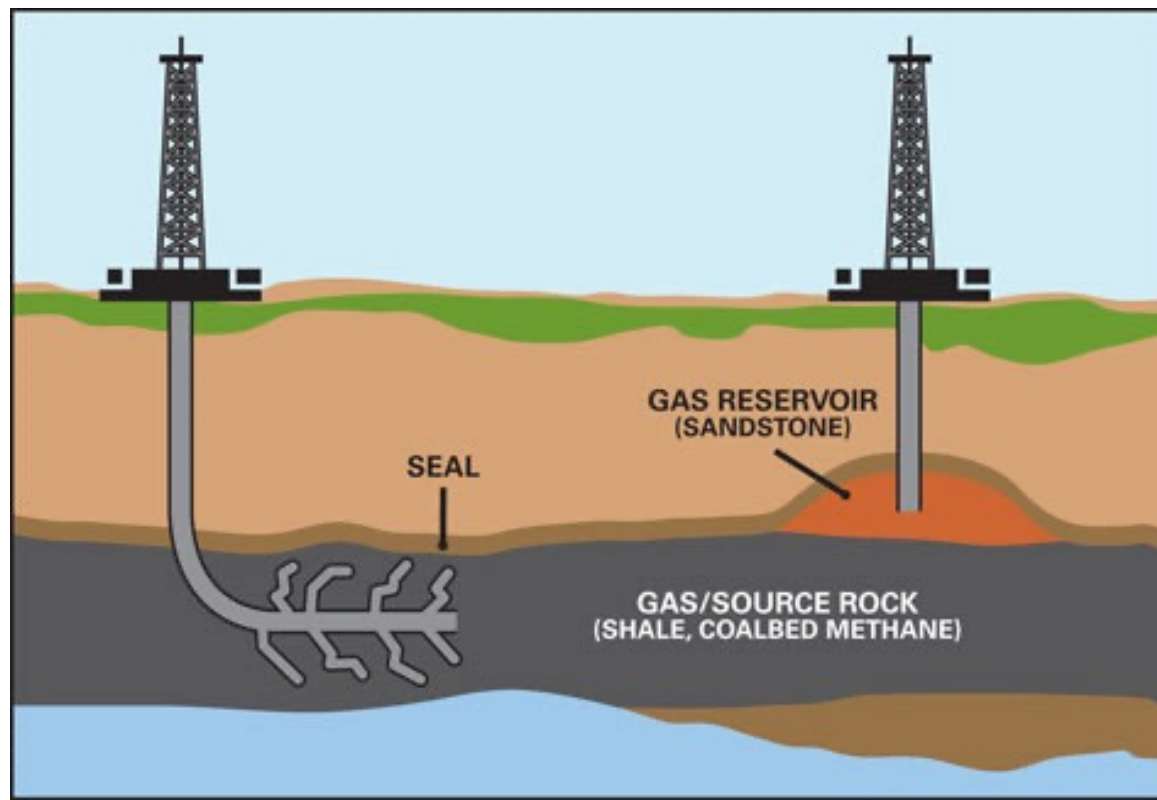


17. Unconventional Natural Gas I: Introduction

Kenneth M. Klemow, Ph.D.

EGY 105 at Wilkes University

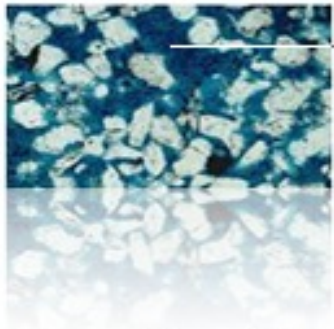


What is unconventional natural gas?

- Natural gas extracted from sources difficult to obtain through conventional drilling techniques.
- Deep sources ($>15,000'$)
- Unconventional natural gas derived from dense (tight) rock formations:
 - Shale
 - Tight sandstone
 - Coal bed methane
- Geopressurized zones
- Methane hydrates

Geologists have long known of gas in tight rock

- Technology didn't exist to extract that gas in marketable quantities.



