Prudent Development

Realizing the Potential of North America's Abundant Natural Gas and Oil Resources

A Comprehensive Assessment to 2035 with Views through 2050

Center for Strategic and International Studies

October 12, 2011

National Petroleum Council (NPC)

Origins: Continuation of WWII government / industry cooperation.

Purpose: Solely to advise the U.S. Secretary of Energy and Executive Branch by conducting studies at their request.

Organization: A Federally chartered, self-funded Advisory Committee. Not an advocacy group, does not lobby.

Membership: Broad and balanced. Approximately 200 members from all segments of the oil and gas industries and broader stakeholders.

Study Participants: Diverse interests and expertise relating to the topic being addressed.

Study Reports: All NPC advice is provided in reports approved by its members and available to the public. They can be viewed and downloaded a no cost from the NPC website – www.npc.org

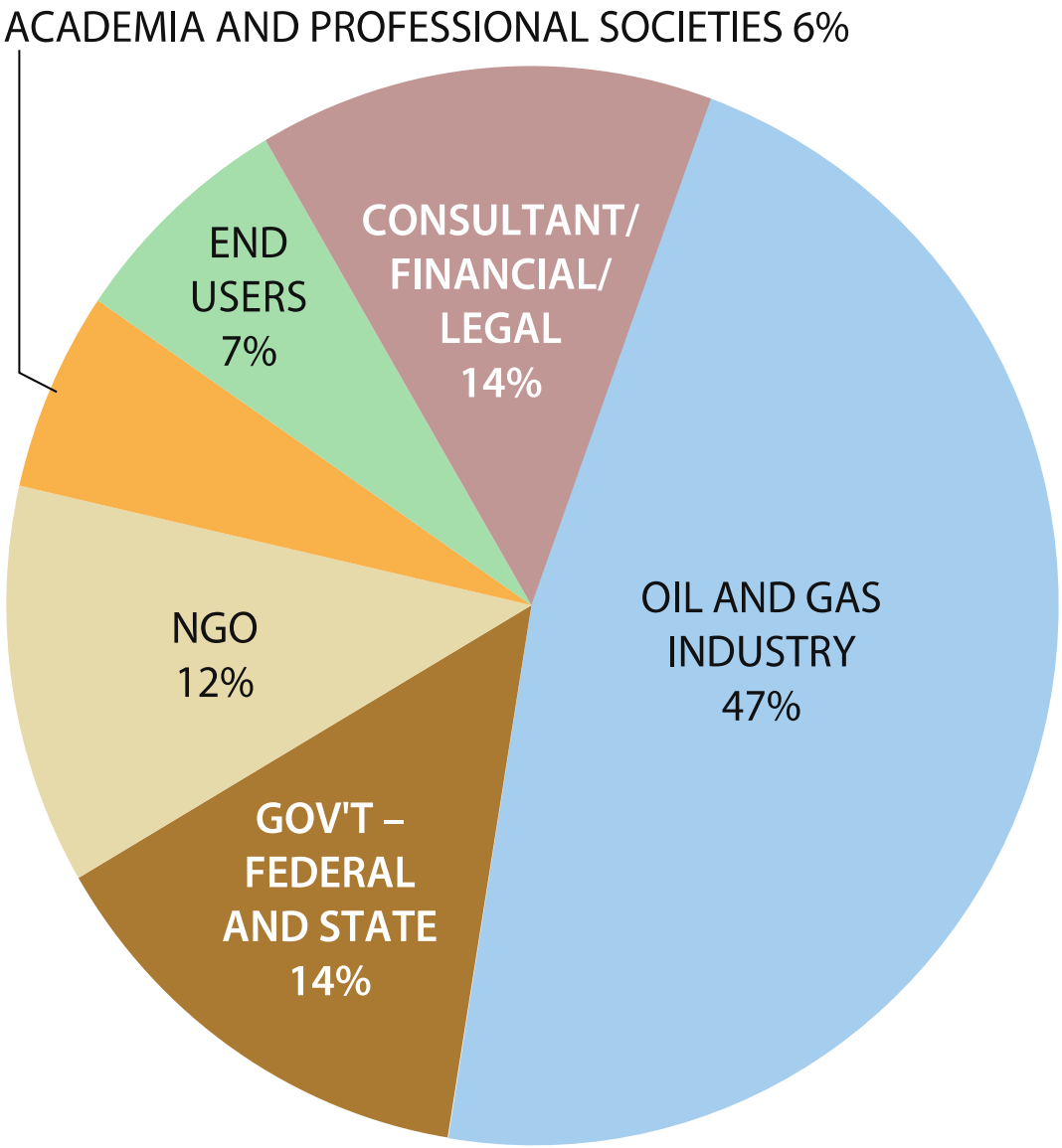
Prudent Development Study Objectives

- **Assess the N. American resource base – natural gas and oil**
  - Conventional
  - Unconventional
- **Describe the role of technology**
  - Environmental
  - Operational
- **Assess N. American supply and demand**
  - Through 2035
  - With a view to 2050
- **Identify the potential role of natural gas to lower emissions**
- **Meet national objectives: economic, environmental, security**

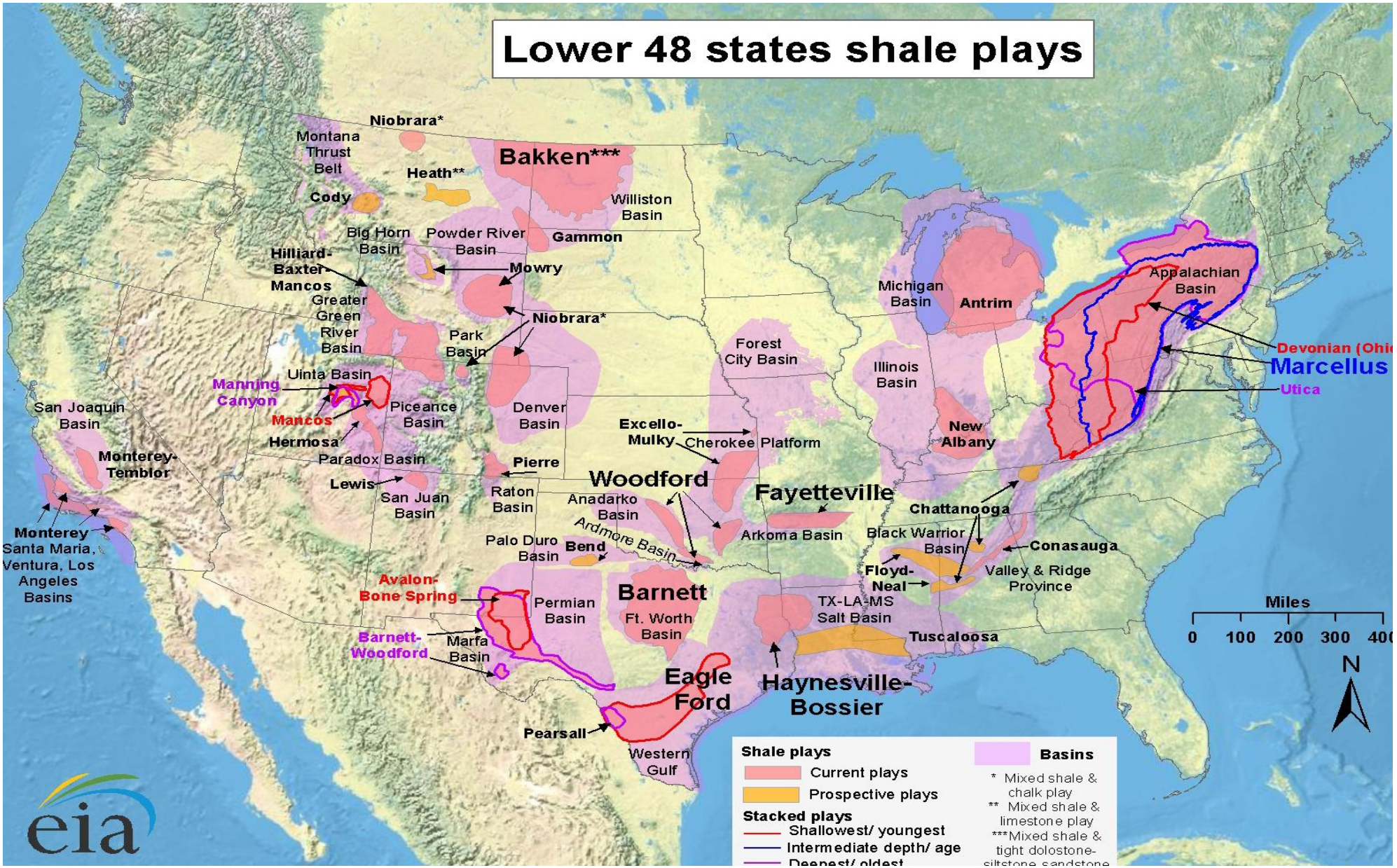
Diverse Study Participation

Study Committee,
CSC,
Task Groups,
Subgroups

Over
400
Participants



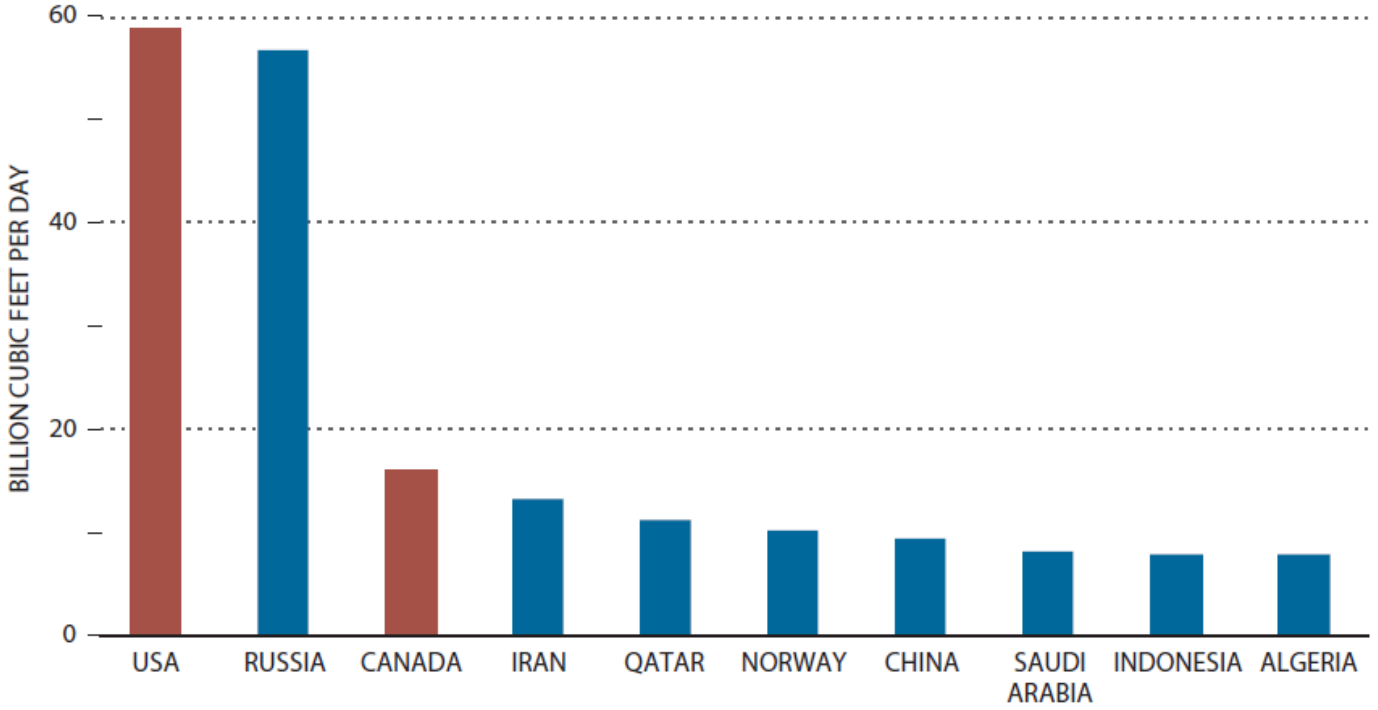
Benefits of Abundant Resources Require Prudent Development



Core Findings and Recommendations

North American global leadership in natural gas and oil production - a platform for development in natural gas…

Natural Gas Production 2010



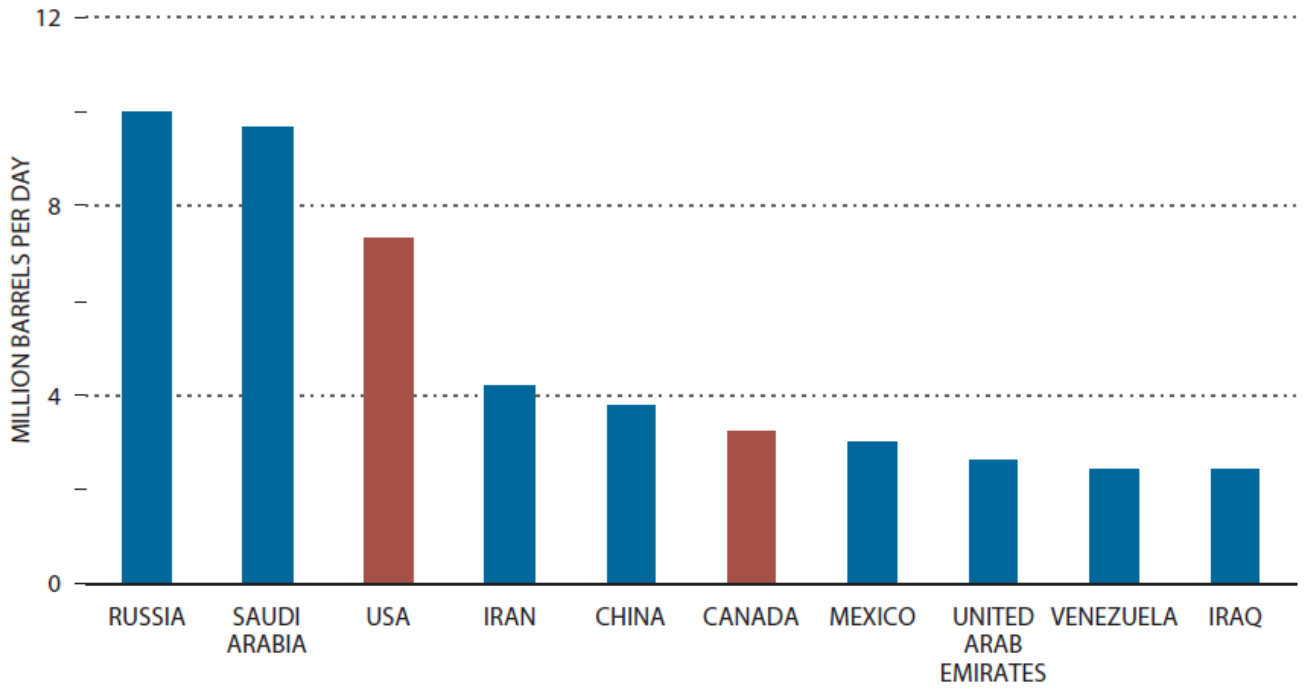
Source: BP Statistical Review of World Energy.

North America has a track record in developing and deploying key technology areas which have led to this position, including for natural gas:

- **offshore drilling, facilities and operations**
- **unconventional gas appraisal, development and production (CBM, tight gas, shale gas)**
- **horizontal drilling and multi-stage fracturing applied to source rock**
- **…**

… And oil production

Crude Oil Production 2010



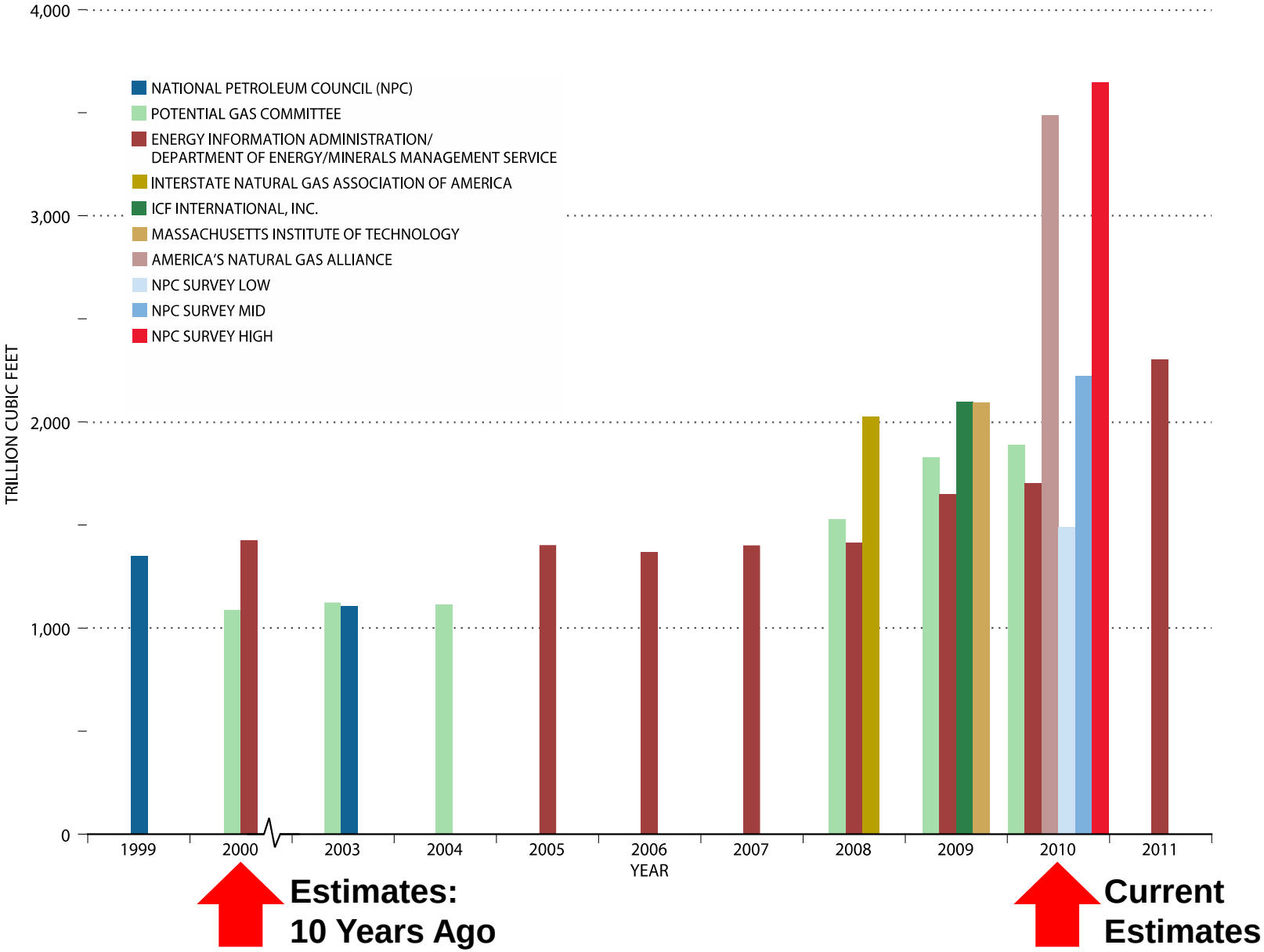
Source: BP Statistical Review of World Energy.

