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Unconventional Gas: Global Impact So Far, Challenges and Future Potential

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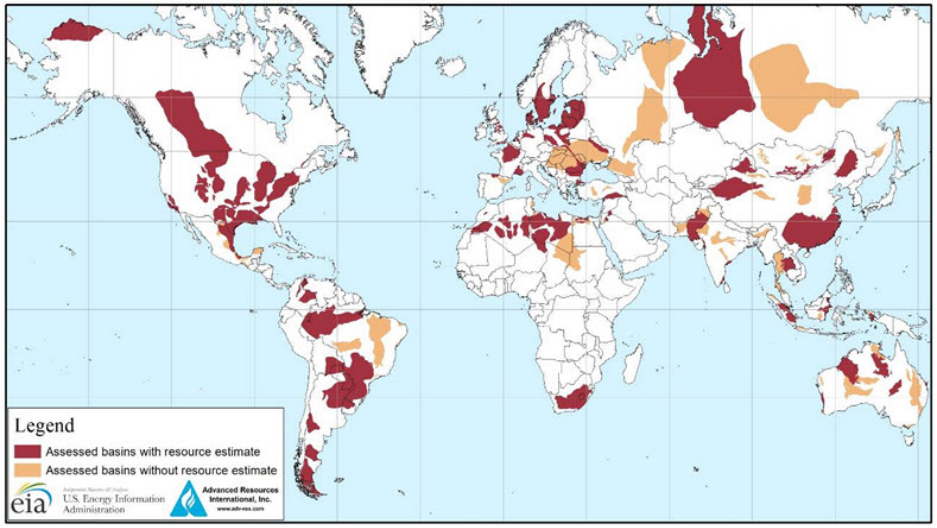
Exploration Operations Manager, Europe

September 24th, 2013

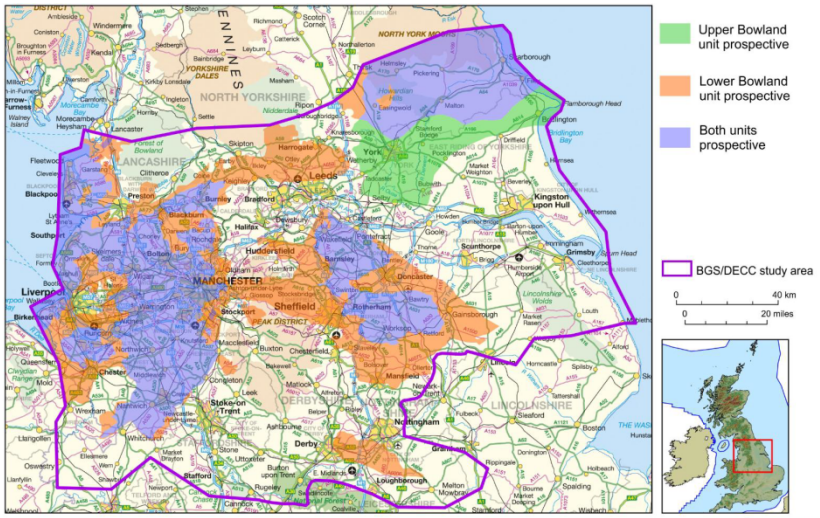
A Significant Resource

Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies

- **U.S. Energy Information Administration (EIA):**
  - 7,299 Tcf (207 Tcm) of technically recoverable **shale gas** in 42 countries[1]
  - Top 3: China, Argentina, Algeria
  - Little to no exploration in most countries assessed
- **International Energy Agency (IEA):**
  - European **unconventional gas** resources: 530 Tcf (15 Tcm)[2]



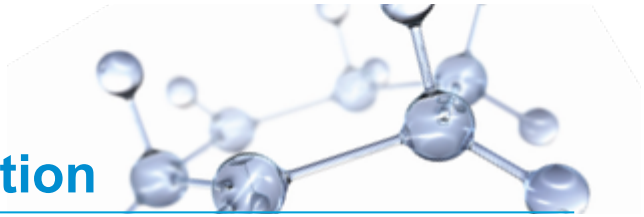
- **British Geological Survey (2013):**
  - **Bowland Shale**: 1,329 Tcf (38 Tcm) gas-in-place[3]
  - Recoverable resources not estimated due to technical and commercial uncertainty
- Ultimate recovery can only be evaluated through **exploration and pilot testing**

(1) Energy Information Administration: Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States; June 2013

