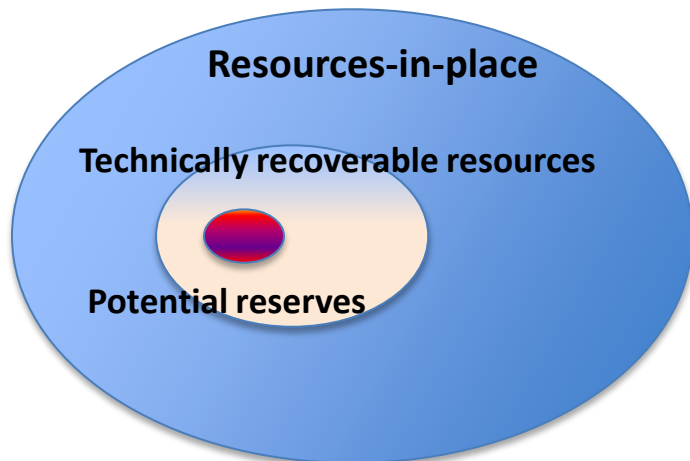


# Shale gas: Key uncertainties

- **Resource availability**
  - Occurrences, resources-in-place, technically recoverable resources, reserves and supplies
- **Market prices (break-even prices)**
  - Full production costs & market prices
- **Field production profiles**
  - Investment & cash flow implications
- **Technology and infrastructure**
- **Environmental concerns and perception**
- **Demand outlook**
- **Vested interests & geopolitics**

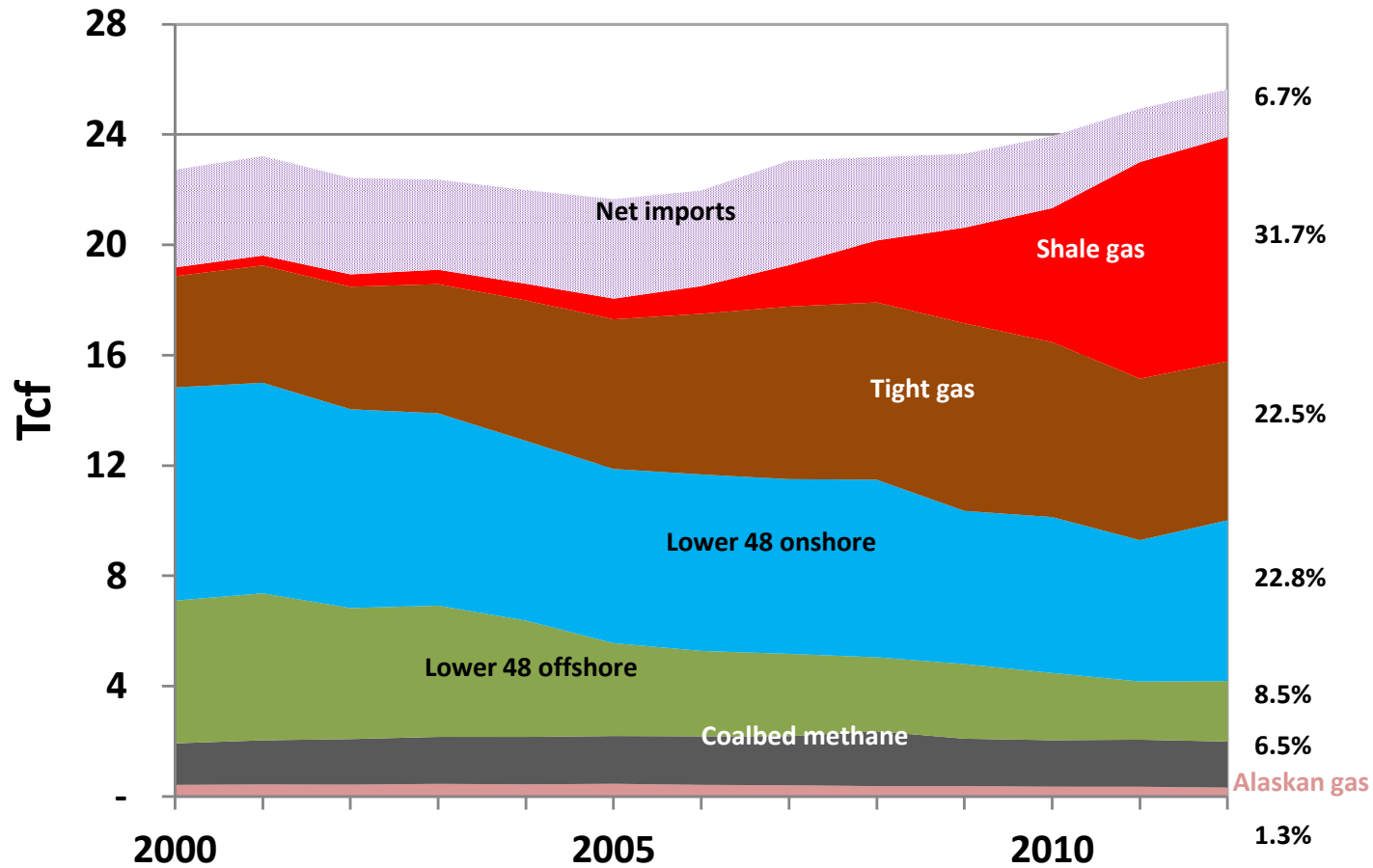
# Shale gas resources

- Gas-in-place and technically recoverable volumes are often confused
- The top 18 countries with assessed technically recoverable shale gas resources combine about 1/3 of conventional reserves
- Technically recoverable  $\neq$  economically producible reserves

