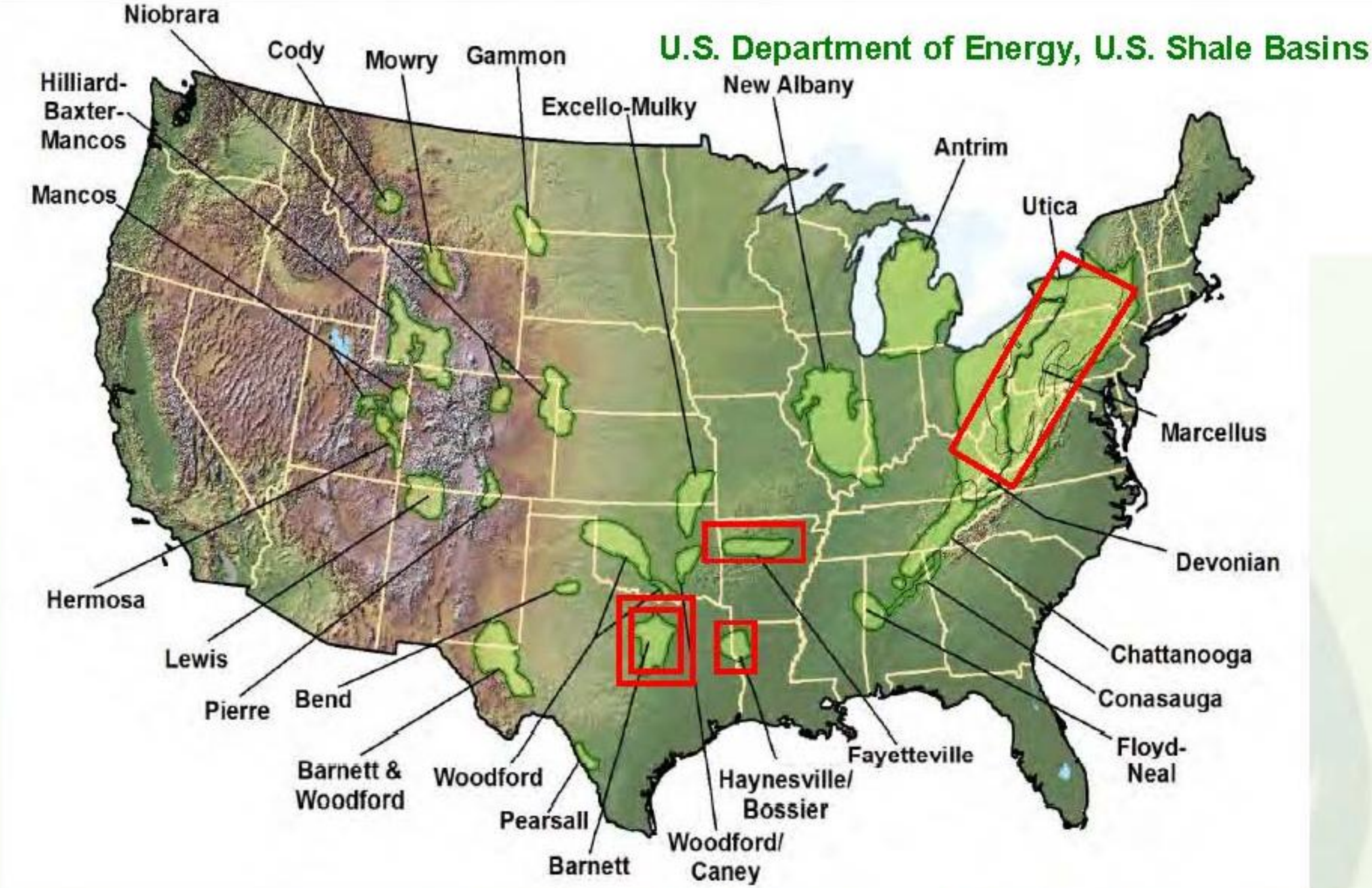
# Shale gas and Hydraulic Fracturing

John Felmy
Chief Economist
American Petroleum Institute
felmyj@api.org

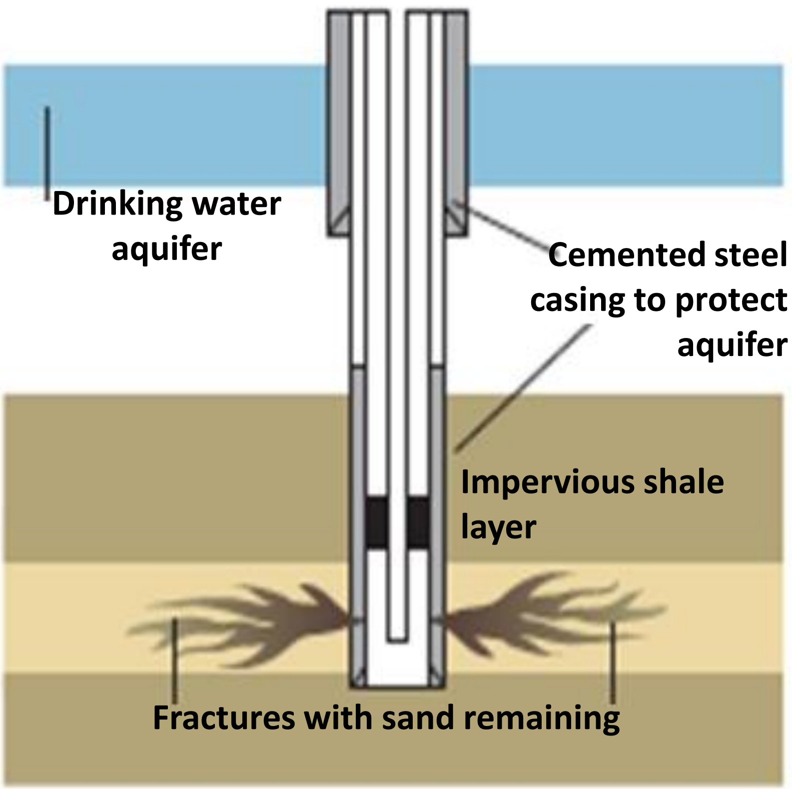



Unlocking shale gas now guarantees the U.S. more than a 100 year supply of clean-burning natural gas

