14th Annual Tulane Engineering Forum
Natural Gas Technology

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Establishing the ARC of Energy Sources

- Best way to properly consider energy choices is the “ARC test”:
  
  Affordable \[\rightarrow\] ARC \[\rightarrow\] Reliable

- Not sensible to have one without the other two
  - We don’t want to pay multiples of current costs for uneconomic technologies
  - We won’t accept “Venezuelan Reliability” (blackouts 4-6 hours per day)
  - We all want cleaner sources that are environmentally positive

- This is the appropriate way to consider energy choices with the growing need for energy worldwide

- It is not a healthy energy policy to exclude viable choices

- Natural gas fits this model well

- Natural gas, oil and coal are expected to still be dominant energy sources over the next 30 years

- Now is the time to consider how renewables also can play a role
Global Fuel Mix by Decade

Source: ExxonMobil - 2013 The Outlook for Energy: A View to 2040.
Energy Mix Continues to Evolve

65% Gas grows faster than any other major fuel source, with demand up 65 percent by 2040.

Source: ExxonMobil - 2013 The Outlook for Energy: A View to 2040.
Global Natural Gas Supply

Billions of cubic feet per day

Source: ExxonMobil - 2013 The Outlook for Energy: A View to 2040.
Expanding Resource Development has Completely Changed the E&P Business
Good Shales are Prevalent in 17 States (and Western Canada)
Historical U.S. Natural Gas Production (Bcf/d)

Source: EIA production release, March 2014.
Shale Gas Leads Growth in Total Gas Production Through 2040

U.S. Dry Natural Gas Production (Bcf/d)

Current Uses of Natural Gas

Natural Gas Use by Sector in the U.S. (2012)

- Electric Power: 36%
- Industrial: 34%
- Residential: 16%
- Commercial: 11%
- Transportation: 3%

Energy Consumption by Fuel (2012)

- Natural Gas: 27%
- Oil and Other Liquids: 37%
- Coal: 18%
- Renewable Energy: 8%
- Nuclear Power: 8%
- BioFuels: 1%

Drilling Technology Brings About Huge New Natural Gas Supply

- Horizontal drilling results in fewer wells for same production
- Multiple stage fracking allows for contact with the producing formation in 10-40 areas in one horizontal length (3,000 – 10,000 feet)
- Needing fewer wells for same amount of production increases profitability
  - Also reduces drilling wastes from multiple wells
  - Decreases footprint of well pads as multiple wells can be drilled from the same surface location
- 3-D and 4-D seismic
  - Allows more optimal drilling
  - 4-D adds the dimension to subsurface changes over time
- Measurement while drilling
  - Allows for real time collection of data
  - Improves decision making and accuracy in the drilling process
- All of these contribute to reduced costs, smarter decision making and therefore improved economics
Natural Gas Infrastructure Broadly Covers the U.S.

U.S. Natural Gas Pipeline Network

Legend
- Blue = Interstate Pipelines
- Red = Intrastate Pipelines

Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System
Global Natural Gas Supply

Source: ExxonMobil - 2013 The Outlook for Energy: A View to 2040.
2008 – Financial crisis plus beginning of massive U.S. shale discoveries
Liquified Natural Gas (LNG)

- LNG is the most efficient way to ship natural gas where pipelines are not practical
- LNG technology overview
  - Natural gas is chilled to -161°C (-259°F)
  - At this temperature it becomes a liquid
  - Its volume is 600 times less than in gaseous state and therefore easier to transport
  - It can be carried on ships throughout the world to regasification facility
- LNG supply and demand
  - Approximately 300 MMtpa today, expected to grow 50% by 2025
  - Approximately 100 MMtpa will need to be new construction
  - 300 MMtpa has been proposed so the winners and losers will be determined by economics
- Currently a big discussion ongoing in the U.S. on LNG exports
  - 10 years ago with diminishing U.S. supply LNG was likely to be imported to U.S.
  - Shale and resource plays completely changed this with now ±100 years of known supply
  - Interesting discussion on free vs. restricted trade
    - Producers want free trade to create new markets
    - Manufacturers rooting for restricted trade to keep low price with oversupply
Natural gas grows from today’s 1 percent of the global transportation fuel mix to 4 percent in 2040.
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Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division, Gas Transportation Information System
Natural Gas as Backup to Solar and Wind

- For power generation, ongoing challenge is how to store large quantities of power supply
- Supply of solar and wind can be irregular so a supplement supply is needed
- Natural gas is a great supplement
  - Readily available
  - It can be stored easily
  - Natural gas plant can be powered up and powered down quickly
- This has been placed on stream by Florida Power & Light
Average U.S. Cost of Electricity Generation in 2030

60%

Natural gas, which emits up to 60 percent less CO₂ than coal when used for electricity generation, will gain the most. By 2040, natural gas will account for 30 percent of global electricity generation, compared to just over 20 percent today.

Source: ExxonMobil - 2013 The Outlook for Energy: A View to 2040
U.S. Manufacturing Renaissance Driven By Huge New Supplies

- Nearly 200 investment projects announced in U.S. in 8 manufacturing industries
  - Aluminum
  - Chemicals
  - Fabricated Metal Products
  - Foundries
  - Glass
  - Iron & Steel
  - Paper
  - Plastic & Rubber Products

  - Vast majority in Chemicals, Plastic and Rubber Products

- American Chemistry Council examined 148 chemical industry investment projects valued at a total greater than $100 billion:

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<th>Economic Contributions from Chemical Industry Investment in the U.S. (1)</th>
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<td><strong>During Peak Investment Year, 2016</strong></td>
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<td><strong>From Higher Chemical Industry Output</strong></td>
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- Inexpensive and prolific natural gas supply is the reason the U.S. is about to experience a manufacturing renaissance. Companies that moved overseas in 2000’s are now moving back to the U.S.

(1) Source: American Chemistry Council – February 2014