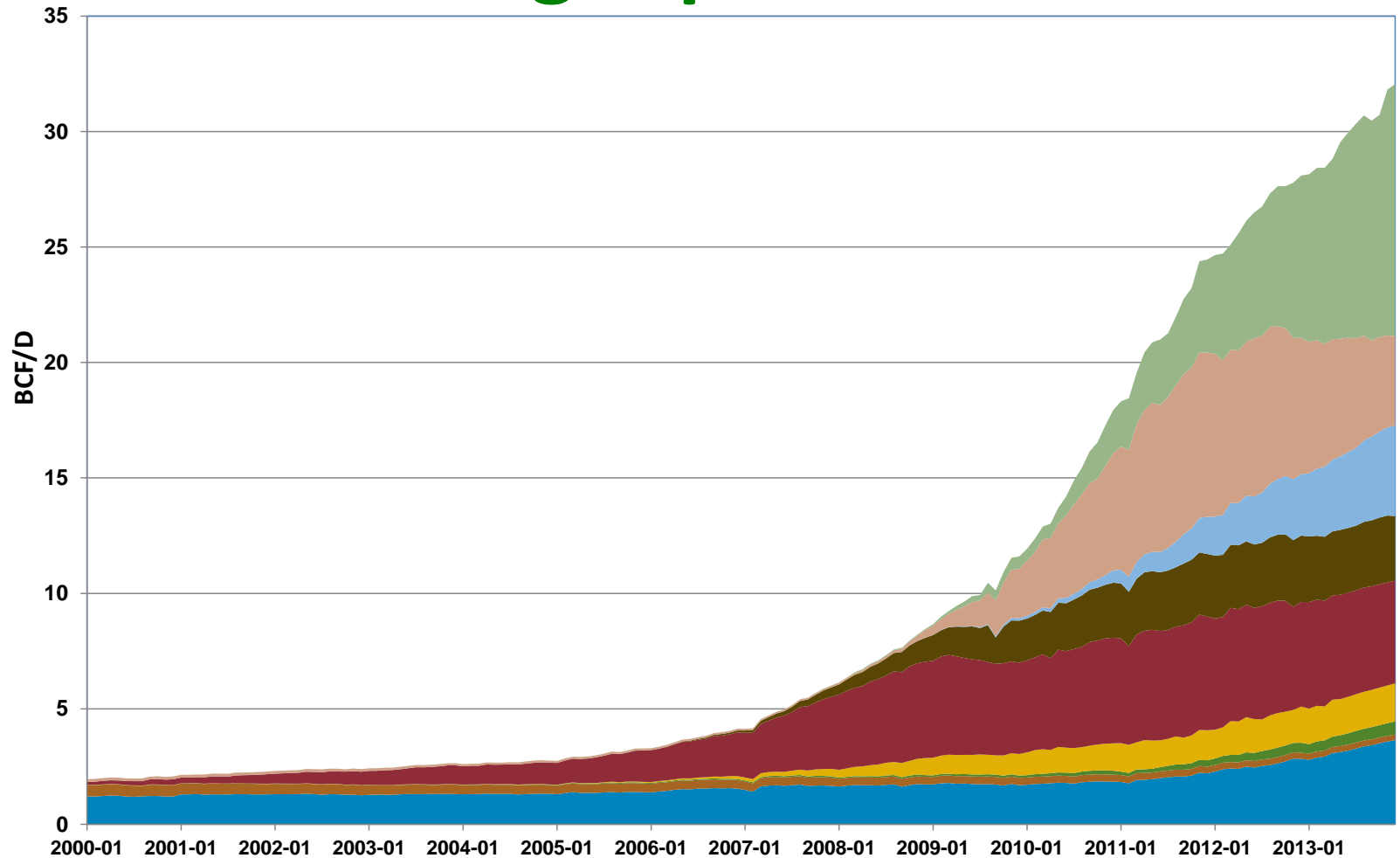


	Risked gas-in-place	Technically recoverable	Proved conventional gas reserves
	tcm	tcm	tcm
U.S.	131.5	32.9	8.5
China	134.4	31.6	3.1
Argentina	91.9	22.7	0.3
Algeria	96.8	20.0	4.5
Canada	68.3	16.2	2.0
Mexico	63.2	15.4	0.4
Australia	57.9	12.4	3.8
South Africa	44.1	11.0	-
Russia	54.4	8.1	32.9
Brazil	36.2	6.9	0.5
Poland	21.6	4.2	0.1
UK	3.8	0.7	0.2
Pakistan	16.6	3.0	0.6
Venezuela	23.1	4.7	5.6
Ukraine	16.2	3.6	0.6
France	20.6	3.9	-
Libya	17.4	3.5	1.5
Egypt	15.1	2.8	2.0
India	16.5	2.7	1.3
Others	83.5	14.3	119.4
<b>Total assessed shale deposits</b>	<b>1,013.2</b>	<b>220.7</b>	<b>187.3</b>

# US natural gas production – the last decade



# US shale gas production



Rest of US 'shale'