Large, well
connected
pores

Conventional Gas
Reservoir rock



Small, poorly
connected
pores

Tight Gas
Reservoir rock



Very small,
hardly
connected pores

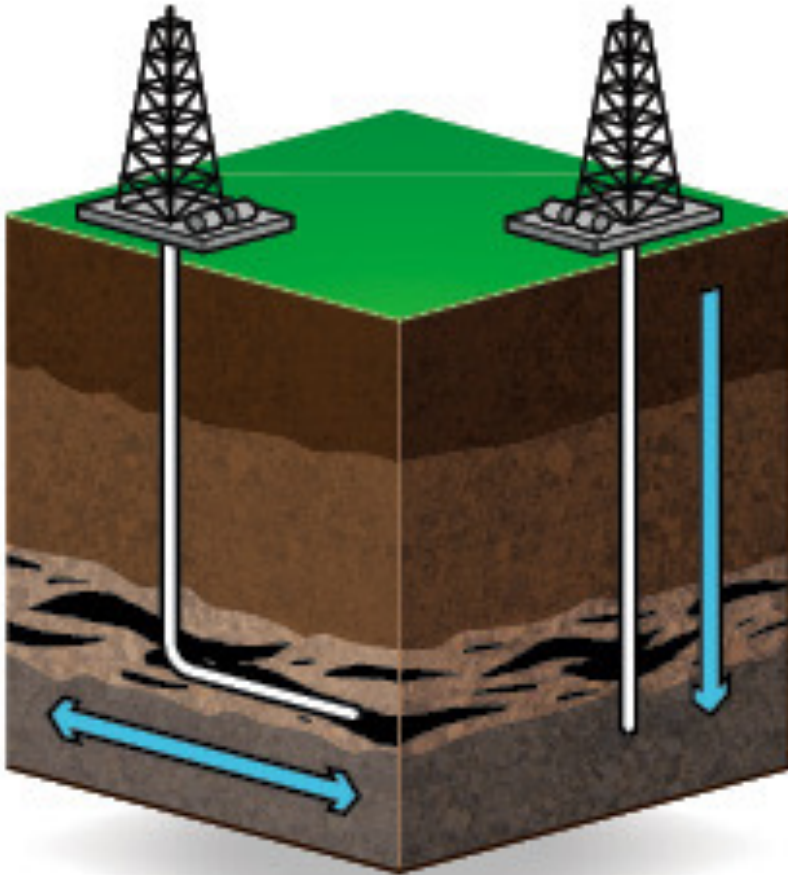
Shale Gas
Reservoir rock

Extracting gas from tight formations

- Problems

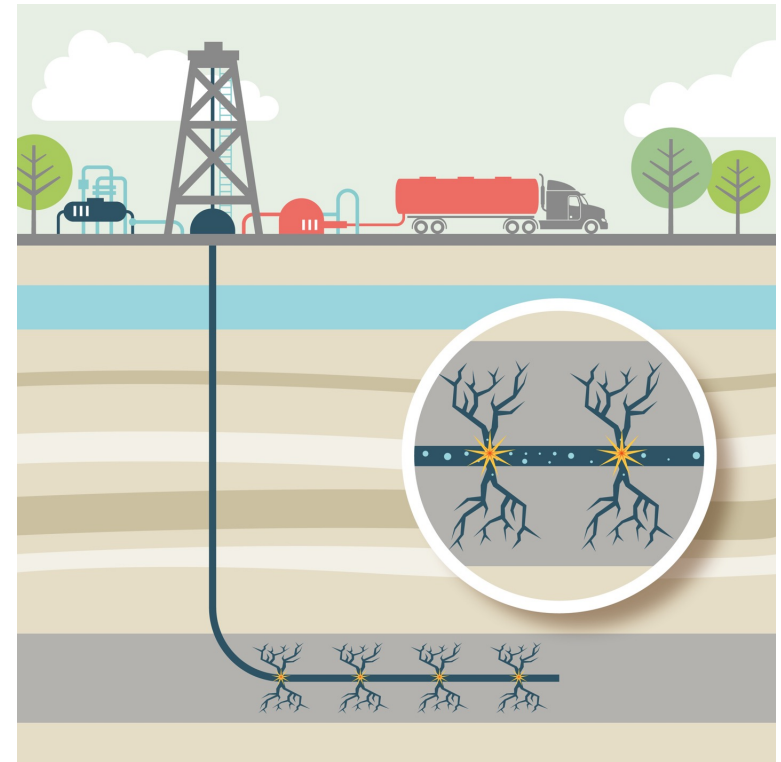
- Occurs in rock that has low permeability
 - Gas locked in small fractures / bubbles
- Much gas associated with horizontally bedded rock

Extracting gas from tight rock possible due to two technologies



<http://magazine.mst.edu>

Horizontal drilling

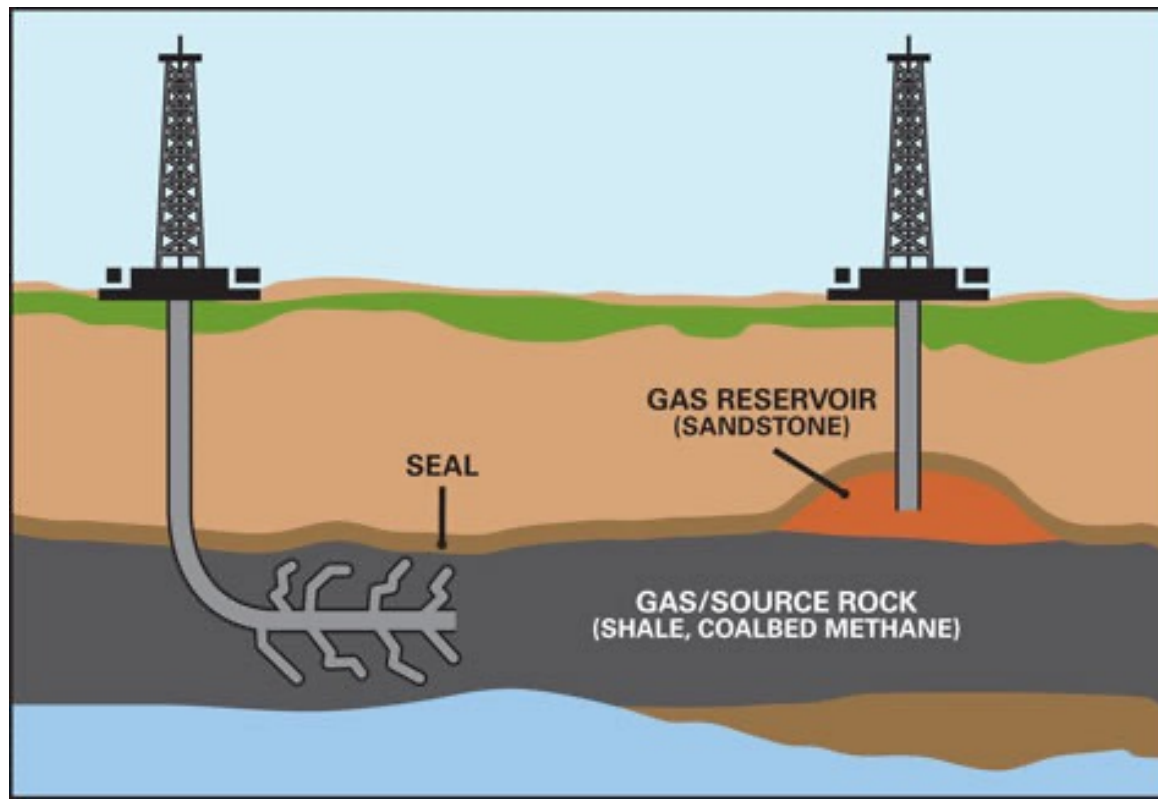


<http://energy.umich.edu/>

Hydraulic fracturing

Horizontal drilling

- Well drilled vertically to gas rich zone, then turned horizontally
- Possible due to advanced drill bits

