



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

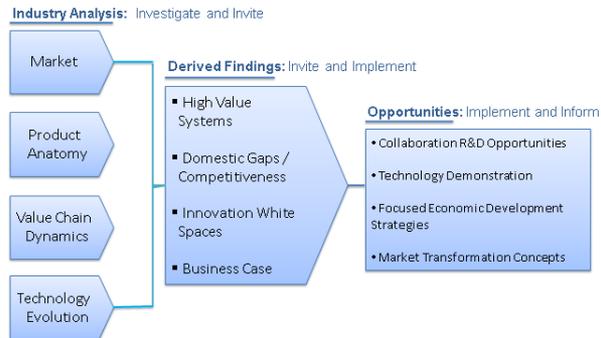
- Company growth
- Development of IP
- Job creation
- Investment attraction



NextEnergy Impact

Leverage people, place and relationships to accelerate growth

Knowledge (people)



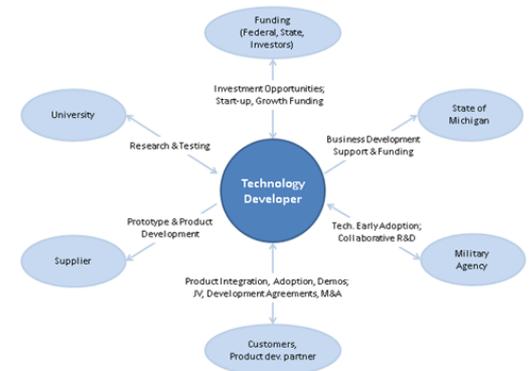
Market Studies
 Technology Roadmapping
 Supply Chain Analysis
 Value Chain Dynamics
 Domestic Competitiveness

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

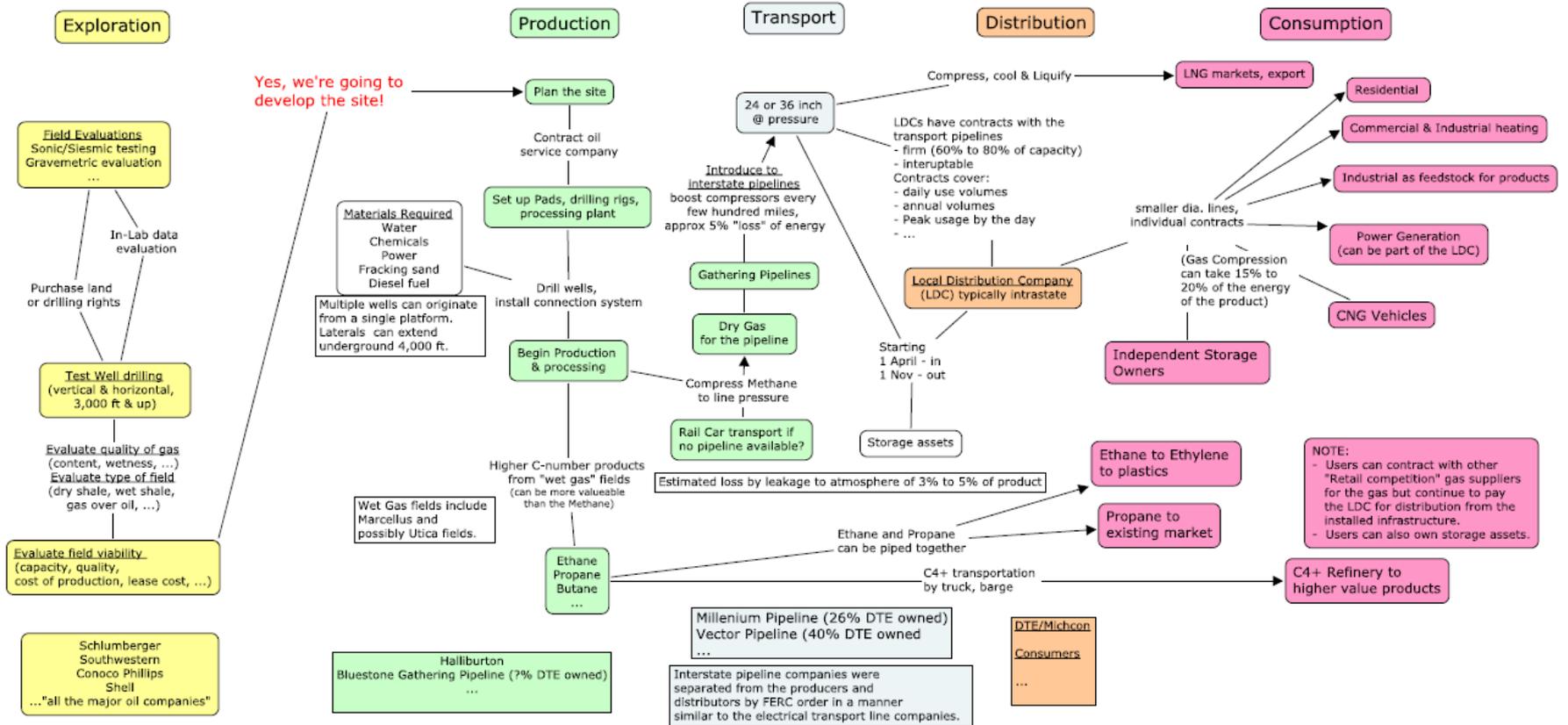
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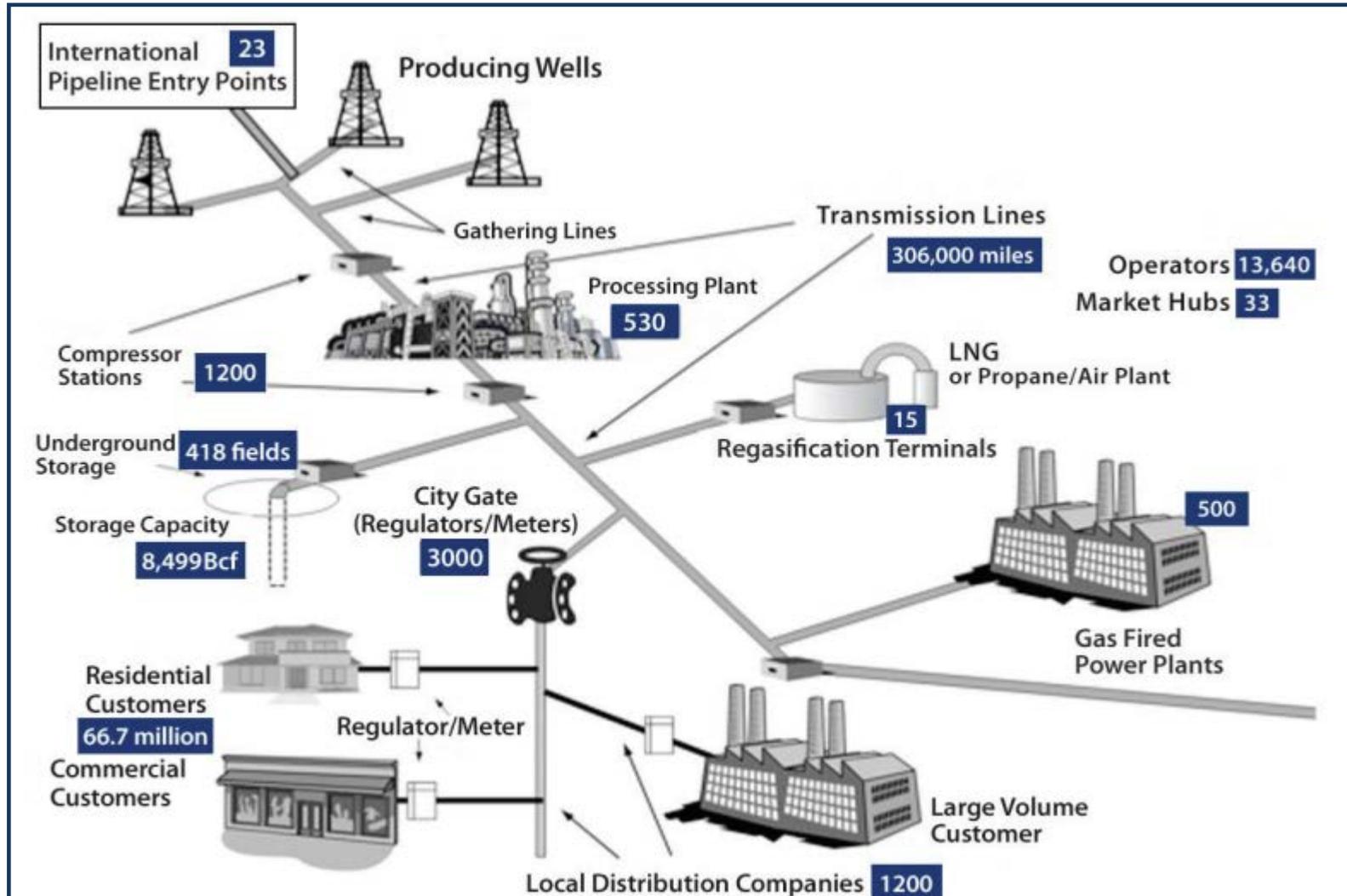


