Hydraulic Fracturing, Water Conservation, and Environmental Protection

Davis L. Ford, Ph.D., P.E.
National Academy of Engineering

Adjunct Professor, College of Engineering,
University of Texas at Austin
Visiting Professor of Petroleum Engineering,
Texas Tech University

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Contents

- Drilling, Completion, Staging, Horizontal, Vertical, and Zipper Fracking
- Renewable Alternative Fuels
- Water, New and Used, Water Demands, Reuse, Flowback and Produced
- Basic Exploration and Production Economics, Debt, and Investing
- Conveyance
- Regulatory
- Global
- Summary

Fossil Fuels

- Natural Gas
- Petroleum Crude
- Coal
- Nuclear (different origin but from the earth and non-renewable)

Alternative Fuels

- Ethanol (corn based)
- Bio diesel (grasses, algae)
- Solar
- Wind Turbines
- Geothermal
- Others

- **The world is currently in an energy transformation.**
- **Fossil fuels extraction technology is resulting in a worldwide exponential increase in the production of oil & gas.**
- **Water may be our most precious natural resource.**
- **What is the role of renewable energy?**
- **How do we maximize world energy production and concurrently minimize environmental impacts?**

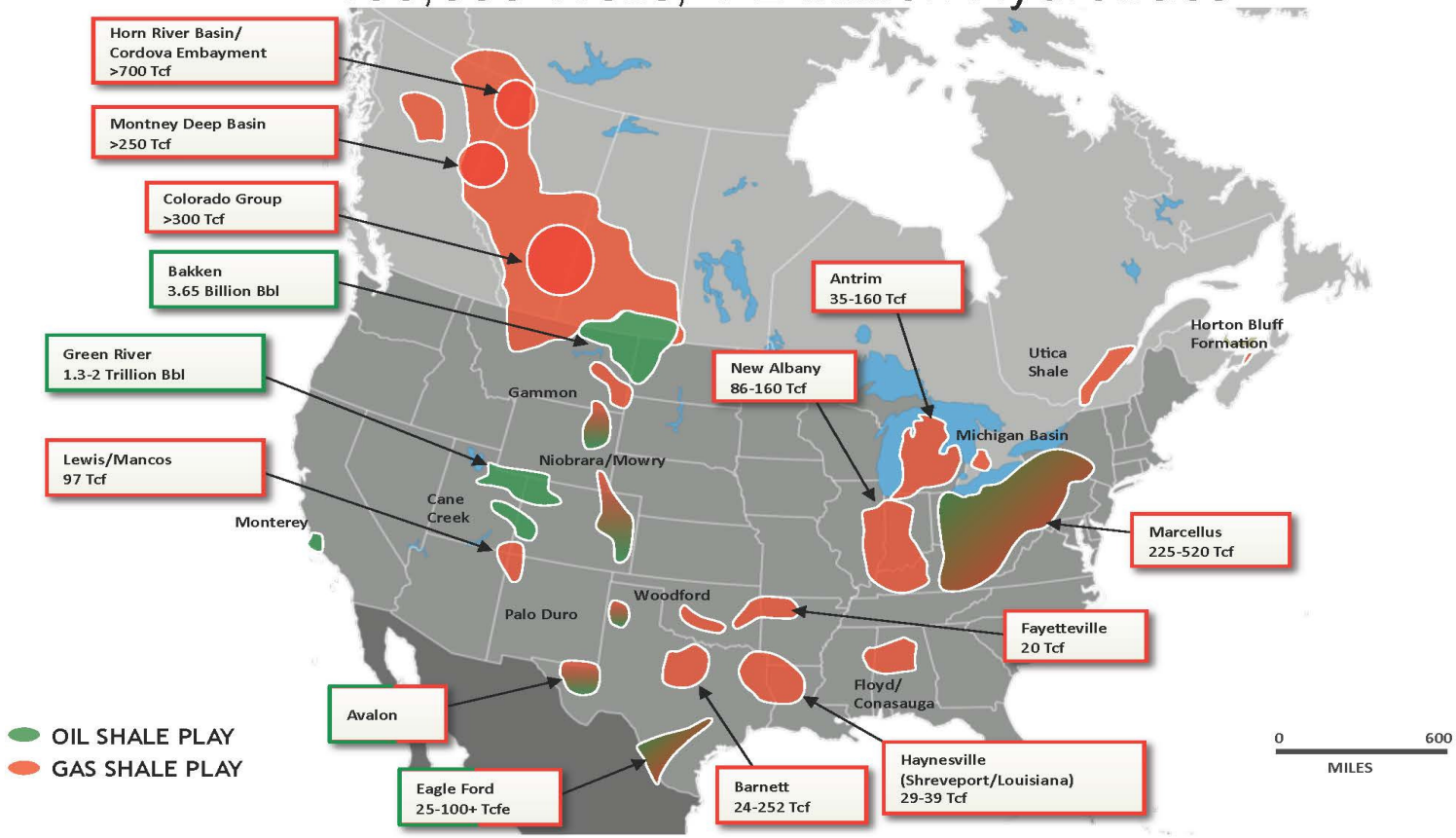
2013 Major Producers of Fossil Energy

1. United States*
2. Russia
3. Saudi Arabia

* Recent, October, 2013 (WSJ)

Most experts predict the United States will be a net exporter of oil & gas in the next 5-7 years.

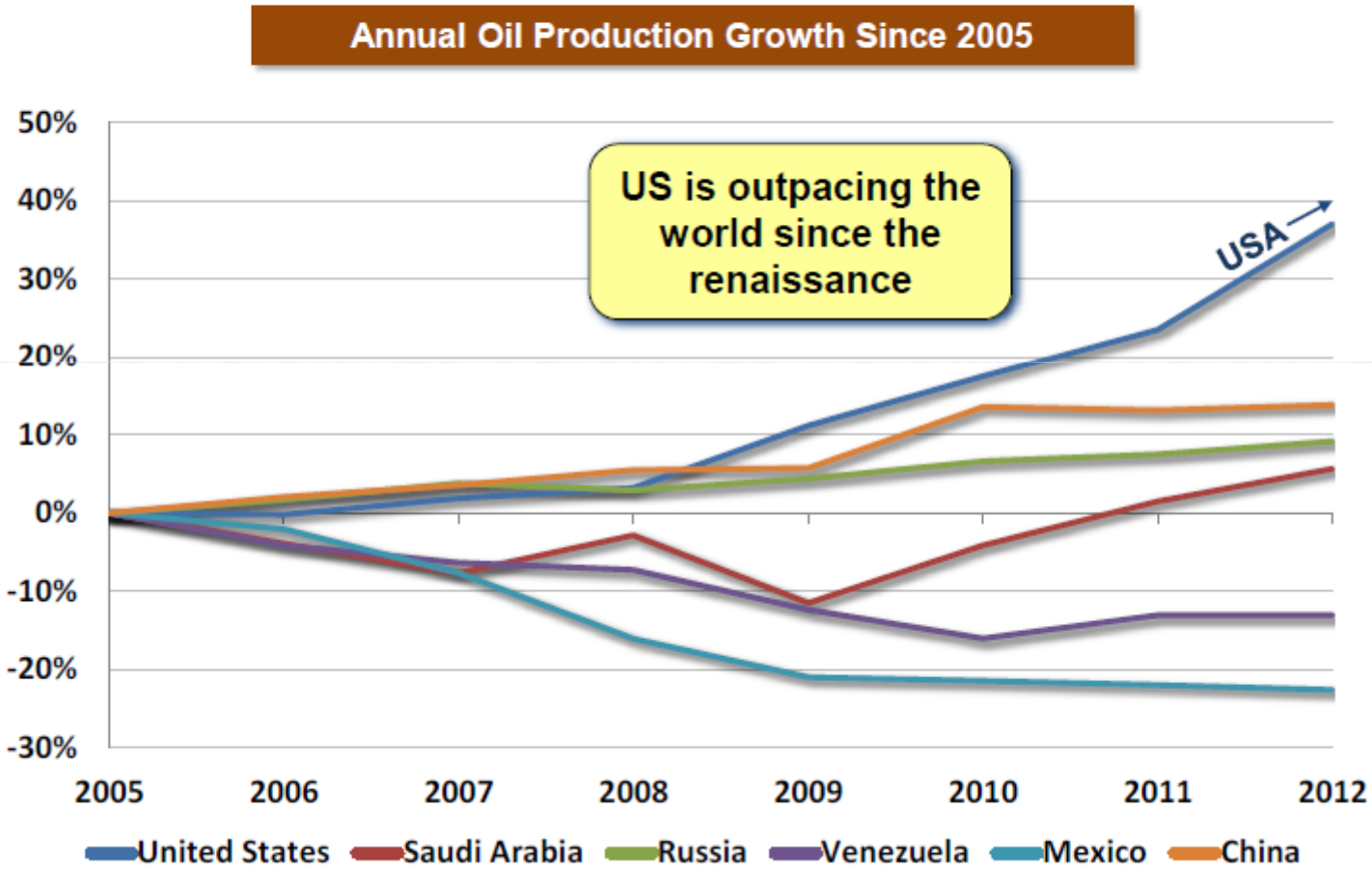
The Next 5-10 Years
~100,000 Wells, 1-2 Million Hydrofracs