Woodford

Eagle Ford

Antrim

Barnett

Haynesville

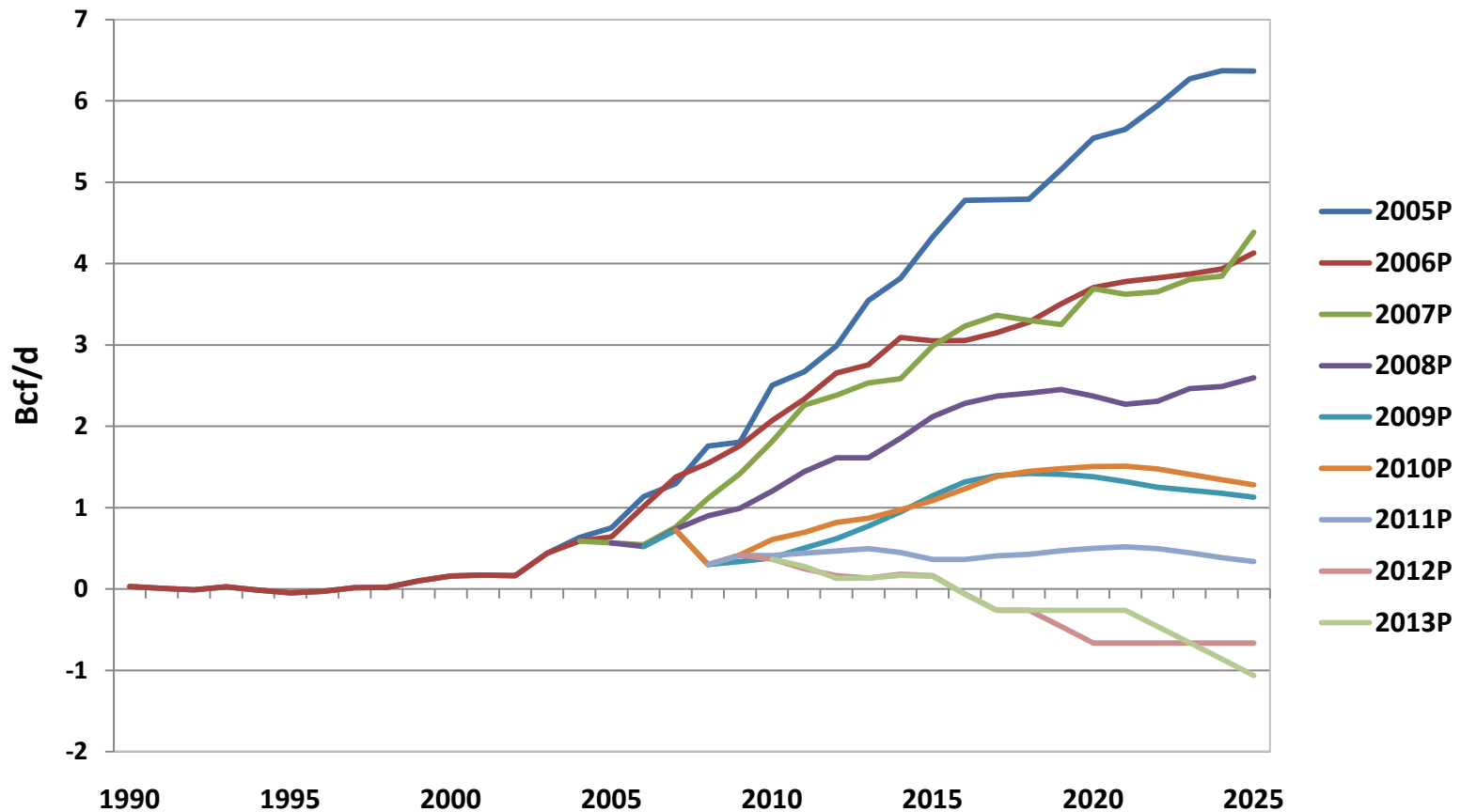
Bakken

Fayetteville

Marcellus

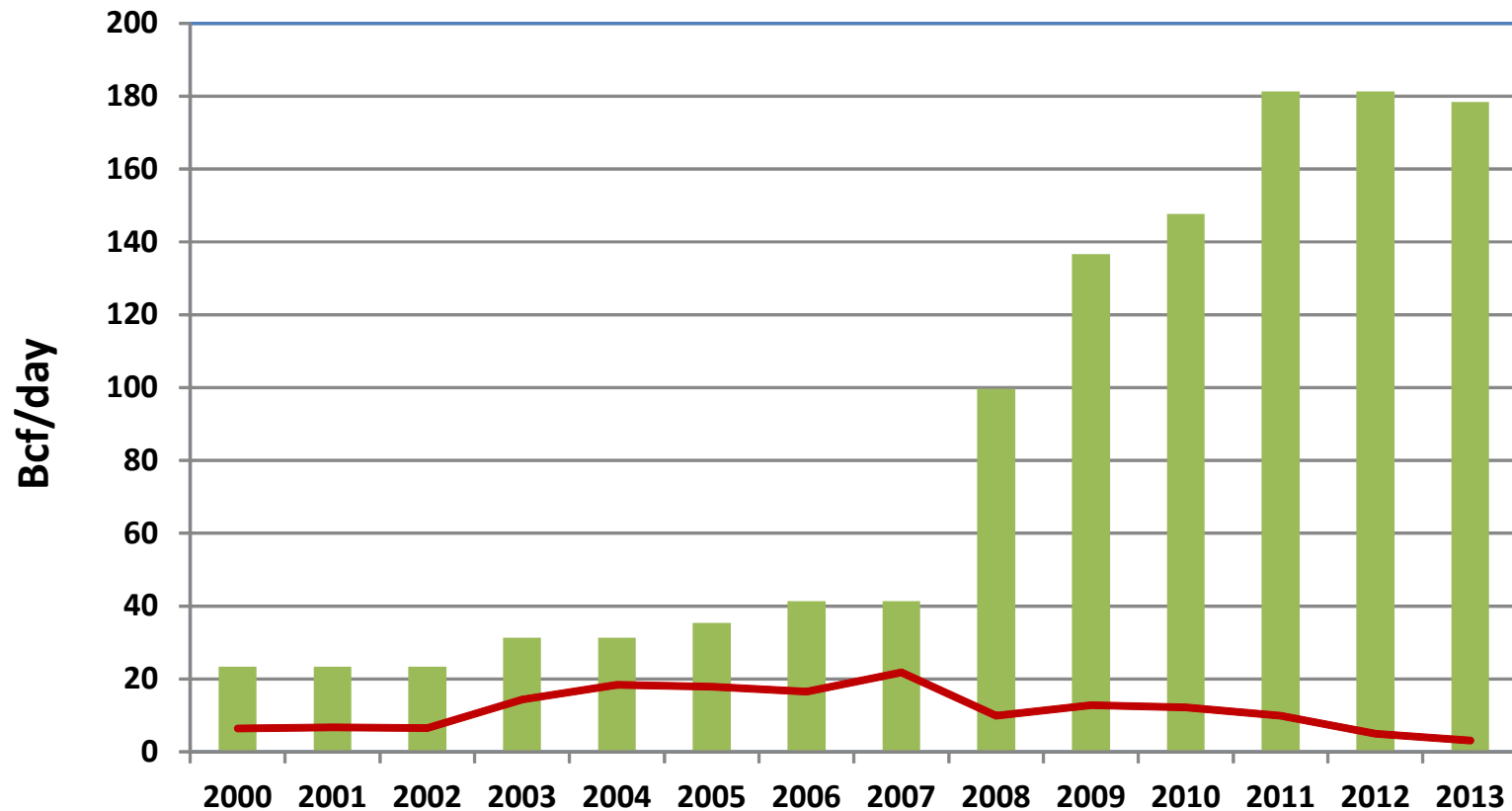
Source: EIA, 2014

# Series of projected natural gas import requirements, USA



Source: EIA, different years