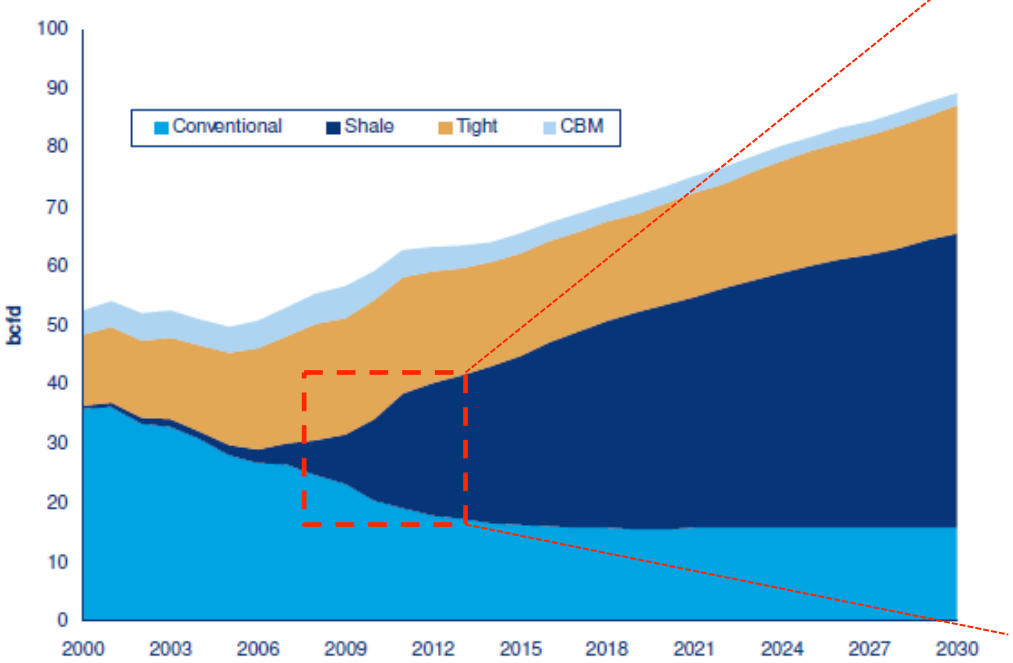
(2) International Energy Agency

(3) British Geological Survey Gas-in-Place Assessment of the Bowland Shale; 2013

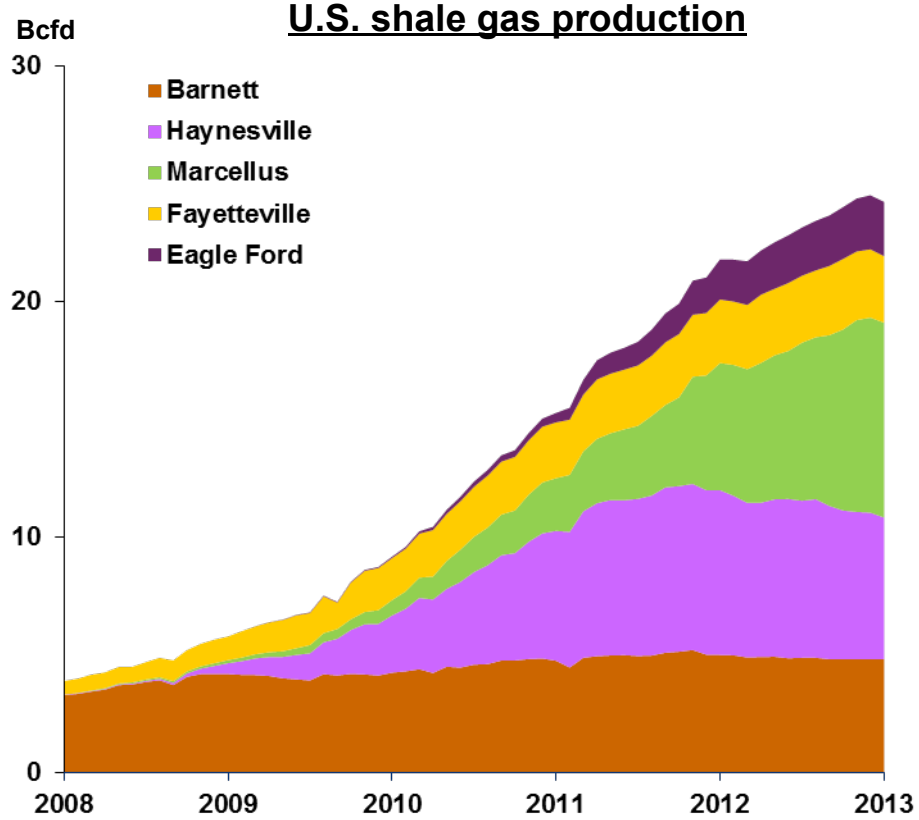
Growth in U.S. Unconventional Gas Production



