

# Efficient Use of Our Natural Gas Resources

## - An Important Component of Energy Sustainability

W. Norman Shade, PE  
ACI Services Inc.

March 10, 2009

Gas Compressor Association  
2010 Annual Trade Show  
Galveston, Texas

# The Energy Sustainability Dilemma

Is this our future?????????



Energy efficient vehicle.  
Runs on oats and grass.  
Caution: Do not step on exhaust.



**Unfortunately, the dilemma is much more serious than that!**

# The Sustainable Energy Dilemma

In the time it takes most people to read this sentence, the world will have used up (forever) about 8,000 barrels of oil - 336,000 gallons; at 1000 barrels per second, it's going fast.

“For the sake of our economy, our security, and the future of our planet, I will set a clear goal as president: in 10 years, we will finally end our dependence on oil from the Middle East.” Barack Obama’s nomination acceptance speech.

“It might take 100 years to develop enough energy from alternative resources to replace fossil fuels. Government energy policies need to be based on hard facts, not on politically popular hot air.”  
ConocoPhillips CEO Jim Mulva - Bloomberg (6/16/09)

“By 2030 the world will need at least 45% more energy than it consumes now. There are no magic bullets, nor is there going to be a ‘one-size fits all’. Natural gas is becoming increasingly important in dealing with the energy and environmental challenges facing the world. As the developing economies continue to expand, demand for power is set to grow exponentially. We believe the best way of meeting this demand growth, while lowering carbon emissions, is through a switch from coal to gas.”  
BP CEO Tony Hayward – O&G Journal (11/25/09)



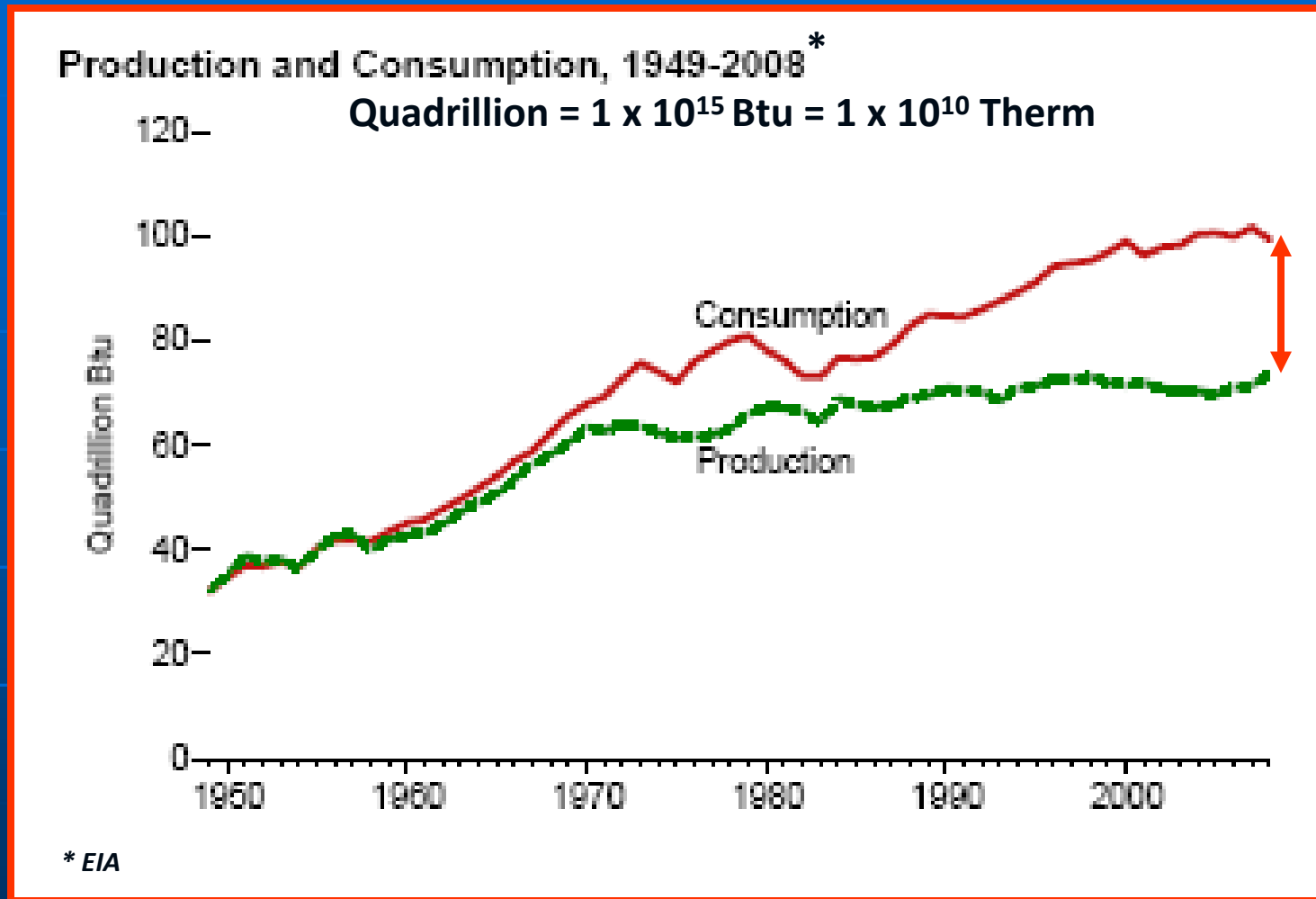
**Building a Case for Efficient Use of Natural Gas in the Energy Sustainability Plan**

# The Sustainable Energy Dilemma



**So what are the facts and the real choices?**

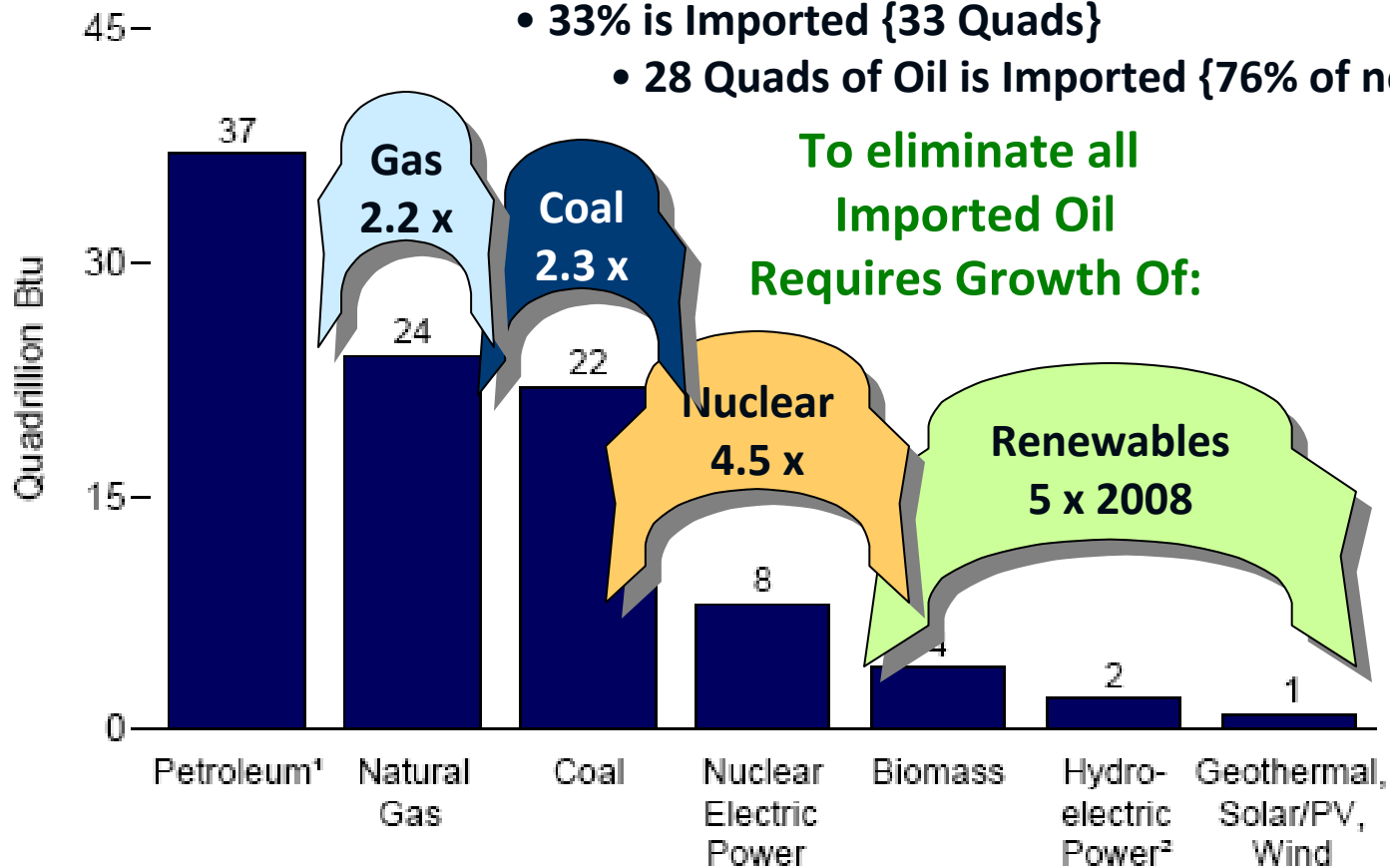
# Primary USA Energy Consumption & Production



- Annual USA Energy Consumption is nearly 100 quadrillion Btu
- USA Energy Production falls short by about 30 quadrillion Btu