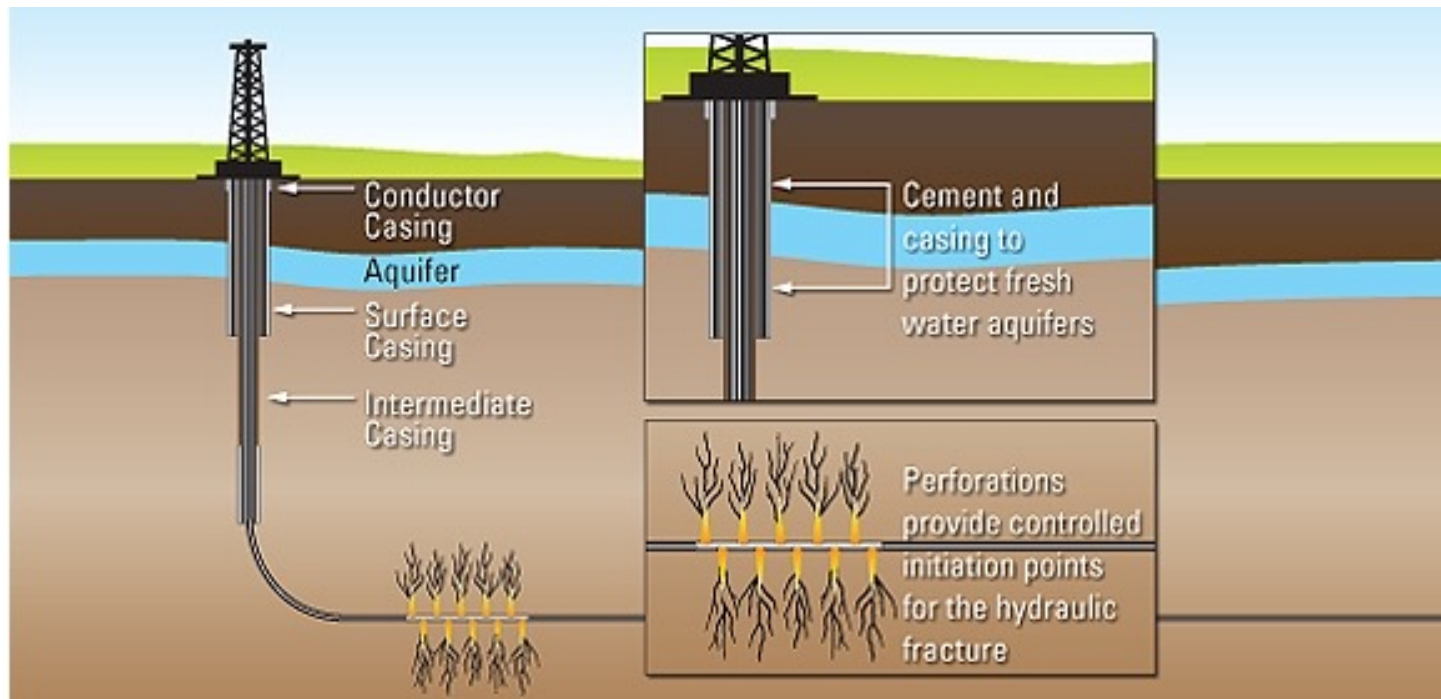


History of horizontal drilling

- First used in WWII in oil wells of northern PA
- During 1970s, expanded to much of the Appalachian basin
- Later employed in large scale in Barnett shales of Texas.

Hydraulic fracturing (HF, “fracking”)

- Fluid forced down wellbore under high pressure
- Open crevices in rocks to liberate methane



Fracking fluid composed of various components

Component	Purpose
Water	Primary solvent
Sand	Prop open pores
Biocides	Kill bacteria
Scale inhibitors	Prevent scale on wellbore
Lubricant	Promote flow through pumps & pipes
Corrosion inhibitors	Prevent rust from forming
Gelling agents	Thicken solution to promote proppant movement
Acid	Dissolve debris in wellbore, opening it up

HF not a new technology

- HF first used in 1947 in an oil well in Grant County, Kansas.
- By 2002, used approximately a million times in US.
- Up to 95% of wells drilled today are hydraulically fractured, accounting for more than 67% of natural gas production.



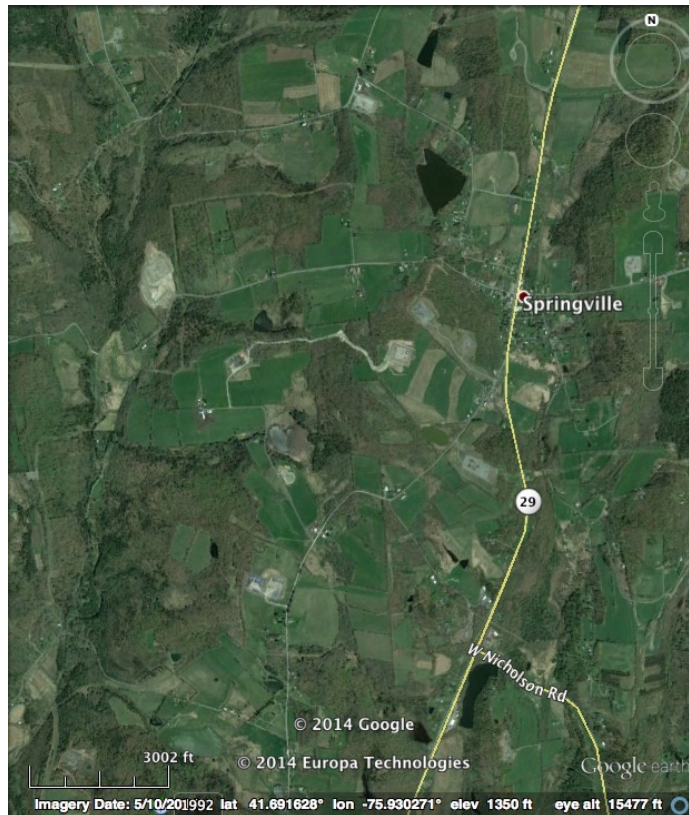
Development of Marcellus

- First attempted by Range Resources in Washington County PA in 2004
- By 2006 other companies started buying and leasing land

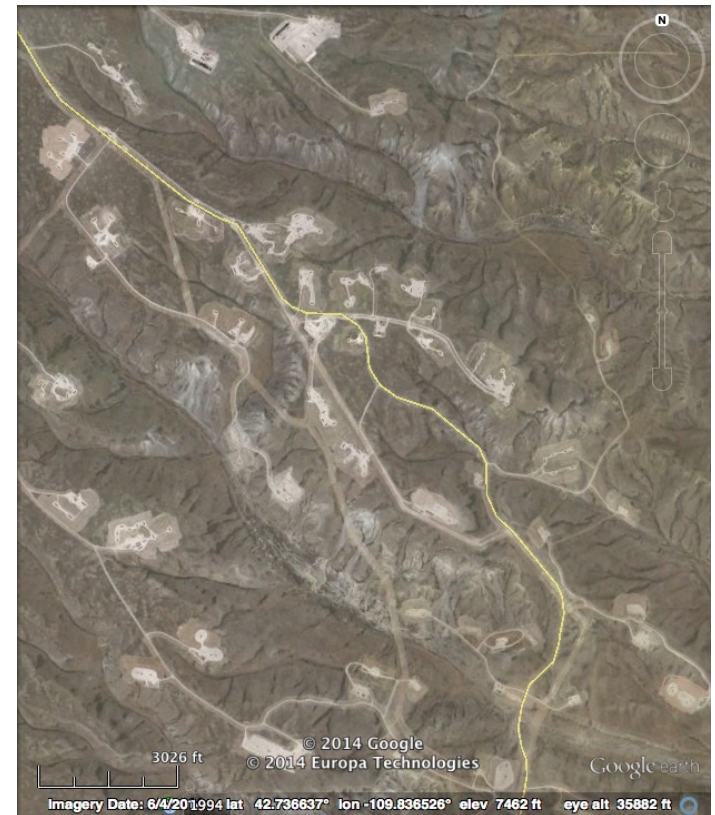


Benefits of horizontal drilling

- Need fewer wells and well pads to obtain gas from rock
 - Thus less surface damage



Horizontal Drilling (PA)