# Marcellus Shale Formation

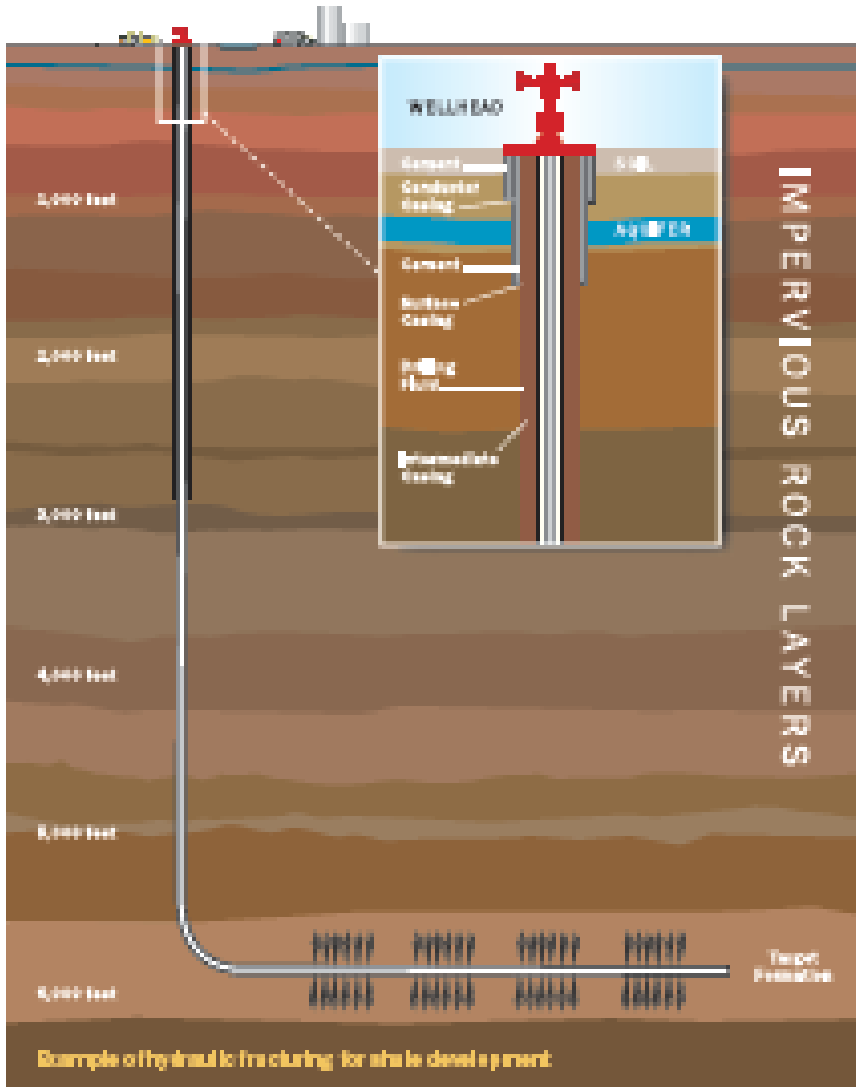
- Marcellus fairway is 40,000 to 50,000 square miles
- Estimates of recoverable reserves up to more than 50tcf; that's equivalent to more than 66 years of Pennsylvania's current consumption.
- Barnett core is 5,000 square miles
- Barnett is largest U.S. gas field, providing 6% of U.S. natural gas

# Hydraulic Fracturing Technology




Hydraulic fracturing is a technology that was developed in the **1940s** and has been continuously improved upon since that time. It has been **used in more than one million wells across the U.S.,** and it has helped **produce more than 600 trillion cubic feet of natural gas and 7 billion barrels of oil**. The technique is used to allow natural gas to move more freely from the rock pores where it is trapped so that it can be brought to the surface.

## Proper well construction provides groundwater protection.




Typically, steel pipe known as surface casing is cemented into place at the uppermost portion of a well for the explicit purpose of protecting the groundwater. The depth of the surface casing is generally determined based on groundwater protection, among other factors. As the well is drilled deeper, additional casing is installed to isolate the formation(s) from which oil or natural gas is to be produced, which further protects groundwater from the producing formations in the well.

Casing and cementing are critical parts of the well construction that not only protect any water zones but are also important to successful oil or natural gas production from hydrocarbon bearing zones.

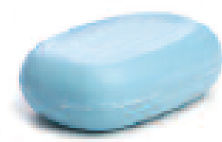
Industry well design practices protect sources of drinking water from the other geologic zones of an oil and natural gas well with multiple layers of impervious rock.[4]

4. [illegible]

## Typical Chemical Additives Used in Frac Water

| 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 |





Source: DOE, GWPC: Modern Gas Shale Development in the United States: A Primer (2009).

# Hydraulic Fracturing is Well Regulated

Hydraulic fracturing is **well regulated** by multiple federal, state and local authorities addressing environmental protection during natural gas operations, covering such items as well permitting, well materials and construction, **safe disposition of** used hydraulic fracturing **fluids, water testing, and chemical recordkeeping and reporting.** These rules and industry practices **effectively protect underground sources of drinking water.**

# Protective measures are in place.

A comprehensive set of federal, state, and local laws addresses every aspect of exploration and production operations. These include well design, location, spacing, operation, water and waste management and disposal, air emissions, wildlife protection, surface impacts, and health and safety.

In addition to government oversight, new industry standards advance operations and practices. The industry has created a number of guidance documents and other initiatives relating to hydraulic fracturing, including recommended practices for environmental protection for onshore oil and natural gas production and leases, well construction and well integrity, water use management, and surface environmental considerations.[5]

New industry standards are continuously evaluated to advance sound operations and practices.

## Taking a look at the history of the SDWA helps clarify the issue.

By the time Congress enacted the SDWA, hydraulic fracturing had been used for 27 years with no environmental problems. Under the SDWA, states developed extensive underground injection control (UIC) programs to manage liquid wastes and the reinjection of produced waters. These programs addressed liquids intended to be periodically injected, continuously injected, and those intended to remain in underground geologic formations.