# Diverging trends: LNG regasification capacity and LNG imports, USA

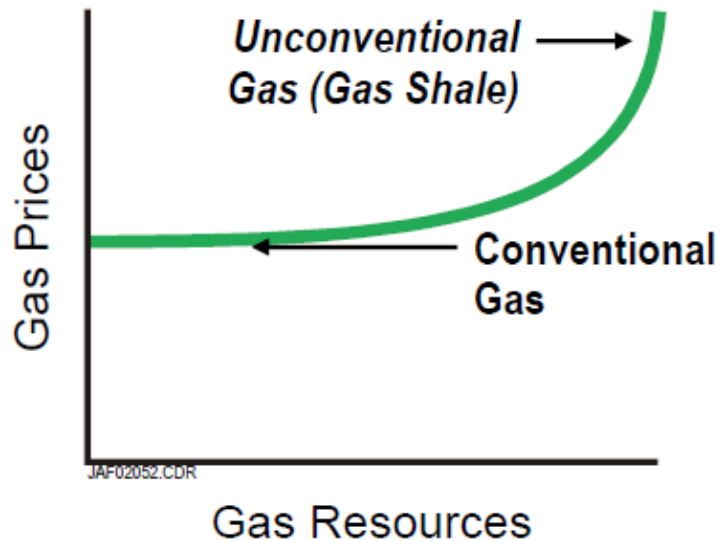


Source: EIA, 2014

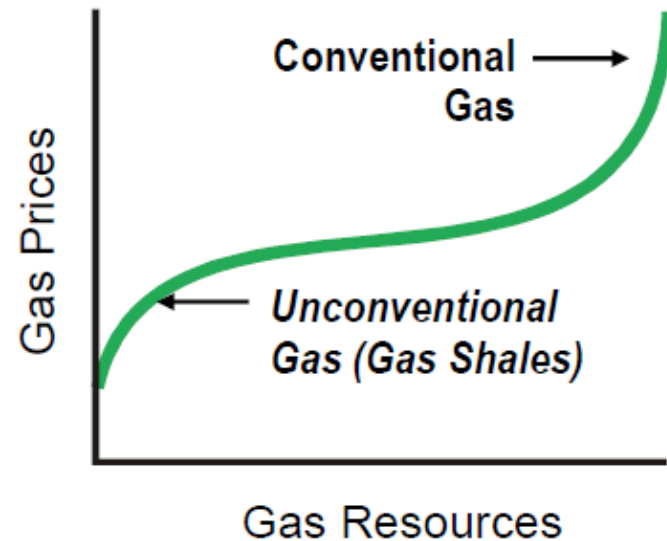
# Shale gas impact on natural gas prices