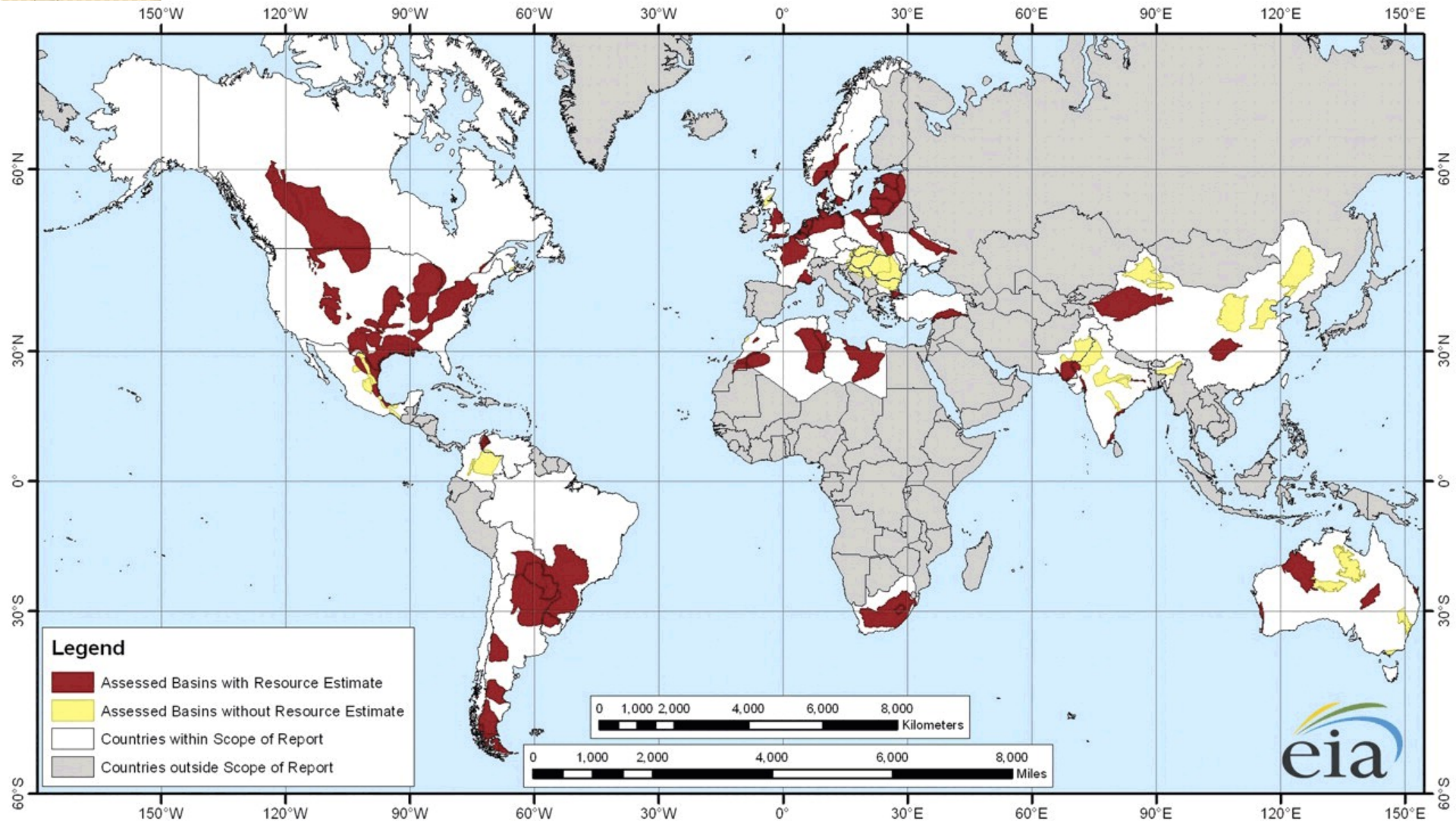


Vertical Drilling (WY)

Employment

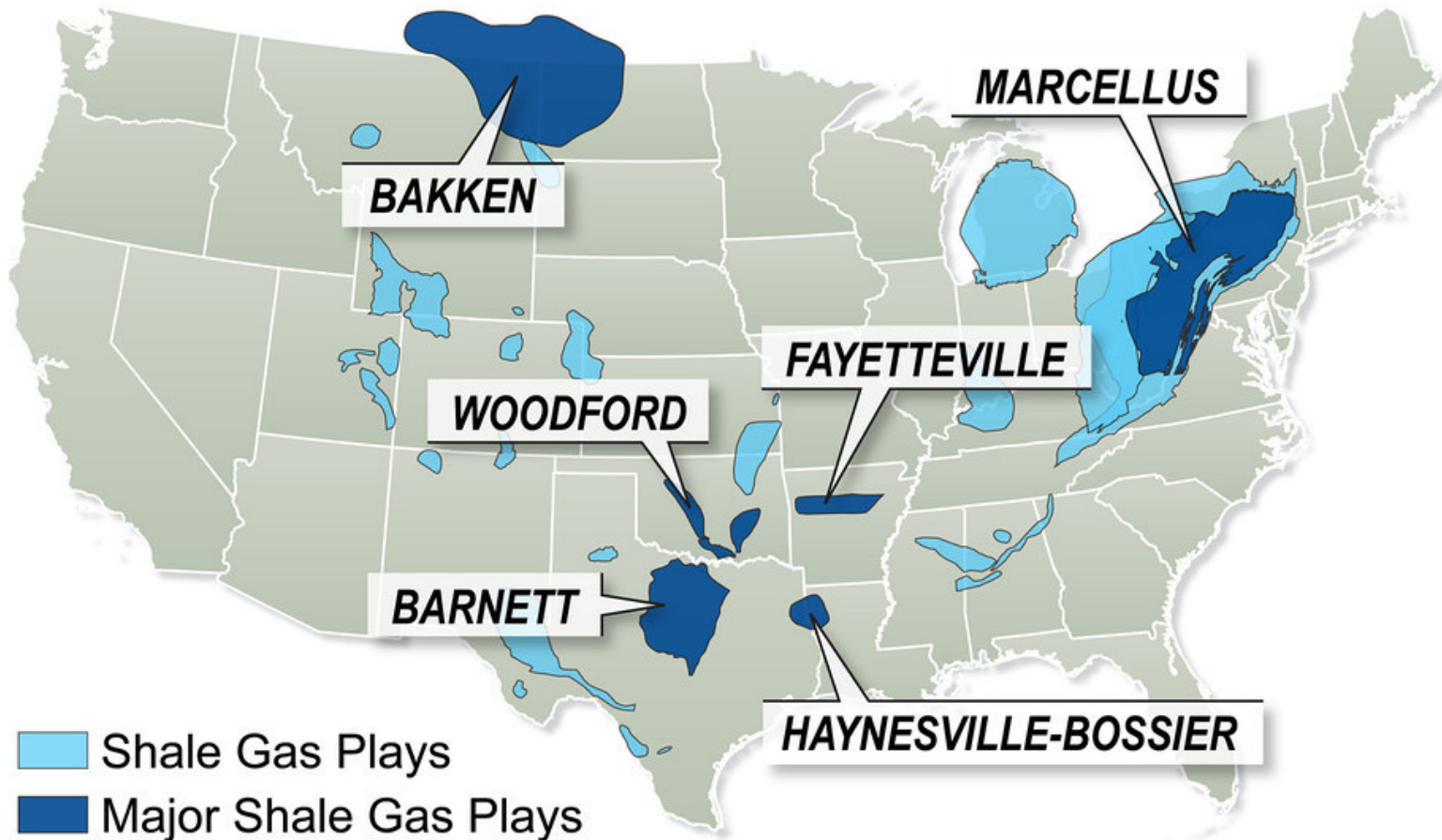
- Penn State study in 2010 predicted fracking in the Marcellus would support 200,000 jobs by 2020.
- Second Penn State study in 2016 stated 26,000 direct jobs were created then.
 - But “indirect” jobs touted to be 123,000 in 2023.
- In March 2024, PA reported 16,831 jobs directly in industry. See WHYY report.
 - <0.5% of all jobs.