By 1980, Congress – recognizing the fact that many state-administered injection programs were in place and well established, creating a need for further state flexibility – modified the SDWA to give states the option of gaining federal "primacy" for existing injection programs based on the demonstrated effectiveness of state oil and natural gas UIC programs.

At no time during these debates was there any suggestion that hydraulic fracturing was considered covered under the UIC waste management requirements. Regardless, litigation in the 1990s and subsequent rulings left the federal statutory and regulatory arenas unsettled with regard to hydraulic fracturing.

# Taking a look at the history of the SDWA continues.

Recognizing the need to provide legislative clarity, Congress addressed the issue of hydraulic fracturing under the SDWA in the Energy Policy Act of 2005 (EPAct) by preserving the state regulatory system that has worked so effectively for the past half century.

EPAct clarified that the SDWA was not the appropriate law for regulating hydraulic fracturing with one exception. During the previous referenced analysis of environmental risk from hydraulic fracturing, EPA hypothesized that the use of diesel fuel as a solvent in the fracturing process of coalbeds might pose a risk.[8]

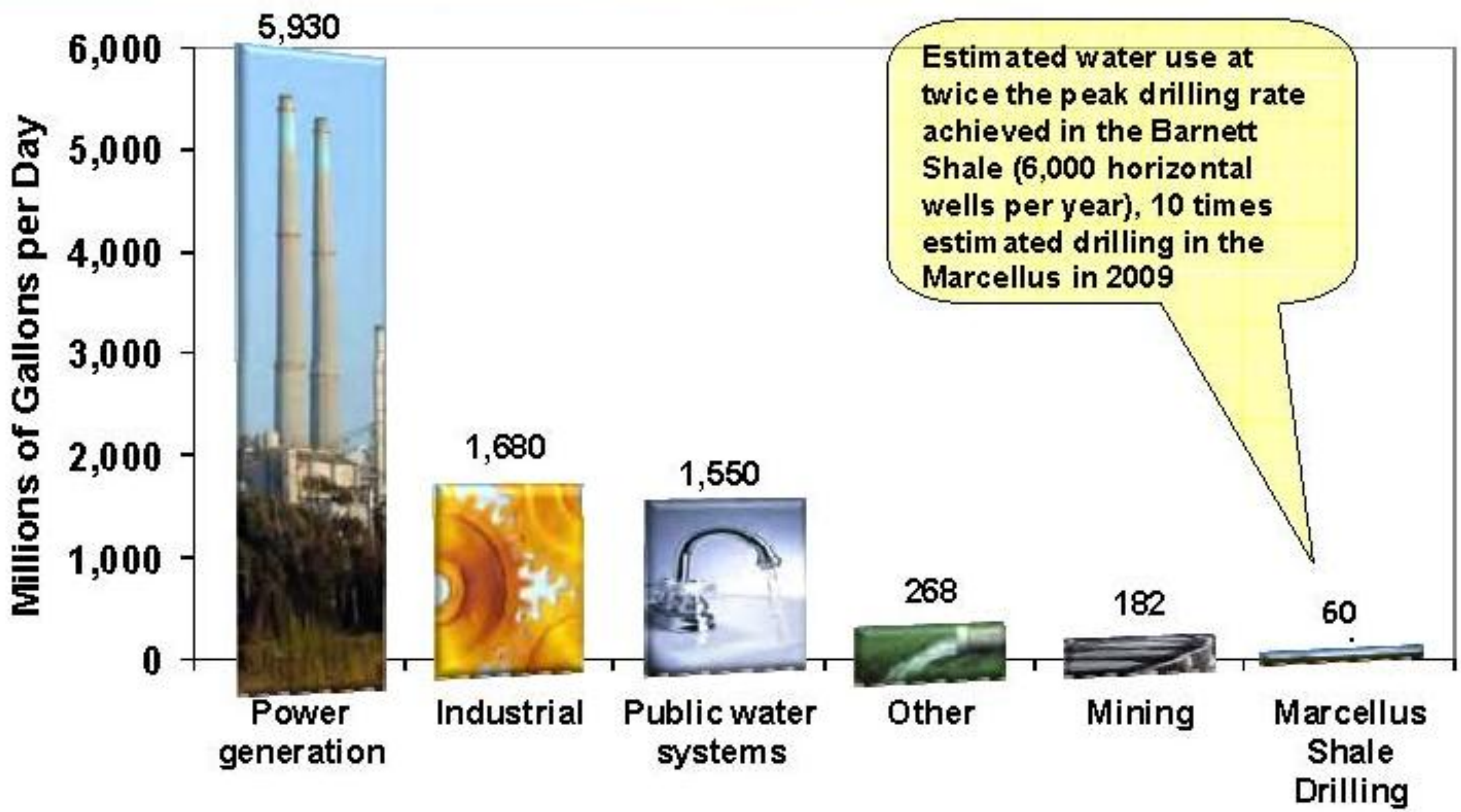
While no incidents of actual damage were identified, Congress preserved the option for the application of the SDWA for regulation of hydraulic fracturing if diesel fuel was utilized.

The current balanced management approach serves the nation well. As reaffirmed by state regulators in October 2007,[9] the current approach retains the effective state regulatory programs that protect the environment. And, it provides for a structure that allows for the essential development of the nation's oil and natural gas.

8 Prior to enactment of the Energy Policy Act, primary providers of hydraulic fracturing had agreed not to use diesel in coalbed fracturing.

9 GWPC Letter to the House Oversight and Government Reform Committee Chair, Henry Waxman, on October 30, 2007.

# How Our Water Usage Stacks Up




Source: USGS, Pennsylvania Water Consumption

# Overview of Industry Guidance/Best Practices on Hydraulic Fracturing (HF)

**HF1 – *Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines*, 1st Edition, October 2009, (API)**

- Highlights industry practices for well construction and integrity for wells that will be hydraulically fractured.
- The guidance identifies actions to protect shallow groundwater aquifers, while also enabling economically viable development of oil and natural gas resources.

