

# Shale Gas and the Outlook for U.S. Natural Gas Markets and Global Gas Resources



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*Organization for Economic Cooperation and Development (OECD)*

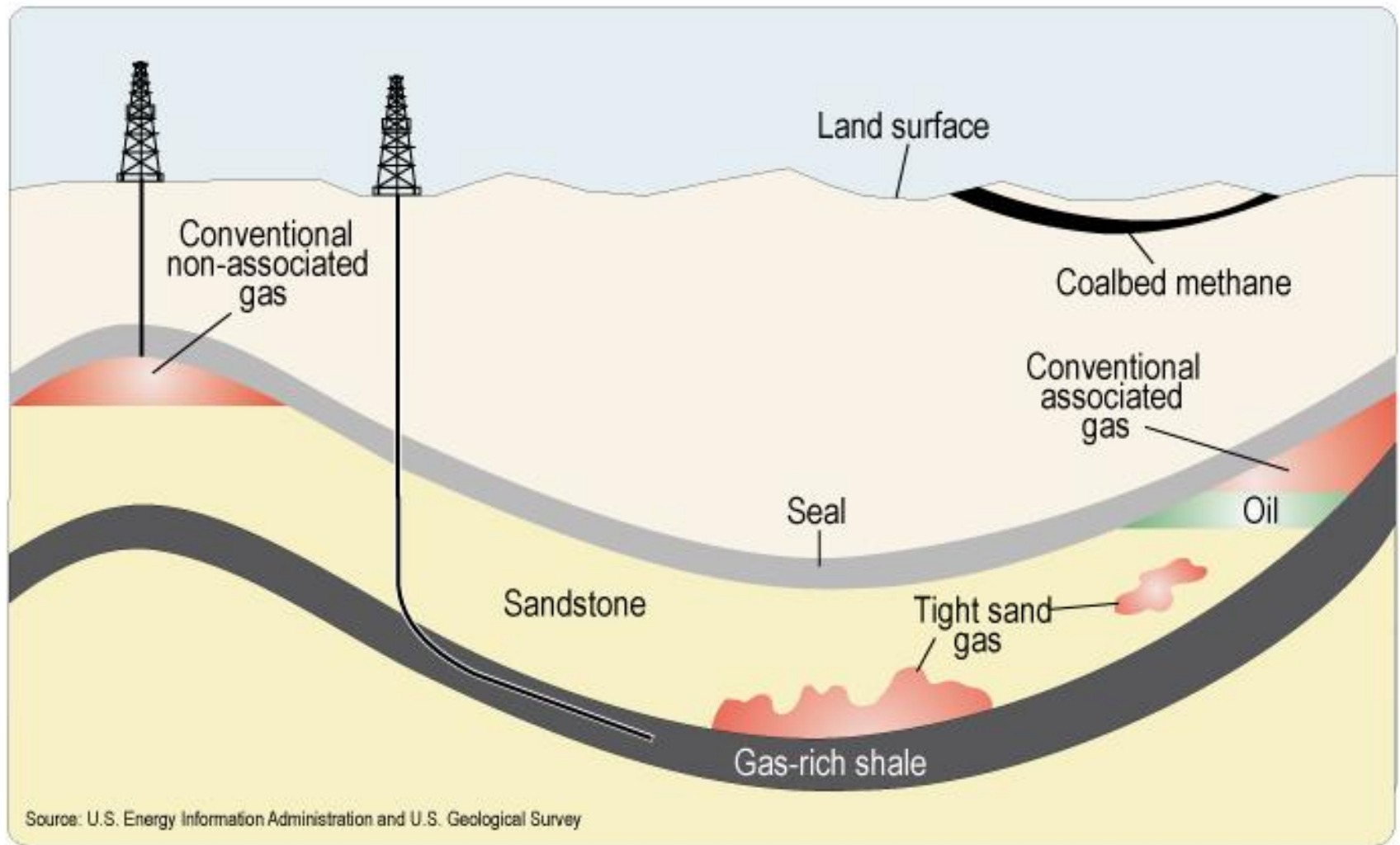
*Richard Newell, Administrator*

*June 21, 2011 | Paris, France*

# Overview

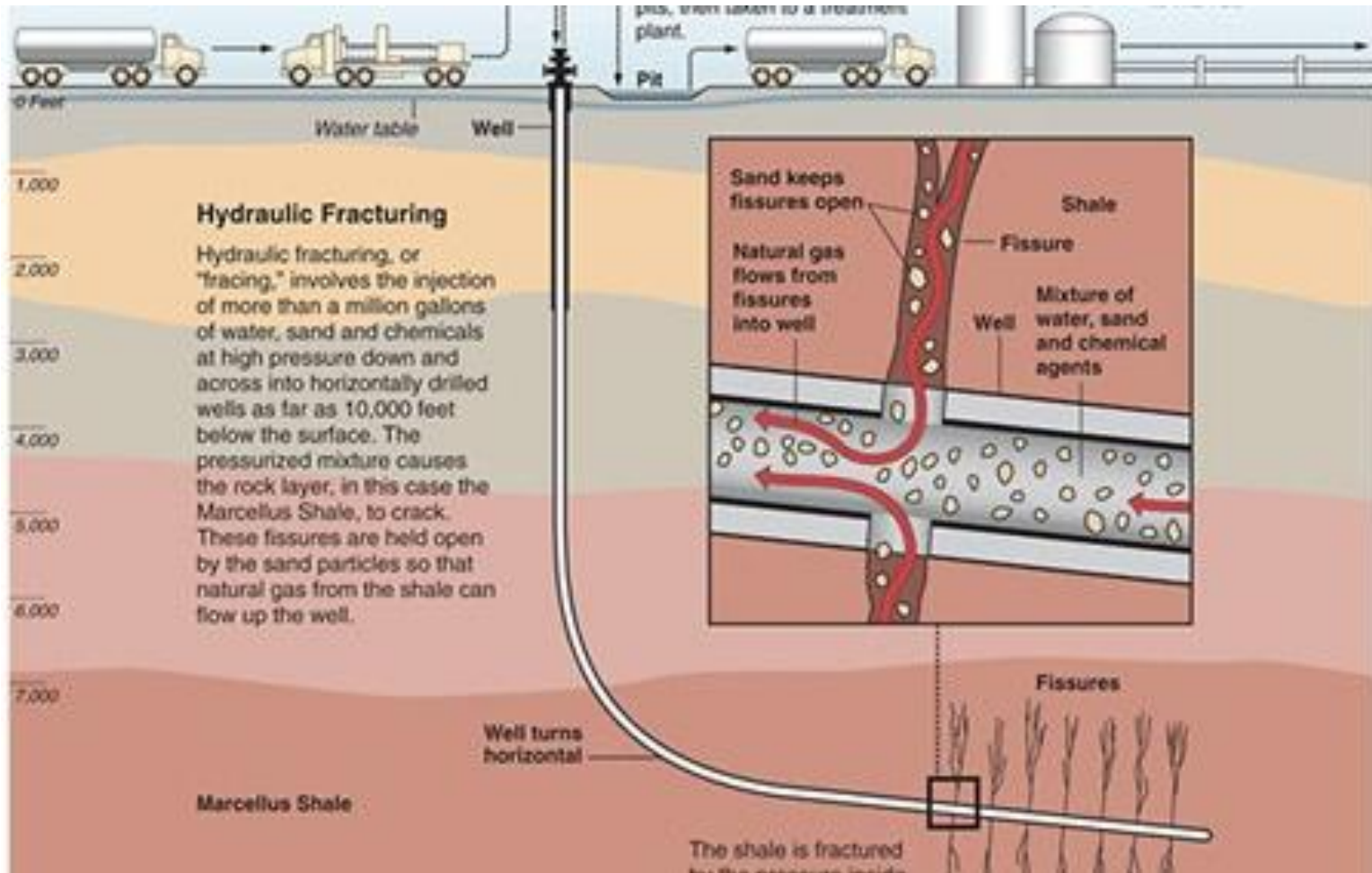
- History of U.S. shale gas production
- Outlook for the U.S. natural gas market
- Implications for electric power
- World shale gas resources: An initial assessment

# Underground sources of natural gas



Source: modified from U.S. Geological Survey Fact Sheet 0113-01

# Diagram of a typical hydraulic fracturing operation

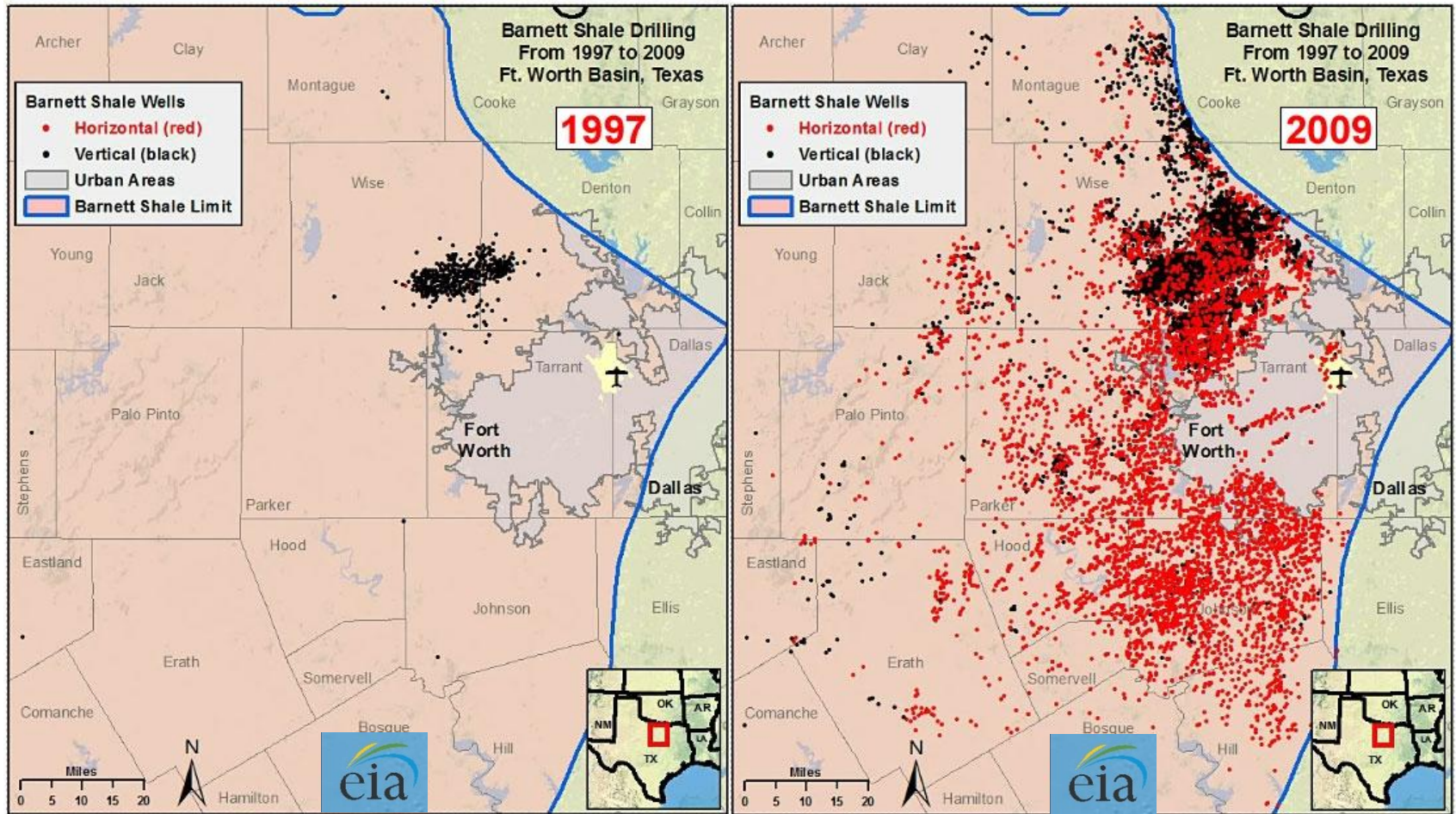


Source: ProPublica, <http://www.propublica.org/special/hydraulic-fracturing-national>