# Primary USA Energy Consumption by Source

By Source, 2008\*



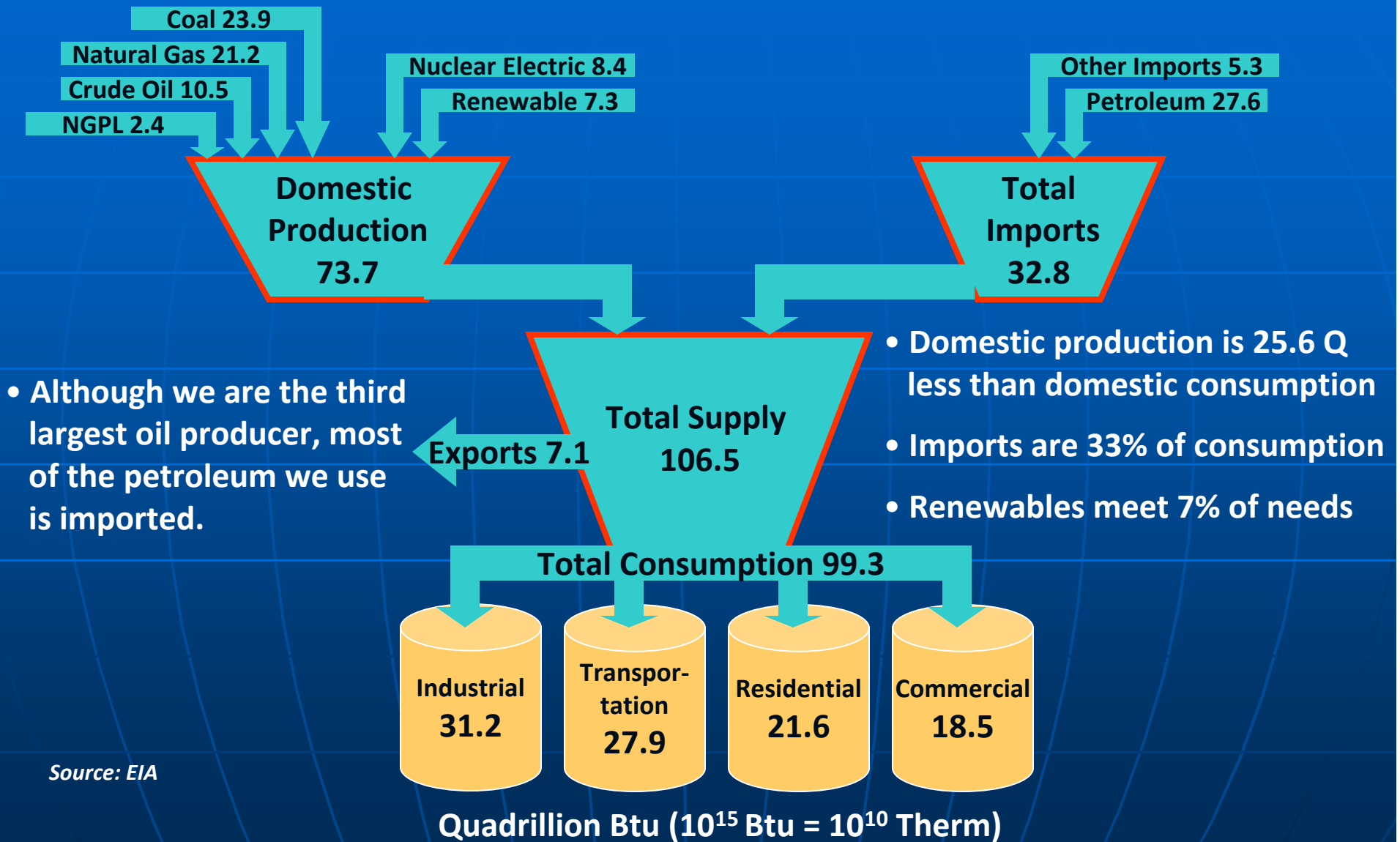
- Total Consumption = 99.3 Quadrillion Btu
- 33% is Imported {33 Quads}
  - 28 Quads of Oil is Imported {76% of needs}

To eliminate all Imported Oil Requires Growth Of:

<sup>1</sup> Petroleum products include oil burned as fuel. Does not include "Biomass." **Practical only with growth in all sources!** Ethanol is included in

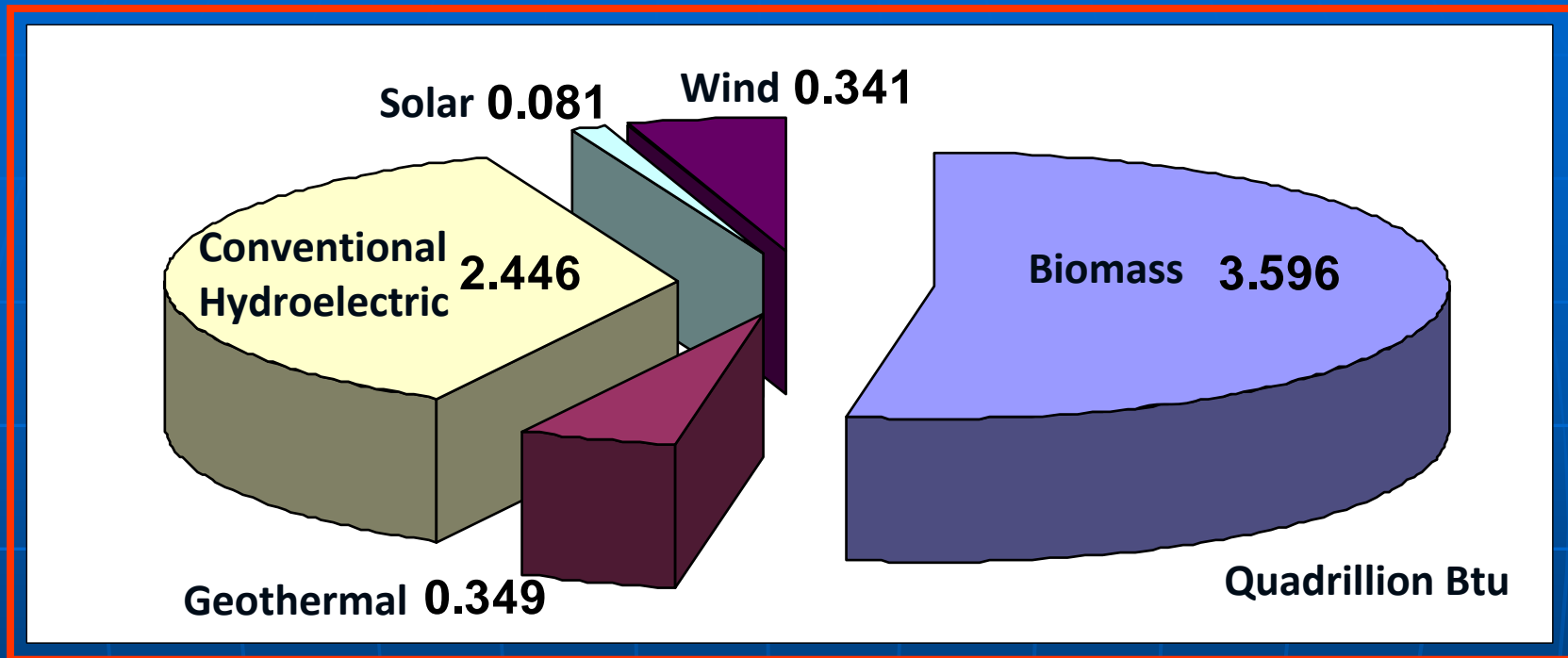
\* EIA

# USA Energy Flow - 2008



Source: EIA

# USA Renewable Energy Sources – 2007



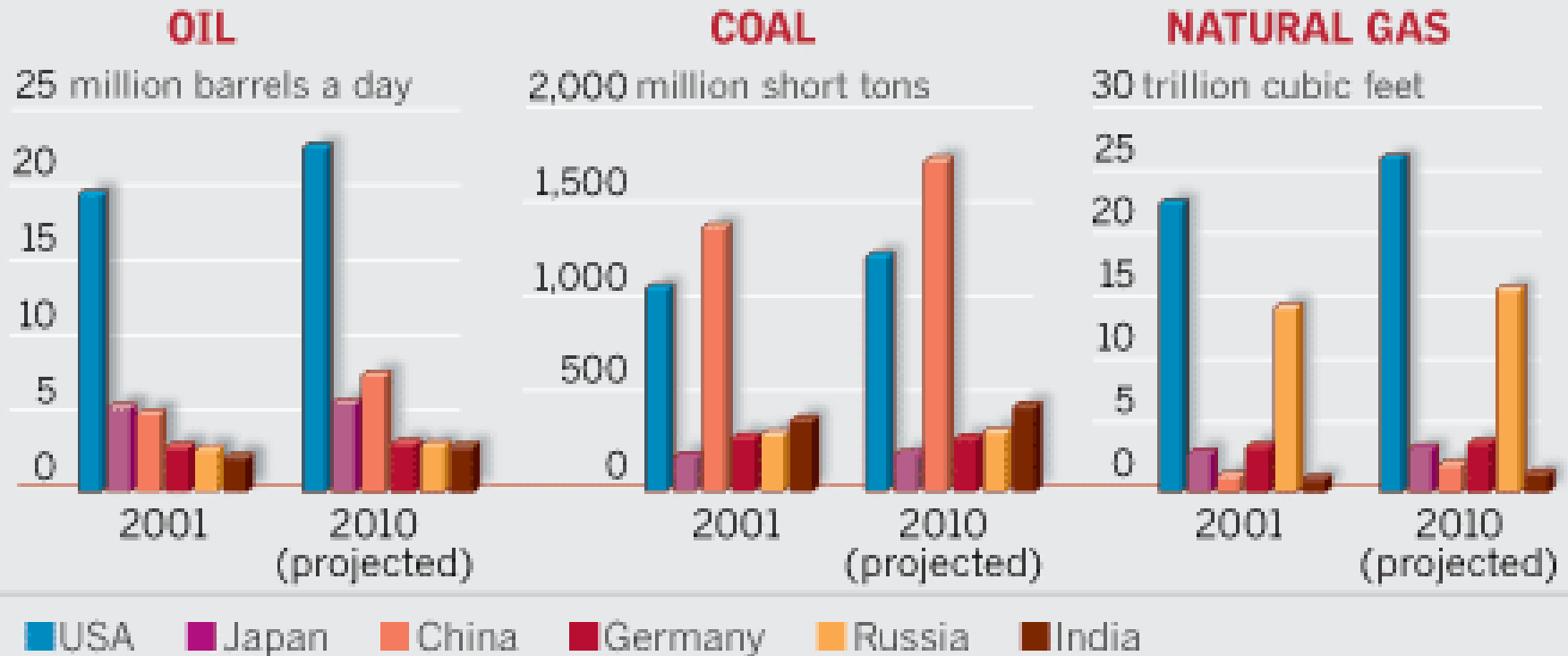
- Biomass & Conventional Hydroelectric meet 6% of USA energy needs
- All other sources (in aggregate) meet about 1% of USA energy needs

