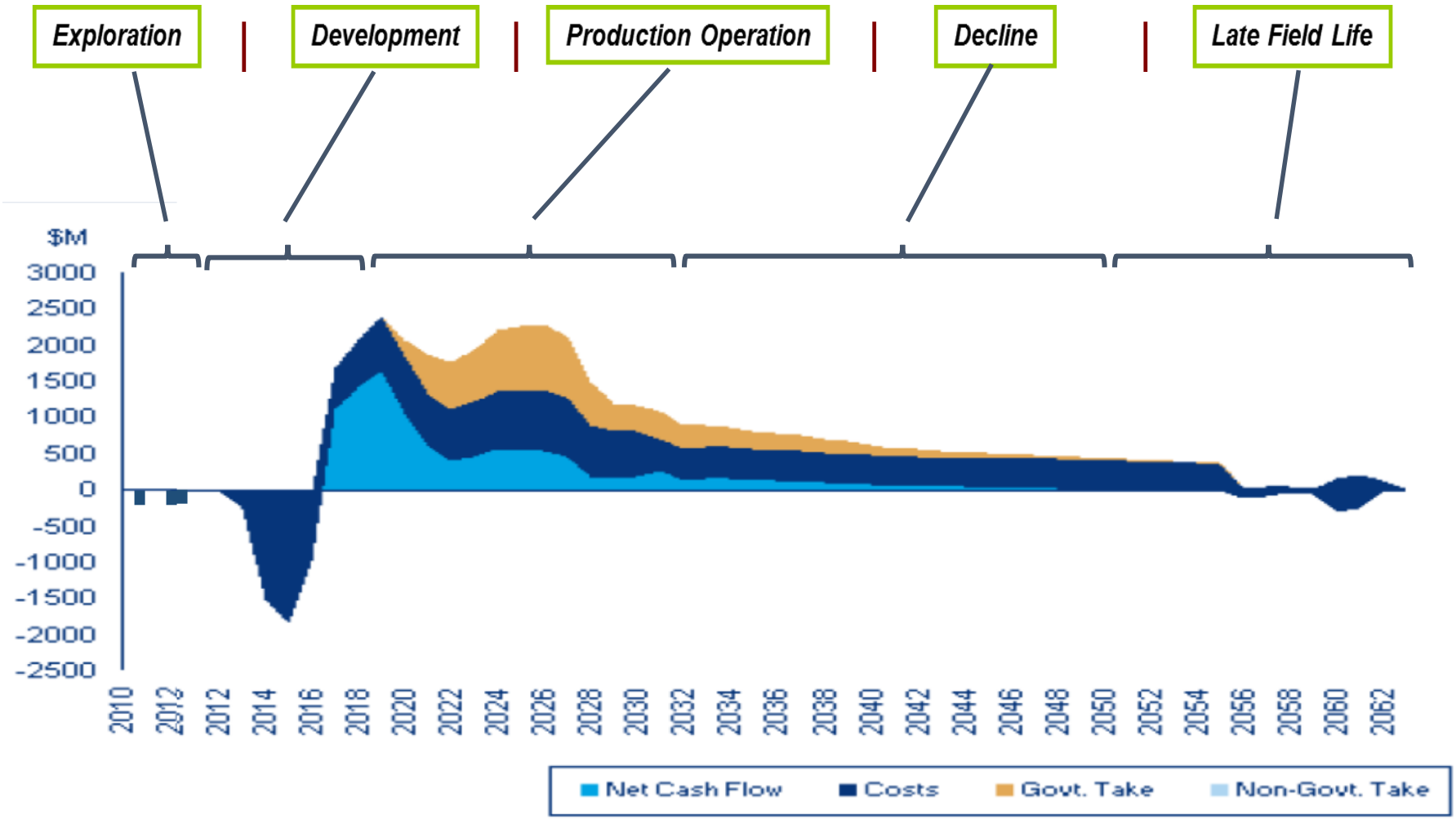
1. Conventional oil and gas
   - E&P life-cycle
   - How it all works
   - Business risk: scale and exposure

2. Unconventional oil and gas
   - What is it and how does it work?
   - North American story
   - What about the UK?

3. What's happening today?

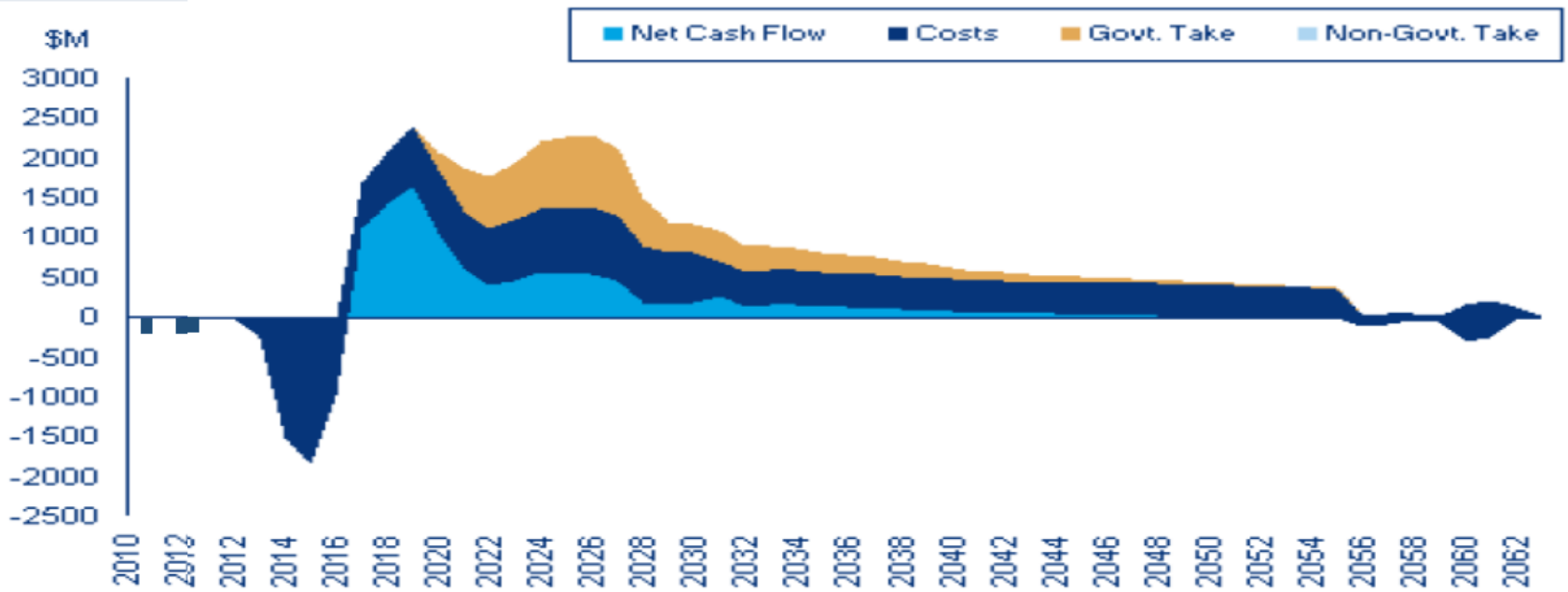
Conventional oil and gas resources

The exploration and production life-cycle of a conventional field



North Sea offshore 350 million barrel oil field example

The exploration and production life-cycle of a conventional field

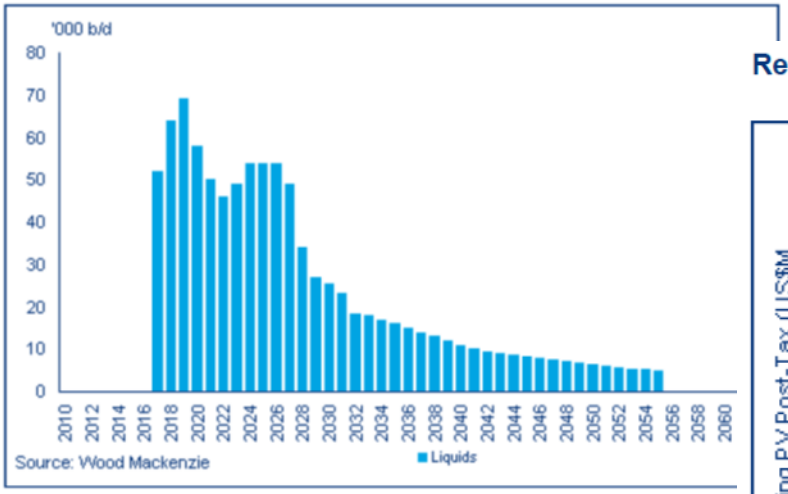


Financial Summary	
Capital costs (2015 terms)	US$7,506M
Capital costs per boe (2015 terms)	US$21.64/boe
Operating costs (2015 terms)	US$11,634M
Operating costs per boe (2015 terms)	US$33.53/boe
Remaining PV (10.0% nominal)	US$2,911M
Remaining PV per boe (10.0% nominal)	US$8.39/boe
Rate of return	14.1%

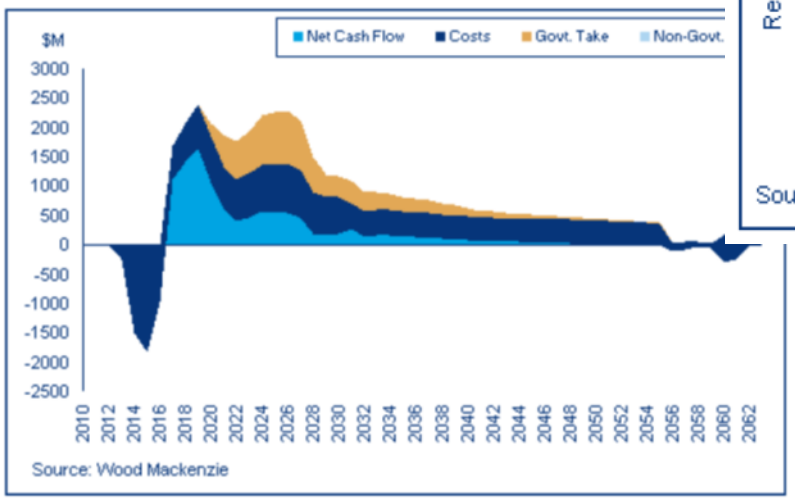
North Sea offshore 350 million barrel oil field example