# History of U.S. shale gas production



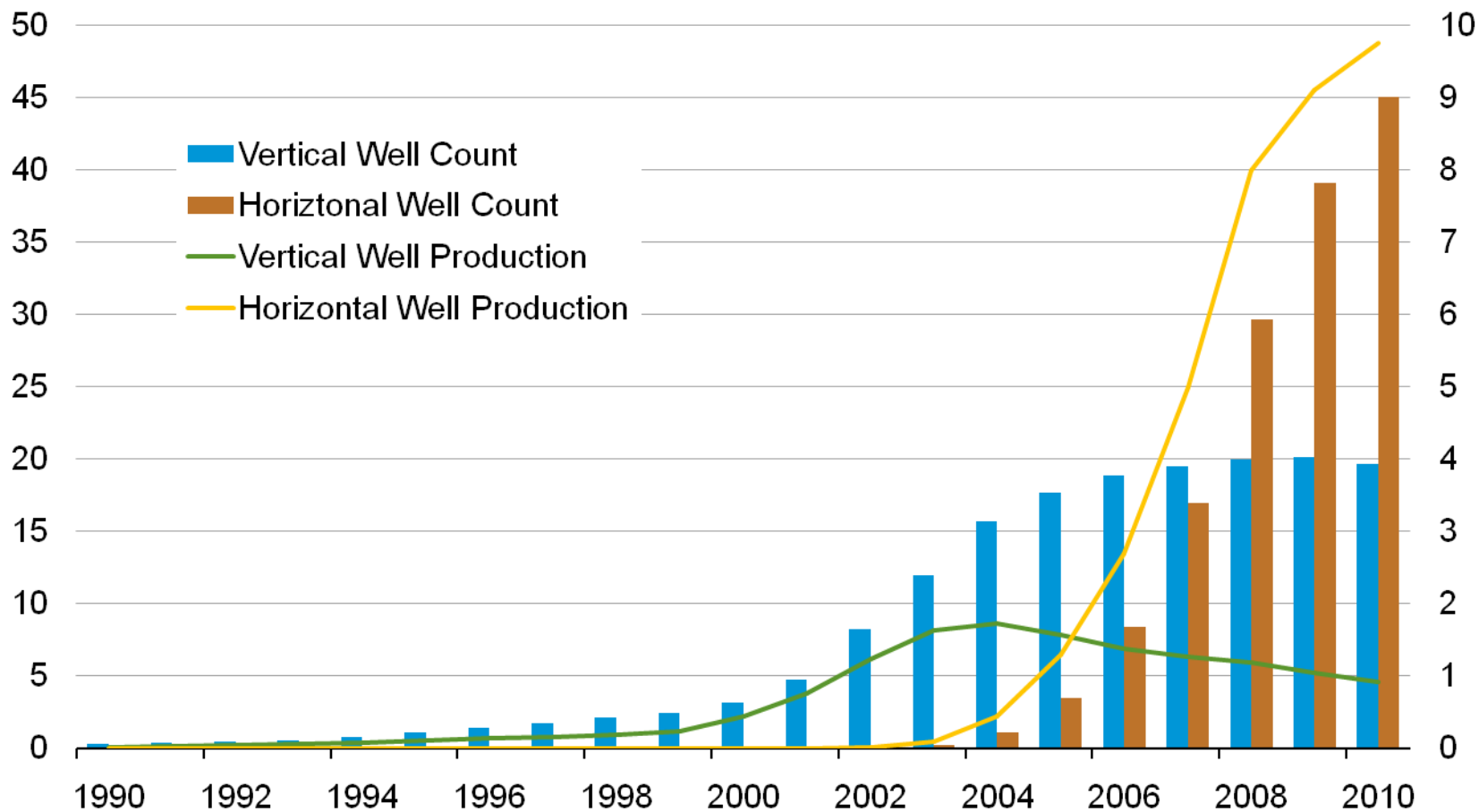
# Since 1997, more than 13,500 gas wells completed in the Barnett shale



# The result has been rapid increases in production from the Barnett field

gas production  
billion cubic meters

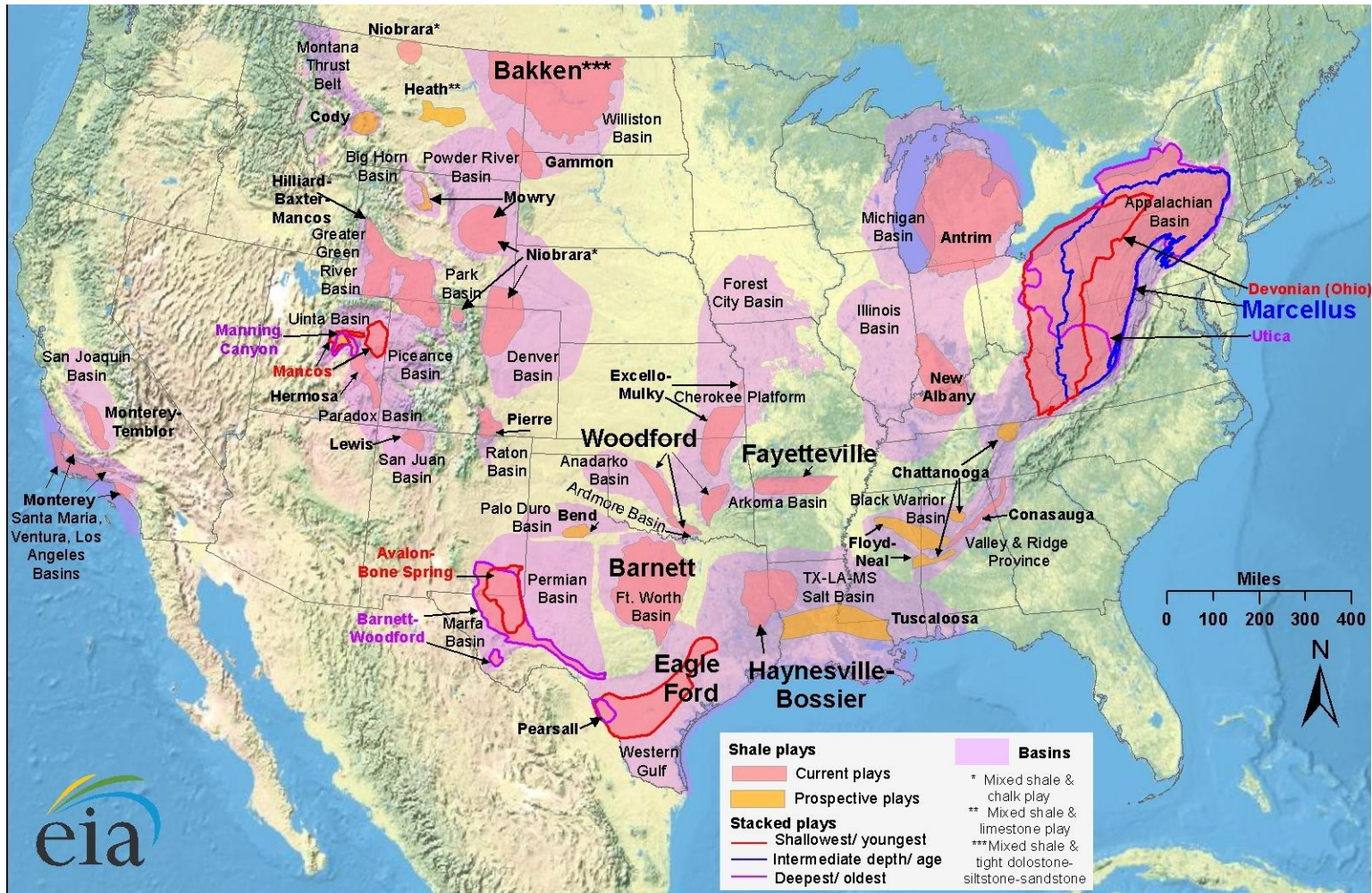
wells drilled  
thousands



Source: EIA



# Shale gas plays, Lower 48 States



Source: Energy Information Administration based on data from various published studies.  
 Updated: May 9, 2011

Source: Energy Information Administration based on data from various published studies.



