

Tight Oil and Worker Safety & Health

John Howard
National Institute for Occupational Safety and Health
Washington, D.C.

24th California Industrial Hygiene Council Conference

3 December 2014
San Diego, California

Energy Outlook 2035

- In developed countries, gas will overtake oil as the dominant fuel by 2031, reaching a share of 31% in primary energy by 2035.
- Among today's energy importers, U.S. is on a path to achieve energy self-sufficiency, while import dependence in Europe, China and India will increase.

--BP Energy Outlook, 2014. http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/Energy_Outlook_2035_booklet.pdf

The U.S. is set to shift from a net importer of gas today to a net exporter in 2018, with net exports reaching 10.6 Bcf/d by 2035.

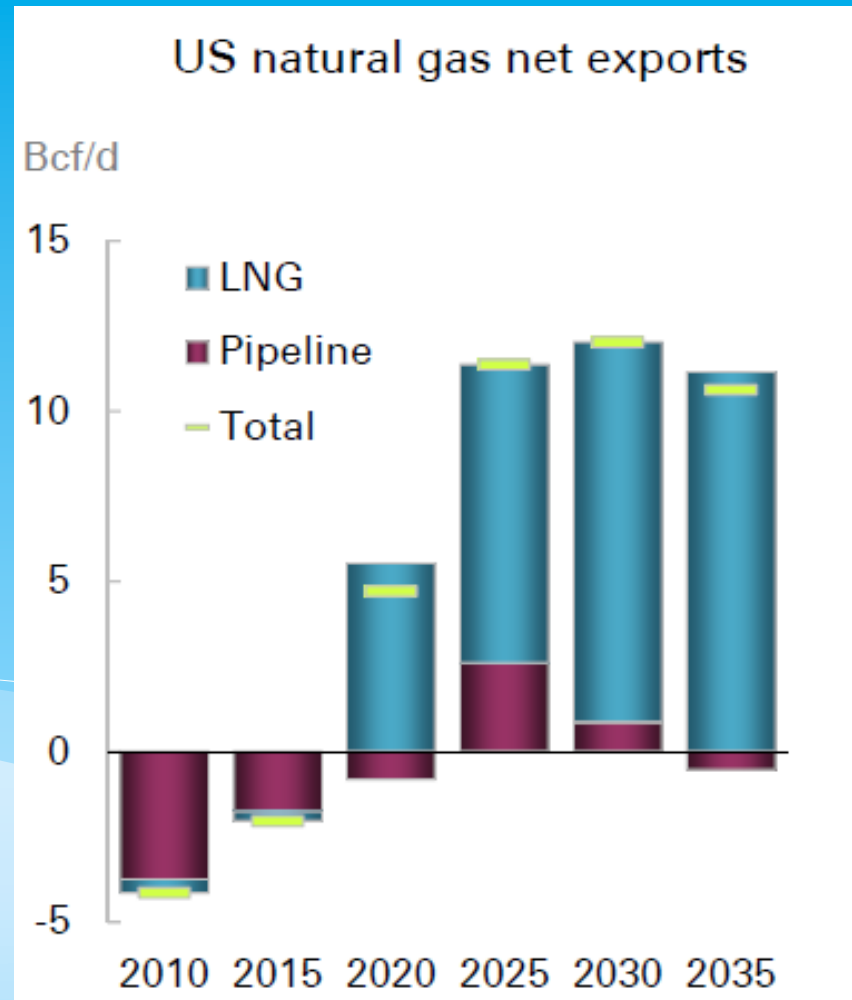
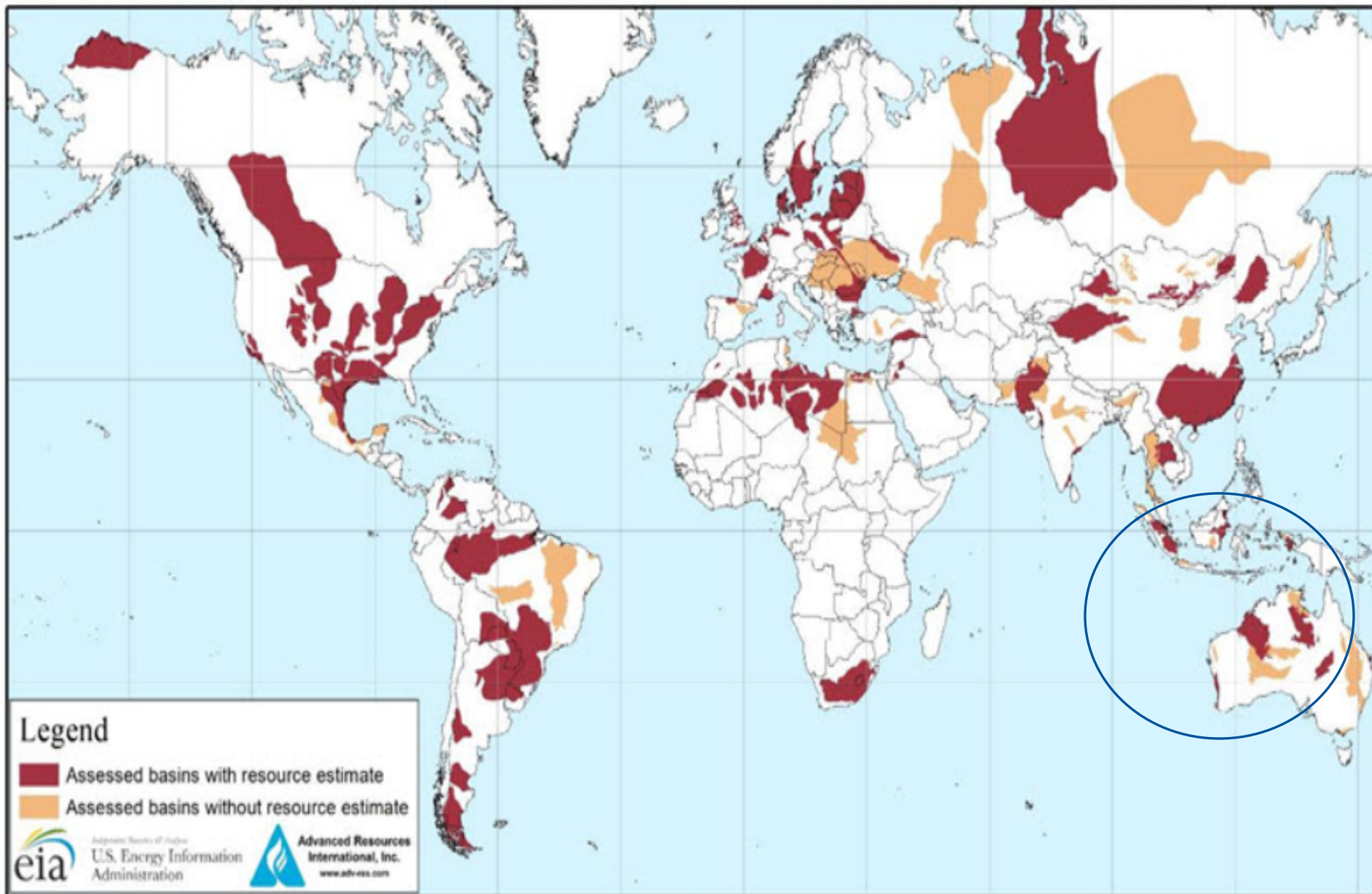
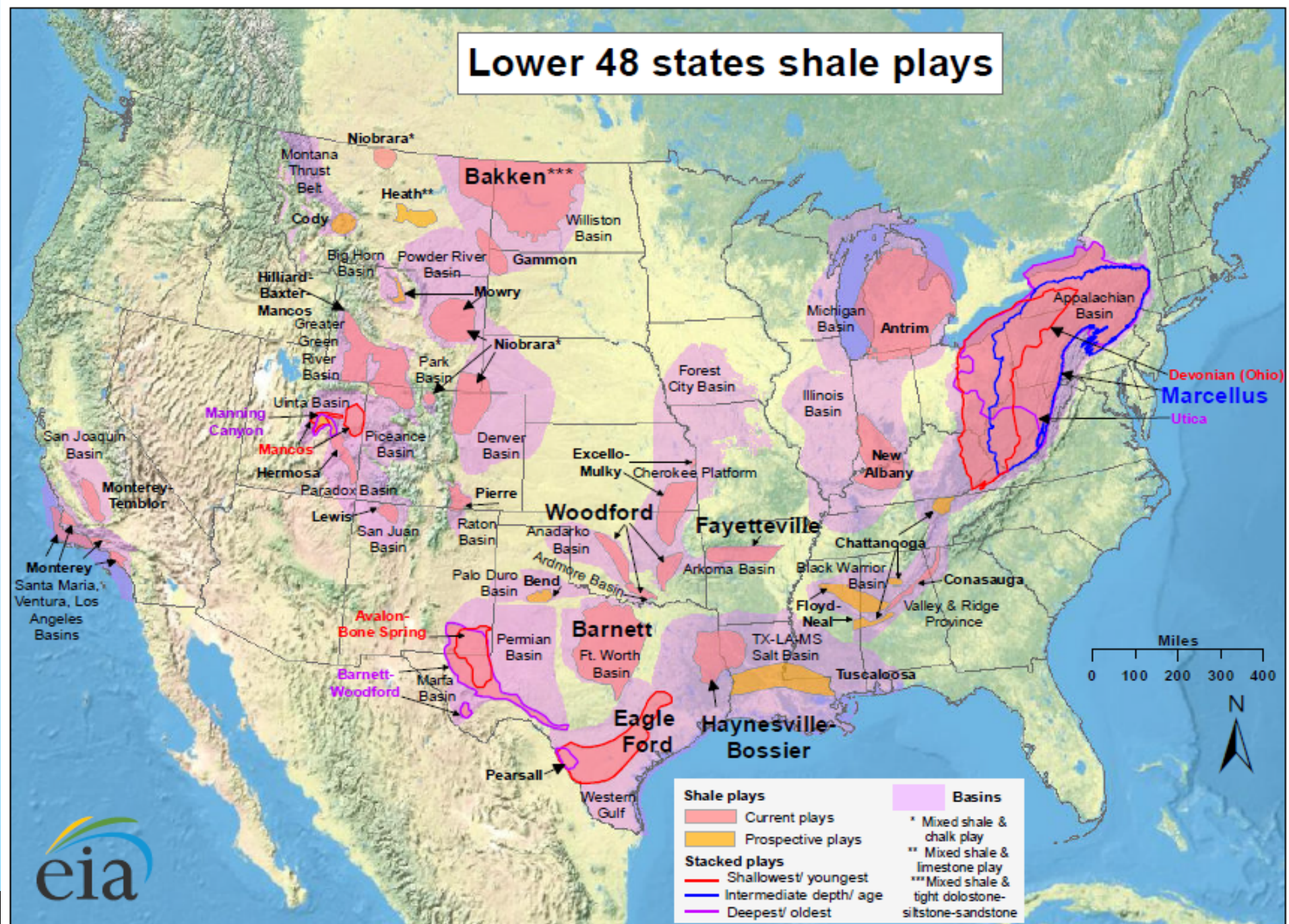


