



HYDRAULIC FRACTURING

BAKKEN SAFETY TOUR 2016
AUGUST 31 - SEPTEMBER 2

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UNITED STATES

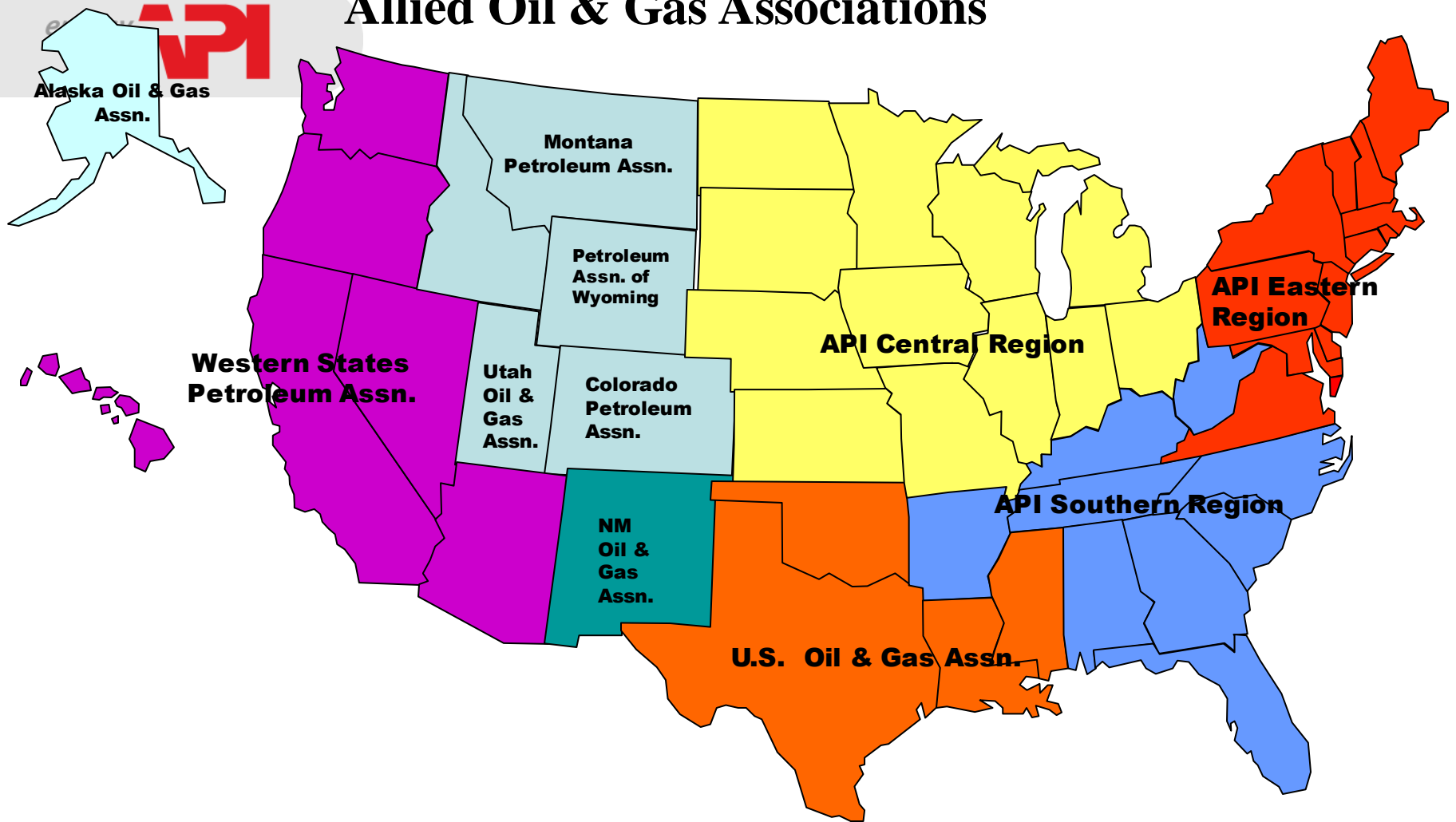
Hydraulic Fracturing and Onshore Oil and Natural Gas Development: **Industry Standards for Safe and Responsible Development**

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Group Director, Upstream & Industry Operations
American Petroleum Institute

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

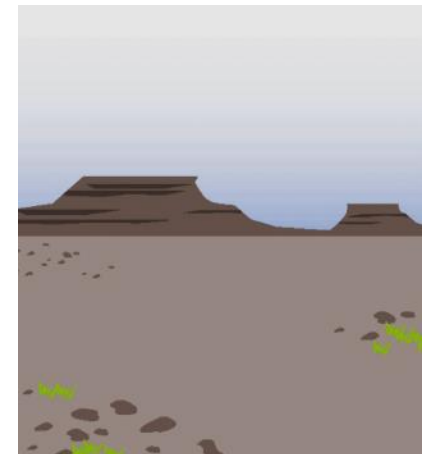
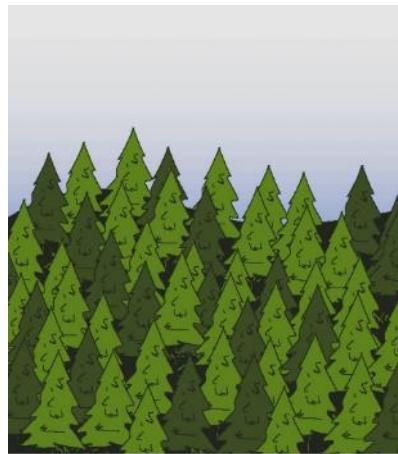
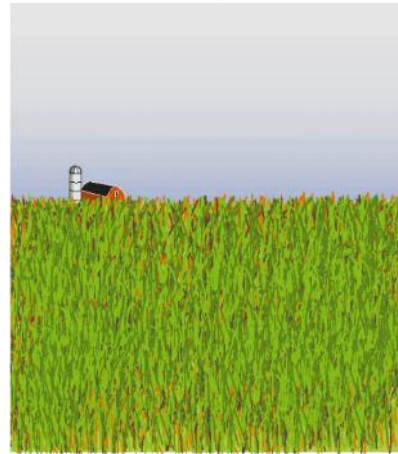
- 600+ Industry Standards and Technical Reports covering:
 - Exploration & Production
 - Refining
 - Marketing
 - Pipeline
 - Measurement
 - Safety and Fire Protection
 - Petroleum E-Commerce

**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

Overview of Industry | Guidance/Best Practices Supporting Hydraulic Fracturing (HF)

- API Spec 4F** Drilling and Well Servicing Structures
- API RP 4G** Drilling and Well Servicing Structure (Inspection and Maintenance)
- API Spec 6A** Wellhead and Christmas Tree Equipment
- API Spec 7K** Drilling Equipment
- API RP 8B** Hoisting equipment (Inspection and Maintenance)
- API Spec 8C** Hoisting Equipment
- API Spec 16A** Drill-through Equipment
- API Spec 16C** Choke and Kill Systems
- API Spec 16D** Control Systems for Drilling Well Control Equipment
- API RP 16ST** Coiled Tubing Well Control Equipment Systems
- API Std 53** Blowout Prevention Equipment Systems
- API RP 92U** Underbalanced Drilling Operations
- API Std 609** Reliability/Maintenance Data
- API Spec 02** QMS Requirements for Service Organizations for the Petroleum and Natural Gas Industry
- API Spec 12B** Production Liquid Storage Tanks (Bolted)
- API Spec 12D** Production Liquid Storage Tanks (Field welded)
- API Spec 12F** Production Liquid Storage Tanks (Shop welded)
- API Spec 12J** Oil and Gas Separators
- API Spec 12K** Indirect Type Oilfield Heaters
- API Spec 12L** Vertical and Horizontal Emulsion Treaters
- API RP 12N** Flame Arresters Operations, Testing and Maintenance