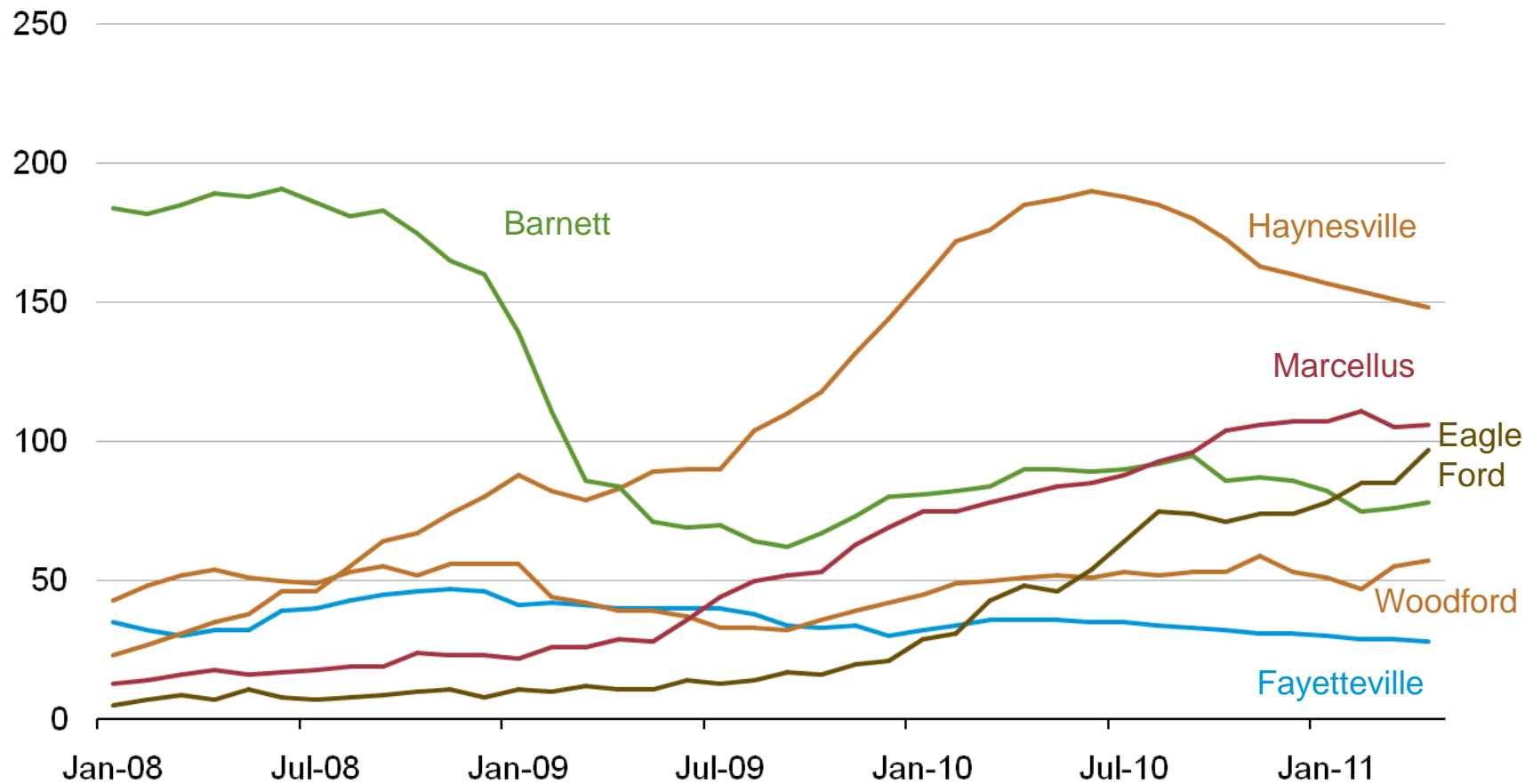
# North American shale plays



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

# At this stage, the Haynesville and the Marcellus formations appear to be the most attractive

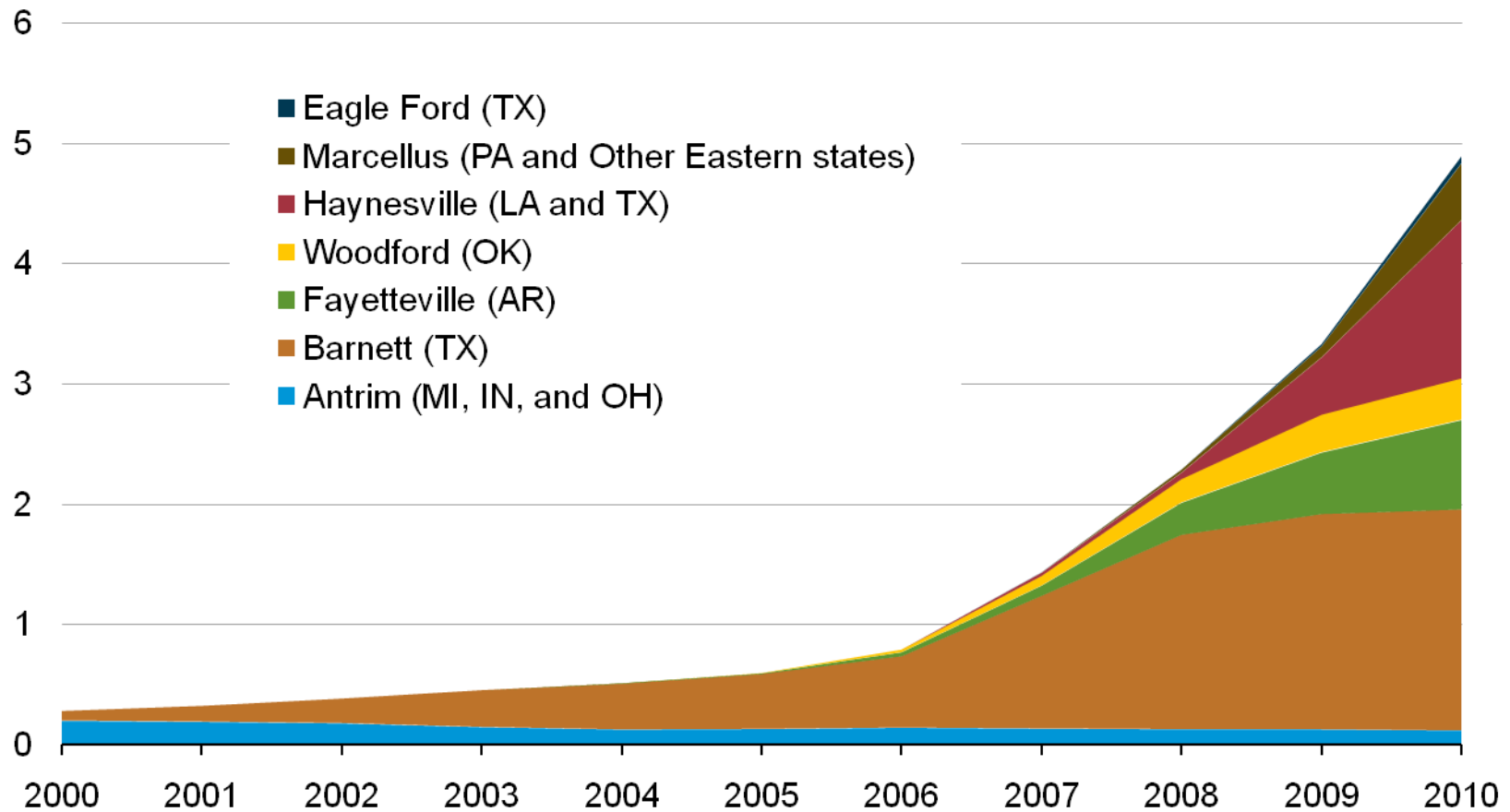
rigs drilling for gas



Source: Smith International

## Over the last decade, U.S. shale gas production has increased 12-fold and now comprises about 25 percent of total U.S. production