## A paradigm shift or wishful thinking?

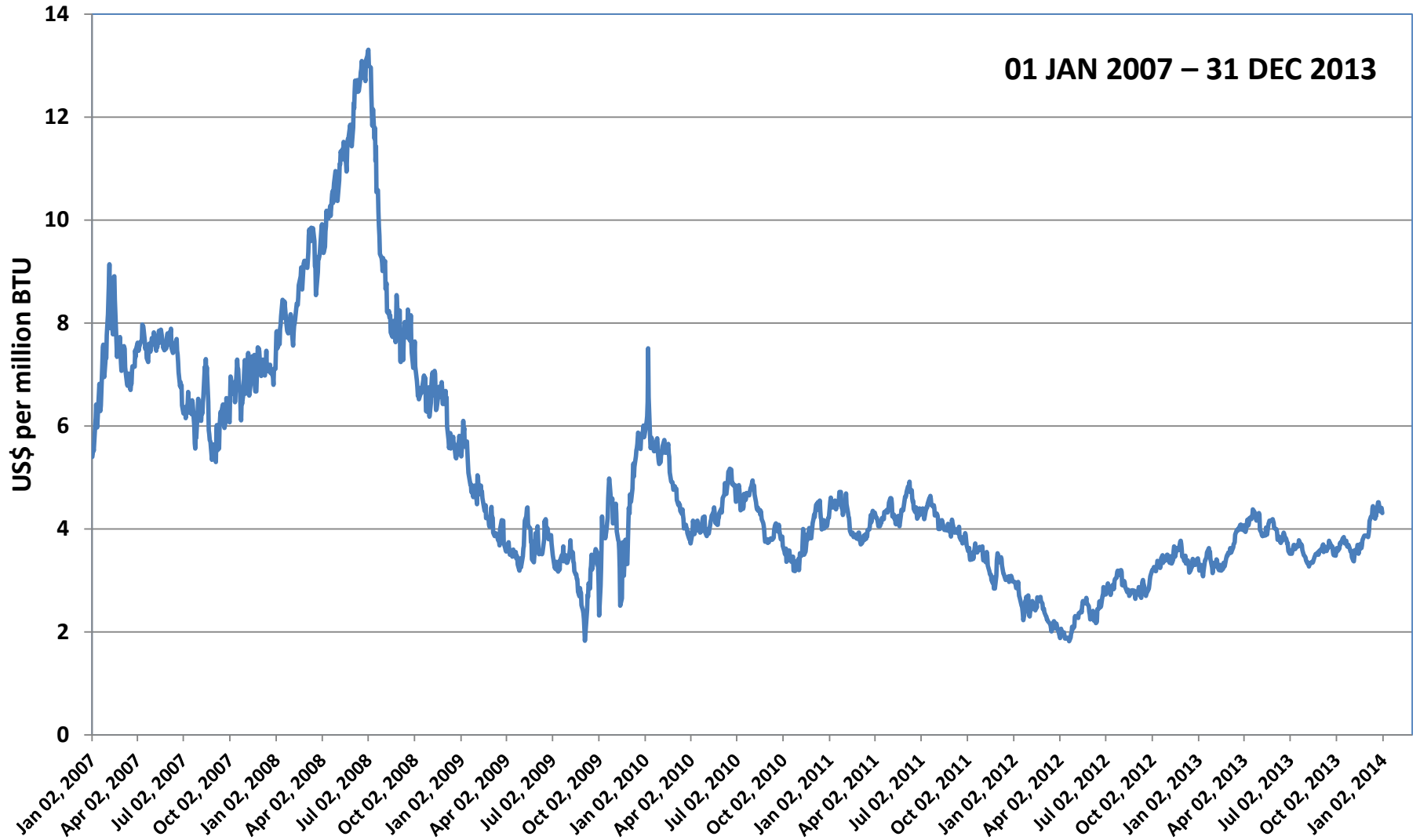
### The traditional perception



### The new "realities" or ignorance of fundamental economics?

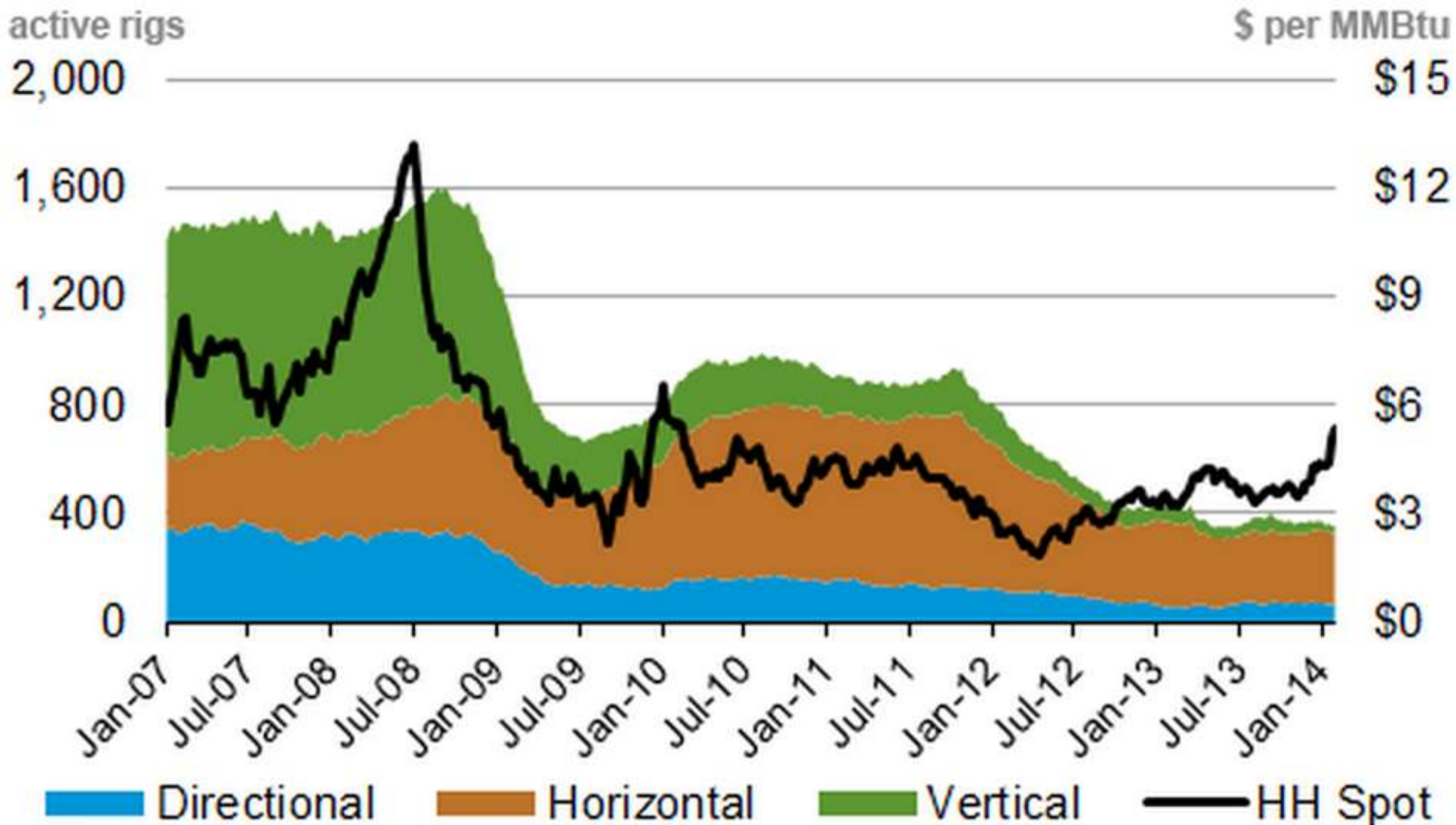


# Henry Hub natural gas spot prices



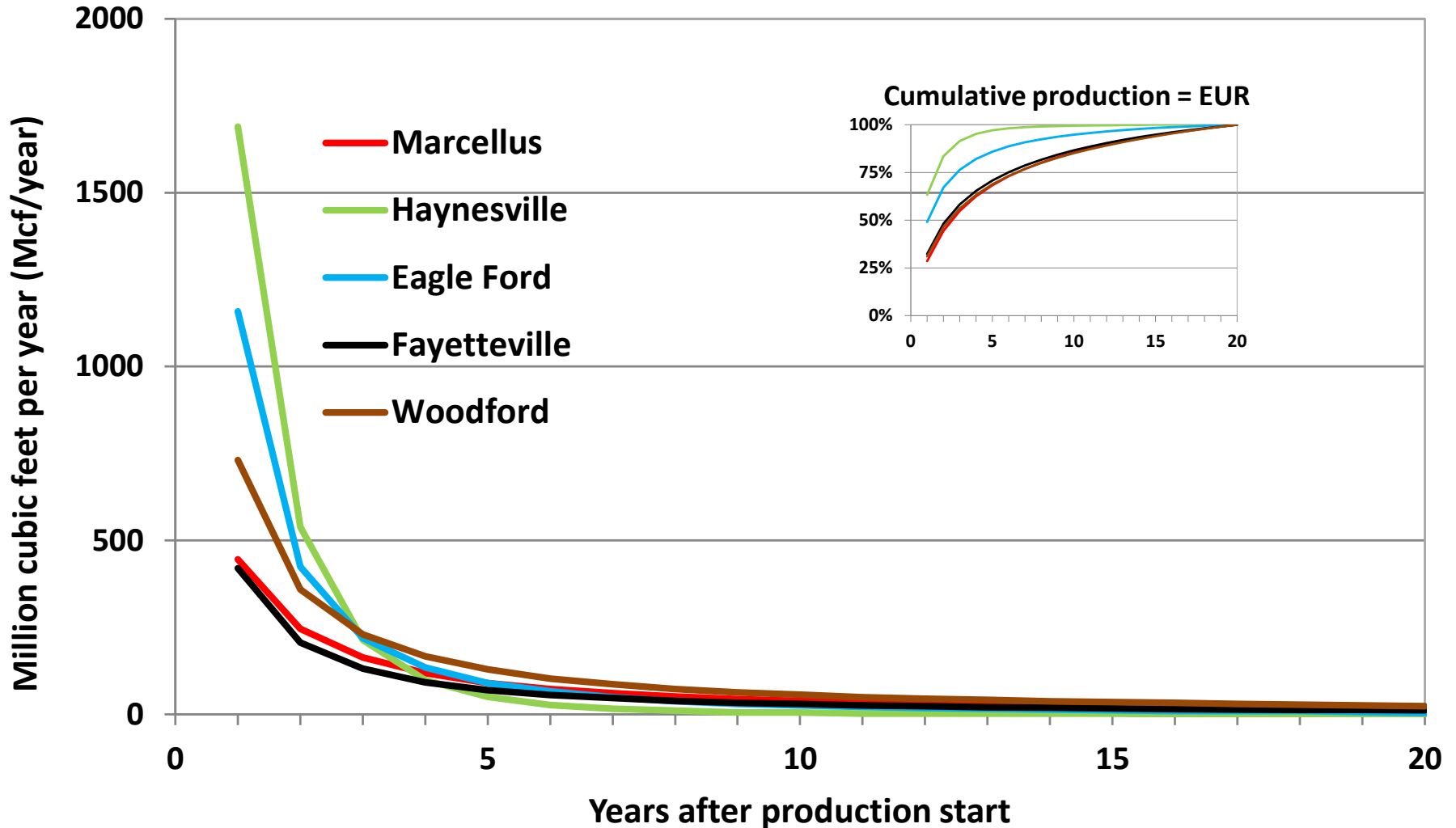


# Natural gas rig count and Henry Hub (HH) gas spot price



Source: EIA, 2014

# Typical shale gas production profiles



# Economics of shale gas

- **Maintaining production levels requires continuous investment**
- **Estimated some 7000 wells need to be drilled per year to maintain current shale gas production**
- **Investments per well now approaching and at times exceeding \$9 million per well (used to be \$2 to \$3 million)**
- **Share of economically producible quantities (recovery rates) yet to be determined**
  - **Initially reserves are a small sub-set of resources but are dynamically changing**
  - **Reserves take years of development drilling and lots of \$ before turning into supplies**
  - **Known reserves may never be developed**
- **Market prices at least \$6-7 per million BTU**
- **Additional innovation needed to contain costs**