- Will We Optimize Resource Development?
- Will We Minimize the Environmental Impact?

- Courtesy of S. Holditch

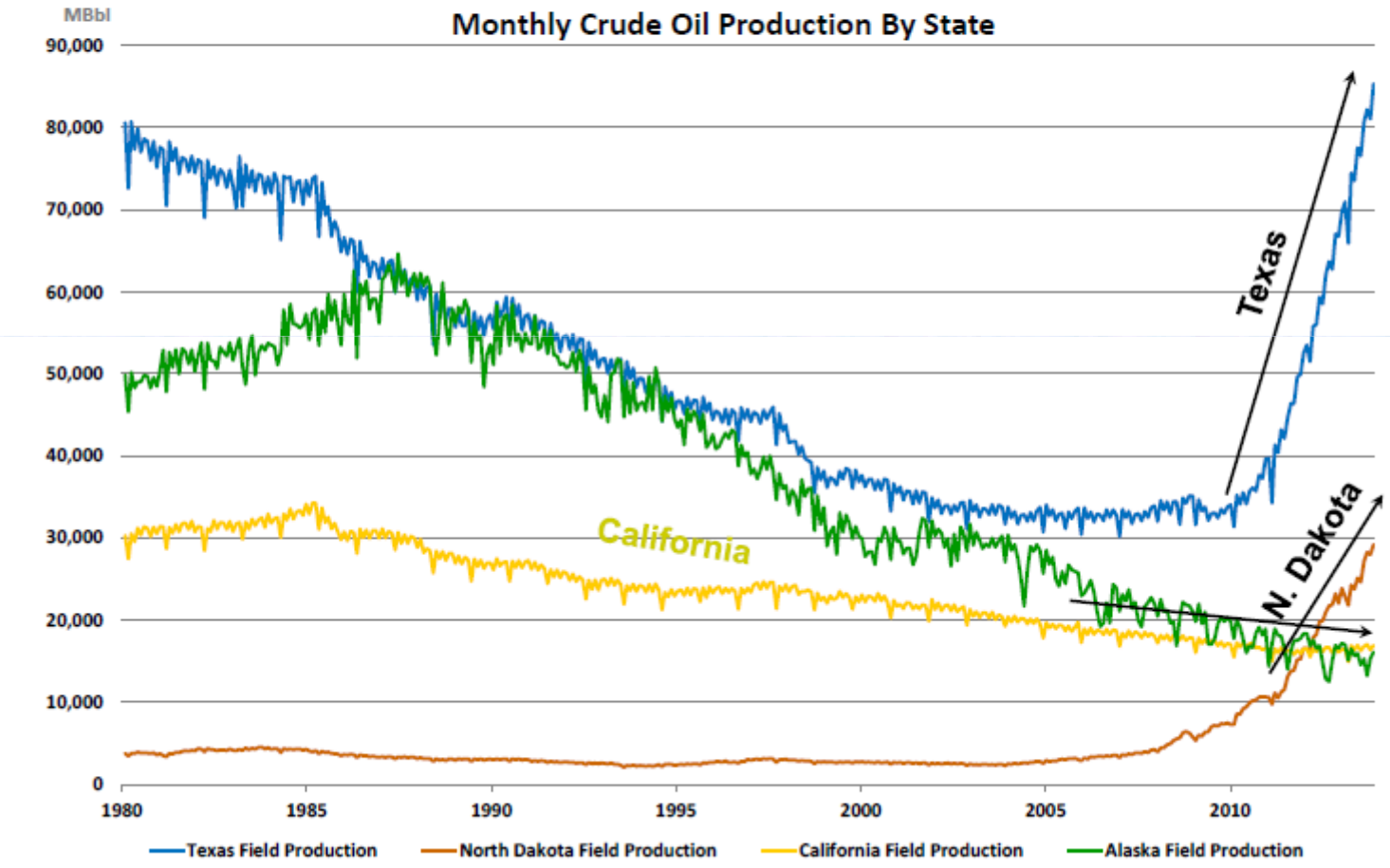
Oil Production Growth



Oil Resource Plays Impact Oil Production Growth

ND Surpasses CA December 2011 / AK March 2012

Oil Resource Production Growth Also in Texas and Commencing in Other States



Source: U.S. Energy Information Administration

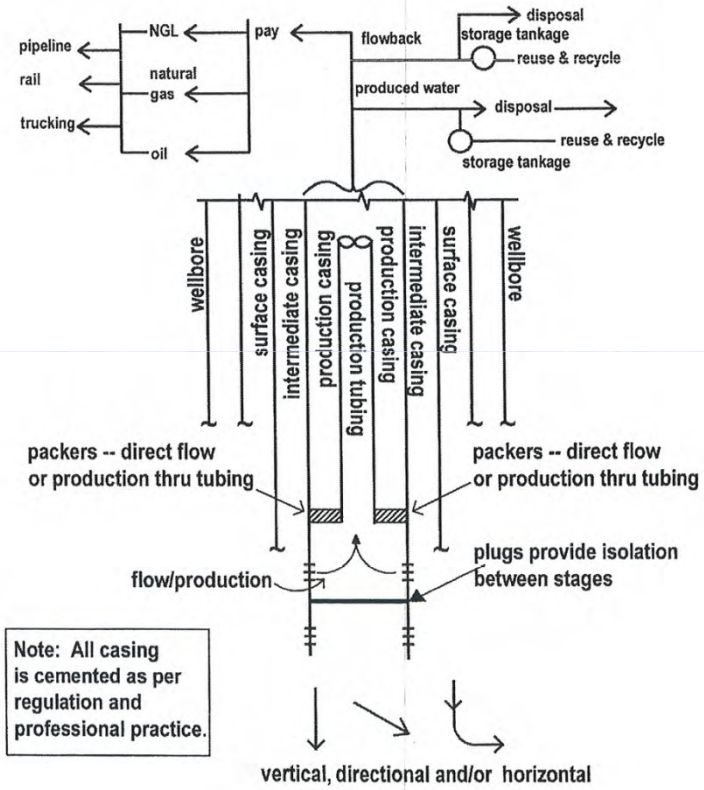
THE BOOM (BY WSJ RUSSELL GOLD)

