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UNITED STATES

Hydraulic Fracturing and Onshore Oil and Natural Gas Development: Industry Standards for Safe and Responsible Development

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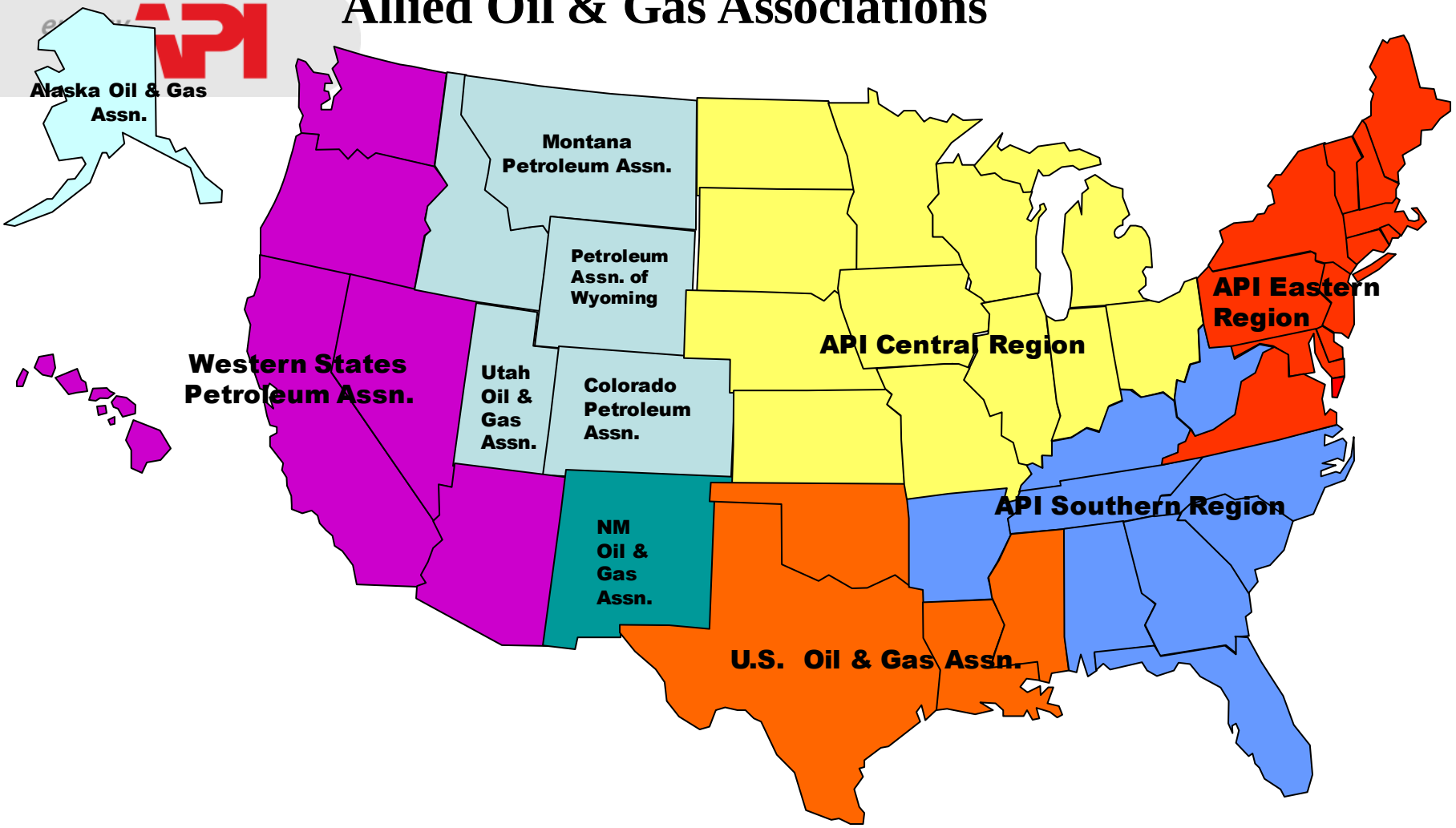
API History

- 1919: API founded as non-profit national trade association, New York City
  - Three initial priorities – taxes, statistics, and equipment standards
- 1969: API relocates to Washington, DC
  - Heightened interest in advocacy issues
- Over 600 Members

API State Petroleum Councils
Allied Oil & Gas Associations



American Petroleum Institute

U.S. Oil & Gas Assn.
Includes TX, OK, LA and MS

Western States Petroleum Assn.
Includes AZ, CA, HI, NV, OR and WA

Global Industry Services

- Standards
- Statistics
- Certification Program
- Training and Education

Headquartered in Washington, D.C. with sales and marketing offices in Houston, Beijing, Dubai, and Singapore.

API Standards

- Over 600 technical standards covering all aspects of the oil and natural gas industry
- Fully accredited by the American National Standards Institute (ANSI), which accredits many national laboratories
- National Technology Transfer and Advancement Act (NTTAA) requires Federal Agencies to use voluntary consensus standards, encourages participation
    - API standards are cited in regulations by agencies including OSHA, EPA, DOT and BSEE
    - 100 API standards are cited over 270 times in the U.S. Code of Federal Regulations

  – API Standards also widely cited by States
    - 184 API standards are cited over 3300 times in state regulations

Standards

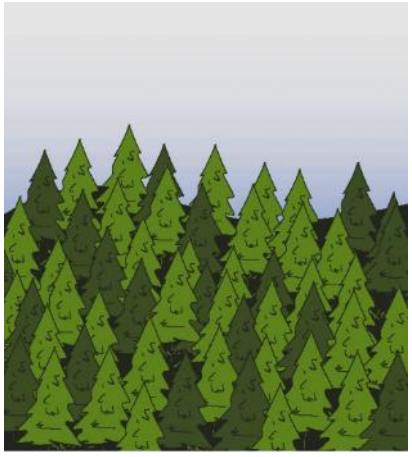
- 600+ Industry Standards and Technical Reports covering:
  - Exploration & Production
  - Refining
  - Marketing
  - Pipeline
  - Measurement
  - Safety and Fire Protection
  - Petroleum E-Commerce

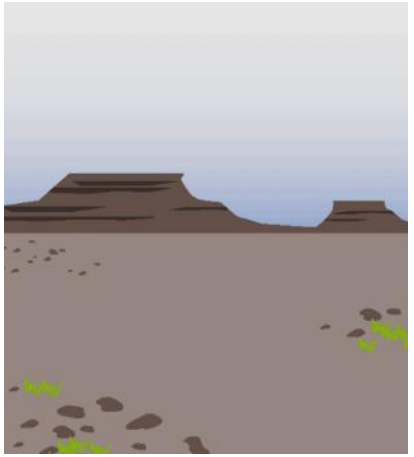
Robust System of Regulations, Industry Standards, and Operational Integrity = Safety and Environmental Protection

State Regulations are Tailored to Geological & Regional Needs

Key state regulations include:

- Review and approval of permits
- Well design, location and spacing
- Drilling operations
- Stimulation
- Water management and disposal
- Air emissions
- Wildlife impacts
- Surface disturbance
- Worker health and safety
- Inspection and enforcement of day-to-day oil and gas operations





Strong permitting is paramount.

SOME of the permits required for a well in Pennsylvania are:

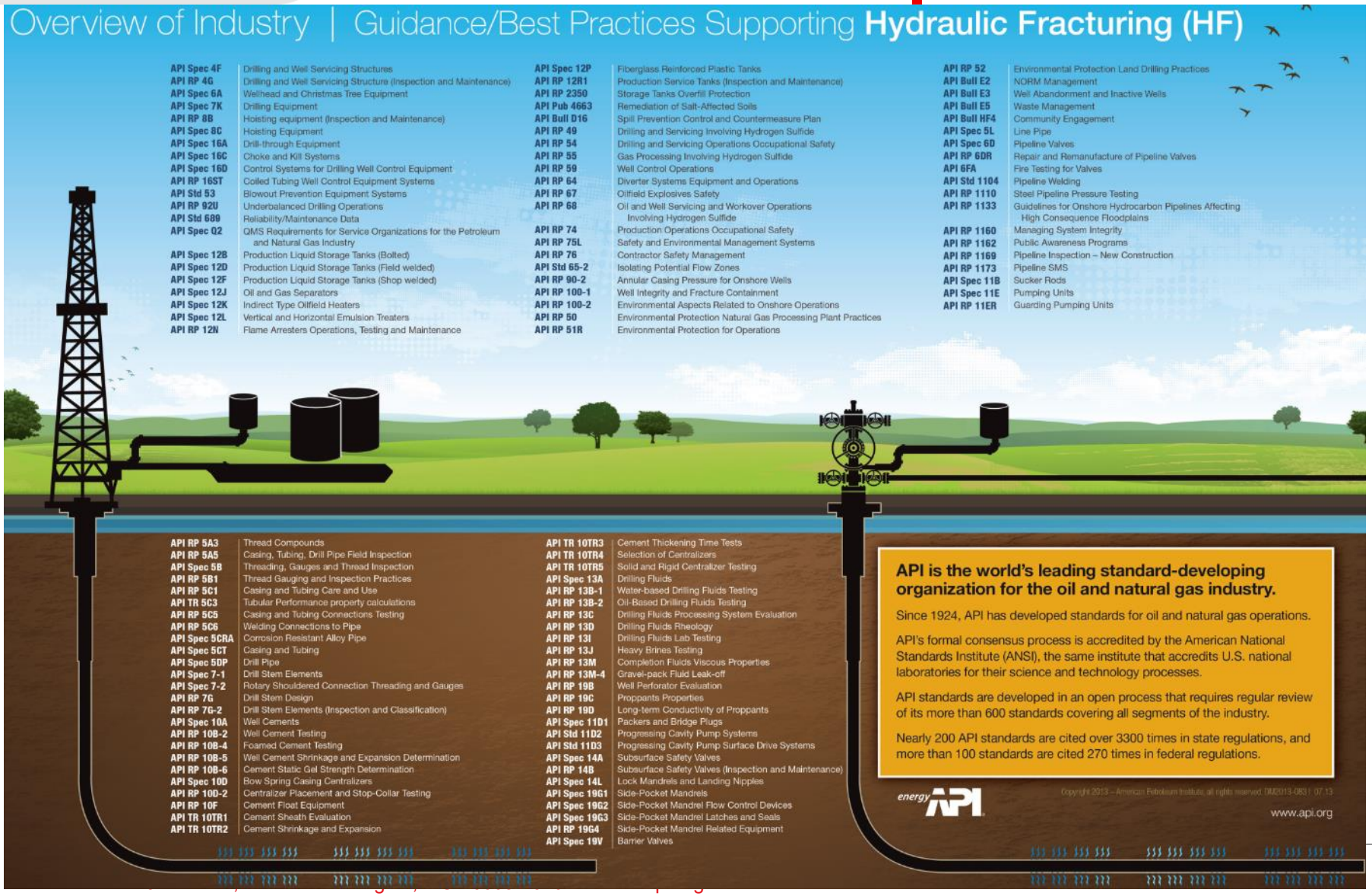
- Well drilling permit (w/ well location plat, casing and cementing plan, PNDI for threatened or endangered species, landowner/water well owner notifications, coal owner or operator notification and gas storage field owner notification)
- Water management plan for Marcellus Shale wells
- Proposed alternate method of casing, plugging, venting or equipping a well
- Bond for Oil and Gas Well(s) (individual or blanket, various bond types allowed)
- Waiver of distance requirements from spring, stream, body of water, or wetland (to put the well closer than 200 feet)
- Variance from distance restriction from existing building or water supply (to put the well closer than 100 feet)
- Proposed alternate method or material for casing, plugging, venting or equipping a well
- Approval for alternative waste management practices
- Approval of a pit for control, handling or storage of production fluids
- Use of alternate pit liner
- NPDES GP-1 for discharges from stripper oil wells
- Water Quality Management Permit for treatment facilities
- Alternative pit liners
- Inactive status
- Roadspreading plan approval
- Transfer of well permit or registration
- Orphan well classification
- Off-site solids disposal
- Residual waste transfer stations and processing facilities
- Transportation of residual waste
- Road use permit – construction of access to state roadway
- Road use bond (PennDOT or municipality)
- Surface use permit (if in the Allegheny National Forest)
- PASPGP-3 or PASPGP-4 for pipelines crossing streams (if < 1 acre)
- Water Obstruction – Encroachment – US Army Corps of Engineers Section 404 Joint Permit
- Dam permit for a centralized impoundment dam for Marcellus Shale gas wells
- GP-11 for non-road engine air emissions
- GP-05 for natural gas compression facilities emissions
- Earth disturbance permit (if > 5 acres)
- Erosion and sedimentation control permit (if > 25 acres)
- NPDES storm water for construction activities
- Water allocation (SRBC, DRBC or DEP for Ohio River basin)
- GP-3 for bank rehabilitation, bank protection, and gravel bar removal
- GP-4 for intake and outfall structures
- GP-5 for utility line stream crossings
- GP-7 for minor road crossings
- GP-8 for temporary road crossings
- GP-11 Maintenance, Testing, Repair, Rehabilitation or Replacement of Water Obstructions and Encroachments

Federal Regulations

Key federal regulations governing shale development include:

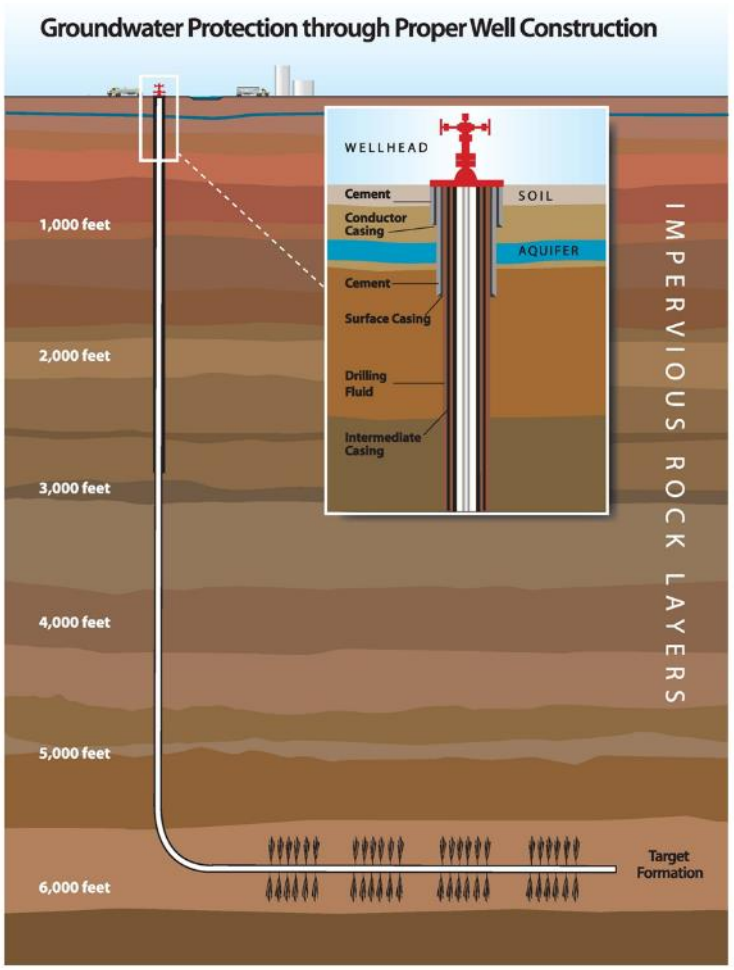
- Clean Water Act
- Clean Air Act
- Safe Drinking Water Act
- National Environmental Policy Act
- Resource Conservation and Recovery Act
- Emergency Planning and Community Right to Know Act
- Endangered Species Act
- Occupational Safety and Health Act

Industry Standards for Onshore Operations



Good well construction and careful operations protect groundwater.

- **API RP 100-1 (Well Construction) and Standard 65-2 (Zonal Isolation)**
- **Well construction:** material selection, performance, evaluation
- **Well integrity:** isolate internal conduit of well from surface & subsurface environment
  - Protect groundwater through a combination of redundant steel casing and cement sheaths, mechanical isolation devices
- **Well logging and other testing:** data gathering tools for formation evaluation, well design and construction



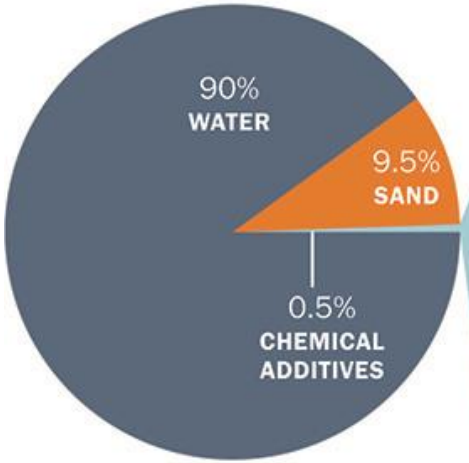
Managing Environmental Aspects of Exploration and Production Operations

API Recommended Practice 100-2

Covers:

- Baseline Water Sampling
- Source Water Management
- Material Selection
- Transportation of Materials and Equipment
- Storage and Management of Fluids
- Management of Wastes
- Air Emissions
- Site Planning
- Training
- Noise