- API Spec 12P** Fiberglass Reinforced Plastic Tanks
- API RP 12R1** Production Service Tanks (Inspection and Maintenance)
- API RP 2350** Storage Tanks Overfill Protection
- API Pub 4663** Remediation of Salt-Affected Soils
- API Bull D16** Spill Prevention Control and Countermeasure Plan
- API RP 49** Drilling and Servicing Involving Hydrogen Sulfide
- API RP 54** Drilling and Servicing Operations Occupational Safety
- API RP 55** Gas Processing Involving Hydrogen Sulfide
- API RP 59** Well Control Operations
- API RP 64** Divertor Systems Equipment and Operations
- API RP 67** Oilfield Explosives Safety
- API RP 68** Oil and Well Servicing and Workover Operations Involving Hydrogen Sulfide
- API RP 74** Production Operations Occupational Safety
- API RP 75L** Safety and Environmental Management Systems
- API RP 76** Contractor Safety Management
- API Std 66-2** Isolating Potential Flow Zones
- API RP 90-2** Annular Casing Pressure for Onshore Wells
- API RP 100-1** Well Integrity and Fracture Containment
- API RP 100-2** Environmental Aspects Related to Onshore Operations
- API RP 50** Environmental Protection Natural Gas Processing Plant Practices
- API RP 51R** Environmental Protection for Operations

- API RP 52** Environmental Protection Land Drilling Practices
- API Bull E2** NORM Management
- API Bull E3** Well Abandonment and Inactive Wells
- API Bull E5** Waste Management
- API Bull HF4** Community Engagement
- API Spec 5L** Line Pipe
- API Spec 6D** Pipeline Valves
- API RP 6DR** Repair and Remanufacture of Pipeline Valves
- API GFA** Fire Testing for Valves
- API Std 1104** Pipeline Welding
- API RP 1110** Steel Pipeline Pressure Testing
- API RP 1133** Guidelines for Onshore Hydrocarbon Pipelines Affecting High Consequence Floodplains
- API RP 1160** Managing System Integrity
- API RP 1162** Public Awareness Programs
- API RP 1169** Pipeline Inspection – New Construction
- API RP 1173** Pipeline SMS
- API Spec 11B** Sucker Rods
- API Spec 11E** Pumping Units
- API RP 11ER** Guarding Pumping Units

- API RP 5A3** Thread Compounds
- API RP 5A5** Casing, Tubing, Drill Pipe Field Inspection
- API Spec 5B** Threading, Gauges and Thread Inspection
- API RP 5B1** Thread Gauging and Inspection Practices
- API RP 5C1** Casing and Tubing Care and Use
- API TR 5C3** Tubular Performance Property calculations
- API RP 5C5** Casing and Tubing Connections Testing
- API RP 5C6** Welding Connections to Pipe
- API Spec 5CRA** Corrosion Resistant Alloy Pipe
- API Spec 5CT** Casing and Tubing
- API Spec 5DP** Drill Pipe
- API Spec 7-1** Drill Stem Elements
- API Spec 7-2** Rotary Shouldered Connection Threading and Gauges
- API RP 7G** Drill Stem Design
- API RP 7G-2** Drill Stem Elements (Inspection and Classification)
- API Spec 10A** Well Cements
- API RP 10B-2** Well Cement Testing
- API RP 10B-4** Foamed Cement Testing
- API RP 10B-5** Well Cement Shrinkage and Expansion Determination
- API RP 10B-6** Cement Static Gel Strength Determination
- API Spec 10D** Blow Spring Casing Centralizers
- API RP 10D-2** Centralizer Placement and Stop-Collar Testing
- API RP 10F** Cement Float Equipment
- API TR 10TR1** Cement Sheath Evaluation
- API TR 10TR2** Cement Shrinkage and Expansion

- API TR 10TR3** Cement Thickening Time Tests
- API TR 10TR4** Selection of Centralizers
- API TR 10TR5** Solid and Rigid Centralizer Testing
- API Spec 13A** Drilling Fluids
- API RP 13B-1** Water-based Drilling Fluids Testing
- API RP 13B-2** Oil-Based Drilling Fluids Testing
- API RP 13C** Drilling Fluids Processing System Evaluation
- API RP 13D** Drilling Fluids Rheology
- API RP 13I** Drilling Fluids Lab Testing
- API RP 13J** Heavy Brines Testing
- API RP 13M** Completion Fluids Viscous Properties
- API RP 13M-4** Gravel-pack Fluid Leak-off
- API RP 19B** Well Perforator Evaluation
- API RP 19C** Proppants Properties
- API RP 19D** Long-term Conductivity of Proppants
- API Spec 11D1** Packers and Bridge Plugs
- API Std 11D2** Progressing Cavity Pump Systems
- API Std 11D3** Progressing Cavity Pump Surface Drive Systems
- API Spec 14A** Subsurface Safety Valves
- API RP 14B** Subsurface Safety Valves (Inspection and Maintenance)
- API Spec 14L** Lock Mandrels and Landing Nipples
- API RP 19G** Side-Pocket Mandrels
- API Spec 19E2** Side-Pocket Mandrel Flow Control Devices
- API Spec 19G3** Side-Pocket Mandrel Latches and Seals
- API RP 19G4** Side-Pocket Mandrel Related Equipment
- API Spec 19V** Barrier Valves

API is the world's leading standard-developing organization for the oil and natural gas industry.

Since 1924, API has developed standards for oil and natural gas operations.

API's formal consensus process is accredited by the American National Standards Institute (ANSI), the same institute that accredits U.S. national laboratories for their science and technology processes.

API standards are developed in an open process that requires regular review of its more than 600 standards covering all segments of the industry.

Nearly 200 API standards are cited over 3300 times in state regulations, and more than 100 standards are cited 270 times in federal regulations.