**HF2 – *Water Management Associated with Hydraulic Fracturing*, 1st Edition, June 2010, (API)**

- Identifies best practices used to minimize environmental and societal impacts associated with the acquisition, use, management, treatment, and disposal of water and other fluids associated with the process of hydraulic fracturing.
- Focuses primarily on issues associated with hydraulic fracturing pursued in deep shale gas development, but also describes the important distinctions related to hydraulic fracturing in other applications.

**HF3 – *Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing*, 1st Edition, February 2011, (API)**

- Identifies the best practices for minimizing surface environmental impacts associated with hydraulic fracturing operations.
- Focused on protecting surface water, soils, wildlife, other surface ecosystems, and nearby communities.
- Includes API's policy on chemical disclosure:
  - API supports transparency regarding the disclosure of the chemical ingredients;
  - States are the proper authority to determine reporting requirements and formatting of reporting and public disclosure;
  - Proprietary information should be protected; and
  - Hydraulic fracturing is effectively regulated by numerous federal, state and local requirements. Hydraulic fracturing should not be placed exclusively under the purview of the Safe Drinking Water Act (SDWA) or any other federal statute.

# Overview of Industry Guidance/Best Practices on Hydraulic Fracturing (HF)

**Std 65 Part 2 – *Isolating Potential Flow Zones During Well Construction,* 2nd Edition, December 2010, (API)**

- Identifies best practices used to minimize environmental and societal impacts associated with the acquisition, use, management, treatment, and disposal of water and other fluids associated with the process of hydraulic fracturing.
- Focuses primarily on issues associated with hydraulic fracturing pursued in deep shale gas development, but also describes the important distinctions related to hydraulic fracturing in other applications.

**RP 51R – *Environmental Protection for Onshore Oil and Gas Production Operations and Leases,* 1st Edition, July 2009, (API)**

- Provides environmentally sound practices for domestic onshore oil and gas production operations, including fracturing. Applies to all production facilities, including produced water handling facilities. Operational coverage begins with the design and construction of access roads and well locations, and includes reclamation, abandonment, and restoration operations.
- **Annex A provides guidance for a company to consider as a "Good Neighbor."**

**API’s documents specific to hydraulic fracturing build on years of industry’s best practice work by incorporating and citing the following additional standards, recommended practices and technical reports:**

- ***API RP 4G, Recommended Practice for Use and Procedures for Inspection, Maintenance, and Repair of Drilling Well Service Structures***
- ***API RP 5A3 / ISO 13678, Recommended Practice on Thread Compounds for Casing, Tubing, and Line Pipe***
- ***API RP 5A5 / ISO 15463, Field Inspection of New Casing, Tubing, and Plain-end Drill Pipe***
- ***API RP 5B1, Gauging and Inspection of Casing, Tubing, and Line Pipe Threads***
- ***API RP 5C1, Recommended Practice for Case and Use of Casing and Tubing***
- ***API RP 5C5 / ISO 13679, Recommended Practice on Procedures for Testing Casing and Tubing Connections***
- ***API RP 5C6, Welding Connections to Pipe***
- ***API RP 7C11F, Recommended Practice for Installation, Maintenance, and Operation of Internal-Combustion Engines***
- ***API RP 11ER, Recommended Practice for Guarding of Pumping Units***
- ***API RP 10B2 / ISO 10426-2, Recommended Practice for Testing Well Cements***

- ***API RP 10B3 / ISO 10426-3, Recommended Practice on Testing of Deepwater Well Cement Formulations***
- **API RP 10B4 / ISO 10426-4,** ***Recommended Practice on Preparation and Testing of Foams and Cement Slurries at Atmospheric Pressure***
- **API RP 10B5 / ISO 10426-5,** ***Recommended Practice on Determination of Shrinkage and Expansion of Well Cement Formulations at Atmospheric Pressure***
- **API RP 10B6 / ISO 10426-6,** ***Recommended Practice on Determining the Static Gel Strength of Cement Formulations***
- **API RP 10D2 / ISO 10427-2,** ***Recommended Practice for Centralizer Placement and Stop Collar Testing***
- **API RP 10F / ISO 10427-3,** ***Recommended Practice for Performance Testing of Cementing Float Equipment***
- **API RP 12N,** ***Recommended Practice for the Operation, Maintenance, and Testing of Flame Arresters***
- **API RP 12R1,** ***Recommended Practice for Setting, Maintenance, Inspection, Operation, and Repair of Tanks in Production Service***
- **API RP 13B1 / ISO 10414-1,** ***Recommended Practice for Field Testing Water-Based Drilling Fluids***
- **API RP 13B2 / ISO 10414-2,** ***Recommended Practice for Field Testing Oil-based***

- **API RP 13C**, ***Recommended Practice on Drilling Fluid Processing Systems Evaluation***
- **API RP-13D,** ***Recommended Practice on the Rheology and Hydraulics of Oil-well Drilling Fluids***
- **API RP 13I / ISO 10416,** ***Recommended Practice for Laboratory Testing Drilling Fluids***
- **API RP 13J / ISO 13503-3,** ***Testing of Heavy Brines***
- **API RP 13M / ISO 13503-1,** ***Recommended Practice for the Measurement of Viscous Properties of Completion Fluids***
- **API RP 13M4 / ISO 13503-4,** ***Recommended Practice for Measuring Simulation and Gravel-pack Fluid Leakoff Under Static***
- **API RP 19B,** ***Evaluation of Well Perforators***
- **API RP 19C / ISO 13503-2,** ***Recommended Practice for Measurement of Properties of Proppants Used in Hydraulic Fracturing and Gravel-packing Operations***
- **API RP 19D / ISO 13503-5,** ***Recommended Practice for Measuring the Long-term Conductivity of Proppants***

- ***API RP 49, Recommended Practice for Drilling and Well Servicing Operations Involving Hydrogen Sulfide***
- ***API RP 53, Recommended Practices for Blowout Prevention Equipment Systems for Drilling Operations***
- ***API RP 54, Occupational Safety for Oil and Gas Well Drilling and Servicing Operations***
- ***API RP 55, Recommended Practices for Oil and Gas Producing and Gas Processing Operations Involving Hydrogen Sulfide***
- ***API RP 65, Cementing Shallow Water Flow Zones in Deep Water Wells***
- ***API RP 67, Recommended Practice for Oilfield Explosives Study***
- ***API RP 74, Occupational Safety for Oil and Gas Well Drilling and Servicing Operations***
- ***API RP 75L, Guidance Document for the Development of a Safety and Environmental Management System for Onshore Oil and Natural Gas Production Operation and Associated Activities***
- ***API RP 76, Contractor Safety Management for Oil and Gas Drilling and Production Operations***