Huge sensitivity to performance and price

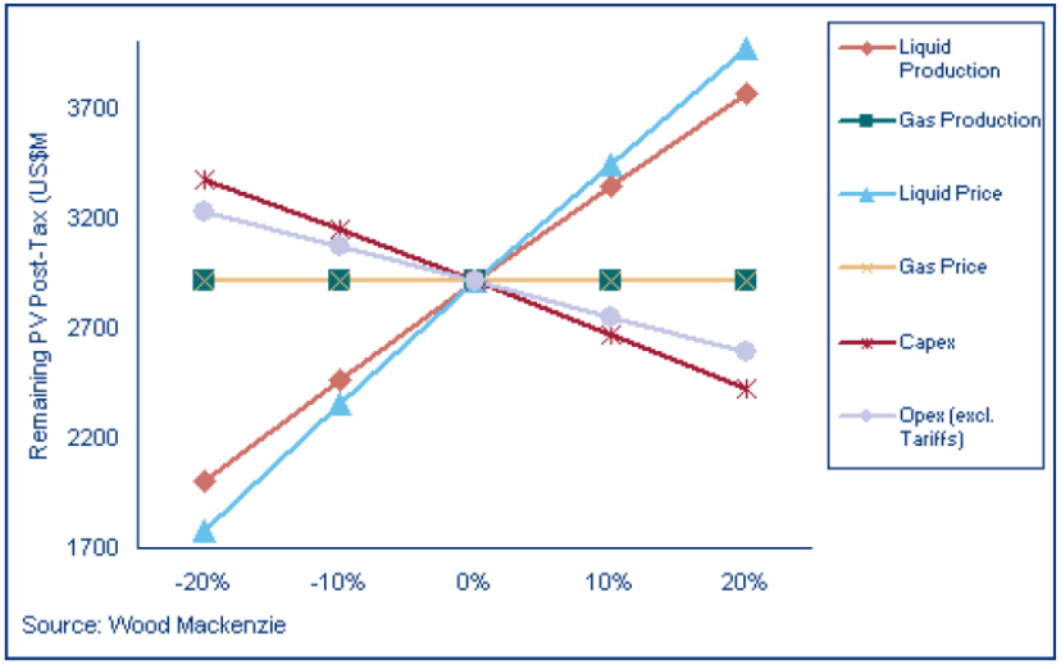
Production Profile



Split of Revenues

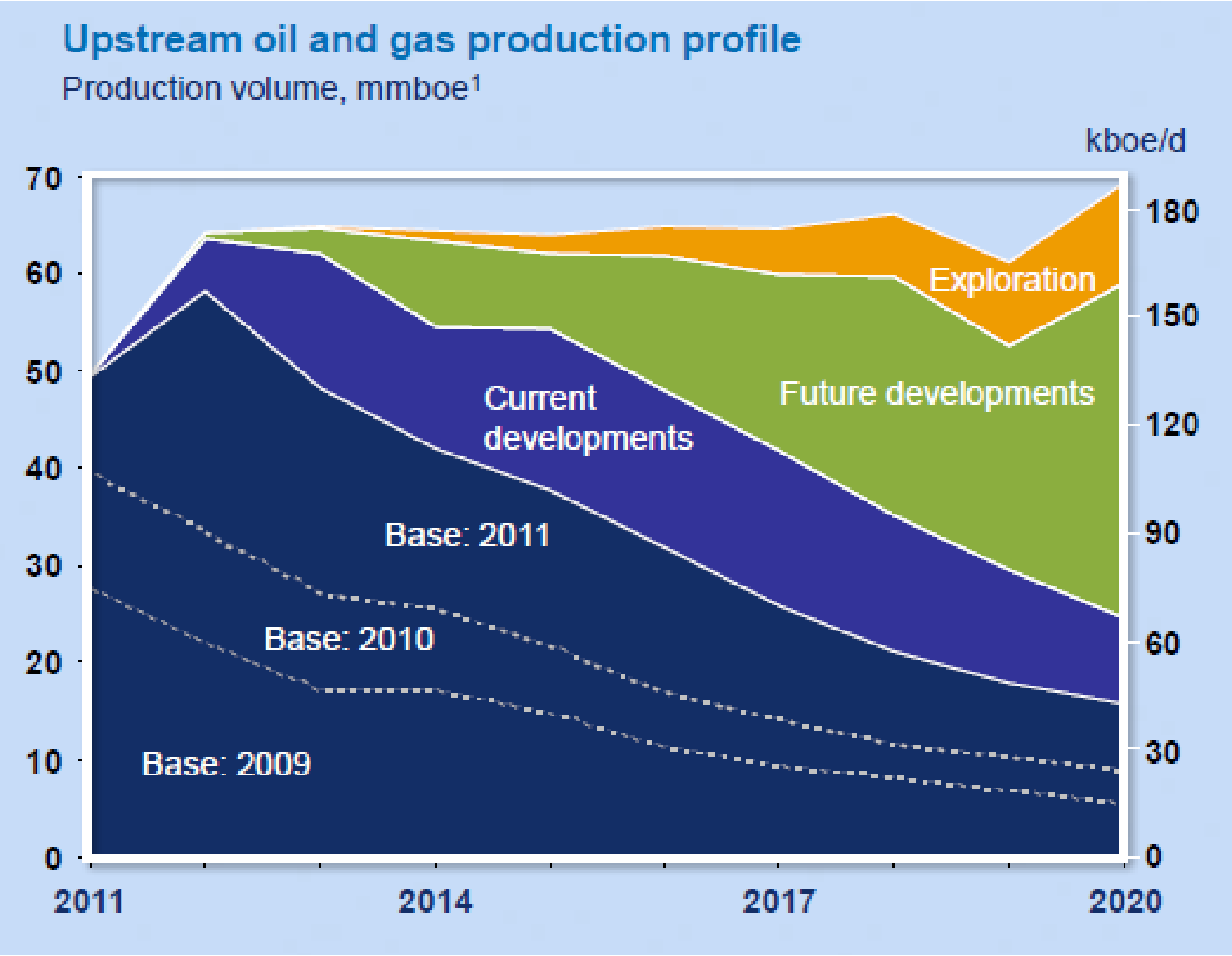


Remaining PV Price Sensitivities

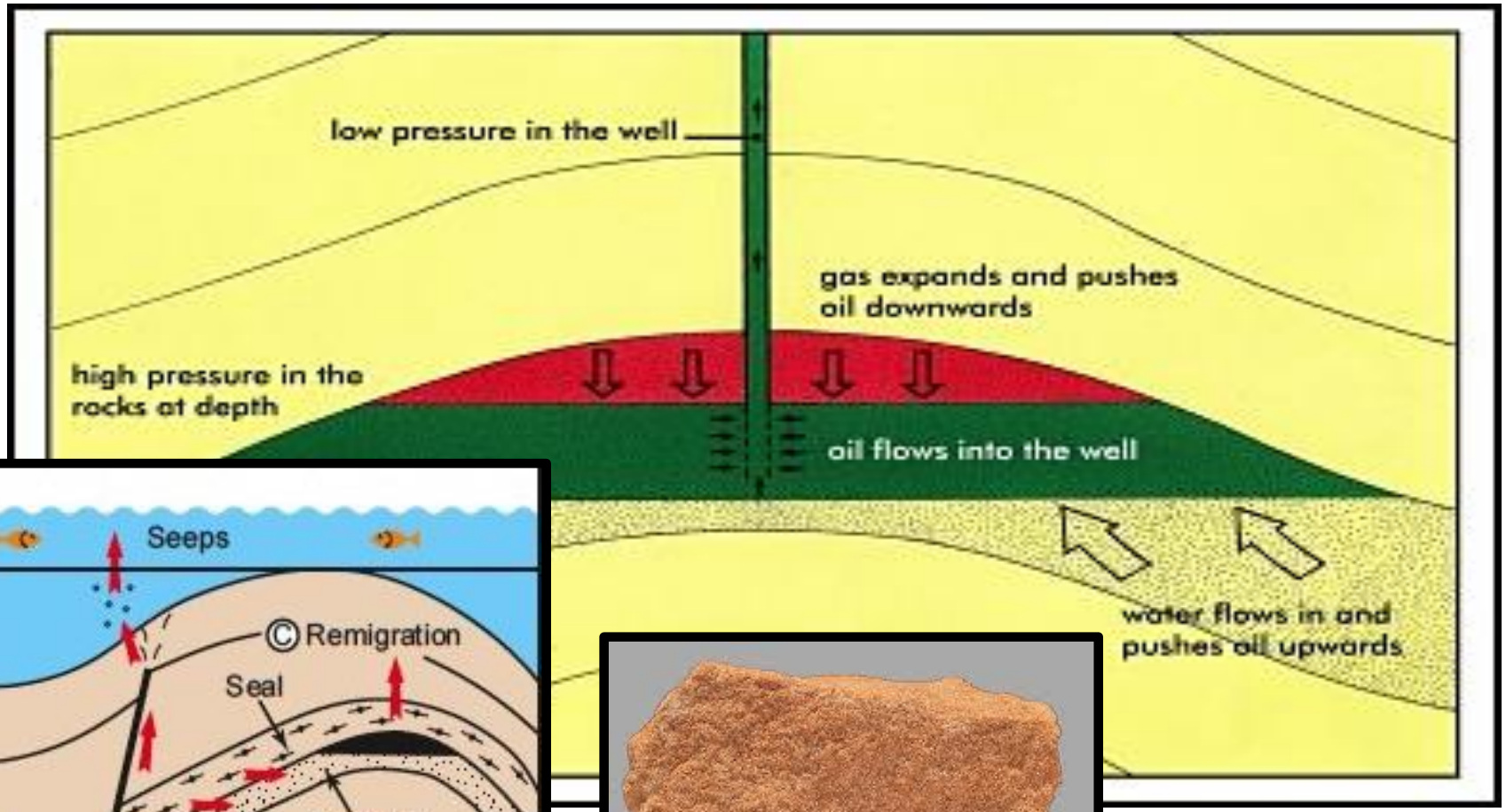


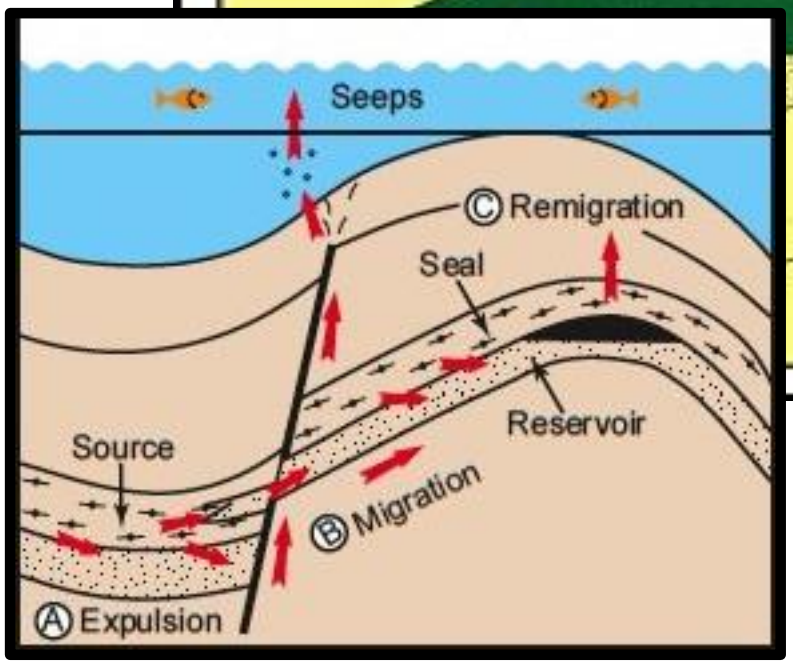
North Sea offshore 350 million barrel oil field example