Total US gas production

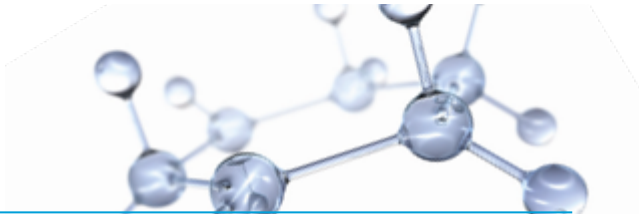


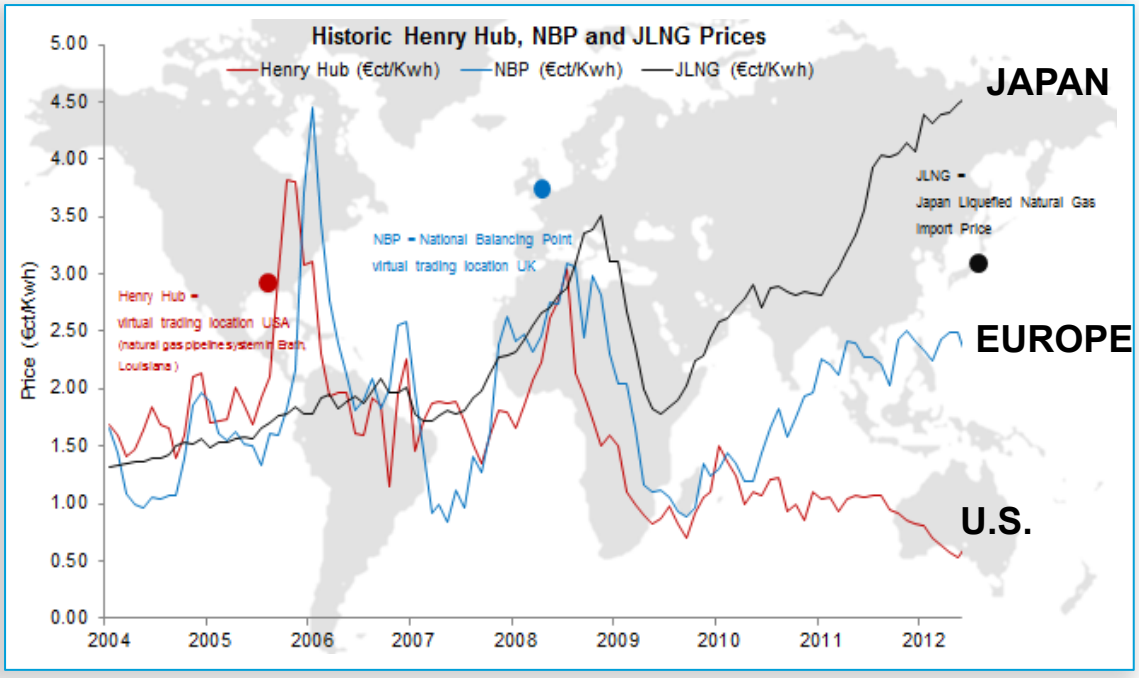
U.S. shale gas production



Source: Wood Mackenzie

Economic Benefits





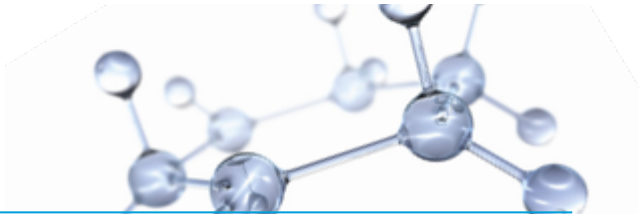
- Shale gas has generated 1.7 million jobs in the U.S.[1]
- **$1.9 trillion investment** into the U.S. economy: 2010 to 2035[2]
- $1.6 trillion of incremental government revenues to 2025[3]
- Disposable income **$1,200 higher in each U.S. household** in 2012[3]
- Unconventional gas development increased U.S. GDP by **$284 billion** in 2012[3]
- Renaissance in manufacturing industries

(1) IHS Report: The Real Stimulus: Low-Cost Natural Gas; October 2012

(2) The Impact of Shale Gas on the U.S. Economy: CERA; March 2012

(3) America's New Energy Future; IHS September 2013

Impact on Energy Flows



- U.S. Oil imports have fallen **25%** since 2006[1]
- By 2022, unconventional resource development impacts will cut U.S deficit by **$180 billion per year**[2]

- U.S. moving from gas importer to **exporter**
- Multiple LNG import terminals being modified to export gas

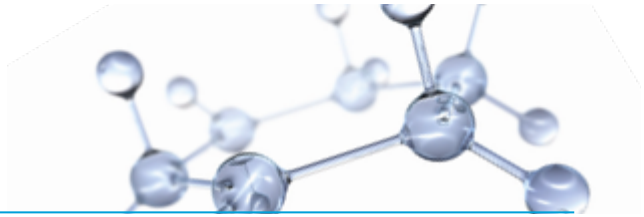
Cheniere's Sabine Pass LNG import terminal, La…