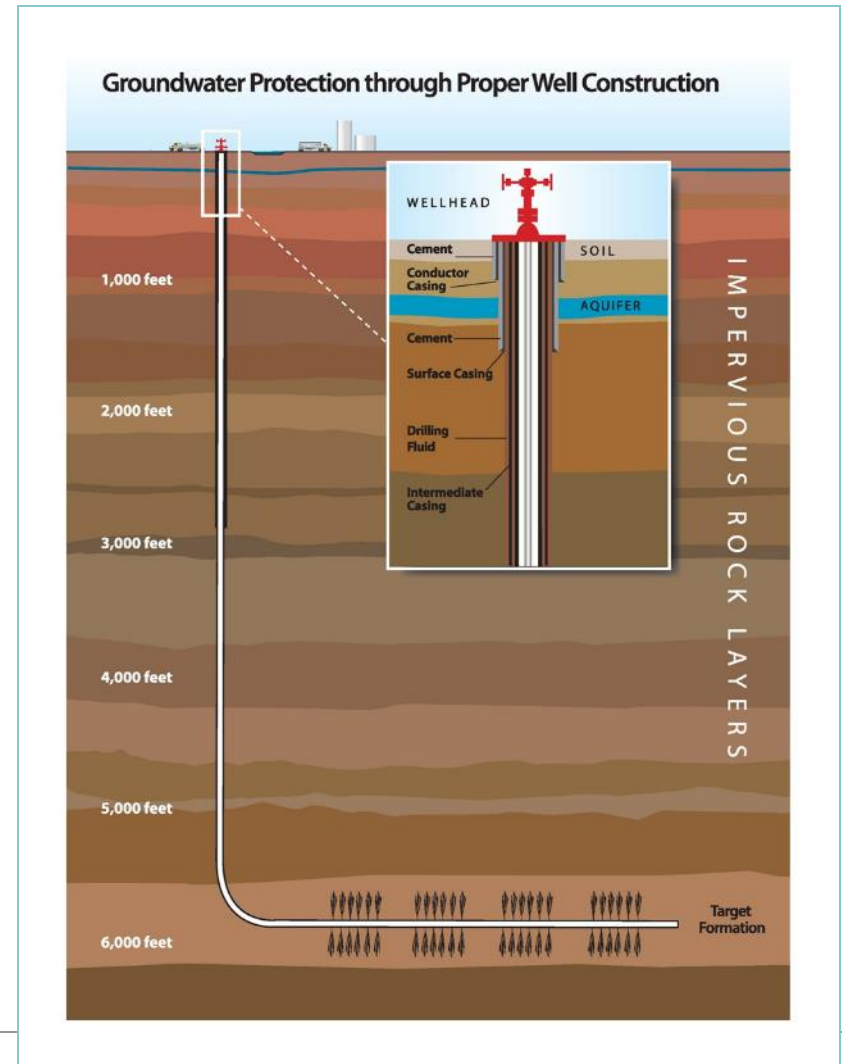


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www.api.org

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



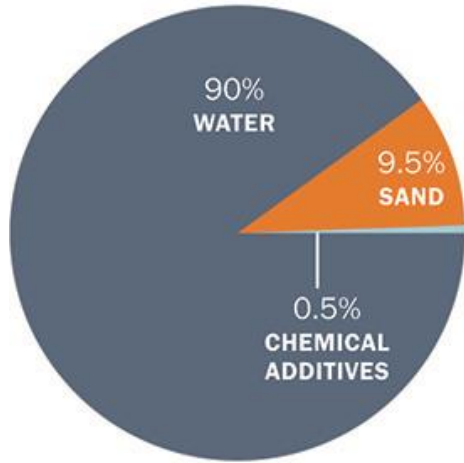
Managing Environmental Aspects of Exploration and Production Operations

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



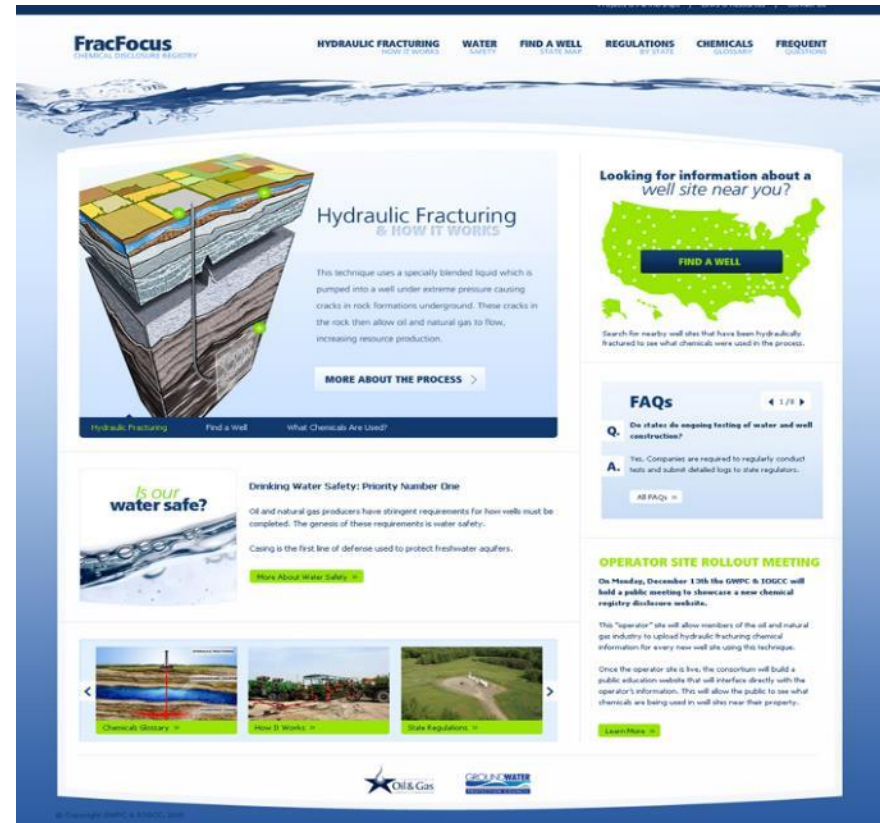
FracFocus:

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

Like other industries:
 Ingredients, not a recipe
 Trade secrets protected

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 glycol	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	INTERNATIONAL FLOXYMETRICS	FRAC GEL	GUAR	9000-30-0	100.00%	0.159264%	
MAVCIDE II	WEATHERFORD	BIOCIDE	2,2-dibromo-3-nitropropionamide	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%	



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

API Bulletin 100-3

Principles:

- Integrity
- Safety and Environmental Responsibility
- Communicating Effectively

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.

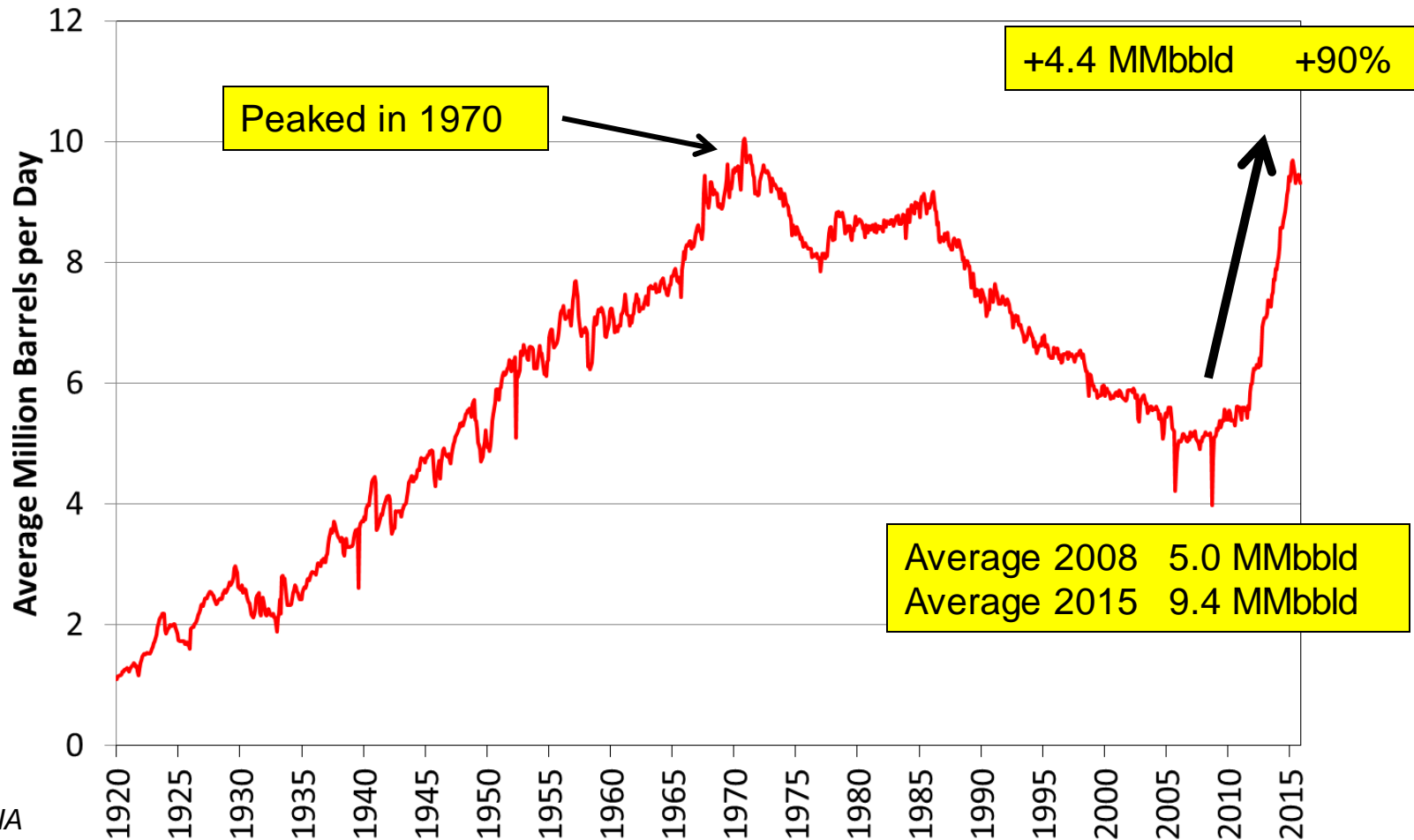
Additional Recent and Ongoing Standards Development Related to Occupational Safety