- ***API RP 90, Annular Casing Pressure Management for Offshore Wells***
- ***API RP 2350, Overfill Protection for Storage Tanks in Petroleum Facilities***
- ***API Spec 4F, Drilling and Well Servicing Structures***
- ***API Spec 5B, Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads***
- ***API Spec 5CT / ISO 11960, Specification for Casing and Tubing***
- ***API Spec 6A, Specification for Wellhead and Christmas Tree Equipment***
- ***API Spec 7B11C, Specification for Internal Combustion Reciprocating Engines for Oil-Field Service***
- ***API Spec 10A / ISO 10426-1, Specification for Cements and Materials for Well Cementing***
- ***API Spec 10D / ISO 10427-1, Specification for Bow Spring Casing Centralizers***
- ***API Spec 10D2 / ISO 10427-2, Specification for Centralizer Placement and Stop Collar Tracing***
- ***API Spec 11N, Specification for Lease Automatic Custody Transfer (LACT) Equipment***
- ***API Spec 12B, Specification for Bolted Tanks for Storage of Production Liquids***
- ***API Spec 12D, Specification for Field Welded Tanks for Storage of Production Liquids***

- ***API Spec 12F, Specification for Shop Welded Tanks for Storage of Production Liquids***
- ***API Spec 12J, Specification for Oil and Gas Separators***
- ***API Spec 12K, Specification for Indirect Type Oilfield Heaters***
- ***API Spec 12L, Specification for Vertical and Horizontal Emulsion Treaters***
- ***API Spec 12P, Specification for Fiberglass Reinforced Plastic Tanks***
- ***API Spec 13A, Specification for Drilling Fluid Materials***
- ***API TR 5C3, Technical Report on Equations and Calculations for Casing, Tubing, and Line Pipe Used as Casing or Tubing; and Performance Properties Tables for Casing and Tubing***
- ***API TR 10TR1, Cement Sheath Evaluation***
- ***API TR 10TR2, Shrinkage and Expansion in Oilwell Cements***
- ***API TR 10TR3, Temperatures for API Cement Operating Thickening Time Tests***
- ***API TR 10TR4, Technical Report on Considerations Regarding Selection of Centralizers for Primary Cementing Operations***
- ***API TR 10TR5, Technical Report on Methods for Testing of Solid and Rigid Centralizers***
- ***API Guidelines for Commercial Exploration and Production Waste Management Facilities***

***• API Environmental Guidance Document E5, Waste Management in Exploration and Production Operations***

***• API Bulletin E2, Bulletin on Management of Naturally Occurring Radioactive Waste Materials (NORM) in Oil and Gas Production***

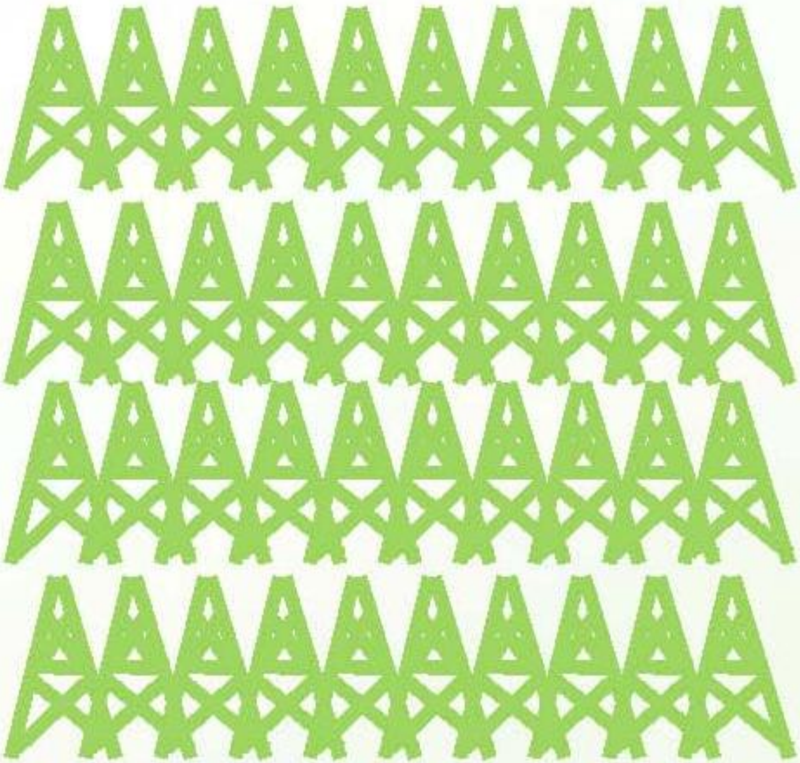
***• API Bulletin E3, Environmental Guidance Document: Well Abandonment and Inactive Well Practices for U.S. Exploration and Production Operations***

***• API Bulletin 11K, Data Sheet for Design of Air Exchange Coolers***

***• API Bulletin 75L, Guidance Document for the Development of a Safety and Environmental Management System for Onshore Oil and Natural Gas Production Operations and Associated Activities***

***• API Publication 4663, Remediation of Salt-Affected Soils at Oil and Gas Production Facilities***

# How Much Salt?




3,100 Horizontal Marcellus gas wells = salt dumped on only state roads annually

# Water Treatment and Disposal

NaturalGas
Tapping Pennsylvania's Potential

Safely re-used or transported to permitted and approved wastewater facilities. The treated water contains higher-than-usual levels of salt, which is then diluted to safe levels in rivers or large streams. This type of treatment has been safely employed across the nation for decades