An Overview of Natural Gas Value Chain

Natural Gas Supply

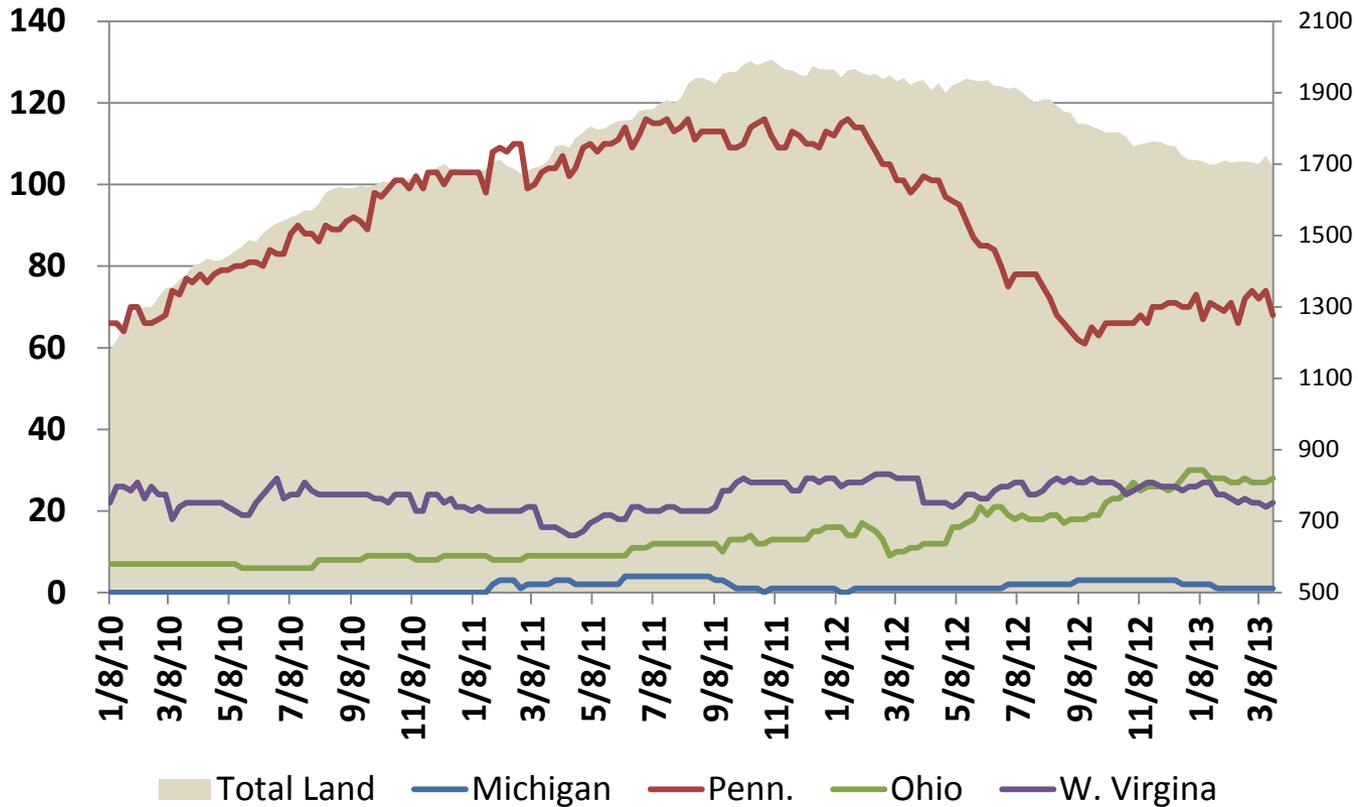


US Natural Gas Infrastructure



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

Solution: CleanWave™ Water Treatment Process, Halliburton. Eliminates biological contaminant, enables on-site recycling



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

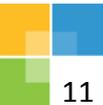
Solution: Green Completions Technology
Captures methane which can be sold, used as fuel, or re-injected to improve well performance