Figure 1. Map of basins with assessed shale oil and shale gas formations, as of May 2013



Source: United States basins from U.S. Energy Information Administration and United States Geological Survey; other basins from ARI based on data from various published studies

Lower 48 states shale plays

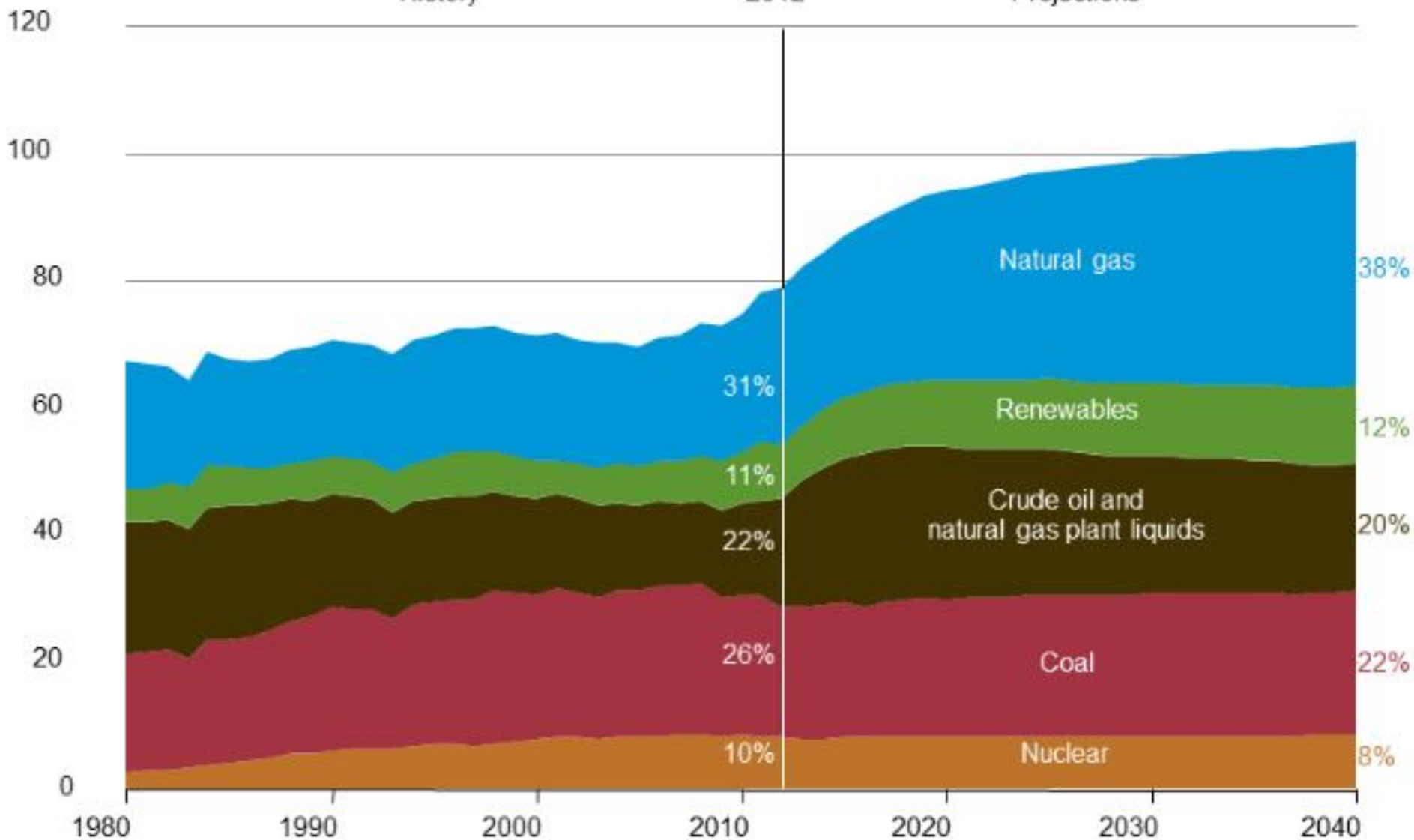


(quadrillion Btu)