- WHILE FRACKING BEGAN 1947, IN THE 1990S GEORGE MITCHELL'S CO. PERFECTED FRACKING IN BARNETT SHALE, UNLOCKING THE KEY
- MITCHELL SOLD TO DEVON ENERGY IN 1998 FOR BILLIONS
- IT TOOK 30+ YEARS TO DEVELOP OFF-SHORE DRILLING & ONLY 10 YEARS TO PERFECT FRACKING.

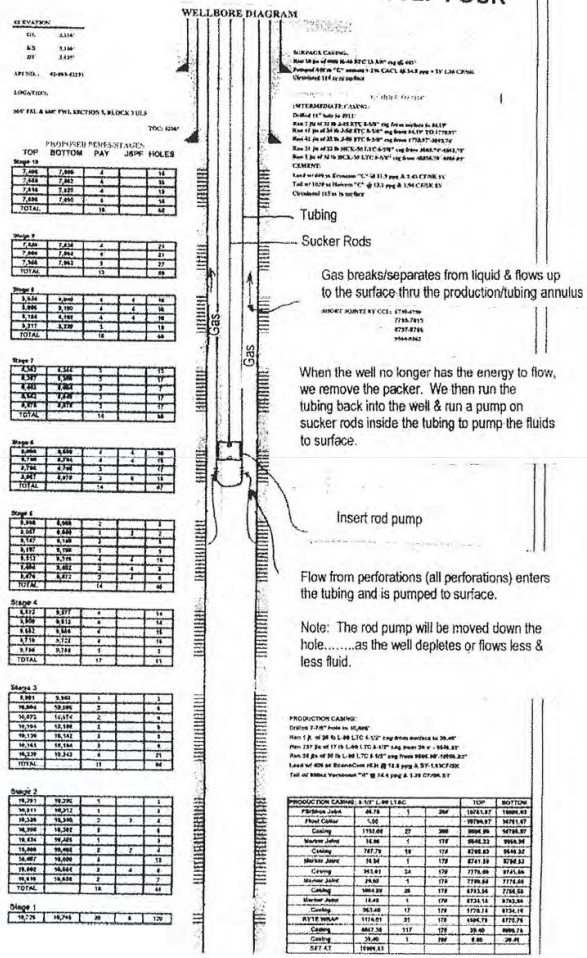
RECENT ENERGY FACTS

- 2014: BOTH EU AND GERMANY SIGNIFCANTLY CUTTING BACK GREEN SUBSIDIES. AREA MANUFACTURERS PAY 3-4 TIMES MORE FOR NATURAL GAS THAN U.S.
- FRACKING INCREASED U.S NATURAL GAS PRODUCTION 41% OVER 2005 LEVELS. CHEAPER, CLEANER, LOWER CARBON FOOTPRINTS & NOT SUBSIDIZED.
- U.S. LEADS IN WORLD CARBON POLICY..WHILE INCREASING ITS GDP
- GERMANY AND OTHER COUNTRIES (EXCLUDING FRANCE) ARE ELIMINATING NUCLEAR POWER PLANTS AND REMOVING WIND SUBSIDIES, PROVIDING MORE COST EFFECTIVE FOSSIL-BASED AND CARBON FRIENDLY-ENERGY.
- WATER MINIMIZATION IN FRACKING IS A U.S.MAJOR ISSUE. FOR EXAMPLE, THE FRACK WATER IN THE 6,000 WELLS DRILLED IN THE TEXAS EAGLE FORD THE LAST TWO YEARS IS THE EQUIVALENT OF 153,000 HOUSEHOLD ANNUAL USE.

Schematic of Modern Drilling Technology Using Staging & Enhanced Oil & Gas Extraction Techniques



STEP FOUR



Gas breaks/separates from liquid & flows up to the surface thru the production/tubing annulus

When the well no longer has the energy to flow, we remove the packer. We then run the tubing back into the well & run a pump on sucker rods inside the tubing to pump the fluids to surface.

Flow from perforations (all perforations) enters the tubing and is pumped to surface.

Note: The rod pump will be moved down the hole……..as the well depletes or flows less & less fluid.

- **U.S. shale oil, much cheaper than North Sea crude used in Europe, are resulting in U.S. refiners to export processed fuel in all time high amounts to all corners of the world.**

- **Refined products, such as gasoline, diesel, and jet fuel shipped abroad, are still cheaper than that available from other sources.**

- **Even though U.S. demand has fallen, demand for U.S. refined products has increased all over the world. Low sulfur content enhances this demand.**

- **Under current U.S. laws, the export of petroleum crude and gas is somewhat restricted (although this might change), but there is little restriction on the export of refined products.**

Remember:

GDP = Consumption

Investments

Government spending

Exports minus Imports

Conclusion:

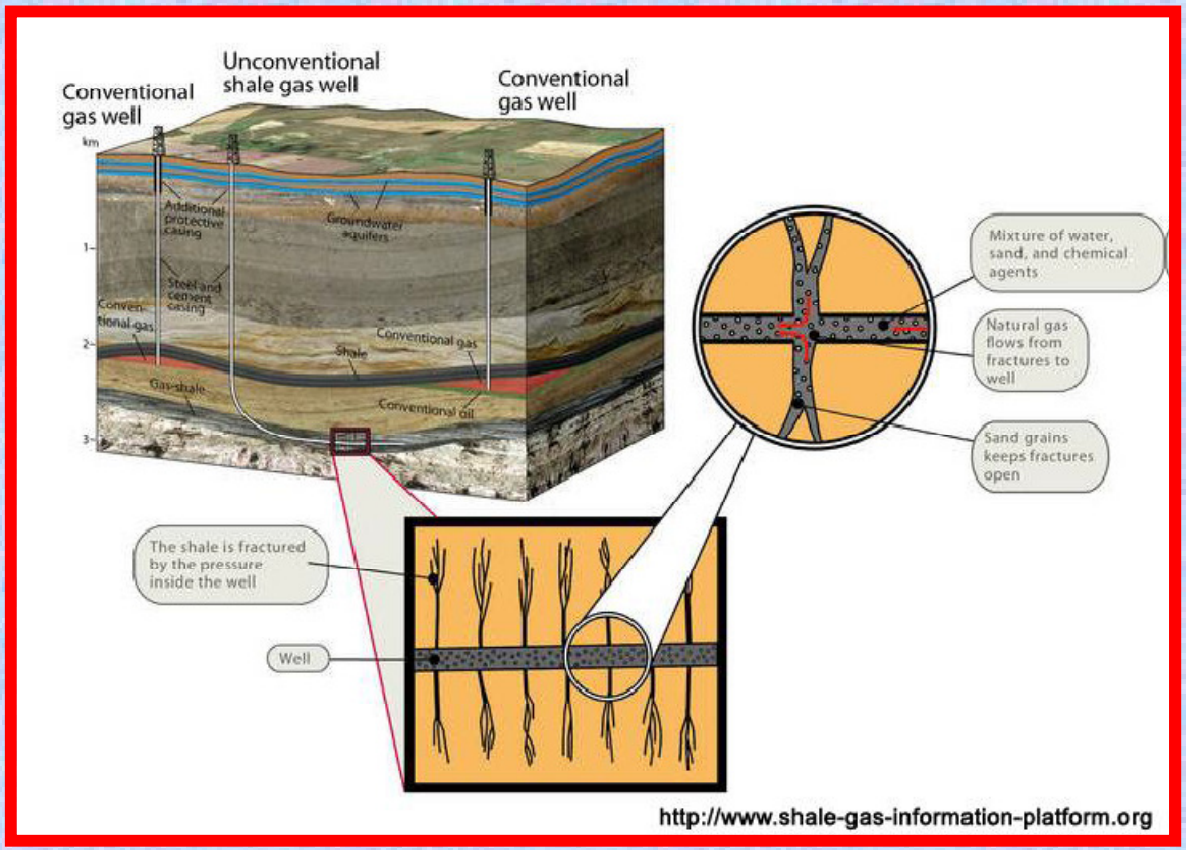
When the U.S. becomes energy independent, the GDP goes up accordingly. This is a major national issue.