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

Source: Halliburton, CAES, OTC, NRDC, MIT

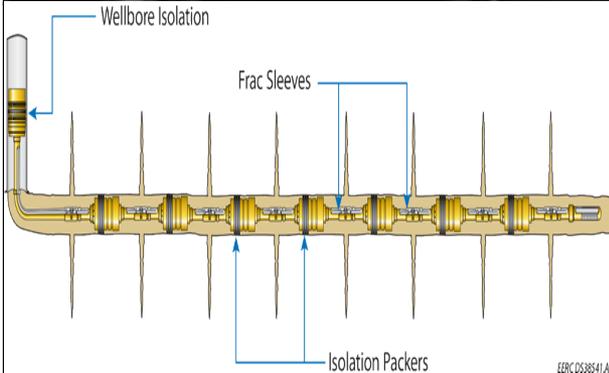


Advancement in Fracking Techniques (2/2)



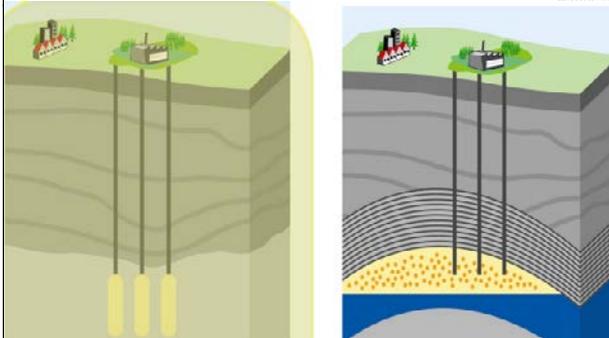
Challenge: Bacteria Control, Corrosion of Iron and Steel

Solution: CleanStream® Service , Halliburton
Uses UV light to control bacteria and reduces need for chemical biocides



Challenge: Water table contamination

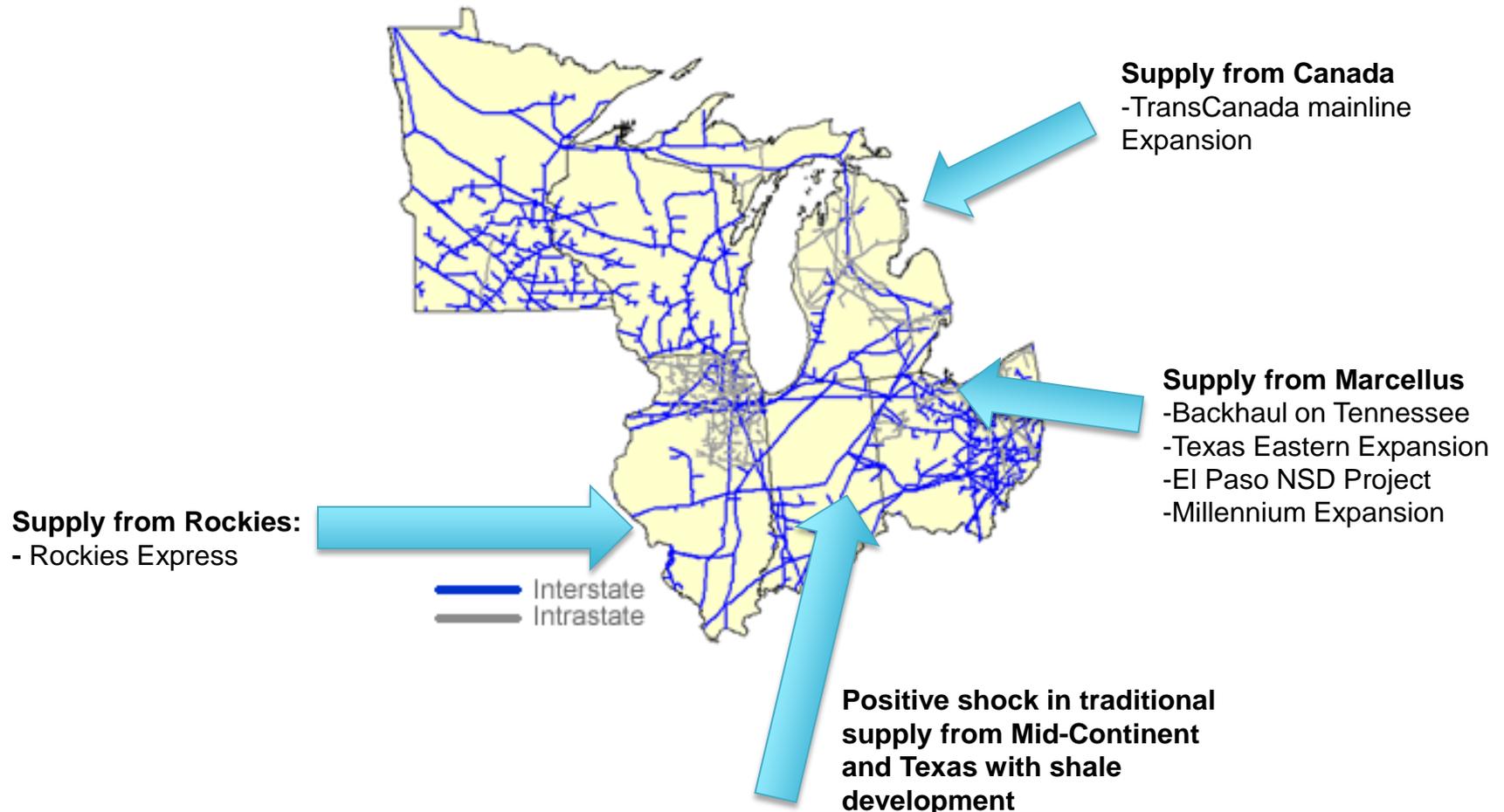
Solution: Openhole sleeves, Positive annular isolation of an uncemented liner with swell packers, Mechanical isolators



Challenge: Siting of CAES facilities may be limited by specific geologic conditions