Source: EIA



# Fossil Fuel Energy Consumption in Major Countries

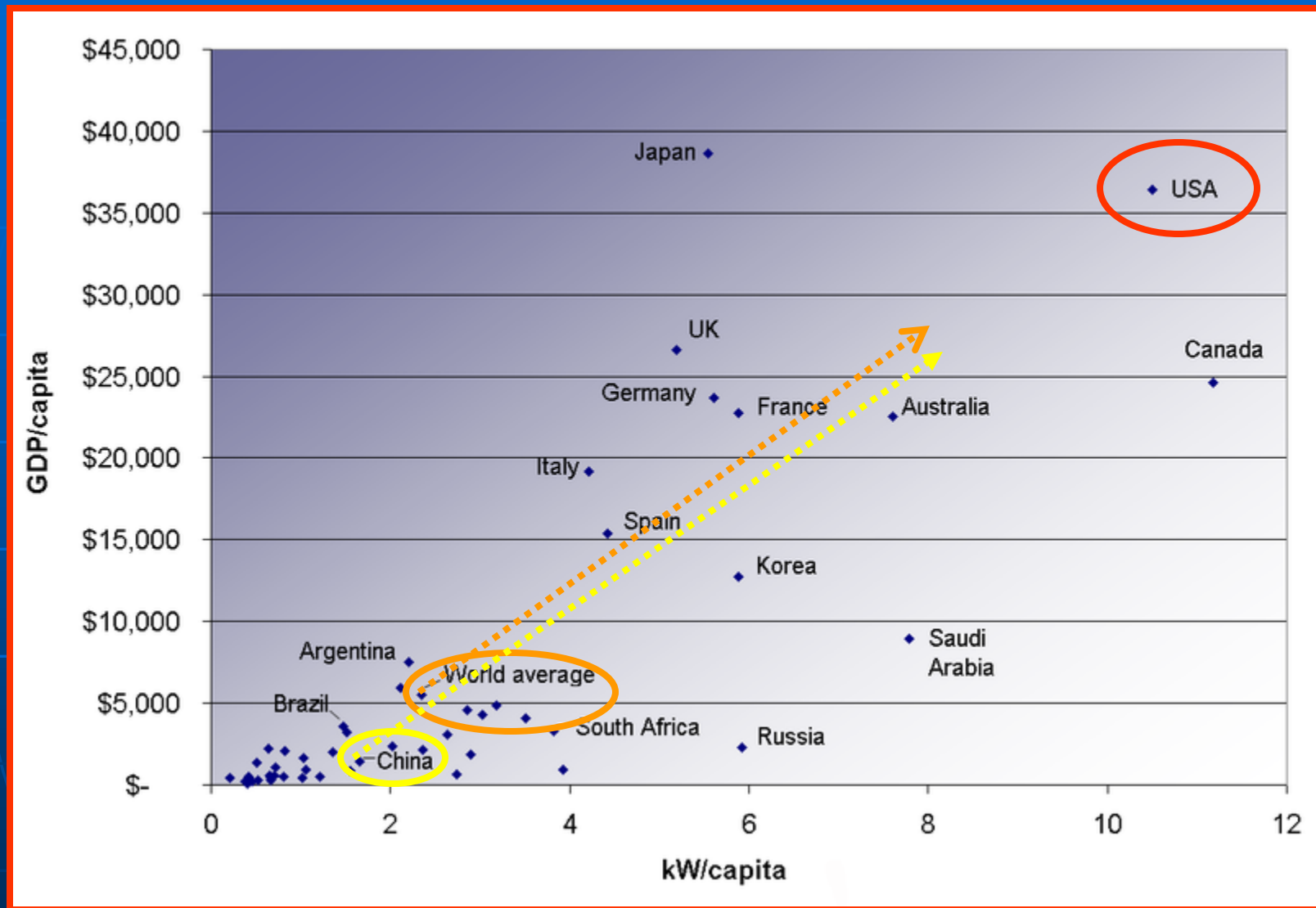
## Energy Consumption by Country



- USA is the dominant consumer of energy in the world
- China is growing rapidly

Source: EIA

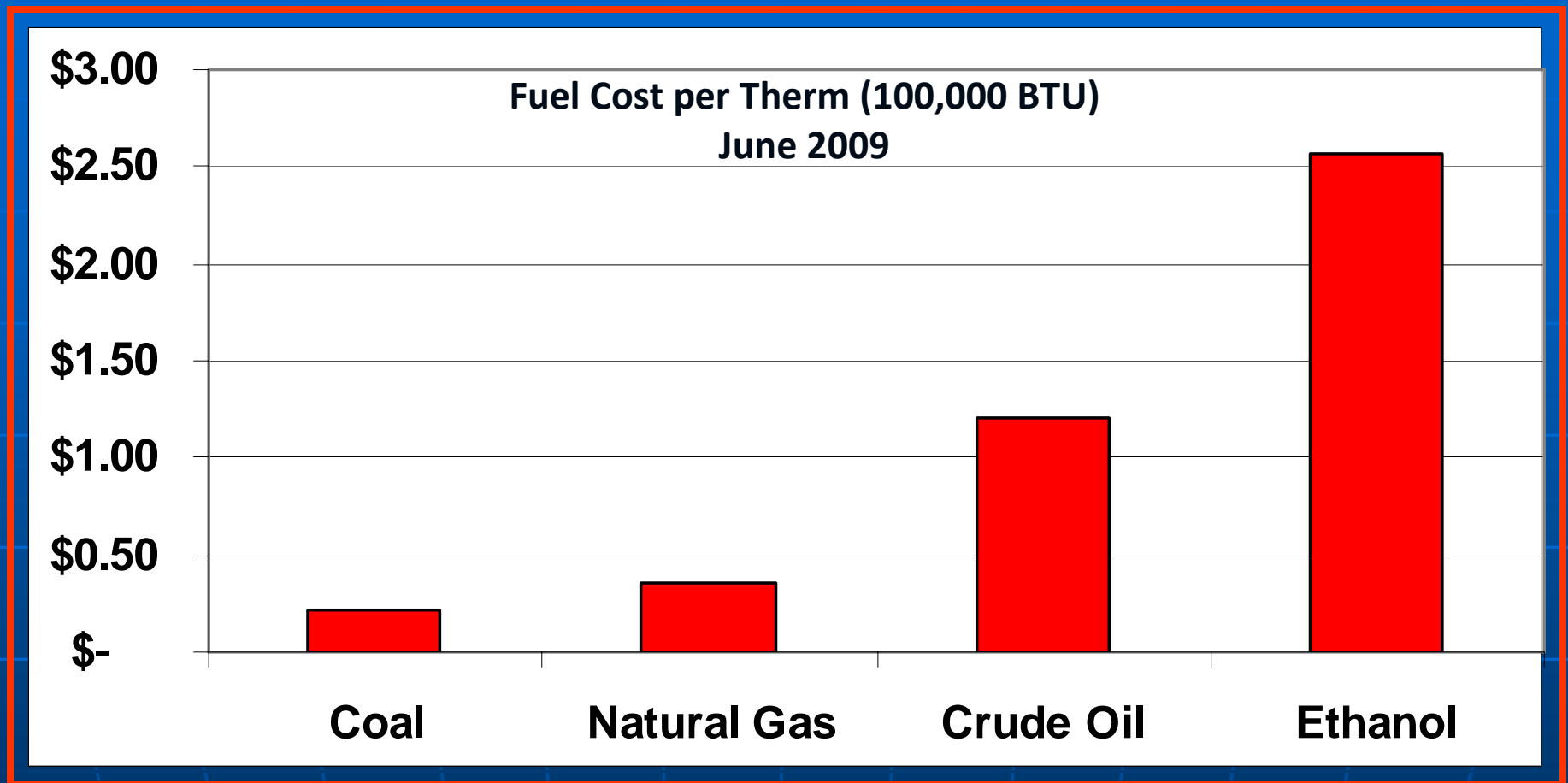
# Energy Consumption in Major Countries



Source: EIA

**Developing Countries Will Continue to Demand More Energy!**

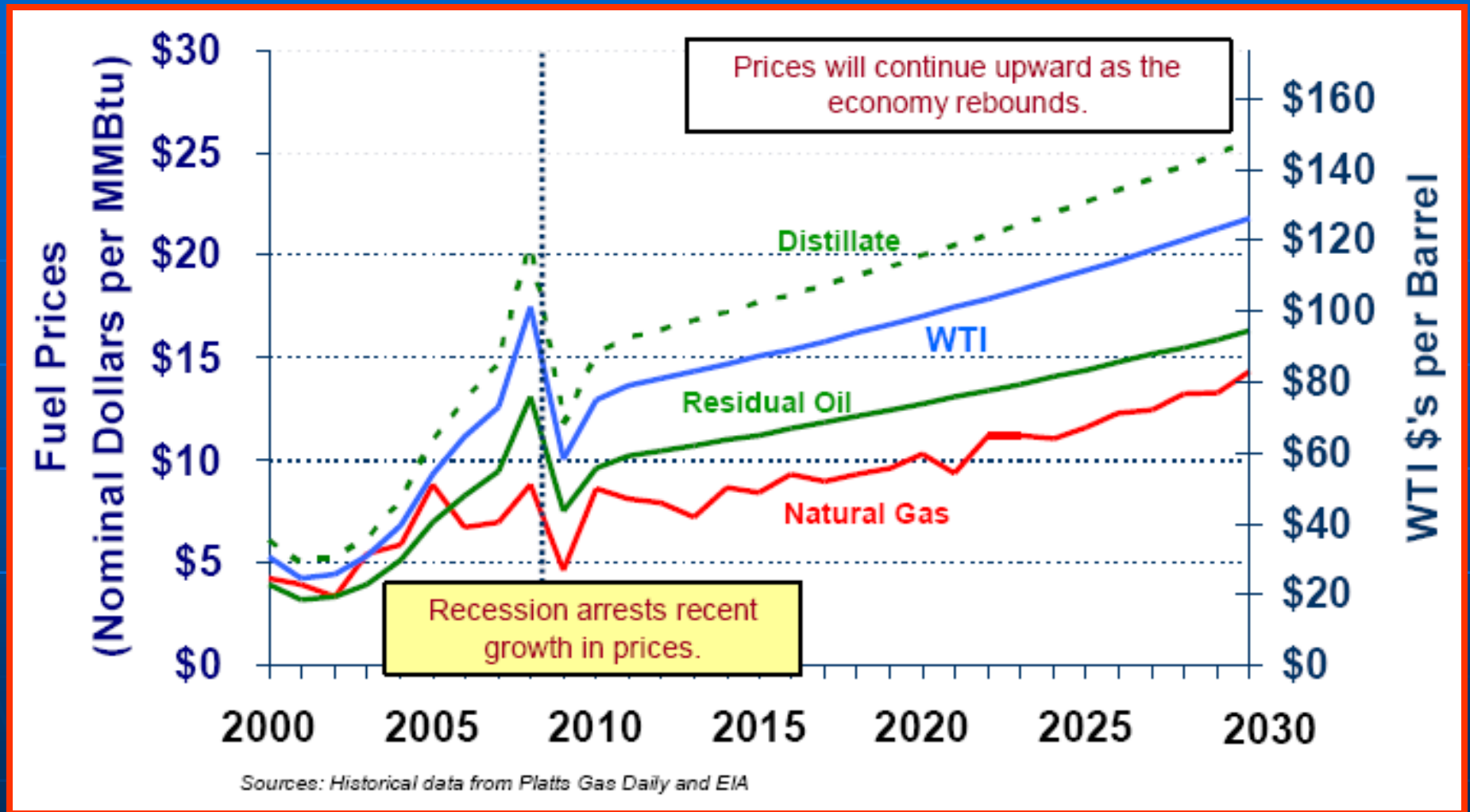
# Fossil Fuel Cost Comparison



Source: EIA

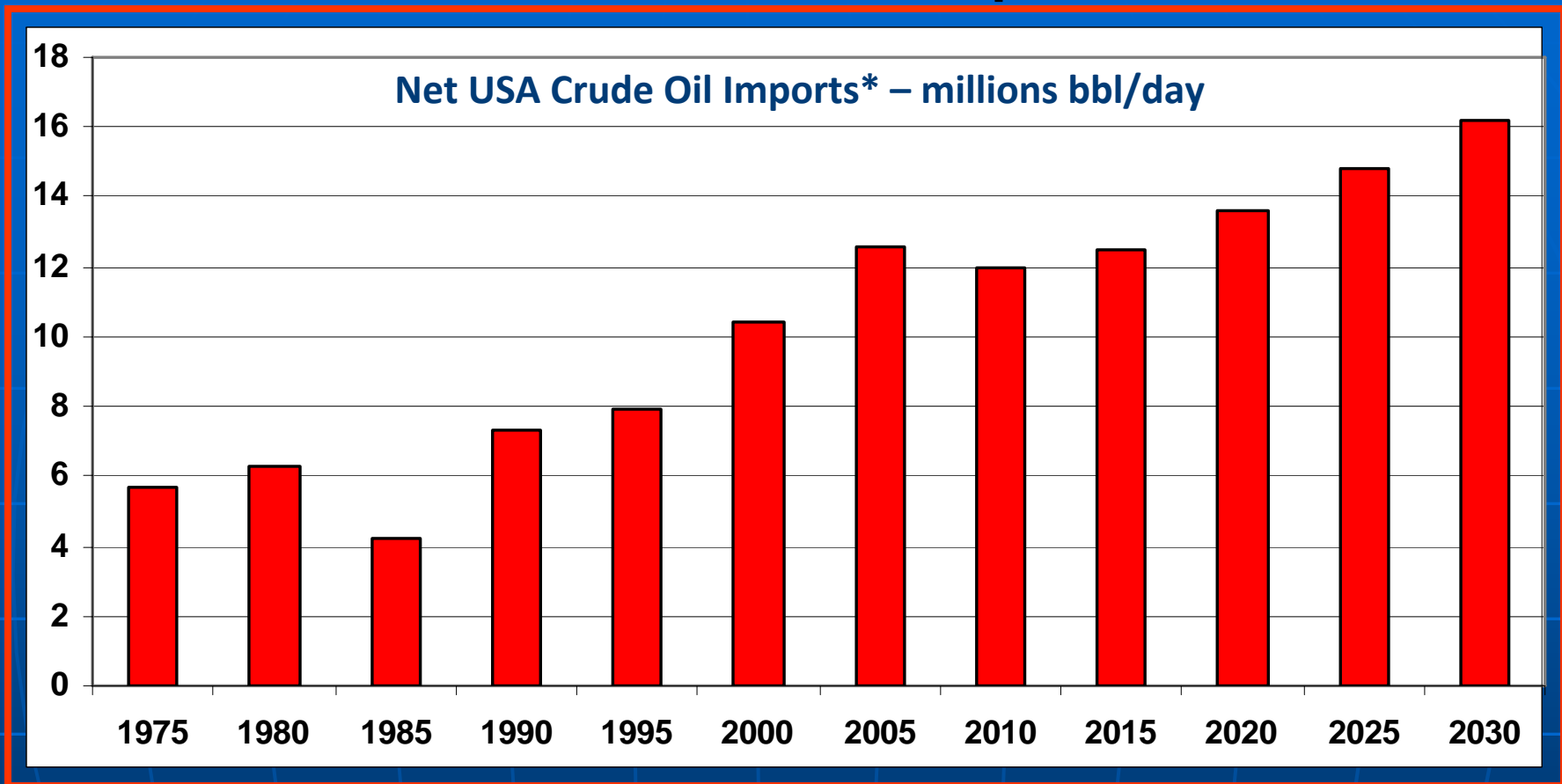
- Coal is cheap, but cap & trade will limit/reduce USA use of coal
- Natural gas is almost as cheap as coal, much cleaner & plentiful
- Oil is mostly imported, with volatile price and supply
- Ethanol is currently not cost effective without major subsidies

# Projected Annual Average Oil & Gas Prices



**Natural gas provides a significant cost advantage!**

# USA Net Crude Oil Imports



\* US DOE & EIA

**USDOE estimates oil imports of 12 million bbl/day in 2010 (estimated price of \$80/bbl)  
Wealth flowing out of the USA = \$960 million/day = \$350 billion/year**

**USDOE estimates oil imports of 16.4 million bbl/day by 2030 (estimated price of \$125/bbl)  
Potential wealth flowing out of the USA = \$2.05 billion/day = \$745 billion/year**





# Traditional Electric Power Generation - Worldwide

<u>Method</u>	<u>Cost/kW-h*</u>	<u>% of Global Demand*</u>	<u>Important Considerations</u>
Natural Gas 	3.9 – 4.4 ¢	15	<ul style="list-style-type: none"><li>- Plant construction quicker &amp; less cost</li><li>- Cleaner than coal</li></ul>
Coal 	4.8 – 5.5 ¢	38	<ul style="list-style-type: none"><li>- Air pollution issues</li><li>- Expensive clean-up technology</li><li>- Mining environmental &amp; safety issues</li><li>- Waste product disposal concerns</li></ul>
Nuclear 	11.1 – 14.5 ¢	24	<ul style="list-style-type: none"><li>- NIMBY</li><li>- Risk &amp; fear of contamination</li><li>- Waste disposal issues</li><li>- Plant construction slow &amp; expensive</li><li>- Very high de-commissioning cost</li></ul>

\* Pure Energy Systems PESWiki

**Traditional Sources make up 77% of worldwide demand.  
Natural gas is the lowest cost traditional fuel source.**

# Conventional Renewable Electric Power Generation

<u>Method</u>	<u>Cost/kW-h*</u>	<u>% of Global Demand*</u>	<u>Important Considerations</u>
<b>Wind</b> 	4.0 – 6.0 ¢	1.4	<ul style="list-style-type: none"> <li>- Only current cost effective renewable</li> <li>- Farms susceptible to lightning strikes</li> <li>- Limited by heavy rain, ice, high winds</li> <li>- Noise &amp; landscape issues</li> <li>- Insufficient utility grid in many zones</li> <li>- 30% reliable – requires standby source</li> </ul>
<b>Geothermal</b> 	4.5 – 30 ¢	0.2	<ul style="list-style-type: none"> <li>- New technology holds promise</li> <li>- Larger scale plants more economic</li> </ul>
<b>Hydroelectric</b> 	5.1 – 11.3 ¢	19.9	<ul style="list-style-type: none"> <li>- Limited locations</li> <li>- Significant effect on aquatic ecosystem</li> </ul>
<b>Solar</b> 	15 – 30 ¢	0.8	<ul style="list-style-type: none"> <li>- Very expensive</li> <li>- Subject to damage by wind &amp; hail</li> <li>- 75% less cost with artificial silicon</li> </ul>

\* Pure Energy Systems PESWiki

**Conventional Renewable Sources (w/o hydroelectric) make up 2.4% of worldwide demand**

# Non-Conventional Renewable Electric Power Generation

<u>Method</u>	<u>Cost/kW-h*</u>	<u>% of Global Demand*</u>	<u>Important Considerations</u>