Fracturing Fluid Components

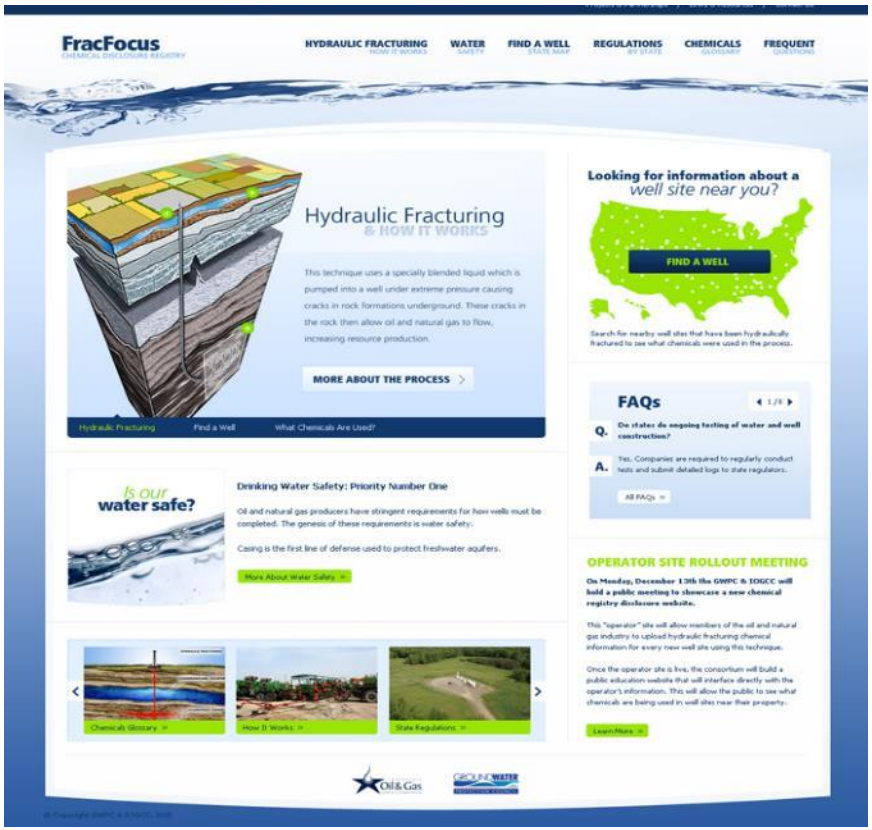


Hydraulic fracturing fluid is 99.5% water and sand.

Compound	Purpose	Common application	
Acids	Helps dissolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner	
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt	
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner	
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti-freeze, deicing agent, household cleaners	
Borate Salts	Maintains fluid viscosity as temperature increases	Laundry detergent, hand soap, cosmetics	
Sodium/Potassium Carbonate	Maintains effectiveness of other components, such as crosslinkers	Washing soda, detergent, soap, water softener, glass, ceramics	
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment	
Guar Gum	Thickens the water to suspend the sand	Thickener in cosmetics, baked goods, ice cream, toothpaste, sauces	
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice	
Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair coloring	

Chemical Disclosure

FracFocus:
A searchable, online database for the contents of fracturing fluids. Currently there are 23 states that allow companies to use FracFocus as the disclosure method to meet state requirements.



As of April 28, 2016 – 5 years in operation

Companies:

- 1,384 participating
- 1,037 reporting
- over 112,000 wells

What FracFocus Discloses

Hydraulic Fracturing Fluid Product Component Information Disclosure

Fracture Date	12/16/2011
State:	CO
County:	YUMA
API Number:	05-125-12006
Operator Name:	NOBLE ENERGY INC
Well Name and Number:	WAKEFIELD TRUST #33-06
Longitude:	-102.455509
Latitude:	39.994521
Long/Lat Projection:	NAD83
Production Type:	Gas
True Vertical Depth (TVD):	2,490
Total Water Volume (gal)*:	35,280

Hydraulic Fracturing Fluid Composition:

Trade Name	Supplier	Purpose	Ingredients	Chemical Abstract Service Number (CAS #)	Maximum Ingredient Concentration in Additive (% by mass)**	Maximum Ingredient Concentration in HF Fluid (% by mass)**	Comments
WATER	CUSTOMER	WATER	BASE FLUID	7732-18-5	100.00%	66.864199%	
BREAKER-503L	EES	LIQUID ENZYME BREAKER	sucrose	57-50-1	50.00%	0.000303%	
			ethylene gycol	107-21-1	50.00%	0.000303%	
CL-57	EES	CLAY CONTROL	WATER	773-18-2	34.00%	0.040767%	
			T-MAC	75-57-0	33.00%	0.039568%	
			METHANOL	67-56-1	33.00%	0.039568%	
CO2	PRAXAIR	CARBON DIOXIDE	CARBON DIOXIDE	124-38-9	100.00%	31.404292%	
MAV-3	INTERNATION PLOYMETRICS	FRAC GEL	GUAR	9000-30-0	100.00%	0.159264%	
MAVCIDE II	WEATHERFORD	BIOCIDE	2,2-dibromo-3-nitriloprpionamide	1022-01-2	100.00%	0.001365%	
						0.000000%	
						0.000000%	
						0.000000%	
						0.000000%	
						0.000000%	
						0.000000%	
HCL	INDUSTRIAL CHEMICAL	ACIDIZE THE FORAMTION	HCL	7647-01-0	7.50%	0.073422%	
			WATER	7732-18-5	92.10%	0.901618%	
MAVHIB 3	EES	ACID INHIBITOR	N-DIMETHY FORMAMIDE	68-12-2	0.10%	0.000003%	
			ISOPROPYL ALCOHOL	107-21-1	0.10%	0.000003%	
			CINNAMALDEHYDE	104-55-2	0.10%	0.000003%	
			METHANOL	67-56-1	0.10%	0.000003%	
S-1	EES	SURFACTANT	4-NONYLPHENYL	127087-87-0	25.00%	0.015317%	

Like other industries:

Ingredients, not a recipe

Trade secrets protected

Key disclosures for 3rd party products available through other resources like MSDS sheets available to health care providers

Community Engagement

API Bulletin 100-3

Principles:

- Integrity
- Safety and Environmental Responsibility
- Communicating Effectively

Community Engagement

API Bulletin 100-3

Five Phase Model:

- Entry
- Exploration
- Development
- Operations/Production
- Exit

Occupational Safety for Oil and Gas Well Drilling and Servicing Operations

API Recommended Practice 54

Recommends practices and procedures for promotion and maintenance of safe working conditions for personnel engaged in drilling operations and well servicing operations, including special services.

Occupational Safety for Oil and Gas Well Drilling and Servicing Operations

API Recommended Practice 54

Covers:

- Injuries and First Aid
- PPE
- Operations
- Fire Prevention/Protection
- Flammable Liquids
- Drilling and Well Servicing Rig Equipment
- Drilling and Well Servicing Rig Electrical Systems
- Pumping Units
- Special Services
- Wireline Service
- Stripping and Snubbing
- Drill Stem Testing
- Acidizing and Fracturing
- Cementing Operations
- Gas, Air or Mist Drilling
- Hot Tapping and Freezing
- Hotwork and Welding

Additional Recent and Ongoing Standards Development Related to Occupational Safety

- **API Manual of Petroleum Measurement Standards Chapter 18.2 (July 2016)**
  - **Custody Transfer of Crude Oil from Lease Tanks Using Alternative Measurement Methods**

Chapter 4. Safety

Safety is an essential part of crude oil trucking operations both on roadways and during custody transfer. API *MPMS* Chapter 18.1 was developed for applications where access to lease tanks to perform the associated measurement and quality tasks was not restricted and where the settling and weathering of crude oil prior to custody transfer was possible. There are many applications today where these conditions cannot be met. Opening thief hatches of storage tanks can lead to the rapid release of high concentrations of hydrocarbon gases and vapors. Be aware that those may result in very low oxygen levels and toxic and flammable conditions around and over the hatch. This standard was developed to encourage uniform, technically defensible measurement and testing practices for crude oil gathered from lease tanks when access to the tank's thief hatch may be restricted.