# The role of technology & innovation

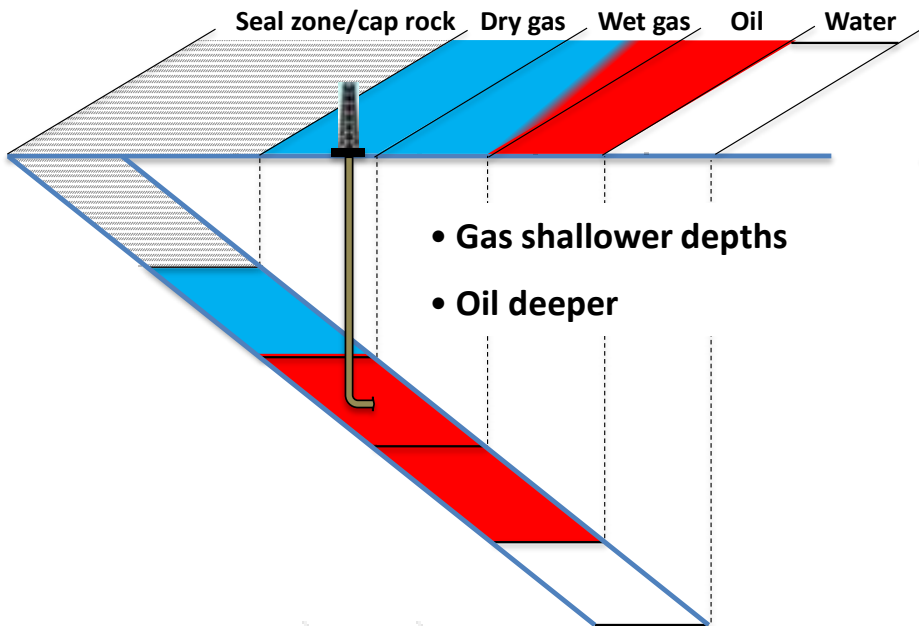


^ Continuous process improvement. Over a four-and-a-half year period, from 2007 to 2011, Southwestern Energy reduced days to drill (dark blue) by 52%, even though the lateral length was increased by more than 84% (pink). Well costs (dark red) were flat to slightly lower during the period but the company's finding and development costs (F&D, light blue) were significantly reduced during the period. Production (gold) and reserves (green) greatly increased during the study period. (Data for 2011 are for the first six months of the year.)

