Natural Gas - Midwest
Supply Chain Opportunities

Dan Radomski, NextEnergy
Outline

- NextEnergy Overview
- Midwest NG Supply Chain Opportunities
  - Upstream and Midstream
- Midwest NG Supply Chain Opportunities
  - Downstream
- Conclusions
NextEnergy’s Role

Non-Profit Focused On Energy
- Accelerate commercialization of advanced energy technologies
- Analysis that inform and supports economic development strategy

Purpose to Improve Domestic
- Company growth
- Development of IP
- Job creation
- Investment attraction
NextEnergy Impact

Leverage people, place and relationships to accelerate growth

Knowledge (people)
- Market Studies
- Technology Roadmapping
- Supply Chain Analysis
- Value Chain Dynamics
- Domestic Competitiveness

Technical Facilities (place)
- Technology Demonstrations
- System Integration
- Validation and Testing

Connections (relationships)
- Funding Sources
- Connect to R&D Institutes
- Go-to-Market Partners
- Customer Connections
- Business Model Support
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An Overview of Natural Gas Value Chain

Natural Gas Supply

Exploration
- Field Evaluations
  - Sonic/Swiss seismic evaluation
  - In-lab data evaluation
- Test Well drilling
  - Vertical & horizontal, 3,000 ft & up
- Evaluate quality of gas
  - Content, velocity, etc.
- Evaluate type of field
  - Dry shales, wet, etc.
- Evaluate field viability
  - Capacity, quality, cost of production, etc.

Production
- Yes, we’re going to develop the site!
- Plan the site
- Contract service company
- Set up pads, drilling rigs, etc.
- Drill wells, install connection system

Transport
- 24 or 36 inch pipe
- Introduce to interstate pipelines
  - Boost compressors every few hundred miles
  - Approx 5% "loss" of energy

Distribution
- Compression, cool & liquify
- LNG markets, export
- Residential
- Commercial & industrial heating
- Industrial as feedstock for products
- Power generation
  - Can be part of the LDC

Consumption
- Independent Storage Owners
- Ethane to Ethylene to plastics
- Propane to existing market
- C4+ Refinery to higher value products

NOTE:
- Users can contract with other "Retail competition" gas suppliers for the gas but continue to pay the LDC for distribution from the installed infrastructure.
- Users can also own storage assets.
US Natural Gas Infrastructure

Source: 2010 MIT Energy Initiative Report
Midwest States Riding Boom in Shale Gas

Source: Baker Hughes

Marcellus play in Pennsylvania and Utica play in Ohio have increased rig counts in recent months due to liquid rich plays.
US NG Opportunity

- Equipment needs are huge: there are over 100 pieces of equipment just for drilling.
- Numerous suppliers for each product: there are over 5700 suppliers just for compressors.
- Most frequently used equipment includes:
  - Drilling rigs
  - Drilling pipes
  - Heavy weight pipes
  - Drilling collars
  - Non-mag drilling collars
  - Drilling bits
  - Fracturing tools
  - Stage tools
  - Liner and Hanger
  - Valves
- Equipment specialization is crucial.
- There is no one company that can supply all the equipment.

The top 50 oil and gas companies raised and spent an annual average of $126 billion over the last six years on drilling, land acquisition and other capital costs within the US, double their capital spending as of 2005, Ernst & Young.
Major Upstream Companies in the U.S.

These companies are the dominant players in the upstream sector

**Operators**
- Chesapeake Energy
- EnCana
- EOG Resources
- ExxonMobil
- Southwestern Energy

**Contractors**
- Pioneer Drilling
- Precision Drilling
- Helmerich & Payne
- Nabors Drilling
- Savanna Drilling

**Service**
- Baker Hughes
- Halliburton
- Schlumberger
- Weatherford
- Cameron
Advancement in Fracking Techniques (1/2)

Challenge: Frac flow back and produced water may contain hydrocarbons, solids, bacteria and heavy metals.


Challenge: Improperly conditioned water can degrade performance of fracturing fluids, and can lead to completion failure, scaling issues, poor conductivity, loss of production.

Solution: Customized Fracturing Fluid. Modifies chemistry of fracturing fluid itself to work optimally with the treated water.

Challenge: Methane gas is released into the atmosphere when natural gas or oil wells are drilled, hydraulically fractured) or repaired.

Solution: Green Completions Technology. Captures methane which can be sold, used as fuel, or re-injected to improve well performance.