Sustainable production is the goal for E&P companies

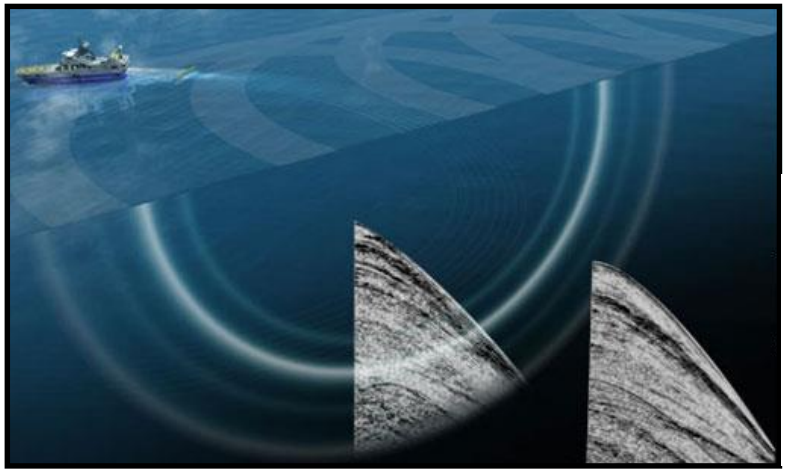


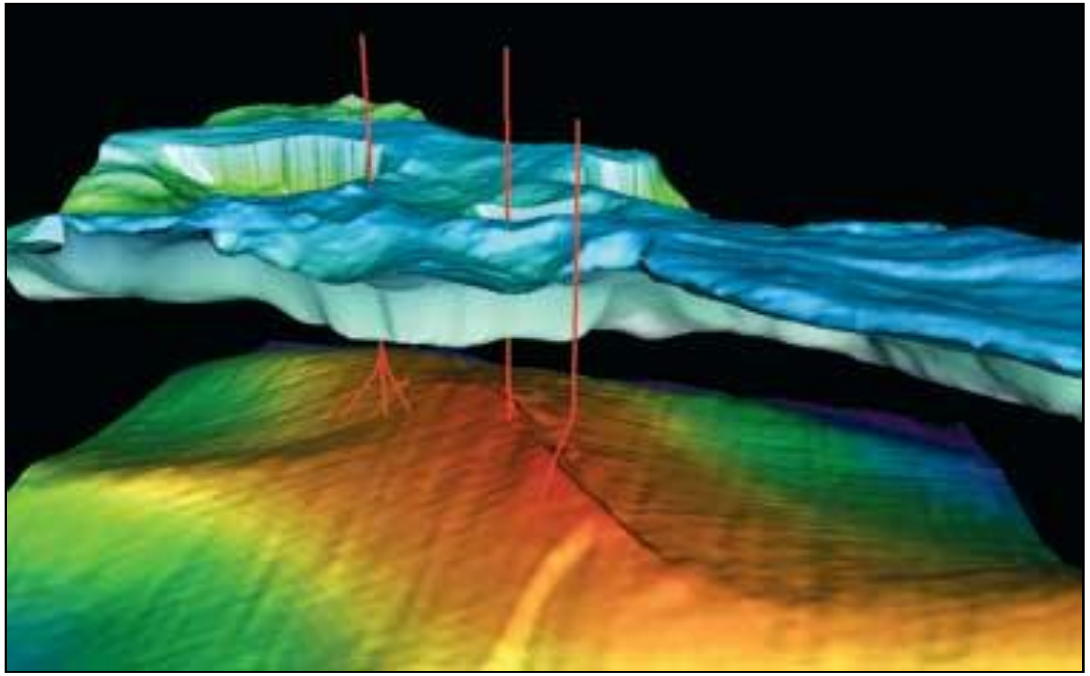
How it all works under the ground



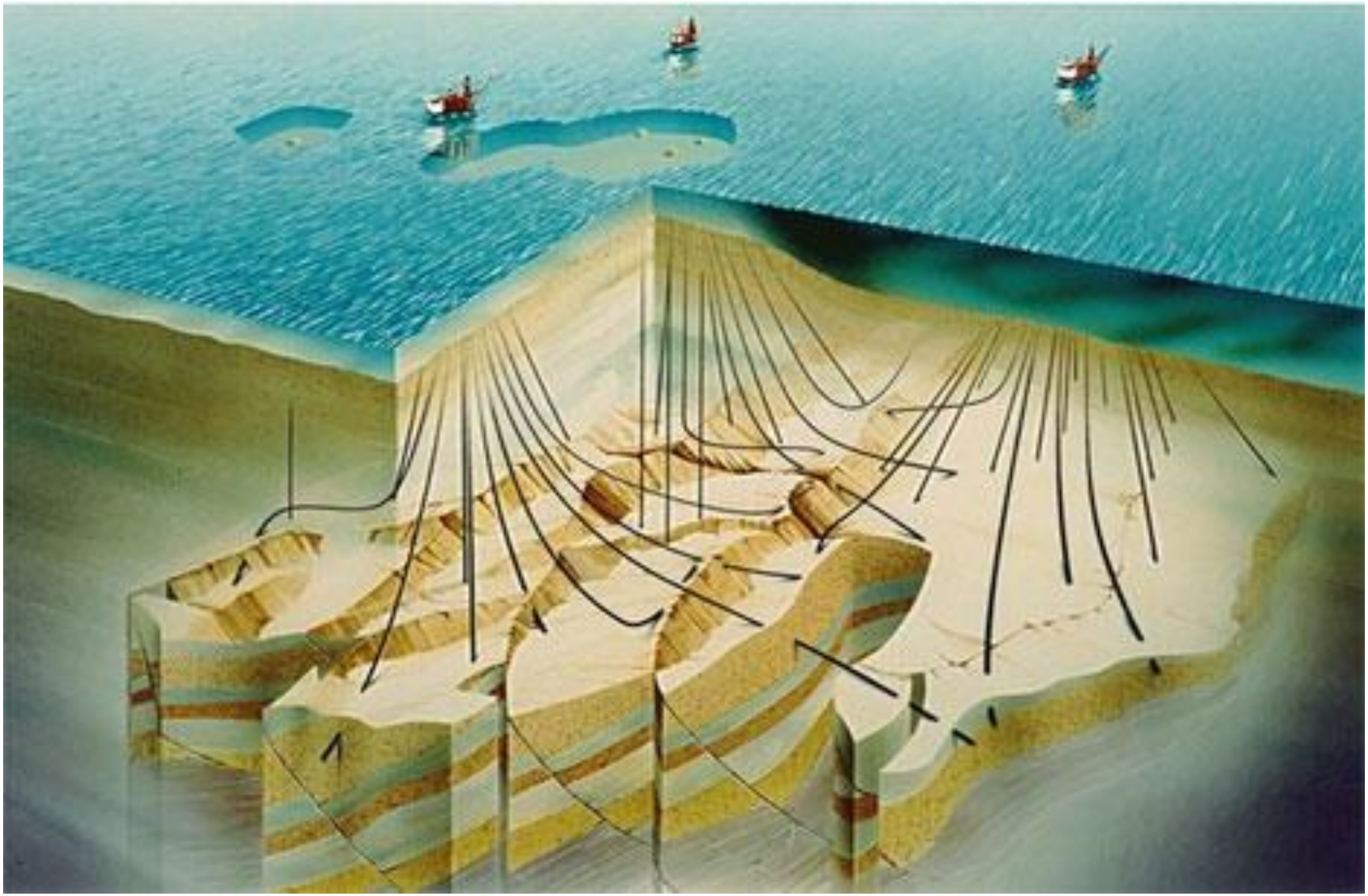


How it all works – exploration to appraisal





How it all works – development to production



Lots of development options

Land rig | Fixed platform | Jack-up | Semi-submersible | Floating production and storage facility | Floating Platform

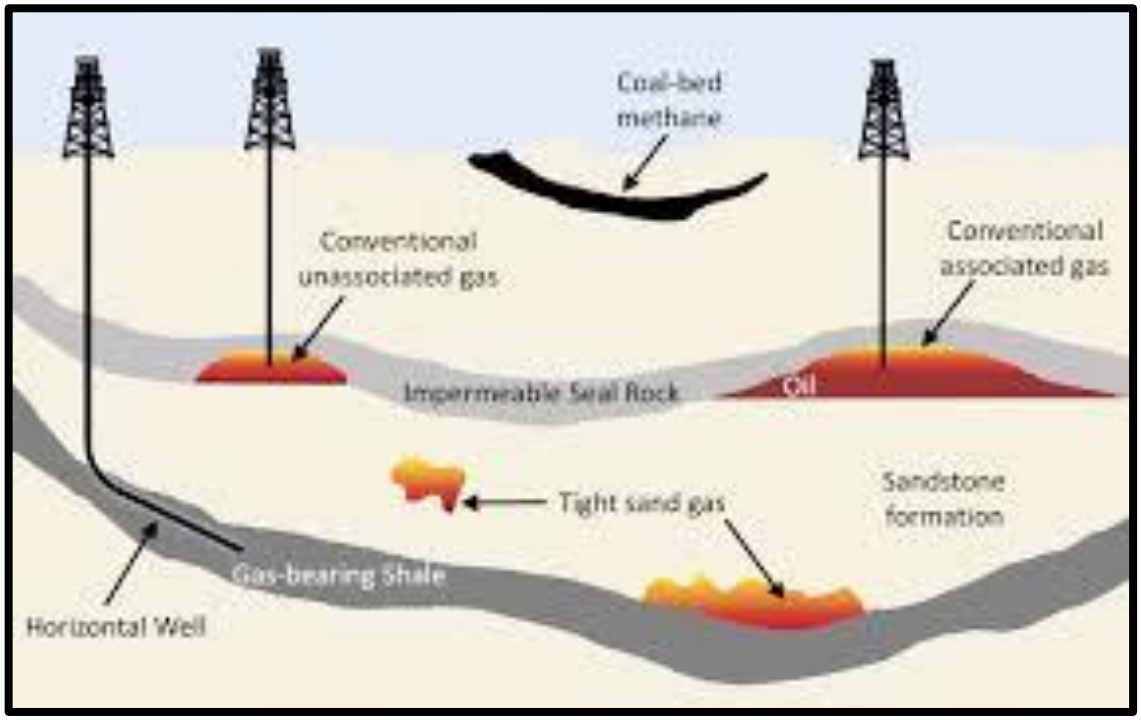
Risks in E&P

- Technical
- Market (including infrastructure)
- Political
- Security
- Price

- Mitigation
  - Technological innovation
  - Balanced portfolio
  - Partnerships
  - Understanding of potential outcomes
  - Risked valuations (including EMV calculation)
  - Willing to take a risk!!