<b>Available Now</b>			
Tide	2 - 5 ¢	insignificant	<ul style="list-style-type: none"> <li>- Tidal fence ready for implementation</li> <li>- Low environmental impact</li> <li>- Tides highly predictable</li> </ul>
<b>Emerging</b>			
Atmospheric cold MWs	0.3 - 1 ¢	none	<ul style="list-style-type: none"> <li>- Requires 1 -2 300km pipelines</li> <li>- End points maximize atm press diff.</li> </ul>
Thermal electric	3 - 15 ¢	none	<ul style="list-style-type: none"> <li>- Chip converts heat to electricity</li> <li>- More efficient and less cost than solar</li> </ul>
Ocean Energy Thermal Conversion	6 - 25 ¢	none	<ul style="list-style-type: none"> <li>- (2) 13MW plants to be built in Hawaii</li> </ul>

\* Pure Energy Systems PESWiki

**Non-Conventional Renewable Sources are insignificant at the current time**



# What About Natural Gas?

**“Conserving and harnessing renewable forms of electricity not only has incredible economic benefits, but is also a crucial piece of the oil dependence puzzle. We should continue to pursue the promise of electric or hydrogen powered vehicles, but America needs to address transportation fuel today. Fortunately, we are blessed with an abundance of clean, cheap, domestic natural gas. Currently, domestic natural gas is primarily used to generate electricity. It has the advantage of being cheap and significantly cleaner than coal, but this is not the only use of our natural gas resources.”**

**T. Boone Pickens**

**"Natural gas is right now. The resource is here. The ability to develop it is here."**

**Chris McGill, managing director of policy analysis for the American Gas Assn.**

**“The amount of natural gas available for production in the U.S. has soared 58% in the past four years. The nonprofit Potential Gas Committee reports that the U.S. has 2,074 trillion cubic feet of natural gas still in the ground, or nearly a century's worth of production at current rates.” Wall Street Journal (6/19/09)**

**Natural gas is too important to ignore as part of an overall energy sustainability plan.**

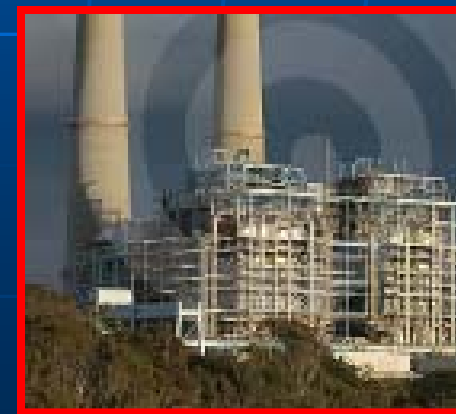


# How Is Natural Gas Used?

Natural gas has many residential, commercial and industrial applications. It is also increasingly used as an alternative transportation fuel. As technology is developed and implemented, additional uses are being found for natural gas.

Key uses include:

- Residential uses
- Commercial uses
- Industrial uses
- Chemical feed stocks
- Power generation
- Transportation fuel



# What is Natural Gas?

- Primarily methane (CH<sub>4</sub>).
- Methane is a nonreactive hydrocarbon which means its emissions do not react with sunlight to create smog.
- Its purity makes it an environmentally friendly fuel.
- Found in large underground fields much like crude oil.
- Compressed natural gas (CNG) is nontoxic, non-carcinogenic and noncorrosive.
- Isn't feasible to transport over land in its gaseous state. Rather, extensive underground pipelines are developed to carry it from the wellhead to customers thousands of miles away.
- Most U.S. households have access to a source of natural gas from a local distribution company (LDC). LDC's provide gas at pressures ranging from 4-50 psig.
- Natural gas is lighter than air, making it a safe fuel for many applications. Any leakage will quickly dissipate into the atmosphere, reducing the risk of an explosion as compared to liquid fuels, which pool on the ground or pollute ground waters.