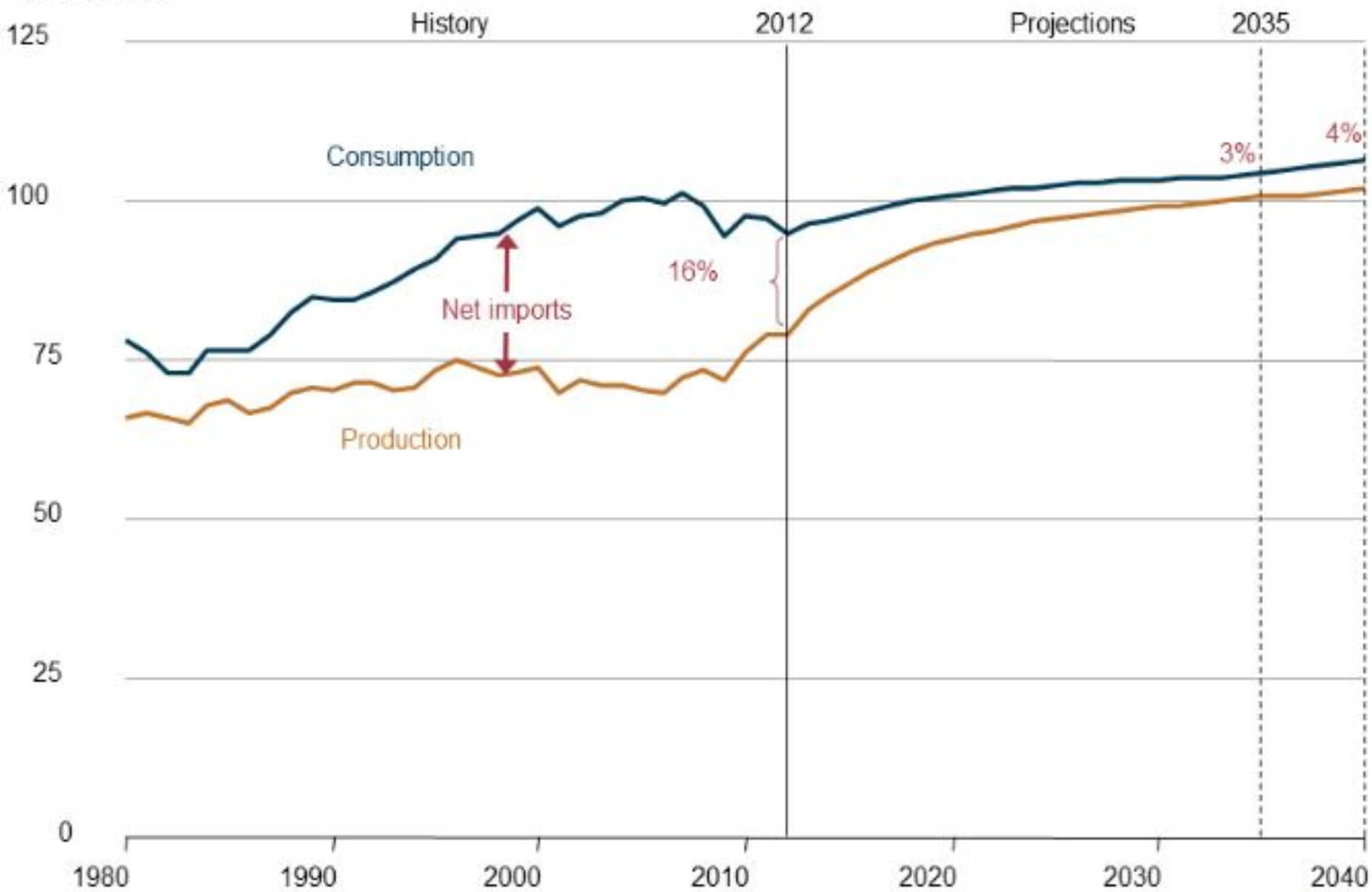
History

2012

Projections



(quadrillion Btu)

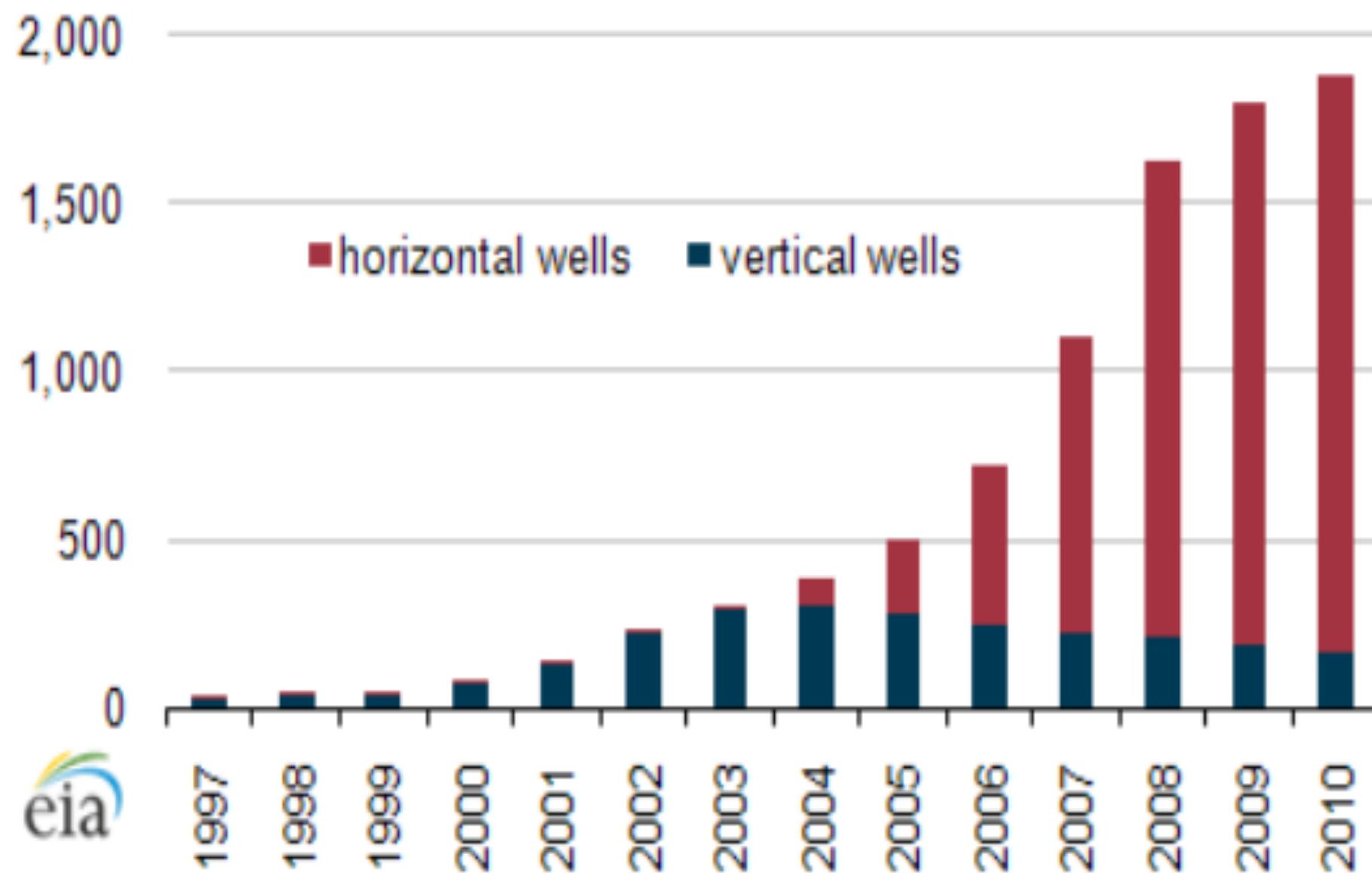


History of U.S. Shale Gas and Oil Plays

- Use of horizontal drilling in conjunction with hydraulic fracturing greatly expanded ability to recover natural gas and oil from low-permeability geologic plays
- Advent of large-scale gas production did not occur until 1980s/90s when Mitchell Energy experimented with hydraulic fracturing in the Barnett Shale in North-Central Texas
- By 2005, Barnett Shale was producing 0.5 trillion cubic feet of natural gas per year