GLOBAL THINKING ON U.S. EXPORT POSITIONS OF NATURAL GAS

WITH THE BOOM OF FRACTURING RELATED OIL AND NATURAL GAS PRODUCTION IN THE U.S., EXPORTING NATURAL GAS (LNG) BECOMES A MAJOR ISSUE.

MANY IN THE EUROPEAN COMMUNITY, INCLUDING THE UKRAINE, POLAND, GERMANY, AND CONTIGUOUS COUNTRIES, ARE PLANNING ON GAS AS THE PRIMARY SUPPLIER OF ENERGY IN THE FUTURE. THIS OPENS UP A MAJOR OPPORTUNITY FOR OUR DOMESTIC PRODUCTION.

ENERGY SOURCES IN POLAND



M.J. Gromiec

Where are gas-bearing shales located in Europe?



Poland and natural gas

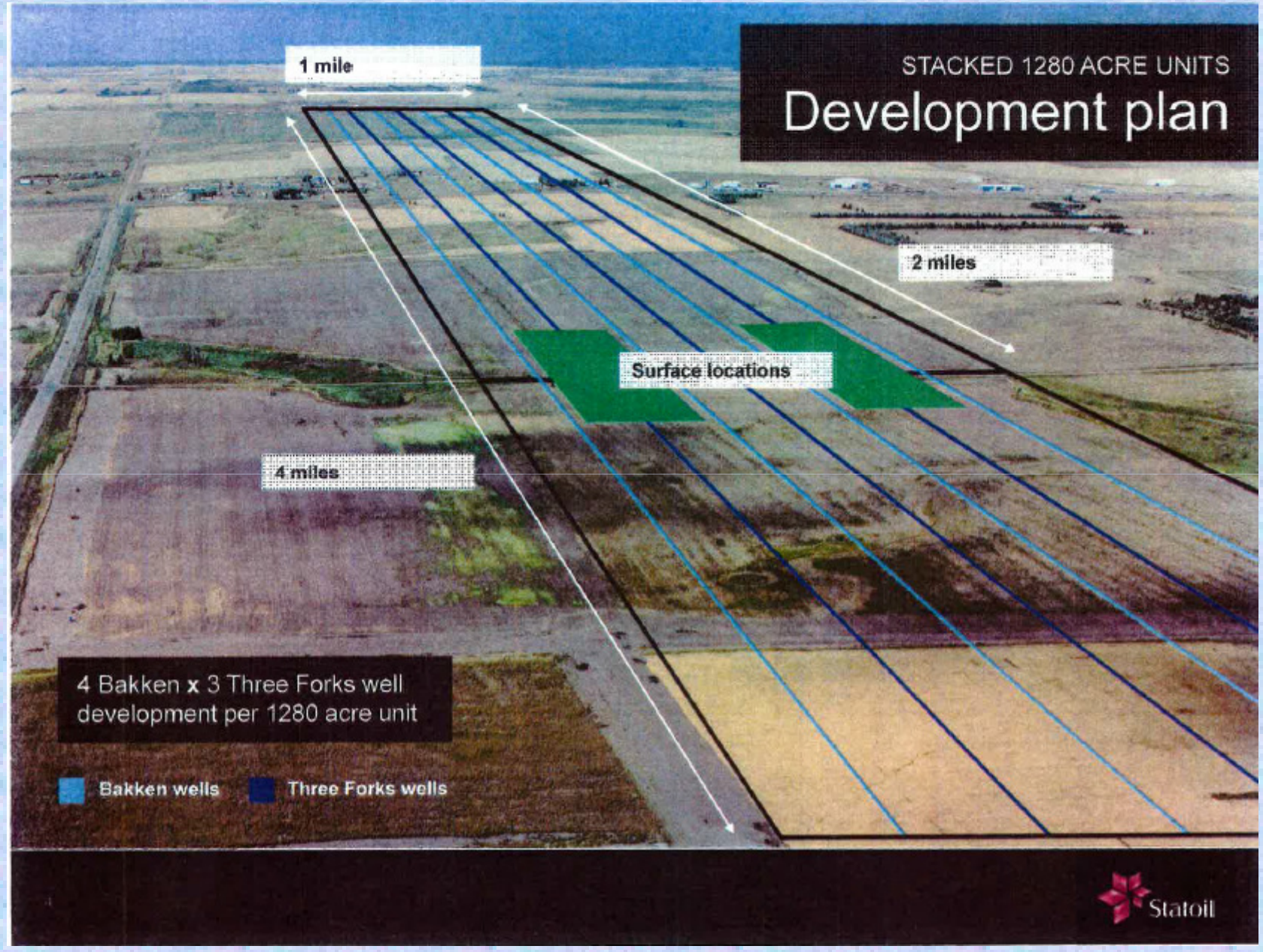
- Poland produces very small quantities and it is a net natural gas importer.
- Natural gas constitued 15 % of the total energy consumption in 2012.
- Poland imports natural gas primarily from Russia, Norway, and Germany.
- Russia transports its natural gas to Poland through the Yamal pipeline, in addition to transporting oil to Europe through Poland.
- A capacity of natural gas transport from Russia to Poland

  is 974 billion cubic feet (Bcf).