Source: Chesapeake Energy Corporation

# Where Does Natural Gas Come From?

- The natural gas we use today began as microscopic plants and animals living in the ocean millions of years ago. As they thrived, they absorbed energy from the sun, which was stored as carbon molecules in their bodies. When they died, they sank to the bottom of the sea and were covered by layer after layer of sediment. As the plants and animals became buried deeper in the earth, heat and pressure began to rise. The pressure, combined with a high degree of heat, compressed the biomatter and produced natural gas.
- After natural gas was formed, it tended to migrate upward through tiny pores in the surrounding rock. Some natural gas seeped to the surface, while other deposits traveled until they were trapped under impermeable layers of rock, shale or clay. These trapped deposits are where we find natural gas today.
- Coal seam gas is another significant source of natural gas.
- Landfill gas, digester gas and other biogas generators contain mostly methane gas, but they are not typically referred to as natural gas.

Source: Chesapeake Energy Corporation

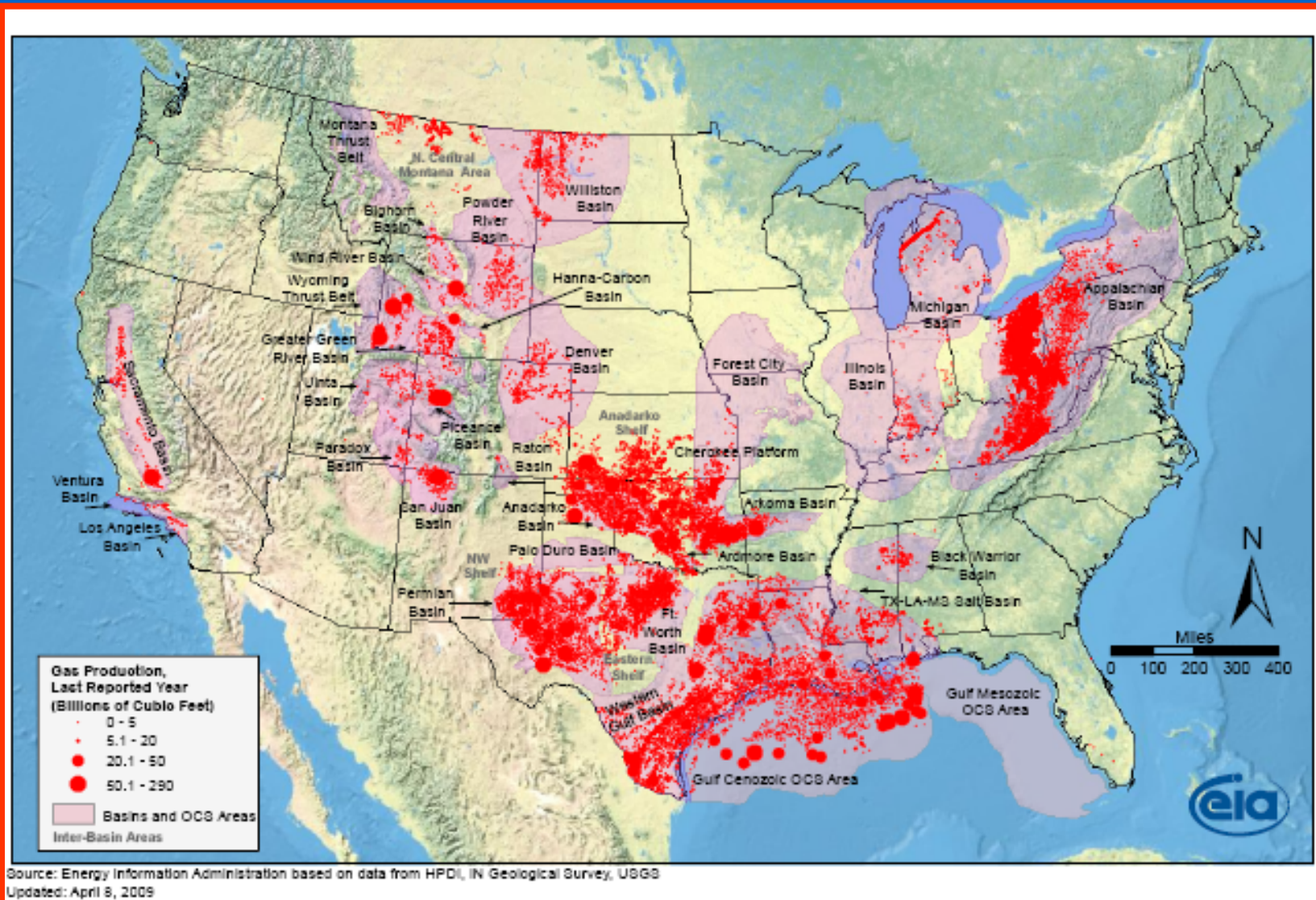
# How Is Natural Gas Extracted?

- Extraction of natural gas can be accomplished through either vertical or horizontal drilling. Recent technological advances in horizontal drilling and fracturing enable the extraction of natural gas from shale or deep rock (tight gas) formations.
- The horizontal drilling method uses vertical drilling from the surface down to a desired level. Then, the drill is turned in a right angle and bores into a gas reservoir horizontally, directed by GPS.
- Fracturing is an innovative technique that involves pumping fluids or water into the wellbore with enough pressure to create fractures in the rock formation. It is these fractures through which natural gas moves into the wellbore and up to the surface.
- Pipelines and compressors transport the natural gas to processing facilities to remove water, heavy hydrocarbons (NGL) for sale, and any undesirable compounds such as  $H_2S$  or  $CO_2$ .
- Natural gas can also be converted to liquid state (LNG) for storage and for transport over long distances where there are no underground pipelines.