Annual Barnett shale natural gas production by well type

billion cubic feet (Bcf)



Source: U.S. Energy Information Administration based on HPDI, LLC

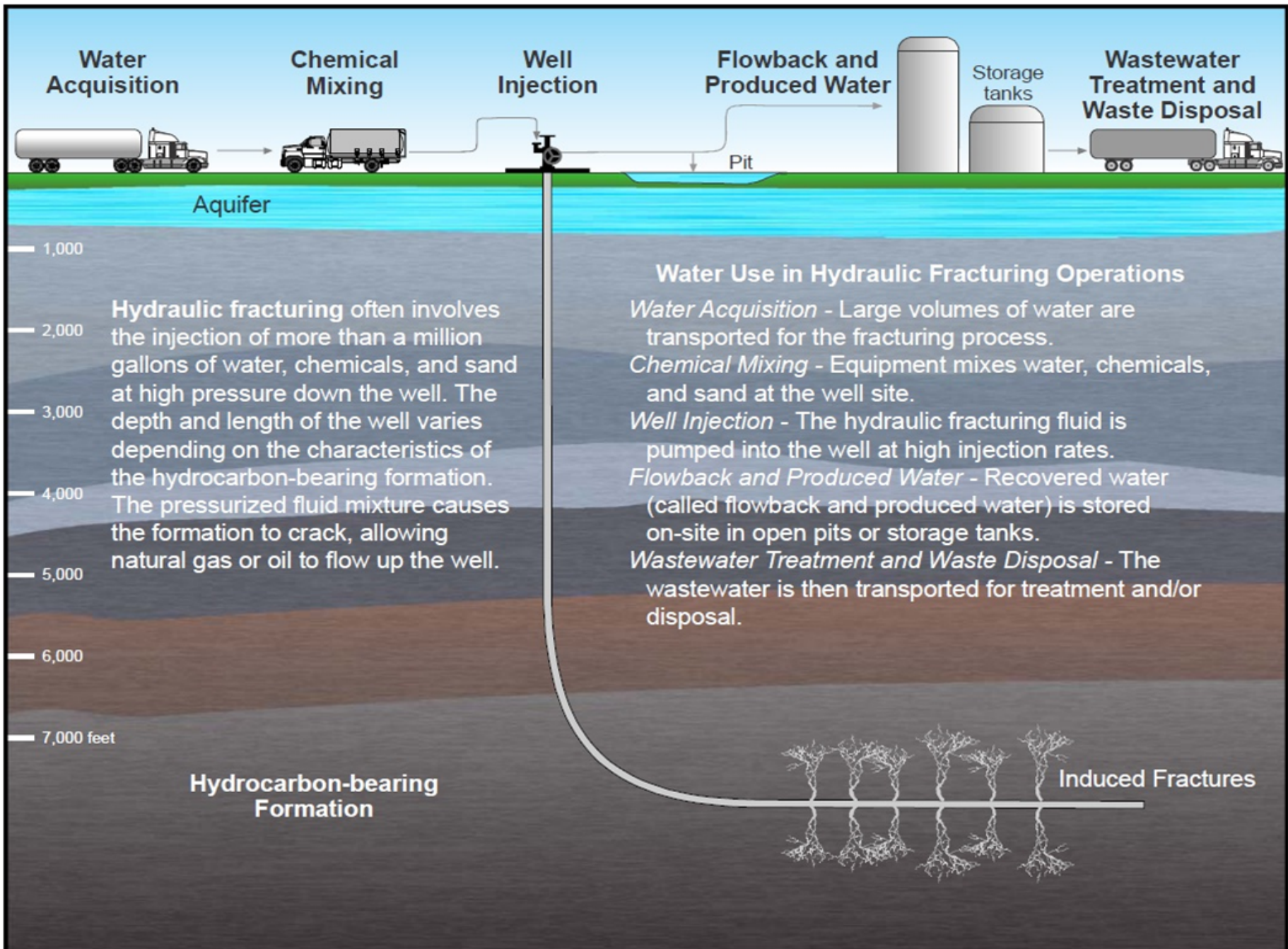


FIGURE 6. ILLUSTRATION OF A HORIZONTAL WELL SHOWING THE WATER LIFECYCLE IN HYDRAULIC FRACTURING

Sand Acts As a Proppant in Hydraulic Fracturing



Source: U.S. Global Investors

Sand as a Proppant

- * Virtually 100% silica
- * 10,000 tons / well
- * **Proppant**--solid material, typically treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment.
- * Added to a **fracking fluid** which may vary in composition depending on the type of fracturing used, and can be **gel, foam** or **slickwater**-based.





Monterey Formation

The Monterey Formation is an extensive Miocene oil-rich geological sedimentary formation in California, with outcrops of the formation in parts of the California Coast Ranges, Peninsular Ranges, and on some of California's off-shore islands



California Fracking Rules Slammed By Environmentalists As Shale Oil Boom Threatens To Remake State

Posted: 12/19/2012 5:48 pm EST | Updated: 12/24/2012 8:02 pm EST



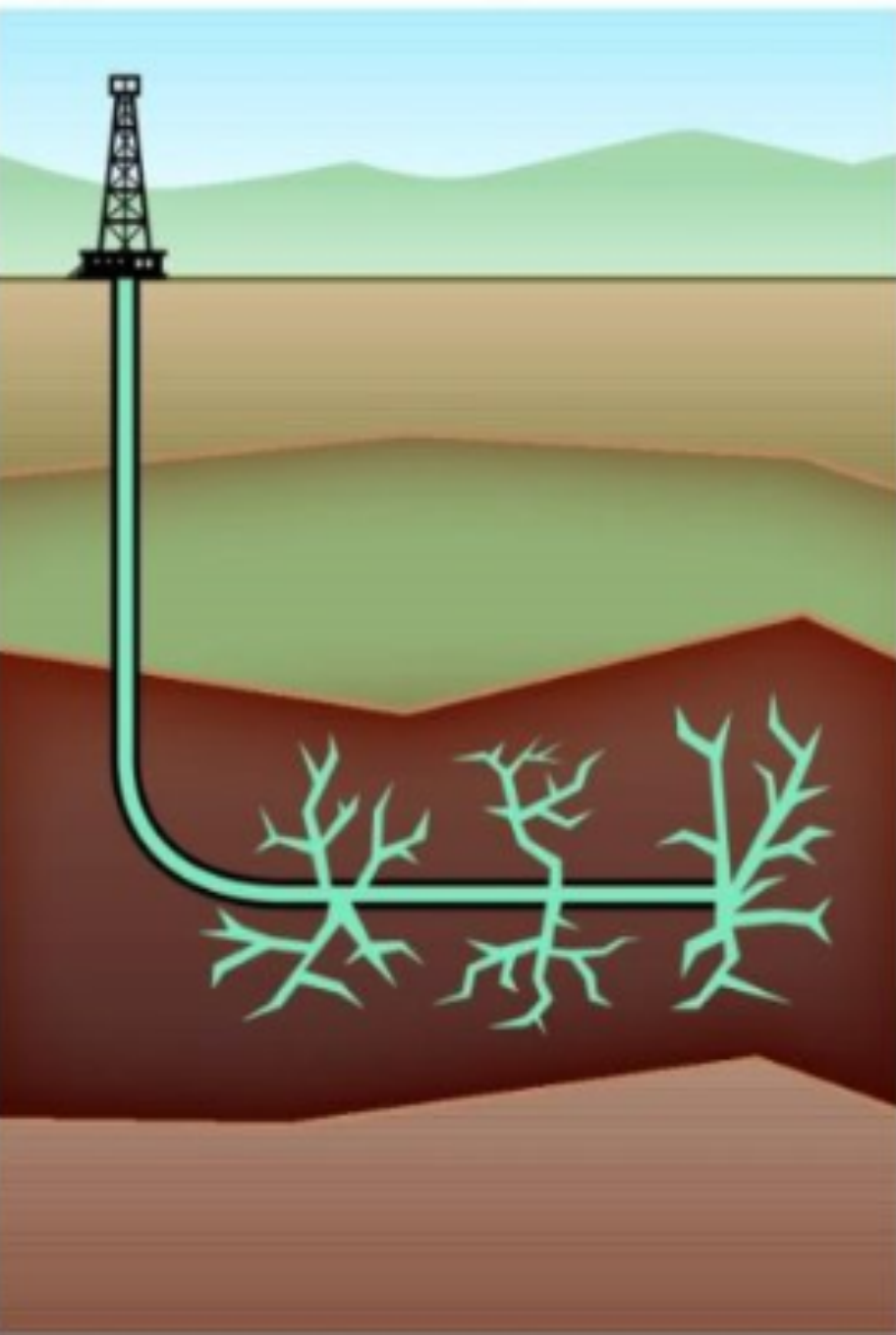
U.S. officials cut estimate of recoverable Monterey Shale oil by 96%