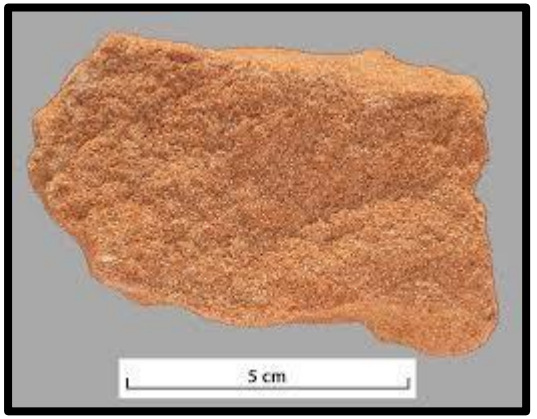
Unconventional oil and gas resources

Conventional versus unconventional oil and gas



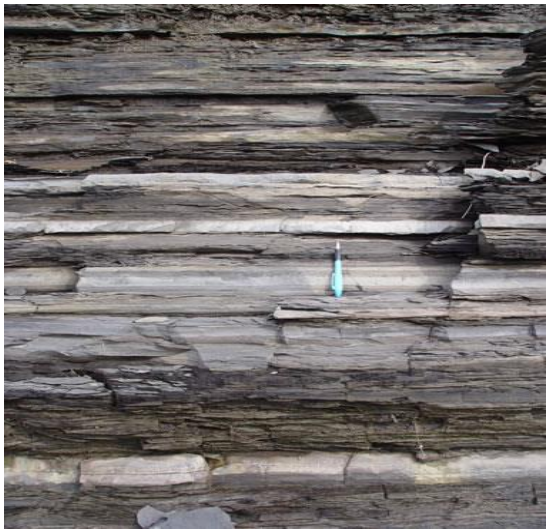
1 – 5 bcf per well

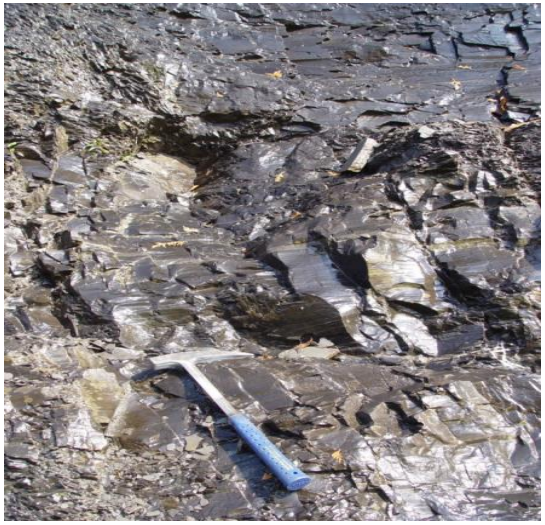
10 – 100 bcf per well



Geology is key to unconventional success

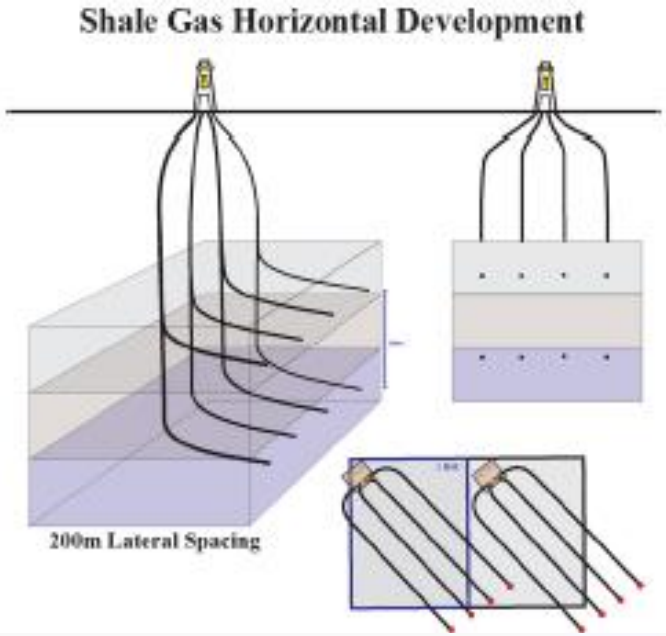
- Frackability
  - Brittleness is good (quartz content)
  - Clay is bad
  - Fracture barriers (good or bad)
- Hydrocarbon content and maturity
  - High TOC good
  - but high TOC is usually ductile rock (not good)
- Depth (> 5000 feet)
- Energy for production
  - Pressure (small over-pressure is good)
- Structural complexity (simple is good)
  - Understanding of regional stress important

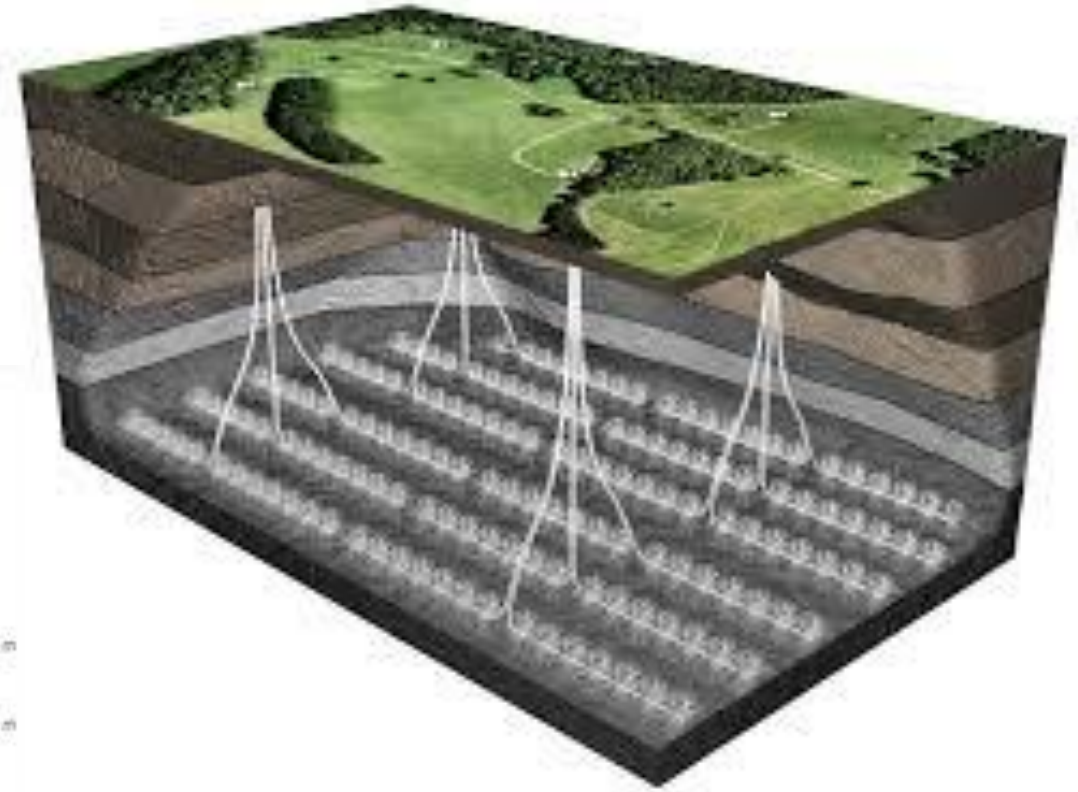


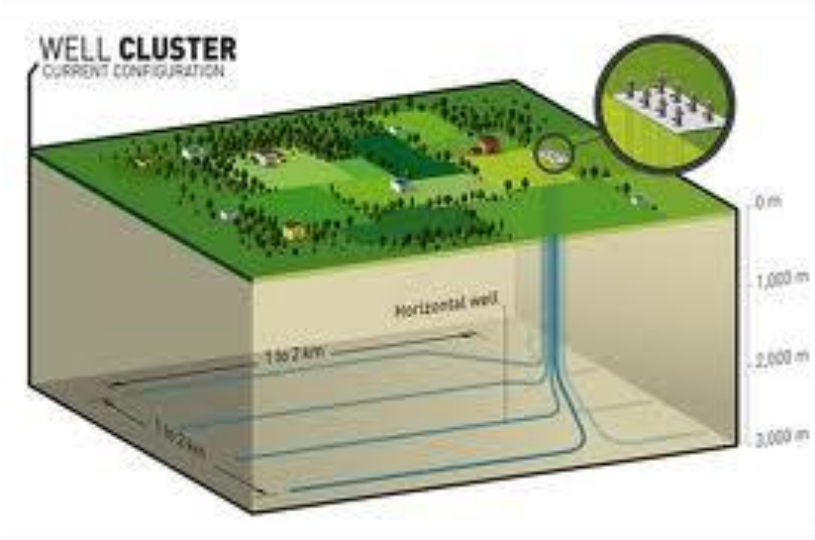


Pictures are from the Utica shale, Canada (A primer for understanding Canadian shale gas, National Energy Board, Canada, 2009)