Source: Halliburton, CAES, OTC, NRDC, MIT
Advancement in Fracking Techniques (2/2)

Challenge: Bacteria Control, Corrosion of Iron and Steel
Solution: CleanStream® Service, Halliburton
Uses UV light to control bacteria and reduces need for chemical biocides

Challenge: Water table contamination
Solution: Openhole sleeves, Positive annular isolation of an uncemented liner with swell packers, Mechanical isolators

Challenge: Siting of CAES facilities may be limited by specific geologic conditions
Solution: Use of exhausted NG wells as compressed air storage caverns

Source: Halliburton, CAES, OTC, NRDC, MIT
New Pipeline Developments in Midwest

* Additional pipeline capacity in the region could bring an additional 2 Bcf/d supply to Midwest in 5 years
* US added 4.5 billion cubic feet per day of new pipeline capacity and 367 miles of pipe totaling $1.8 billion in capital expenditures in 2012, over half were in Northeast US
* North America – 26,300 miles in planning stages, 5,651 miles under construction

Supply from Rockies:
- Rockies Express

Supply from Marcellus:
- Backhaul on Tennessee
- Texas Eastern Expansion
- El Paso NSD Project
- Millennium Expansion

Supply from Canada:
- TransCanada mainline Expansion

Positive shock in traditional supply from Mid-Continent and Texas with shale development
US Natural Gas Storage

Figure 2. Underground Natural Gas Storage Facilities in the Lower 48 States

Source: Energy Information Administration (EIA), EIA GasTran Geographic Information System Underground Storage Data Base.
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A Surge in Applications for LNG Export Terminals

**North American LNG Import/Export Terminals**

* **Proposed/Potential**

- **Import Terminal**
  - Proposed to FERC
    - 1. Robbinston, ME: 0.5 Bcfd (Koch/Natural Gas - Downeast LNG)
    - 2. Astoria, OR: 1.5 Bcfd (Oregon LNG)
    - 3. Corpus Christi, TX: 0.4 Bcfd (Cheniere - Corpus Christi LNG)
    - Potential U.S. Sites Identified by Project Sponsors
    - 4. Offshore New York: 0.4 Bcfd (Liberty Natural Gas)

- **Export Terminal**
  - Proposed to FERC
    - 5. Freeport, TX: 1.3 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/PLNG Liquefaction)
    - 6. Corpus Christi, TX: 2.1 Bcfd (Cheniere - Corpus Christi LNG)
    - 7. Coos Bay, OR: 0.9 Bcfd (Jordan Cove Energy Project)
    - 8. Lake Charles, LA: 2.4 Bcfd (Southern Union - Trunkline LNG)
    - 9. Hackberry, LA: 1.7 Bcfd (Sempra - Cameron LNG)
    - 10. Cove Point, MD: 0.75 Bcfd (Commonwealth Cove Point LNG)
    - 11. Astoria, OR: 1.30 Bcfd (Oregon LNG)
    - 12. Lavaca Bay, TX: 1.38 Bcfd (ExxonMobil - Exports Liquefaction)
    - 13. Elba Island, GA: 0.5 Bcfd (Southern LNG Company)
    - 14. Sabine Pass, LA: 1.3 Bcfd (Sabine Pass Liquefaction)
    - 15. Lake Charles, LA: 1.07 Bcfd (Magnolia LNG)

- **Proposed Canadian Sites Identified by Project Sponsors**
  - 16. Kitimat, BC: 0.7 Bcfd (Apache Canada Ltd.)
  - 17. Douglas Island, BC: 0.25 Bcfd (BC LNG Export Cooperative)

- **Potential U.S. Sites Identified by Project Sponsors**
  - 18. Brownsville, TX: 2.8 Bcfd (Gulf Coast LNG Export)
  - 19. Poncagoule, MS: 1.5 Bcfd (Gulf LNG Liquefaction)
  - 20. Sabine Pass, TX: 2.6 Bcfd (ExxonMobil - Golden Pass)
  - 21. Plaquemines Parish, LA: 1.07 Bcfd (CE FLNG)
  - 22. Cameron Parish, LA: 0.16 Bcfd (Waller LNG Services)
  - 23. Englewood, TX: 1.00 Bcfd (Pangea LNG (North America))
  - 24. Cameron Parish, LA: 0.20 Bcfd (Gazpec Development)

- **U.S. - MARAD/COAST GUARD**
  - 25. Gulf of Mexico: 3.22 Bcfd (Main Pass - Freeport-McMoRan)