Diversifying the natural gas imports

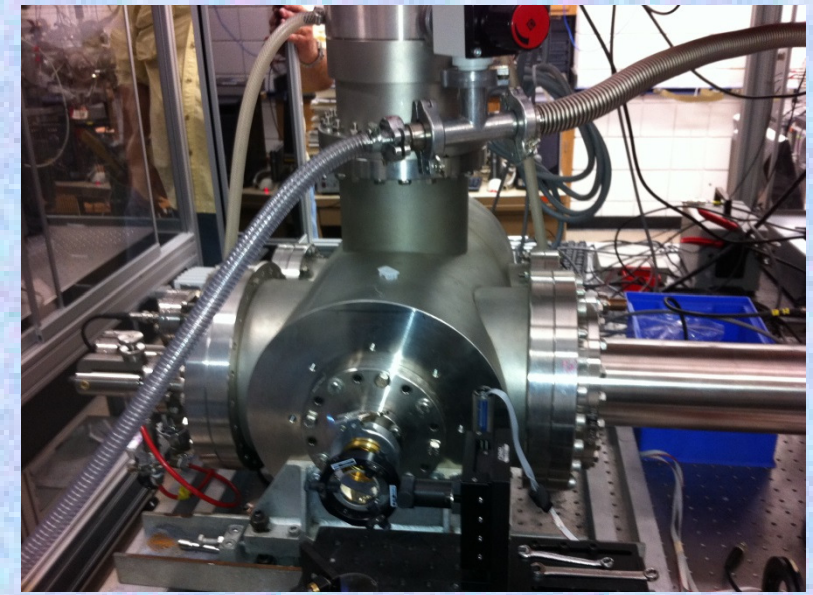
- As the result of the Crimea conflict, the EU is paying increased attention to the need for energy source divesification of its individual member states
- Poland has proposed joint purchases of natural gas by EU member countries
- The current capacity of LNG terminals in Europe is not sufficent to replace supplies from Russia
- In Poland, LNG terminal under construction- 5 bcm with option to expand up to 7.5 bcm

ARGENTINA HAS VAST AMOUNTS OF TIGHT NATURAL GAS, ALTHOUGH THE DEVELOPMENT THROUGH ENHANCED EXTRACTION IS NOT OCCURRING. BOTH ARGENTINA AND CHILE IMPORT MOST OF THEIR FOSSIL FUEL, PRIMARILY FROM EAST ASIA (INDONESIA, ETC)


STACKED 1280 ACRE UNITS
Development plan
1 mile
2 miles
Surface locations
4 miles
4 Bakken x 3 Three Forks well development per 1280 acre unit
Bakken wells
Three Forks wells
Statoil



Vacuum Chamber



Detection Cylinder



FEDERAL SUBSIDIES FOR ENERGY

(DOLLARS PER MEGAWATT HR)

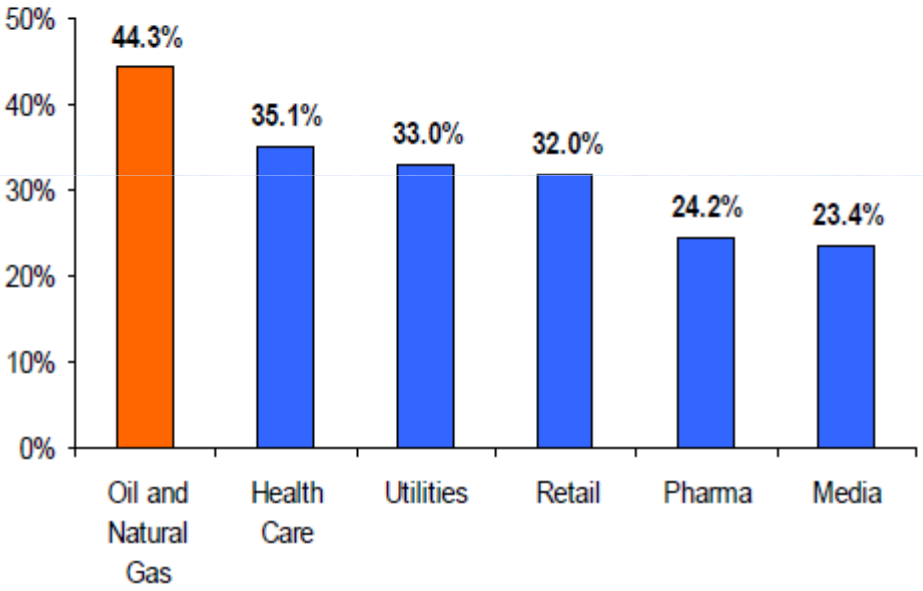
(U.S. DPARTMENT OF ENERGY, 2011)

OIL AND GAS	$ 0.64
HYDRO	0.84
COAL	0.64
NUCLEAR	3.14
WIND	56.29
SOLAR	775.64

Risks and Threats to Prosperity

Is Our Golden Goose Potentially Endangered?

So where are all those subsidies?

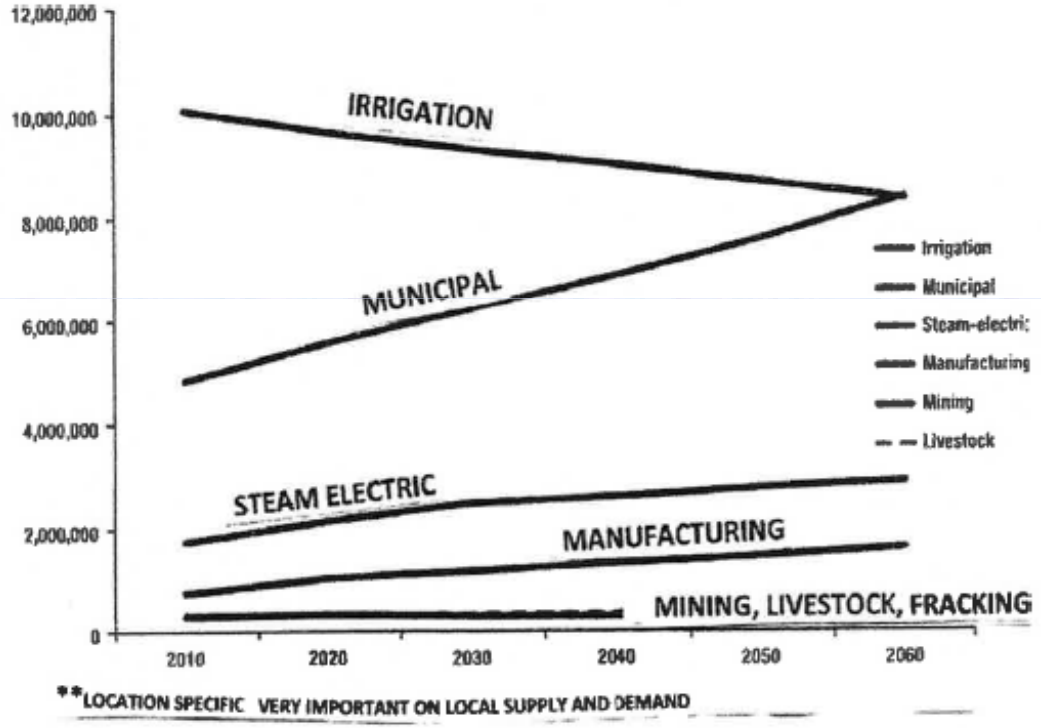


- **From 2006-2011 O&G paid an effective tax rate higher than any other industry**
- **O&G industry delivers ~$86 million/day to the federal treasury**
- **O&G industry average non-gas station salary was almost $93,000 in 2011.**

Source: Standard & Poor's Research Insight

Texas Water Plan 2012

FIGURE 3.6. WATER DEMAND PROJECTIONS BY USE CATEGORY (ACRE-FEET PER YEAR).*



**LOCATION SPECIFIC VERY IMPORTANT ON LOCAL SUPPLY AND DEMAND

2014

Energy Resource	Range of Gallons of Water Used per MMBTU of Energy Produced	Range of Power Generation Costs Dollars (U.S.) mwh	Dollars (Europe) mwh
Natural Gas		15-40	25-70
Conventional Oil	8-20	20	40-60
Synfuel-Coal Gasification	11-26	70	110-150
Oil Shale Petroleum	22-56	35-40	60-80
Tar Sands Petroleum	27-68	———	———
Synfuel-Fisher Tropsch (coal)	41-60	———	———
Fuel Ethanol (from irrigated corn)	2,510-29,100	———	———
Biodiesel (from irrigated soy)	13,000-75,000	———	———
Onshore Wind		70+	260+

Note: These are approximate numbers depending on regional differences within the U.S. and European countries.