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**

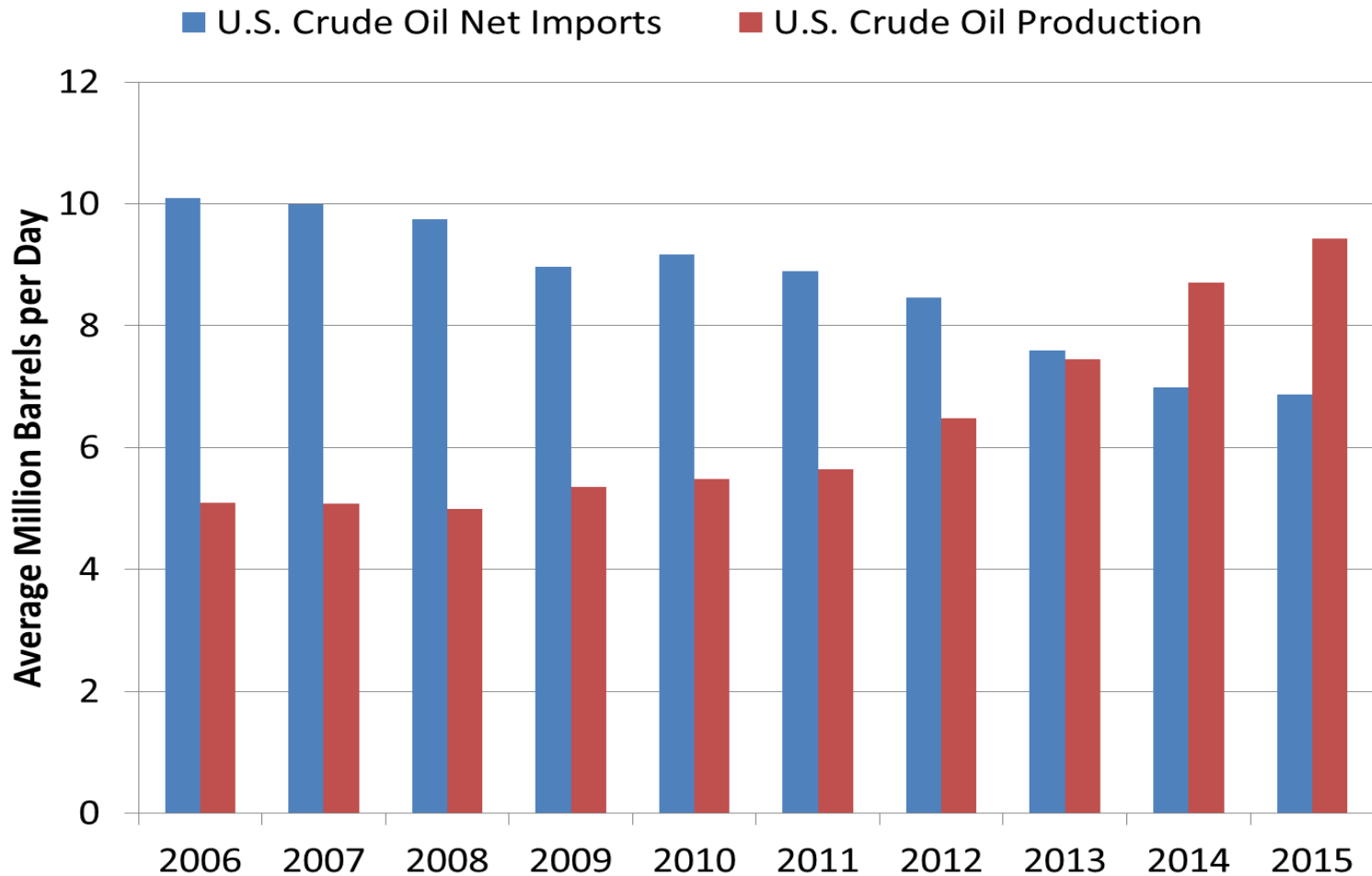
Shale Energy Production is Driving Energy Security and Environmental Benefits

US Crude Oil Production



Source: EIA

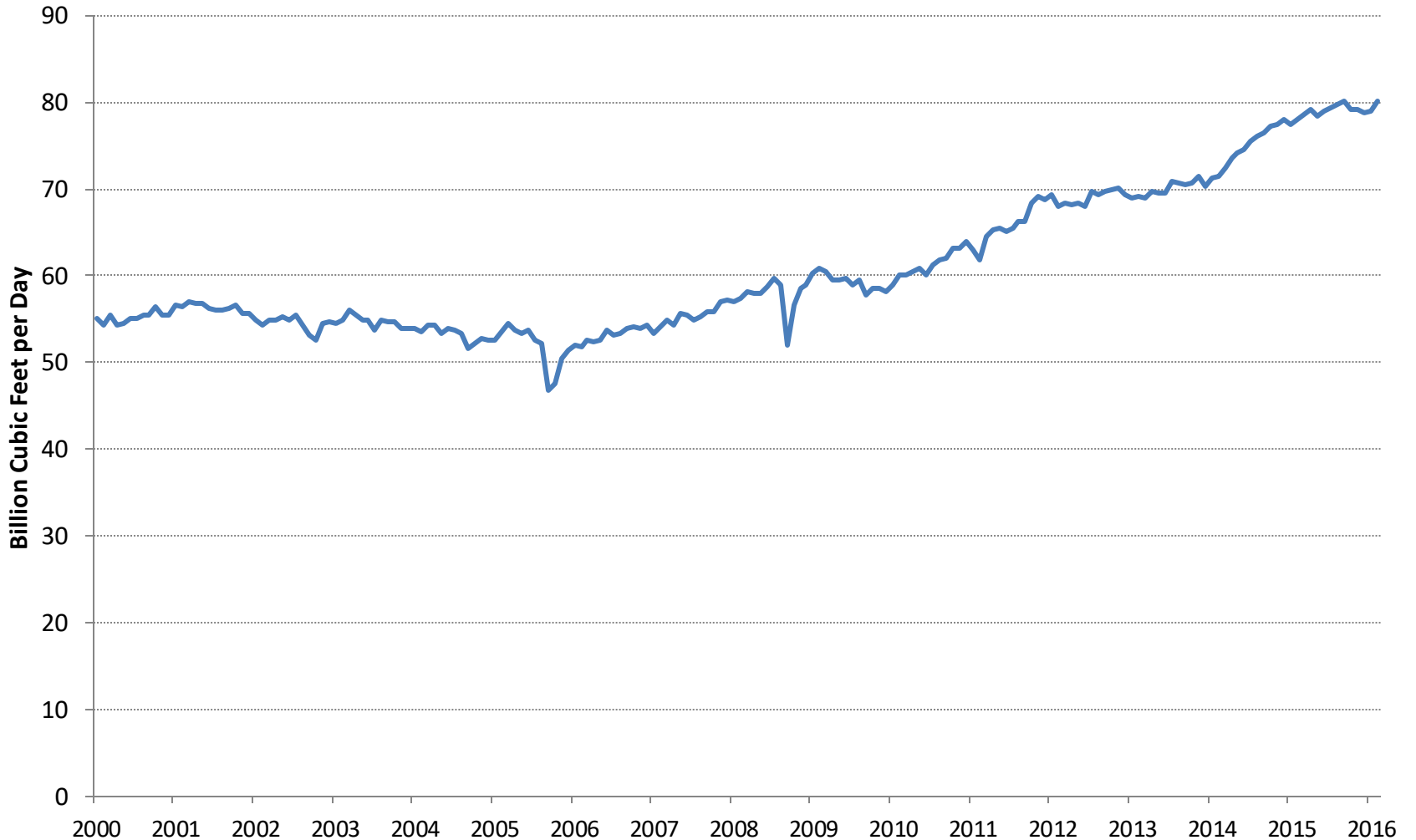
U.S. Crude Oil Net Imports vs. Production