…under reconstruction to export up to 18 MTA of LNG

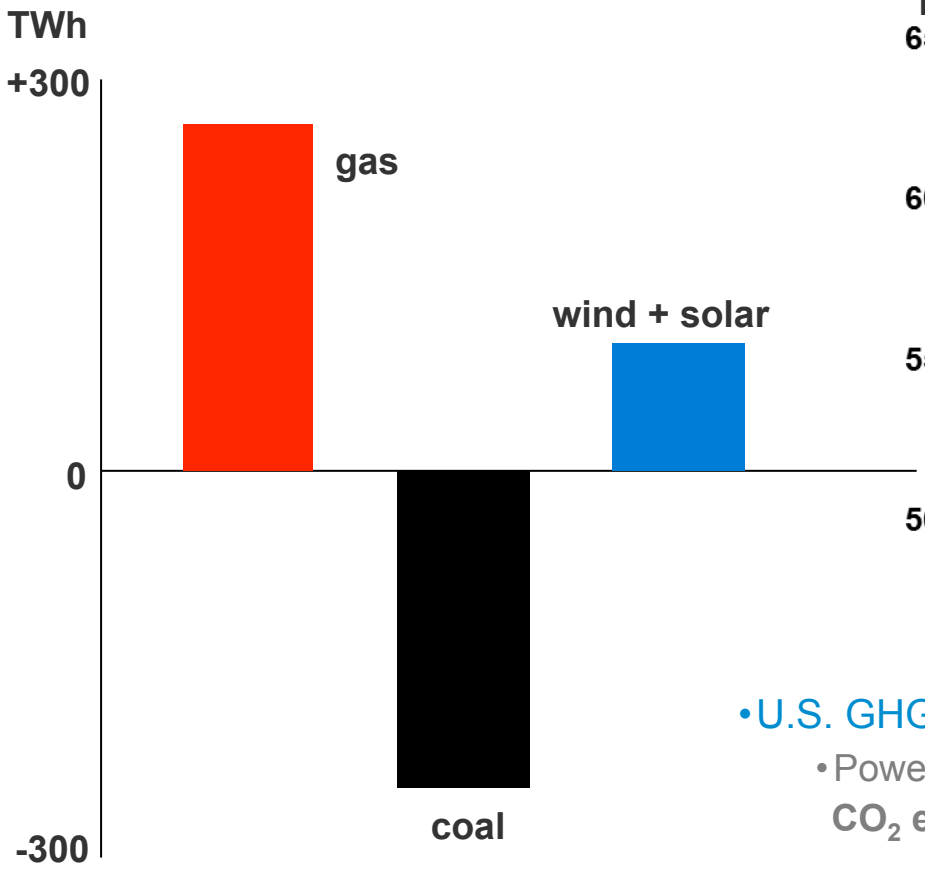
(1) Energy Information Administration

(2) America's New Energy Future; IHS September 2013

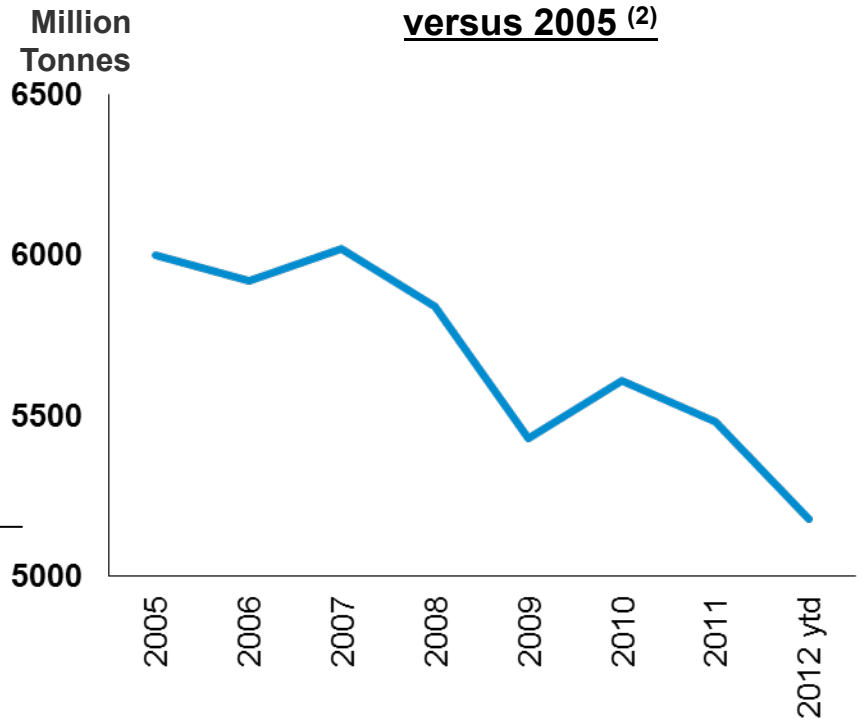
Environmental Benefits



Changes in U.S. Power Generation: 2011 versus 2005 (1)



Changes in U.S. CO2 Emissions: 2011 versus 2005 (2)

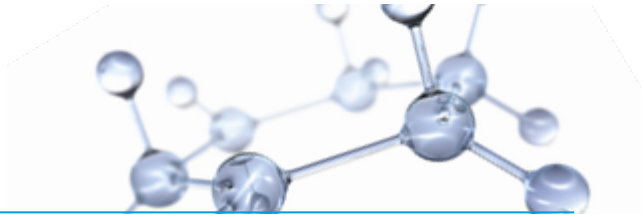


- U.S. GHG emissions now at **mid-1990s levels**
  - Power generators switching to gas, which produces **60% less CO_2 emissions** than coal[2]

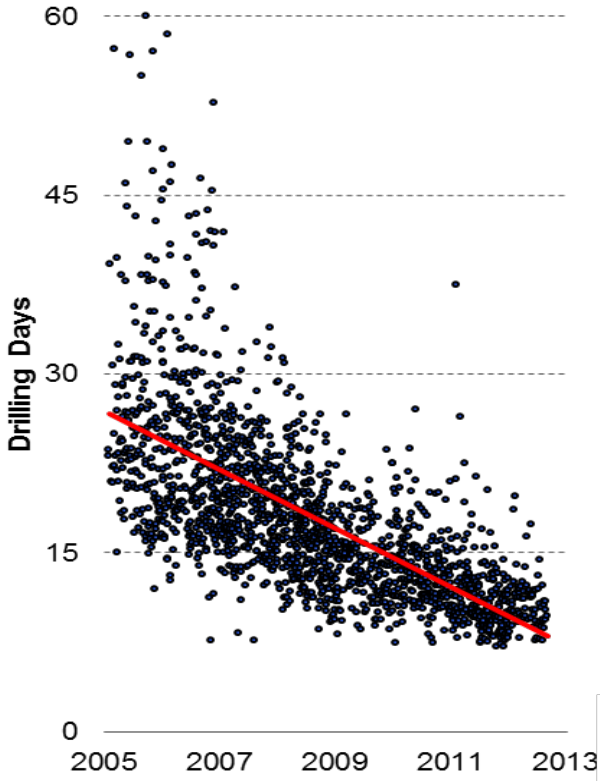
(1) International Energy Agency; 2: *IHS CERA 2011 pg. II-2&II-3*