North America has a track record in developing and deploying key technology areas which have led to this position, including for crude oil:

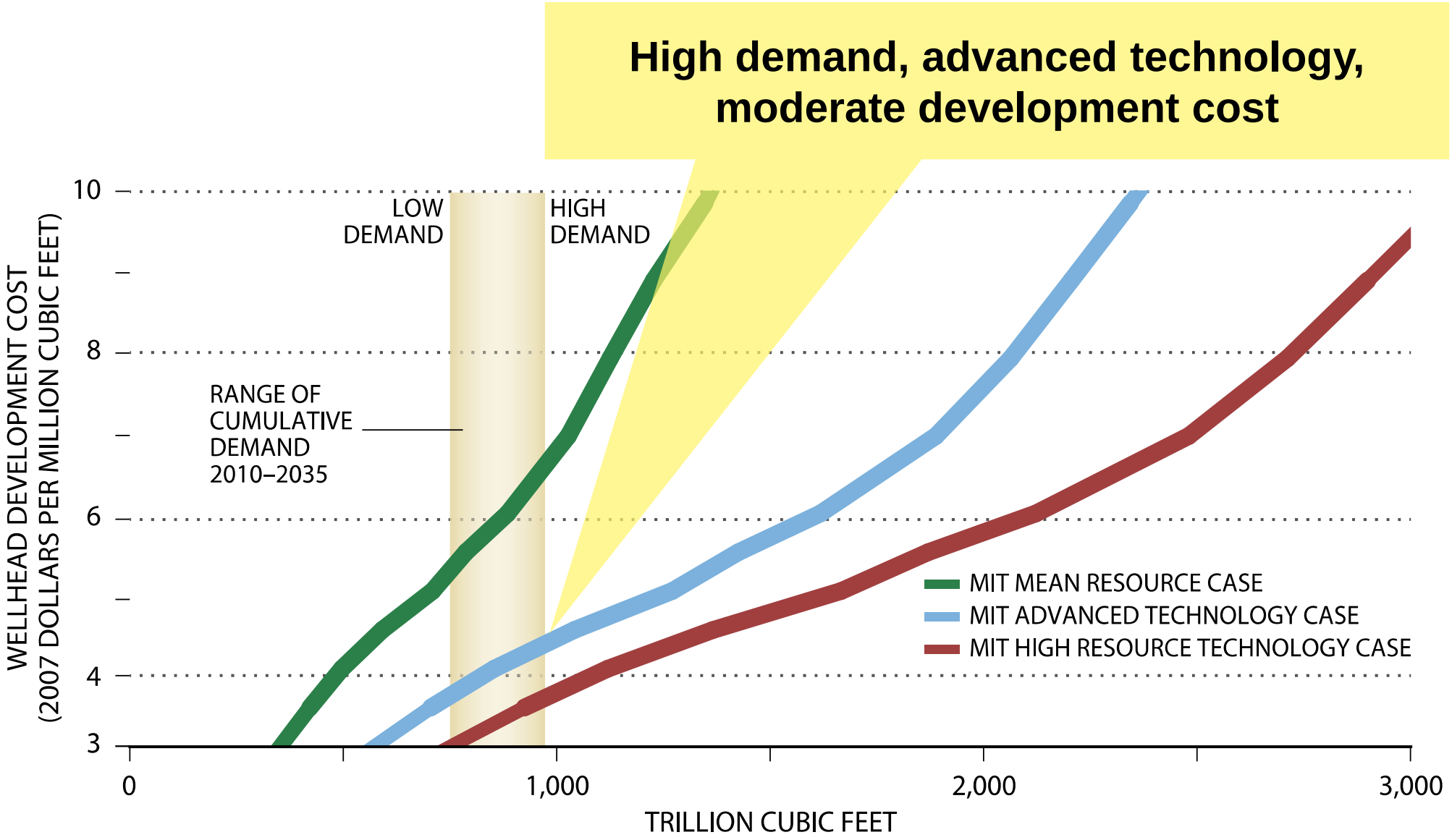
- **Arctic drilling and operations**
- **offshore drilling, facilities and operations**
- **oil sands development, mining and in-situ**
- **horizontal drilling and multi-stage fracturing applied to source rock**
- **…**

North American Natural Gas Resource Estimates have Transformed the Supply Outlook

Recent Estimates of Natural Gas Resources

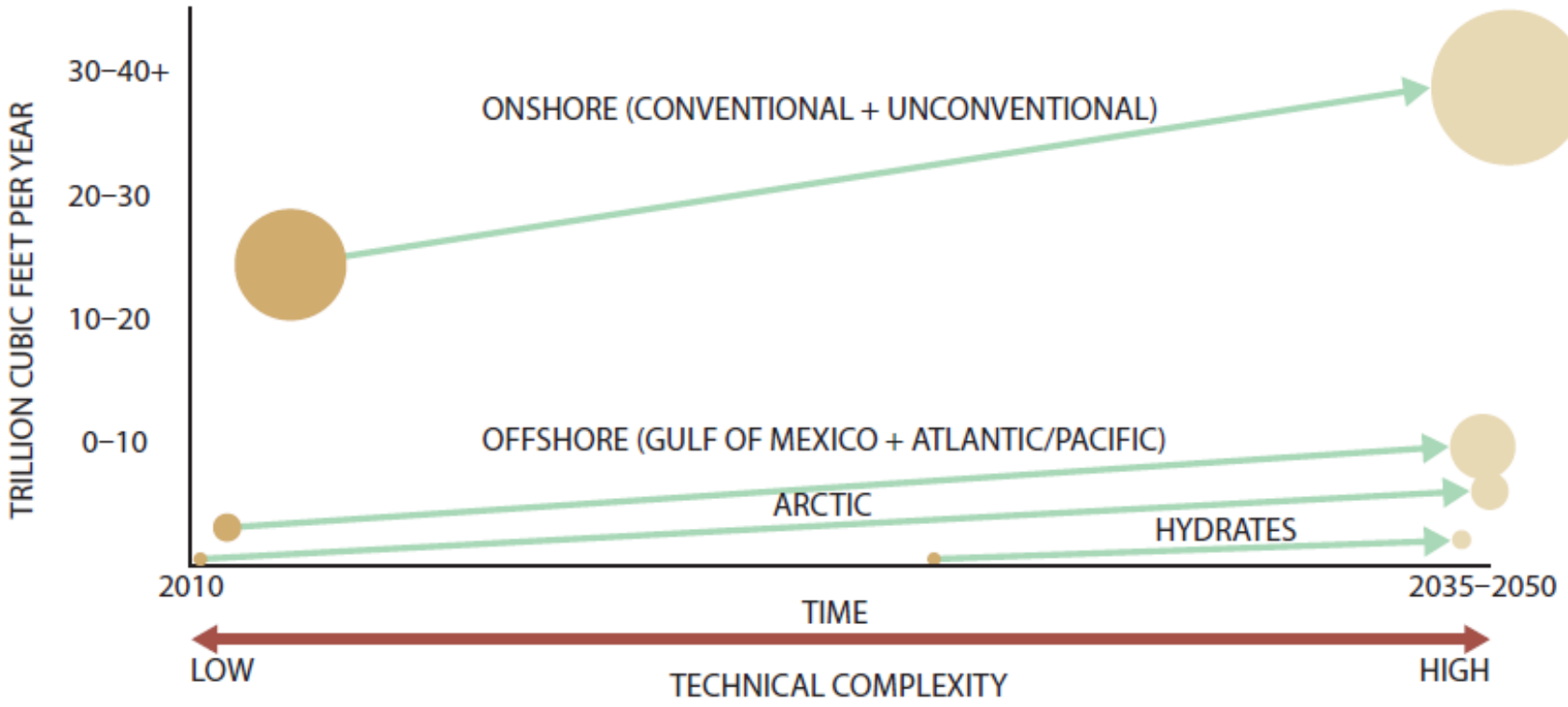


N.A. Gas Resources Have Potential to Supply the Market for Decades



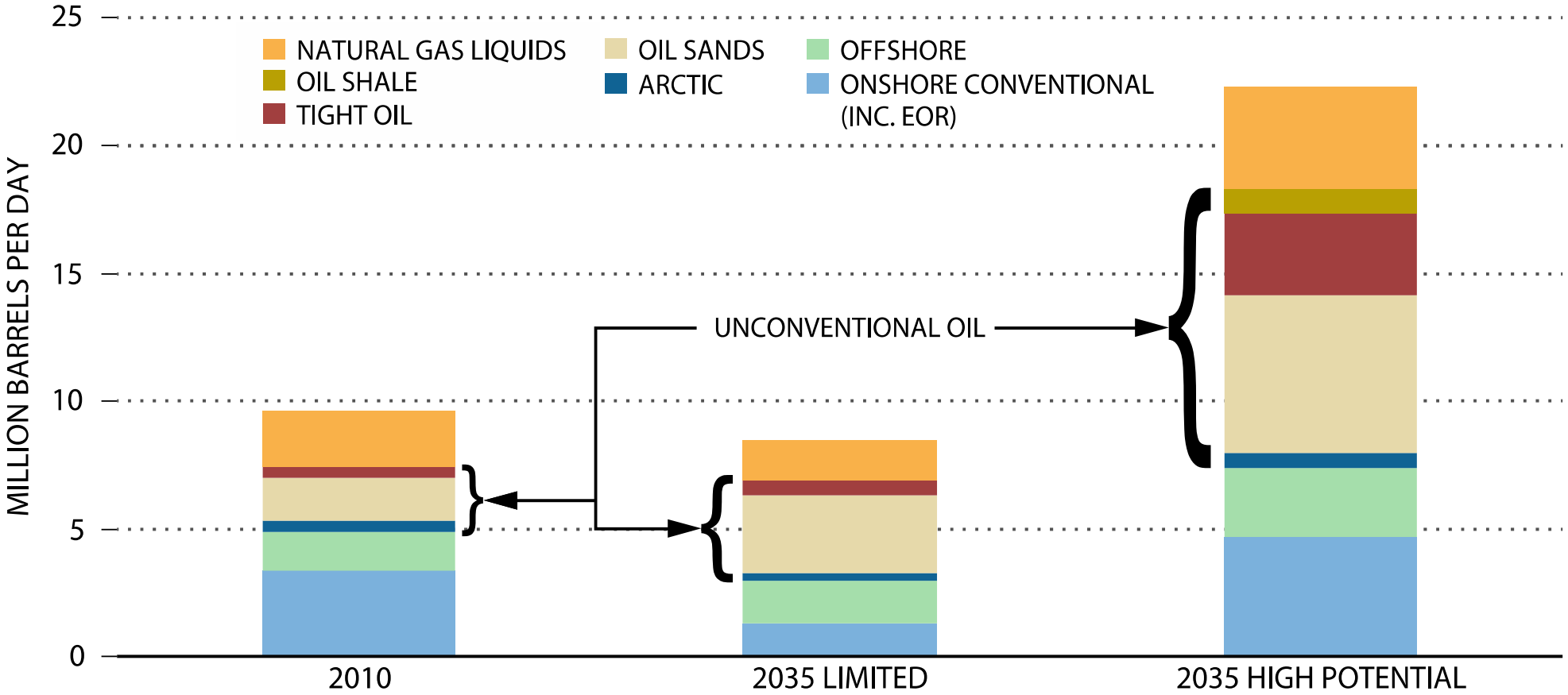
Natural Gas Production Potential can develop from a diversity of sources

Actual and Potential North American Gas Production Sources



N.A. Oil Supply Has Upside Potential But Risk of Decline

High production opportunities enabled by access frameworks



Natural Gas and Oil Have a Portfolio of Available Domestic Supply Options

- **In the near-term, currently commercial developments:**
  - Gulf of Mexico, Oil Sands, EOR, tight oil, onshore unconventional gas
- **In the medium-term, recognised high-potential areas with currently restricted access:**
  - Arctic, “new” offshore regions, plus all the above
- **In the long-term, resources which need new technologies and/or new access and regulatory regimes:**
  - Methane hydrates, shale oil (kerogen), U.S. oil sands, plus all the above
- **Medium and long-term options need sustained access, appropriate regulatory certainty, technology development and focus on environmental performance**
- **Pipeline, storage and processing facilities will need to expand to accommodate increased supply**

Policy Choices Can Enable Prudent Development of Supply Options

- Develop appropriate leasing and royalty frameworks
- Establish long-term technology partnerships
- Maintain energy data and analysis capabilities serving government and industry
- Conduct resource assessments covering all prospective areas
- Maintain effective infrastructure permitting

Policy Choices Can Enable Prudent Development of Supply Options

1. **Implement appropriate federal leasing and royalty policies which recognize the specific characteristics of each resource type**
   - Tailor the length of leases to the development lead times in each area
   - Maintain or implement tailored royalty relief to support pre-commercial investment by early adopters of new technology or new resource types.

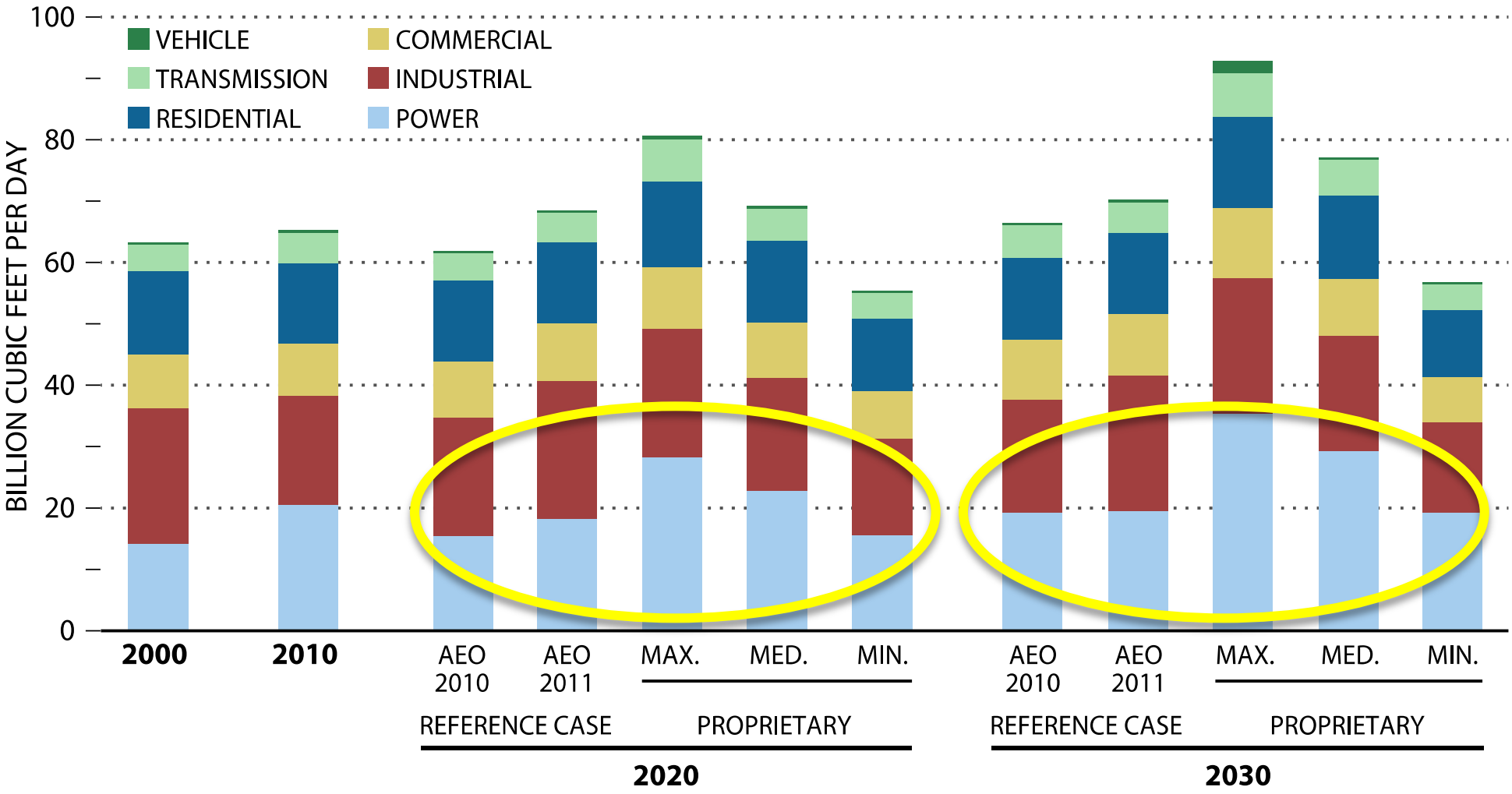
2. **Maintain and enhance government energy data and analysis capacity to support informed policy choices**
   - Ensure adequate funding and staffing for government agencies which collect, analyze and disseminate energy-related data, such as EIA