Key Points

- **Major investments are being driven by a future of cheap, plentiful natural gas from shale.**
- **Water demand substantial---of concern in arid plays.**
- **Brackish groundwaters viable water source.**
- **Reuse and recycling flowback/produced water can further reduce impacts on potable waters.**
- **There are opportunities (e.g. waste gas) to encourage water treatment.**

Table 1

Liquid Usage: Drilling, Fracturing

Gallons Used: Drilling	Gallons Used: Fracturing	Millions Gallons Used: per Well
250,000	3,800,000	~4.0
600,000	5,000,000	~5.6
65,000	4,900,000	~4.9
85,000	5,500,000	~5.6
125,000	6,000,000	~6.1

- 0.5 to 3 gallons of water is required to refine 1 gallon of crude oil to 1 gallon of gasoline.
- 1,500 gallons of water is required to ferment irrigated corn into 1 gallon of ethanol. The energy input to create ethanol exceeds its product energy.
- A wind farm requires 40,000 acres to produce 1,000 MW of power.

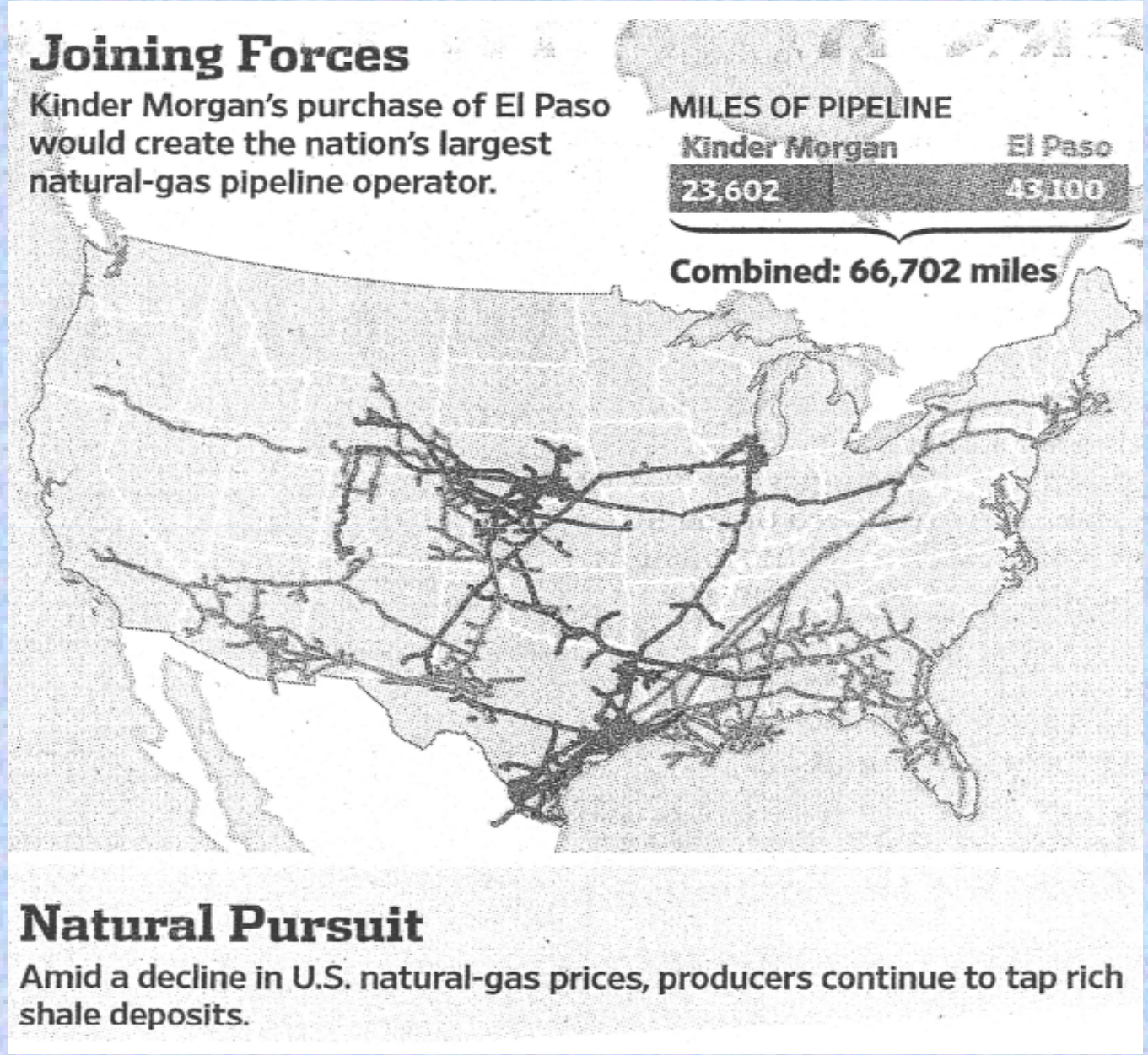
I never drink water because of all the horrible things that fish do in it.
W.C. Fields

Whisky is for drinking – water is what you fight over.
Mark Twain

The major crisis the world faces in the future is the scarcity of water.
Senator Grasso
Senate President, Republic of Italy (World Science Conference, Key Note Speech, Sicily, August, 2013)

I like new water over old water, but what I really like is making old water new.
Davis L. Ford

"Water, like religion and ideology, has the power to move millions of people. Since the very birth of human civilization, people have moved to settle close to it. People move when there is too little of it. People move when there is too much of it. People journey down it. People write, sing and dance about it. People fight over it. And all people, everywhere and every day, need it"
Mikhail Gorbachev



Natural Pursuit

Amid a decline in U.S. natural-gas prices, producers continue to tap rich shale deposits.