- **Potential Canadian Sites Identified by Project Sponsors**
  - 26. Prince Rupert Island, BC: 1.0 Bcfd (Shell Canada)
  - 27. Goldboro, NS: 0.67 Bcfd (Merida Energy Canada)
  - 28. Kitimat, BC: 2.0 Bcfd (LNG Canada)

**As of March 20, 2013**

Source: Federal Energy Regulatory Commission

* First export project, Sabine Pass in LA, could be online as soon as 2015
* EU paying 2-3x, China paying 4-5x US NG prices
* LNG Plant Investment $5B+ ($1000+ per ton per year of capacity)
LNG Innovation – Floating LNG Plants

- Shell, Mobil, Exxon/BHP and Statoil are all developing large-scale FLNG projects in Australia, Nigeria and Namibia
- Shell Australia FLNG Plant – $10-12B, 3.6MM metric tons of LNG, 200km out to sea, produce gas from offshore fields & liquefy it onboard
Coal Plants Retirements Will Boost Gas Demand

Source: EIA Annual Energy Outlook 2013

More coal power plants will retire before the end of decade, and natural gas plants are expected to fill the gap.
Coal Retirements Impact on Midwest Region
Opportunity for NG CC Power Generation Plants/Retrofits

Between 2012 and 2025 50 GWs of coal-fired capacity retirements have been announced, representing a 5.4 Bcf/d potential NG demand opportunity.

Source: Encana Fundamentals, company announcements.
GE H series power generation gas turbine: in combined cycle configuration, this 480MW unit has a rated thermal efficiency of 60%
NG Gas Pipeline Grid & Key Industries in Midwest

Petrochemical companies are benefiting from increased production in wet gas and are moving offshore industrial plants back to the U.S.
Industry to Invest $80 Billion In Manufacturing Renaissance

Source: Dow Chemicals
NG Pipeline Grid and Key Industries in Midwest

- Petro-Chemical Manufacturing Facility
  Announcements in Midwest is weak in comparison to other regions in US
  - Chemical & Fertilizer: 3
  - Steel & Aluminum: 7
  - Tires: 1
  - Plastics: 1

Source: Bureau of Labor Statistics, U.S. Department of Labor; Dow Chemicals
Industry to Invest $80B In Manufacturing Renaissance

Source: Dow Chemicals
Natural Gas Vehicles and Fueling Investments
112,000 NGV’s in US, 600 NG fueling stations, 14.8 million NGV’s worldwide

Total NGV Station Count

<table>
<thead>
<tr>
<th>Year</th>
<th>CNG</th>
<th>LNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>831</td>
<td>38</td>
</tr>
<tr>
<td>2009</td>
<td>825</td>
<td>36</td>
</tr>
<tr>
<td>2010</td>
<td>952</td>
<td>44</td>
</tr>
<tr>
<td>2011</td>
<td>1030</td>
<td>46</td>
</tr>
</tbody>
</table>

Industry Announcements

Station Infrastructure
- Shell/Travel Centers of America
  - 100 LNG stations planned
- Clean Energy LNG station expansion
  - “America’s Natural Gas Highway”
- Encana/Heckmann
  - Mobile and fixed stations
- Over 100 new CNG stations planned

New Natural Gas Vehicles and Engines
- “Big 3” offering pick-ups
- Volvo/Navistar – on road
- Cummins/Westport – on road
- Caterpillar/Cummins – off road
- Caterpillar/Westport – rail

Growth Since 2008
197 CNG Stations & 8 LNG Stations
Total Capital ~$500 Million

Source: Energy Information Administration (EIA), 2010; Statistics Canada; U.S. Dept of Energy AFDC.
NG Downstream Technology Innovation

Source: Advanced Research Projects Agency-Energy, US DOE
NG Downstream Technology Innovation (1/2)

Chilled Natural Gas for At-Home Refueling
Developer: GE Global Research
Partners: Chart Industries, University of Missouri

Modular Natural Gas Tank
Developer: United Technologies Research Center
Partners: Lincoln Composites

Low Pressure Material-Based NG Fuel System
Developer: Ford Motors
Partners: BASF, University of Quebec Trois Rivieres, University of California-Berkeley

Sorbent-Based Natural Gas Tank
Developer: SRI International

Source: Advanced Research Projects Agency-Energy, US DOE
NG Downstream Technology Innovation (2/2)

Gas-Compressing Engine
Developer: Oregon State University
Partners: Colorado State University

Conformable Core Gas Tank
Developer: REL, Inc
Partners: Endres Machining Innovations, LLC

Low-Pressure Conformable NG Vehicle Tank
Developer: Gas Technology Institute
Partners: Northwestern University

Intestinal Natural Gas Storage
Developer: Otherlab, Inc.