Policy Choices Can Enable Prudent Development of Supply Options

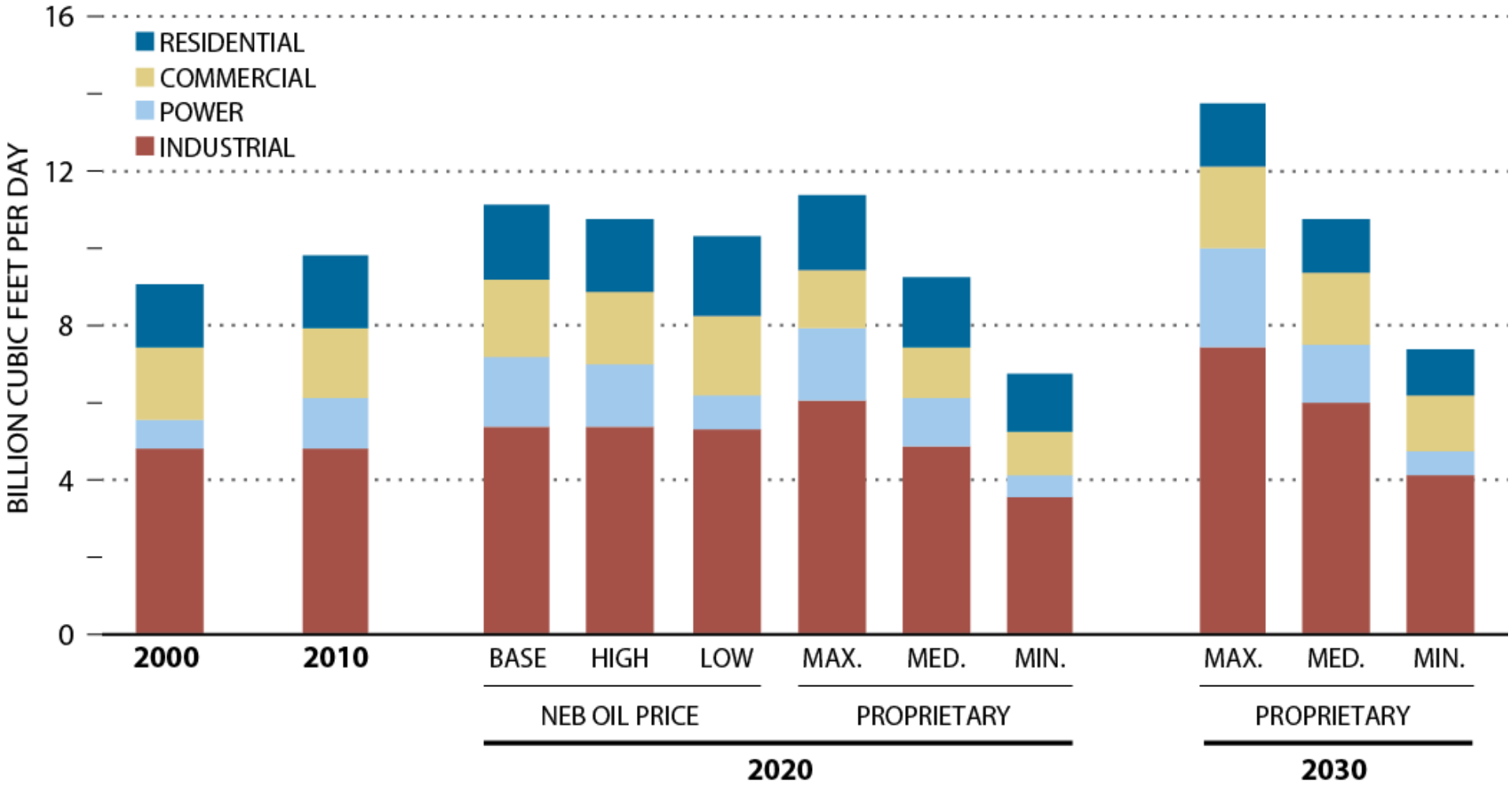
3. **Sustain focused government involvement in technology development, particularly in areas such as**
   - The environmental impact of oil spills and cleanup, including residual effects of chemical dispersants, and science-based risk assessments
   - Science and pre-commercial technology relating to new long-term resources, such as methane hydrates
   - Technology and methods for understanding, quantifying, and mitigating the environmental impacts and other risks of natural gas and oil development to improve the environmental performance of exploration and development activities

4. **Update and maintain resource assessments, particularly relating to areas currently with restricted development access**

Power Sector Most Influences the Outlook for Natural Gas Demand

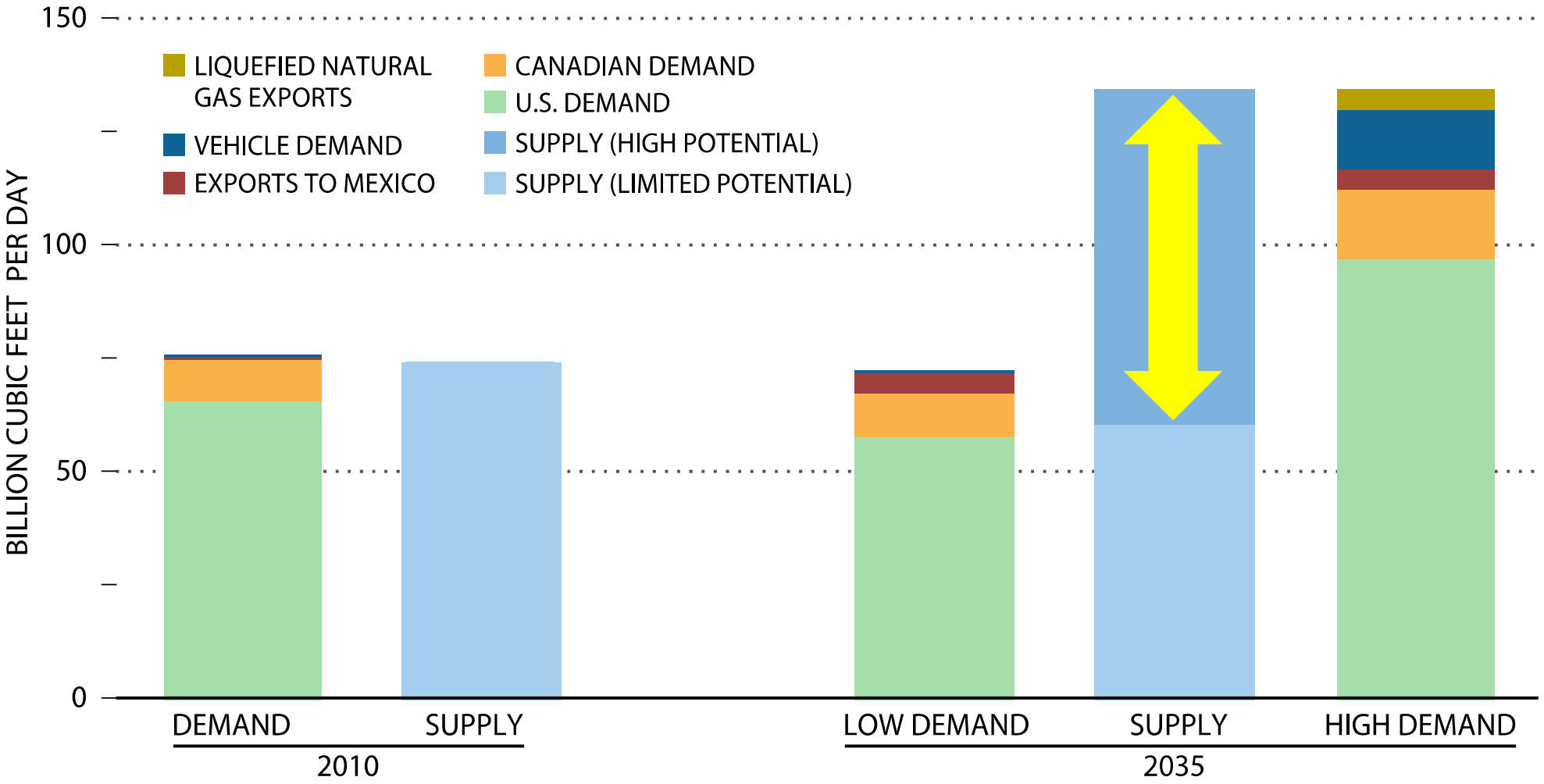


Wide Range of Canadian End Use Demand Projections

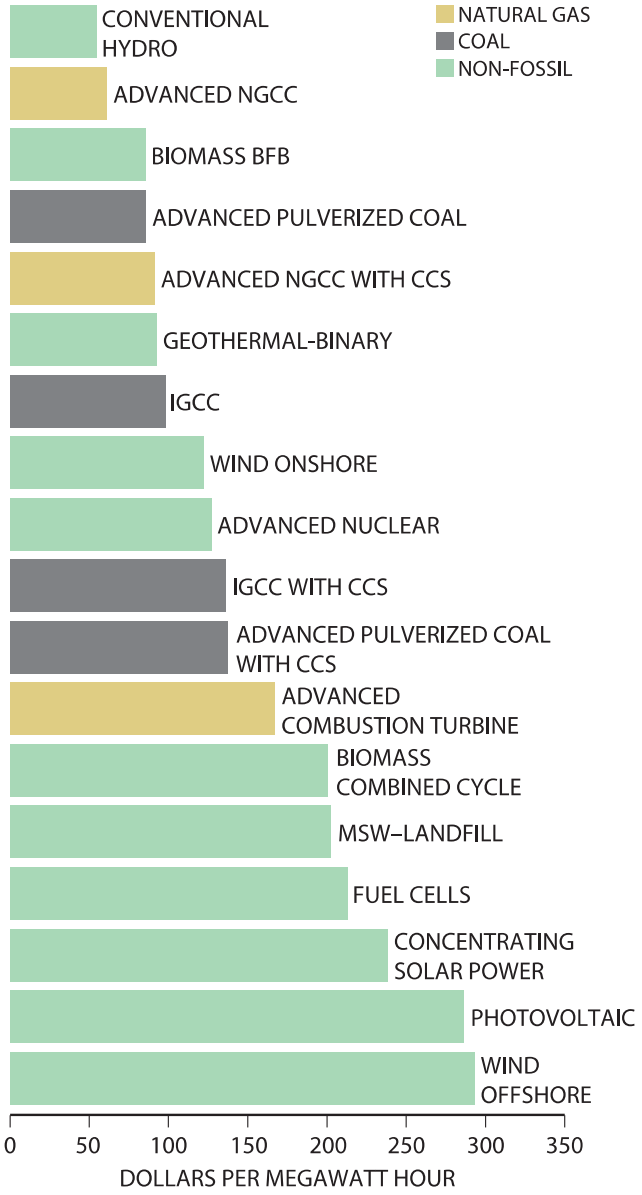


Source: NPC
Notes: NEB = National Energy Board 2009 Cases

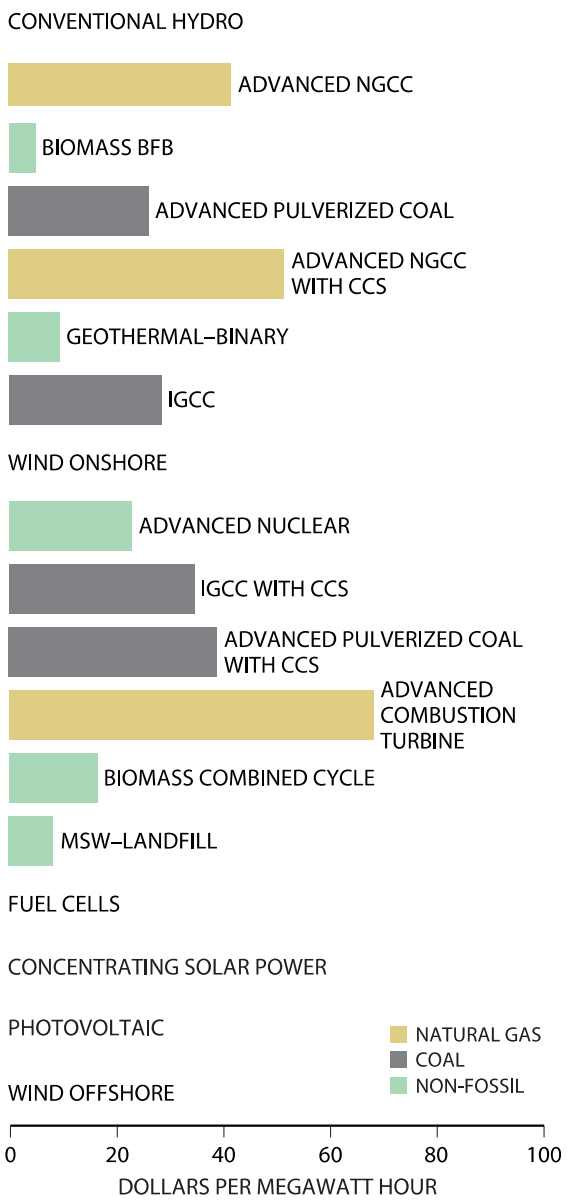
North American Natural Gas Can Meet Even the Highest Potential Demand



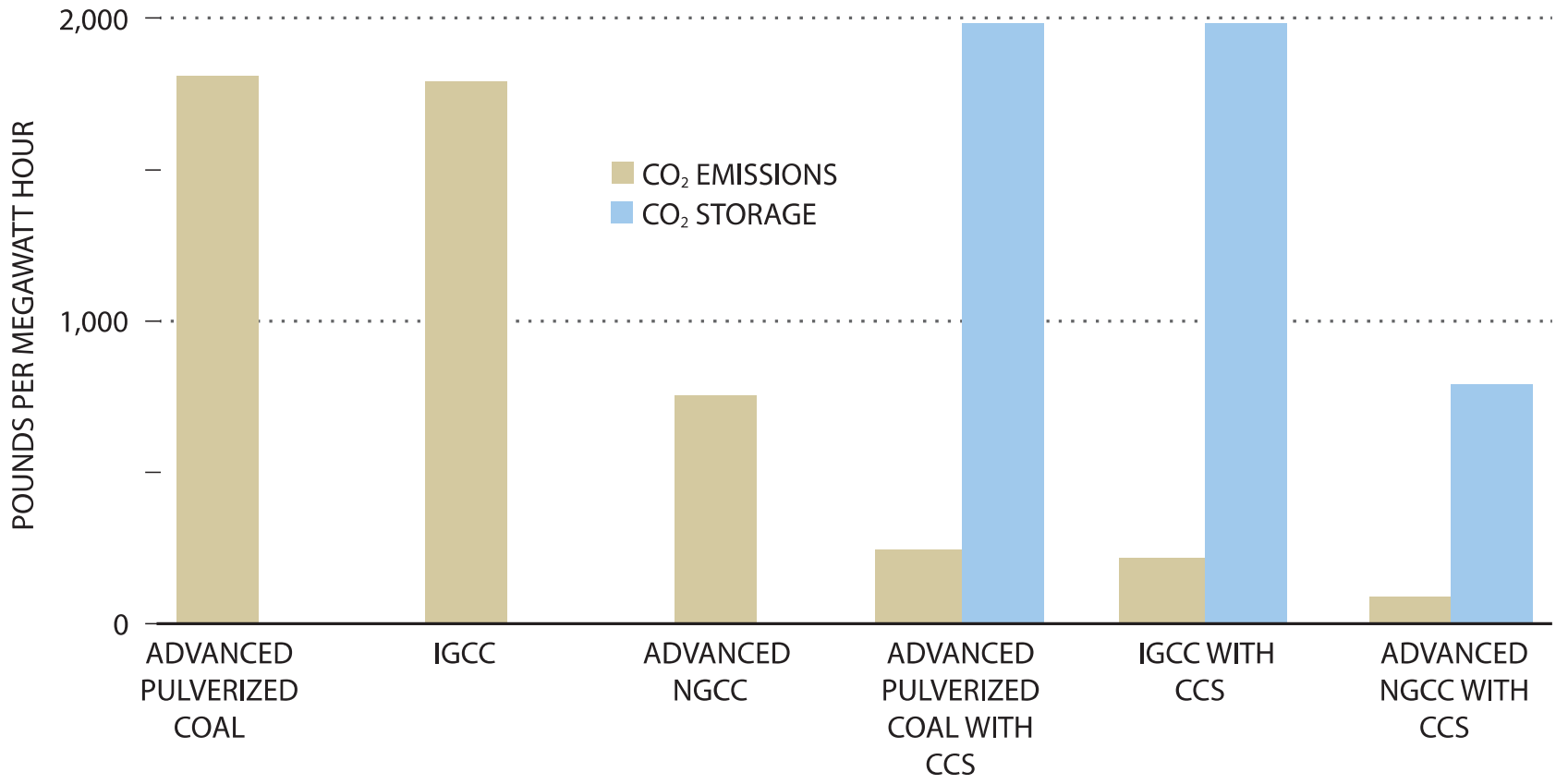
Levelized Cost of Electricity



Dispatch Cost of Electricity



Natural Gas and Coal Generation CO_2 Emissions With and Without Carbon Capture and Sequestration