Worldwide distribution of UNG



US Distribution of UNG

Shale Gas Resources



How much gas is there?

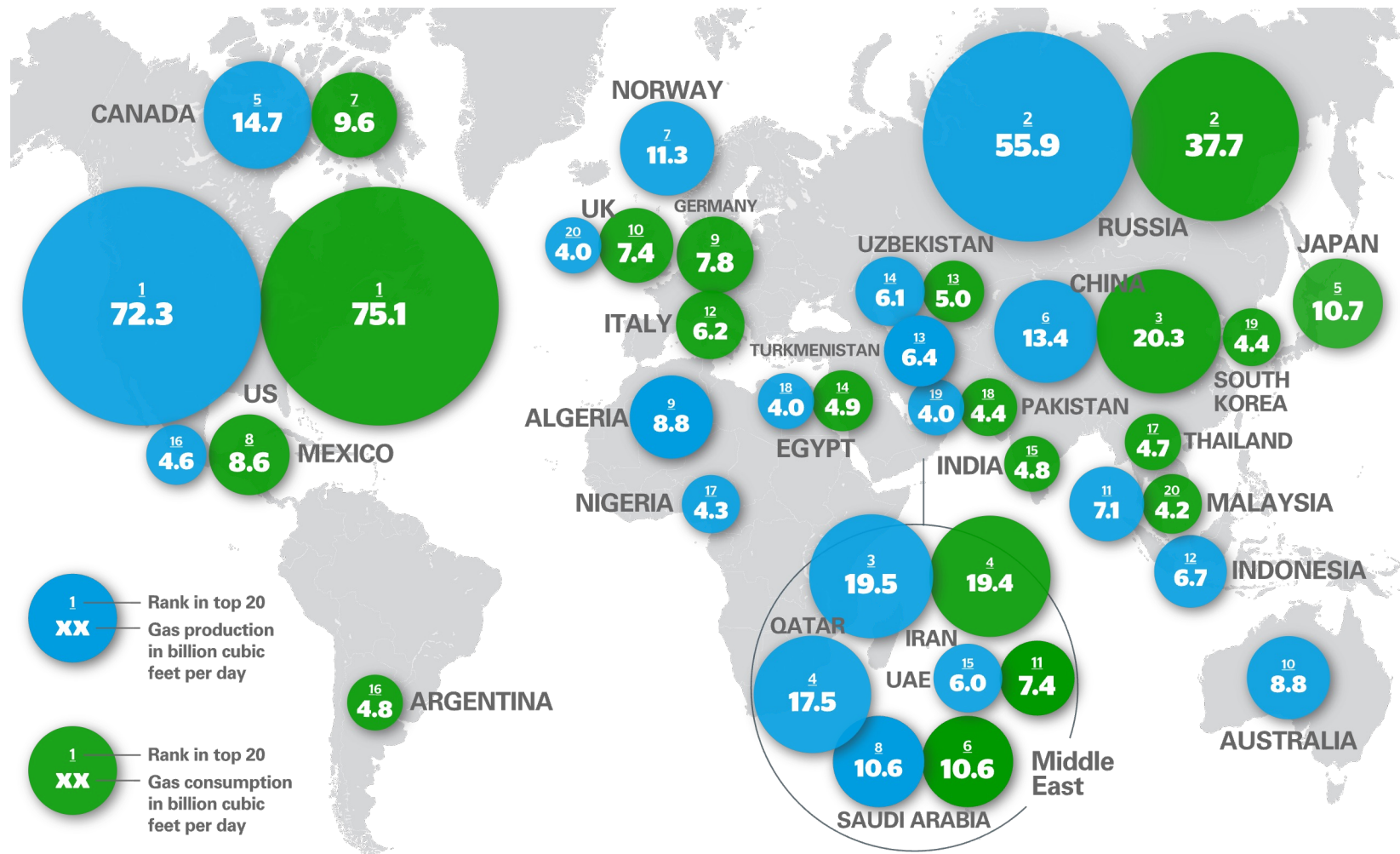
- Different estimates:
 - Total in place
 - Technically recoverable
 - Proven
 - Unproven
- Estimates difficult
 - Undiscovered shale
 - Several variables:
 - % gas content in given volume of shale
 - % recoverable of total
 - Depletion rates of wells

Technically recoverable gas (Tcf)