Solution: Use of exhausted NG wells as compressed air storage caverns

New Pipeline Developments in Midwest



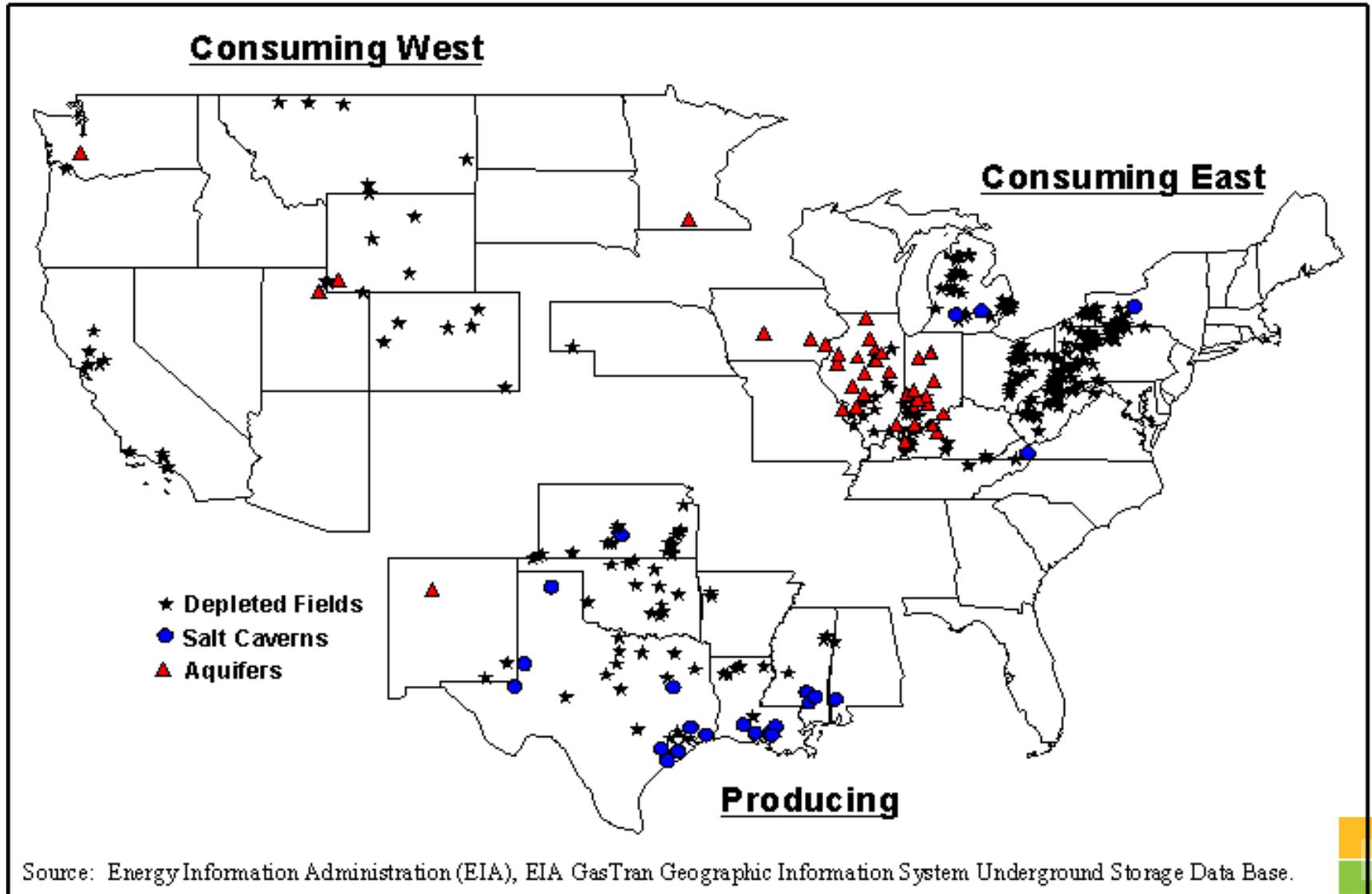
* Additional pipeline capacity in the region could bring an additional 2 Bcf/d supply to Midwest in 5 years

* 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

US Natural Gas Storage

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



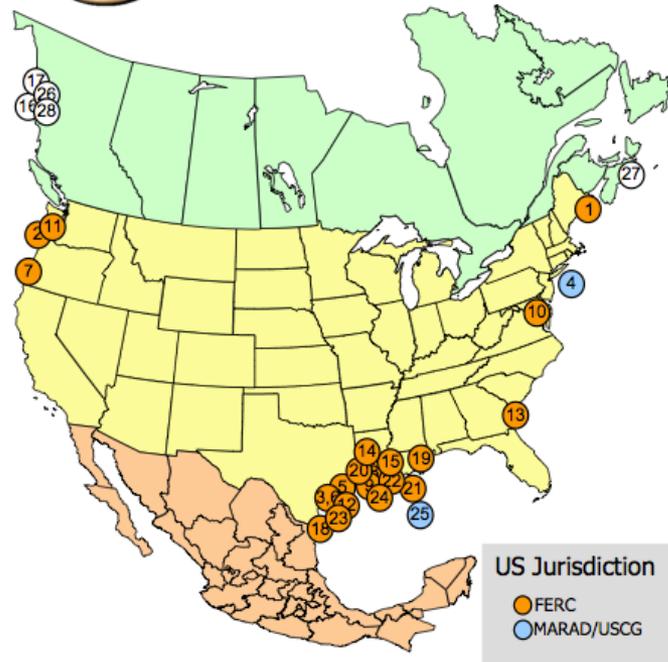
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A Surge in Applications for LNG Export Terminals



North American LNG Import/Export Terminals *Proposed/Potential*



As of March 20, 2013

Import Terminal

PROPOSED TO FERC

1. Robbinston, ME: 0.5 Bcfd (Kestrel Energy - 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: 1.8 Bcfd (Freeport LNG Dev/Freeport LNG Expansion/FLNG 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 (Semptra - Cameron LNG)
10. Cove Point, MD: 0.75 Bcfd (Dominion - Cove Point LNG)
11. Astoria, OR: 1.30 Bcfd (Oregon LNG)
12. Lavaca Bay, TX: 1.38 Bcfd (Excelerate 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. Pascagoula, 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. Ingleside, TX: 1.09 Bcfd (Pangea LNG (North America))
24. Cameron Parish, LA: 0.20 Bcfd (Gasfin 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 (Pieridae Energy Canada)
28. Kitimat, BC: 2.0 Bcfd (LNG Canada)

Office of Energy Projects

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)