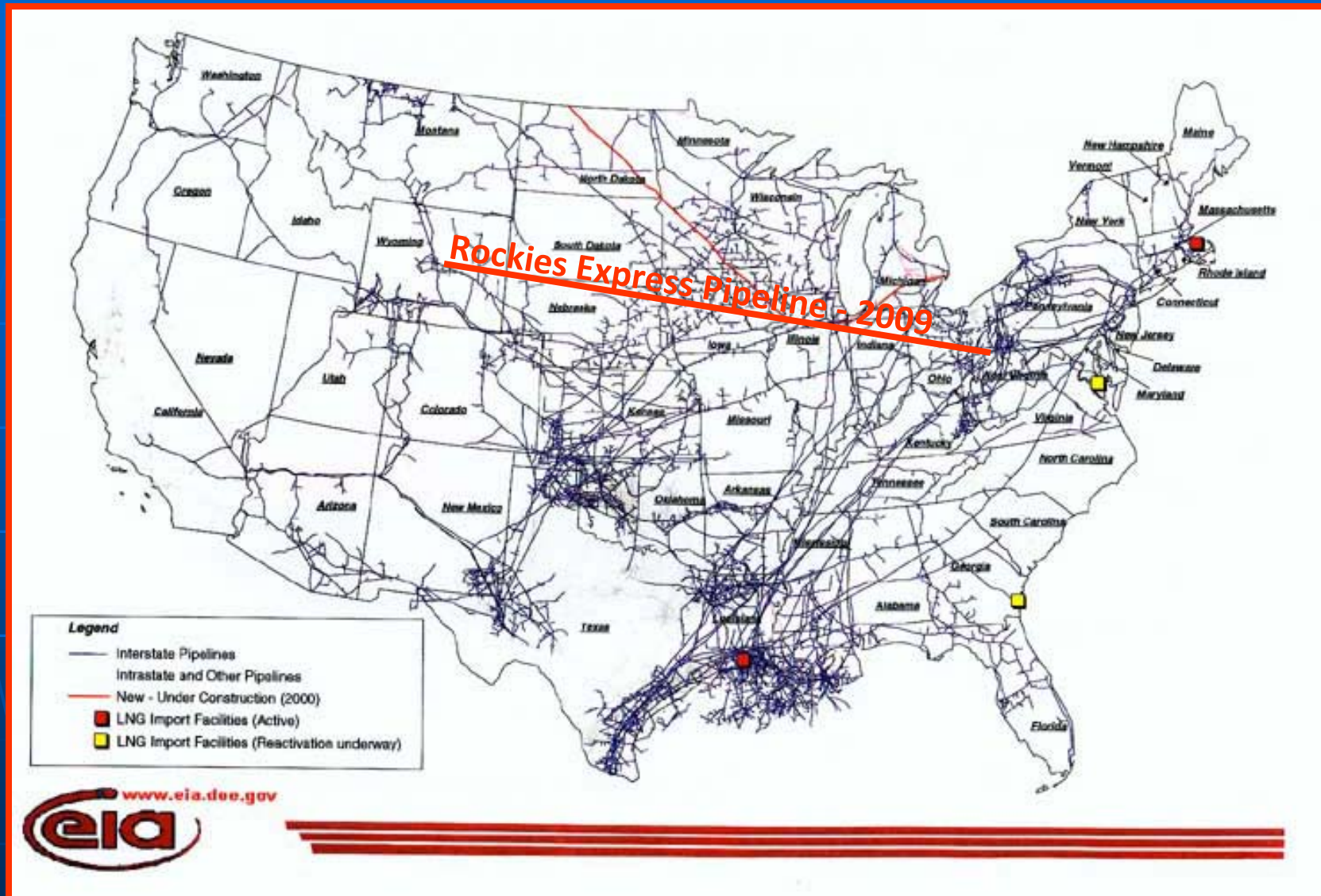
Source: Chesapeake Energy Corporation

# Conventional Gas Production in Lower 48 States



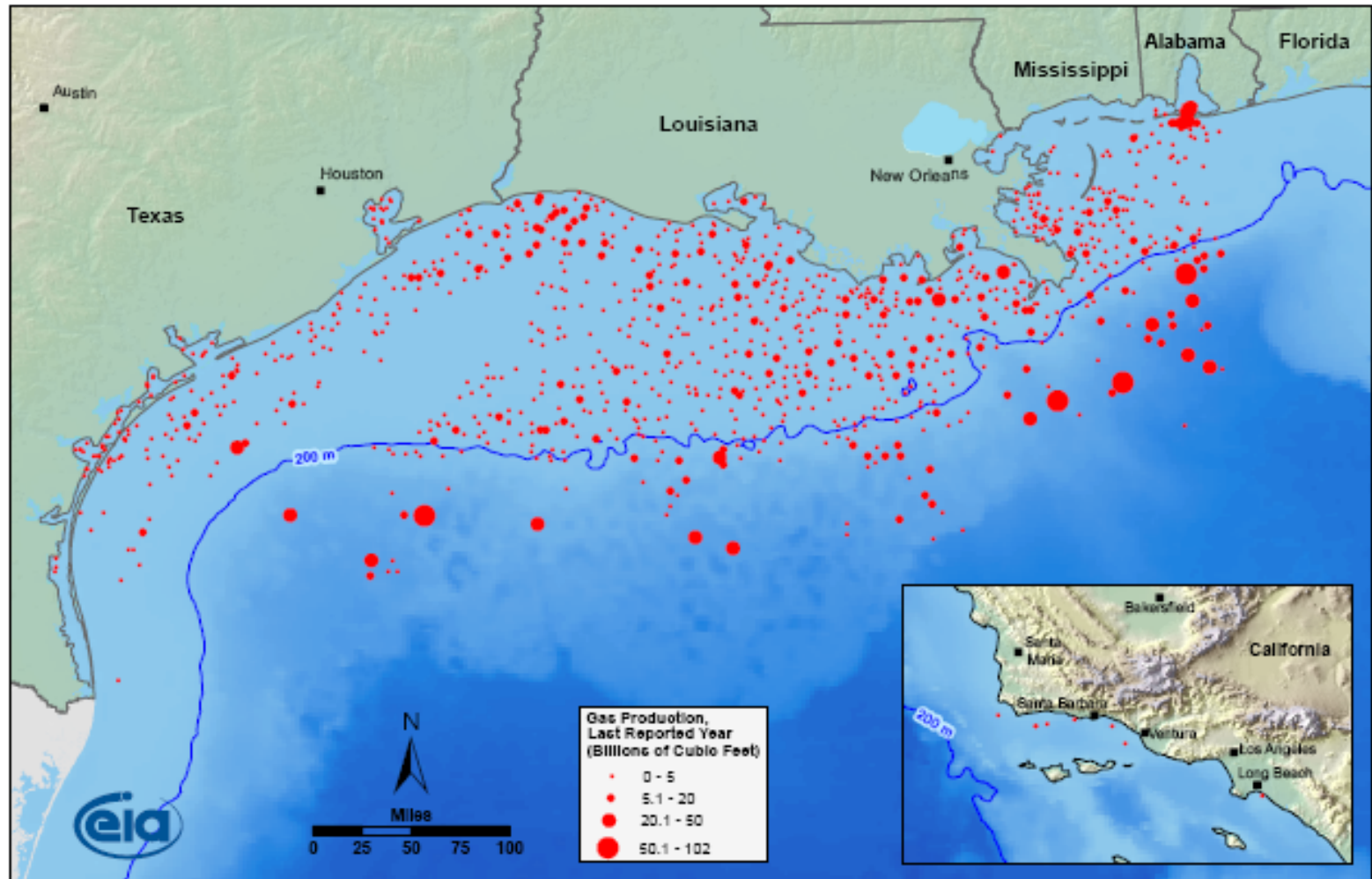
**Conventional fields were declining & the outlook was bleak until 2006**

# USA Natural Gas Pipeline Network - 2000



An extensive underground pipeline network moves gas to high population areas.

# Offshore Gas Production in Lower 48 States

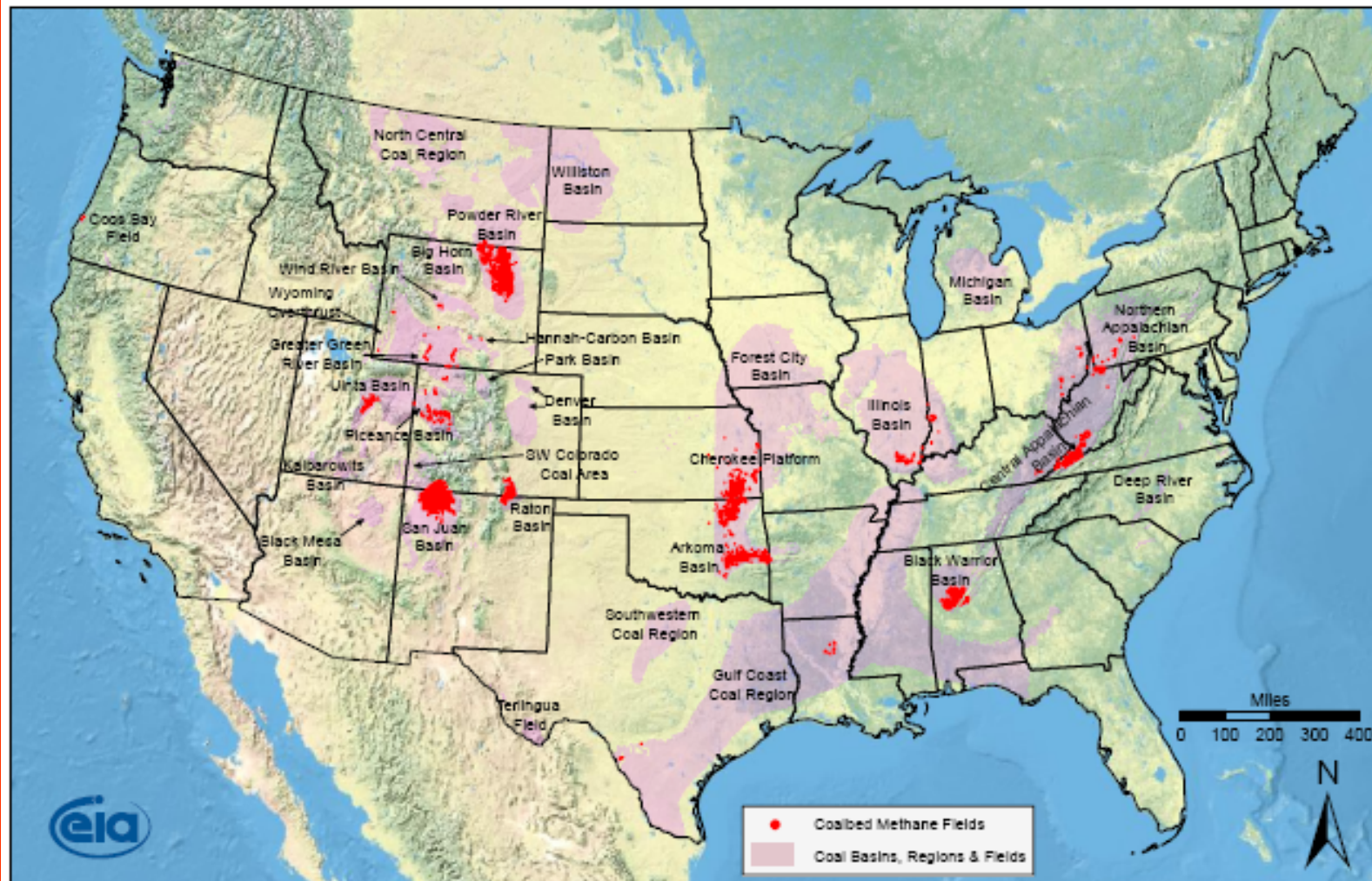


Source: Energy Information Administration based on data from MMS, HPDI, CA Dept of Oil, Gas & Geothermal  
Updated: April 8, 2009

**The Gulf of Mexico holds great potential using new deep water technology.**



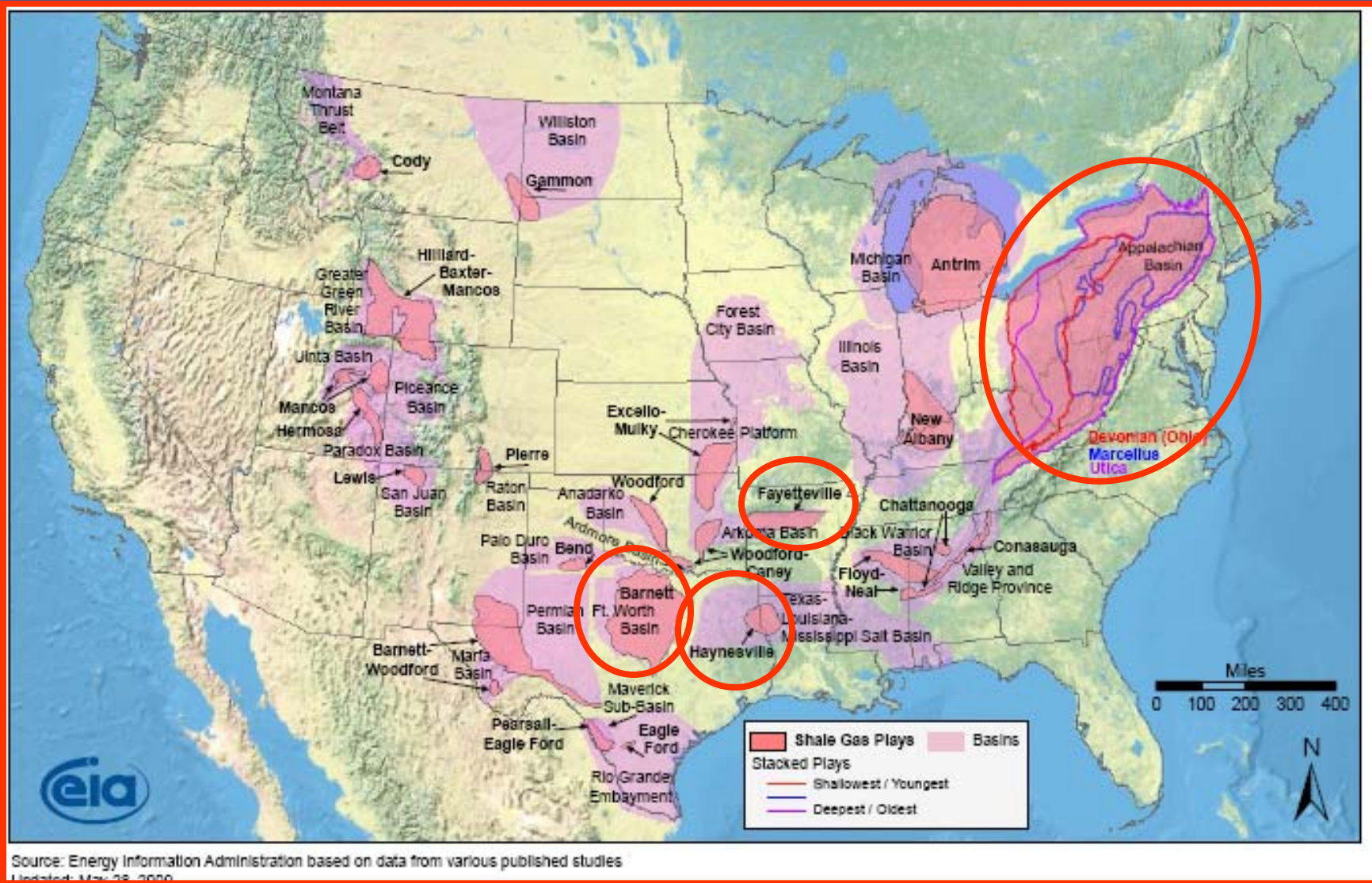
# Coal Bed Methane Fields in Lower 48 States



Source: Energy Information Administration based on data from USGS and various published studies  
Updated: April 8, 2009