annual shale gas production  
trillion cubic feet



Sources: EIA and Lippman Consulting

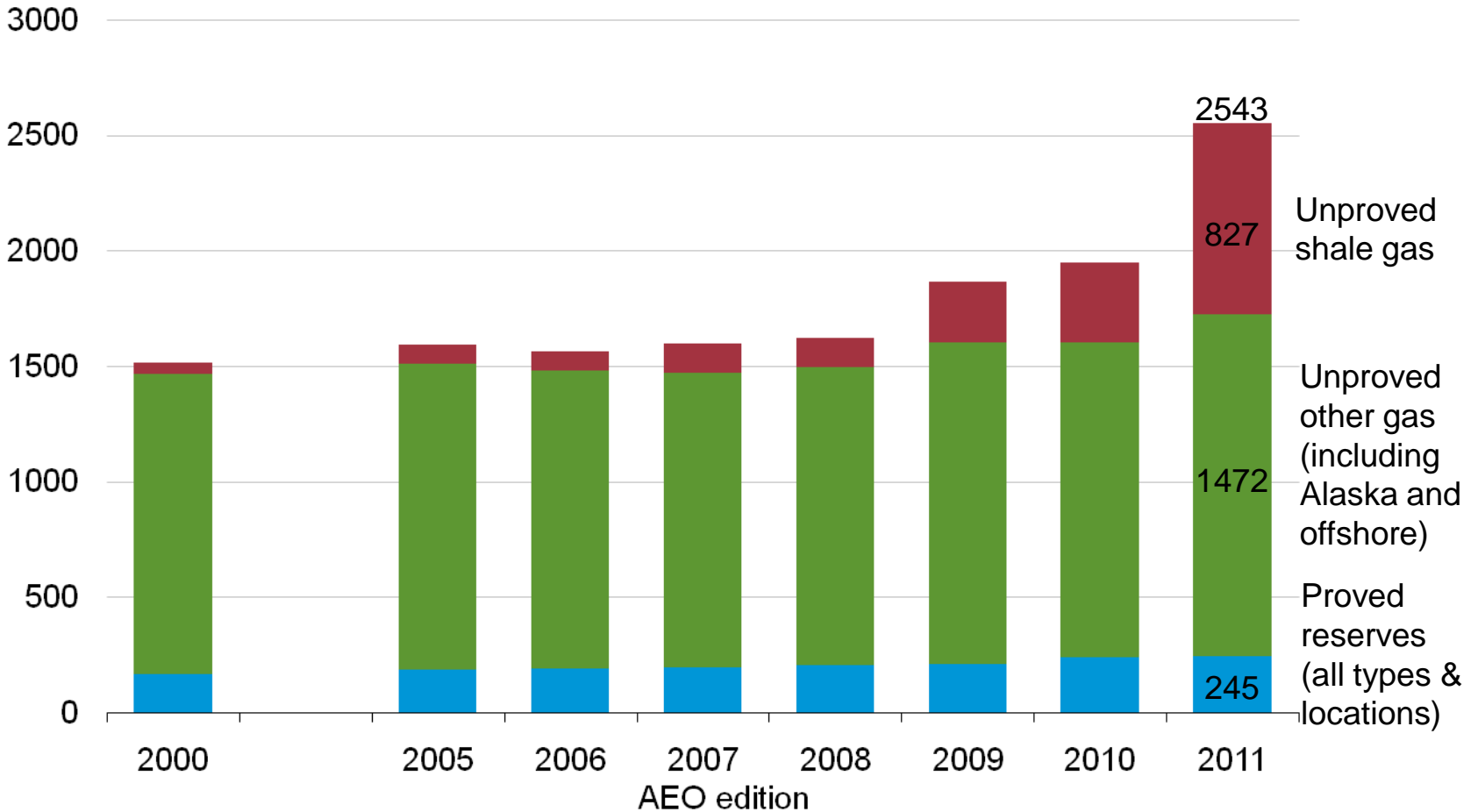


# Outlook for U.S. gas market

# Recent Annual Energy Outlook natural gas resources

U.S. dry natural gas resources

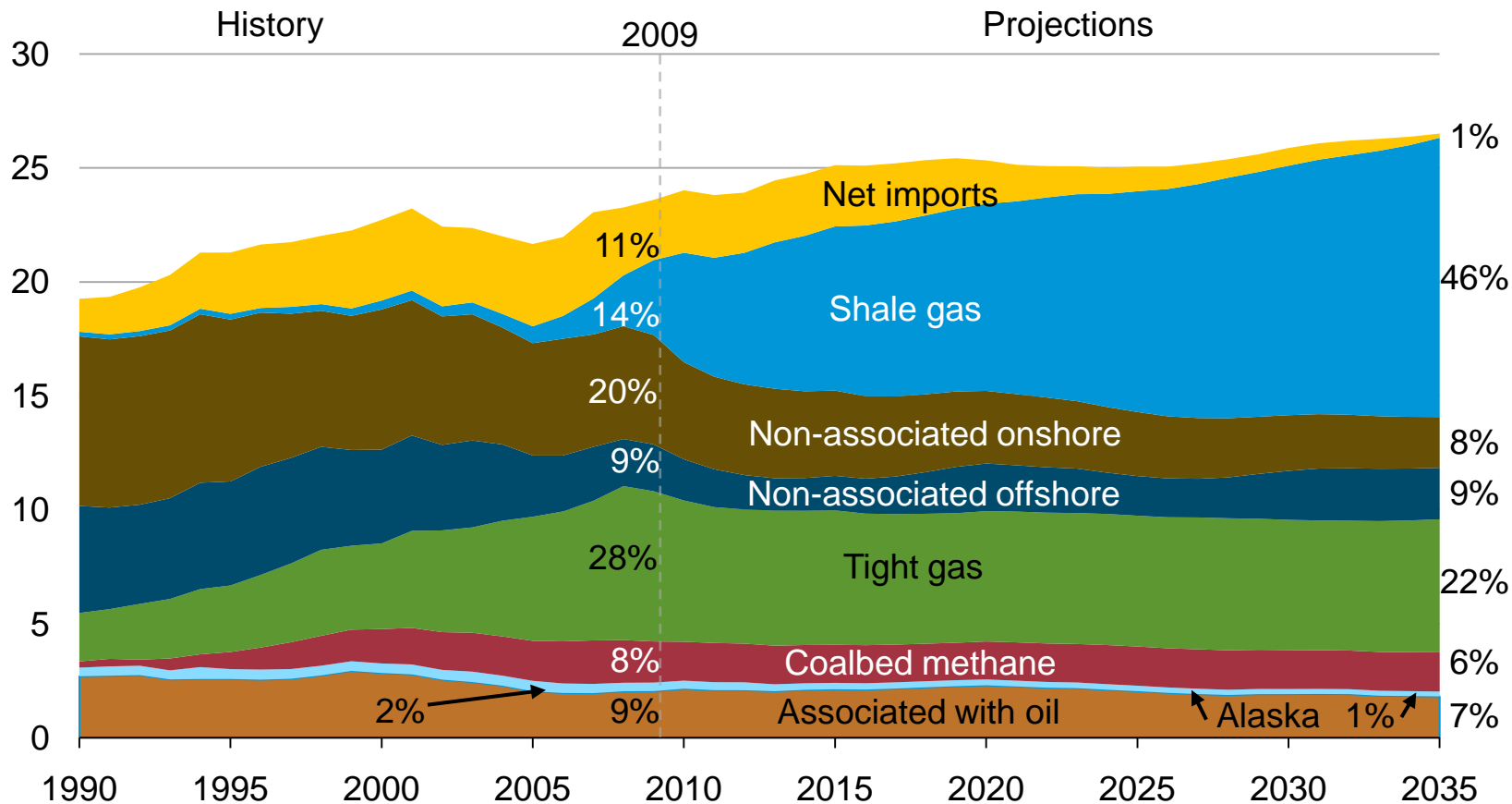
trillion cubic feet



Source: EIA, Annual Energy Outlook 2011 and earlier editions

# Shale gas offsets declines in other U.S. supply to meet consumption growth and lower import needs

U.S. dry gas  
trillion cubic feet per year

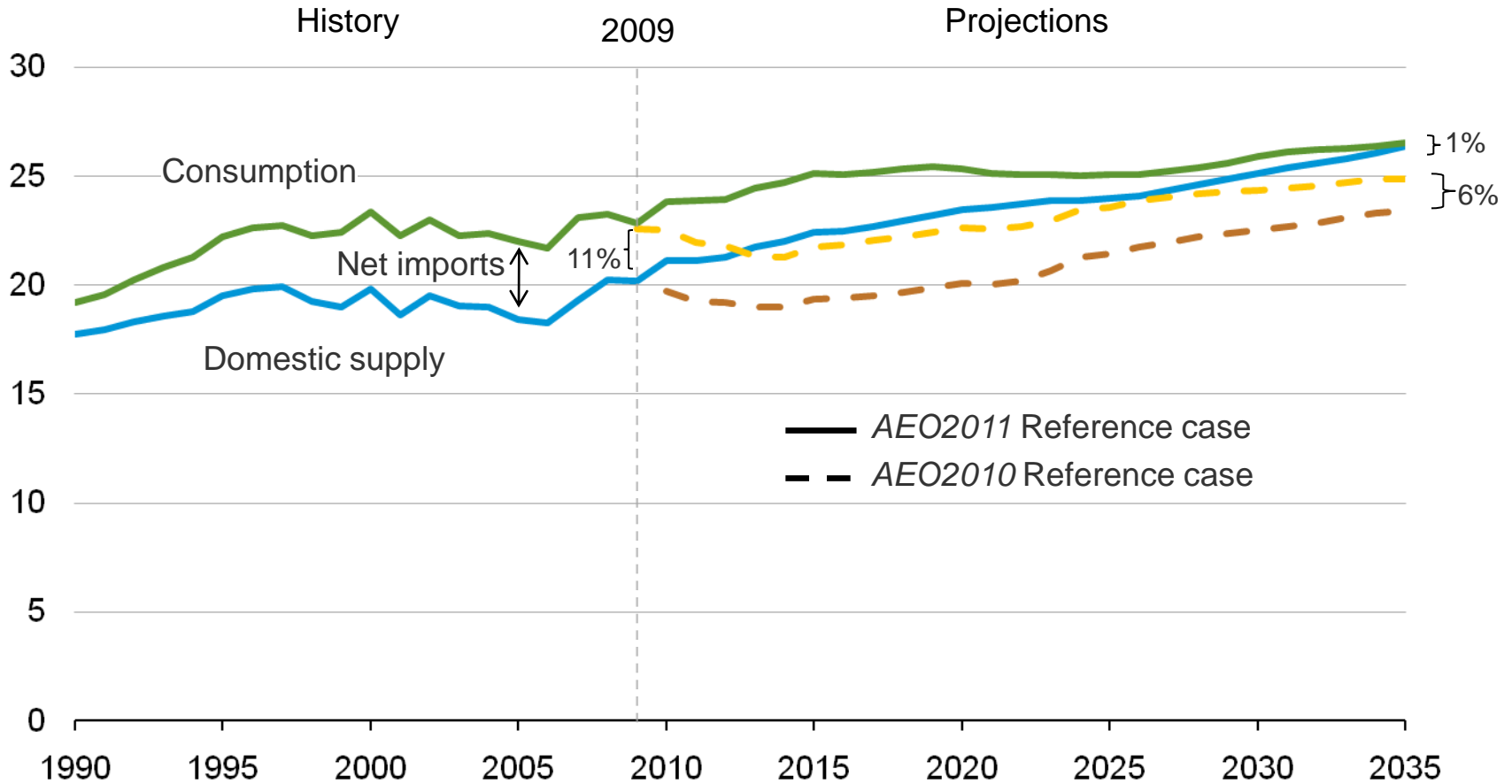


Source: EIA, Annual Energy Outlook 2011



# 30% domestic gas production growth outpaces 16% consumption growth, leading to declining imports

U.S. dry gas  
trillion cubic feet per year

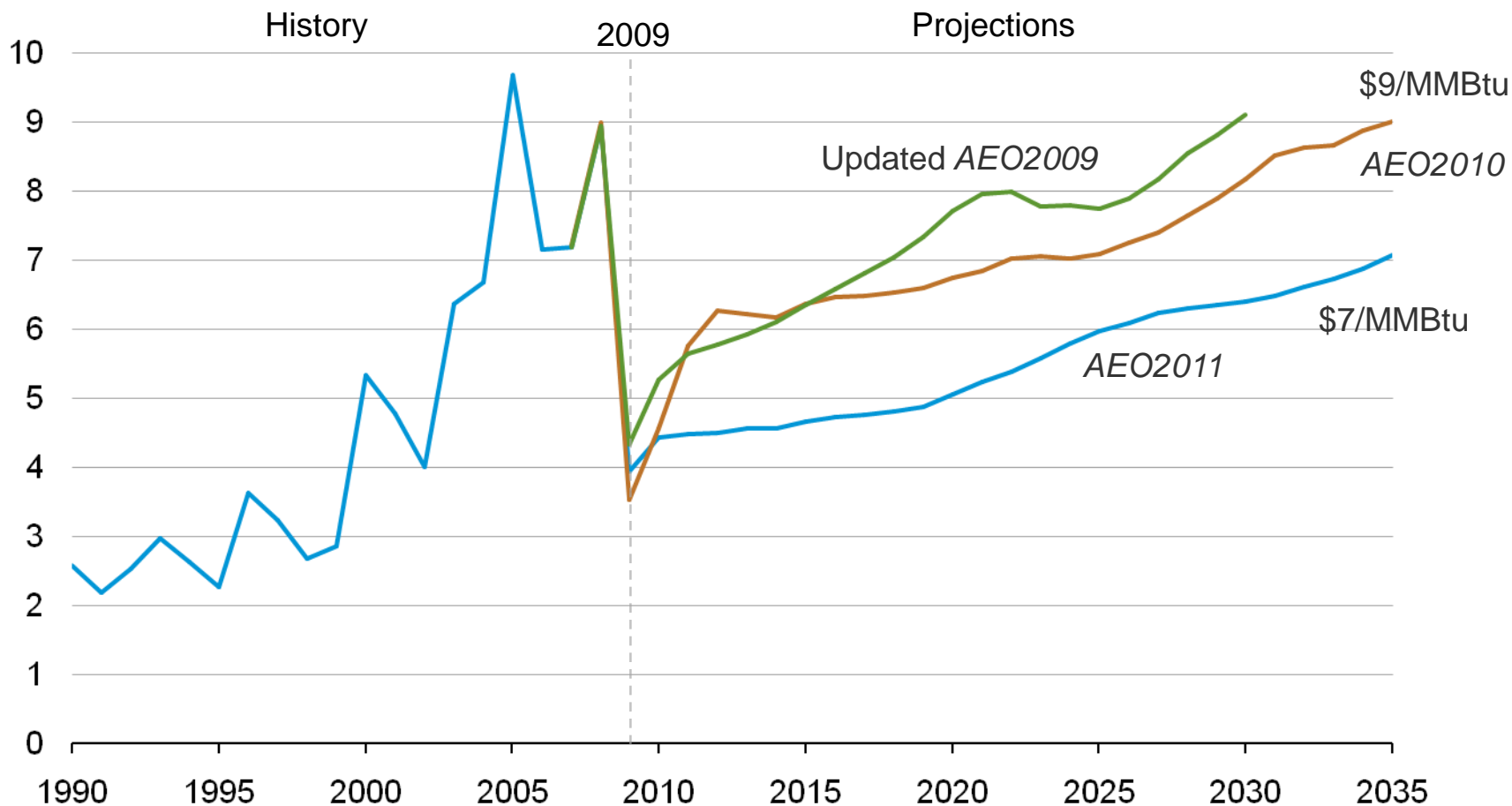


Source: EIA, Annual Energy Outlook 2011

# Natural gas price projections are significantly lower than past years due to an expanded shale gas resource base

natural gas spot price (Henry Hub)