# The Industry is not opposed to disclosing the chemical makeup to public health officials

- The natural gas industry **supports the disclosure of what is used** in the hydraulic fracturing process to state regulators, local authorities and hospitals to ensure they have the information they need.  Disclosing specific fluid formulas is generally not required by states, but the **industry is not opposed to disclosing them** so long as proprietary business information is kept confidential. Colorado has a system that **protects the confidentiality of businesses while also providing to public health and medical professionals when a need arises** the detailed and important information about the specific mix of ingredients used by each company

# Drilling

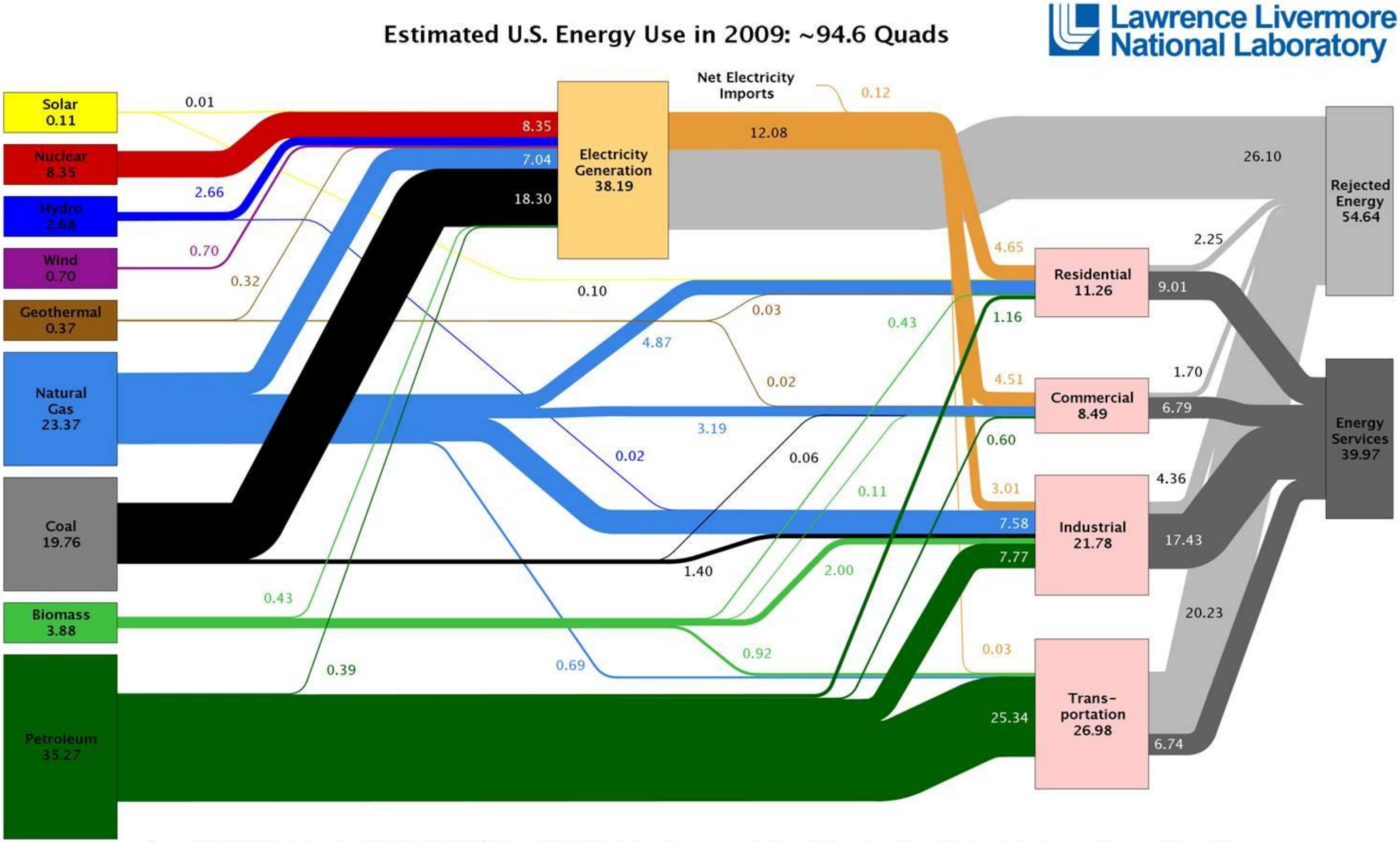
**Fracing**

# Fracing

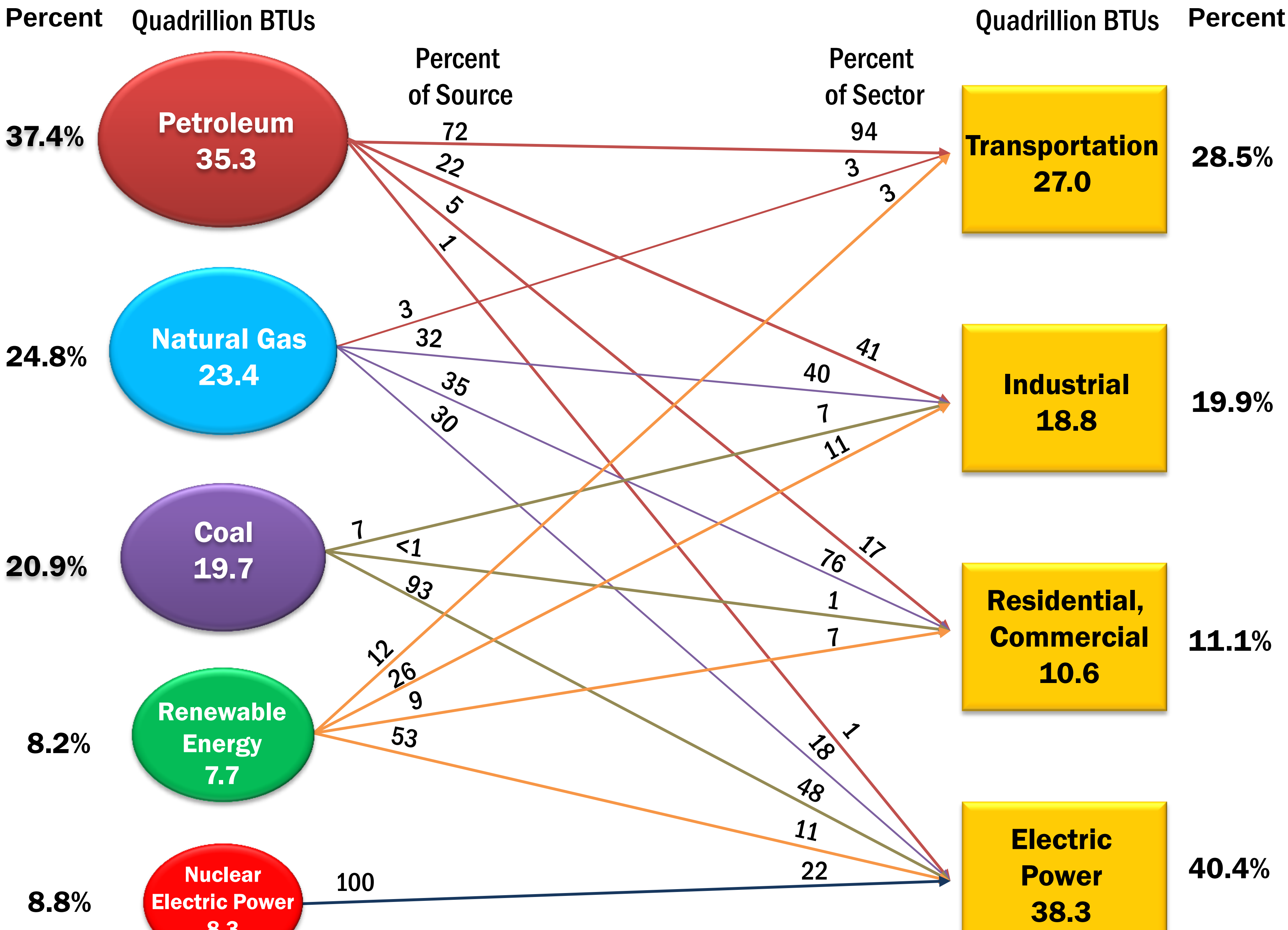
**Production,** roughly size of a 1-2 car garage