**Shallow Coal Seam Gas continues to be a significant supply contributor.**

# Shale Gas Plays In Lower 48 States



**Higher Prices and New Technology Make Shale Gas the New Mother Lode!**

# Tight Gas Plays In Lower 48 States

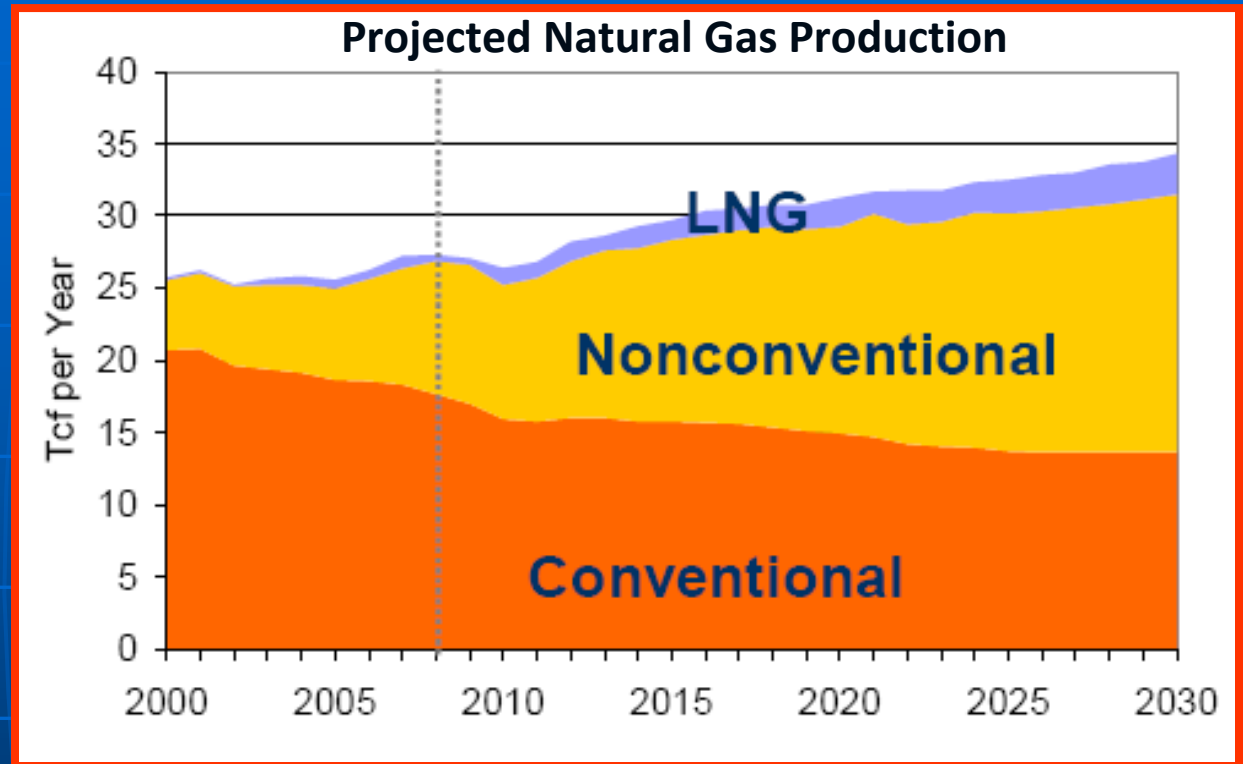


Source: Energy Information Administration based on data from various published studies  
Updated: April 8, 2009

**Deeper Tight-Gas plays hold potential as gas prices increase and production costs decrease.**

# USA Natural Gas Supply

- Domestic gas resources are abundant.
- Technological advances are spurring development.
- Drilling activity is sensitive to gas price.
- Gas deliverability responds quickly to development activity due to high reserves per well.
- Prices at or above \$5 per MMBtu will be needed to support growth of non-conventional supplies (CBM, shale, tight gas).



Source: ICF International

**Shale (not LNG) is the gas supply of the future**

# USA Natural Gas Price Outlook?????

“Natural gas prices could remain low during the next few years as a spate of new coal-fired electricity plants open, reducing the overall amount of the fuel needed in the U.S. for power generation. Once the plants are completed, however, natural gas demand could rise sharply as older coal-fired plants are retired and government policies show a greater preference for cleaner energy sources. Prices could even spike to \$10 per million BTU in the 2013 - 2014 timeframe as producers struggle to keep up, before falling back to the \$6.50 range after that period.”

Jen Snyder, Woods Mackenzie – Houston Chronicle (11/21/09)

“With the economy growing again and producers trimming natural gas output amid record storage levels, the average spot price in 2009 should rise from \$4.03 per million cubic feet to \$5.01 in 2010.” EIA (11/21/09)

# Natural Gas – An Important Energy Component

- Natural gas is by far the cleanest-burning hydrocarbon on the planet, with much lower CO<sub>2</sub> emissions and fewer pollutants than coal or oil when burned.
- It offers a relatively low greenhouse signature compared with other fossil fuels.

## Fossil Fuel Emission Levels - Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends

- It is energy efficient and comparatively easy to use with current technology.

**Natural Gas is Environmentally Friendly**



# Natural Gas – An Important Energy Component

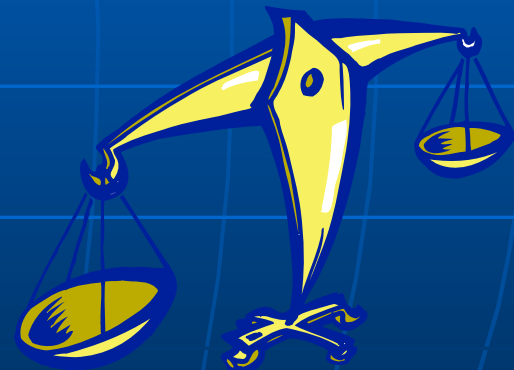
- Natural gas has become a key part of national energy policies in many countries.
- It accounts for 22% of the world energy mix, and demand is growing, particularly in the electricity sector.
- The USA has 2,074 trillion cubic feet (2,225 Quads) of natural gas still in the ground, or more than a century's worth of production at current rates of consumption.
- The surge in domestic gas resources is the result of a 5-year-long drilling boom spurred by high natural gas prices, easy credit and new technologies that allowed companies to produce gas from a dense kind of rock known as shale.
- Natural gas is projected to continue to be a lower cost energy source than any others in the foreseeable future.
- Since known natural gas reserves were declining until the recent 2005 to 2008 boom, marketing has not kept pace with supply.



**Natural Gas is Abundant and Comparatively Low Cost**

# Natural Gas – An Important Energy Component

- Must develop the resource in an environmentally appropriately way – protect water supplies, develop new technologies to reclaim water, clean up after the drilling is completed, minimize air emissions, etc.
- Continued development of this important resource will depend on:
  - appropriate natural gas prices (\$5 to \$10/MCF)
  - access to capital for exploration, lease purchases, drilling & development
  - ongoing operator commitment to take risks
  - continuing technological breakthroughs
  - a reasonable government regulatory climate
  - availability of water sources for frac processes
  - growth in demand for natural gas



**Too important to ignore as part of an overall energy sustainability plan**



# Natural Gas – An Important Energy Component

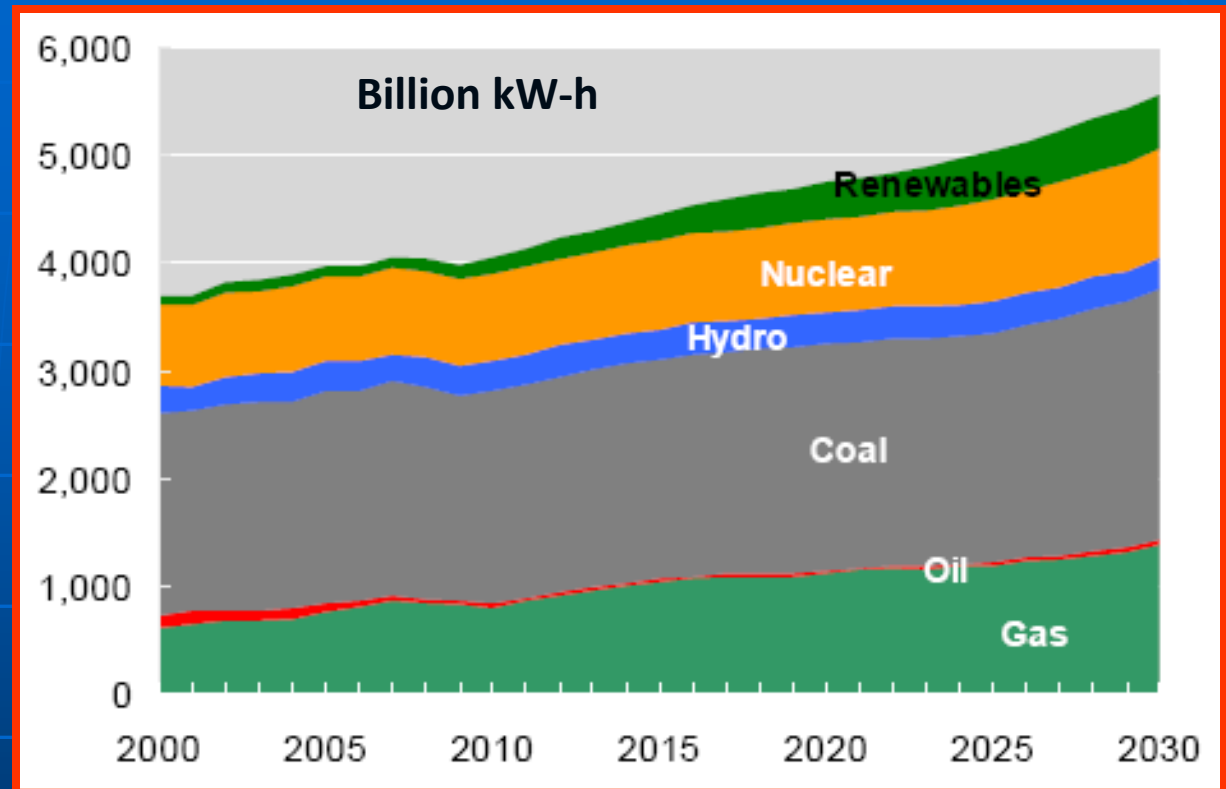
- 2,074 tcf will last about 101 years at current rate of consumption (21.2 QBtu)
- By increasing consumption in the short term, domestic natural gas can be used to reduce our level of oil imports now while bridging the serious gap between supply and demand until renewable sources, efficiency improvement and conservation have significant impacts.
- Feasible opportunities:
  - Increase natural gas usage by at least 30% in 5 years (6.4 QBtu/yr)
  - Incremental power generation capacity until nuclear & renewables grow
  - Significant use for natural gas vehicle (NGV) fuel
    - can supply 23% of transportation fuel needs within 5 years
    - 23% reduction in oil imports within 5 years
  - Have 75 year supply at this rate of use



**These are very conservative projections if government decides to embrace natural gas.  
Too important to ignore as part of an overall energy sustainability plan.**

# 2008 USA Power Generation Projections

- In the next ten years, gas-based power generation is projected to grow to 25% of total generation.
- Growth in market share of gas-based generation will slow after 2020 as new clean coal, renewable capacity and some new nuclear units enter the market.