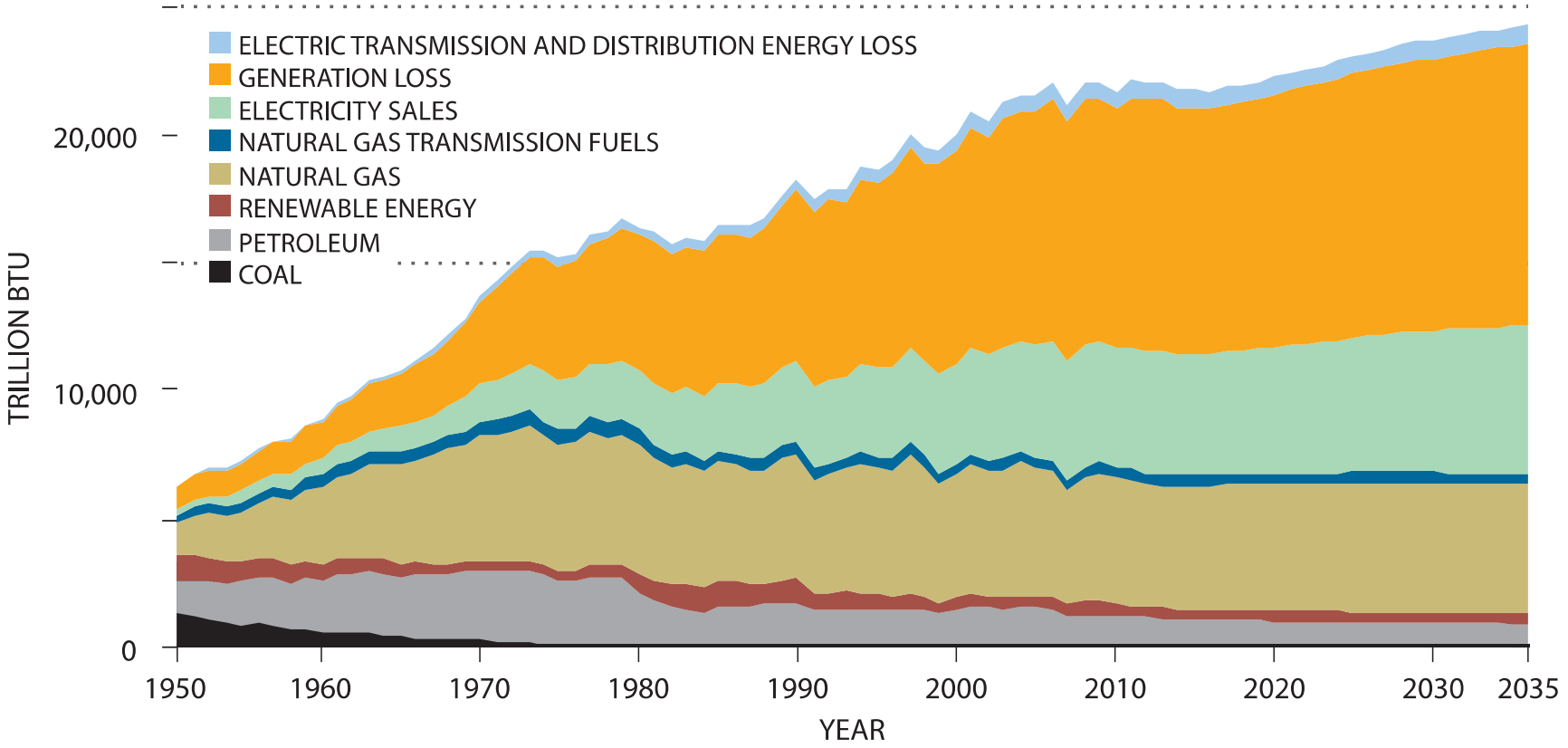


Notes: CCS = carbon capture and sequestration; IGCC = integrated gasification combined cycle; NGCC = natural gas combined cycle.
Source: Energy Information Administration's AEO2011 Reference Case.

What Is Harmonizing Natural Gas and Power Wholesale Markets All About

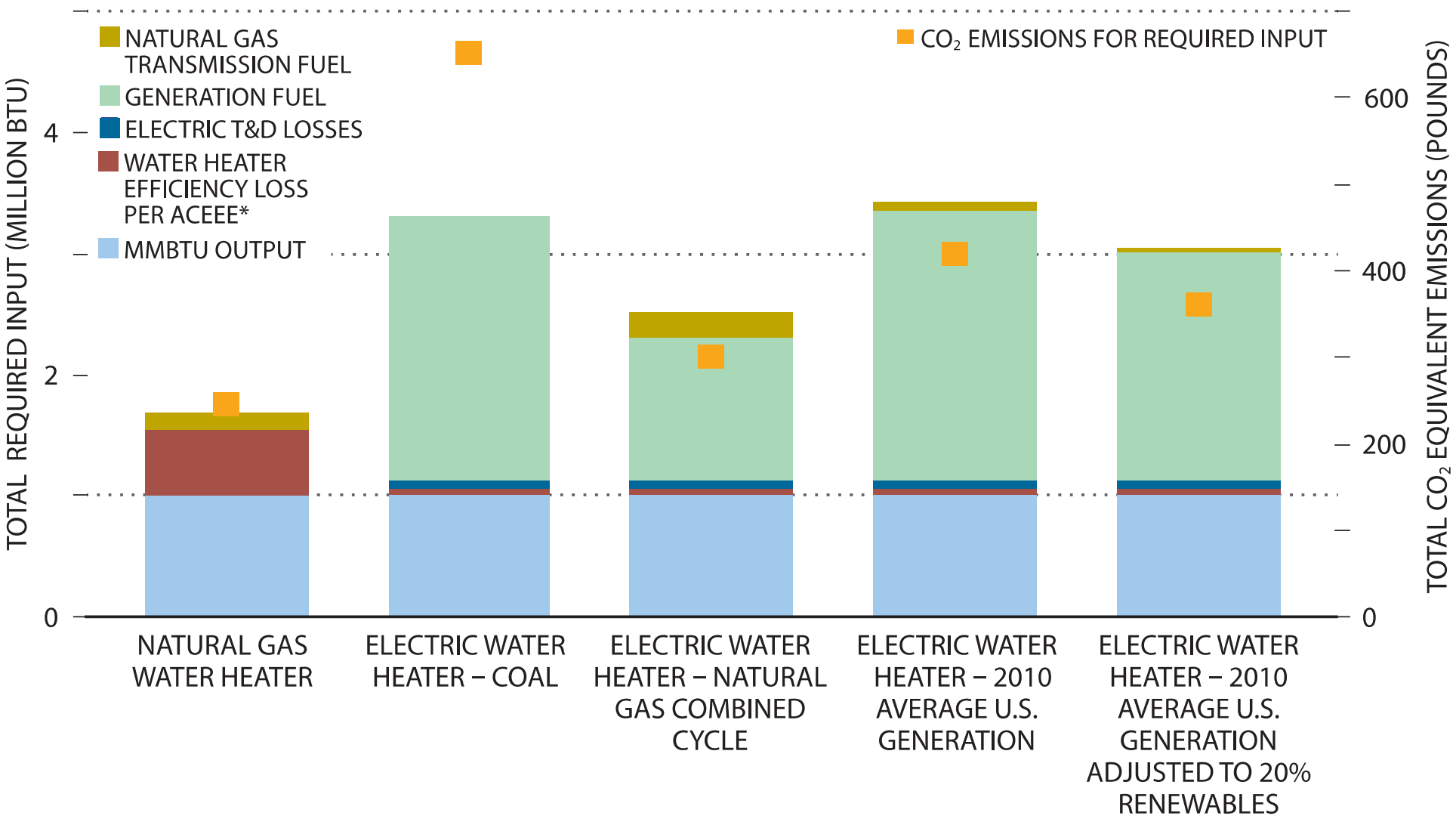
- Natural gas and power markets are becoming increasing dependent upon each other to provide reliable service
- Natural gas and electric markets involve complex networks and operating rules that evolved separately to meet the needs of their stakeholders
- Terms and conditions of natural gas service may not fully meet the needs of power generators
- Gas generation is increasingly being relied upon to balance power markets, but current contract and regulatory practices may not allow either gas suppliers or gas generators to fully recover costs

U.S. Residential Energy Use by Fuel



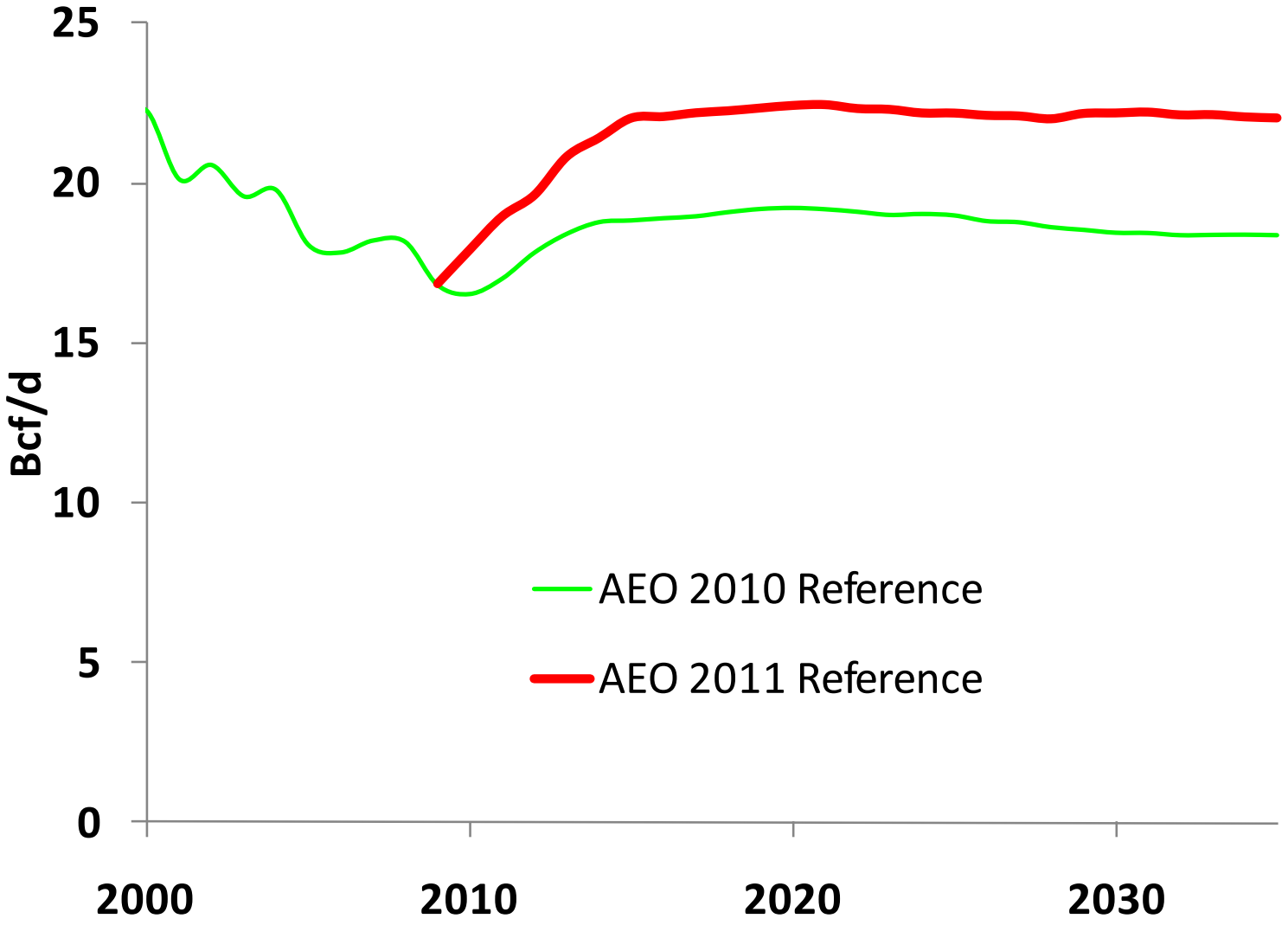
Note: Renewable energy includes wood, and petroleum includes liquefied gases such as propane.
Source: Energy Information Administration.

Full Fuel Cycle Analysis More Comprehensively Assesses Energy Consumption, Energy Efficiency and Emissions Differentials



*Water efficiency loss includes Btu and CO_2 content of fuel plus upstream methane emissions.
ACEEE = American Council for an Energy Efficient Economy.

Abundant Shale Gas Has Reinvigorated U.S. Industrial Natural Gas Demand



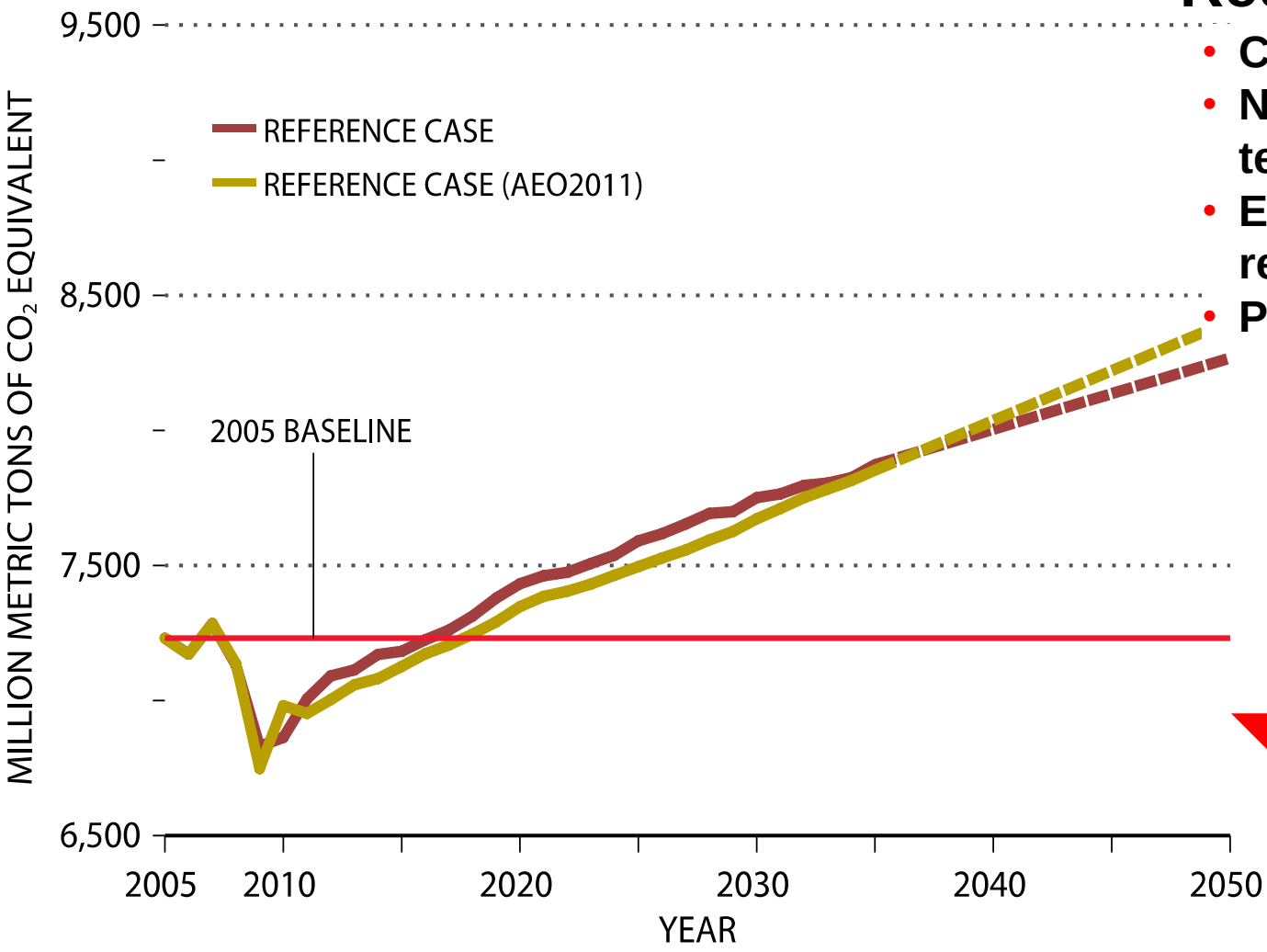
Demand Related Recommendations

- **Better Reflect Environmental Impacts in Markets and Fuel/Technology Choices**
  - Keep option for deep reductions of GHG emissions by supporting Carbon Capture and Sequestration (CCS) R&D that is fuel neutral
  - Develop and Adopt Methodologies for Full Fuel Cycle Analysis

- **Enhance the Efficient Use of Energy**
  - Support Energy Efficiency Measures for Buildings and Appliances
  - Remove Disincentives for Utilities to Deploy Energy Efficiency Measures
  - Remove Barriers to Combined Heat and Power

- **Enhance the Regulation of Markets**
  - Allow Utilities to Effectively Manage Natural Gas Price Risk
  - Harmonize Interaction between Natural Gas and Power Markets