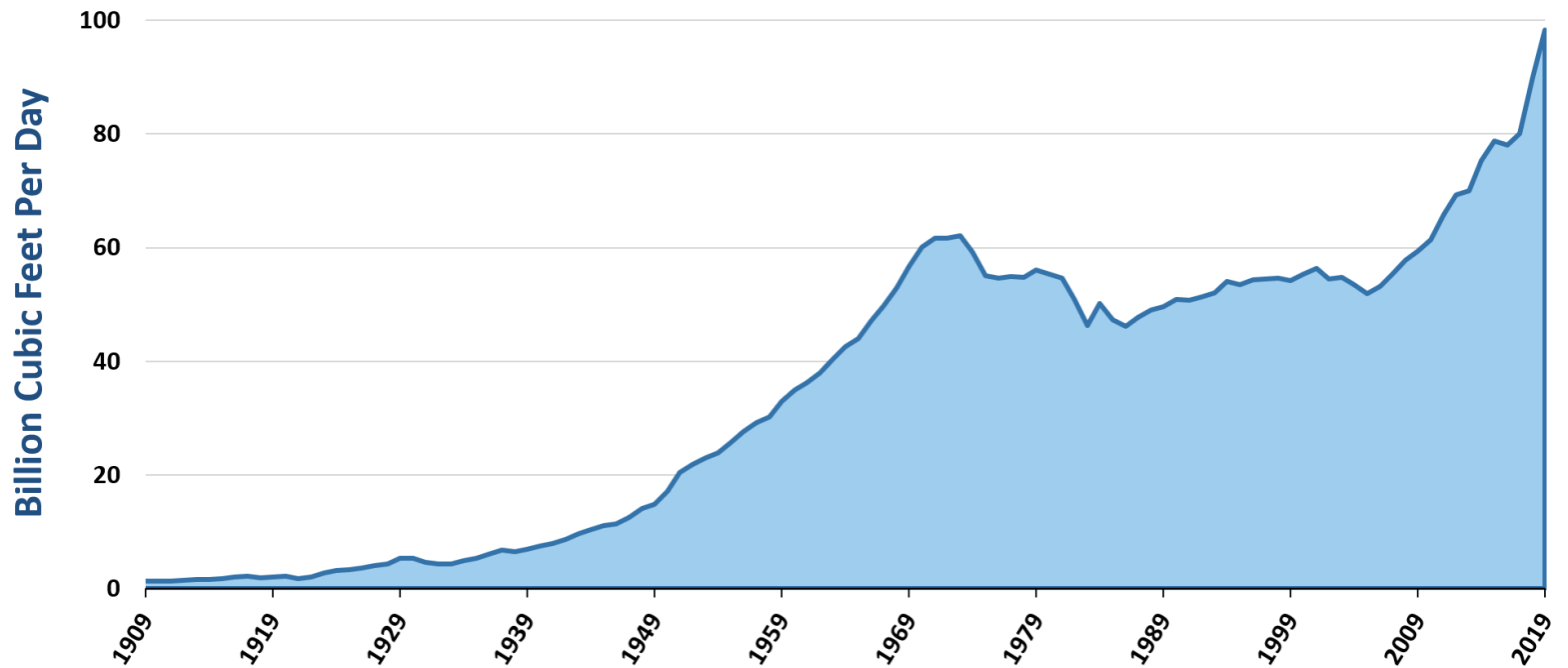
(EIA 2023)

- World: 16,000 – 22,000
 - China: 1,115
 - Argentina: 802
 - Algeria: 707
 - US: 3,352 (<https://www.aga.org/>)
 - Canada: 573
- Annual consumption:
 - Worldwide: 132.3 Tcf
 - US: 34.5
 - 1 Tcf can heat 15 million homes for a year
- Much uncertainty
 - Behr (2013)
<http://www.eenews.net/stories/1059976102>

World natural gas consumption and production (2016)



U.S. Natural Gas Marketed Production



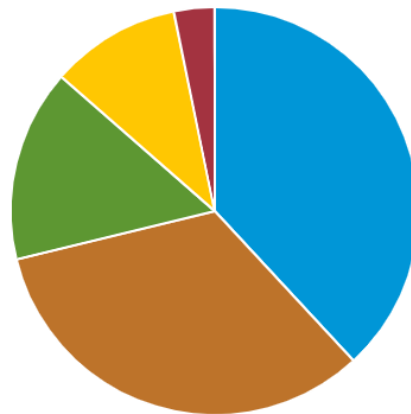
Source: EIA.gov

ShaleCrescentUSA
THE OHIO VALLEY ENERGY ADVANTAGE

US Natural Gas Consumption 1950-2020

U.S. natural gas consumption by sector, 2020

Total = 30.48 trillion cubic feet



● electric power
● residential
● transportation
● industrial
● commercial

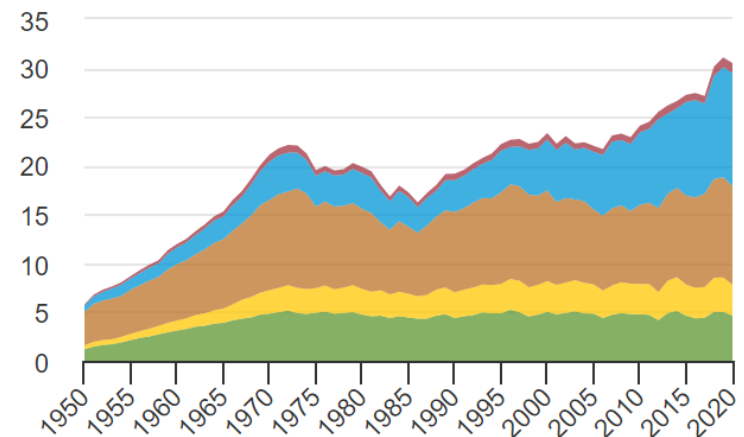
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 4.3, April 2021, preliminary data

Note: Transportation includes pipeline and distribution use and vehicle fuel.



U.S. natural gas consumption by sector, 1950-2020

trillion cubic feet



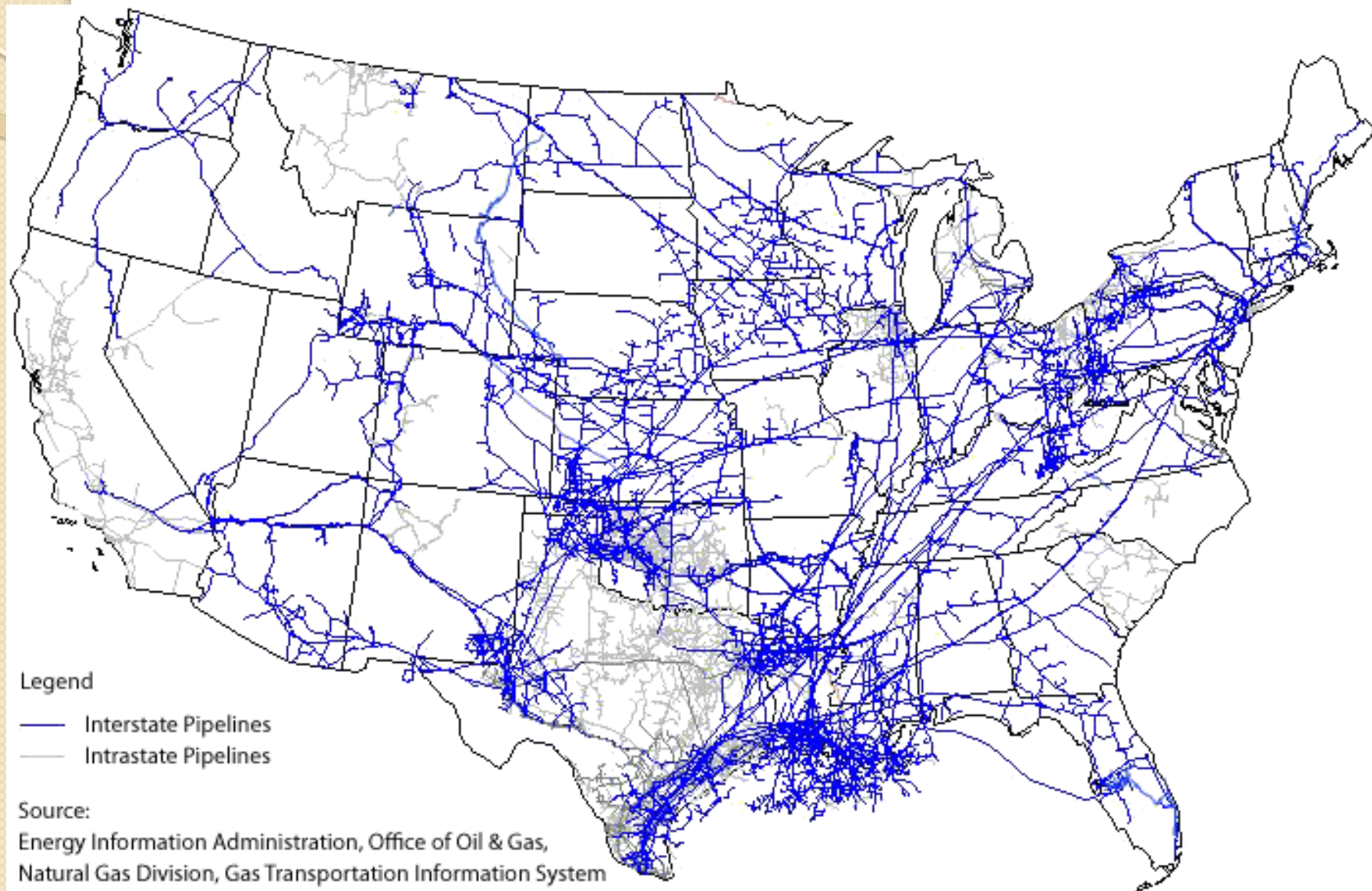
● residential
● industrial
● commercial
● electric power
● transportation