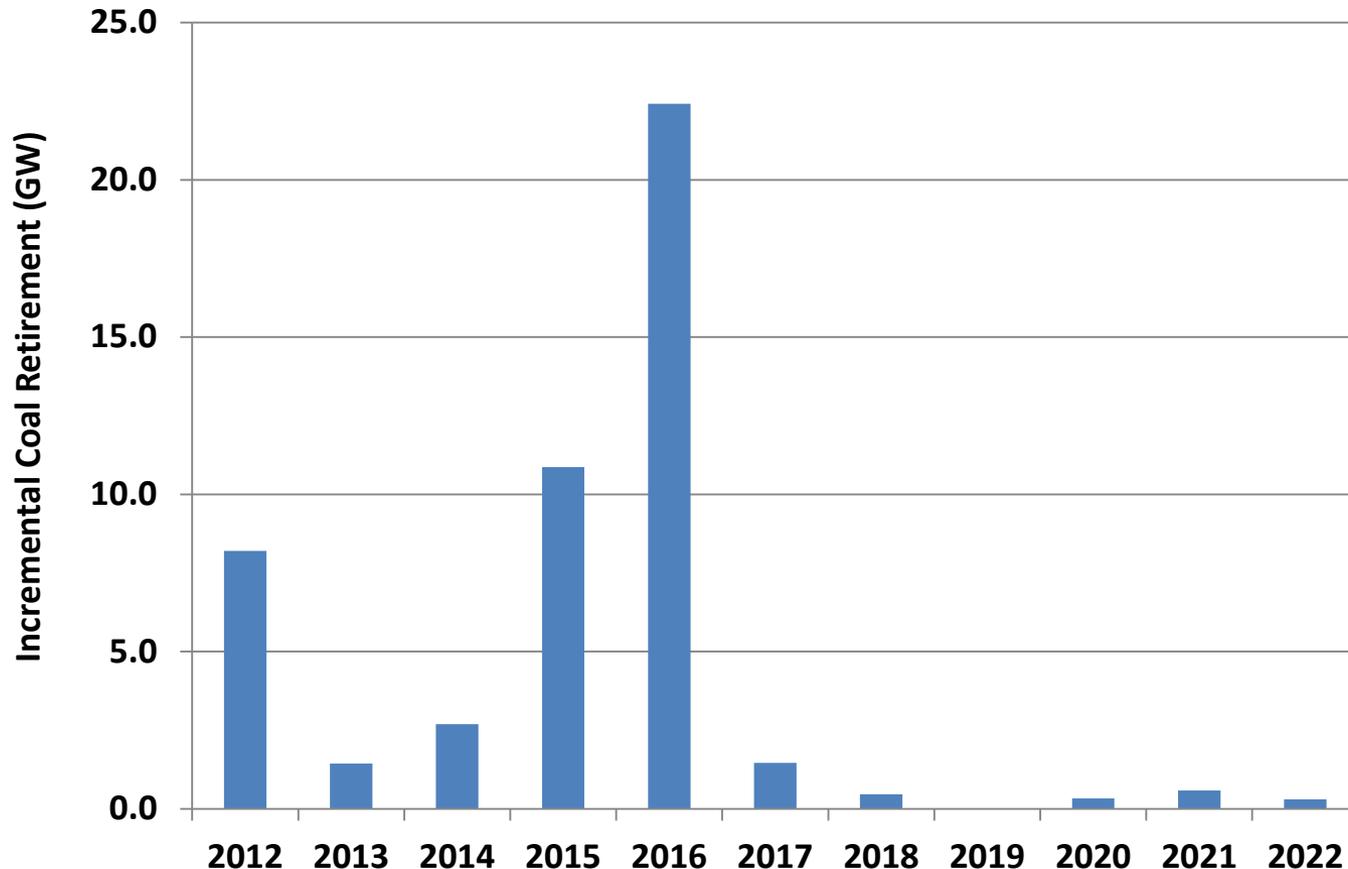


LNG Innovation – Floating LNG Plants



- 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

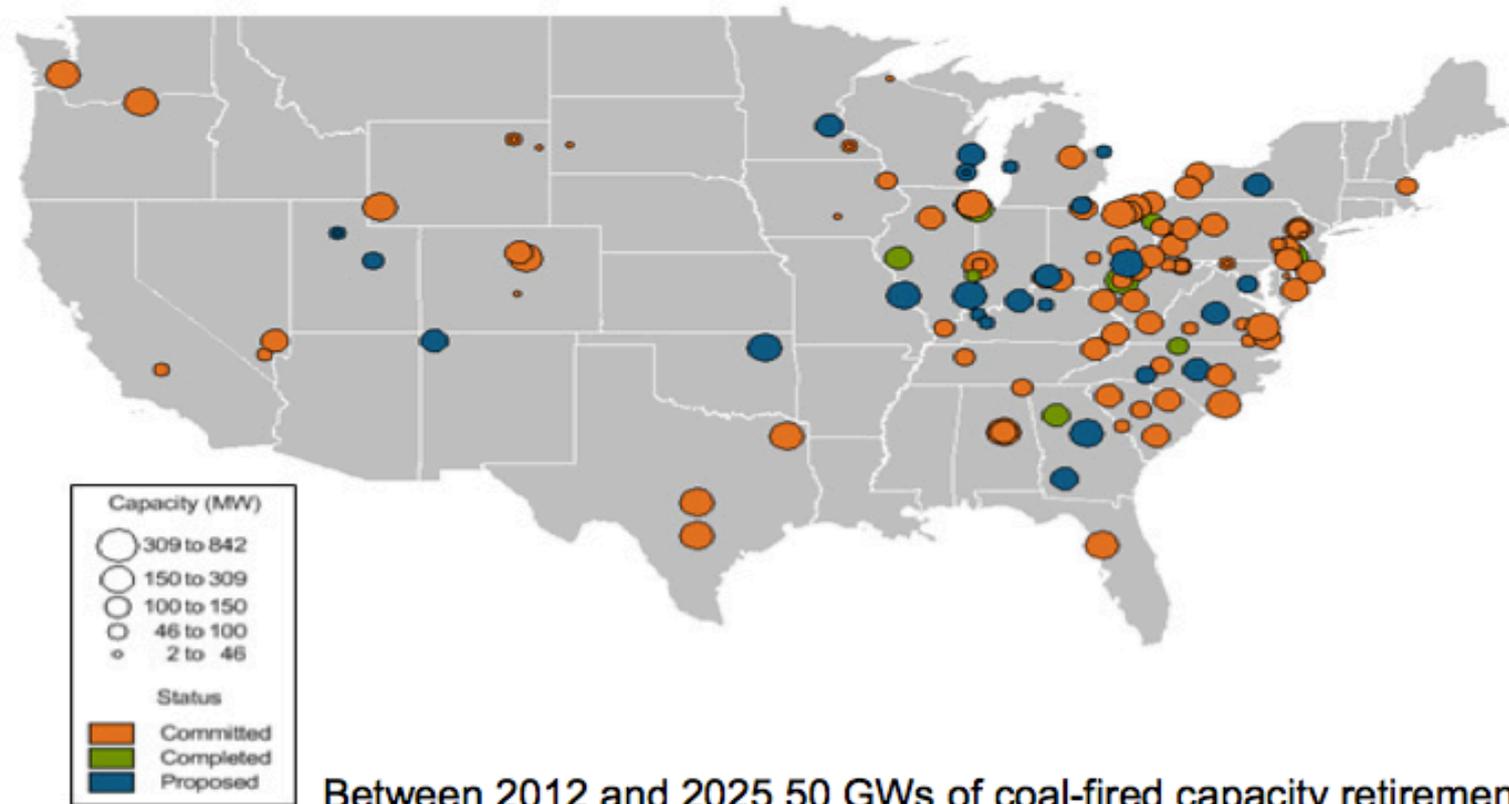


Source: EIA Annual Energy Outlook 2013

More coal power plants will retire before the end of decade, and natural gas plants are expected to fill the gap.