Reeves County Pipeline System

Gas

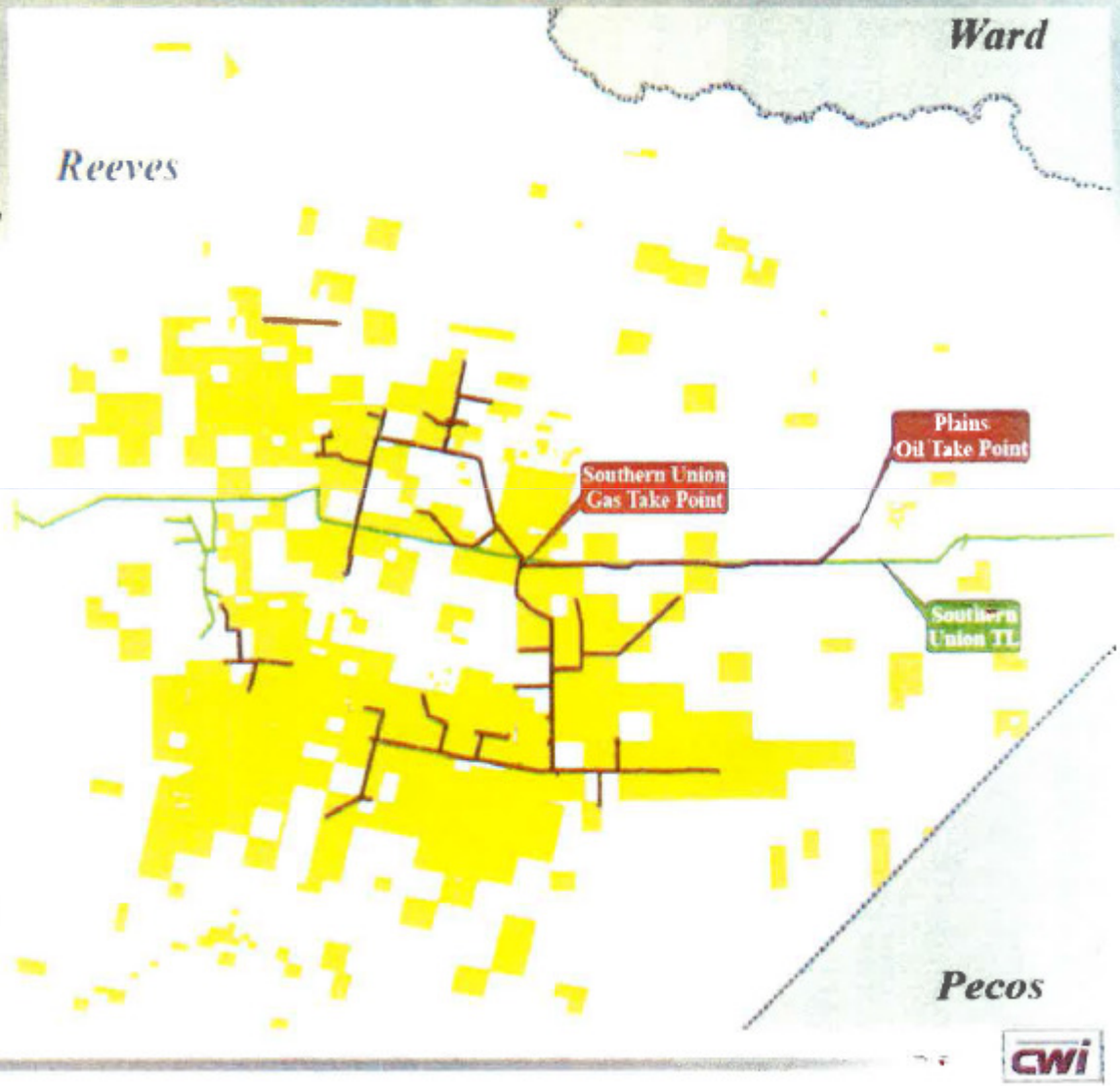
- 70 miles
- 3" to 8" diameter
- 25,000 MMCF/D capacity

Oil

- 71 miles
- 3" to 8" diameter
- 18,000 BOPD capacity

Salt Water Disposal

- 65 miles
- 3" to 6" diameter
- 20,000 BWPD capacity
- 1 CWEI disposal well & 2 3rd party disposal wells

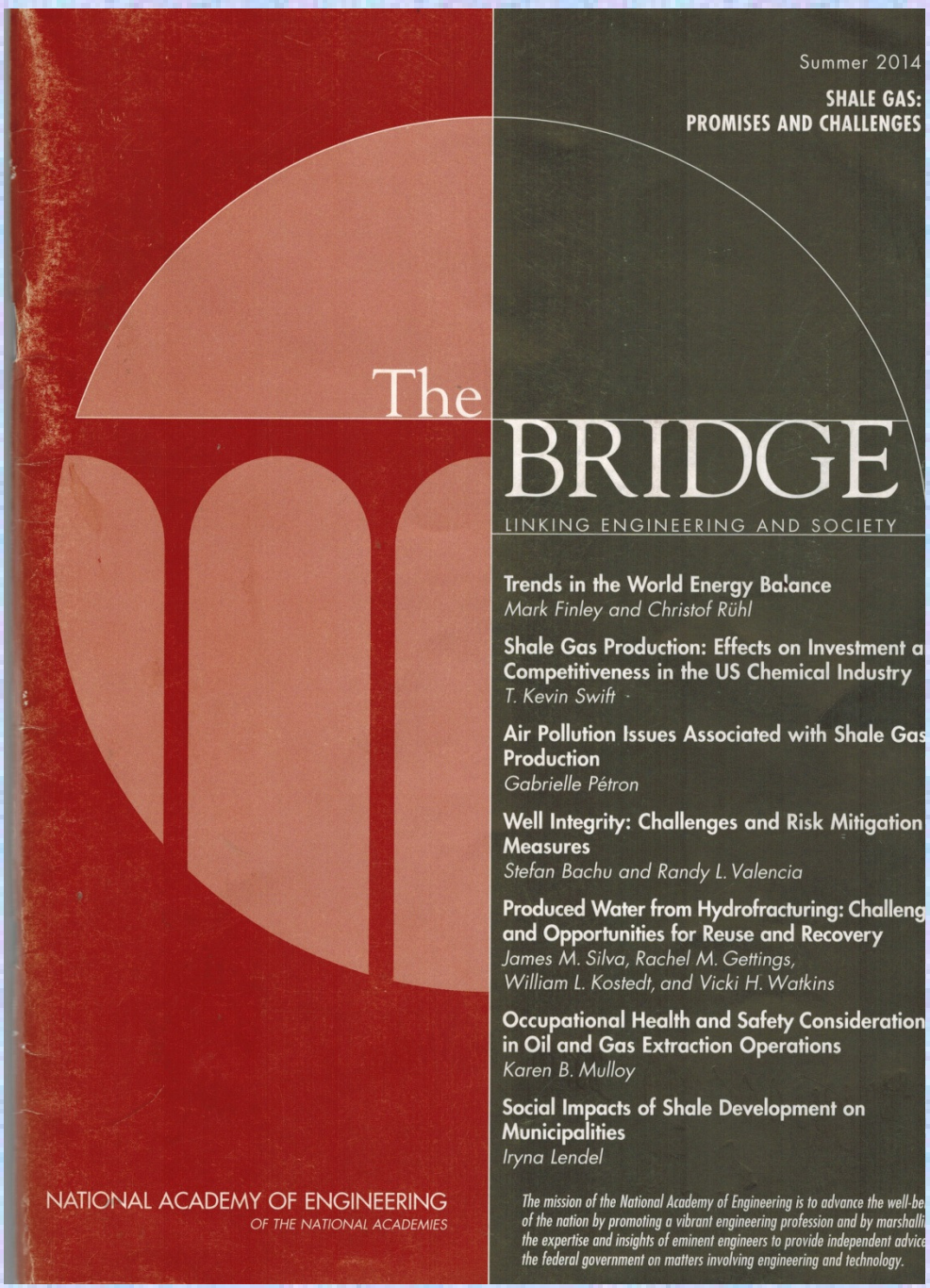


Estimated Relative Cost per Wet Ton Mile (Oil and Products)