Final Reclamation

## Estimated U.S. Energy Use in 2009: ~94.6 Quads




Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527



Percent
Quadrillion BTUs
Percent of Source
Percent of Sector
Quadrillion BTUs
Percent
37.4%
Petroleum 35.3
24.8%
Natural Gas 23.4
20.9%
Coal 19.7
8.2%
Renewable Energy 7.7
8.8%
Nuclear Electric Power 8.3
Transportation 27.0
28.5%
Industrial 18.8
19.9%
Residential, Commercial 10.6
11.1%
Electric Power 38.3
40.4%
72
22
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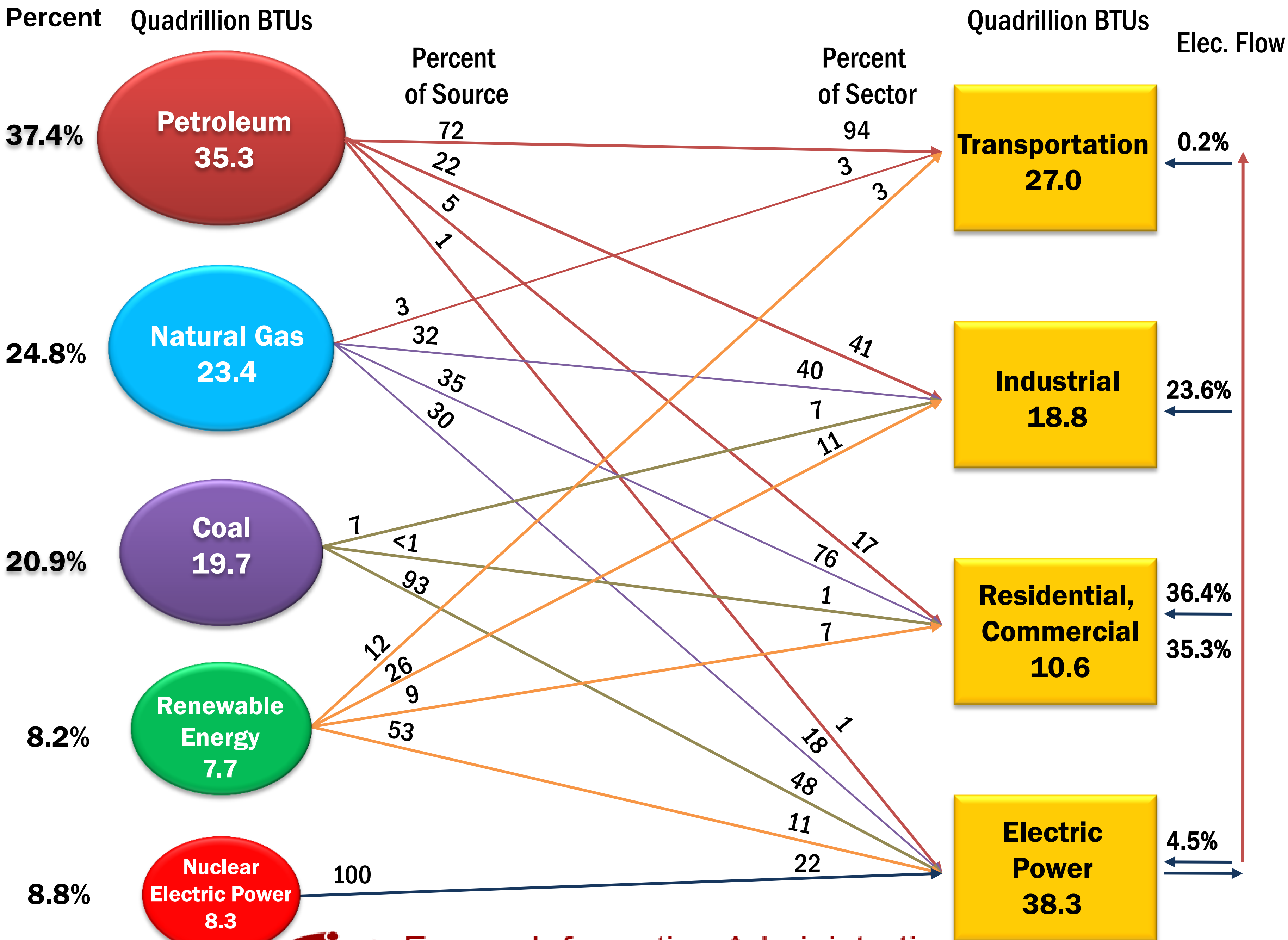
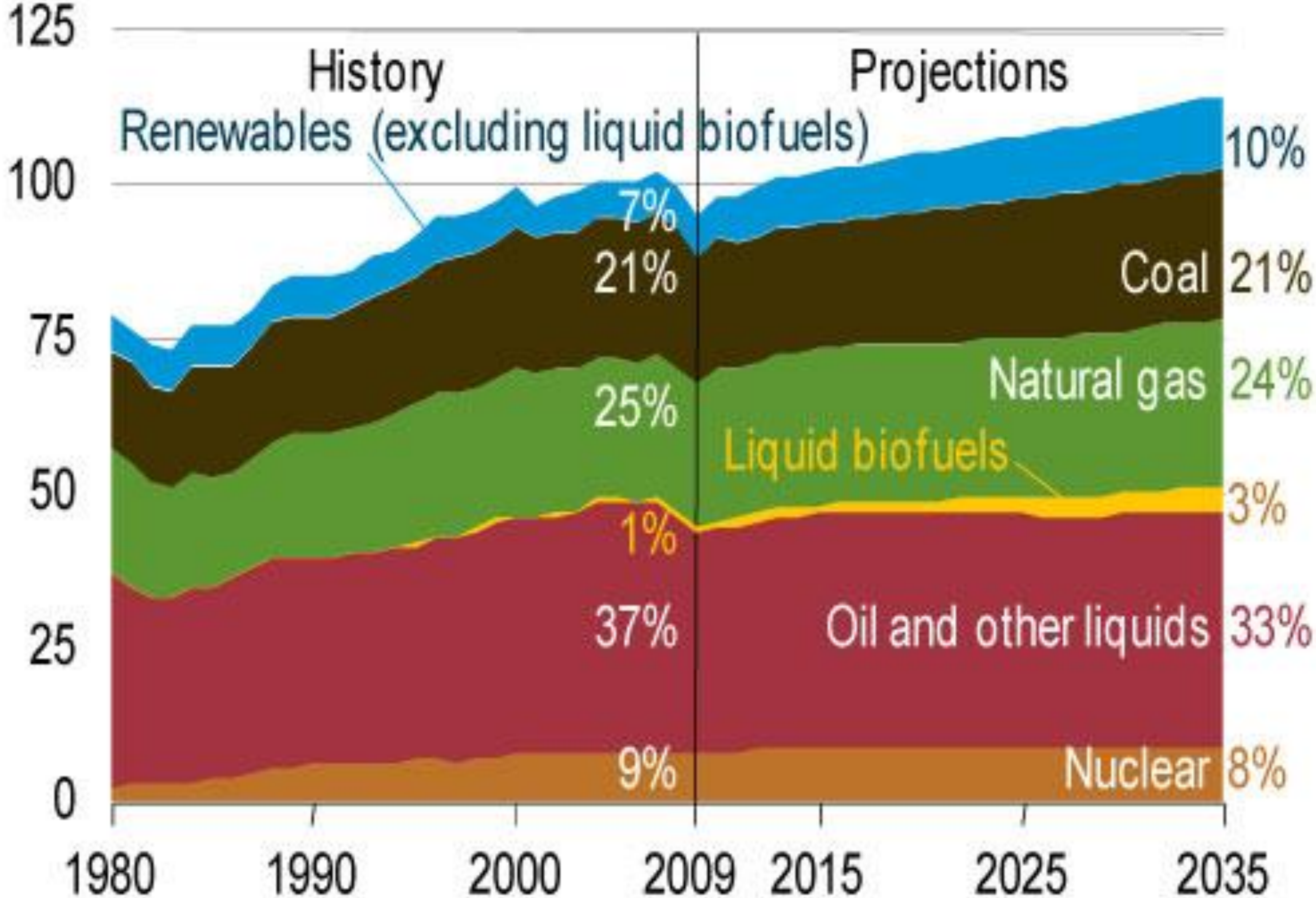



Energy Information Administration
Official Energy Statistics from the U.S. Government

Figure 7. Energy consumption by fuel, 1980-2035

Primary energy consumption (quadrillion Btu per year)




Energy Information Administration

Official Energy Statistics from the U.S. Government

| | 2009 | | 2035 | | % Change |
|---|---|---|---|---|---|
| **Consumption** | **Quads** | *% Share* | **Quads** | *% Share* | |