Greenhouse Gas Emissions



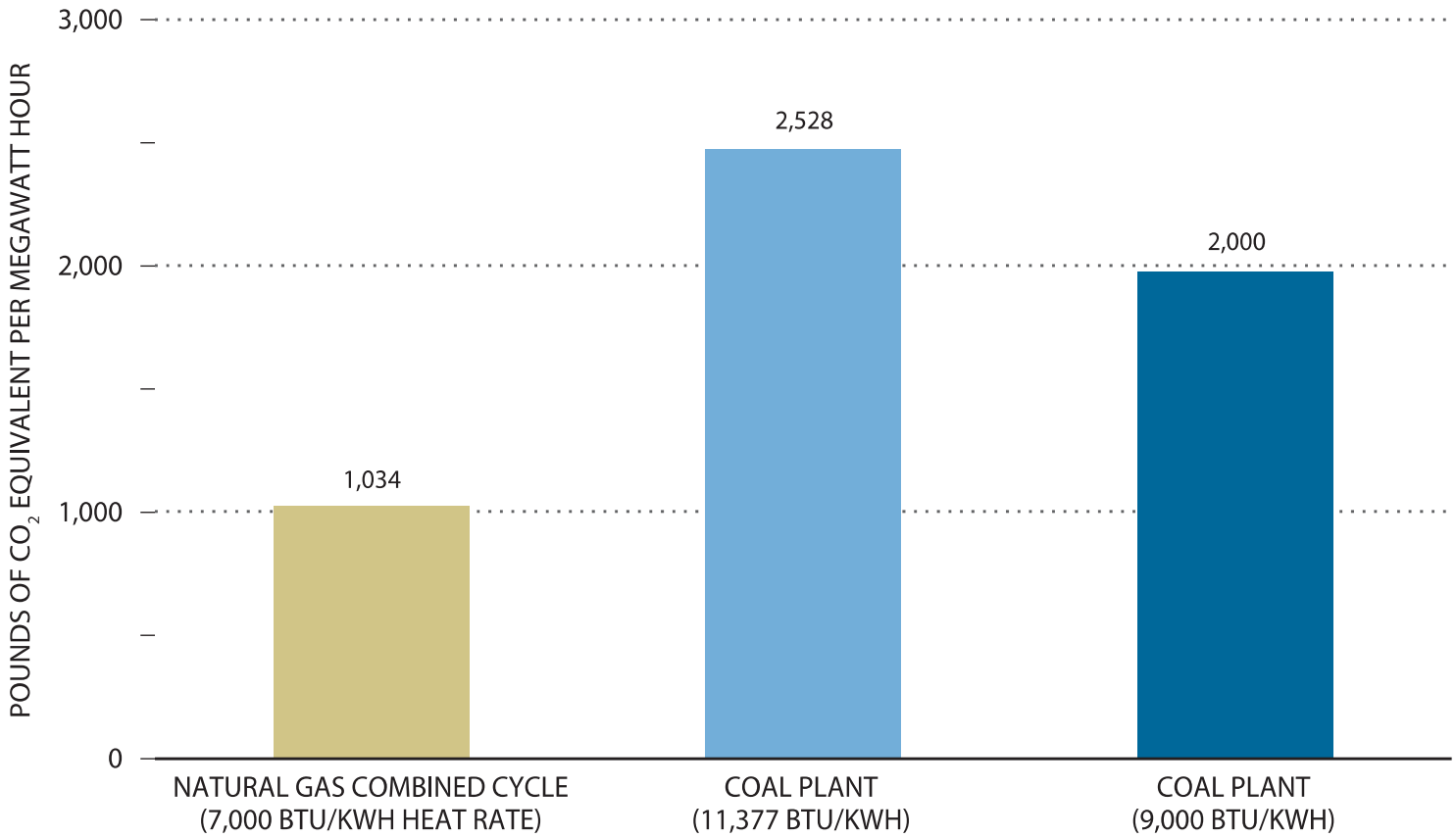
Reduction Pathways

- Coal displacement
- Natural gas end-use technologies
- EPA non-GHG regulations
- Price on carbon

GHG Emissions Are Rising – But Natural Gas Can Be Part of the Solution to Help to Lower GHG Emissions

Natural Gas Has Lower GHG Emissions

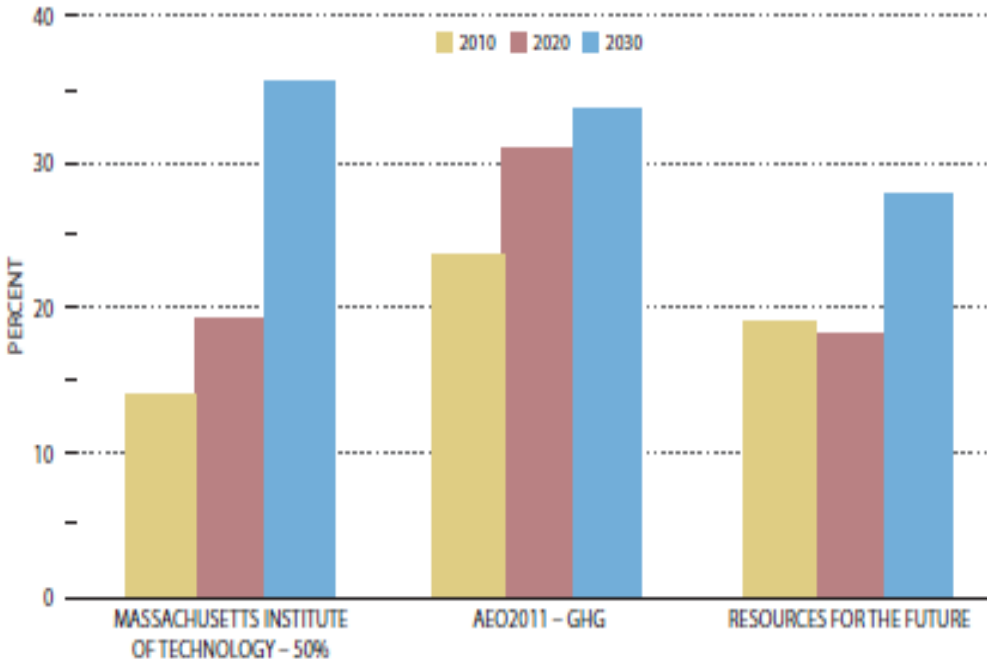
LCA GHG Emissions from Natural Gas-Fired Plants are 50-60% Lower than Existing Coal-Fired Plants



Gas Combined Cycle Plants have 99% Lower SO_2 and Hg Emissions and about 82% Lower NO_x Emissions Relative to Pulverized Coal Units

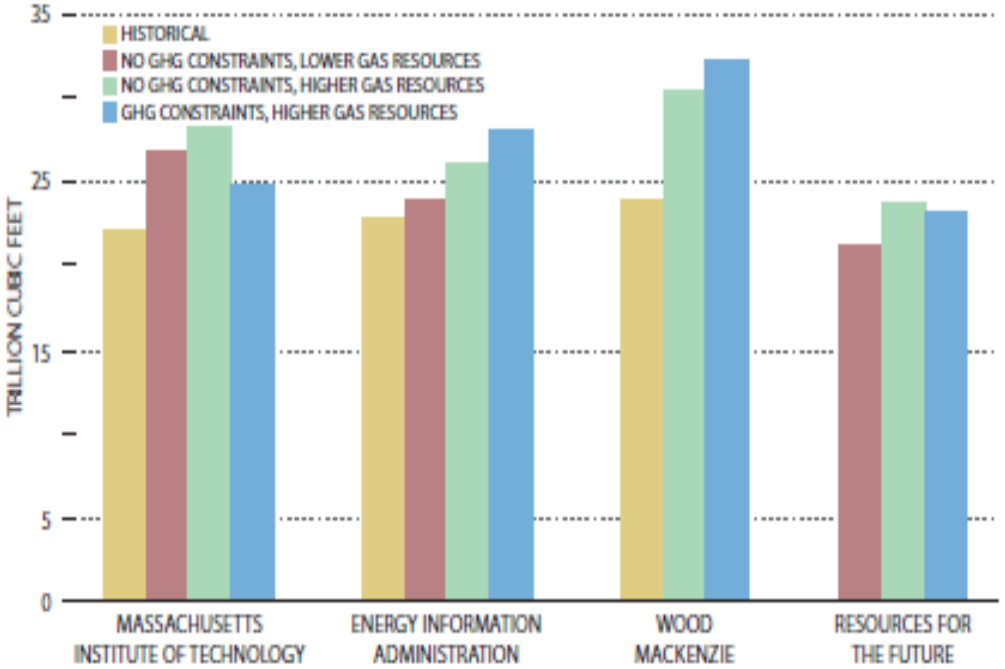
Carbon Constraints & Natural Gas Demand

Natural Gas Generation Intensity in Carbon-Constrained Scenarios



Note: GHG = greenhouse gas.

Total Natural Gas Consumption in 2030



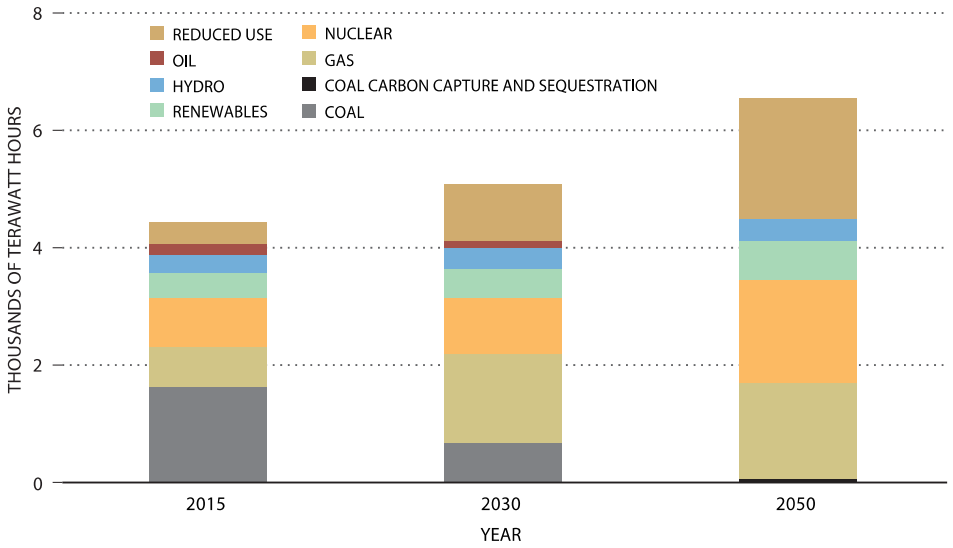
Note: GHG = greenhouse gas.

Carbon Constraints & Resource Mix

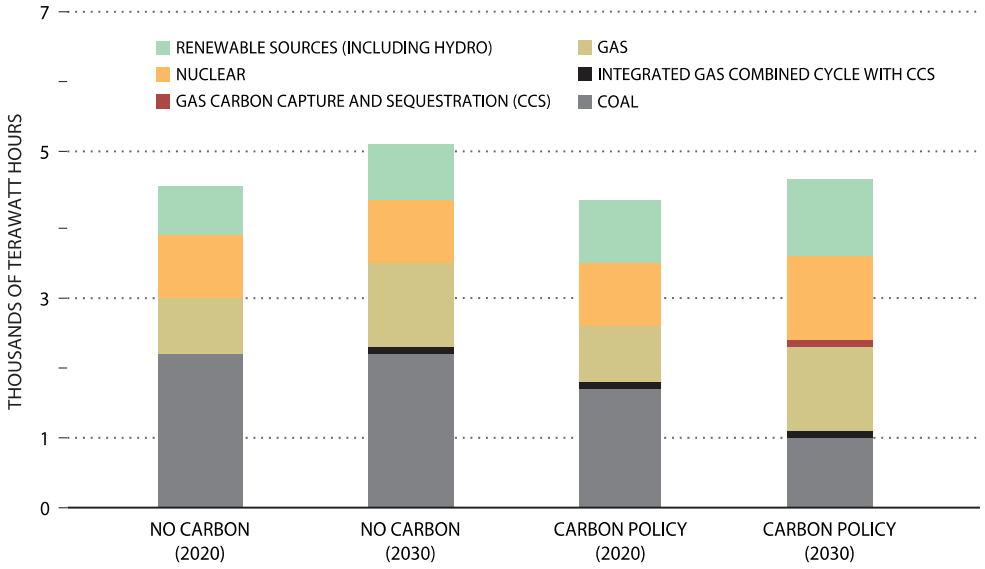
Implications of Increased Natural Gas Supplies and Lower Prices:

- *Viable, Economical Option for 50% GHG Reduction by 2050*
- *More Aggressive (80%) Reductions Will Require Low-to-Zero Emitting Technologies*
- Even with updated resource natural gas resource estimates, the electricity mix in a carbon-constrained economy will be comprised of a diverse mix of low-carbon resources

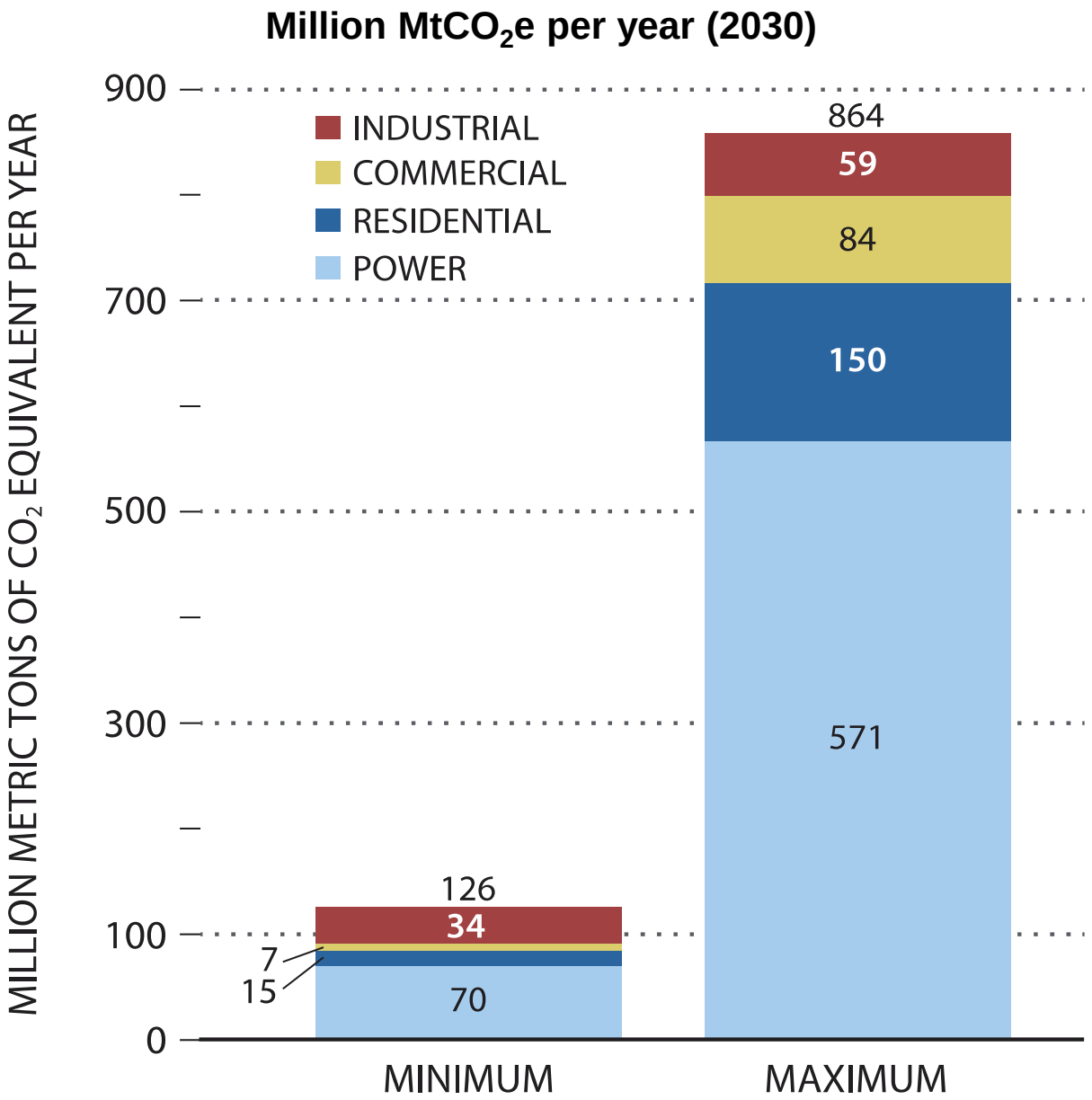
MIT: Energy Mix Under Carbon Policy – 50% Reduction by 2050



RFF: Energy Mix Under Carbon Policy – 42% Reduction by 2030

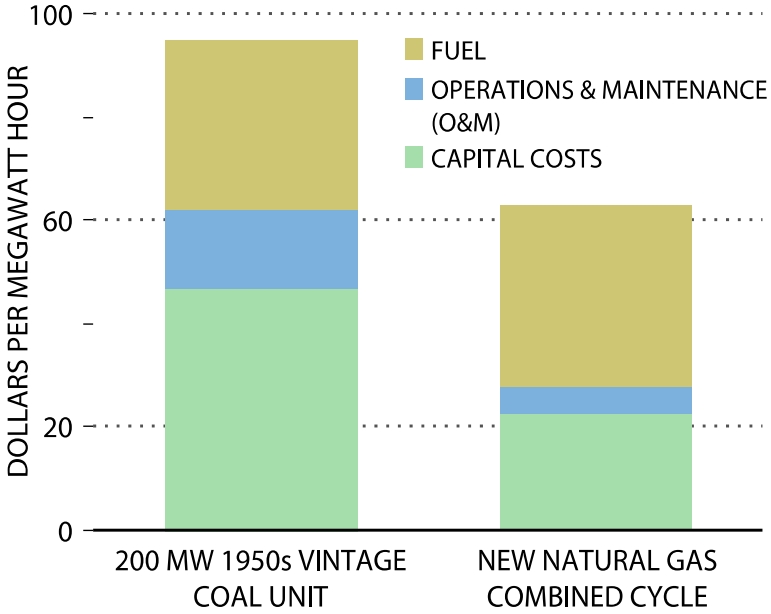


Range of Potential GHG Emissions Reductions in End-Use Sectors through Natural Gas Technologies



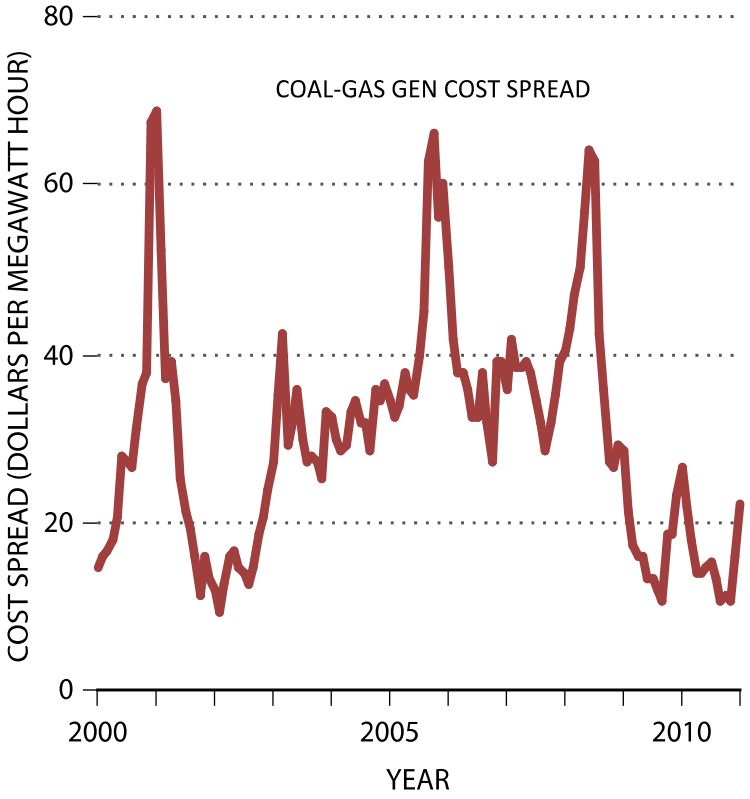
EPA non-GHG Rules – Coal Plant Retirement Decision

The spread between generating electricity from gas and coal has diminished.