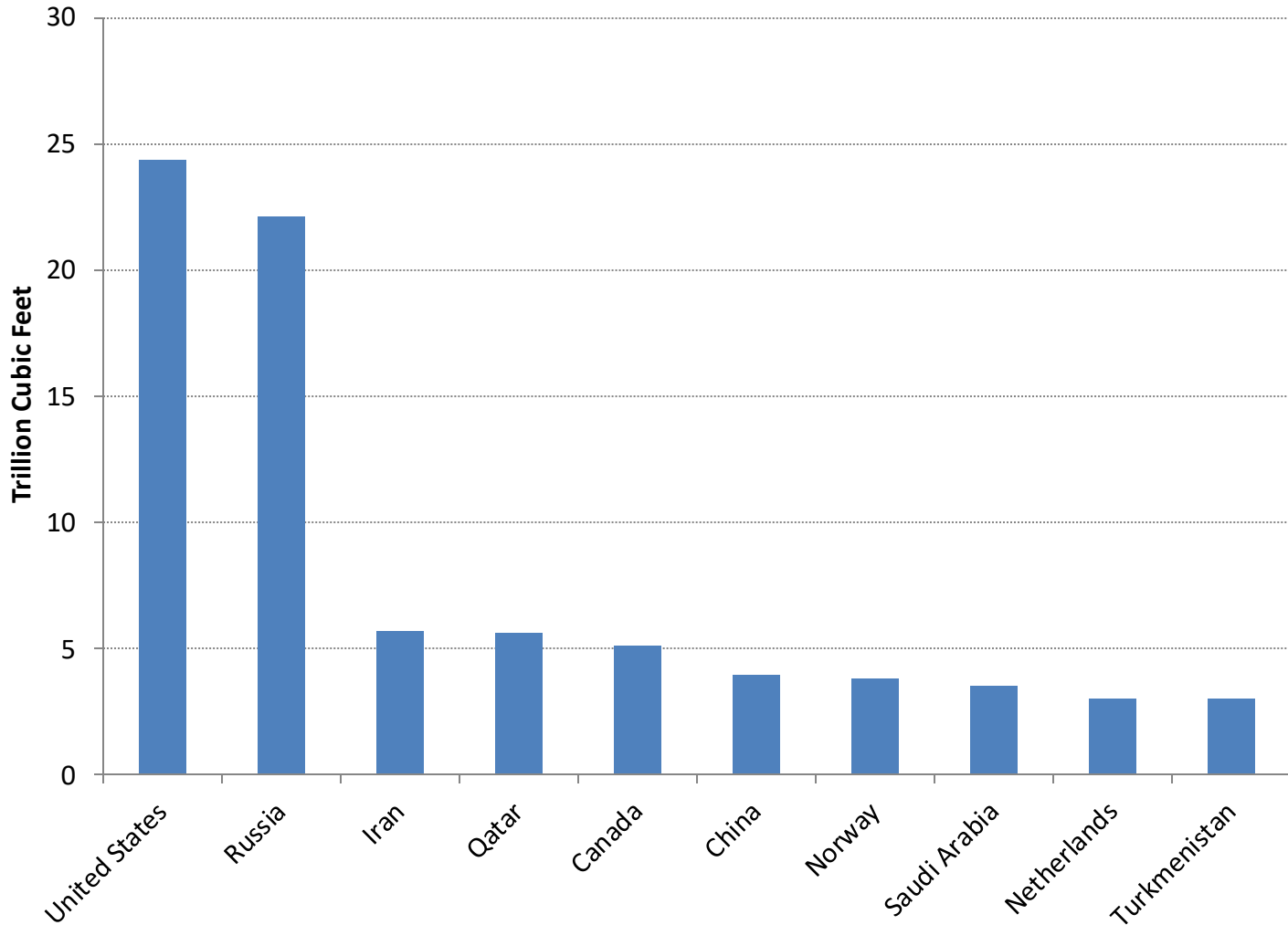
Source: EIA



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 (CO ₂)	14,264	9,832	4,076	0.0
Nitrogen Oxides (NO _x)	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 (SO ₂)	0.0	4.77	0.03	0.0
Mercury	0.0	0.0001	0.0	0.0