| **Liquid Fuels and Other Petroleum** | **36.62** | **38.6%** | **41.70** | **36.5%** | **13.9%** |
| Oil | 35.63 | 37.6% | 37.97 | 33.2% | 6.6% |
| Ethanol, Biodiesel and Green Liquids | 0.99 | 1.0% | 3.73 | 3.3% | 276.8% |
| | | | | | |
| Natural Gas | **23.31** | **24.6%** | **27.24** | **23.9%** | **16.9%** |
| | | | | | |
| Coal | **19.69** | **20.8%** | **24.3** | **21.3%** | **23.4%** |
| | | | | | |
| Nuclear Power | **8.35** | **8.8%** | **9.14** | **8.0%** | **9.5%** |
| | | | | | |
| Hydropower | **2.69** | **2.8%** | **3.09** | **2.7%** | **14.9%** |
| | | | | | |
| Biomass & Renewables | **3.81** | **4.0%** | **8.47** | **7.4%** | **122.3%** |
| | | | | | |
| Other* | 0.32 | 0.3% | 0.25 | 0.2% | **-21.9%** |
| | | | | | |
| **Total** | **94.79** | 100.0% | **114.19** | 100.0% | **20.5%** |
| | | | | | |
| **Oil and Natural Gas** | **58.94** | 62.2% | **65.21** | 57.1% | **10.6%** |
| | | | | | |
| **Oil, Natural Gas and Coal** | **78.63** | 83.0% | **89.51** | 78.4% | **13.8%** |

# Thank You

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