Assumptions:

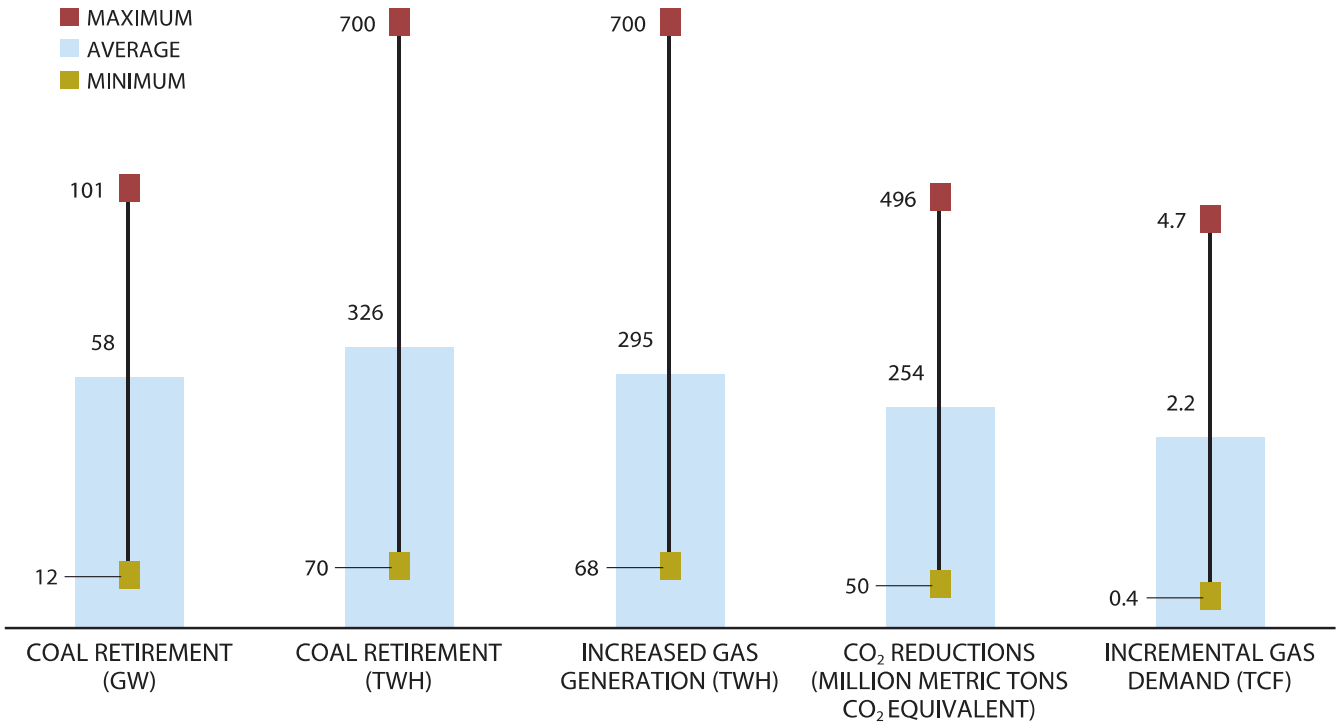
1. Retrofit and new build capital cost and O&M assumptions are from Environmental Protection Agency estimates.
2. Coal combustion residual (CCR) capital cost is from industry estimates.
3. Uncontrolled coal unit (200 MW) requires flue gas desulfurization (FGD) + selective catalytic reduction (SCR) + CCR: Capital cost – ~$1,450/kW; retrofit life – 15 years; 11,000 Btu/kWh heat rate; $3/million Btu coal price.
4. Natural gas combined cycle: Capital cost – ~$1,000/kW; life – 30 years; 7,000 Btu/kWh heat rate, $5/million Btu gas price.



Impact of EPA non-GHG Rules

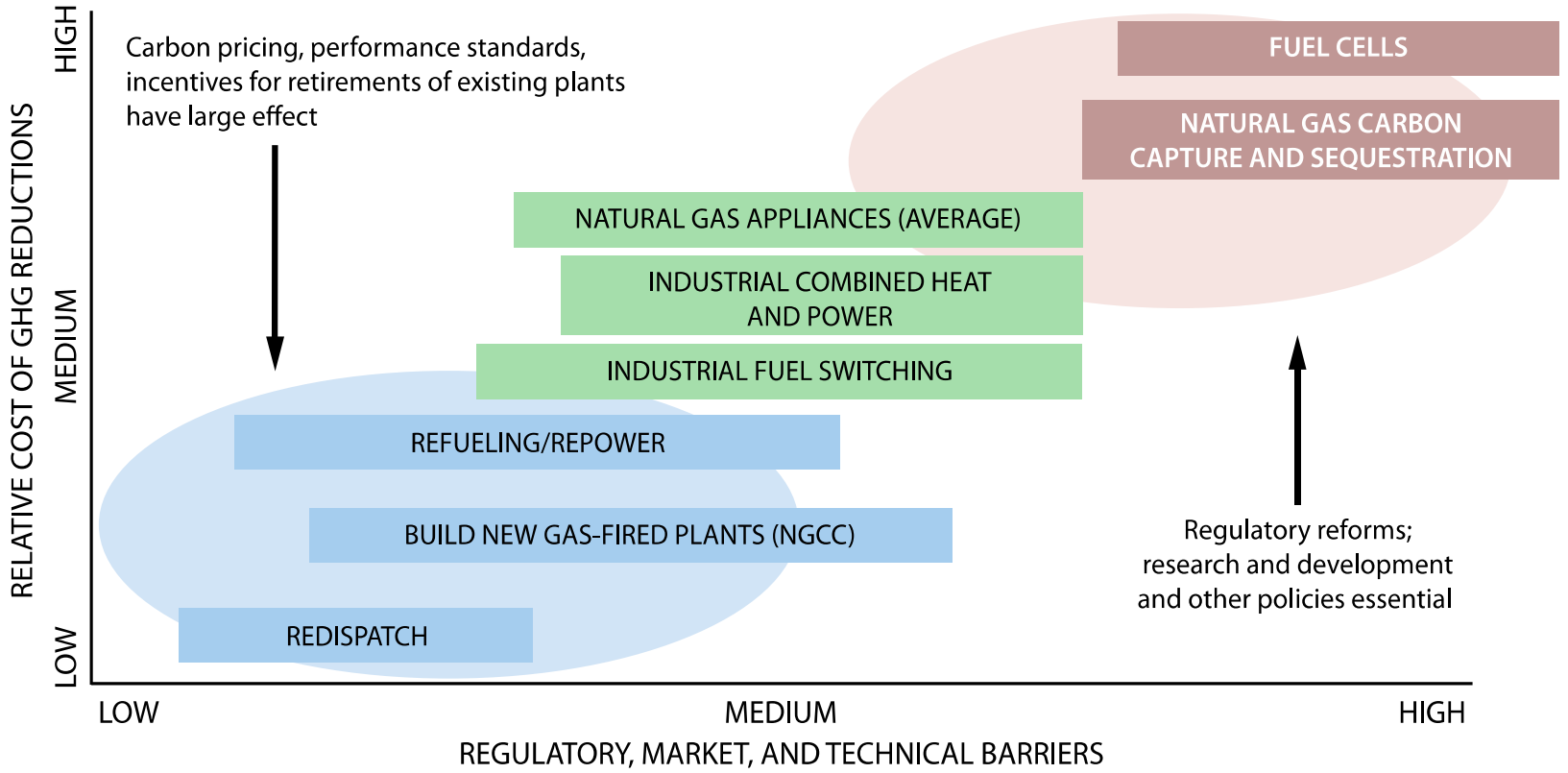
Impact of non-GHG EPA Rules on Coal Plants Averages 58 GW of Retirements (~18% of the 316 GW of Total U.S. Coal-Fired Generation Capacity)

Summary of Results – Average, Maximum, and Minimum Values across All Studies



Favorable fuel prices and pending non-GHG rules may improve natural gas-fired power plants' relative economics and greatly influence a power company's decision to retire or retrofit its coal plants.

Evaluating Natural Gas End-Use Policy Options to Reduce GHG Emissions



Note: Low relative-cost of GHG reductions means that the technology is at or near competitive with low or zero cost per metric ton CO_2 emission avoided. High relative-cost of GHG reductions means that much larger policy signals – including possibly high costs for CO_2 emissions – would be needed for commercial deployment of the technology.

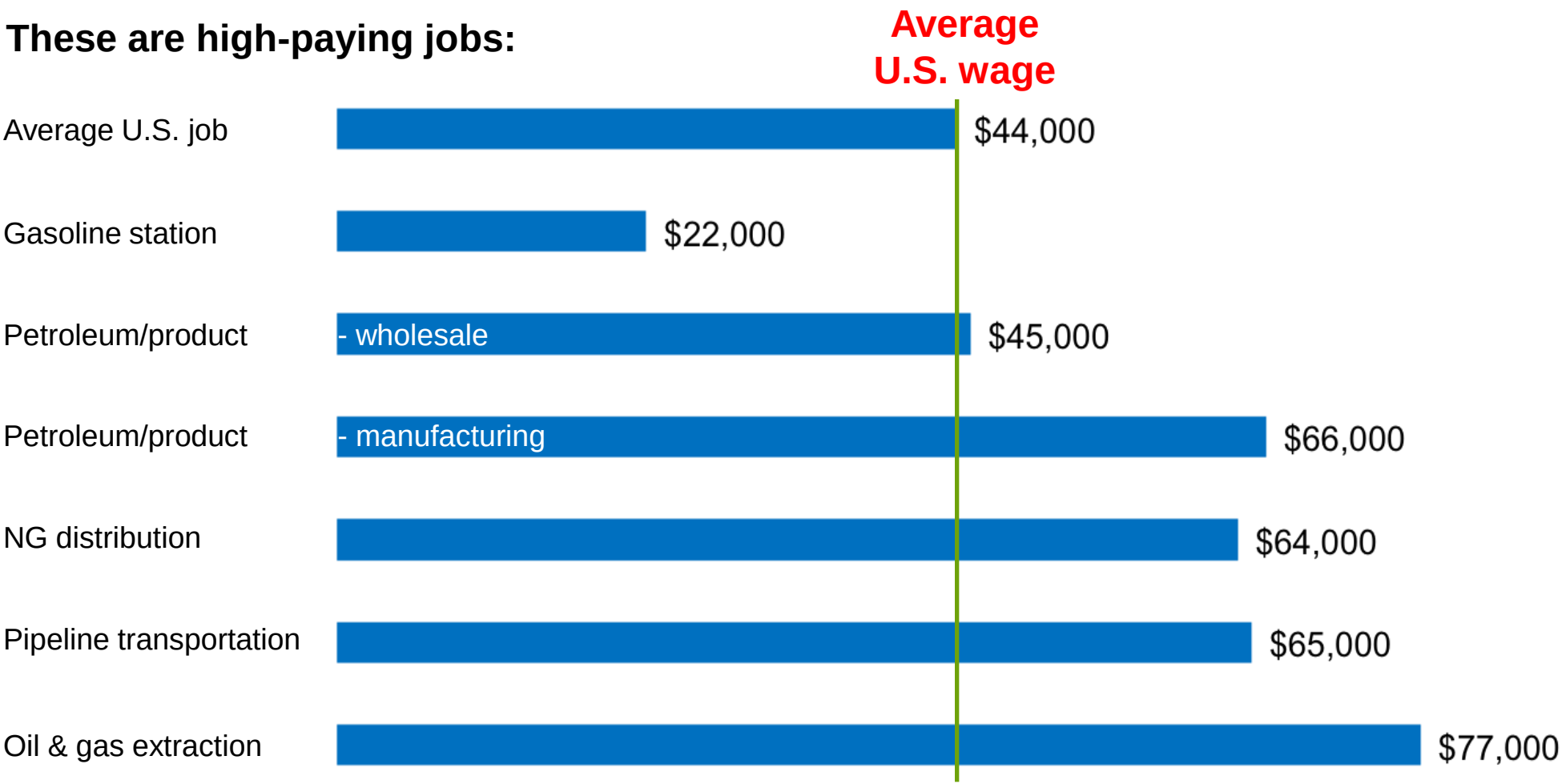
Emissions Related Recommendations

- **Provide regulatory certainty to the power sector on the EPA non-GHG rules**
- **Use industry-government partnerships to promote technologies, protocols, and practices to measure, estimate, report, and reduce emissions of methane in all cycles of production and delivery**
- **As policymakers consider energy and environmental policies, they should consider effective and efficient methods to internalize the cost of carbon impacts**
  - Policies should be national, economy-wide, market-based, and part of an effective global framework
- **Keep option for deep reductions of GHG emissions through lower emitting technologies or Carbon Capture and Sequestration (CCS) R&D that is fuel neutral**

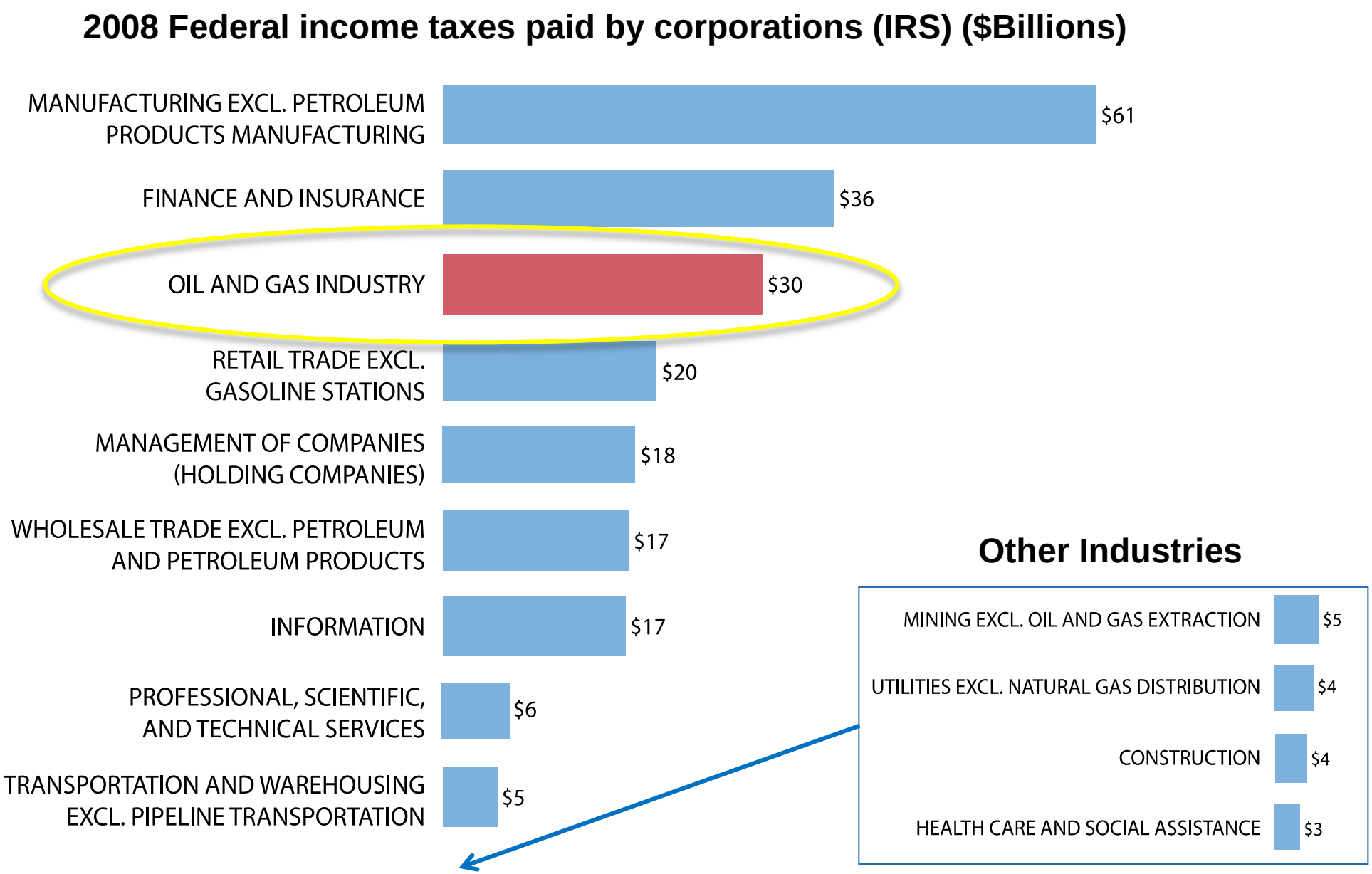
Economic Benefits Also Flow From More Domestic Gas & Oil Development

- Direct jobs in the oil & gas industry: 2+ million
- Total direct/indirect jobs from oil & gas industry activity: 9+ million

These are high-paying jobs:



Other Benefits: Industry Payments of Federal Corporate Income Taxes



Financial Incentives To The Natural Gas And Oil Industry Are Limited Compared To Other Energy Sources