Shale exploitation techniques



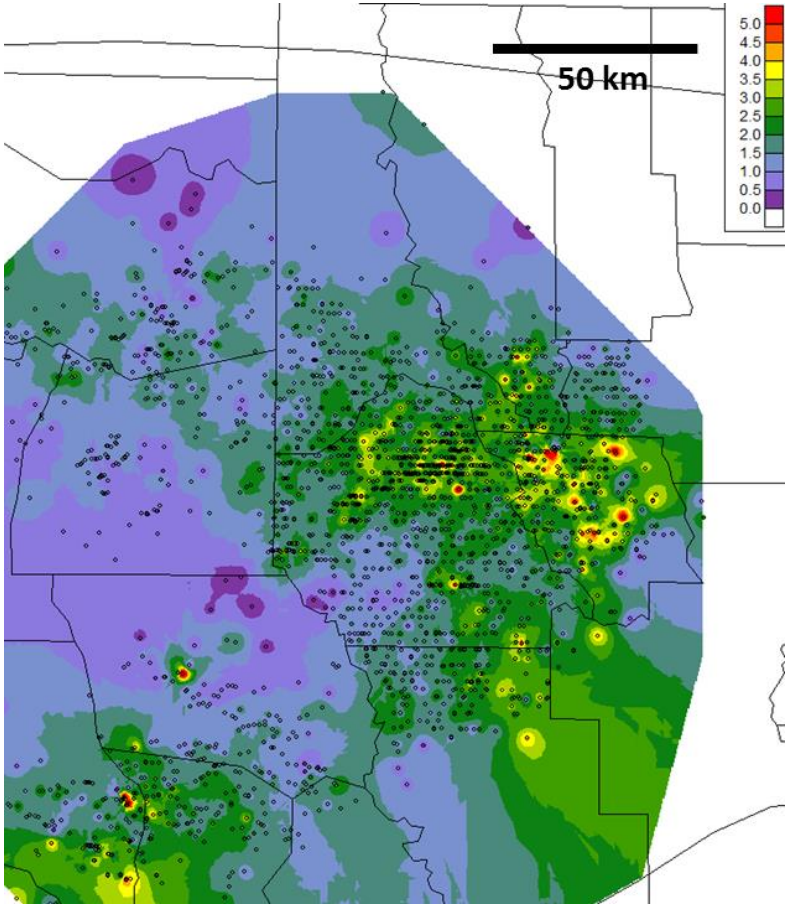




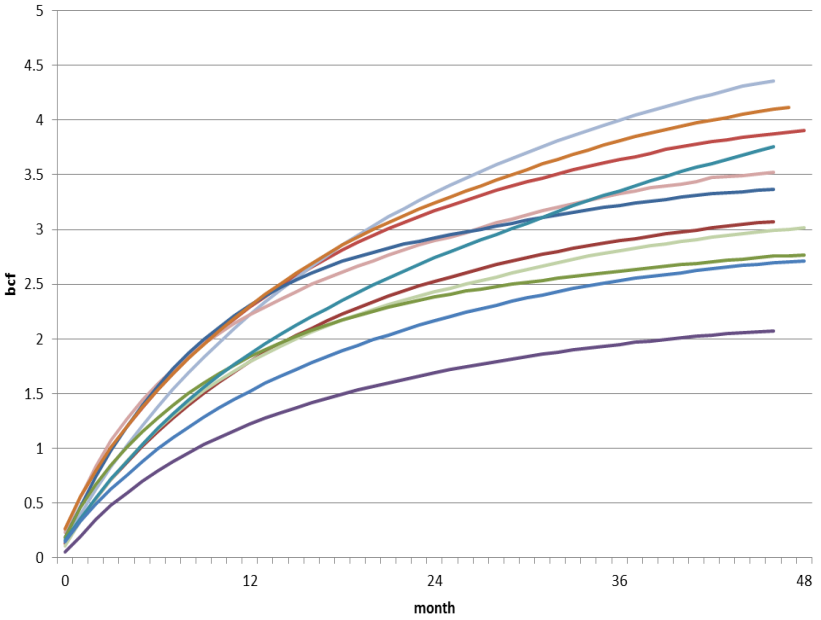
Shale well operations

Huge variation in a single play: Eg: Haynesville (US)

Peak Gas Rate (MMcfpd/1,000ft, 30 Day Average)



Average cumulative production per well (bcf)



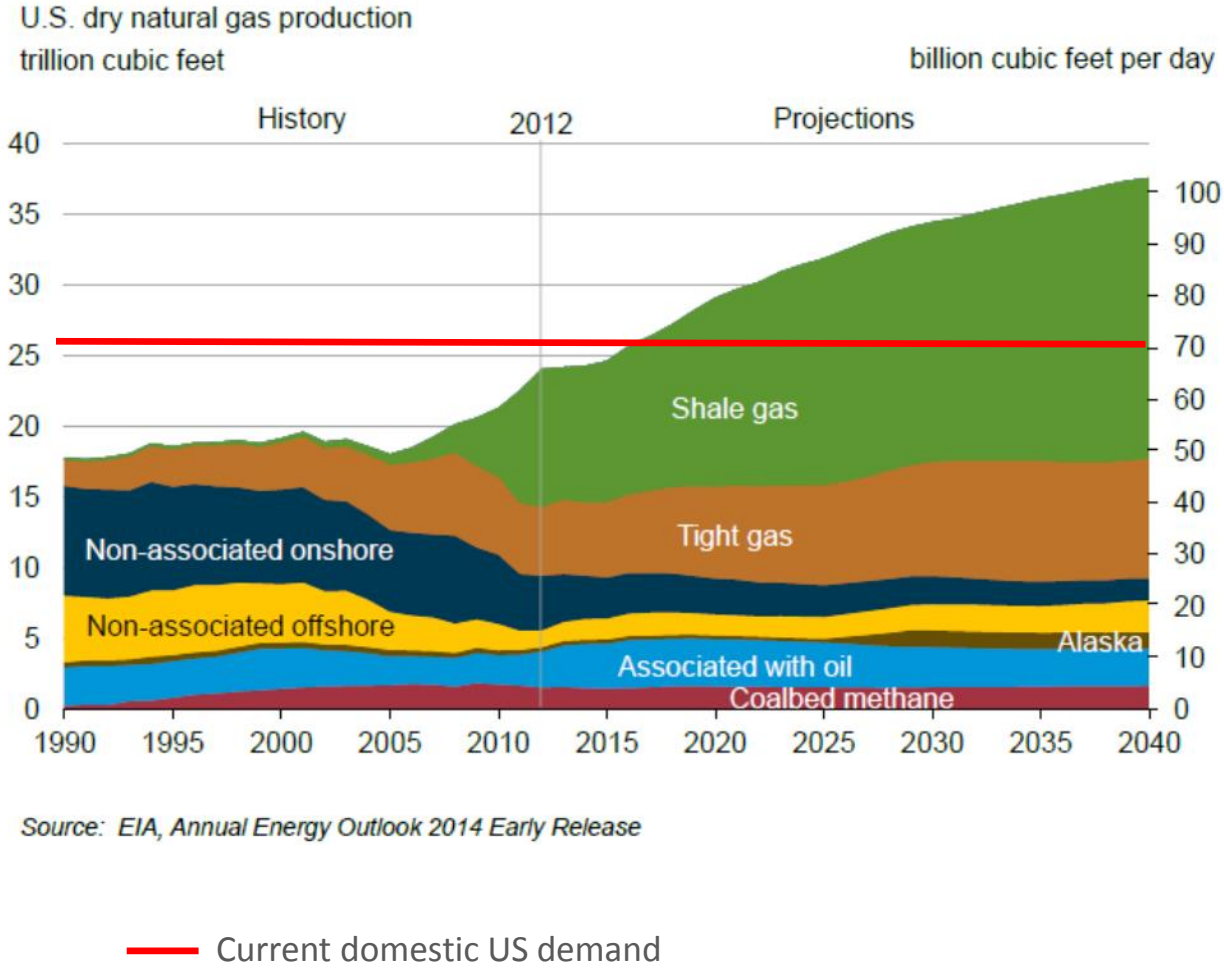
- Peak gas rates range from 0 – 5 mmcfpd
- Single wells produce 2.5 – 4.5 bcf during their life

Data from drillinginfo database

Unconventional oil and gas resources: the US story

The US shale gas revolution

- Dependency on shale gas to meet demand
- 45% of gas production in US is now from shale
- In 2013 US gas consumption was 26 TCF. 26 TCF was produced (12 TCF from shale)
- 46 TCF produced to end 2013; 665 TCF remaining technically recoverable*