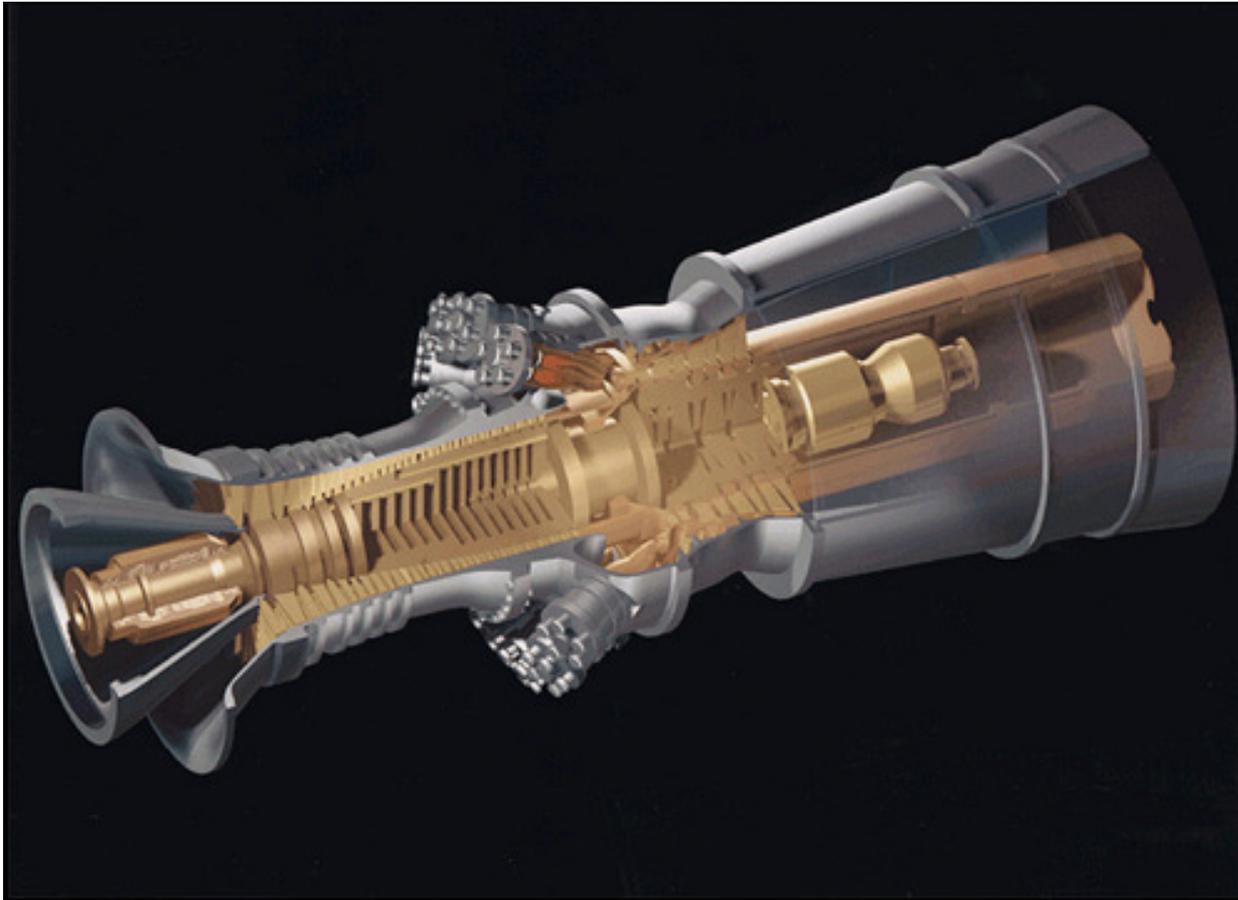
Coal Retirements Impact on Midwest Region Opportunity for NG CC Power Generation Plants/Retrofits



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.