EIA: *Technical Recoverability Using Today's Methods Reduced*

- The amount of oil in the Monterey Shale has not changed.
- There were approximately 400 billion barrels of oil in the Monterey Shale yesterday, and the same amount exists today.
- Estimate of recoverability—13.7 to 15.4 billion to 600 million *using today's techniques*

Typical shale deposit



Monterey Shale



Public and Worker Health Concerns

* Public Concerns:

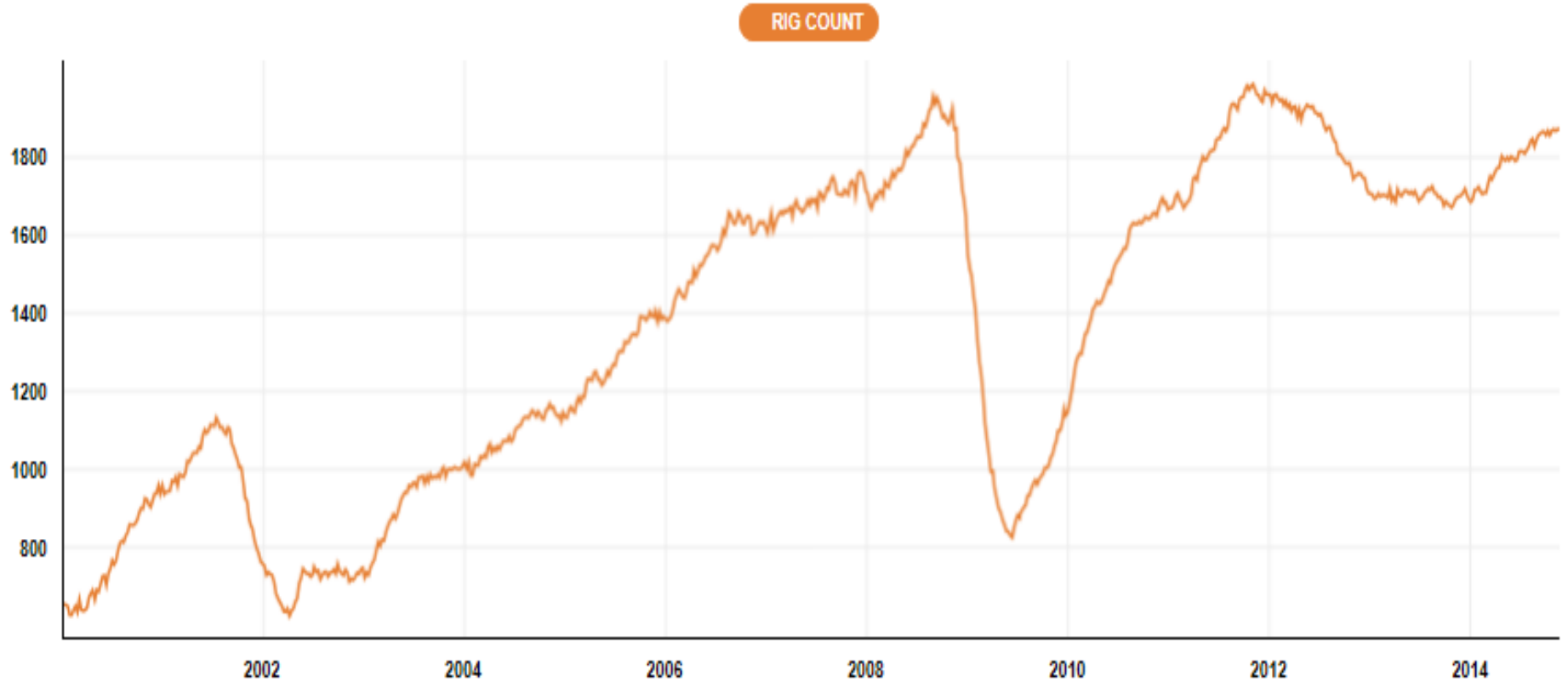
- * Increased greenhouse gas emissions
- * Decreased incentive for renewable sources
- * Contamination of the water table
- * Earthquakes
- * Increased trucking and RR transport
- * Keystone pipeline controversy—spills and environmental degradation

* Worker Concerns?

A Decade of Growth in the U.S. Oil and Gas Extraction Industry

- * Number of workers employed in the industry has doubled since 2003—293,000 to 587,000
- * Number of active rotary rigs has increased by 70%

Industry Activity Index—Rotary Rig Count



Relationship Between Growth & Safety

- * **Economic expansion can result in increases in workplace injury rates/workers' comp claims**
 - * Changes in incidence rates are significantly correlated with annual changes in economic variables such as aggregate employment and increased economic output
- * Safety measures have a counter effect on injuries, illnesses and workers' compensation claims

* Ussif, Al-Amin. *Monthly Labor Review* 2004:41-51

NIOSH Oil and Gas: 1983

Comprehensive Safety Recommendations for Land-Based Oil and Gas Well Drilling

NIOSH

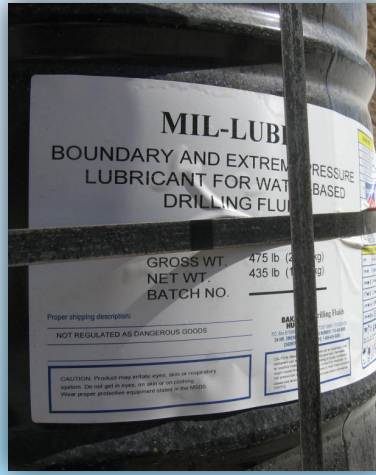
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