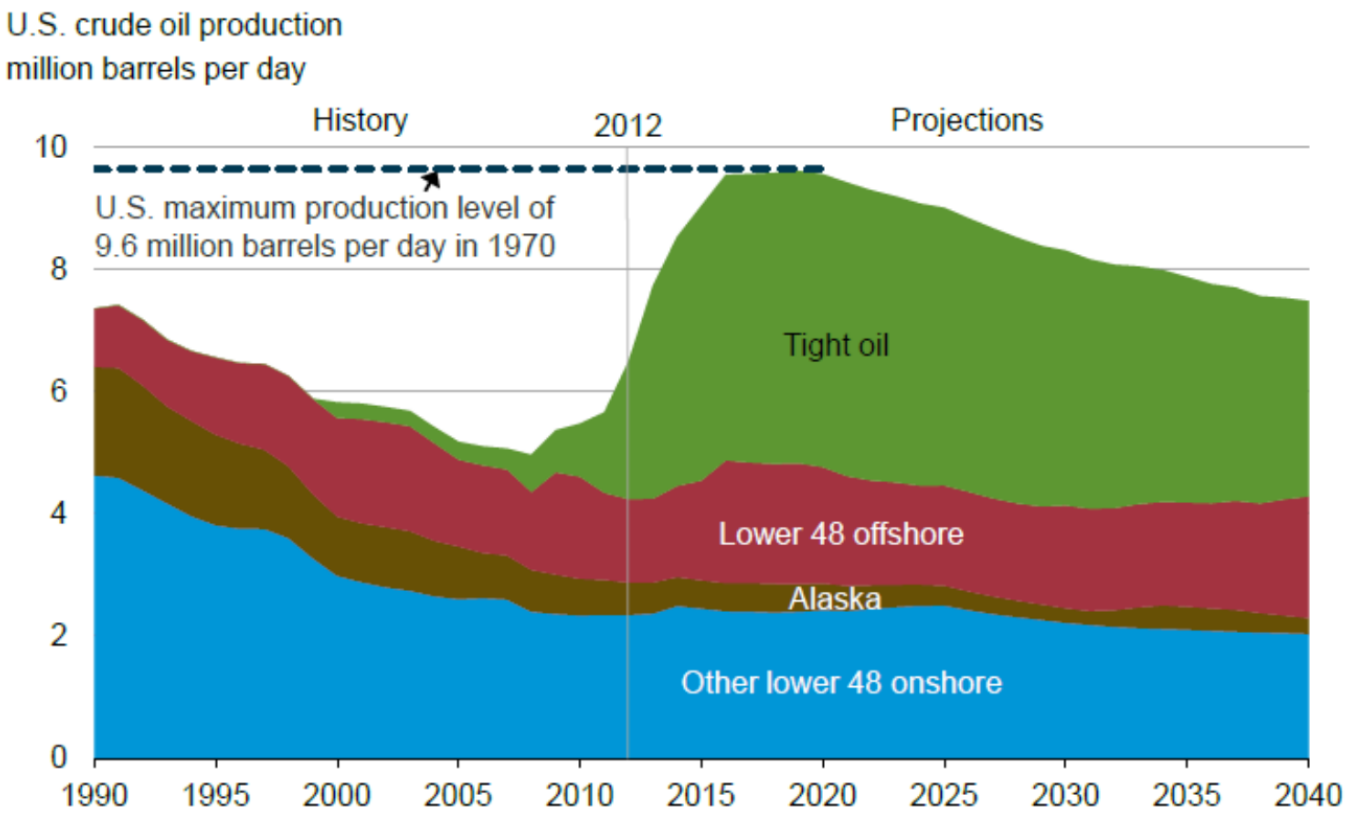


Source: EIA, Annual Energy Outlook 2014 Early Release

* *Note: ARI estimates U.S. shale oil resources at 48 billion barrels and U.S. shale gas resources at 1,161 trillion cubic feet.*
Source: United States: EIA and USGS; Other basins: ARI.

…closely followed by oil from shale

- >50% of oil production in US is now from shale (~5.2 million barrels per day)
- In 2013 US oil consumption was 18.9 million barrels per day
- 58 billion barrels remaining technically recoverable*



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The US shale story

- **Big tax incentives early on**
  - Federal Tax Section 29 nonconventional fuels production tax credit (on 'tight' wells drilled between 1980 – 1992)

- **Lots of experimentation early on**
  - Antrim Shale: first development in 1965: 1,200 wells drilled in tax credit period (natural fractures)
    - 3.3 TCF produced to date
  - Barnett Shale: 275 vertical wells drilled in tax credit period. Slick water frac breakthrough in 1997. Horizontal development drilling starts in 2003. Experimentation continues in fracking
    - 13 TCF produced to date

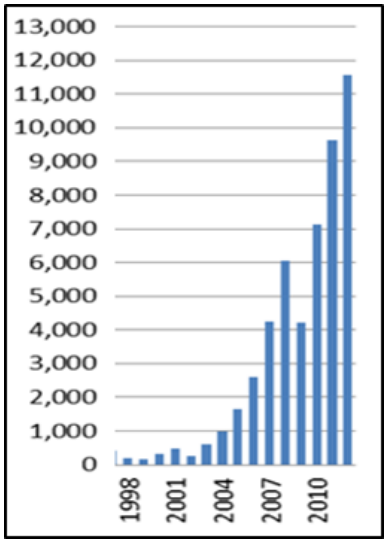
- **Technological breakthroughs**
  - Horizontal drilling
  - Hydraulic fracturing

US shale: scale of operations

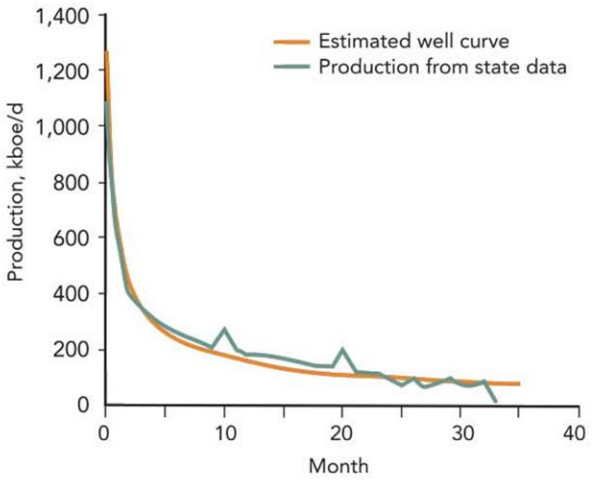
- Huge scale of operation
  - 1,600 land rigs in operation in US
  - 36,000 wells drilled in 2013
- Over 30,000 wells are currently on production from shales.
  - For oil on average each well produces 315 barrels oil per day
  - For gas on average each well produces 1.6 million standard cubic feet per day
- Very high level of drilling must continue in order to sustain production as individual wells only have 1- 5 year economic life

No. of horizontal wells drilled per year 1998 - 2012

~23,000 horizontal wells in 2013



Typical oil production from a single Bakken well



Source: NASWellData by Rystad Energy

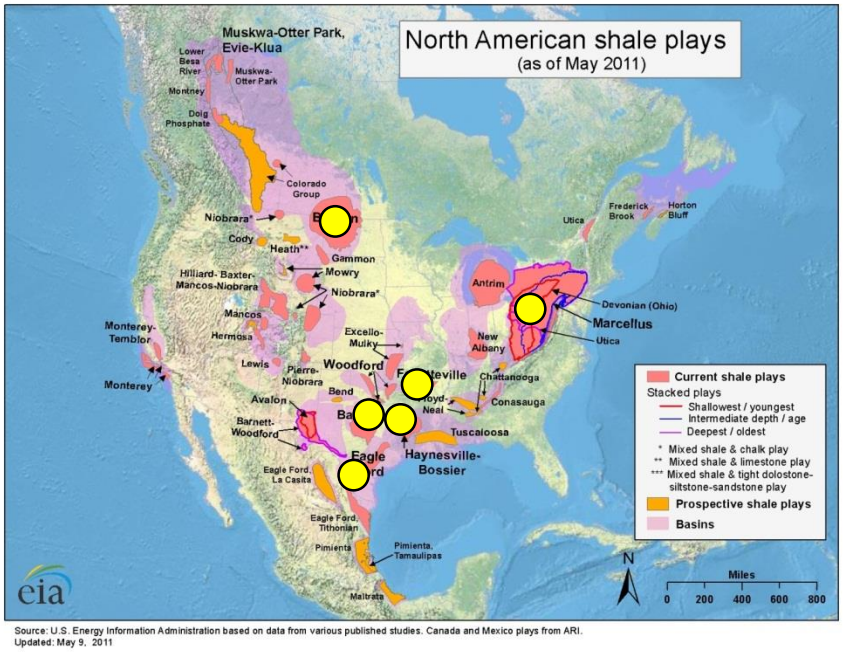
Where does it all come from?

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011

- 64 key shale plays
- 28 are ‘pure shale’
- 36 are ‘hybrid’
- Huge variation in liquids content

BUT only a few plays have production

- 6 shale plays are bulk of production*
- 126 TCF and 2.4 billion barrels already produced by end 2013*
- These plays alone have potential to still produce 800 TCF and 13 billion barrels



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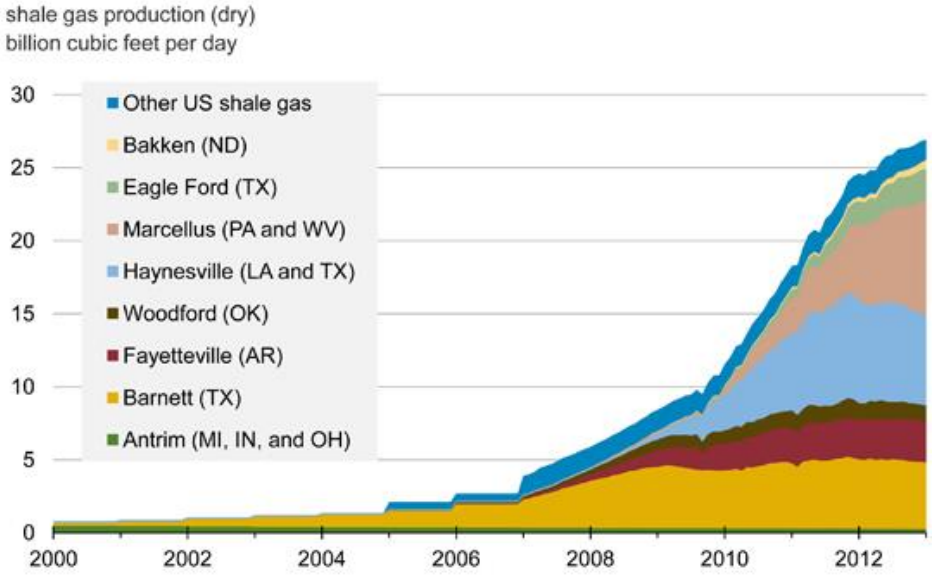
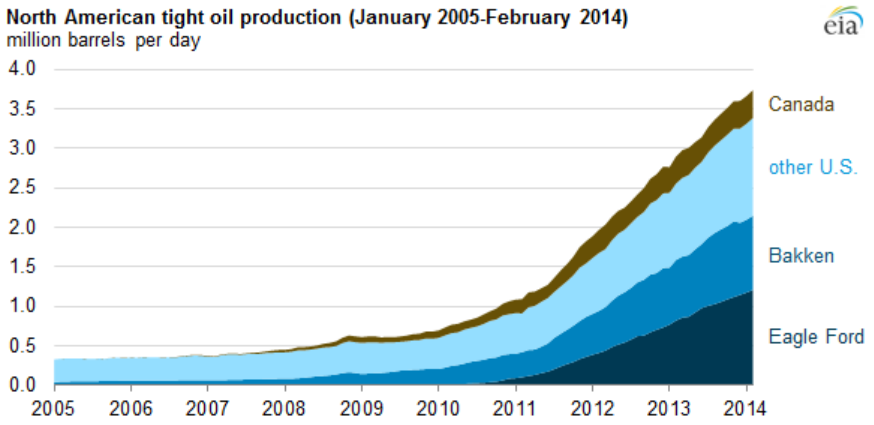


Sources: LCI Energy Insight gross withdrawal estimates as of January 2013 and converted to dry production estimates with EIA-calculated average gross-to-dry shrinkage factors by state and/or shale play.