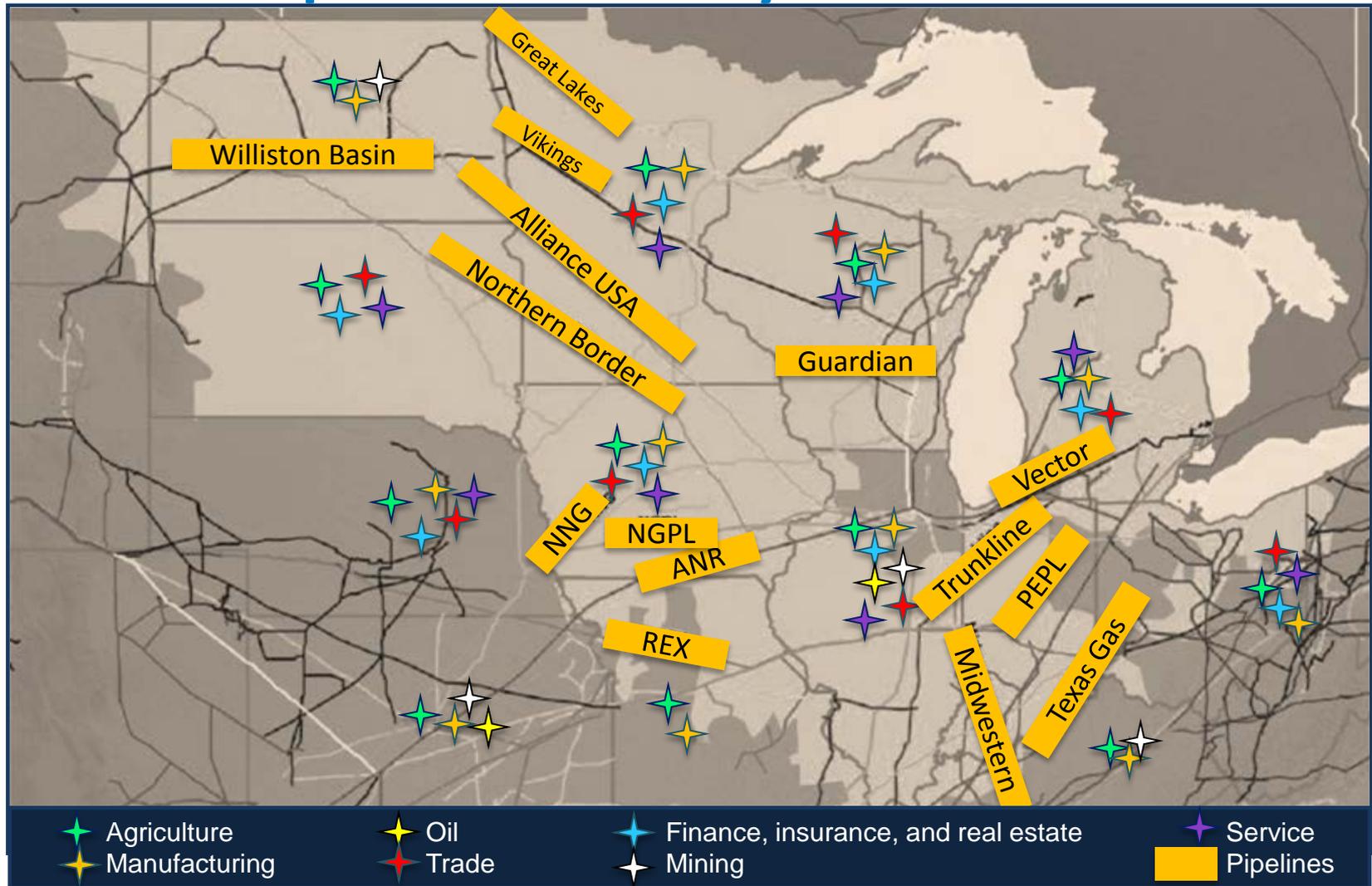
Natural Gas Power Generation Innovation



GE H series power generation gas turbine: in combined cycle configuration, this 480MW unit has a rated thermal efficiency of 60%