NIOSH Oil & Gas: 2014

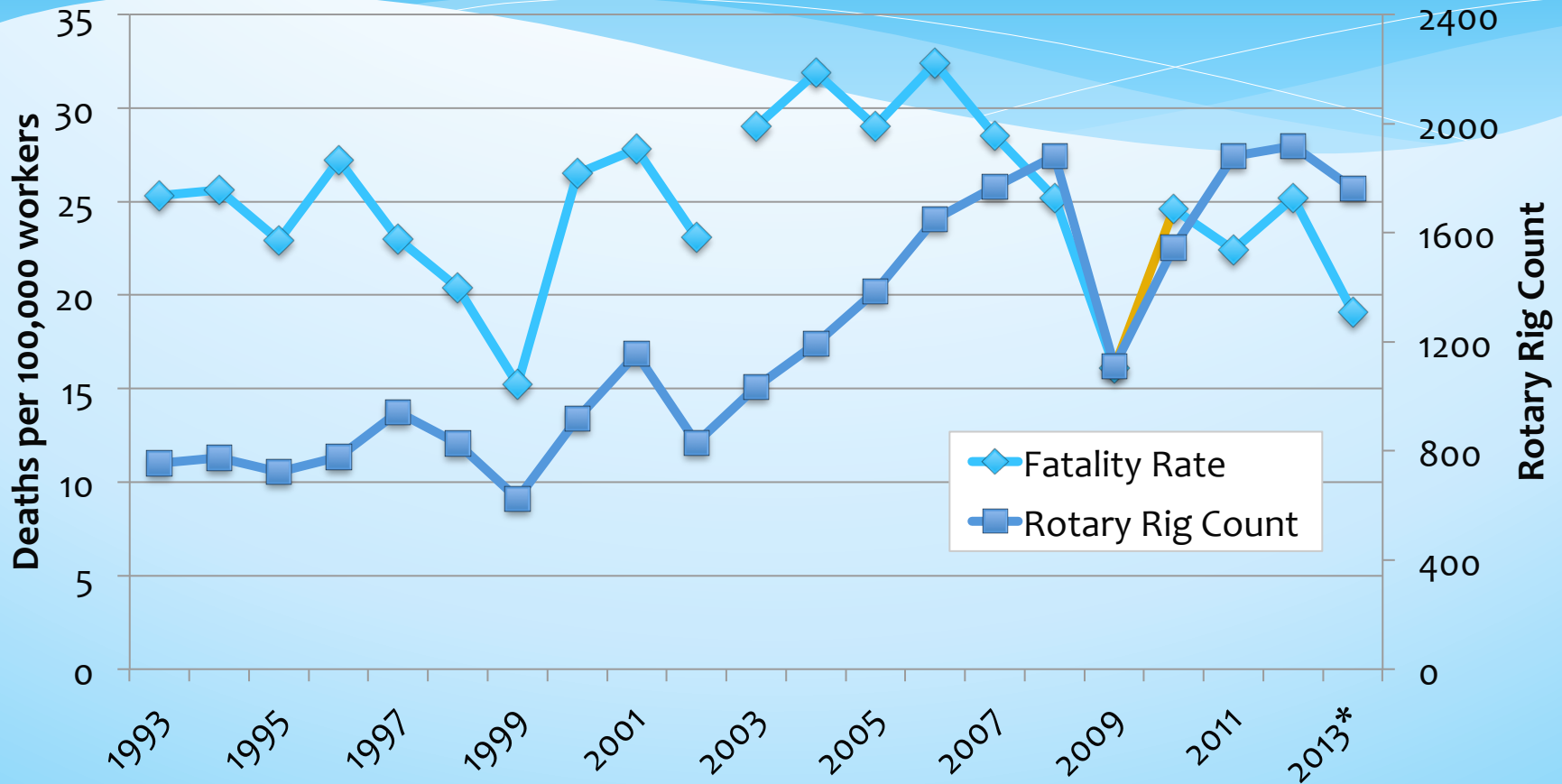
- * **Research** to identify and characterize the most significant safety and health issues in modern oil & gas exploration and extraction
- * **Partner** with industry, labor, and other stakeholders to leverage talent and commitment for the safety and health of workers
- * **Prevent** injury and illness through development of high-impact prevention strategies, recommendations & practical workplace technological solutions



Occupational Exposure Risks?



Occupational Fatality Rate and Industry Activity, Oil & Gas Extraction: 1993-2013



NORA Oil & Gas Extraction Council Members



Possible Chemical Exposures

- * Silica
- * Diesel emissions
- * Volatile organic compounds (VOCs)
- * Hydrogen sulfide (H₂S)
- * Acids/bases
- * Ozone, oxides of nitrogen
- * Biocides (aldehydes, others)
- * Polycyclic Aromatic Hydrocarbons (PAHs)
- * Metals (e.g., Pb)

Not an inclusive list



Sand Operator



Exposure Assessment: Sand Moving



Dragon's tail



Blender hopper

Sand refill truck

Dust Generation Points

- * Release from top hatches, sand movers
- * Transfer belt under sand movers
- * Site traffic
- * Sand dropping in blender hopper
- * Release from T-belt operations
- * Release from “dragon’s tail”
- * Dust ejected from fill ports on sand movers

11 Site visits, 116 PBZ samples for silica



54 / 116 (47%) > OSHA PEL
92 / 116 (79%) > NIOSH REL
36 / 116 (31%) > 10 X NIOSH REL

Worker Exposure to Silica during Hydraulic Fracturing



https://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html

**Work premises
and facilities**

**Tools and
equipment**

Processes

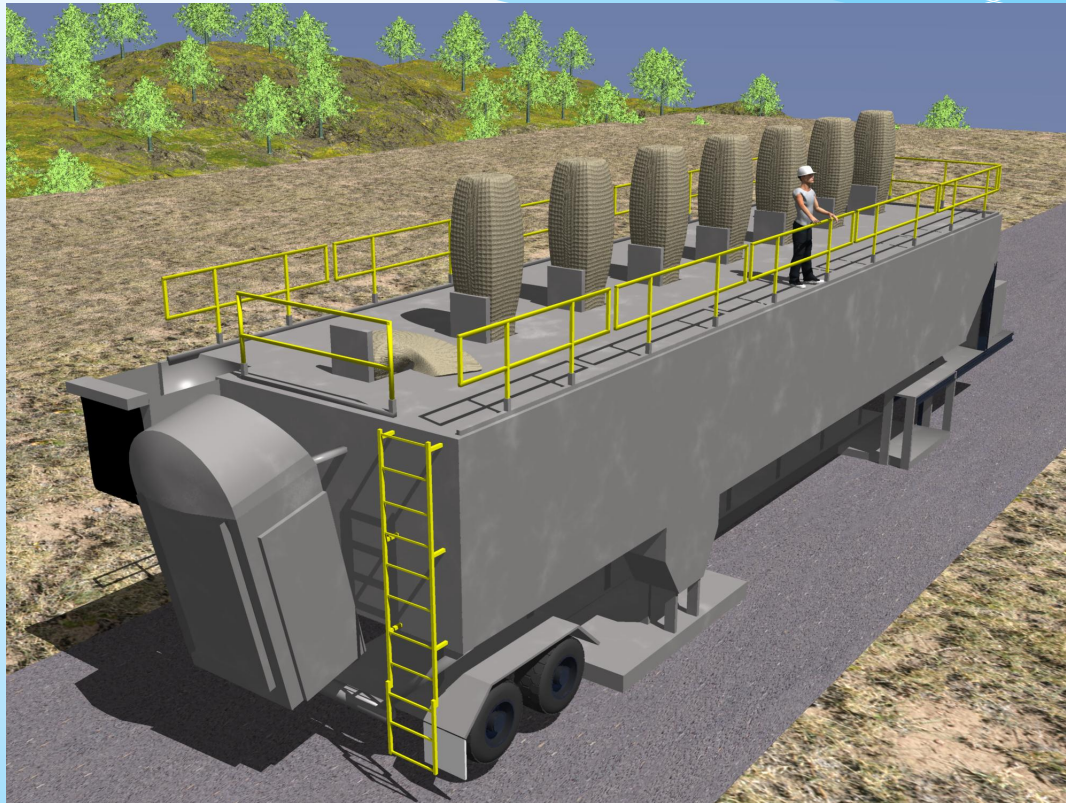


**Work methods
and organization
of work**

Products

Engineering Control Concepts

NIOSH Mini-Baghouse retrofit assembly



NIOSH Mini Baghouse Retrofit Assembly

- * Conceive
- * Design, fabricate
- * Proof of concept
- * Refine design
- * Field trials
- * License
 - * Patent pending
- * Manufacture
- * Distribute