* Includes Bakken which is a 'hybrid' play

So why does it work in the US?

Reproducibility of shale development may have limits

Many factors support production from U.S. shale resources that do not exist in many other countries:

- Resource quality and geologic distribution details matter
- Major private ownership of subsurface mineral rights, often by surface owners, provides a strong incentive for development
- Availability of many independent operators and supporting contractors with critical expertise and advanced technology
- Pre-existing gathering and pipeline infrastructure
- Public acceptance of hydraulic fracturing as well as related activities, including transportation of material, and availability and disposal of water/wastewater; population density

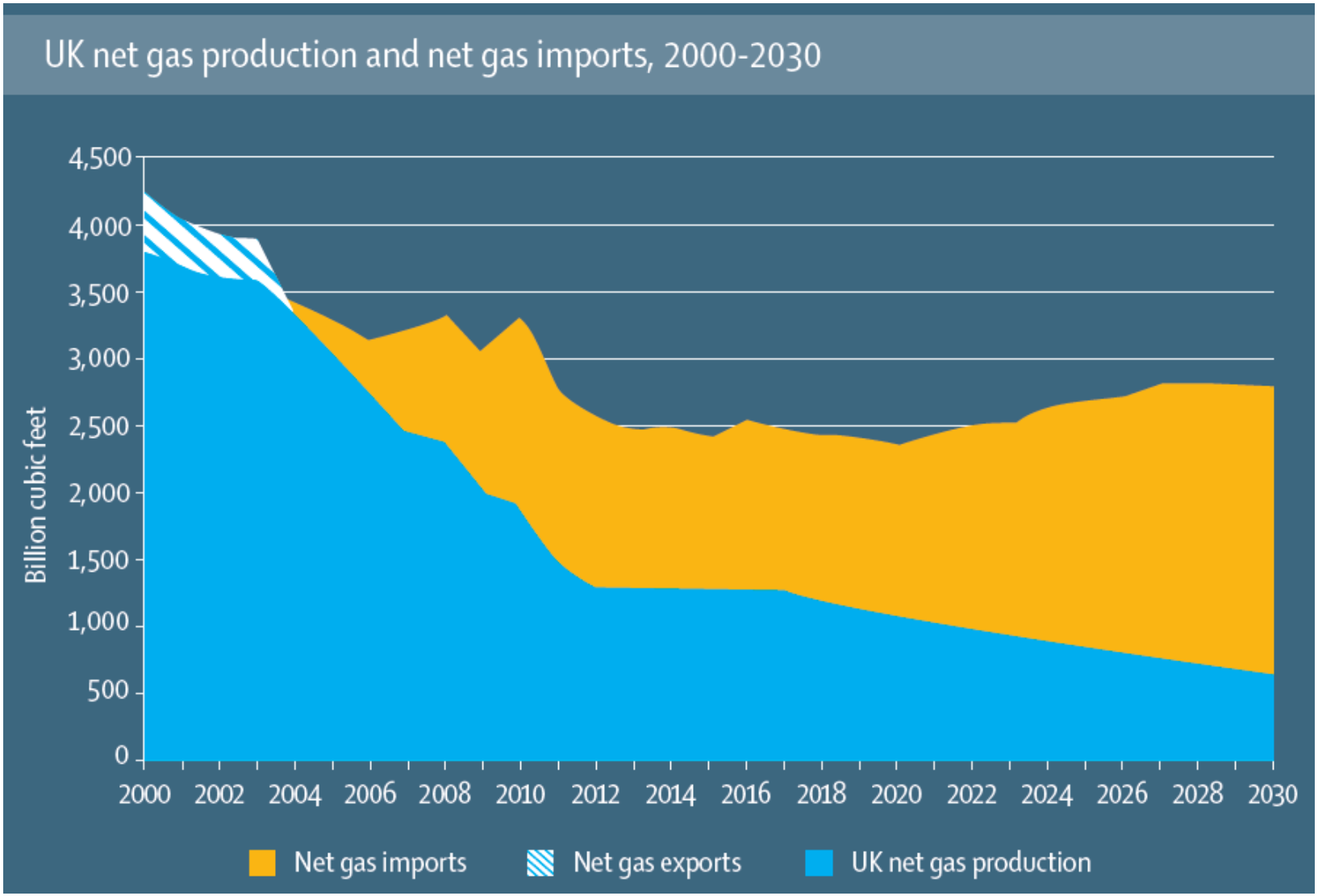
From a presentation by:
Adam Sieminski, EIA Administrator

Argus Americas Crude Summit
January 22, 2014 | Houston, TX

Canada? Huge resources but needs LNG export

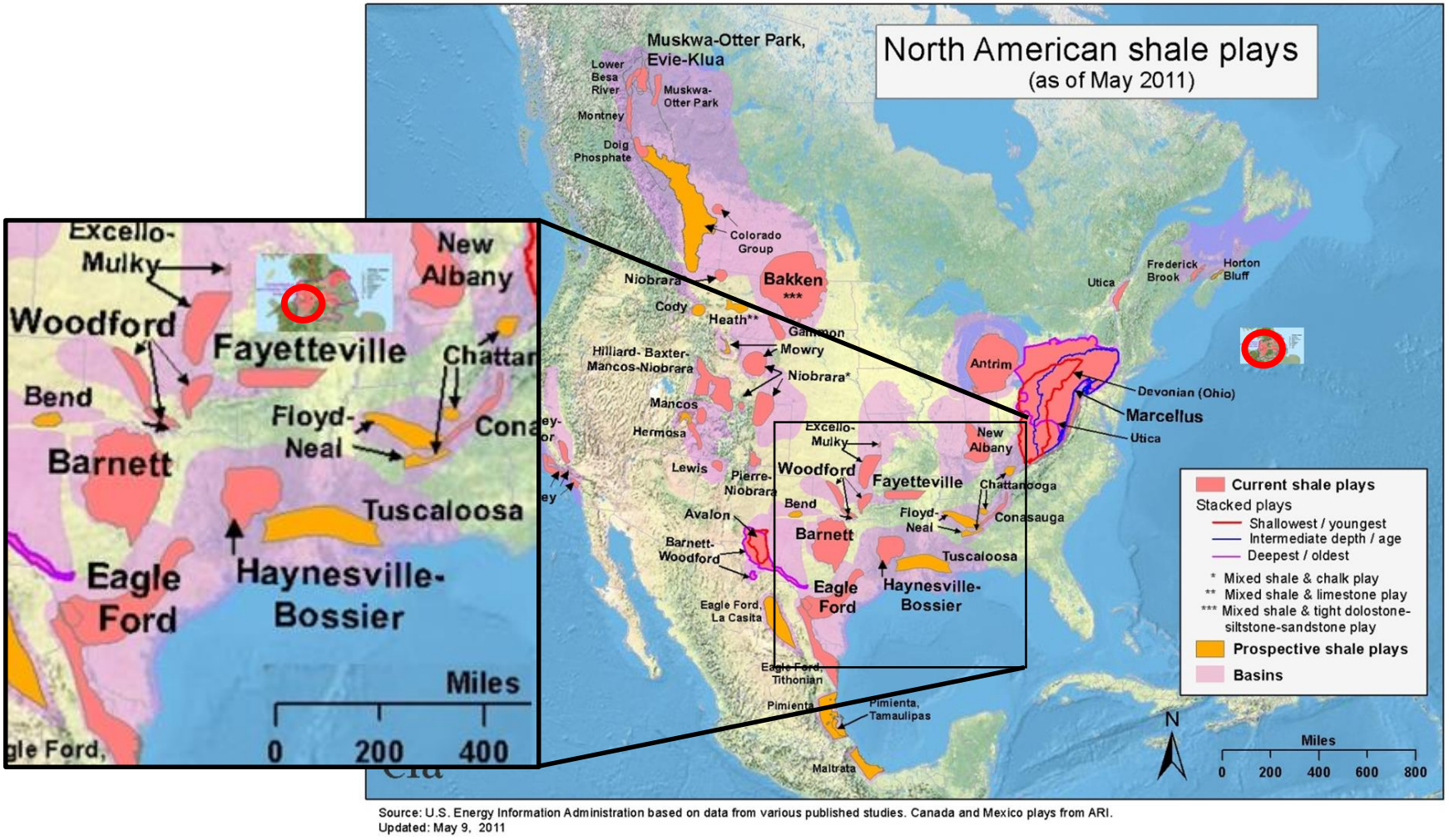
ministration based on data from various published studies. Canada and Mexico plays from ARI.

The UK: setting the scene



Source: IoD report (2014) 'Getting shale gas working'

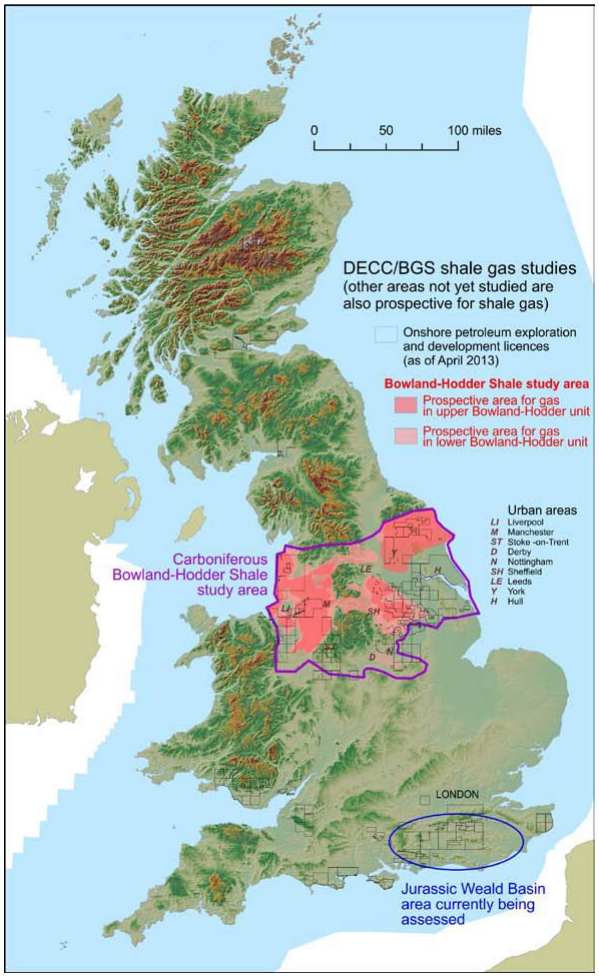
UK – US area comparison



Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.
Updated: May 9, 2011

UK: how do we compare?