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 4.3, April 2021, preliminary data for 2020

Note: Transportation includes pipeline and distribution use and vehicle fuel.



Major NG pipelines in US



Pricing natural gas

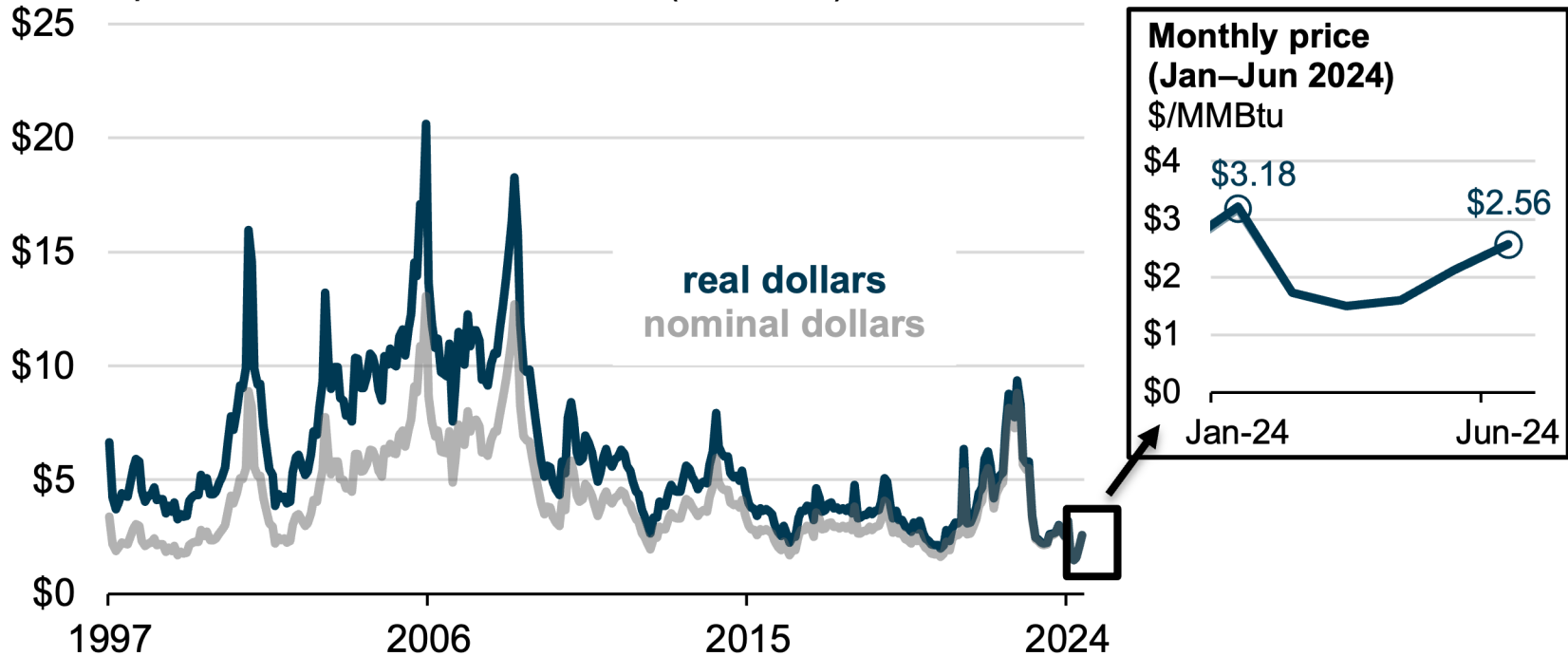
- Natural gas sold by volume
 - Typical basis 1000 cubic feet (Mcf)
 - Also used
 - 1 million cf (MMcf)
 - 1 billion cf (Bcf)
 - 1 trillion cf (Tcf)
 - 1 Mcf = 1 million BTU