Source: ICF International

## Gas Generation as Percent of Total US Generation

2006: 20%

2017: 24%

2030: 25%

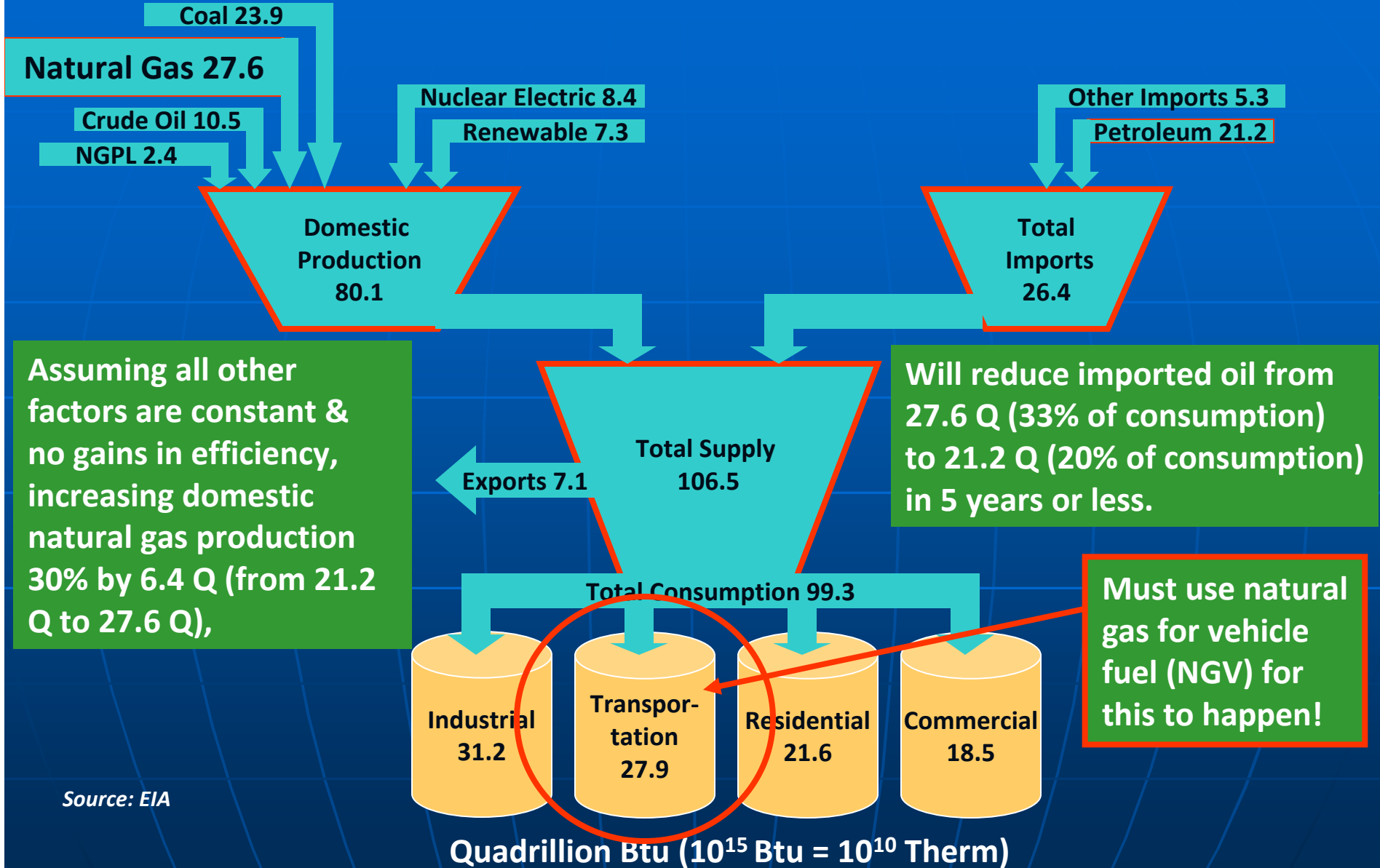
Natural Gas usage grows by only 0.15 QBtu/year

# Wind Power's Limitations Lead to More Opportunities for Natural Gas

- Germany's extensive wind turbine system supplies less than 6% of their electrical load.
- It's impossible to schedule wind – back-up natural gas generation is required.
- NorthWestern Energy's huge Montana wind farm has ramped up from 0 to 131 MW in 10 minutes & has ramped down from 131 MW to 0 in a similar time period!
- "The days of double-digit gas prices in the U.S. are over."  
Chesapeake Energy Chairman and Chief Executive Aubrey McClendon (12/30/09)
- "There's certainly the potential for the natural-gas producers and the utilities to develop a new relationship that has not been possible historically."  
Devon Energy Chairman & CEO Larry Nichols (12/30/09)

**The market may be bigger than we think!**

# USA Energy Flow – 2014 or sooner



Source: EIA

# Natural Gas Vehicle (NGV) Fuel

- Worldwide there are more than 10 million NGVs in use, but only 151,000 in the USA.
- The USA is ranked 10<sup>th</sup> in the world as far as NGV deployment, behind countries like India, Italy, China, Bangladesh and Brazil.
- Where available, CNG is 30 to 60% less cost than gasoline.
- Los Angeles has 2800 NGV buses in operation today.
- Boston, Dallas and Washington D.C. also have significant NGV fleets.
- California, home of two of the nation's largest ports – LA and Long Beach – has a program to replace diesel fuel with natural gas for their cargo handling vehicles.
- UPS and Waste Management also operate significant fleets NGV powered trucks.



Cheap oil and (previously) declining domestic natural gas reserves have left the USA behind other countries.

# Natural Gas Vehicle (NGV) Fuel

- General Motors produces 18 different NGV models under its various global brands yet sells none of them in the USA today.
- The Honda Civic is the only NG vehicle made in this country.
- CNG option for cars adds \$5K premium before incentives.
- CNG option for heavy trucks and busses adds \$10-30K premium
- CNG conversions are available for an incremental 20%
- Few fueling stations are available
  - costly
  - require maintenance
- The government sends conflicting signals:
  - Congress has encouraged conversion of cars to CNG with a tax credit of up to 50% of the auto conversion cost and the CNG home filling station cost.
  - A new Senate bill promotes increased use of NGVs.
  - But, while CNG is a much cleaner fuel, the conversion requires a type certificate from EPA. Meeting type certificate requirements can cost up to \$50K.



Many barriers to overcome for NGV use to increase.

# Natural Gas Vehicle (NGV) Fuel

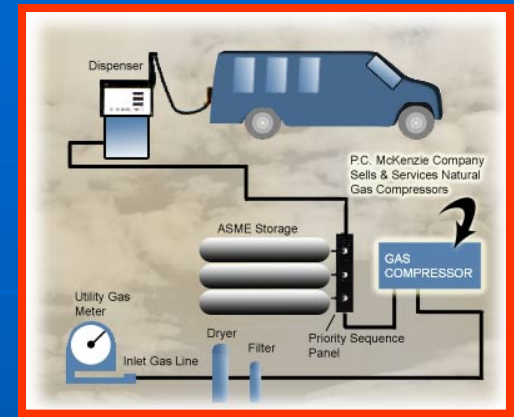
- Nearly 20% of every barrel of oil we import is used by 18-wheelers moving goods around and across the country.
- Current battery technology is not adequate for use in an over-the-road truck, so natural gas is the only near term alternative to diesel.
- Fleet vehicles like buses, taxis, express delivery trucks, and municipal and utility vehicles (any vehicle which returns to the "barn" each night where refueling is a simple matter) should be replaced by vehicles running on domestic natural gas.
- It's much more cost effective to convert large vehicles than light-duty vehicles (autos)
- Fuel savings and environmental benefits result.



**Priority applications for natural gas fuel**

# NGV Growth – What Is Needed?

- Focus NGV on heavy and medium duty trucks and bus fleets.
- Build NGV fueling stations at strategic locations
  - truck & bus terminals
  - throughout major metros
  - along interstate highway system (NGV highways)
- Favorable government advocacy for use of natural gas
- More natural gas vehicles produced in the USA – tax incentives?
- Favorable and consistent bureaucratic regulatory environment – EPA, BLM, DOT, FERC
- Reasonable natural gas prices - \$5 to \$8 per MCF will drive more development while keeping it competitive as a fuel
- Don't increase taxation on domestic production
- If CO2 is sequestered, use it for enhanced domestic oil & gas production
- Continued technological breakthroughs to drive higher production & reduce cost
- Good stewardship of water usage in drilling and fracing operations
- Consider an oil import tax to subsidize natural gas and renewable development



**NGVs – An Opportunity to reduce imported oil by at least 23% by 2014**



# USA Natural Gas Vehicles

“We must get serious about using cleaner burning natural gas and renewable energy, and this legislation is a strong step in the right direction.” Sen. Harry Reid in introducing NGV bill (7/8/09)

“Our economic crisis has shined a spotlight on the urgent need for alternative, cleaner and cheaper sources of energy that we don’t have to import. By making it easier and cheaper to own a vehicle that runs on natural gas, we can help families save money on energy, create new manufacturing jobs and clean our air.” Sen. Robert Menendez.

“I believe strongly that an extra push is needed to spur the greater use of natural gas and to get more gas-fueled vehicles on the road. Utah is in a position to lead the US in NGV use and refueling station placement. Governor Huntsman has helped promote making the state’s major north-south highway, Interstate 15, an NGV corridor.” Sen. Orin Hatch

Colorado Gov. Bill Ritter announced that his energy office applied to the US Department of Energy for a \$10 million grant to dramatically expand compressed natural gas’s use as a transportation fuel in the state.

Recently, 17 Democrats wrote: "Unfortunately, the taxes proposed in President Obama's budget would disproportionately penalize America's independent producers and will serve only to discourage companies from investing in additional projects and jobs, such as the new shale gas plays across the nation."

**Promising signs that *some* politicians see the opportunity!**

# In Conclusion

- The domestic supply of natural gas is plentiful.
  - 100 to 120 years at current consumption rates
- Natural gas is the lowest cost and cleanest burning of all fossil fuels.
- Increased supply is available now and accessible throughout most of the USA.
- Useful for power generation, chemical feed stocks, heating and transportation.
- Progressive policies and continued technological developments are needed to maximize the development and use of this important resource to reduce USA dependency on imported oil.
- Natural gas can help bridge the gap while technology and infrastructure are developed for commercializing renewable, nuclear and hydrogen energy sources while increasing efficiency and conservation to mitigate demand growth.



## An Urgent Assignment:

**“Teach” Your Senators & Congressional Representatives About the Benefits of Natural Gas!  
Take advantage of every opportunity to market our industry to the rest of the country!**

**Thanks for your attention!**

**Questions?**