(2) US Dept of Energy

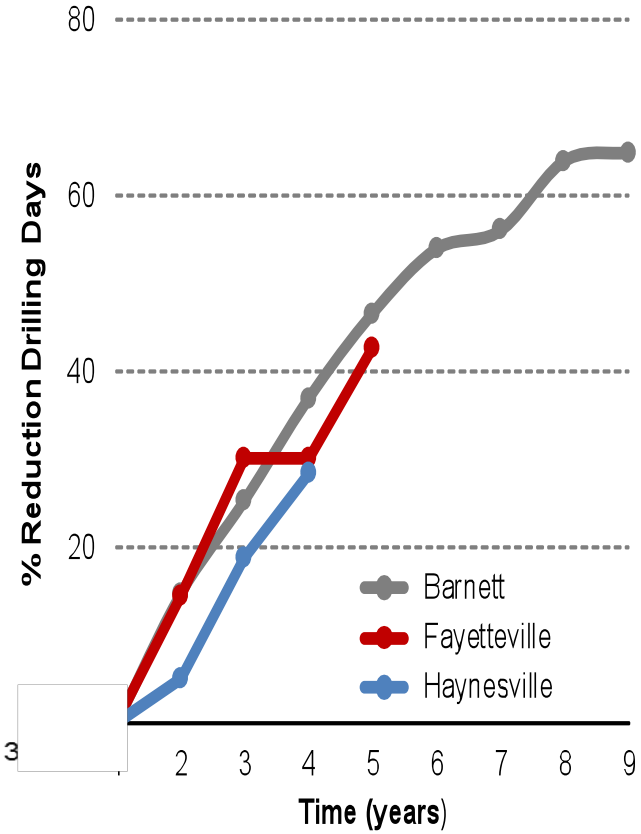
Operational and Technical Learnings



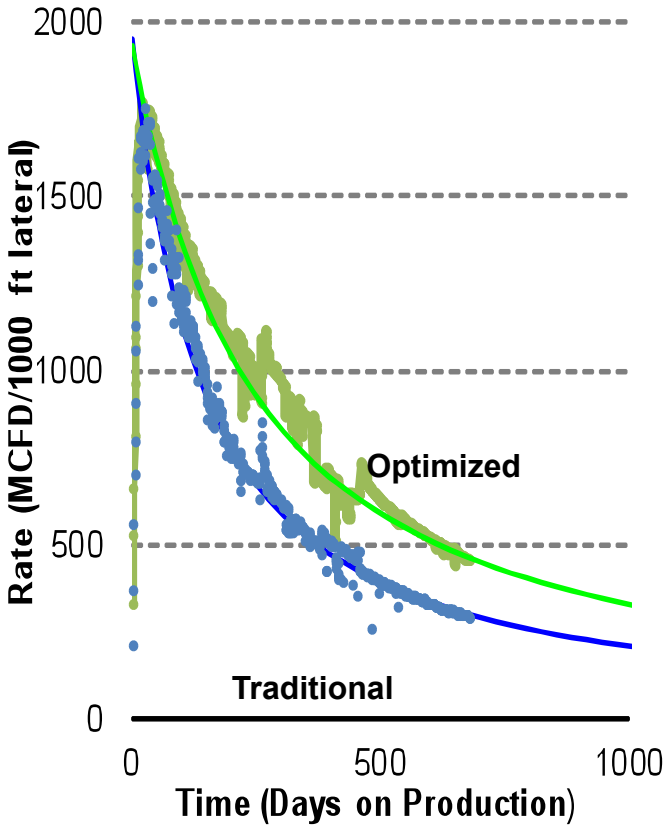
Barnett Shale: XTO Drilling Days



Drilling Performance Improvements: 3 U.S. shale gas plays



XTO Haynesville: Optimizing Completions



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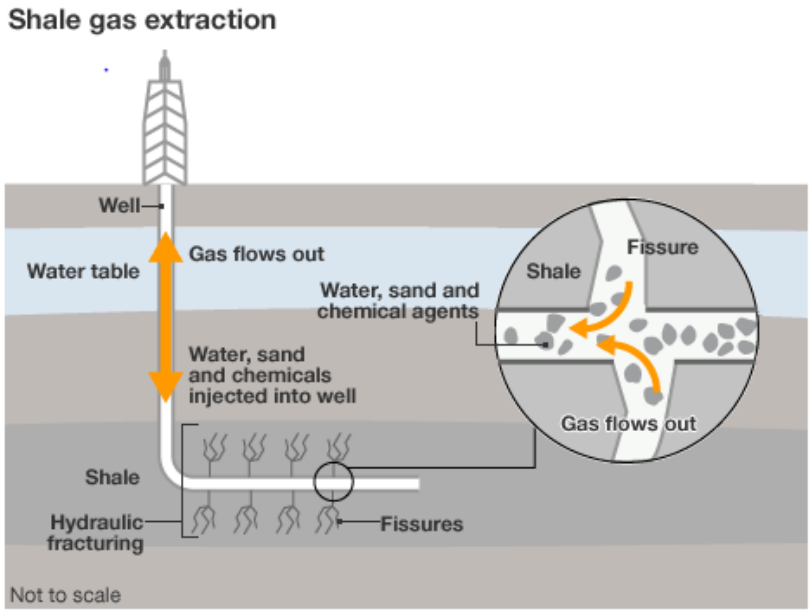
Public Perception Is Shaped by Images

Image from *GasLand* film

"*Gasland incorrectly attributes several cases of water well contamination in Colorado to oil and gas development when our investigations determined that the wells in question contained biogenic methane that is not attributable to such development.*"

STATE OF COLORADO OIL & GAS CONSERVATION COMMISSION

BBC News Website



Source: BBC News (online), 19 January 2012

- Image drastically reduces the apparent distance between groundwater and hydraulic fracturing
- Lacks detail in showing multiple layers of steel casing and cement used to protect ground water

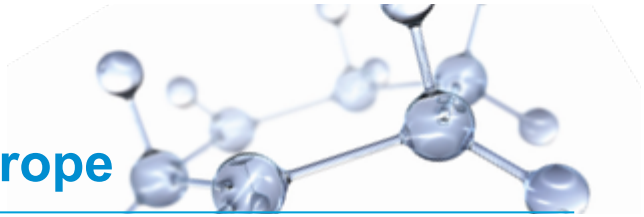
Opposition to Shale Gas / Hydraulic Fracturing

Germany well site

Balcombe, Sussex

- Opposition to shale gas has grown in last 3 years
  - Film ***Gasland*** screened in Europe during 2010: generated negative sentiment, against backdrop of Macondo disaster
- Shale gas opponents express a variety of concerns
  - Potential harm to environment
  - Not renewable: could prolong the use of fossil fuels
  - May lead to reduced investment / subsidies in renewables

Regulatory Environment and Response: Europe



Existing Regulatory Environment

- Hydrocarbons Directive (1994)
- Water (1998, 2000, 2006, REACH)
- Environment (2011, 1998, 2004)
- Biodiversity (1979, 1992, 2000)
- Mining waste (2006); Noise (2002)
- Safety & Health of Workers