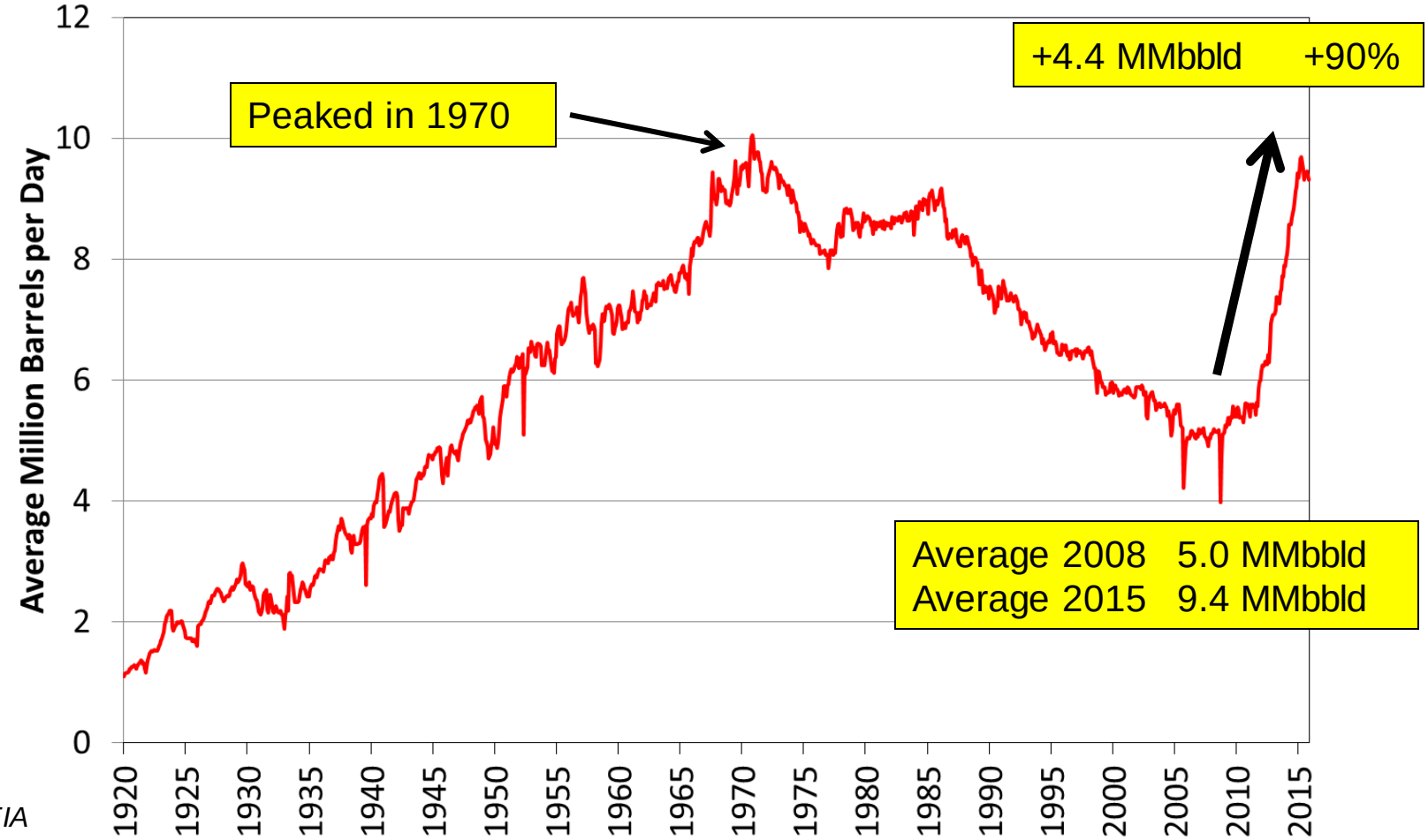
Additional Recent and Ongoing Standards Development Related to Occupational Safety

API Recommended Practice 77, Risk-based Approach for Managing Hydrocarbon Vapor Exposure during Manual Tank Gauging and Sampling of Onshore Production Facilities (under development)

- Hazard Identification
- Hazard and Risk Assessment
- Mitigation
- Personnel Training and Hazard Communication
- Operator and Contractor Interface
- Recordkeeping

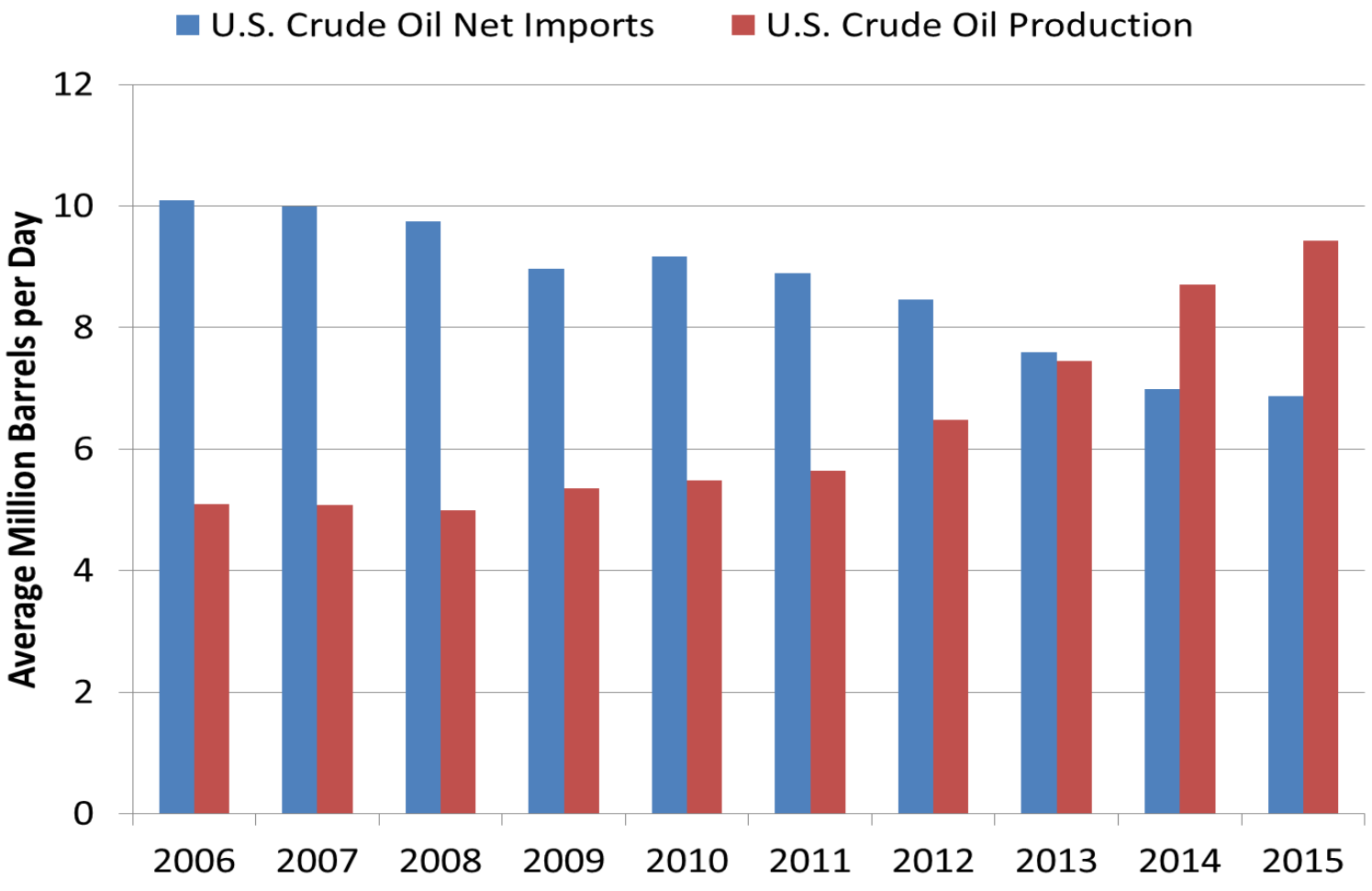
Shale Energy Production is Driving Energy Security and Environmental Benefits