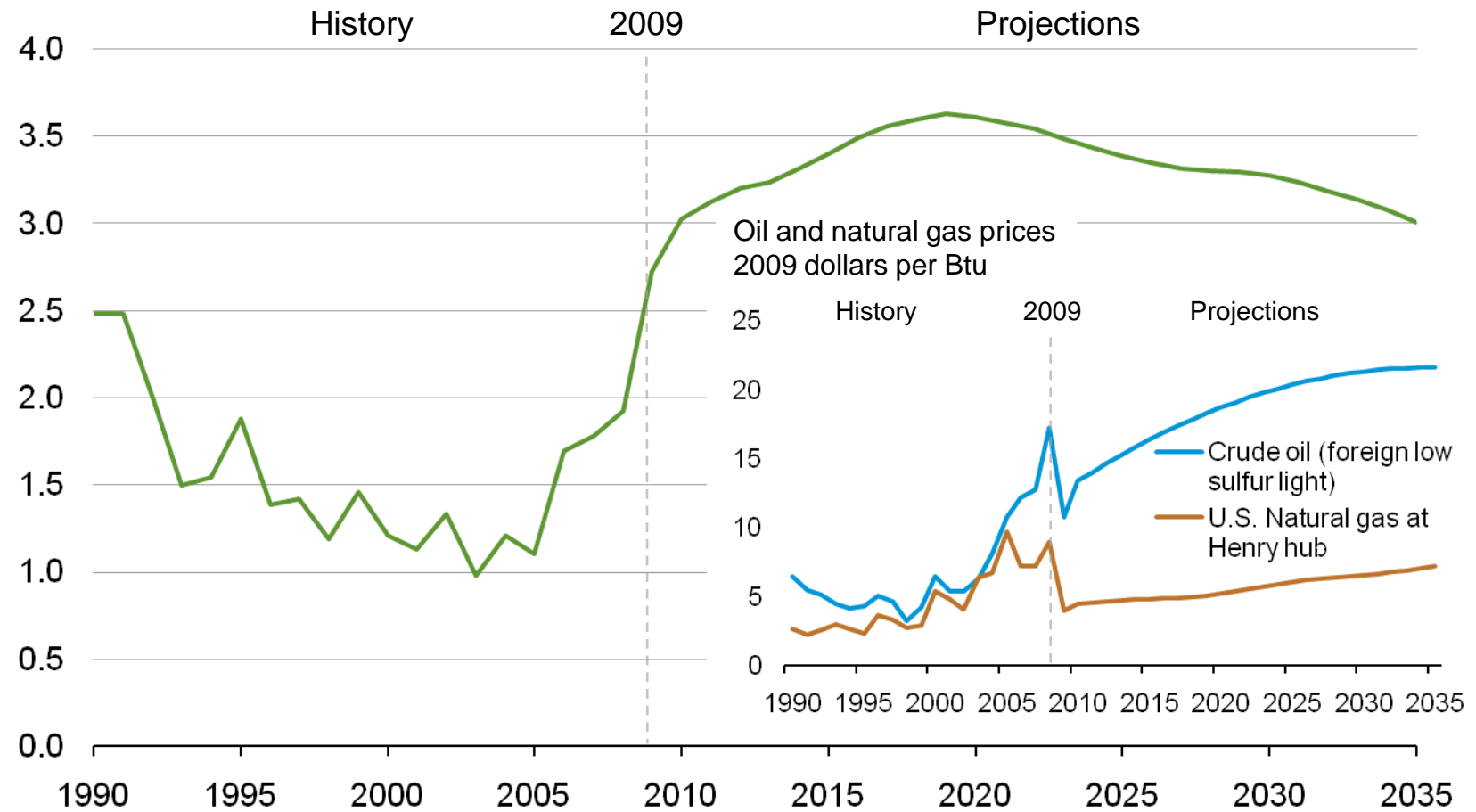
2009 dollars per million Btu



Sources: EIA, Annual Energy Outlook 2011; EIA, Annual Energy Outlook 2010; and EIA, An Updated Annual Energy Outlook 2009 Reference Case

# Oil to natural gas price ratio remains high over the projection

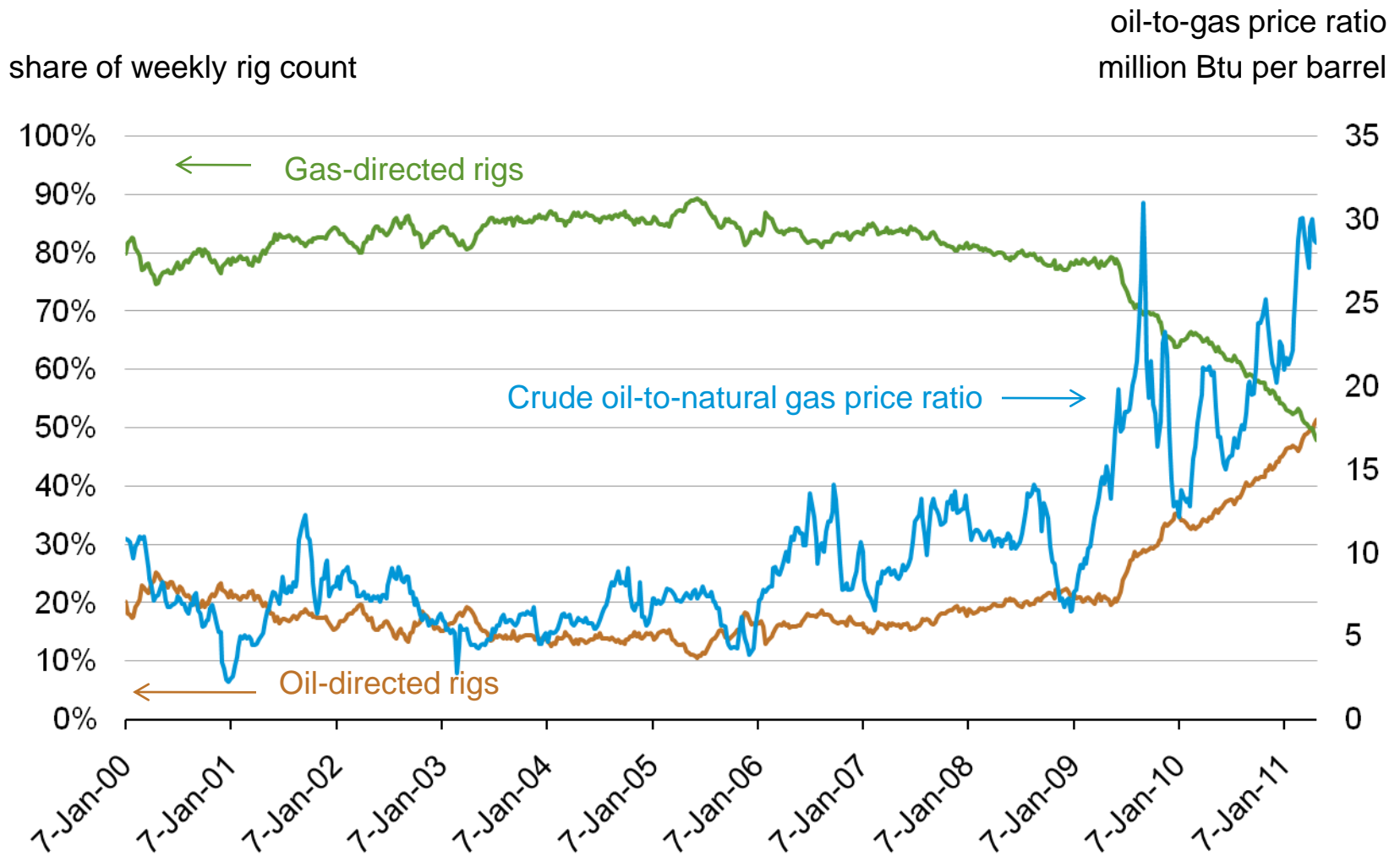
ratio of oil price to natural gas price



Source: EIA, Annual Energy Outlook 2011



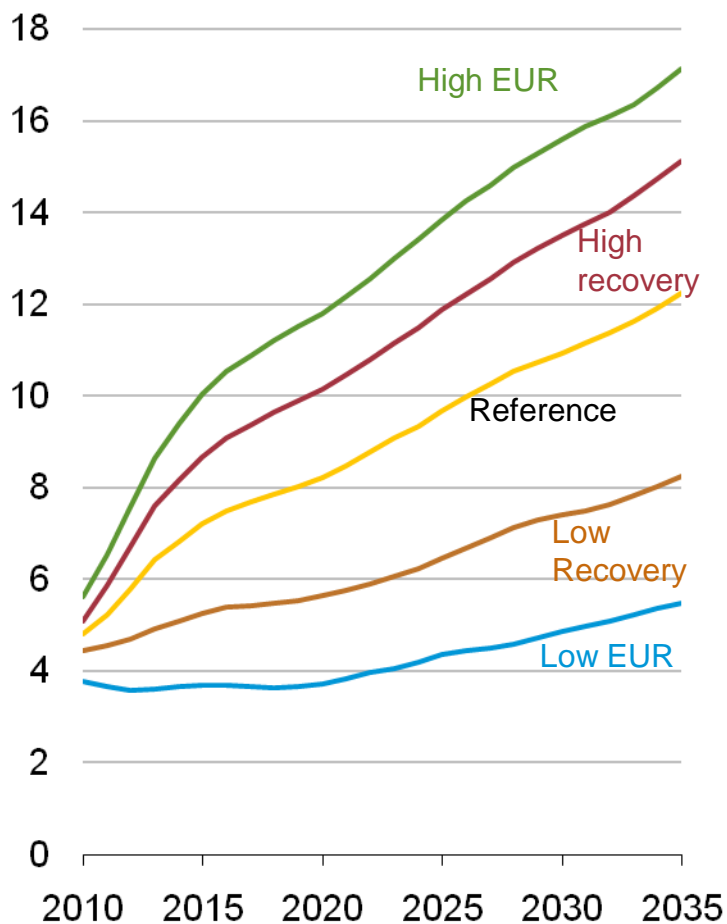
# U.S. oil rig count overtakes natural gas rig count



Sources: EIA, Baker Hughes

# Shale gas resource potential and related costs remain highly uncertain

shale gas production  
trillion cubic feet



## Four alternate cases

**High Estimated Ultimate Recovery (EUR) case** assumes an EUR per shale gas well set 50% higher than in the Reference case. Results in lower per Mcf costs.