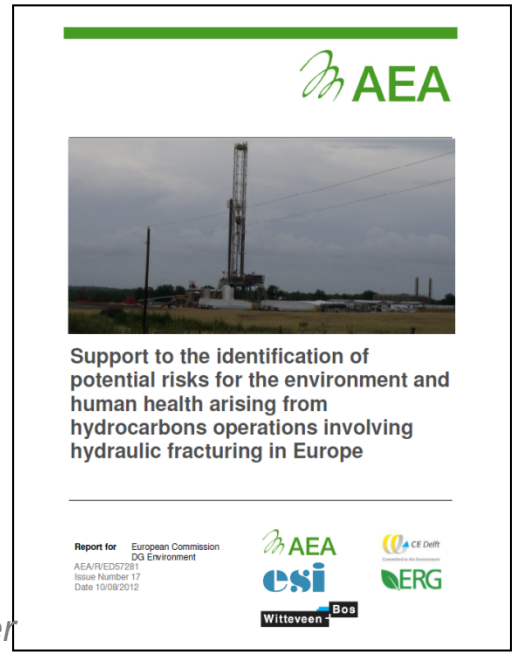
- …+ Extensive national legislation

EU & International Studies

- EP ITRE (Sept 2012)
- EP ENVI (Sept 2012)
- Joint Research Centre (Sept 2012)
- DG Clima (Sept 2012)
- DG Environment (Sept 2012)
- German Fed. Env. Ministry (Sept 2012)
- North Rhine Westphalia, Germany (Sept 2012)
- German Geological Study (June 2012)
- UK Royal Soc. & Academy Eng. (June 2012)
- IEA 'Golden Rules' (May 2012)
- German Expert Dialogue (April 2012)
- DG Energy (Jan 2012)
- Carnegie Mellon University (Aug 2011)
- IHS CERA (Aug 2011)
- *… Plus dozens of others in the past 2years*

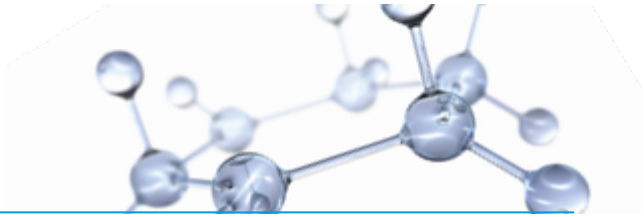
The Importance of Objective Studies

- Regulators, media and the general public have a multitude of reports to interpret
- Some studies on unconventional gas assign risk based on subjective judgment, and / or broad assumptions
- 2012 Report "*Support to the identification of potential risks…involving HF in Europe*" produced for European Commission's **DG Environment**
  - Executive Summary: "*risk of water contamination….is **deemed to be high***"
  - Author notes the study has a "*lack of centralized and comprehensive data"*
  - Risk levels are assigned subjectively, and not supported by objective, empirical data
  - Page 161: "*An adequately installed casing throughout the entire well, together with ongoing inspection, monitoring and maintenance, **provides sufficient protection against groundwater pollution***"
- For society to make informed choices, it is essential to **quantify risks**, with objective data, and place those data in **context**
- Most comprehensive study of groundwater contamination: GWPC[1] report on 389,000 HF'd U.S. gas wells, including 16,000 shale gas wells drilled 1993-2008: **zero contamination incidents**

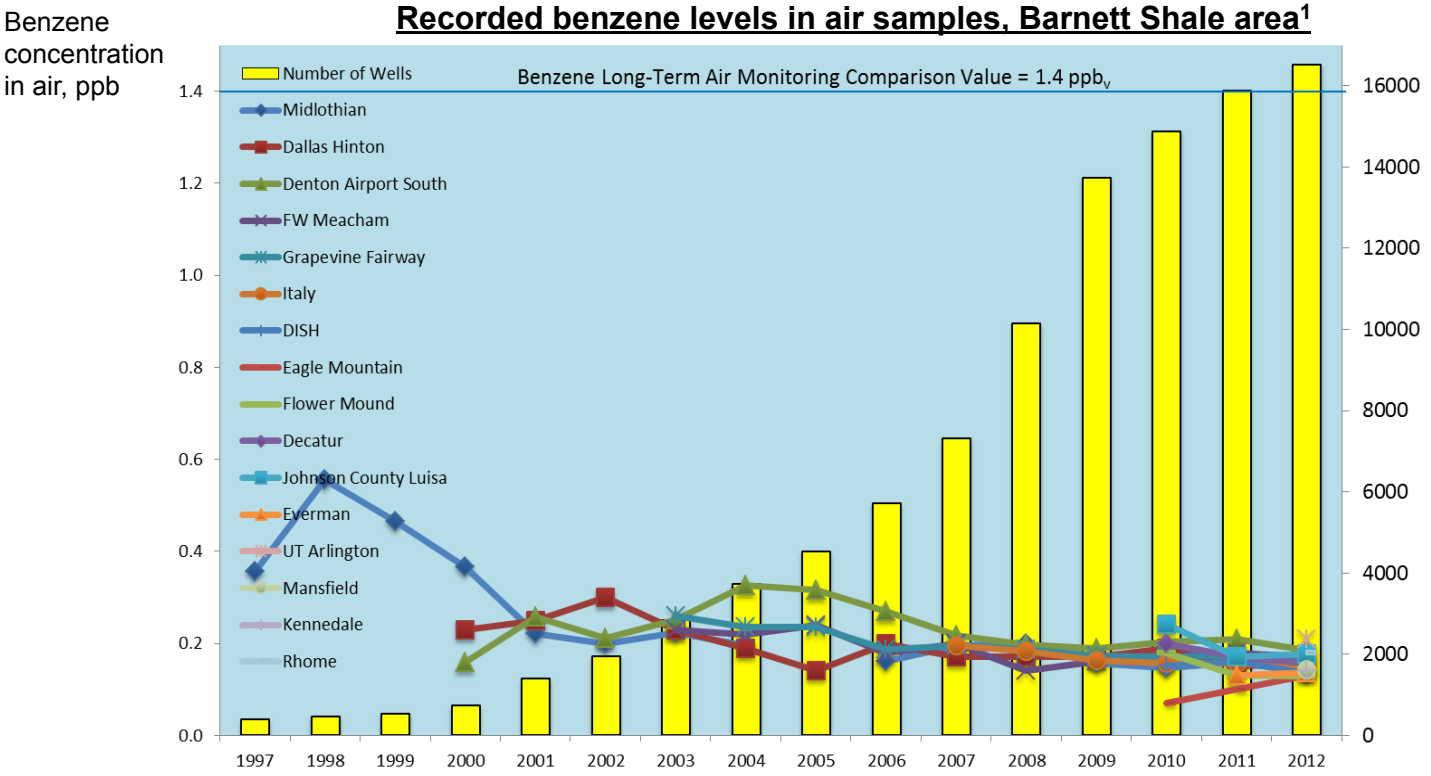


(1) Ground Water Protection Council 2011

Barnett Shale: Air and Water



Recorded benzene levels in air samples, Barnett Shale area[1]