US Crude Oil Production



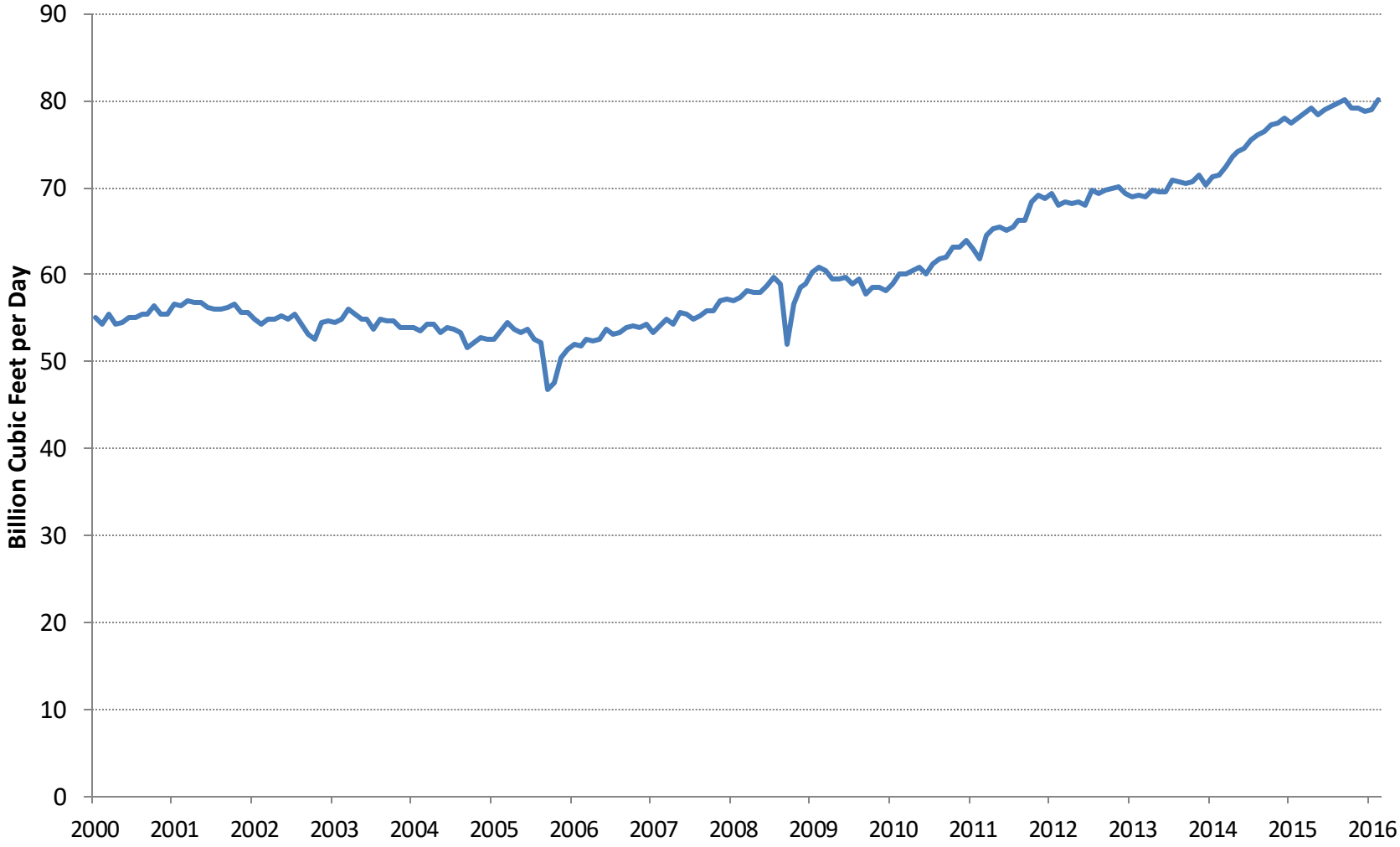
Source: EIA

U.S. Crude Oil
Net Imports vs. Production

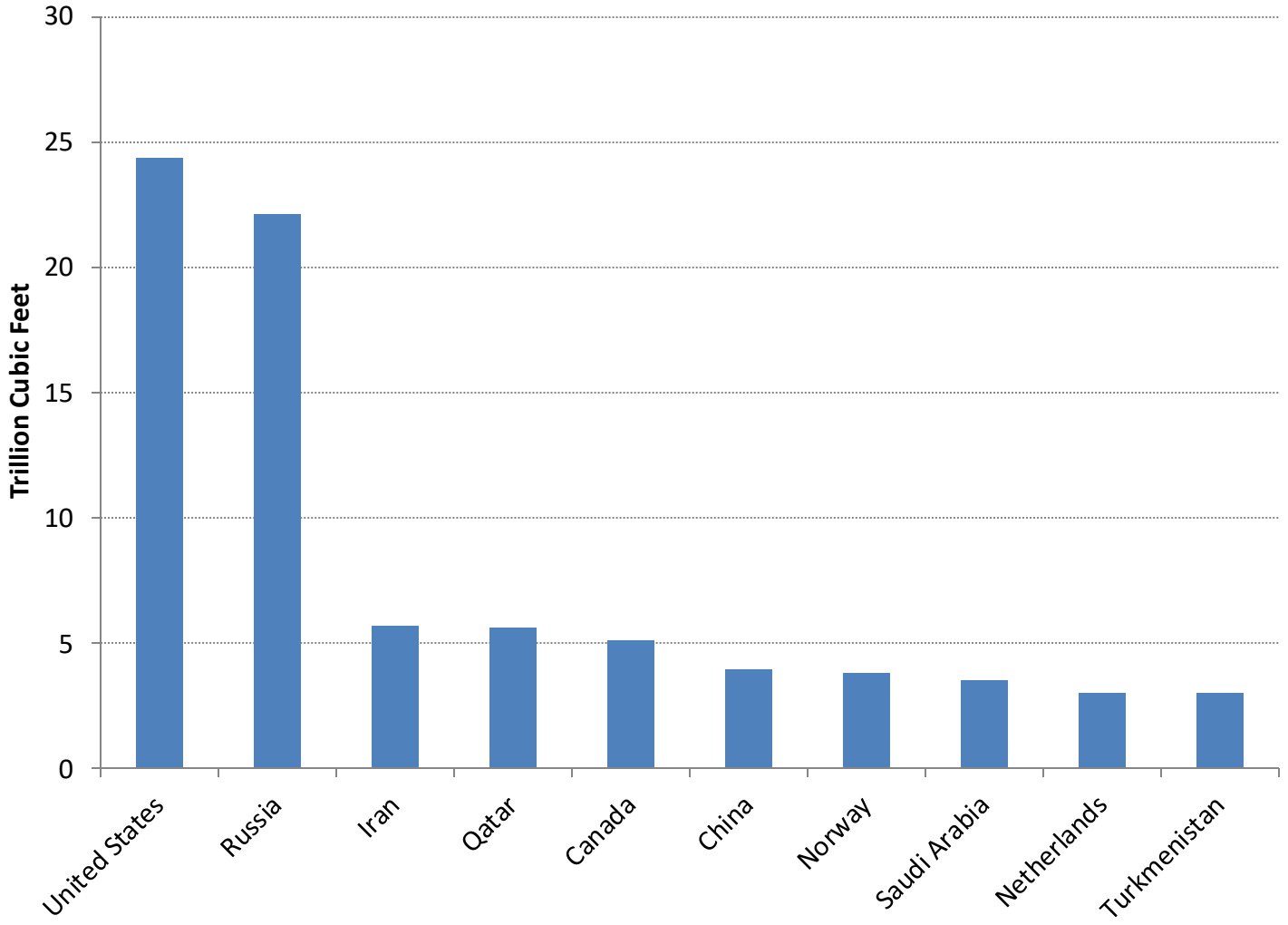


Source: EIA

US Natural Gas Marketed Production



World Dry Gas Production in 2013 was 121 Tcf. The US accounts for over 20% of World natural gas production.



Natural gas generates cleaner power

Tons per year per thousand households	Biomass (Wood)	Coal	Natural Gas	Nuclear & Renewables
Carbon Monoxide (CO)	11	7.2	0.3	0.0
Carbon Dioxide (CO2)	14,264	9,832	4,076	0.0
Nitrogen Oxides (NOx)	5.9	2.9	0.3	0.0
Particulate Matter	0.73	0.48	0.17	0.0
Volatile Organic Compounds (VOC)	.15	0.14	0.17	0.0
Sulfur Dioxide (SO2)	0.0	4.77	0.03	0.0
Mercury	0.0	0.0001	0.0	0.0