Most emissions



Middle emissions



Least emissions

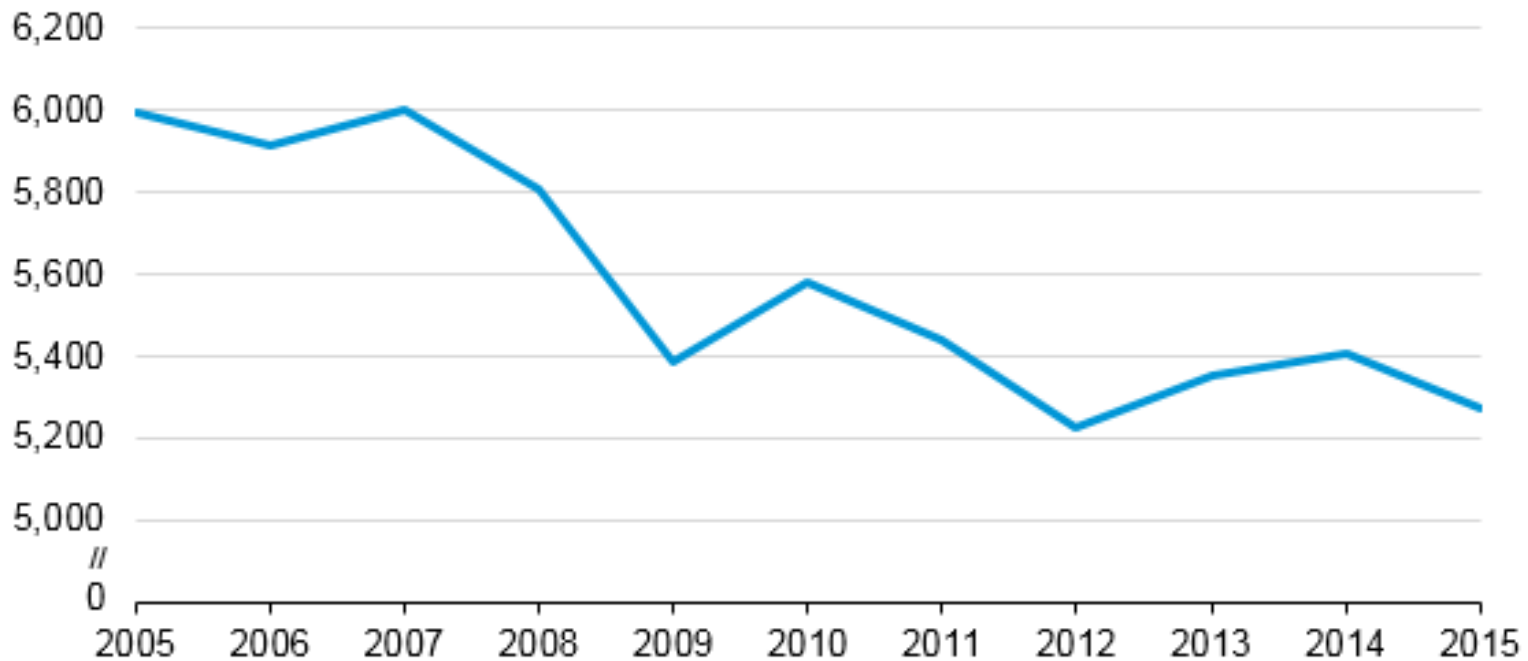


Natural gas is clean burning

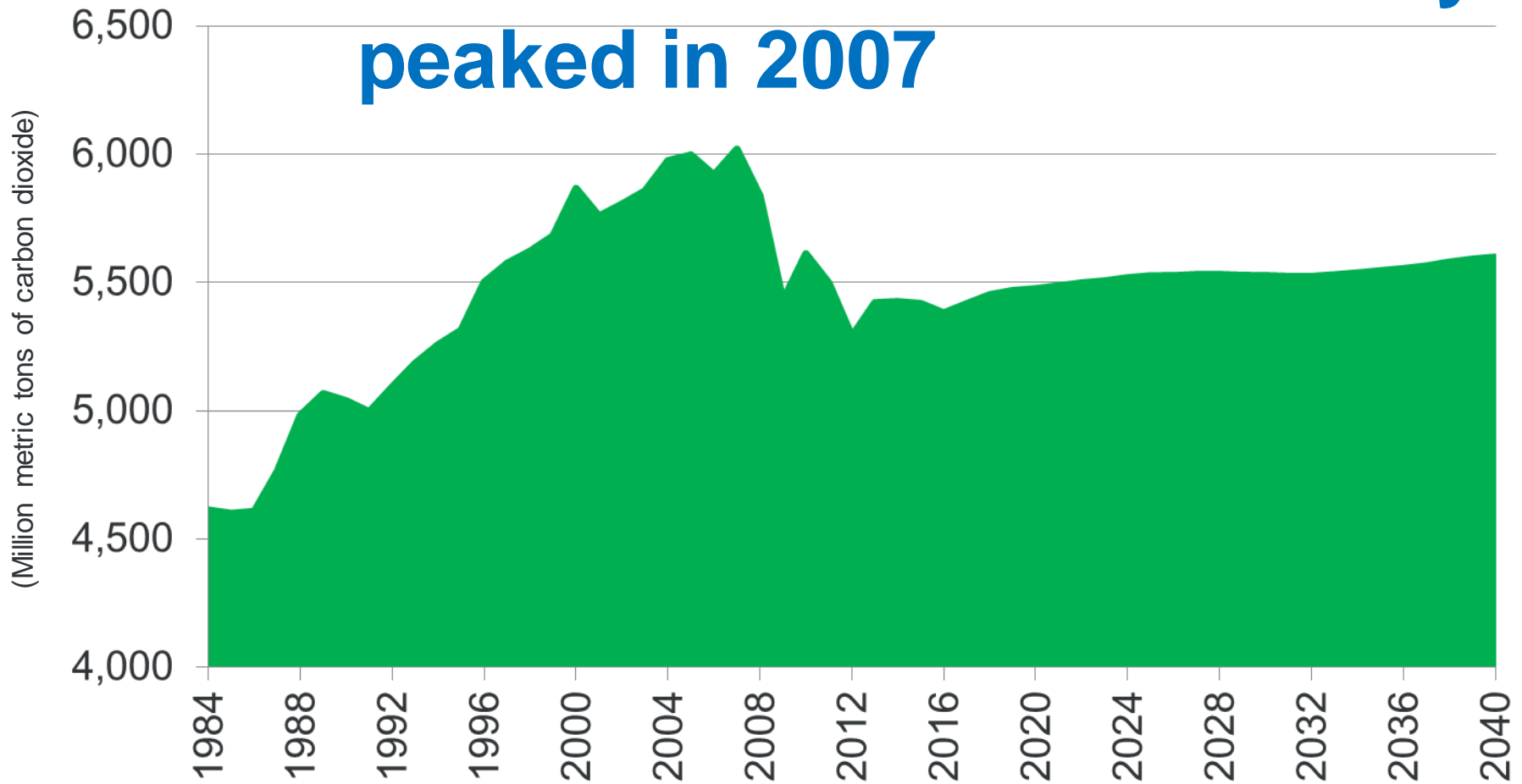
Source: R.W. Beck

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

U.S. energy-related carbon dioxide (CO2) emissions (2005-15)
million metric tons

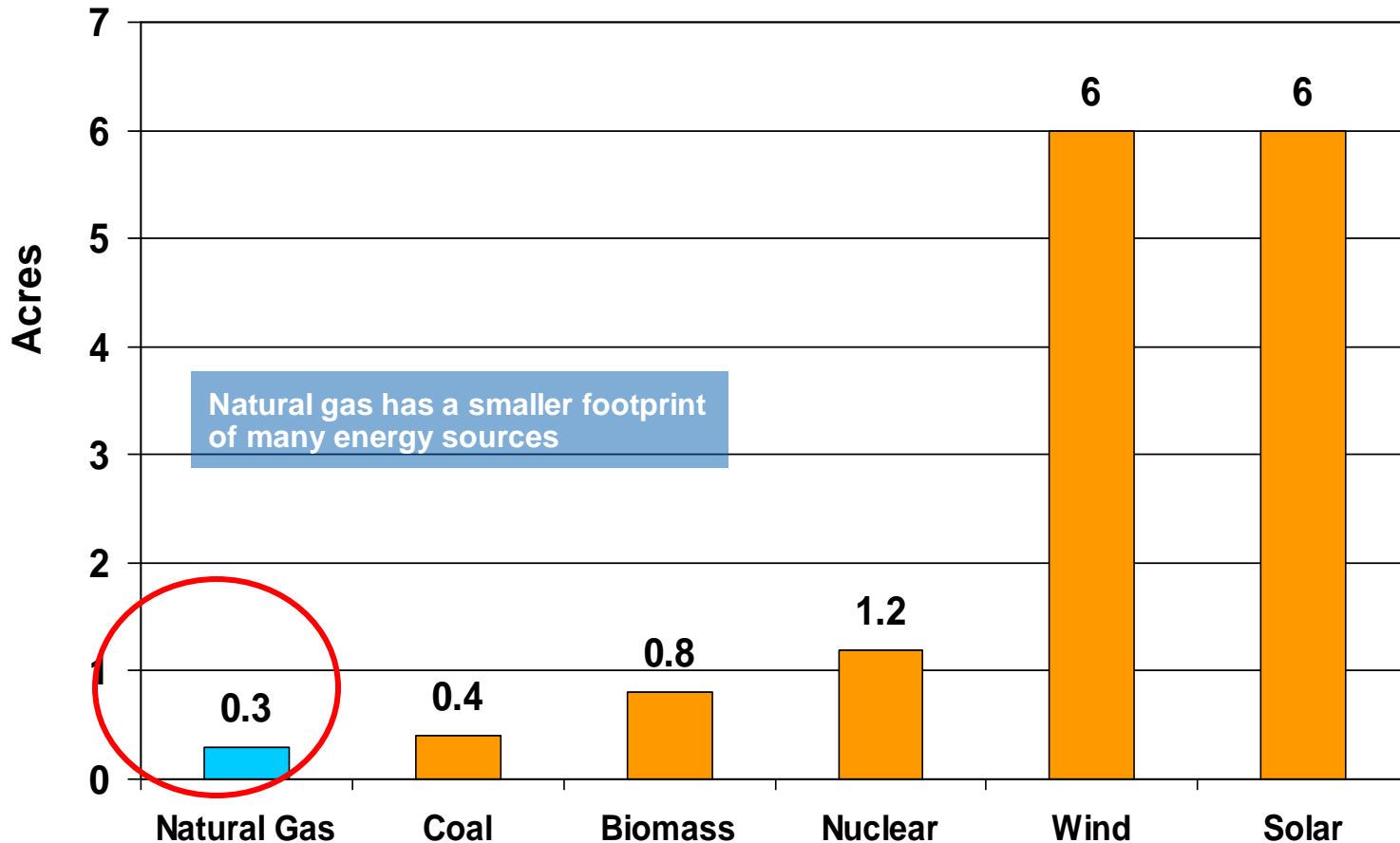


The EIA projects U.S. energy-related CO2 emissions will be lower in 2040 than when they peaked in 2007