**High Recovery case** assumes 50% more natural gas can be recovered from the shale formation than in the Reference case. Per Mcf costs are unchanged.

**Low Recovery case** is like High Recovery but less.

**Low EUR case** is like High EUR but lower.

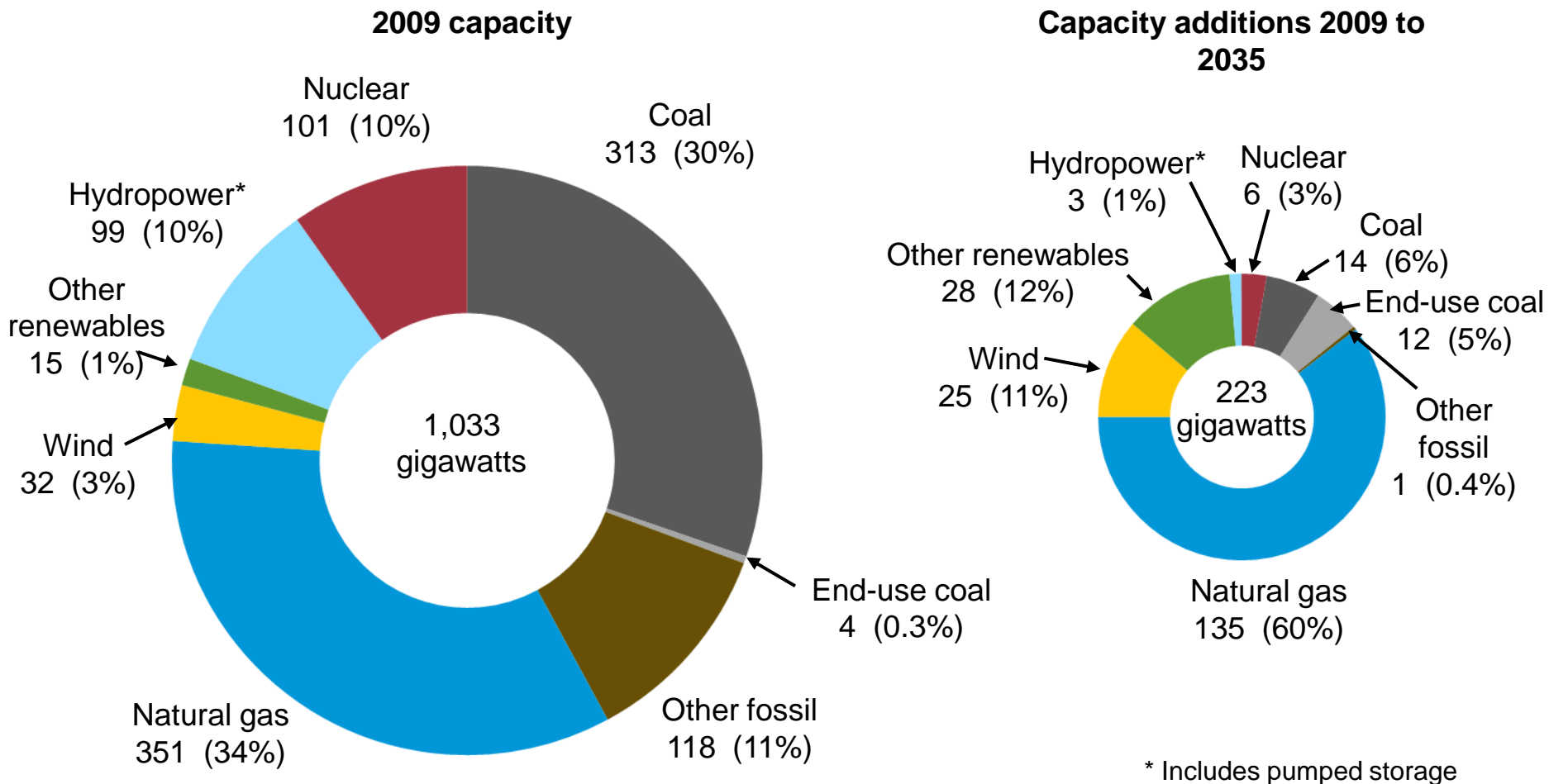
## 2035 Results

Projection	Ref	High EUR	High Recov.	Low EUR	Low Recov.
Shale gas prod. (tcf)	12.3	17.1	15.1	5.5	8.2
Total gas prod. (tcf)	26.3	30.1	28.5	22.4	24.6
Henry Hub price (09\$/Mcf)	7.07	5.35	6.03	9.26	8.17

# Implications for electric power



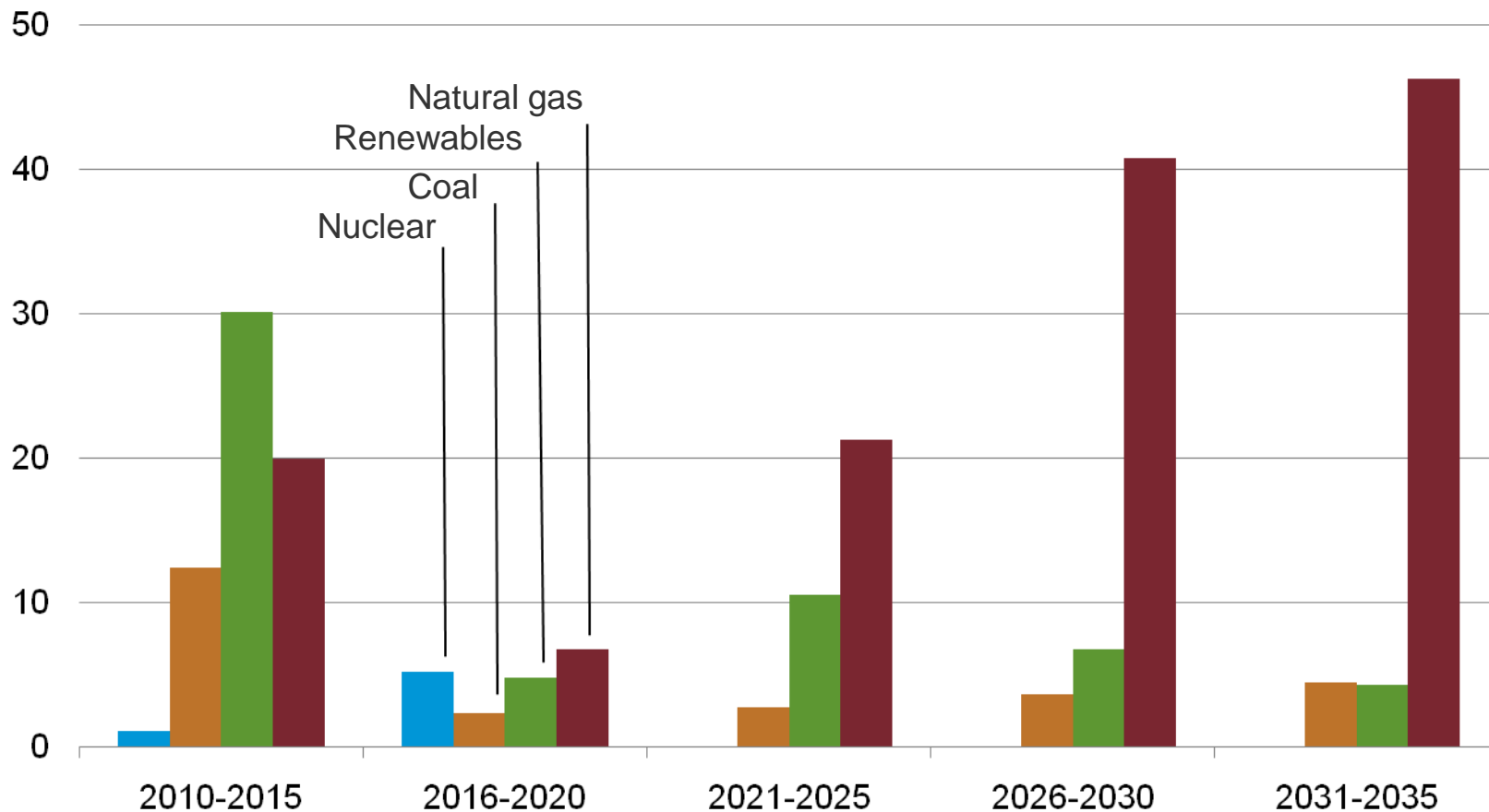
# Natural gas, wind and other renewables account for the vast majority of capacity additions from 2009 to 2035