Most emissions

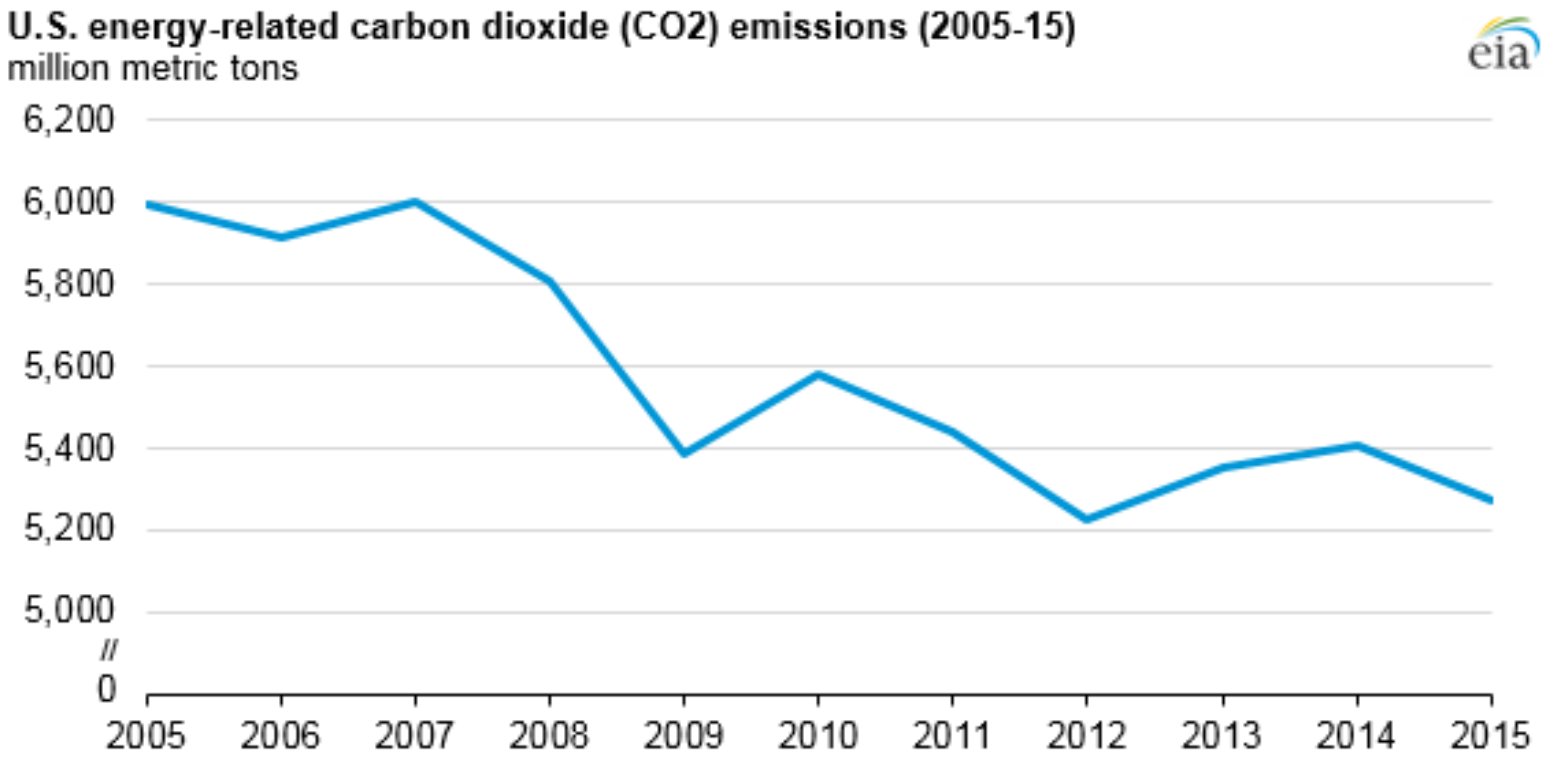
Middle emissions

Least emissions

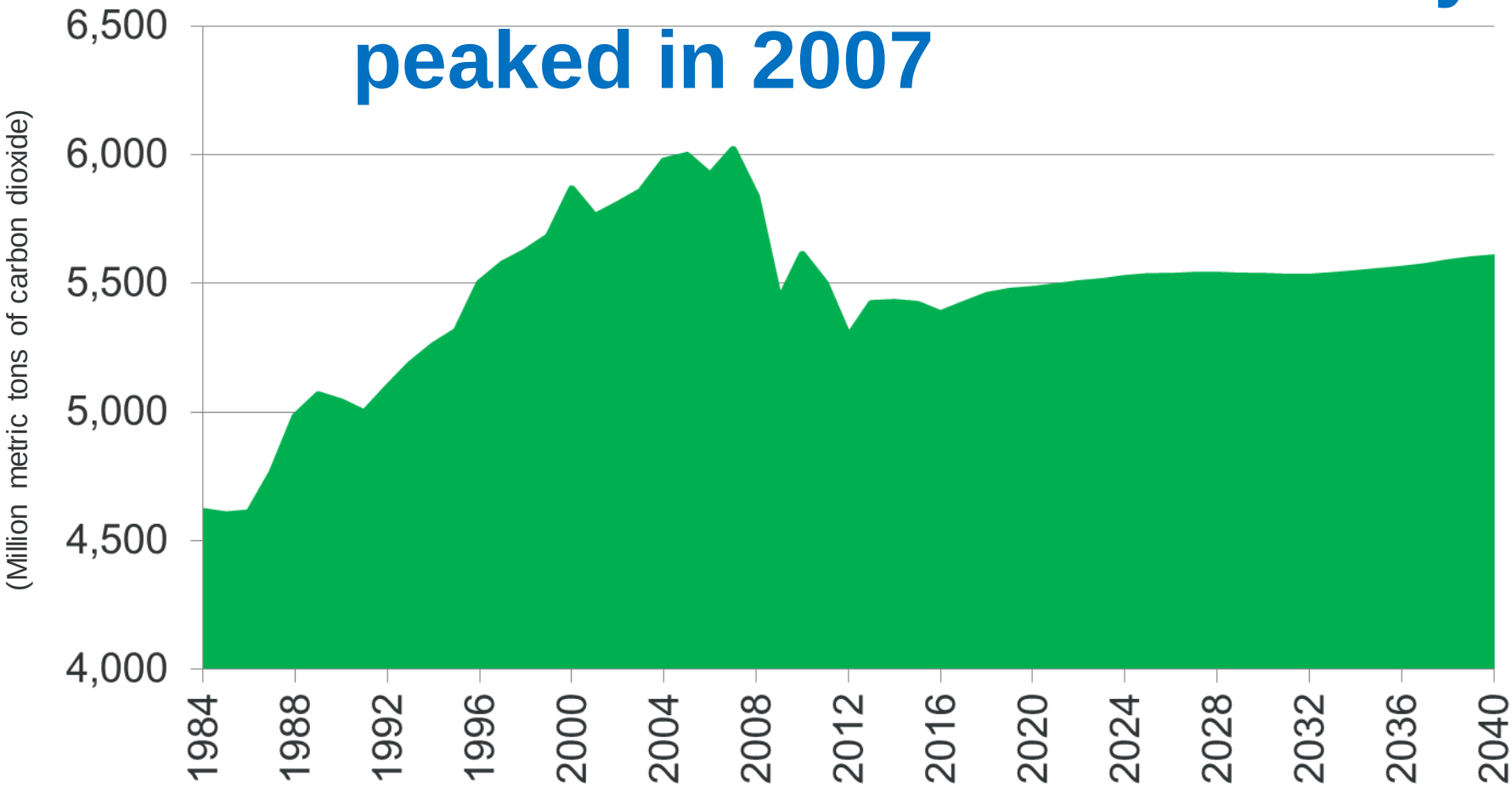
Natural gas is clean burning

Source: R.W. Beck

U.S. Energy Related CO2 Emissions Are Down Because of Natural Gas

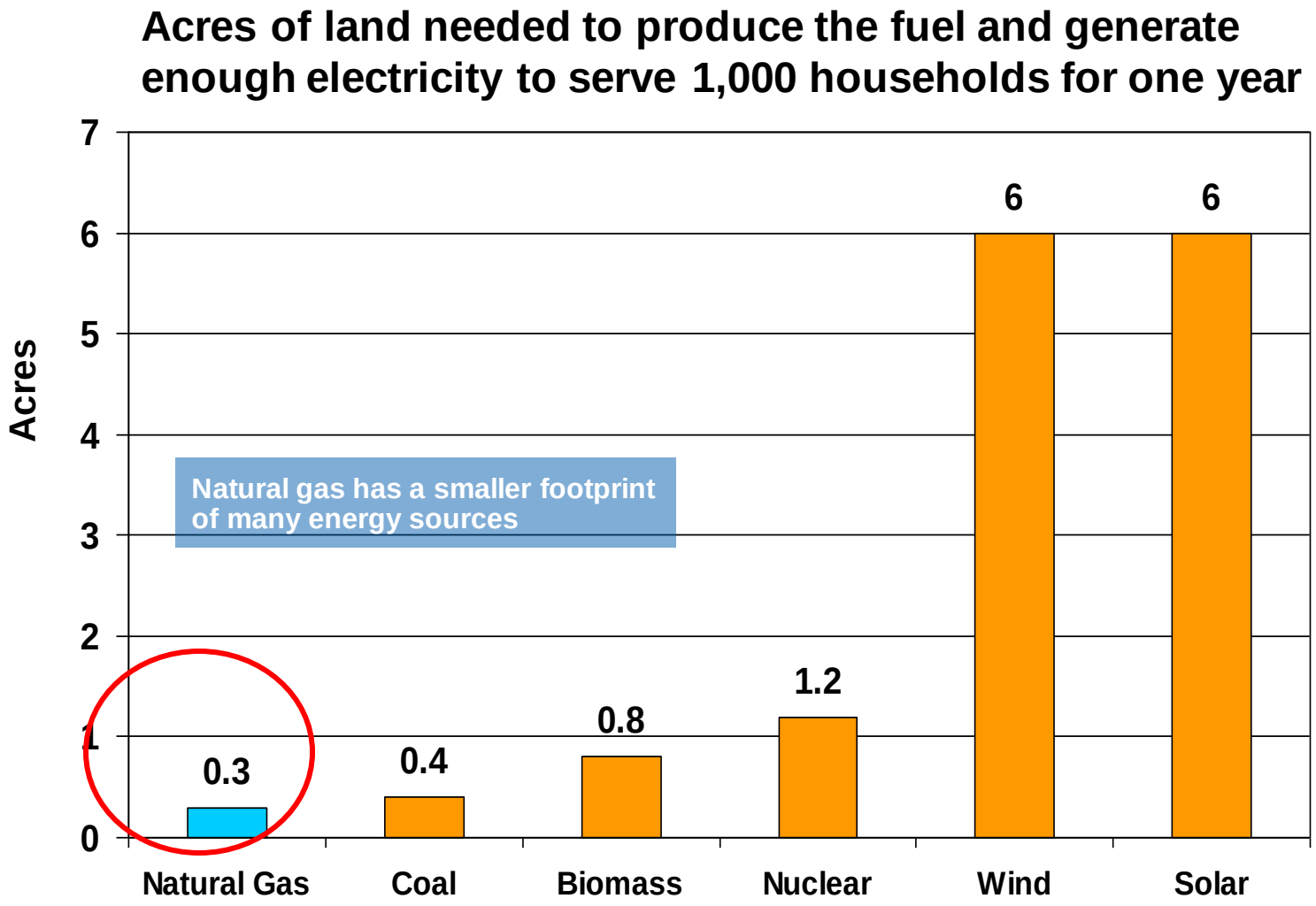


The EIA projects U.S. energy-related CO2 emissions will be lower in 2040 than when they peaked in 2007