Source: Advanced Research Projects Agency-Energy, US DOE
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## Midwest Impact of US Shale Gas Development
### Upstream & Midstream

<table>
<thead>
<tr>
<th>Value Chain Opportunity</th>
<th>Technology/Opportunity</th>
<th>Who Benefits</th>
<th>Investment Potential</th>
<th>Economic Impact (Jobs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery / Production (including Fracking and Drilling Equipment)</td>
<td>- Hydraulic Fracturing - High-tech Drilling Technology</td>
<td>Land owners, Steel, Rigs, Cement, Equipment, Large mfg./fab. Suppliers</td>
<td>High</td>
<td>High Longer Term</td>
</tr>
<tr>
<td>Pipeline Infrastructure</td>
<td>- Lateral pipelines - Compressor additions - Composites and lining technology - O&amp;M Techniques</td>
<td>- Construction firms - Pipeline mfg’s - Utilities</td>
<td>High</td>
<td>High Shorter Term</td>
</tr>
<tr>
<td>Storage Capacity</td>
<td>- On site LNG - Battery compression</td>
<td>- Utilities - Storage Asset Owners</td>
<td>High</td>
<td>Low Longer Term</td>
</tr>
<tr>
<td>Gathering / Distribution</td>
<td>- New pipeline lining - Maintenance technologies</td>
<td>Machinery, Construction firms, Utilities</td>
<td>Medium</td>
<td>Medium Shorter Term</td>
</tr>
</tbody>
</table>

*Source: MIT, HIS Global Insight, KKR, PWC, US EIA, Chatham House, Forbes, Dow Chemicals*
## Midwest Impact of US Shale Gas Development Downstream (1/2)

<table>
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<th>Who Benefits</th>
<th>Investment Potential</th>
<th>Economic Impact (Jobs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG Export</td>
<td>- Floating LNG Plants</td>
<td>- Large Oil &amp; Gas&lt;br&gt;- US Trade</td>
<td>Low</td>
<td>Low&lt;br&gt;Longer Term</td>
</tr>
<tr>
<td>NG Power gen plants and components</td>
<td>- More efficient combined cycle technology&lt;br&gt;- Turbine component design</td>
<td>- NG turbine OEM’s and component suppliers&lt;br&gt;- Large mfg./fab. suppliers</td>
<td>Medium</td>
<td>Medium&lt;br&gt;Longer Term</td>
</tr>
<tr>
<td>NG Vehicles</td>
<td>- NGV Infrastructure&lt;br&gt;- On board low pressure NG tank tech</td>
<td>- Vehicle OEM’s&lt;br&gt;- Component Suppliers&lt;br&gt;- Fleets</td>
<td>Medium</td>
<td>Medium&lt;br&gt;Longer Term</td>
</tr>
<tr>
<td>NG use related products (e.g., CNG engines)</td>
<td>- Transportation and stationary power applications</td>
<td>- OEMs/Tier 1s&lt;br&gt;(Cummins, CAT, Roush)</td>
<td>Medium</td>
<td>Medium&lt;br&gt;Longer Term</td>
</tr>
</tbody>
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*Source: MIT, HIS Global Insight, KKR, PWC, US EIA, Chatham House, Forbes, Dow Chemicals*
## Midwest Impact of US Shale Gas Development Downstream (2/2)

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<th>Who Benefits</th>
<th>Investment Potential</th>
<th>Economic Impact (Jobs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fueling infrastructure</td>
<td>- Residential higher pressure quick fuel systems</td>
<td>- Utilities - Fleets</td>
<td>Medium</td>
<td>Medium Shorter term</td>
</tr>
<tr>
<td>Petro-Chemical product precursor</td>
<td>New Ethylene, Ammonia Expansion, Propylene Expansion</td>
<td>- Chemical companies (Dow, BASF)</td>
<td>High</td>
<td>High Longer Term</td>
</tr>
<tr>
<td>Steel and Aluminum</td>
<td>Capacity expansion Increased demand for iron ore pellets</td>
<td>- Metal Producers/Foundries (ArcelorMittal, Essar, Gerdau, Timken)</td>
<td>High</td>
<td>Medium Longer Term</td>
</tr>
<tr>
<td>Fuel Cell applications</td>
<td>Natural gas fuel cells</td>
<td>- Fuel cell developers - Stationary back up power systems</td>
<td>Low</td>
<td>Medium Longer Term</td>
</tr>
</tbody>
</table>