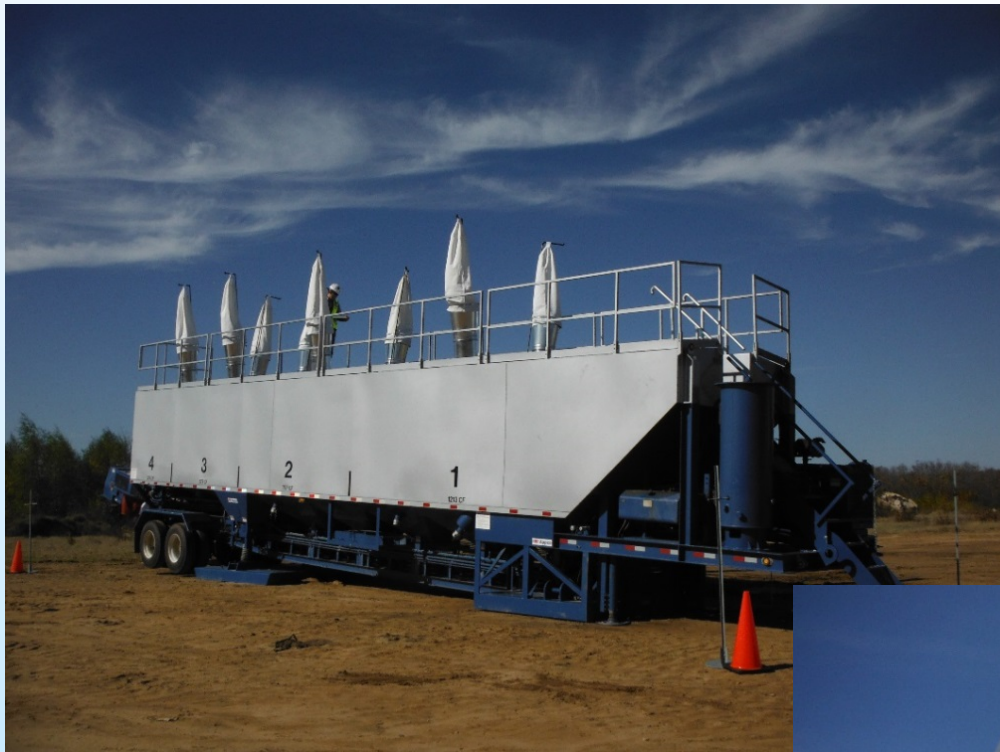


Field Evaluation



Field Evaluation





Controlled vs. Uncontrolled



Controlled vs. Uncontrolled



Simultaneous Filling – 4 bins



A few glitches...



Spring Clamp



Spring clamp failure



Bag Failure



Sharp
edges on
spring
clamp
pierced bag

Portable on-site baghouse



Ductwork Connected to Thief Hatches



Potential Chemical Exposures

- * Diesel particulate s
 - * <http://www.cdc.gov/niosh/topics/cancer/diesel/>
- * Volatile organic compounds (NBTEX)
- * Hydrogen sulfide (H₂S)
- * Acid gases (HCL)
- * Aldehydes (biocides)
- * Metals (Pb)

Flowback Operations: Pit Aeration



Volatile organic compounds (VOCs):
- Naphthalene, benzene, toluene, ethylbenzene, xylenes (NBTEX)

Workers Evaluated

- * Flowback Tech
- * Gauging or strapping flowback tanks



Workers Evaluated

Flowback Leadman Monitoring/Operating Separator



Workers Evaluated

- * Production Watch
- * Gauging production tanks



Workers Evaluated

- * **Water management**
 - * Pump operation, gauging, pumping tanks

- * **Miscellaneous**
 - * Lease operators
 - * Water treatment
 - * Water haulers

Diesel particulate (DPM)



Photo: courtesy of Jeff Swenson, for the NY Times

Diesel particulate (DPM)



Daytime



Early morning

Industrial Bactericides



Baker Petrolite Corporation
 A Baker Hughes Company
 12645 W. Airport Boulevard
 Sugar Land, TX 77478-5050

Emergency Telephone Numbers:
CHEMTREC: 1-800-424-9300
Baker Petrolite Corporation: 1-800-231-3666
For Emergencies or Product Information:
(001)281-276-5400

CHEMTREC Intl.: 01-703-527-3887

PRECAUTIONARY STATEMENTS
HAZARD TO HUMANS AND DOMESTIC ANIMALS

Avoid breathing dust, fumes, or mist. Do not get on skin. Corrosive. Causes eye irritation. Do not get in eyes or on clothing. Wear goggles or face shield and rubber gloves when handling. Avoid contamination of food.

ENVIRONMENTAL HAZARDS

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans or other waters, unless in accordance with the requirements of a National Pollution Discharge Elimination System (NPDES) permit and the receiving authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without the approval of the local sewage treatment plant authority. For more information, contact your State Water Board or Regional Office of the EPA.

PHYSICAL OR CHEMICAL HAZARDS

Keep away from heat and flame.

X-CIDE® 102
Industrial Bactericide

FOR USE IN INDUSTRIAL PROCESSES ONLY.
 NOT FOR DOMESTIC USE.

| | |
|--------------------|--------|
| ACTIVE INGREDIENT: | 25.0% |
| Glutaraldehyde | 25.0% |
| INERT INGREDIENTS: | 100.0% |
| TOTAL: | 100.0% |

KEEP OUT OF REACH OF CHILDREN
DANGER

SEE SIDE PANELS FOR ADDITIONAL PRECAUTIONARY STATEMENTS

| FIRST AID | |
|--|--|
| Call poison control center or doctor immediately for treatment advice. Have the product container or label with you when calling a poison control center or going for treatment. | |
| IF IN EYES | <ul style="list-style-type: none"> Flush eyes open and rear slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after flushing. Then resume flushing. |
| IF ON SKIN OR CLOTHING | <ul style="list-style-type: none"> Take off contaminated clothing. Remove all contaminated clothing. |
| IF SWALLOWED | <ul style="list-style-type: none"> Call a physician or poison center or doctor immediately for treatment advice. Give person at least 8 glasses of water or milk to swallow. Do not induce vomiting unless told to do so by the poison control center or doctor. Do not give anything to drink to a conscious person. |
| IF INHALED | <ul style="list-style-type: none"> Move person to fresh air. If person is not breathing, call 911 or an ambulance. Then give artificial respiration. If person is not breathing, use a resuscitator if you are trained. Do not use mouth-to-mouth respiration. Do not give anything to drink to a conscious person. |

NOTE TO PHYSICIAN: Product may cause allergic reactions. Reaction of certain people. Symptoms depend on severity of exposure. Irritation and symptoms may be delayed.

EPA Registration Number: 1007-60
 EPA Establishment Number: 10107 TX-008, 10107 TX-003, 10107 LA-001, 10107 ME-001

DISTRIBUTED BY: [Company Name]

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

X-CIDE® 102 Industrial Bactericide is a bactericide used for controlling sulfate reducing bacteria in water/food processing systems with the "usually characteristic" air flotation unit in the clear water injection pump.

X-CIDE® 102 Industrial Bactericide is a bactericide used for controlling sulfate reducing bacteria in water/food processing systems with the "usually characteristic" air flotation unit in the clear water injection pump.

X-CIDE® 102 Industrial Bactericide is a bactericide used for controlling sulfate reducing bacteria in water/food processing systems with the "usually characteristic" air flotation unit in the clear water injection pump.

STORAGE: Do not store in areas where children can access. Do not store in areas where children can access.