Source: EIA, Annual Energy Outlook 2011

# Electricity generation capacity additions by fuel type, 2010-2035

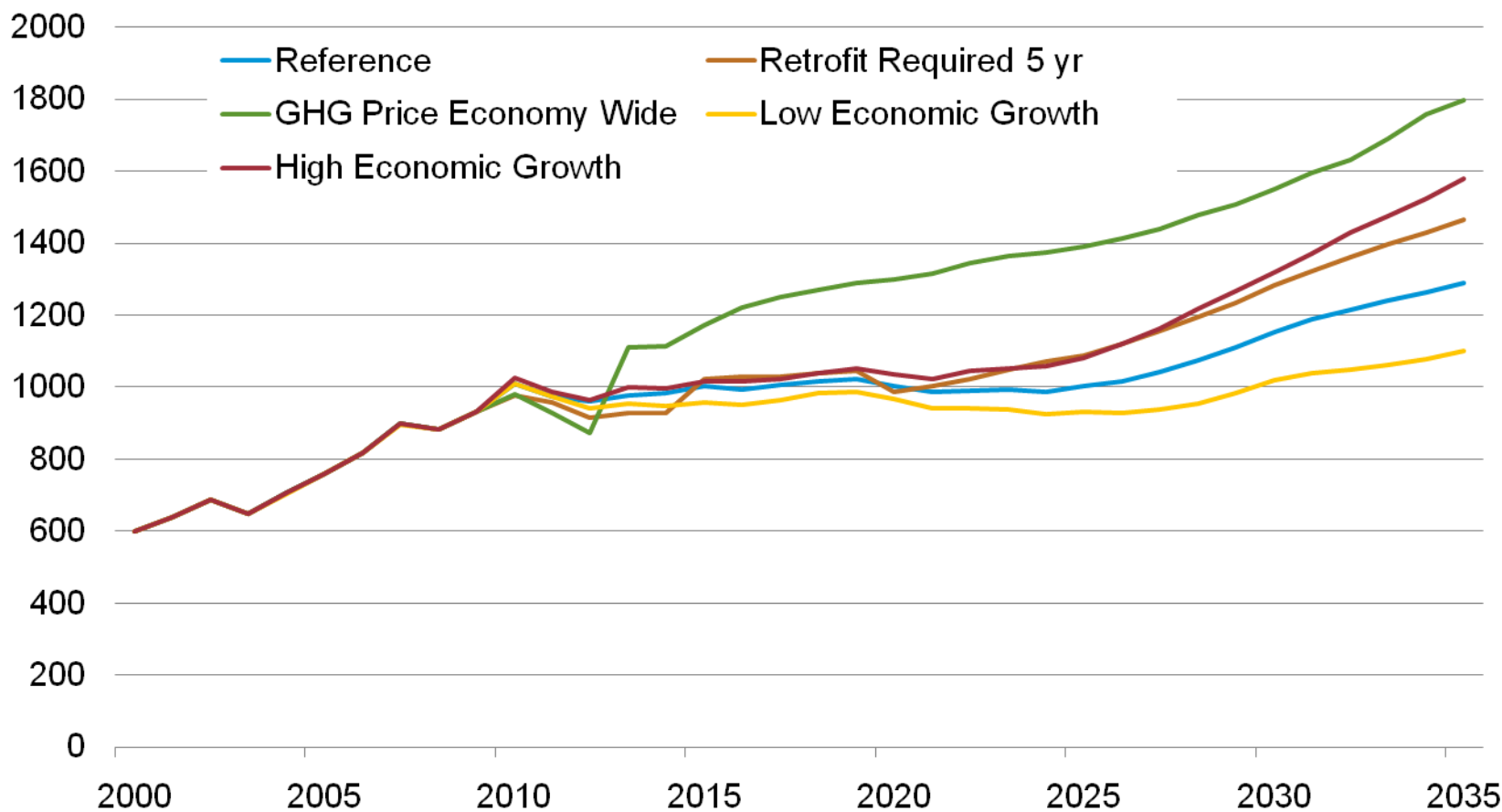
electric power capacity additions  
gigawatts



Source: EIA, Annual Energy Outlook 2011

# Natural gas electricity generation outlook varies with economic growth and regulatory policies

electricity generation  
billion kilowatthours

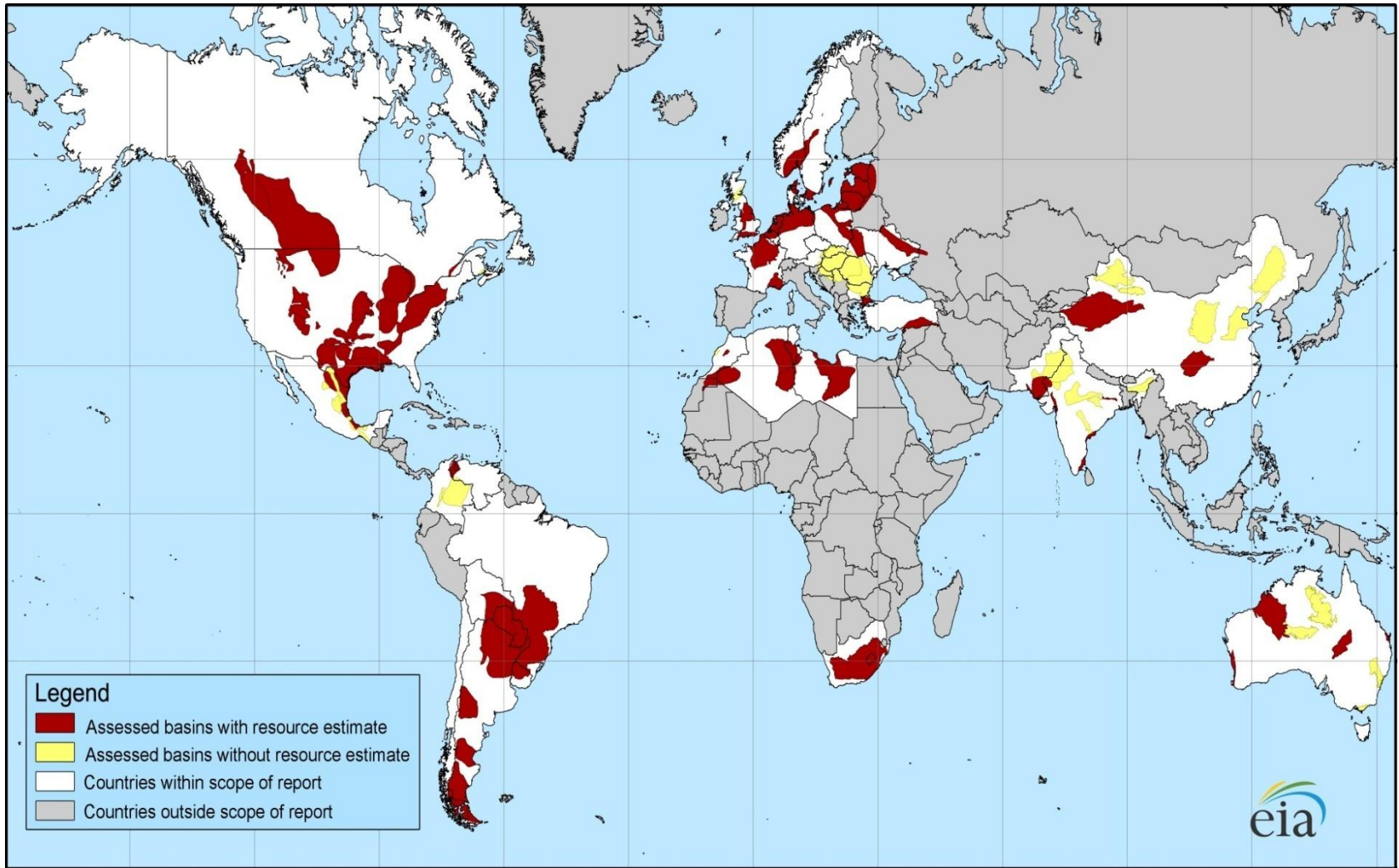


Source: EIA, Annual Energy Outlook 2011

# World shale gas resources: an initial assessment



# Initial assessment of shale gas resources in 48 major shale basins in 32 countries indicates a large potential



Source: U.S. Energy Information Administration

# 32 countries covered in the report

- North America
  - Canada, Mexico
- South America
  - Colombia, Venezuela, Argentina, Bolivia, Brazil, Chile, Uruguay, Paraguay
- Australia
- Europe
  - Denmark, France, Germany, Netherlands, Norway, Sweden, United Kingdom, Lithuania, Poland, Ukraine, Turkey
- Africa
  - Algeria, Tunisia, Libya, Morocco, Mauritania, Western Sahara, South Africa
- Asia
  - China, Pakistan, India

# Approach and methodology

1. Conducted preliminary geologic and reservoir characterization of shale basins and formation(s)
2. Established the areal extent, thickness and key reservoir properties of the major shale gas formations
3. Defined the prospective area of each shale gas formation
4. Estimated the risked shale gas in-place
5. Calculated the technically recoverable shale gas resource

# Findings

- The initial shale gas technically recoverable resource (TRR) estimates for the 32 countries outside the U.S. is 5,760 Tcf
  - More than six times EIA's 862 Tcf TRR estimate for U.S. shale gas
- Together with U.S. shale gas, world shale gas TRR of 6,622 Tcf raises total estimated world TRR by over 40% to 22,600 Tcf
- These are moderately conservative 'risked' estimates
  - Not probabilistic estimates
  - The methodology employed recognizes the sparseness and uncertainty of the data and includes conservative discounting of the potential resource

## Findings (continued)

- Countries dependent on imports but have significant shale gas resource estimates relative to their production or consumption
  - France, Poland, Turkey, Ukraine, South Africa, Morocco, Chile
- Countries that already produce a substantial amount of natural gas and are currently estimated to have a large amount of shale gas
  - U.S., Canada, Mexico, China, Australia, Libya, Algeria, Argentina, Brazil



# Technically recoverable shale gas resource estimates (trillion cubic feet)

Continent		Technically Recoverable (Tcf)
North America (non U.S.)	Canada, Mexico	1,069
	U.S.	862
Total North America		1931
Africa	Morocco, Algeria, Tunisia, Libya, Mauritania, Western Sahara, South Africa	1,042
Asia	China, India, Pakistan	1,404
Australia		396
Europe	France, Germany, Netherlands, Sweden, Norway, Denmark, U.K., Poland, Lithuania, Ukraine, Turkey	624
South America	Colombia, Venezuela, Argentina, Bolivia, Brazil, Chile, Uruguay, Paraguay	1,225
Total		6,622
Total without U.S.		5,760