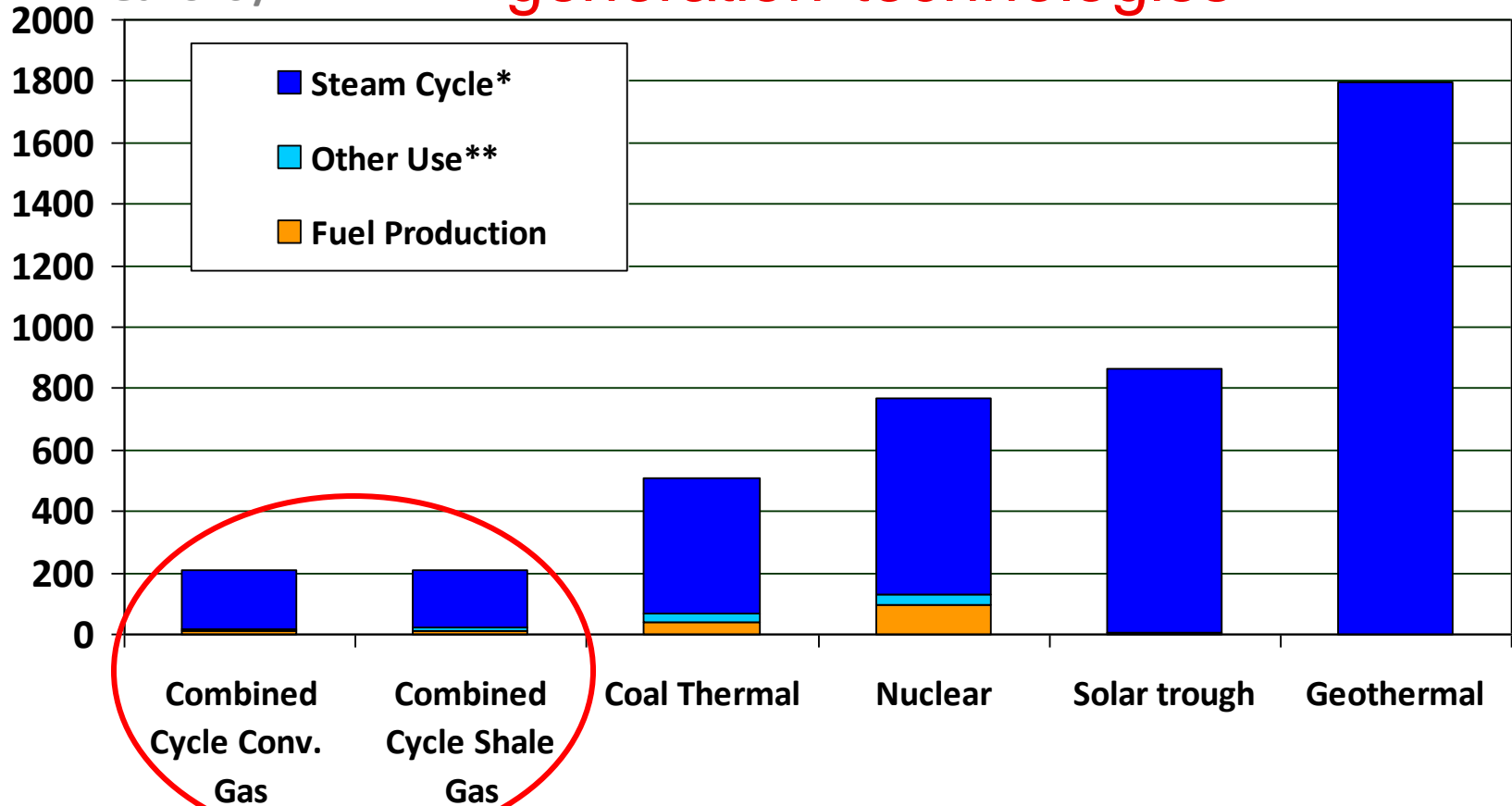


Natural gas generates more electricity from less land than other power sources.

Acres of land needed to produce the fuel and generate enough electricity to serve 1,000 households for one year



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

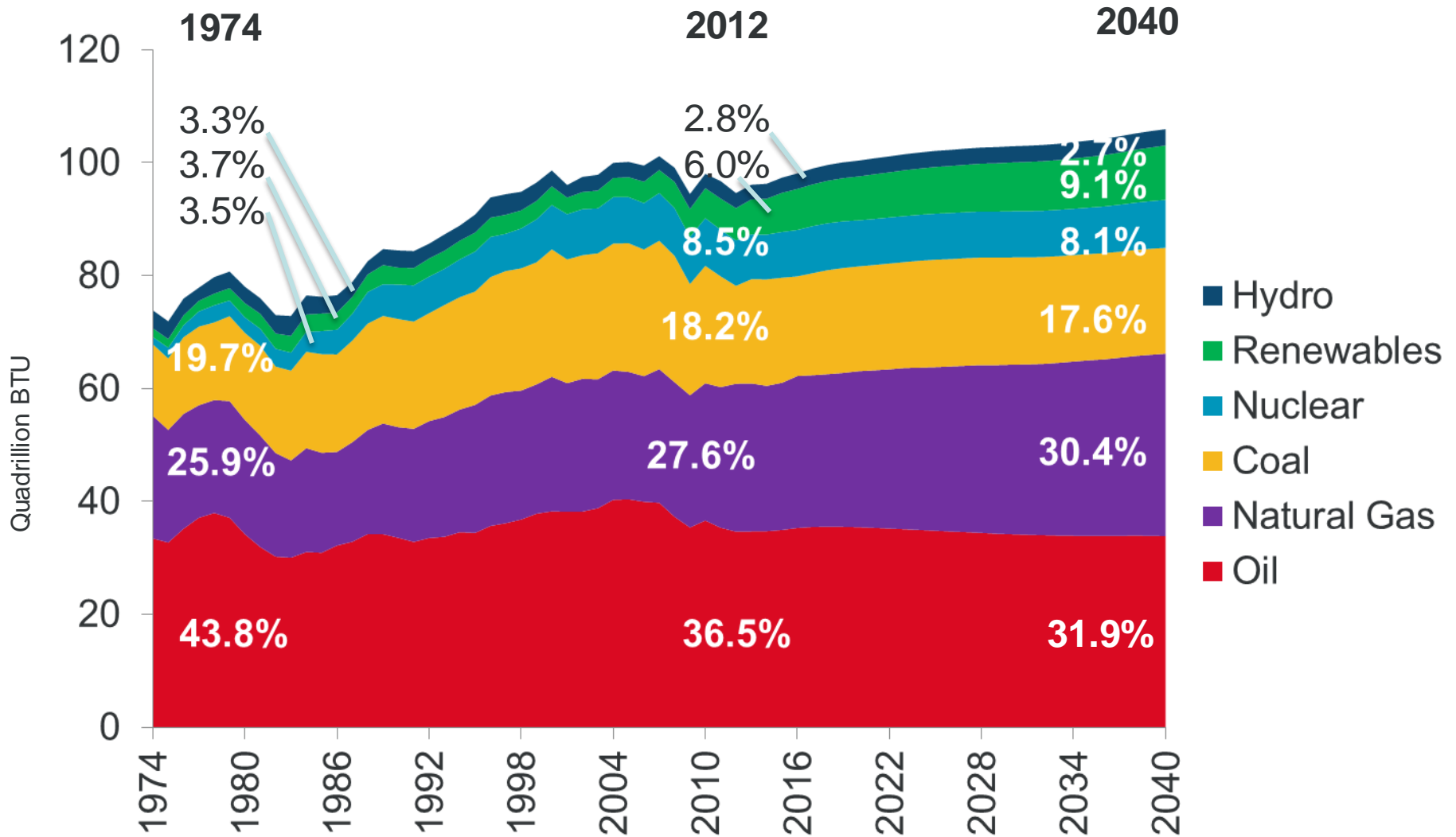
To learn more about the oil and natural gas industry, from policy and regulation to the science behind our operations, visit us online, engage with us via social media and ask us questions.