- **250,000 air samples** collected / 11 million tests conducted
- For comparison: pumping petrol: 910 ppb benzene[2]
- Counties in Barnett Shale area **use less than one percent** of their water for drilling and fracturing

(1) Texas Commission on Environmental Quality; Air Quality Division

(2) Toxicological Profile for Benzene, U.S. ATSDR, 2007

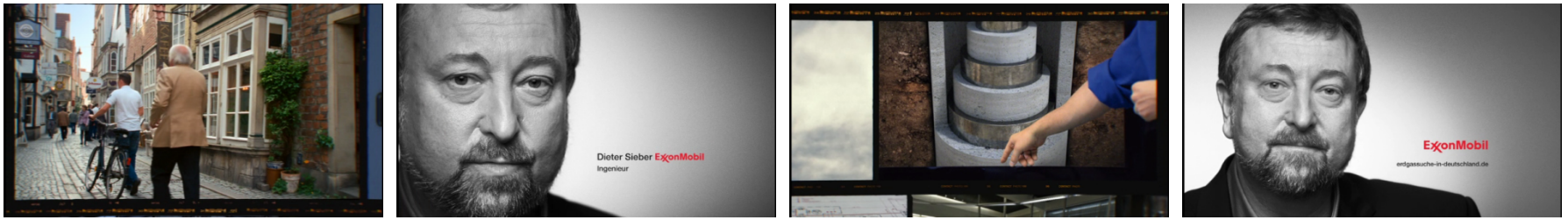
Public Engagement: Germany Example

- **Essential to engage communities early,** to meet residents and address their concerns
- EM initiated and sponsored an **independent expert study** into hydraulic fracturing

ExxonMobil Germany: Community "Info Markt"

Expert Dialogue Process: Stakeholder Q&A

TV ads



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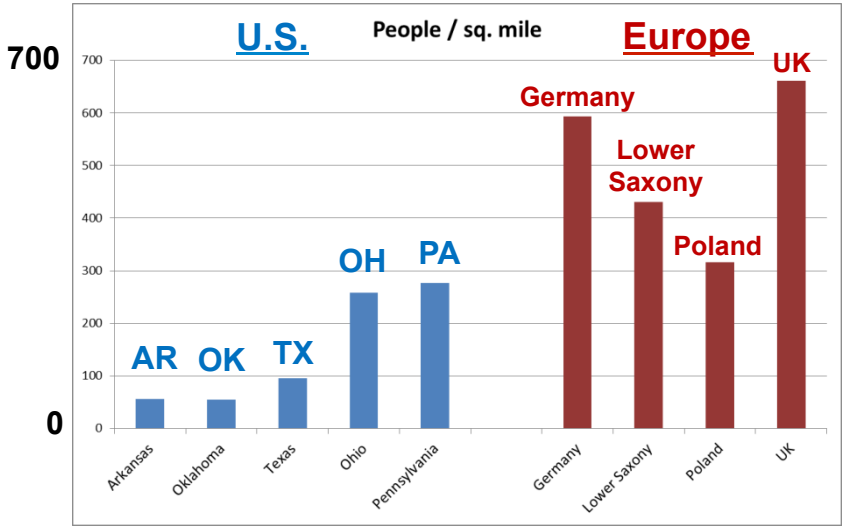
How Europe Differs from the U.S.

- Population density generally **higher**
- **Mineral rights** retained by government
- Higher costs / limited service industry
  - ~100 land rigs in Europe vs. 2,000 in U.S.
- Society less familiar with land operations

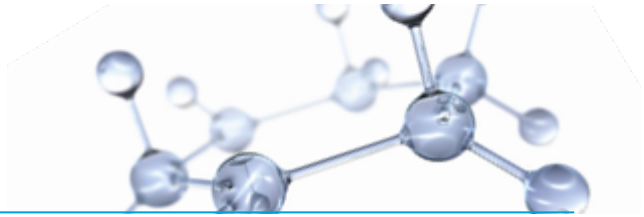
Poland well site during frack operation



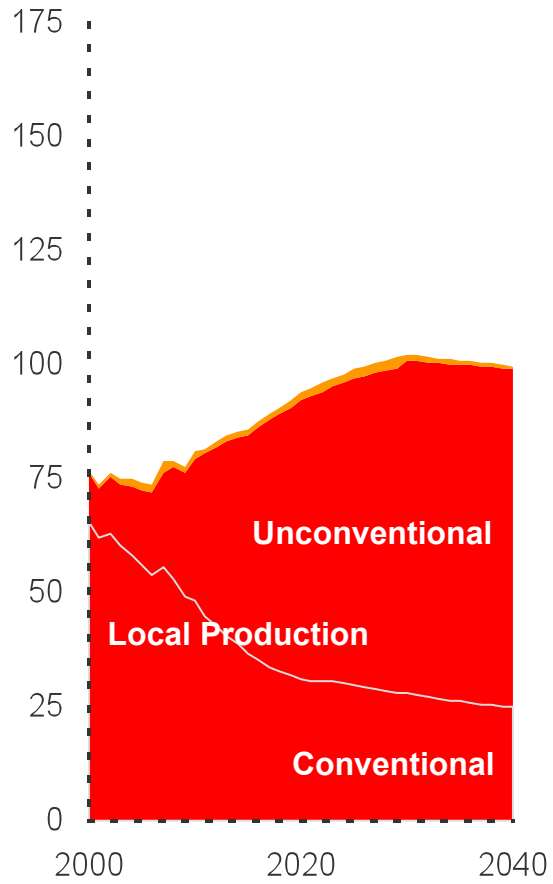
Population Density: people / square mile

- **Licenses issued by governments**
  - **More control** over companies selected
- Larger license areas / less emphasis on early production = **more efficient development**
- Europe / rest of the world can benefit from the advances in technology coming from the U.S.