Source: EIA ARI World Shale Gas Resources

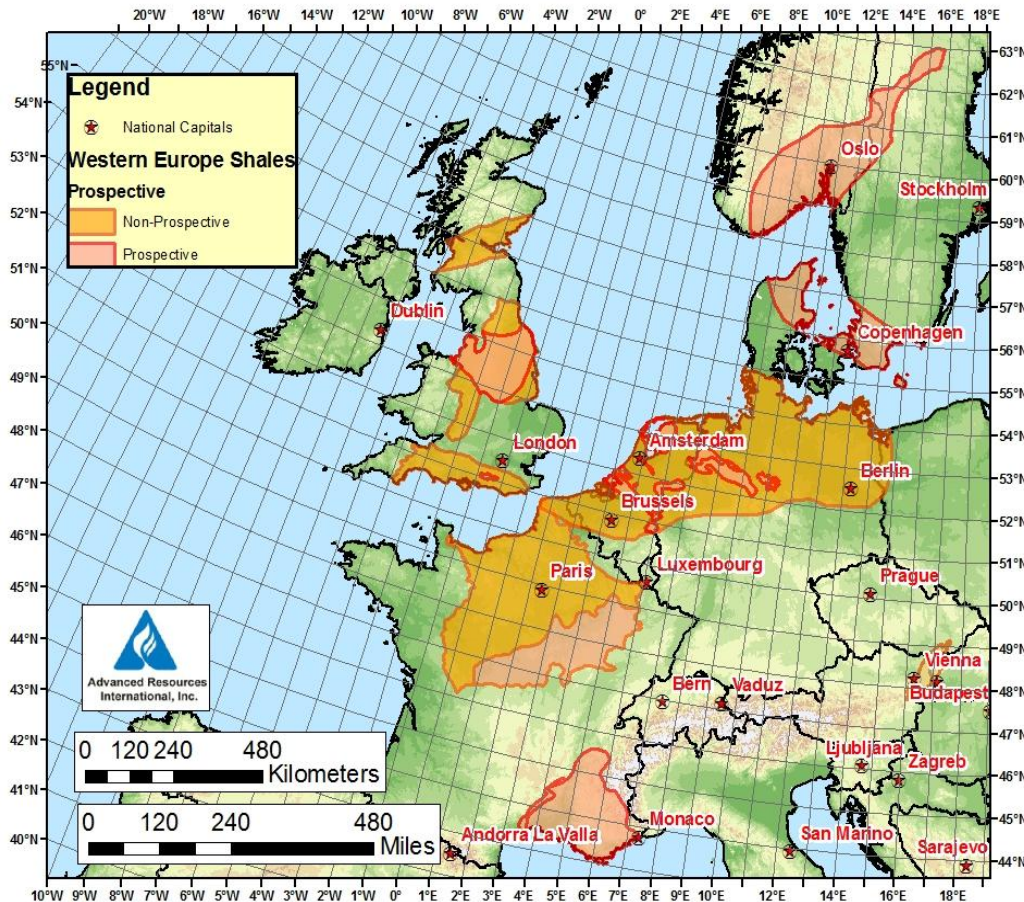
# Technically recoverable shale gas resource estimates (trillion cubic meters)

Continent	Country	Technically Recoverable (Tcm)
North America (non U.S.)	Canada and Mexico	30.3
	U.S.	24.4
Total North America	Canada, Mexico, U.S.	54.7
South America	Colombia, Venezuela, Argentina, Bolivia, Brazil, Chile, Uruguay, Paraguay	34.7
Europe	France, Germany, Netherlands, Sweden, Norway, Denmark, U.K., Poland, Lithuania, Ukraine, Turkey	17.7
Africa	Morocco, Algeria, Tunisia, Libya, Mauritania, Western Sahara, South Africa	29.5
Asia	China, India, Pakistan	39.8
Australia		11.2
Total		187.4
Total excluding U.S.		163.2

Source: EIA ARI World Shale Gas Resources

# Western Europe's shale gas resources and basins

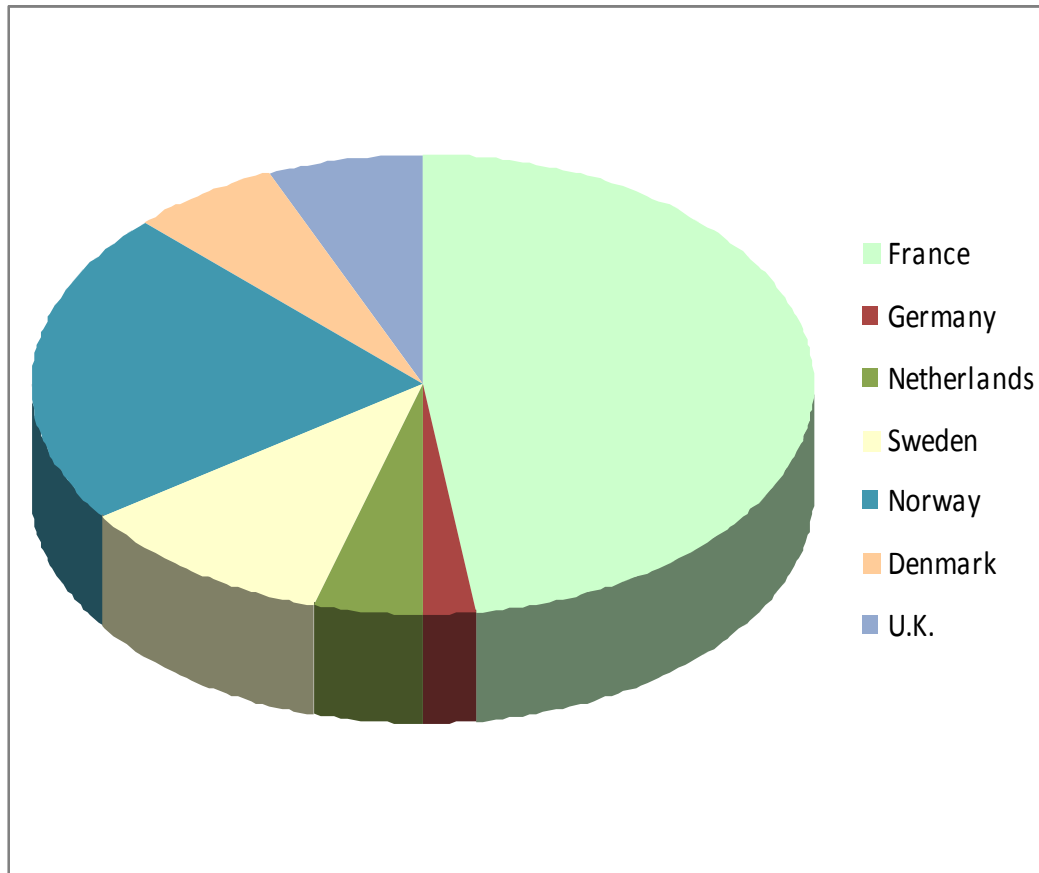
## Onshore shale gas basins of Western Europe



- Western Europe's shale gas resources (assessed by our study) exist in the Ordovician Alum shale of Scandinavia, the Permian/Carboniferous shale of the Paris basin, and a host of Jurassic-age shale basins.
- Our shale gas assessment for Western Europe indicates a major resource:
  - 372 Tcf (10.54 Tcm) of technically recoverable resource.

Source: EIA ARI World Shale Gas Resources

## Distribution of Western Europe's shale gas resources



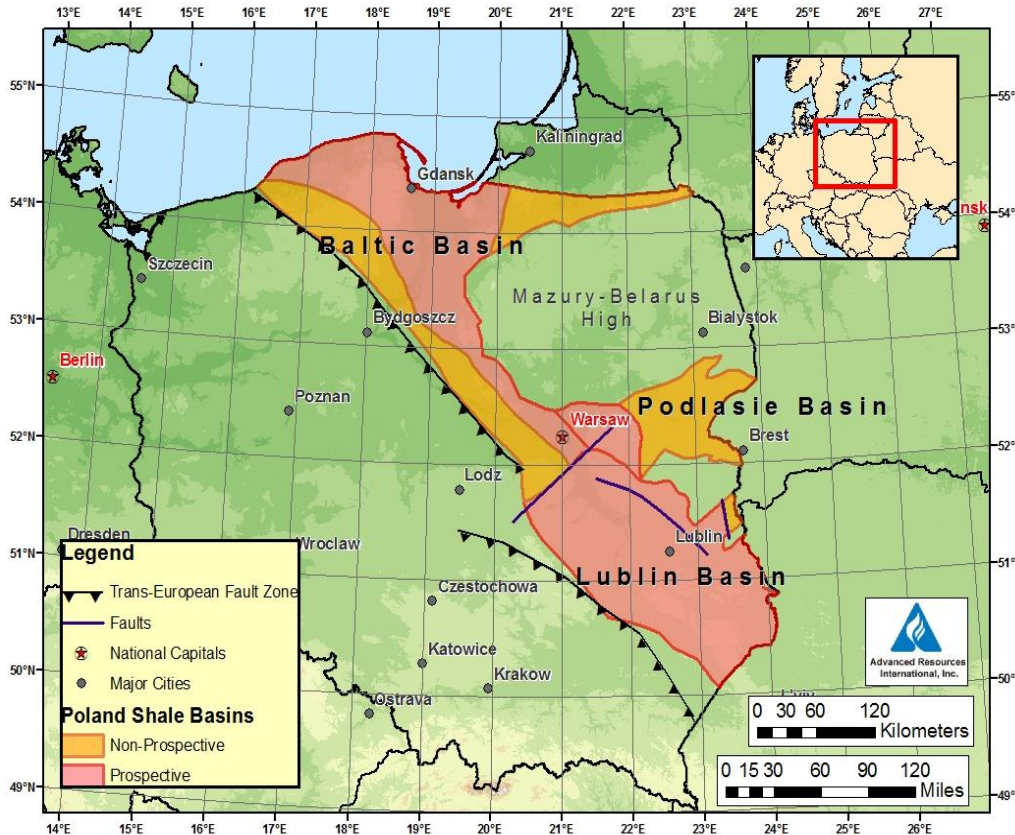
- France holds large technically recoverable shale gas resources (180 Tcf or 5.10 Tcm) in the Paris and South-East basins.
- Norway's (83 Tcf or 2.35 Tcm) and Sweden's (41 Tcf or 1.16 Tcm) shale gas resources are within the Alum shale of the Baltic basin.
- Smaller but still significant shale gas resources exists in Denmark (23 Tcf or 0.65 Tcm), Netherlands (17 Tcf or 0.48 Tcm) and Germany (8 Tcf or 0.23 Tcm).

Source: EIA ARI World Shale Gas Resources



# Poland's shale gas resources and basins

## Onshore Shale Gas Basins of Poland



- Poland appears to hold some of the geologically most favorable shale gas resources in Europe, primarily in three basins:
  - Baltic
  - Lublin
  - Podlasie
- Our shale gas assessment for Poland indicates a large resource base:
  - 187 Tcf (5.30 Tcm) of technically recoverable resource.

Source: EIA ARI World Shale Gas Resources



# For more information

U.S. Energy Information Administration home page | [www.eia.gov](http://www.eia.gov)

Short-Term Energy Outlook | [www.eia.gov/steo](http://www.eia.gov/steo)

Annual Energy Outlook | [www.eia.gov/aeo](http://www.eia.gov/aeo)

International Energy Outlook | [www.eia.gov/ieo](http://www.eia.gov/ieo)

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