Pricing NG – 1997-2024

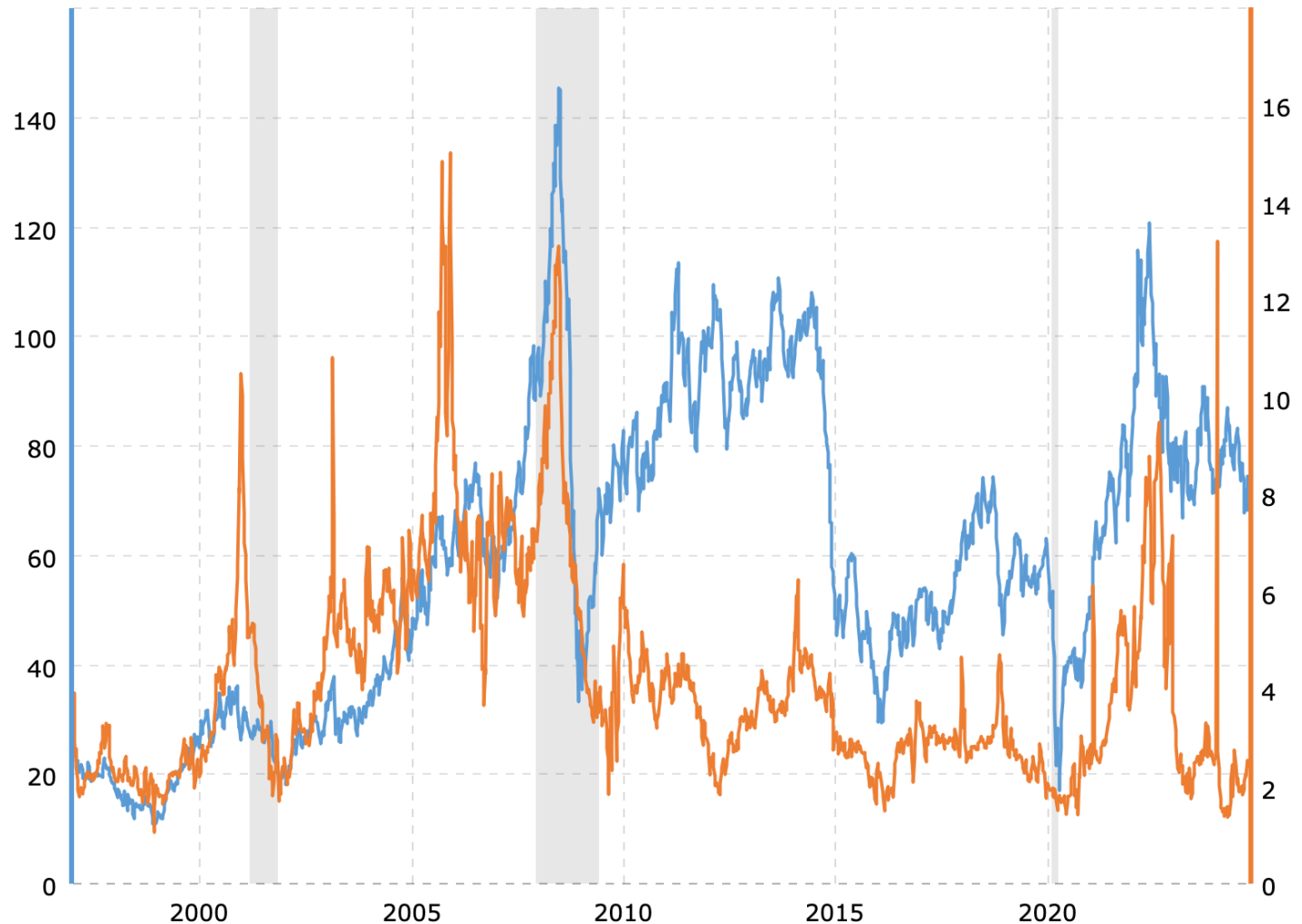


Monthly average Henry Hub natural gas prices (Jan 1997–Jun 2024)

dollars per million British thermal units (\$/MMBtu)

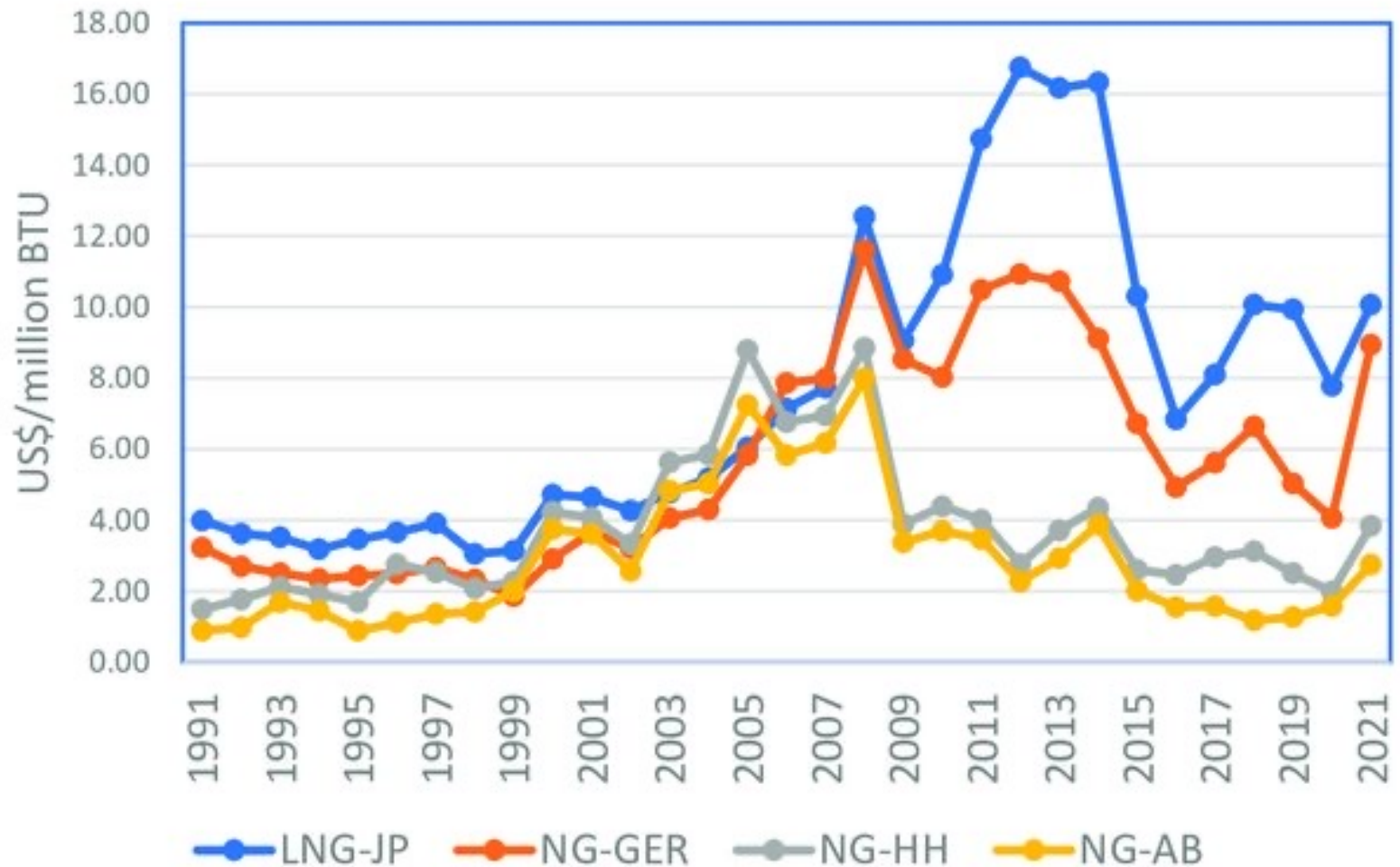


Pricing NG – Comparing fuels (1997-2024)



<http://www.aei-ideas.org/2013/02/us-households-will-save-billions-in-2012-from-falling-natural-gas-prices-offsetting-higher-gasoline-prices/>

International price trends (1991-2021)



Up next: Lecture 18 - UNG 2.

- Issues associated with fracking
- Moratoria
- Coal gas methane, Methane hydrates



<https://stateimpact.npr.org/pennsylvania/2017/12/13/study-newborns-close-to-fracking-site-have-higher-risk-of-low-birth-weight>.