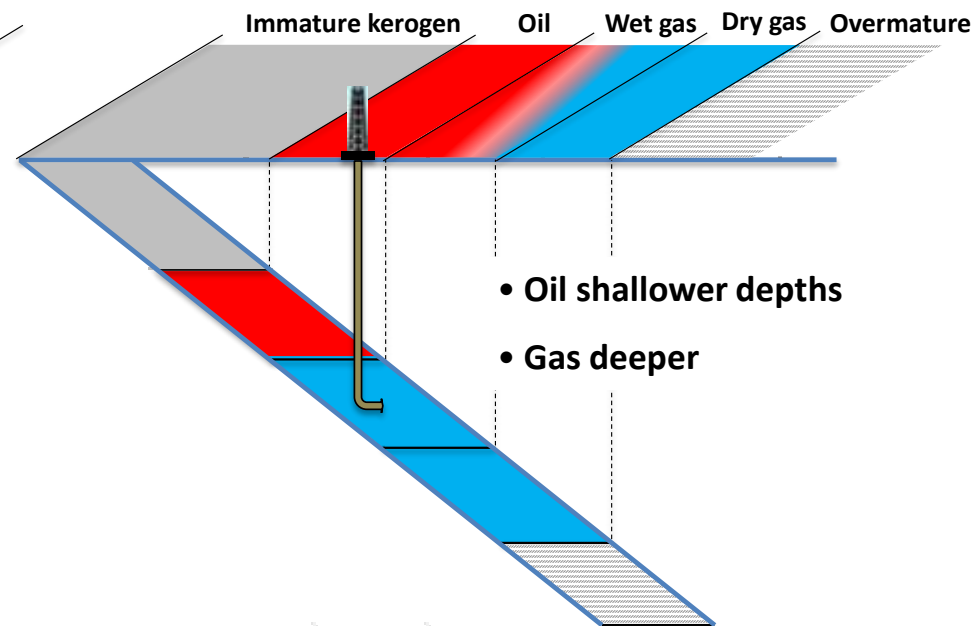
Source: Schlumberger, 2011

# Different hydrocarbon windows

## Conventional associated gas plays



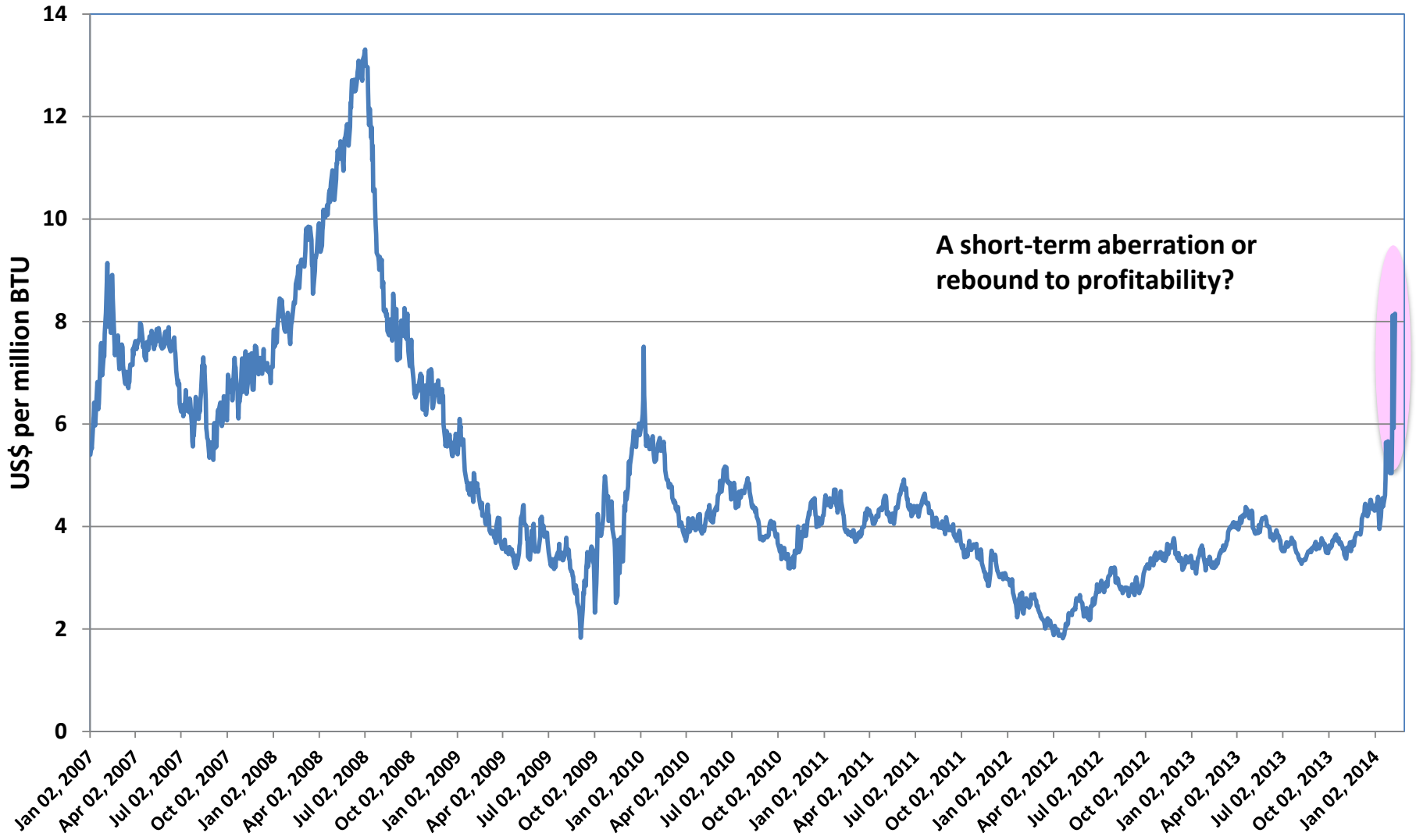
## Shale gas plays



More complex factors include:

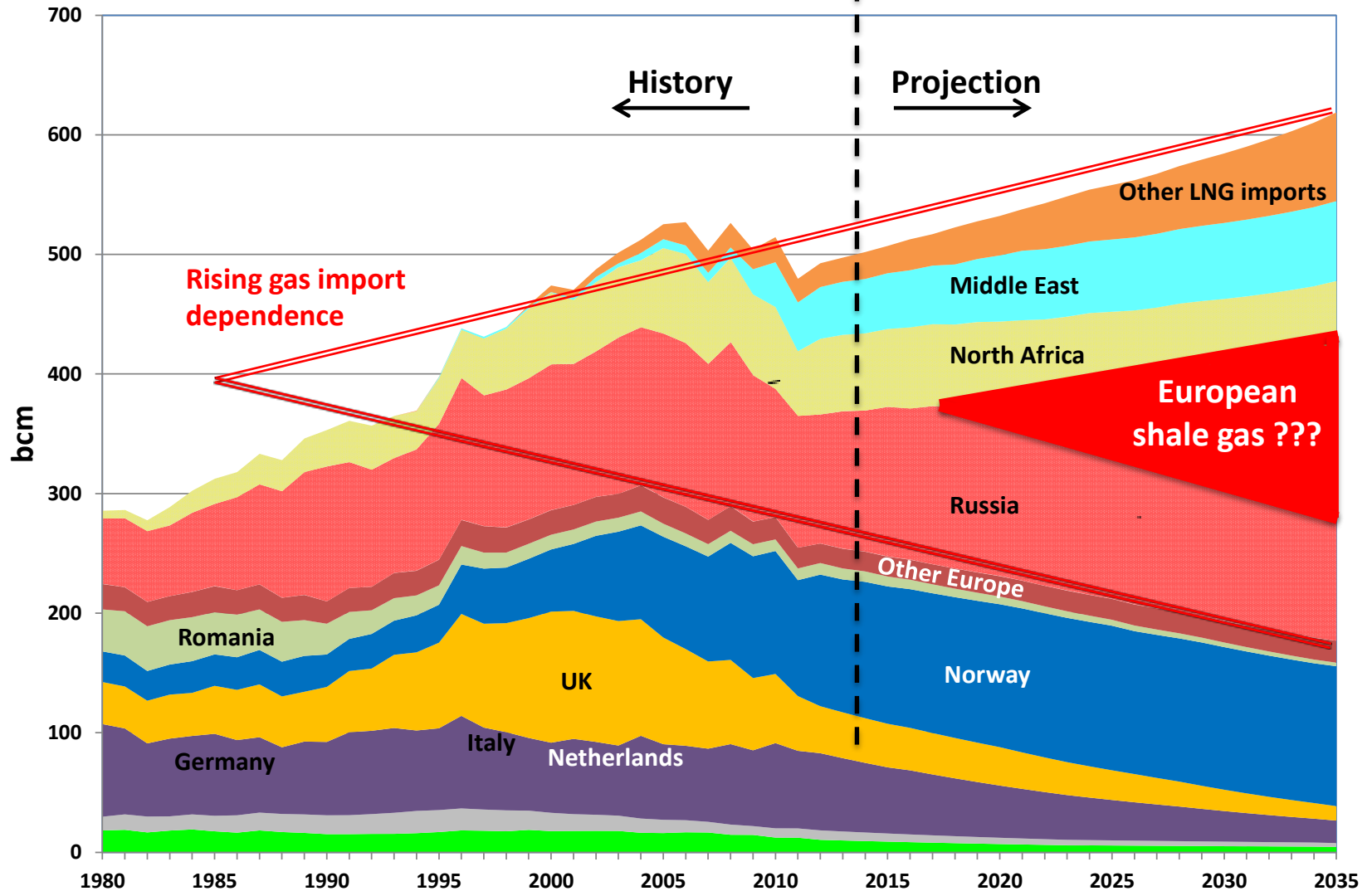
- Understand and work with regional stress fields
- Work with & connect to the natural fissures
- Delineate sweet spots
- Select appropriate proppants & treatment

# Henry Hub natural gas spot prices



# European natural gas supply

Energy security, prices plus climate mitigation  
– drivers for shale gas?



# Issues for Europe (and elsewhere)

- **Little exploration to data – results have yet to meet expectations**
- **Population density**
- **Strong environmental NGOs**
- **Mineral rights**
- **Entrepreneurial risk averseness**
- **Lack of technology, infrastructure & know-how**
- **Need for innovation, especially for finding “sweet spots”**