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- The Energy Tomorrow e-newsletter provides the latest in American energy development, regulatory, legislative and industry news. Sign up to be in-the-know.
 - www.EnergyTomorrow.org/Stay-Informed



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

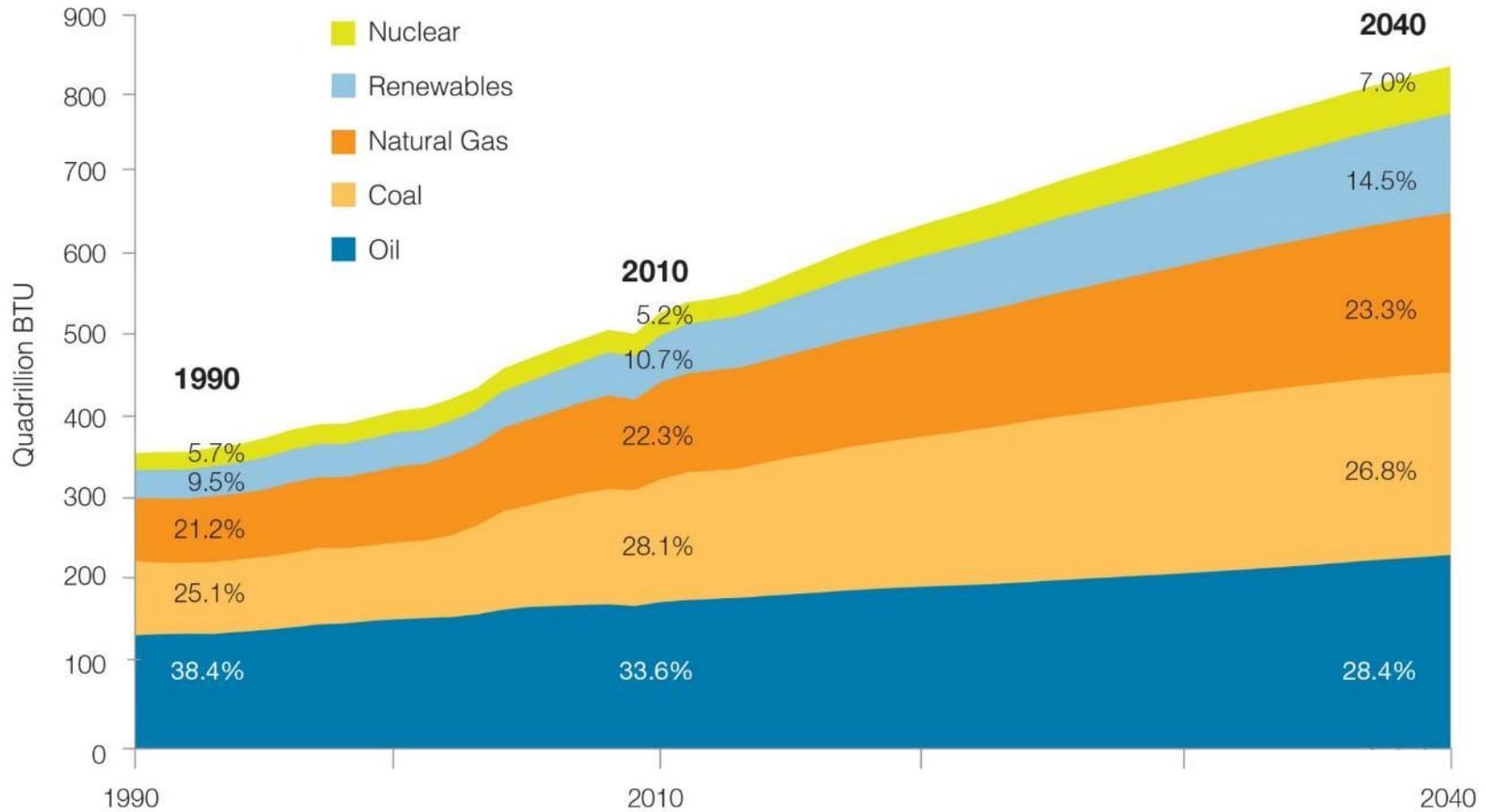




Most energy analysts agree that sustaining even modest economic growth worldwide for the next several decades will require massive new investments in oil and natural gas

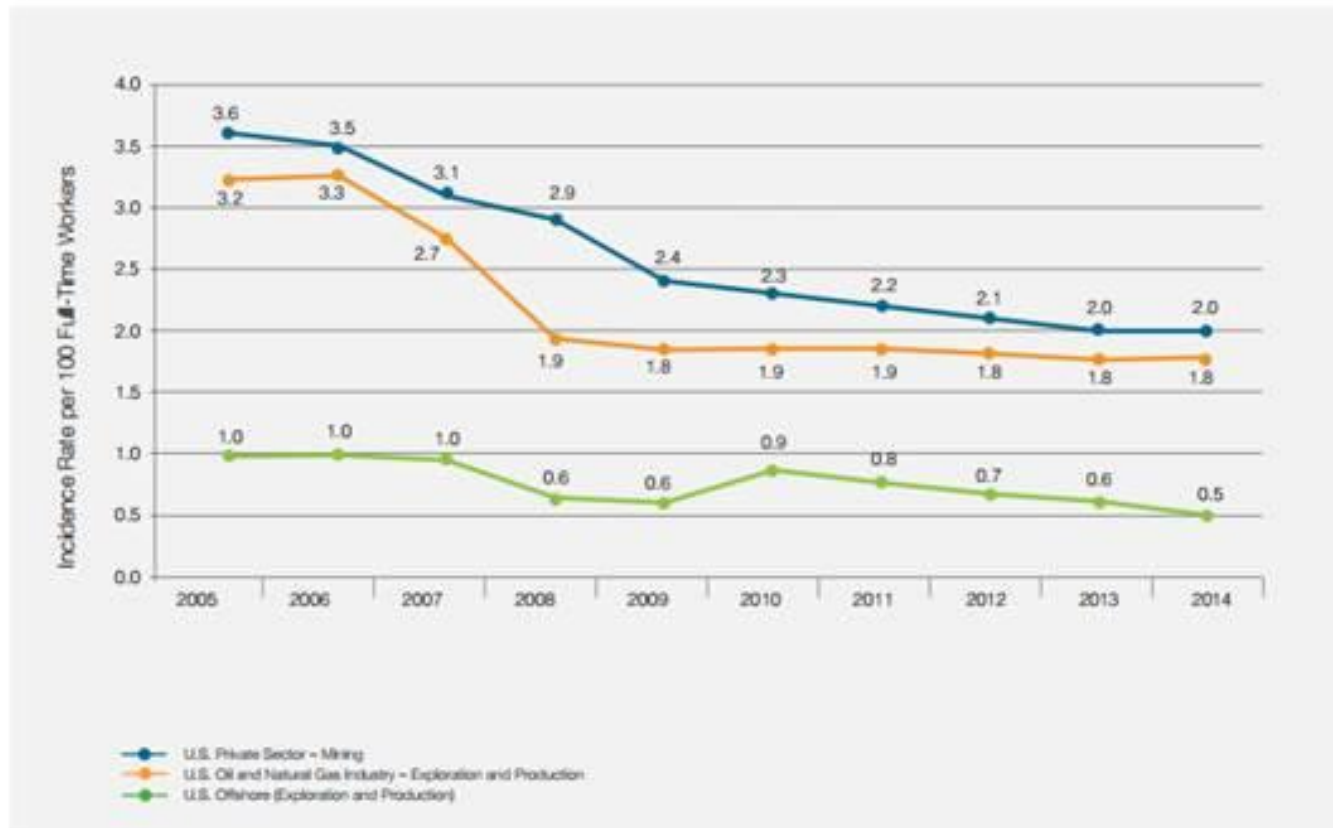
Future Global Energy Demand

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



JOINT US/EU



**CONFERENCE ON HEALTH
AND SAFETY AT WORK**

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