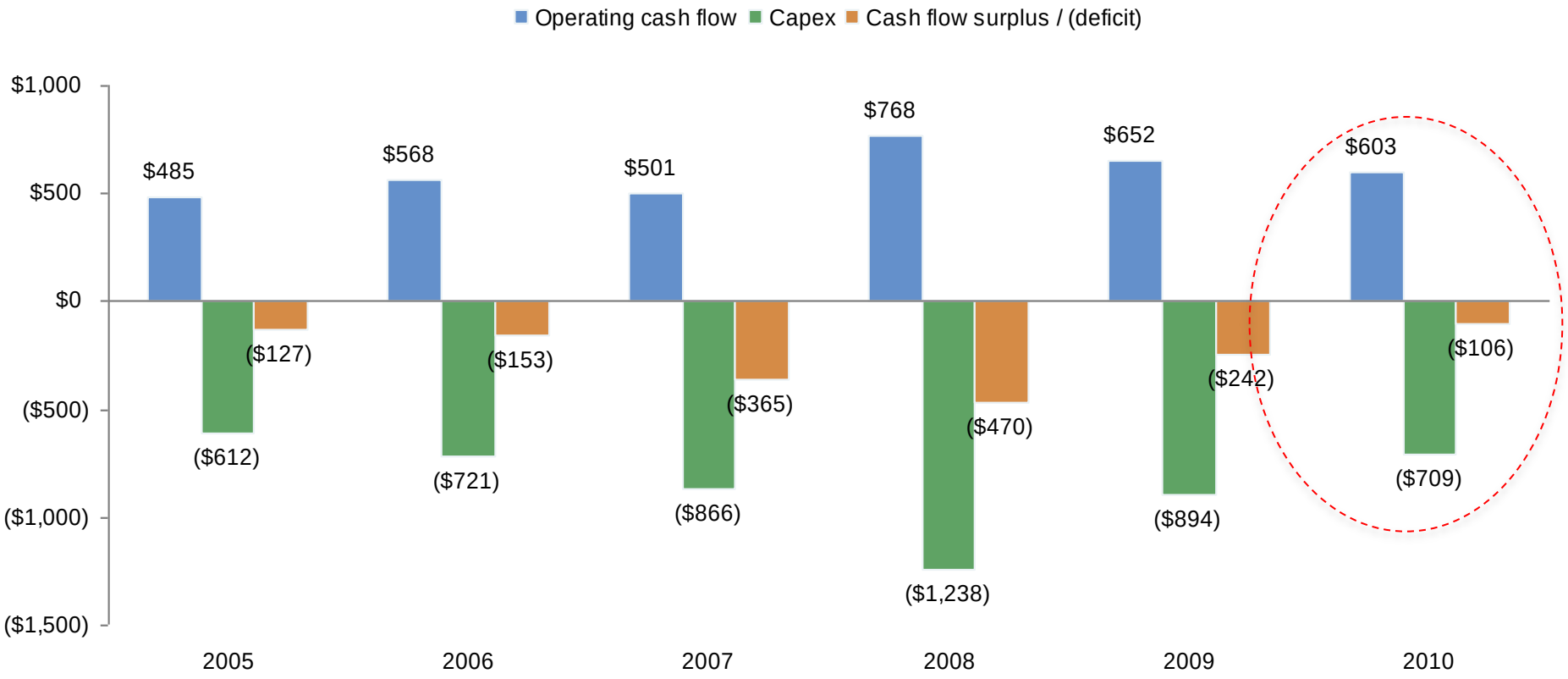
Federal Incentives by Energy Source ($/MMBtu)

Energy Source	2006	2007	2008	2009	2010
Biofuels	$5.83	$6.06	$6.56	$6.47	$5.74
Coal	$0.14	$0.14	$0.03	$0.01	$0.01
Conventional Power	$0.07	$0.06	$0.01	$0.03	$0.80
Green Power	$1.78	$1.53	$2.44	$5.14	$16.67
Oil and Gas	$0.25	$0.24	$0.28	$0.25	$0.26

Natural Gas And Oil Companies Reinvest Their Cash Flow To Grow Production And Reserves

Average cash flows for U.S. E&P companies with market cap from $1-10 billion

(Amounts in $mm)



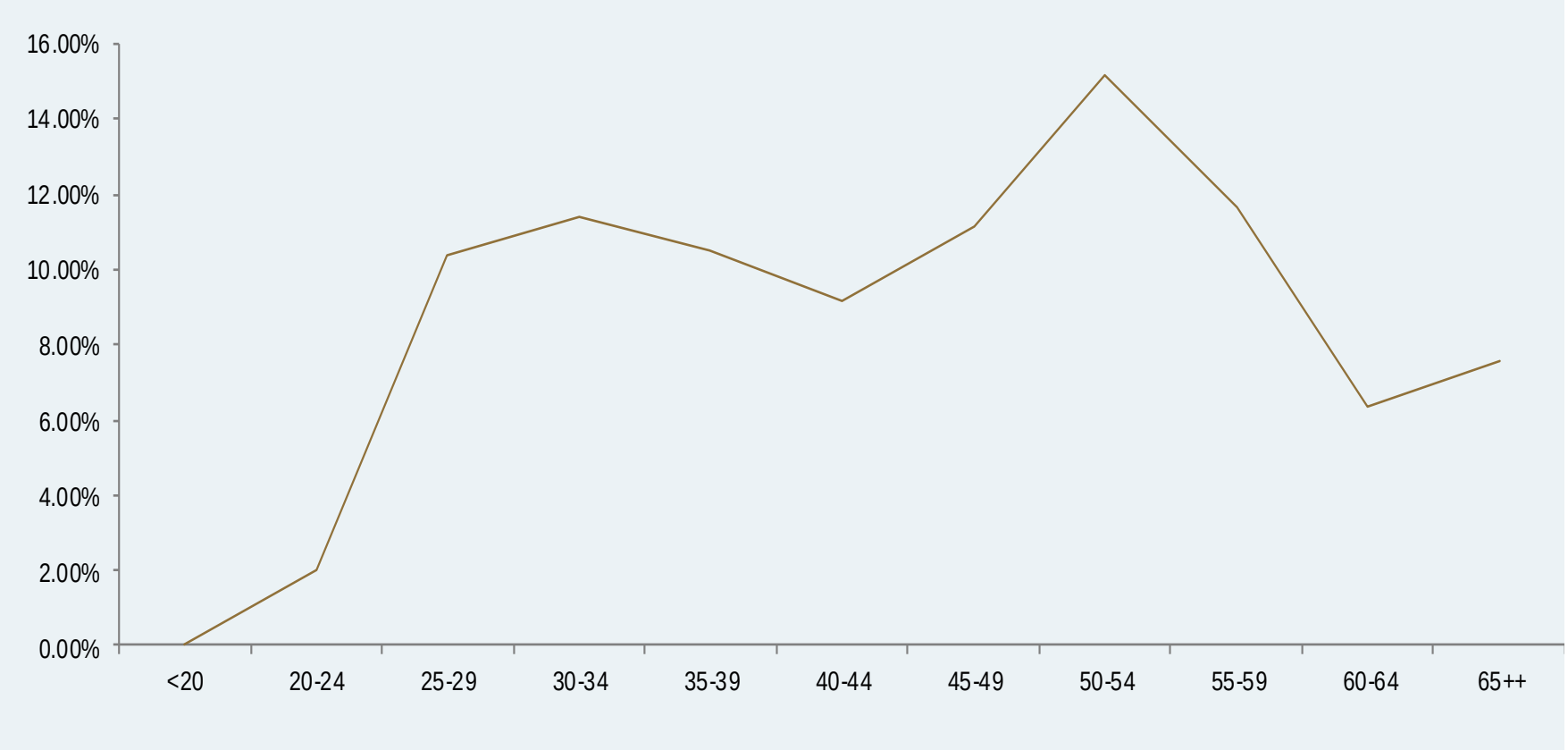
Abundant natural gas supplies can dampen natural gas price volatility

- **Volatility - Two definitions:**
  - "Traditionally defined" volatility – defined as a measure that evaluates the standard deviation of the log returns
  - "Challenging" volatility – accuracy (or inaccuracy) of price expectations
    - Mitigatants:
      - Increased elasticity of supply: greater production, storage, and LNG import capacity
      - Increased elasticity of demand: transparency of pricing
      - Contracting practices of buyers and sellers
- **Emergence of unconventional gas is making the supply curve of the United States more elastic (dampening price response to demand increases)**

Many technical professionals are reaching retirement age

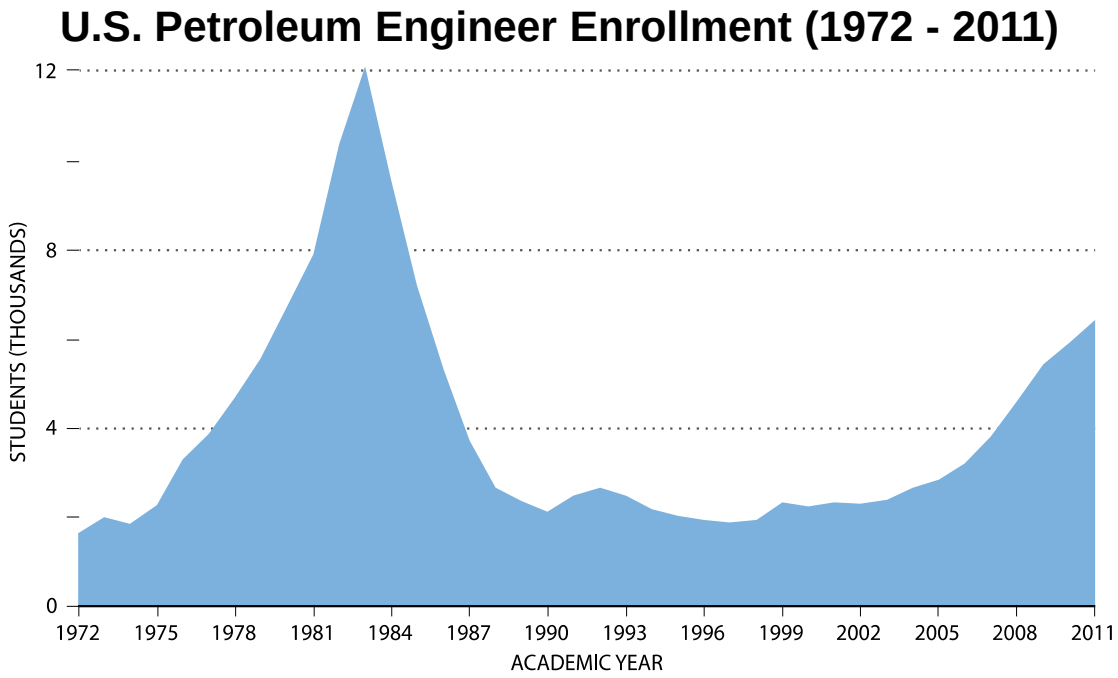
- **The oldest Baby Boomers turn 65 this year, highlighting the demographic change under way in the natural gas and oil industry (and other industries)**

Age distribution of Society of Petroleum Engineers membership



Intellectual Capital and Skilled Workforce

- **The solution will require a greater degree of engagement by the federal government and natural gas and oil companies at the undergraduate and post-graduate level to encourage interest in the industry**
- **All levels of government need to invest in K-12 science and math education to improve the pipeline of future technical professionals**



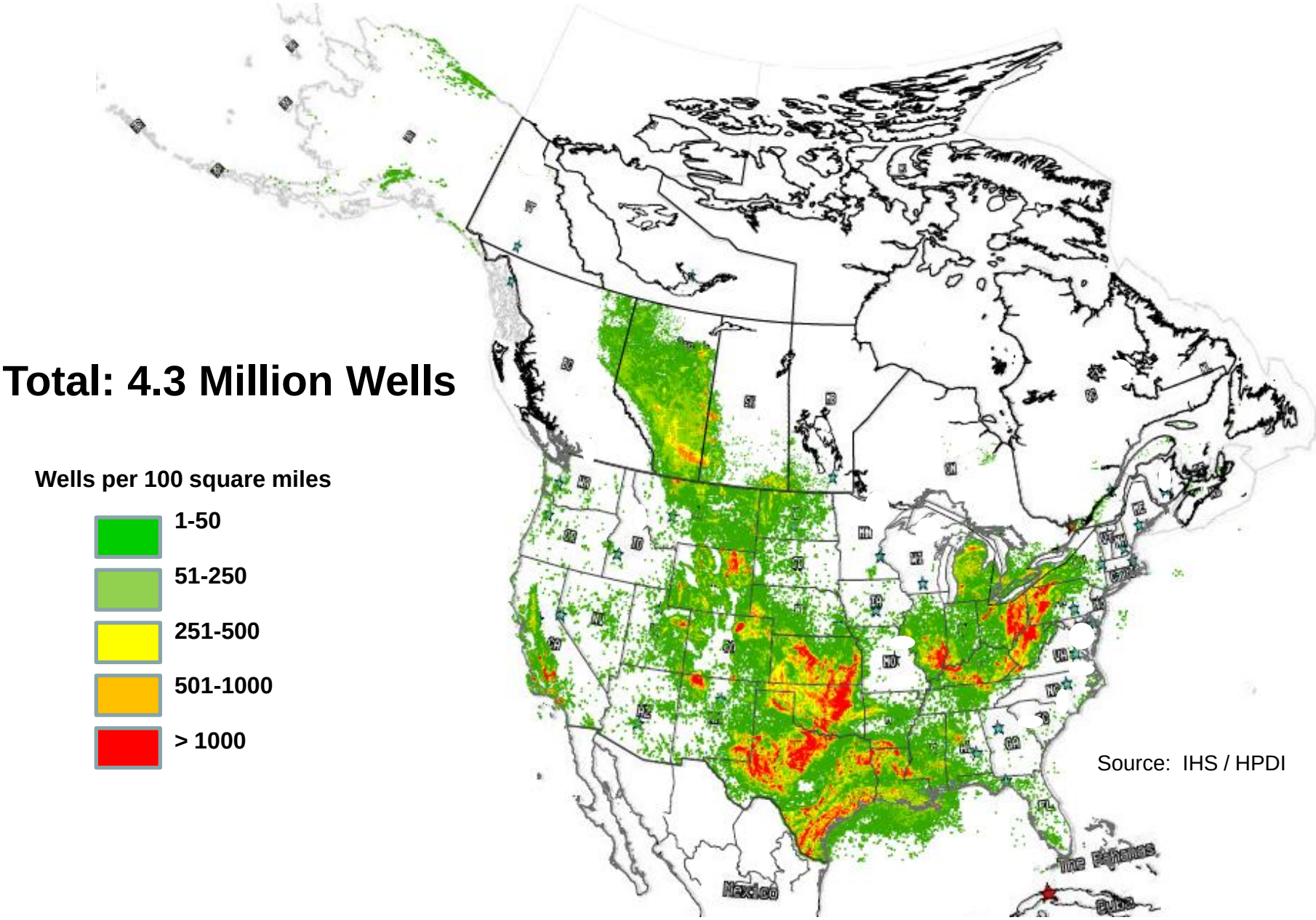
Prudent Development

In order for the U.S. to realize the benefits of substantial resource abundance, development must be done prudently.

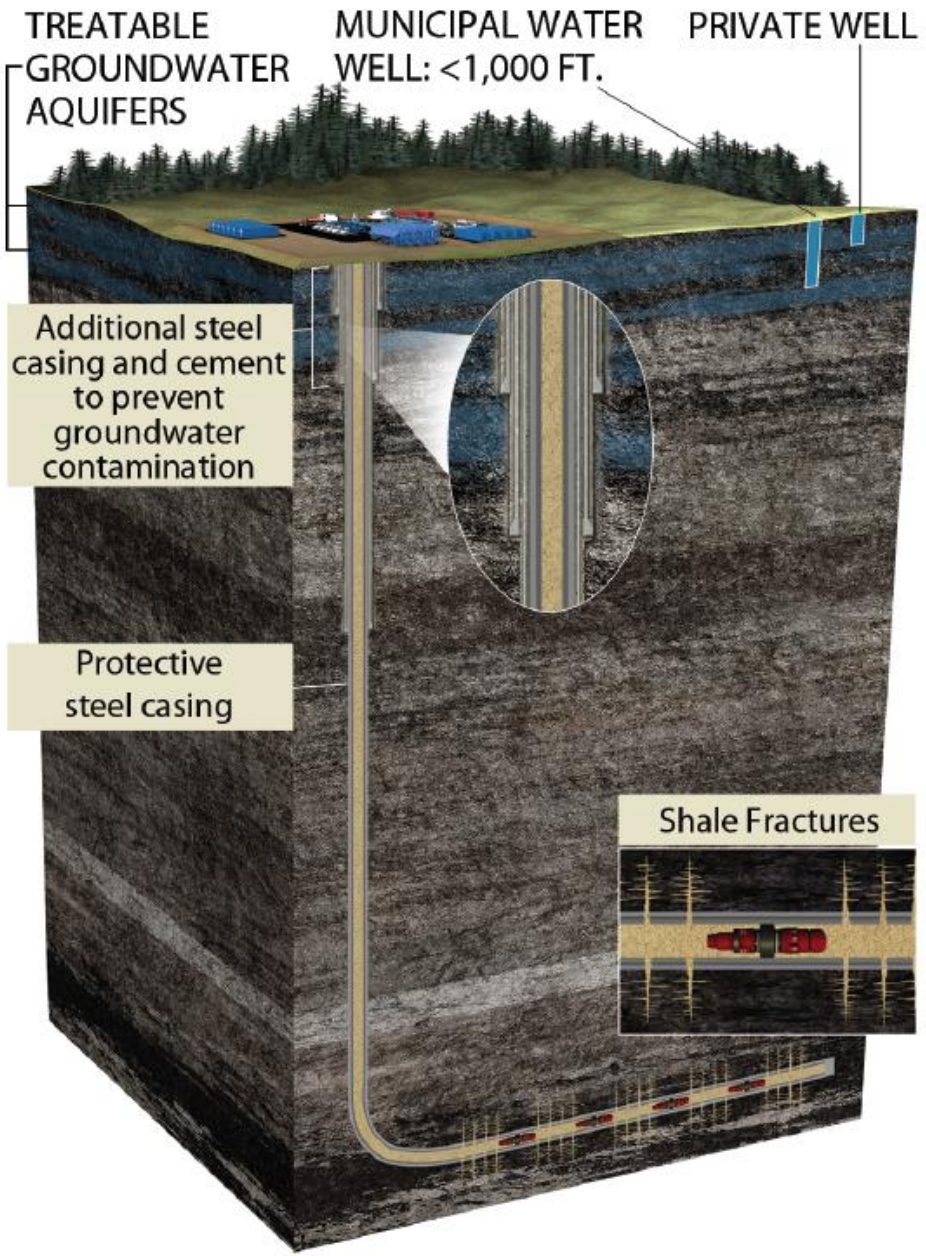
Prudent development is:

- **Essential for public trust and confidence**
- **Required for continued and expanded access**
- **Fundamental for long term industry success**

The Geographic Reach of Oil & Gas Development in N. American Wells is Large

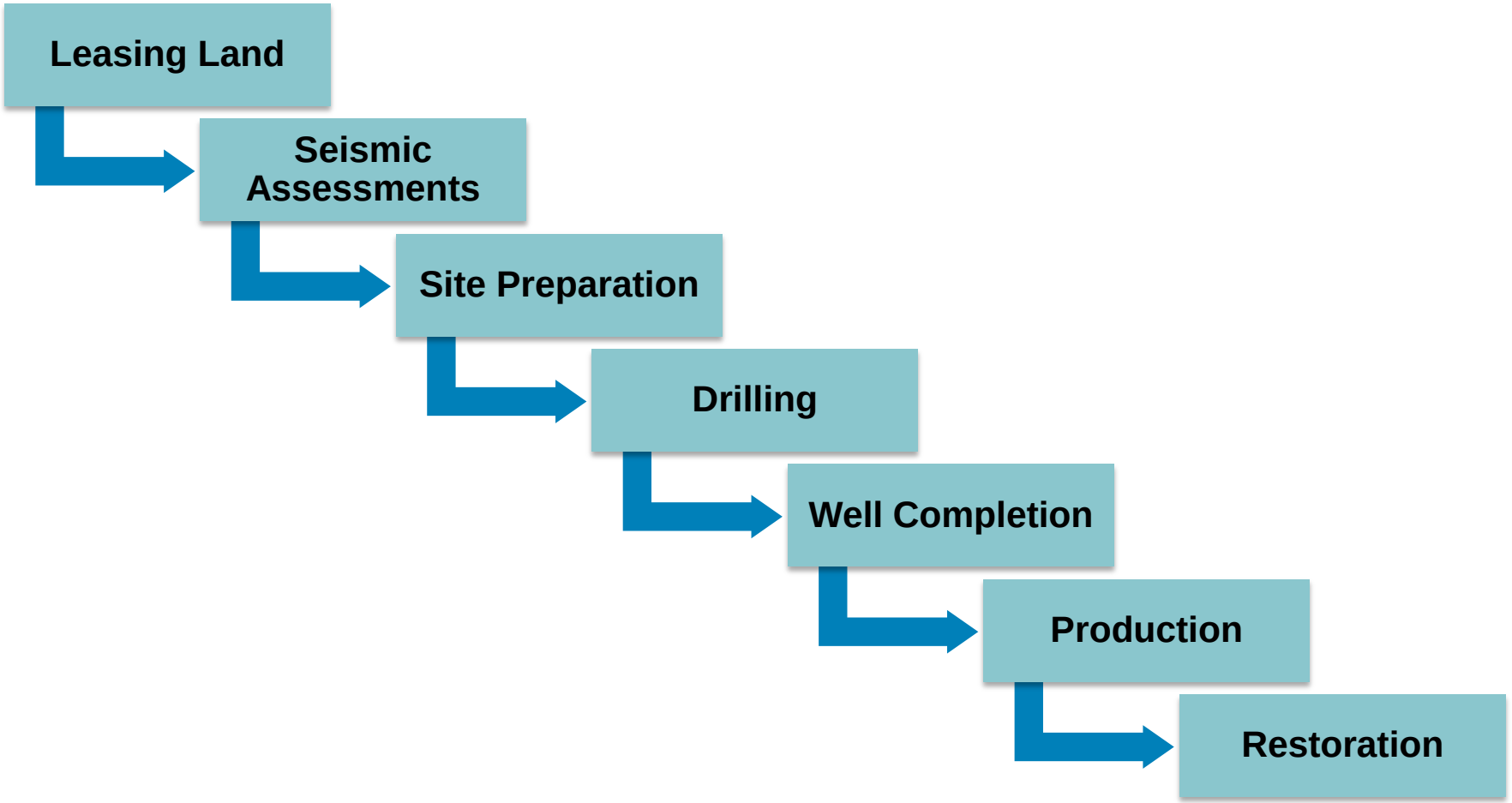


Technology Drives Industry

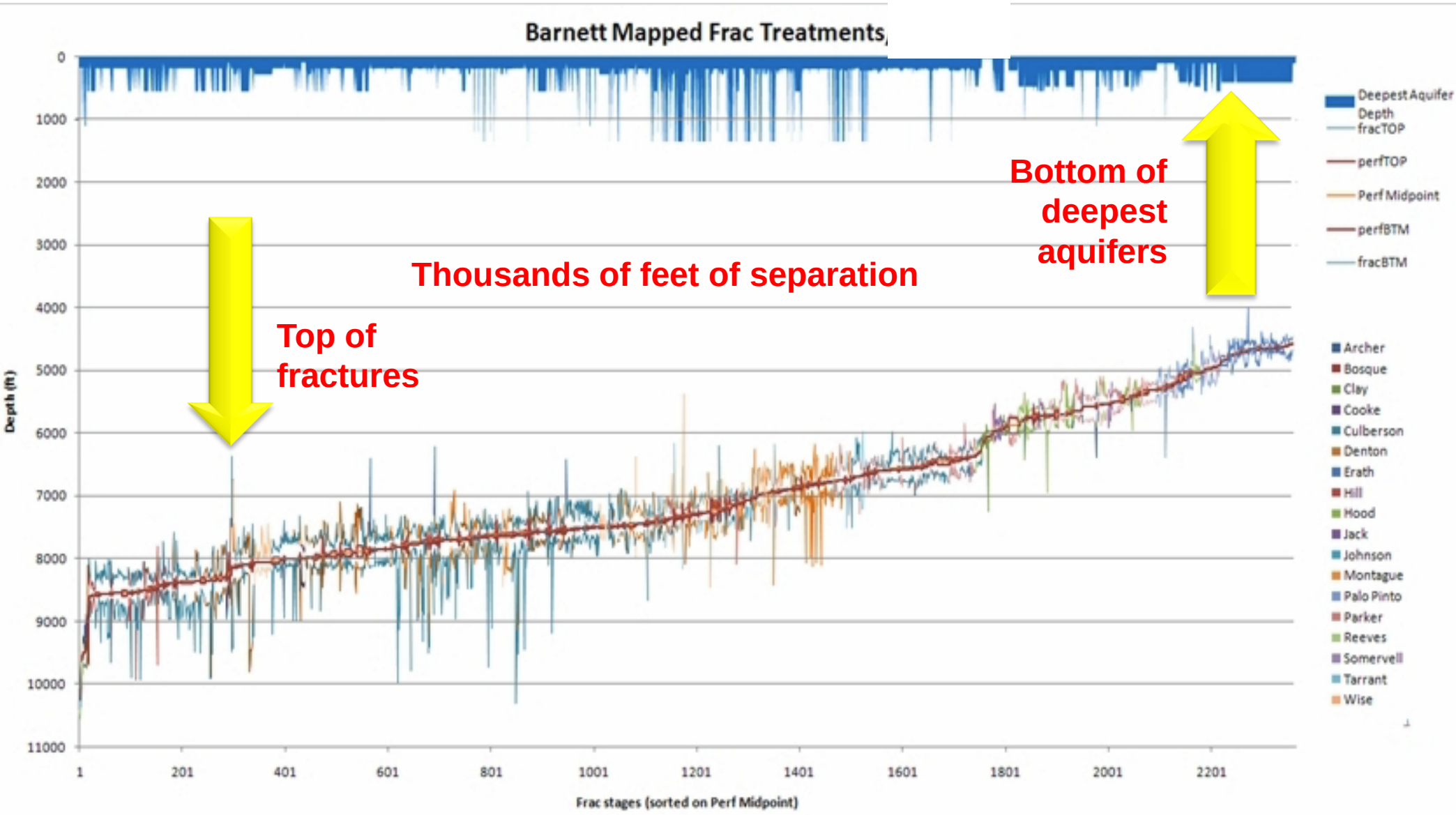


- Advances in technology lead regulation
- Importance of information sharing
- Strengthens environmental performance
- Support for innovation

Oil and Gas Development is Regulated Through the Life Cycle



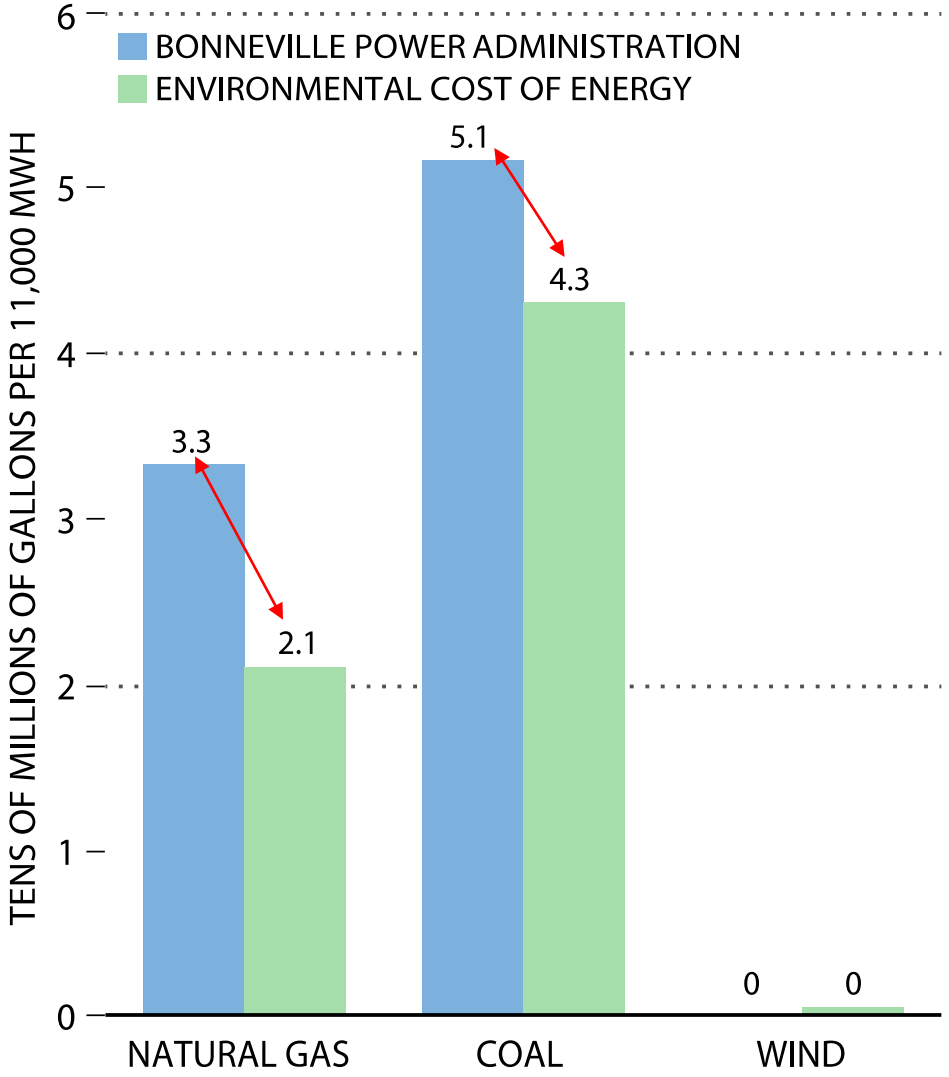
Technology Improves Understanding of Fracking Impacts



Fracture Height Determination – Microseismic

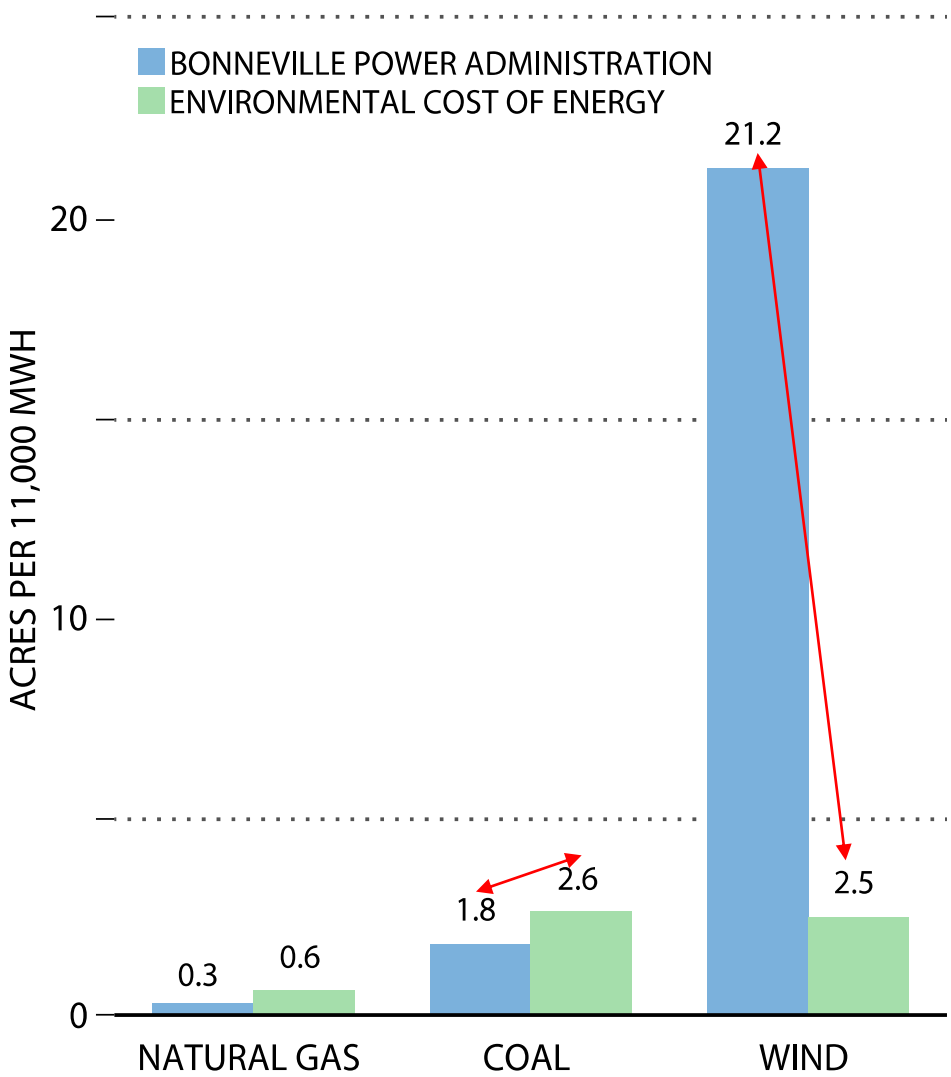
Comparing Different Estimates of Environment Footprints of Energy Sources

WATER USE ESTIMATES



Water Consumed to Provide Electricity to 1,000 Average U.S. Households Annually

LAND DISTURBANCES



Area Disturbed to Provide Electricity to 1,000 Average U.S. Households Annually

Recommendations for Industry and Government

Support Prudent Natural Gas and Oil Resource Development and Regulation

- Leadership Commitment in Industry and Government
- Establish Regional Councils of Excellence
- Adopt Policies for More Effective Regulation
- Commit to Community Engagement
- Develop Consistent Methodologies for Environmental Footprint Analysis

Key Recommendations:

What is Needed

1. Support Prudent Development

- **Establish Regional Councils of Excellence to share effective environmental, health, and safety practices**
- **Adopt policies for more effective regulation of natural gas and oil reduction and operations**
- **Commit to and carry out community engagement**
- **Measure and reduce methane emissions**
- **By supporting prudent development, provide access to resources**

2. Better Reflect Environmental Impacts in Markets & Choices

- **Develop and use tools to better analyze and compare the full environmental impacts of fuels and technologies**
- **Consider options for internalizing the cost of carbon impacts into fuel prices**
- **Keep open technology options for reducing GHG emissions from gas in the long run**

3. Enhance the Efficient Use of Energy

- **Encourage mechanisms to support greater adoption of energy efficiency in buildings and appliances**
- **Remove barriers to utilities' promotion of efficiency and combined heat and power**

4. Enhance the Regulation of Markets

- **Allow utilities to effectively manage their natural gas price risk**
- **Harmonize interactions between natural gas and power markets**
- **Provide greater certainty in environmental regulations affecting the power sector**

5. Support Intellectual Capital and Skilled Workforce

- **The solution will require a greater degree of engagement by the federal government and natural gas and oil companies at the undergraduate and post-graduate level to encourage interest in the industry**
- **All levels of government need to invest in K-12 science and math education to improve the pipeline of future technical professionals**

Summary

- **We have enormous oil and gas resources – of potential value and importance to the nation**
- **There's enough supply to support national objectives – including our economic, environmental and security interests**
- **The lynchpin to realizing these benefits is prudent development – We have to do this right.**
- **And our recommendations help us move toward these outcomes.**

Prudent Development

Realizing the Potential of North America's Abundant Natural Gas and Oil Resources

A Comprehensive Assessment to 2035 with Views through 2050

Center for Strategic and International Studies

October 12, 2011