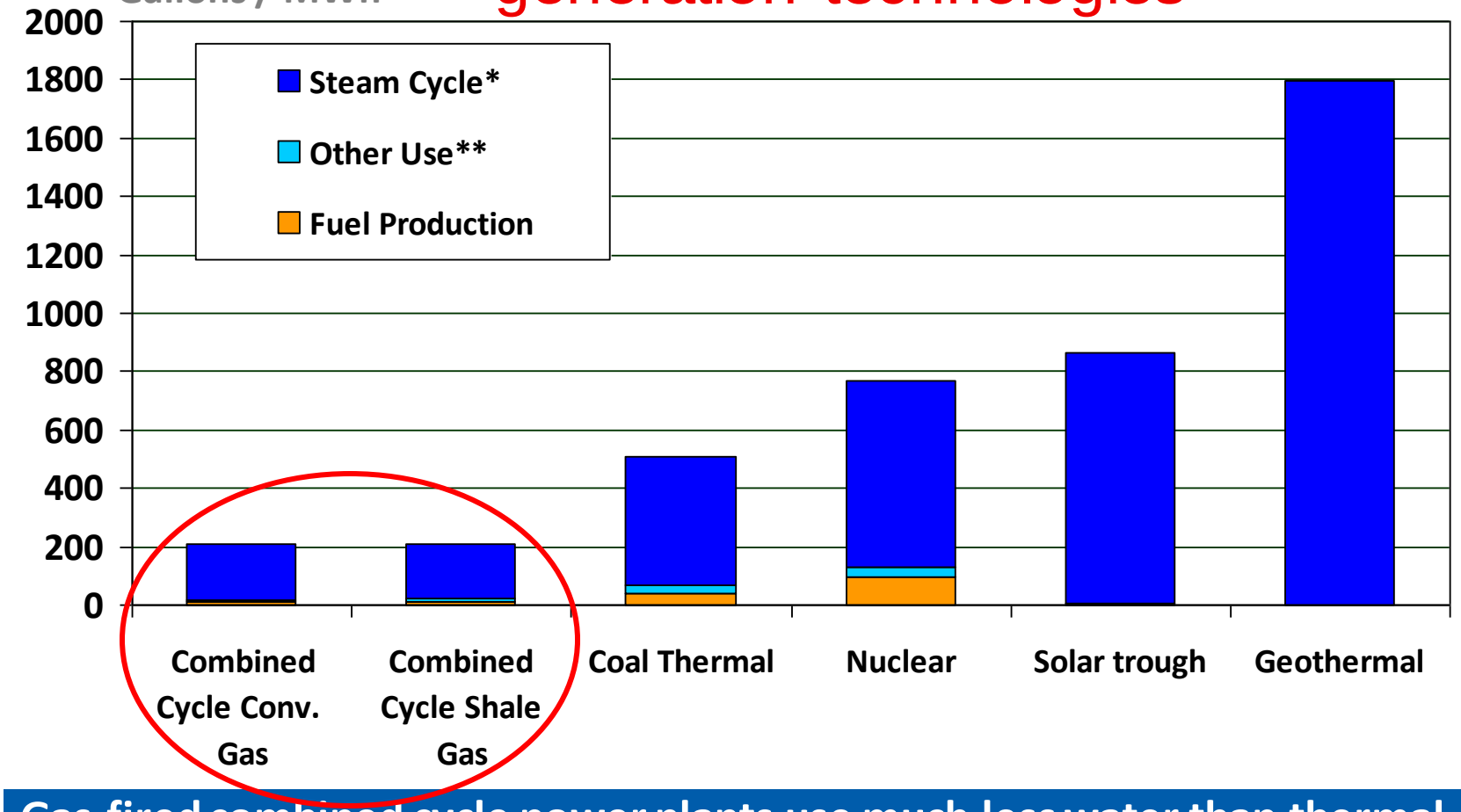
Source: EIA

Natural gas generates more electricity from less land than other power sources.



Source: R.W. Beck and Black and Veatch for NGSA

Water intensity for various power generation technologies



Gas-fired combined cycle power plants use much less water than thermal power plants with only a small contribution from gas production

Sources: U.S. Department of Energy, "Energy Demands on Water Resources", December 2006; NREL, "A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies," March 2011; Chesapeake for shale gas water use

* Assumes closed loop cooling tower

**Other use includes water for other process uses such as emissions treatment, facilities

More Information

To learn more about the oil and natural gas industry, from policy and regulation to the science behind our operations, visit us online, engage with us via social media and ask us questions.

- Stay informed by following Energy Tomorrow on Twitter and Facebook:
  - https://www.facebook.com/Energy.Tomorrow
  - https://twitter.com/energytomorrow

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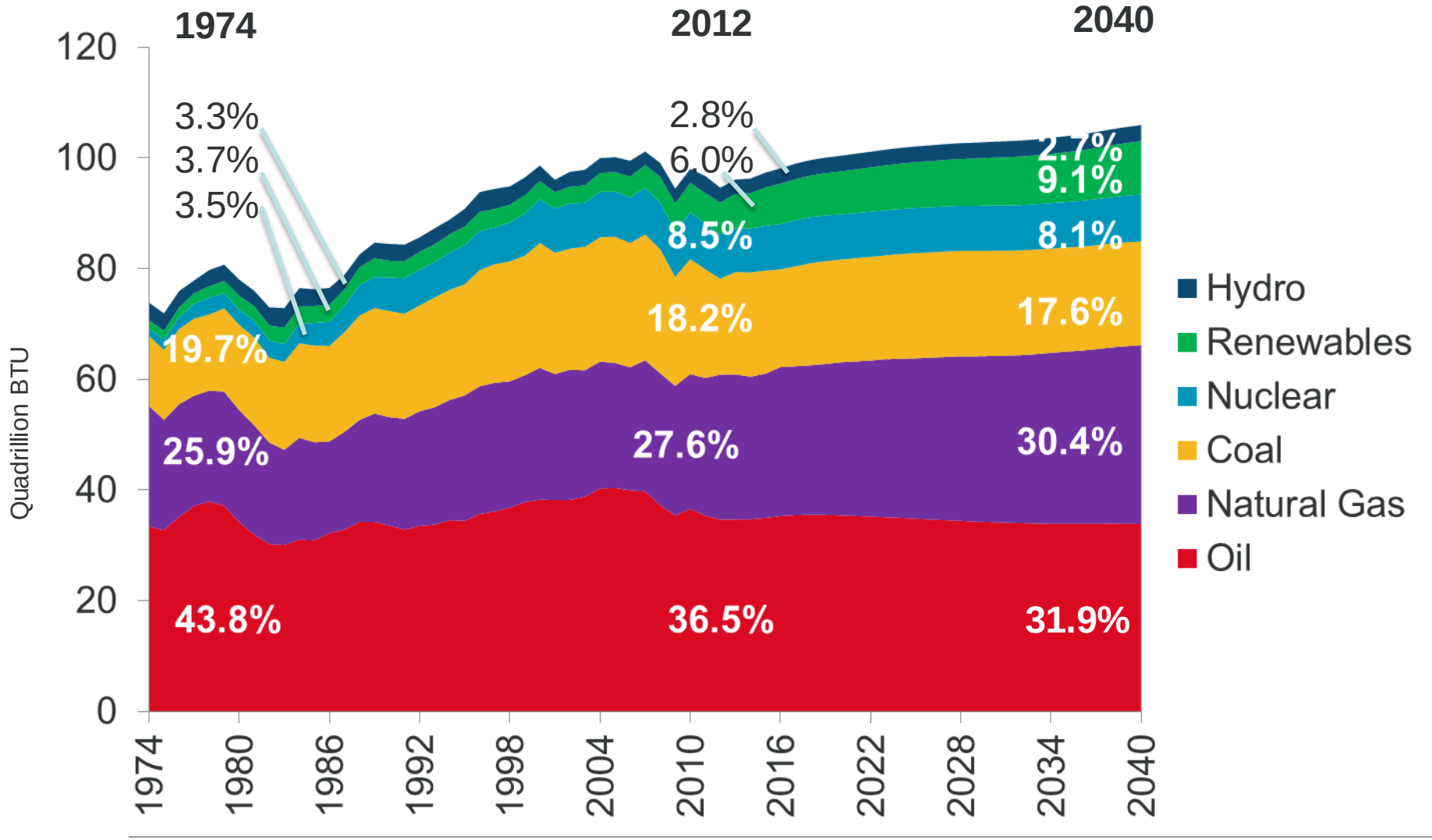
America and the World are Fueled by Oil and Natural Gas