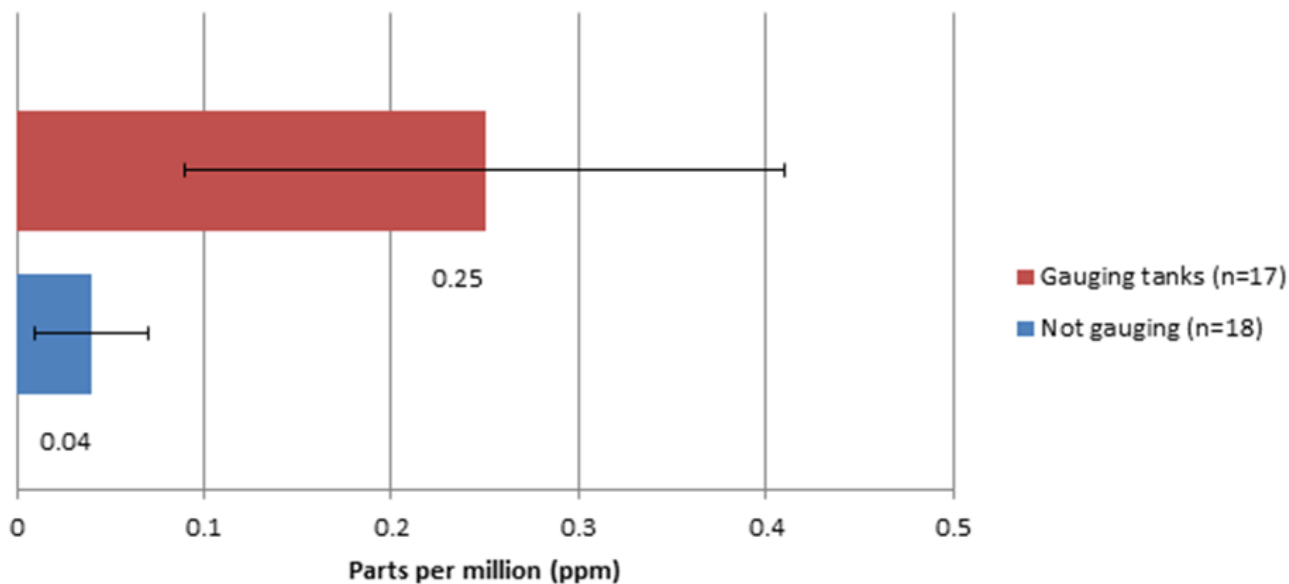
RESTRICTION: Do not use in areas where children can access. Do not use in areas where children can access.

CONTAINER: Do not use in areas where children can access. Do not use in areas where children can access.



Benzene – Tank Gauging Personal Breathing Zone

PBZ Mean Benzene Concentrations



Range: N.D. to 0.65 ppm

Spot Measurements: Tank Headspace

- * Flowback tank (no controls)

- * VOCs: 10–2000 ppm
- * Benzene : 0–>250 ppm

- * Flowback tanks (with controls)

- * Reduced Emissions Completions (REC)
- * VOCs: 10–400 ppm
- * Benzene: 0–30 ppm



Spot Measurements: Tank Headspace

- * Production tanks
 - * VOCs: 10→2000 ppm
 - * Benzene: 0→300 ppm
- * Water tanks
 - * VOCs: 10–200 ppm
 - * Benzene: 0→40 ppm



Other Compounds Monitored

* Glutaraldehyde:

- * All PBZ and area samples below limit of detection (LOD), except for one
- * one PBZ sample returned a trace concentration

* Propargyl Alcohol ($\text{HC}\equiv\text{CCH}_2\text{OH}$):

- * All area samples below LOD, except for one
- * one area sample returned result of 0.0043 ppm

* Methanol:

- * All area samples below LOD

Flammable/Explosive Hazards

- * **Direct reading instruments showed instances of short term excursions measuring as high as 40% of the Lower Explosive Limit (LEL)**

Hydraulic Fracturing: Future Work

- * Exposure characterization of diesel particulate, VOCs, metals, physical hazards
- * Animal studies to research mixed exposures
- * Worker Registry
- * Health Hazard Evaluations



Oil & Gas Extraction Products

RIG CHECK

Rig Check was developed by the National Institute for Occupational Safety and Health (NIOSH) in partnership with safety reports from the oil and gas extraction industry. It is made up of 36 inspection forms. The forms are designed to be used by rig workers to document the inspection of tools and equipment commonly found on rotary and surface rigs. Each inspection form includes instructions for completing and recording the condition of the equipment. Where applicable, relevant federal regulations and industry best practices are included.

The Rig Check inspection forms are an excellent training tool for short-tenure employees, who may not be familiar with the tools and equipment found on oil and gas rigs. Rig Check complements safety and health resources available on the Rig Check website for enhancing their rig programs. The forms can also be downloaded from the website located at: www.cdc.gov/niosh/publications/rigcheck.html.

Rig Check Monthly Inspection Forms:

| Emergency Response | Tools & Rigging | Lockout & Tagout |
|--|---------------------------------|----------------------------------|
| 1. Emergency Response Plan | 1. Fall Protection | 1. Lockout & Tagout Plan |
| 2. Emergency Evacuation | 2. Fall Protection Training | 2. Lockout & Tagout Training |
| 3. Emergency Evacuation Drills | 3. Fall Protection Equipment | 3. Lockout & Tagout Equipment |
| 4. Emergency Evacuation Routes | 4. Fall Protection Inspections | 4. Lockout & Tagout Inspections |
| 5. Emergency Evacuation Procedures | 5. Fall Protection Use | 5. Lockout & Tagout Use |
| 6. Emergency Evacuation Responsibilities | 6. Fall Protection Storage | 6. Lockout & Tagout Storage |
| 7. Emergency Evacuation Communication | 7. Fall Protection Removal | 7. Lockout & Tagout Removal |
| 8. Emergency Evacuation Documentation | 8. Fall Protection Disposal | 8. Lockout & Tagout Disposal |
| 9. Emergency Evacuation Reporting | 9. Fall Protection Maintenance | 9. Lockout & Tagout Maintenance |
| 10. Emergency Evacuation Review | 10. Fall Protection Replacement | 10. Lockout & Tagout Replacement |

NIOSH

TAKE PRIDE IN YOUR JOB: SEAT BELTS

TAKE PRIDE IN YOUR JOB: FALL PROTECTIVE

NIOSH

MOVE IT!

Rig Move Safety for Roughnecks

NIOSH

MOVE IT!

Rig Move Safety for Truck Drivers

NIOSH

OIL & GAS EXTRACTION SECTOR COUNCIL

NORA

The Business Impact of Injuries and Incidents

Warren Hubler, CSP
VP for HSE & Training, H&P-IDC
07 February 2012

NIOSH FACT SHEET

NIOSH FIELD EFFORT TO ASSESS CHEMICAL EXPOSURE RISKS TO GAS AND OIL WORKERS

BACKGROUND

There is a lack of existing information regarding the variety and magnitude of chemical exposure risks to oil and gas extraction workers. To determine if risks are present, NIOSH wants to develop partnerships with the oil and gas extraction industry to identify, characterize and (if needed) control workplace chemical exposures. This work will occur as part of the NIOSH Oil and Gas Extraction Safety and Health Program, which seeks to prevent injuries and illnesses among oil and gas extraction workers. Strategic objectives include identifying possible exposures, determining risk, and preventing chemical exposures to workers involved in oil and gas extraction industry.

PURPOSE

The goals of this NIOSH field effort include: 1) identifying processes and activities where chemical exposures could occur; 2) characterizing potential exposures to vapors, gases, particulates and fumes (e.g., solvents, diesel particulate, crystalline silica, acids, metals, aldehydes, and possibly other chemicals identified during the study); 3) depending on results of the field effort, recommending safe work practices and/or proposing and evaluating exposure controls (to include engineering controls, substitution, and personal protective equipment).

Contributor at hydraulic fracturing operations, image courtesy of Jeff Swenson for the New York Times.

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