- Very small areas compared to North America
- Structurally complex basins
- Much thicker shale sequences and therefore volumes could still be interesting
- BGS/DECC estimate ~1,300 TCF GIIP for Bowland (P50)
  - BUT ??? recovery factor and commerciality
- In the UK we are still very much in the **EXPLORATION** stage – we will have to wait and see



From Andrews (2013) The Carboniferous Bowland Shale gas study: geology and resources estimation. BGS/DECC

World rankings for shale resources

Top ten countries with technically recoverable shale resources

Shale oil

rank	country	billion barrels
1	Russia	75
2	United States	58
3	China	32
4	Argentina	27
5	Libya	26
6	Venezuela	13
7	Mexico	13
8	Pakistan	9
9	Canada	9
10	Indonesia	8
	World total	**345**

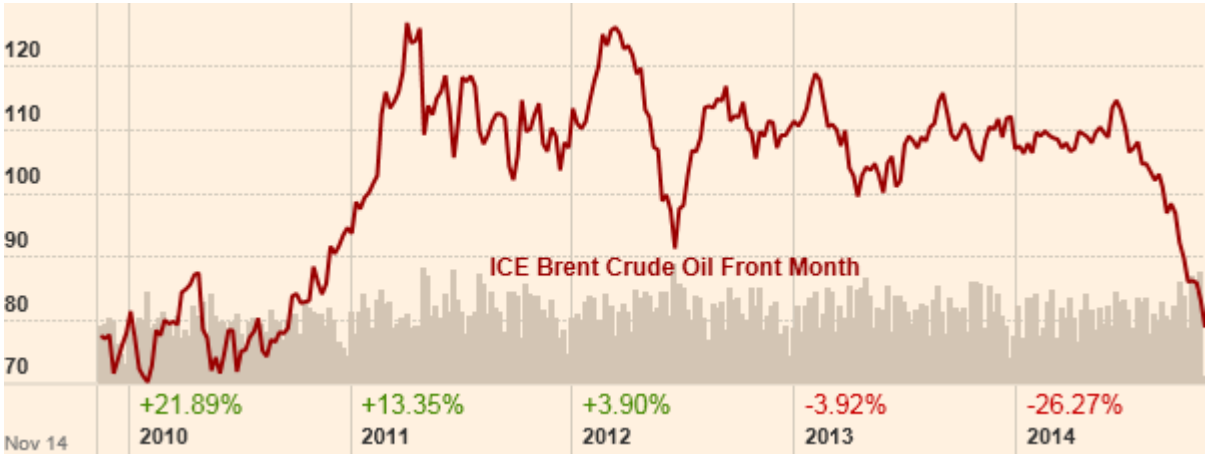
Shale gas

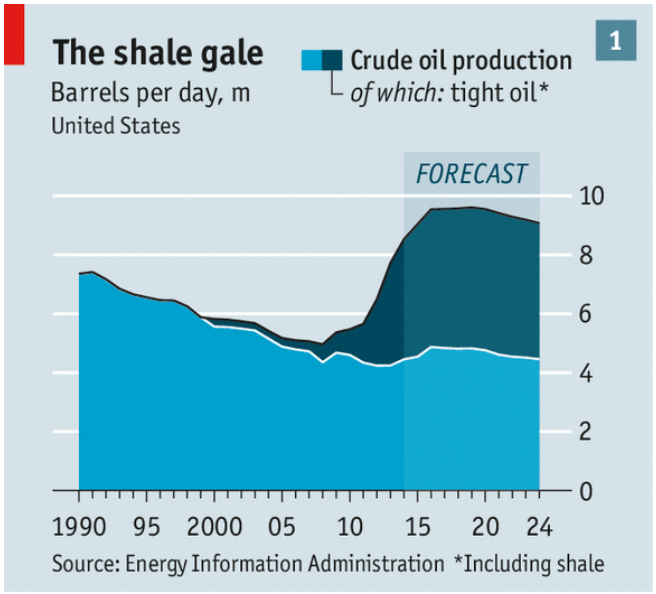
rank	country	trillion cubic feet
1	China	1,115
2	Argentina	802
3	Algeria	707
4	United States	665
5	Canada	573
6	Mexico	545
7	Australia	437
8	South Africa	390
9	Russia	285
10	Brazil	245
	World total	**7,299**

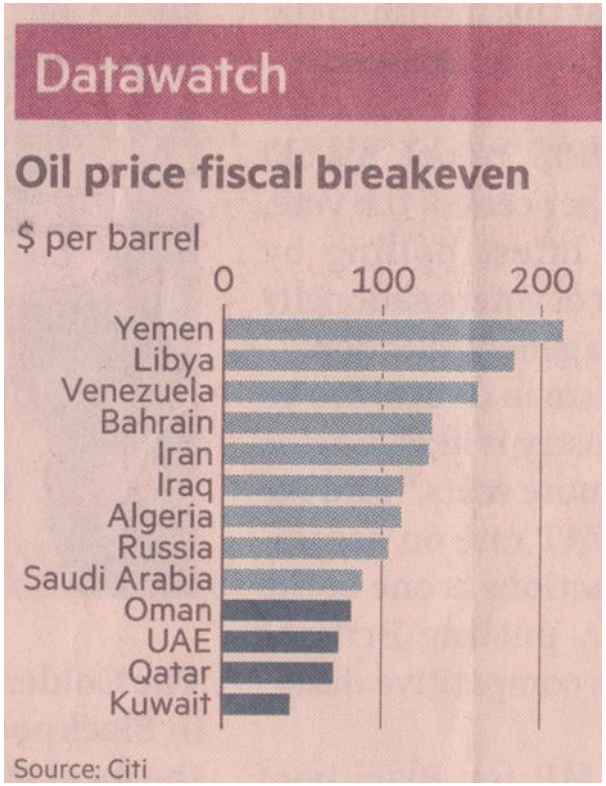
Note: ARI estimates U.S. shale oil resources at 48 billion barrels and U.S. shale gas resources at 1,161 trillion cubic feet.
Source: United States: EIA and USGS; Other basins: ARI.

Today’s uncertain world

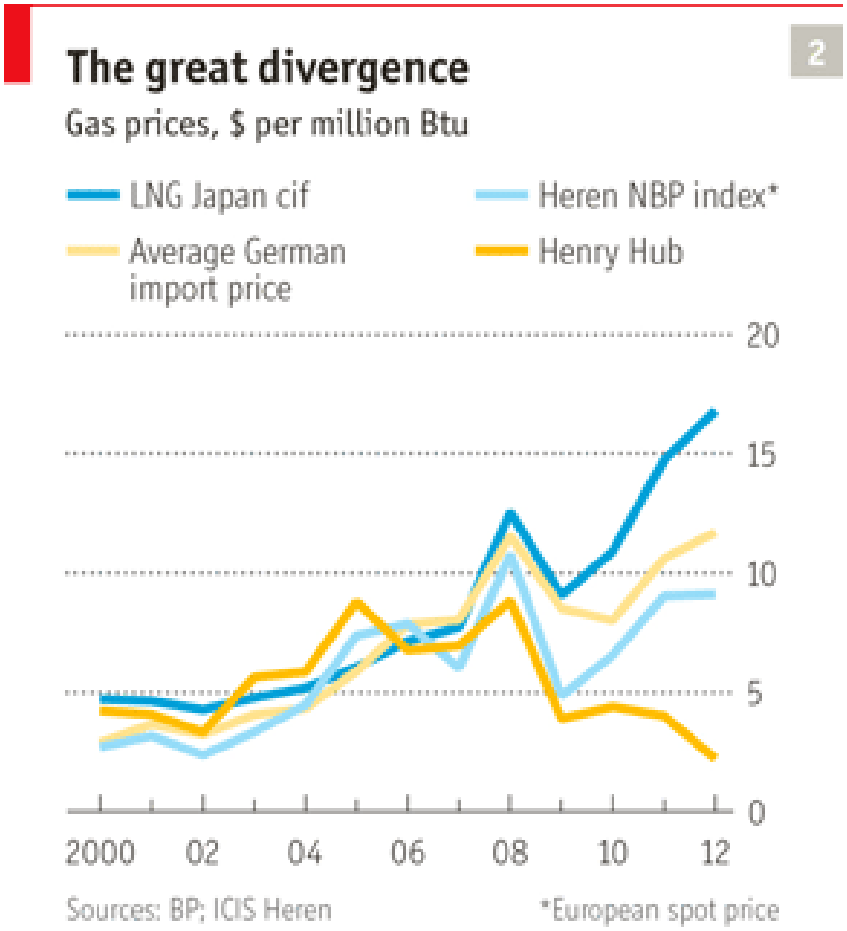
Oil price – a global commodity

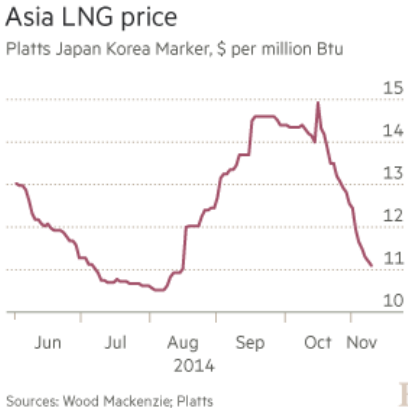


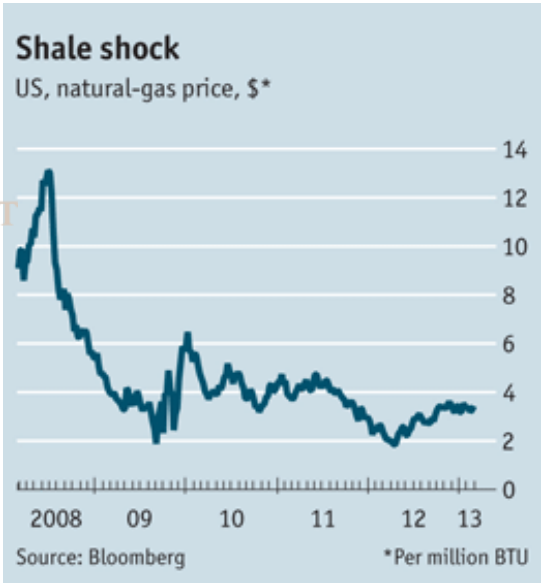




Gas price – not yet global








ANY QUESTIONS?