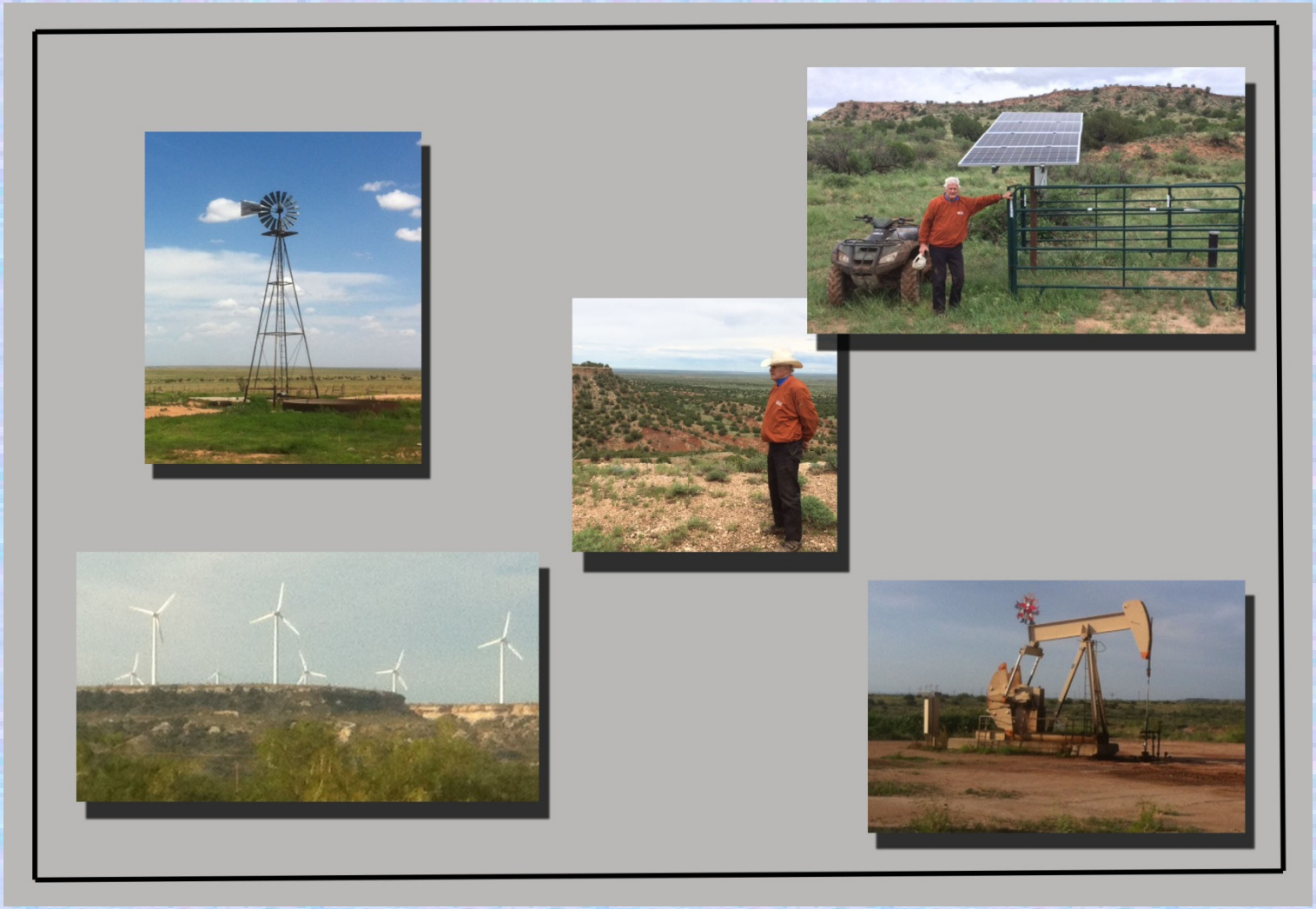
Pipelines	0.5
Rail	10-15
Trucks	20-30

Disciplines Related to Fracking of Tight Oil and Gas

- Description of the Hydraulic Fracking Process
- Subsurface Fate and Transport, Oil and Gas
- Remediation of Frack Contaminated Water Wells
- Recovered Frack Water, Produced Water, and Mud Storage, Treatment, Reuse, and Disposal
- Redisposal or Off-Site Disposal Regulatory Issues---
  - Exemptions to RCRA, and
  - Pending New Legislation Triggering Non-Exempt Chemicals Under The Safe Drinking Water Act
- Litigation
- Selected Treatment and Water Reuse
- Frack Chemical Issues, Inclusion/Exclusion
- Water Demand per Produced Energy (new/reuse)
- Cost/Benefit/Risk Analysis for Fracking
- Possible Air Contamination Issues, Gas VOCs, etc.


Summer 2014
SHALE GAS:
PROMISES AND CHALLENGES
The
BRIDGE
LINKING ENGINEERING AND SOCIETY
Trends in the World Energy Balance
Mark Finley and Christof Rühl
Shale Gas Production: Effects on Investment a
Competitiveness in the US Chemical Industry
T. Kevin Swift
Air Pollution Issues Associated with Shale Gas
Production
Gabrielle Pétron
Well Integrity: Challenges and Risk Mitigation
Measures
Stefan Bachu and Randy L. Valencia
Produced Water from Hydrofracturing: Challeng
and Opportunities for Reuse and Recovery
James M. Silva, Rachel M. Gettings,
William L. Kostedt, and Vicki H. Watkins
Occupational Health and Safety Consideration
in Oil and Gas Extraction Operations
Karen B. Mulloy
Social Impacts of Shale Development on
Municipalities
Iryna Lendel
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the federal government on matters involving engineering and technology.

The American West Uses Solar and Wind to Augment Energy Production



Abstract

The discovery of enormous amounts of energy reserves, mostly proven, which are in "tight" shale and sandstone formations, both oil and gas, is transforming the United States to be totally independent of foreign fossil energy. Our import energy has dropped from over 60% to less than 30% in the past few years, dramatically enhancing our GDP. Recently, the United States has passed Russia and Saudi Arabia in fossil fuel production. Currently, over 90% of U.S. energy demand depends on fossil fuel. Subsidies for "green energy" are now under review. While wind and solar energy are increasing in selected areas, biofuels and particularly ethanol, because of their huge water demand, are becoming less popular and cost effective.

Natural gas is the least cost option for new power generation in most areas, and has a minimal greenhouse gas footprint.

The fundamentals of this enhanced oil and gas extraction will be outlined in this presentation, with major emphasis on the associated water issues. It is imperative that the use of fresh water in the fracking process be reduced or eliminated through conservation and cost effective reuse of flowback and

produced water generated in this process. The reuse technologies such as reverse osmosis, electrocoagulation, and related desal technologies generally are in place, but reduced costs per volume is essential in the overall enhanced oil and gas economics as well as the preservation of fresh water sources for human and crop irrigation uses. Although the fracking process normally occurs in depths of 8,000 feet or more below the surface, drinking water quality can be adversely affected by poor surface casing and/or imperfect cementing, as well as surface contamination from tank storage of fuel and trucking activities (spills and leaks)

All of these issues will be addressed in this presentation.