The U.S. will require 12 percent more energy in 2040 and more than 60 percent of it will be met by oil and natural gas

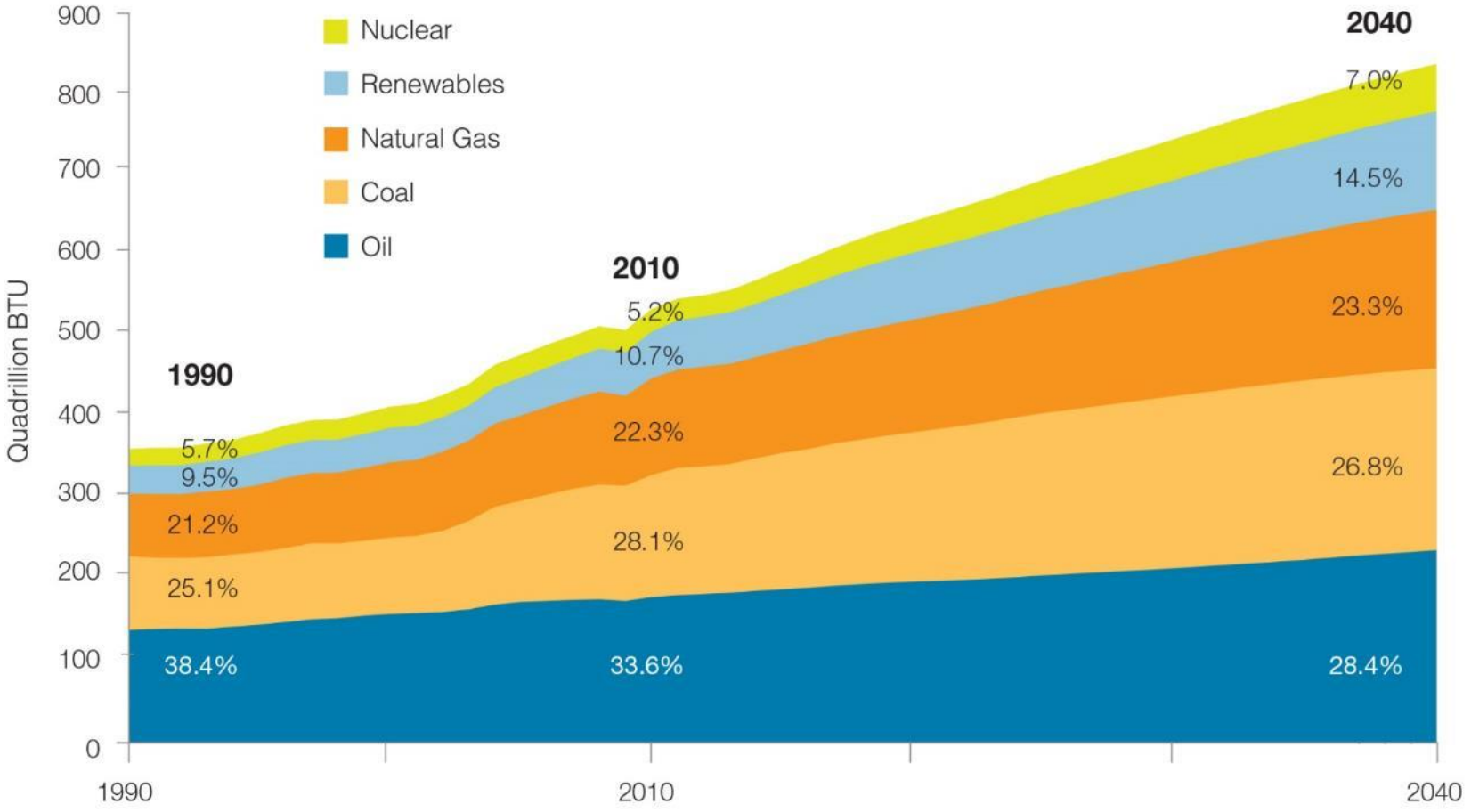


Source: EIA

Most energy analysts agree that sustaining even modest economic growth worldwide for the next several decades will require massive new investments in oil and natural gas

Future Global Energy Demand

The world will require 56 percent more energy in 2040 than in 2010.

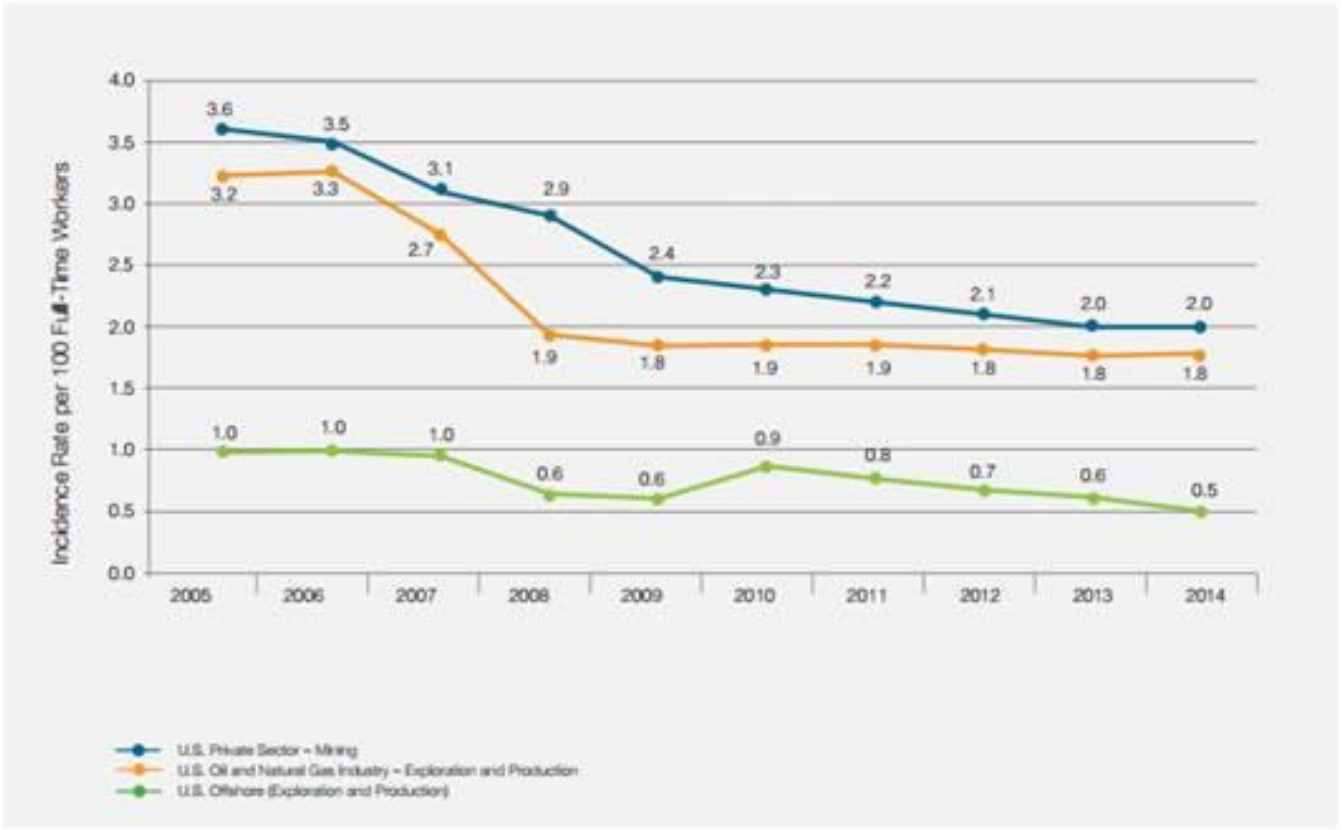


Source: EIA, *International Energy Outlook 2013*.

Figure 2

Exploration and Production vs. Mining (2005-2014)

Injuries and Illnesses Incidence Rates

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