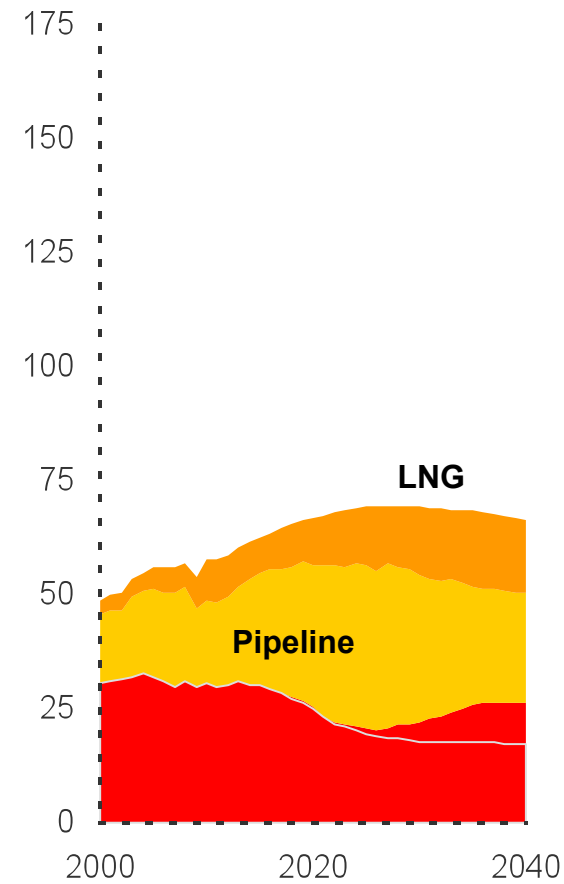
Projected Global Gas Supply and Demand



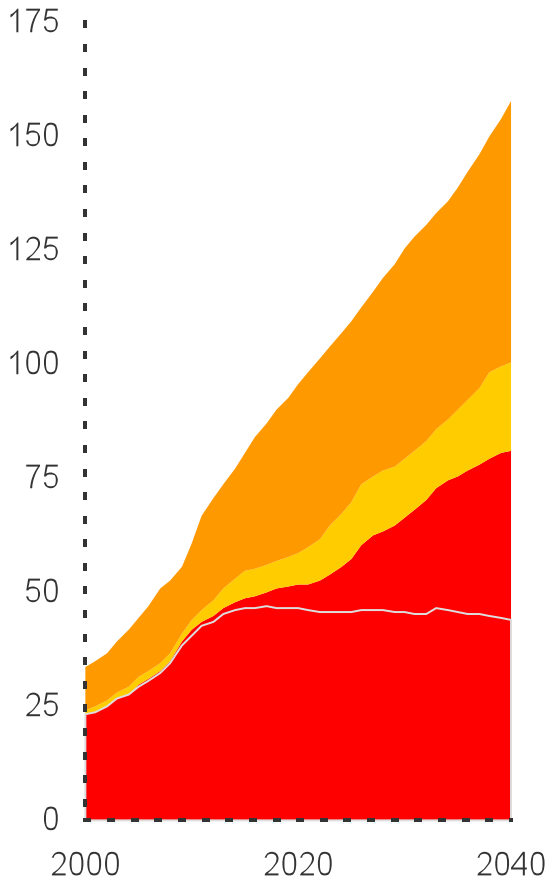
North America
BCFD



Europe
BCFD



Asia Pacific
BCFD

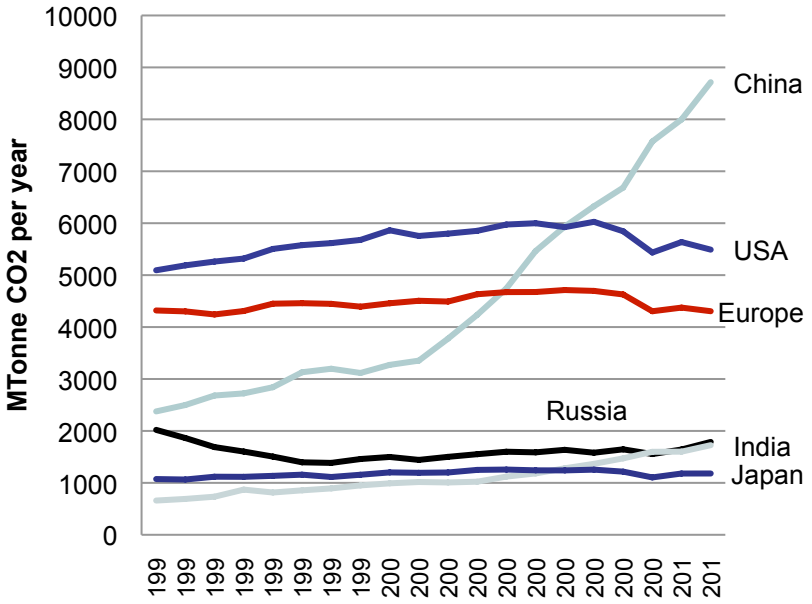


Source: ExxonMobil 2013 Outlook for Energy

Closing Comments on Unconventional Gas

- A globally significant energy source
- Both **economic and environmental benefits**
  - Increased **security of supply**
  - Enhanced economic **competitiveness**
  - **Reduced emissions**: compliments intermittent wind
- Learnings from the U.S. are making the technology more and more efficient
- Objective data demonstrates that the technology is safe, the **risks are manageable** and environmental impacts are limited
- Society acceptance is not universal
  - **Proactive, early community engagement** is essential
  - Stakeholders must be given **objective data** on which to base their assessments of risk
  - Much of "The Debate" occurs in **images and headlines**

CO2 Emissions by Region and Year



US Energy Information Administration (EIA)

Technologists have provided the opportunity…and must also ensure it is understood