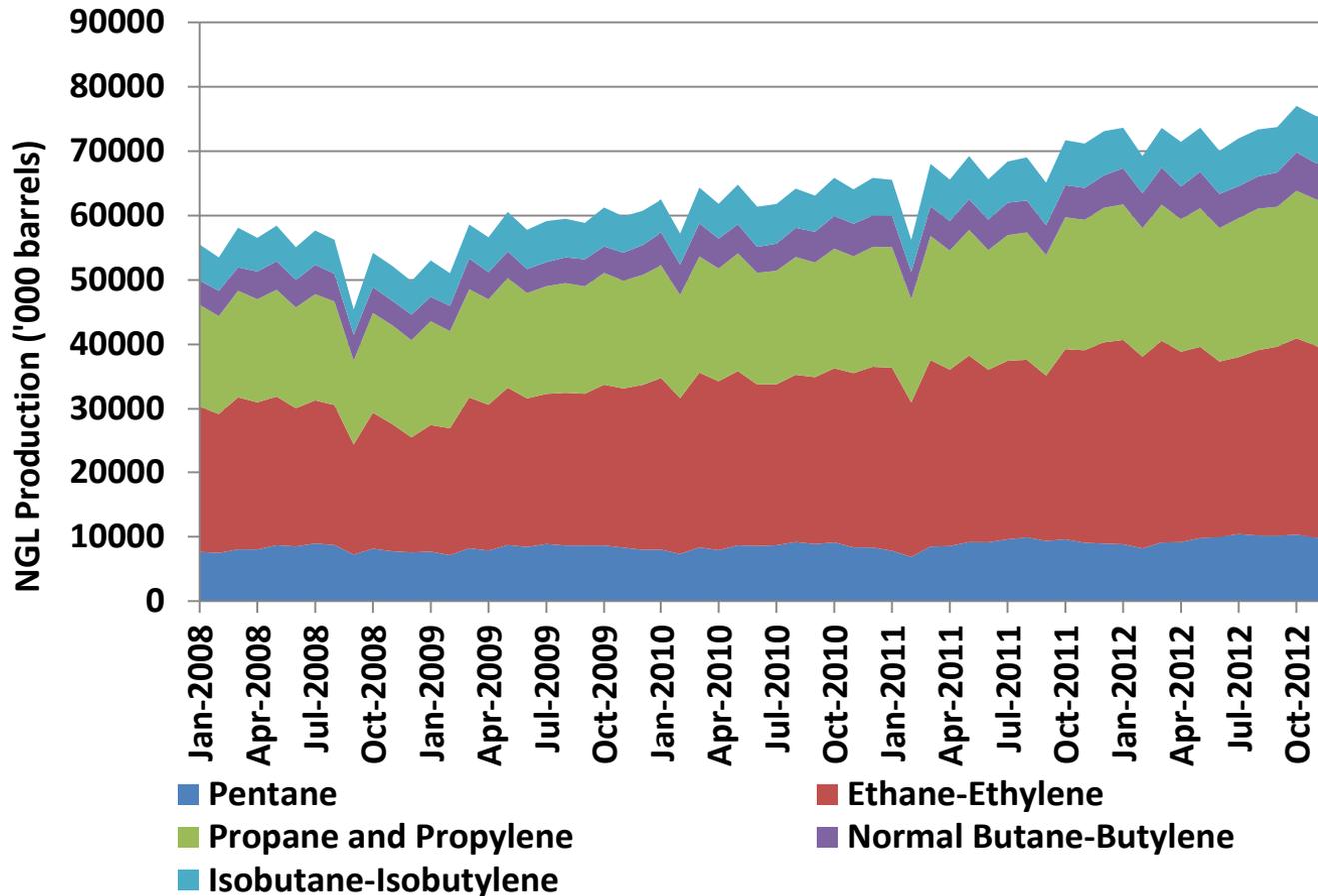


NG Gas Pipeline Grid & Key Industries in Midwest



Source: Bureau of Labor Statistics, U.S. Department of Labor

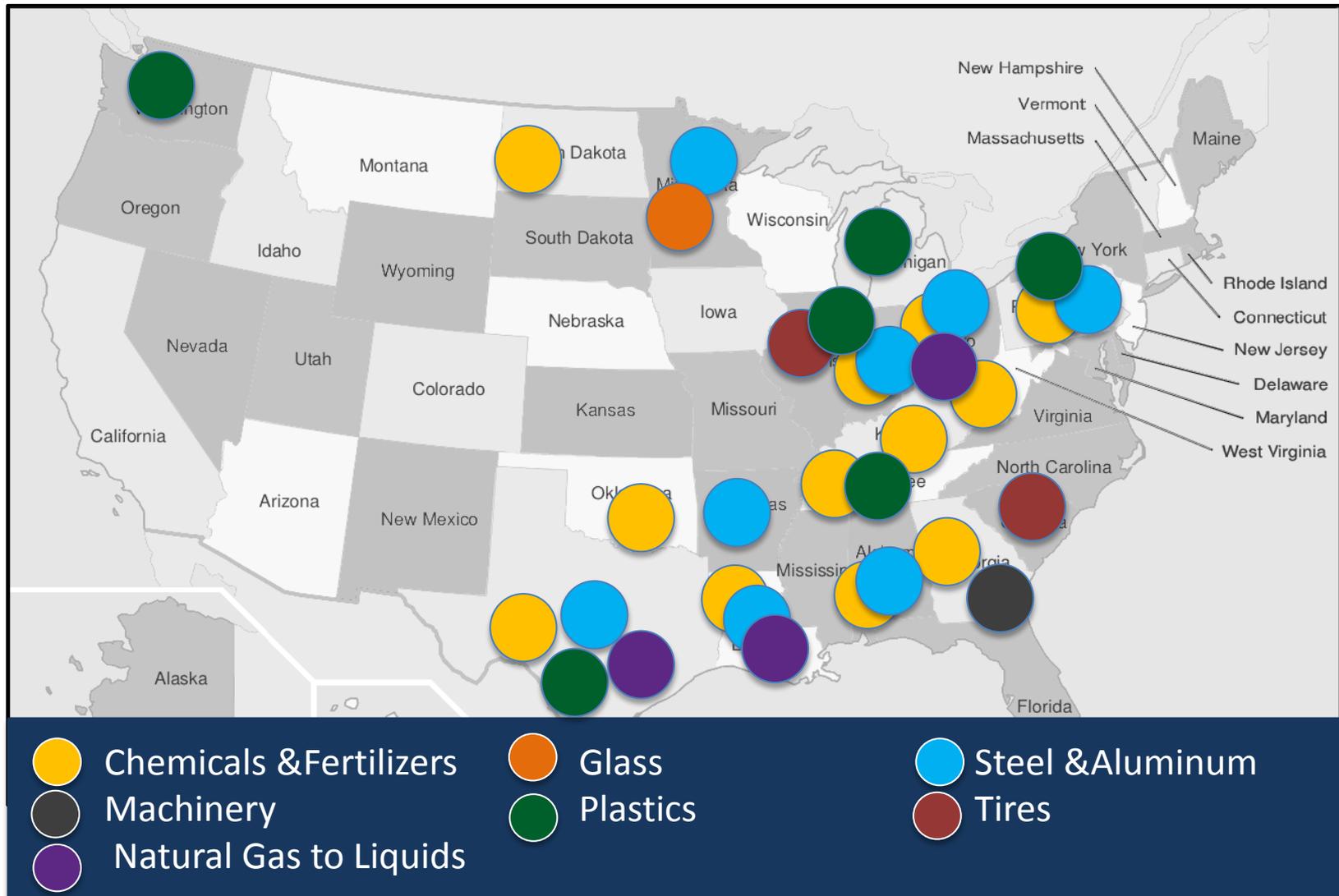
Industrial Projects Get Boost from Increased NGL Production



Source: EIA

Petrochemical companies are benefiting from increased production in wet gas and are moving offshore industrial plants back to the U.S.

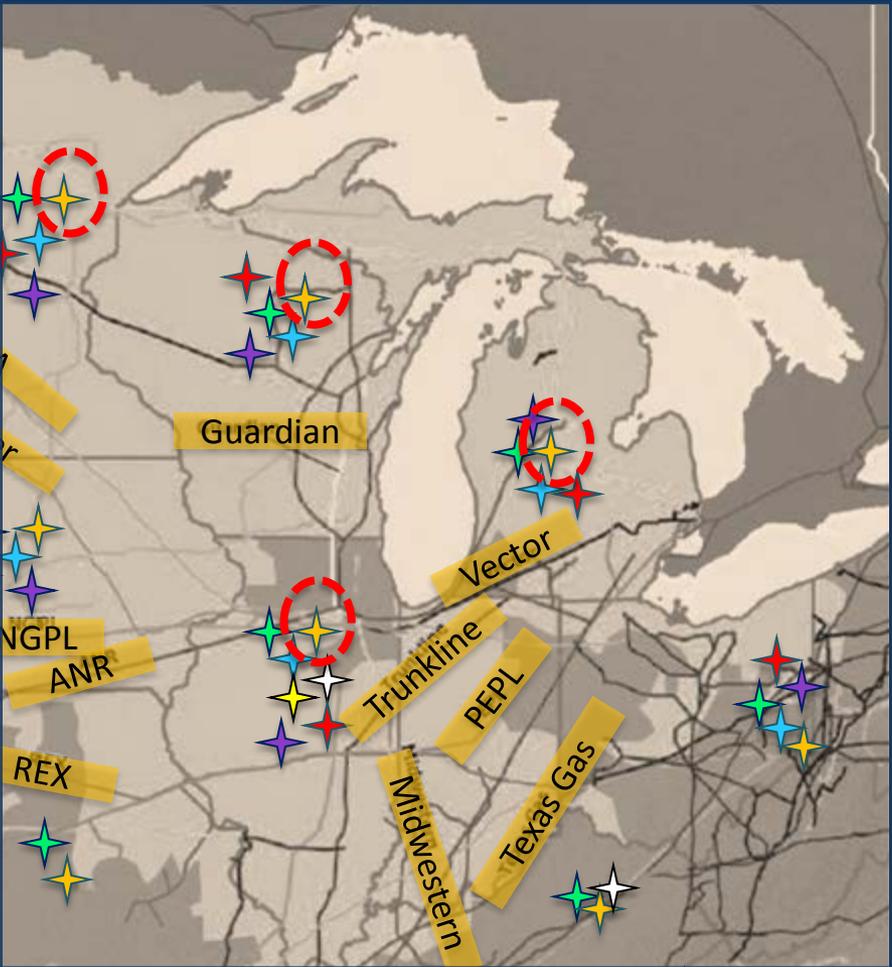
Industry to Invest \$80 Billion In Manufacturing Renaissance



Source: Dow Chemicals

NG Pipeline Grid and Key Industries in Midwest

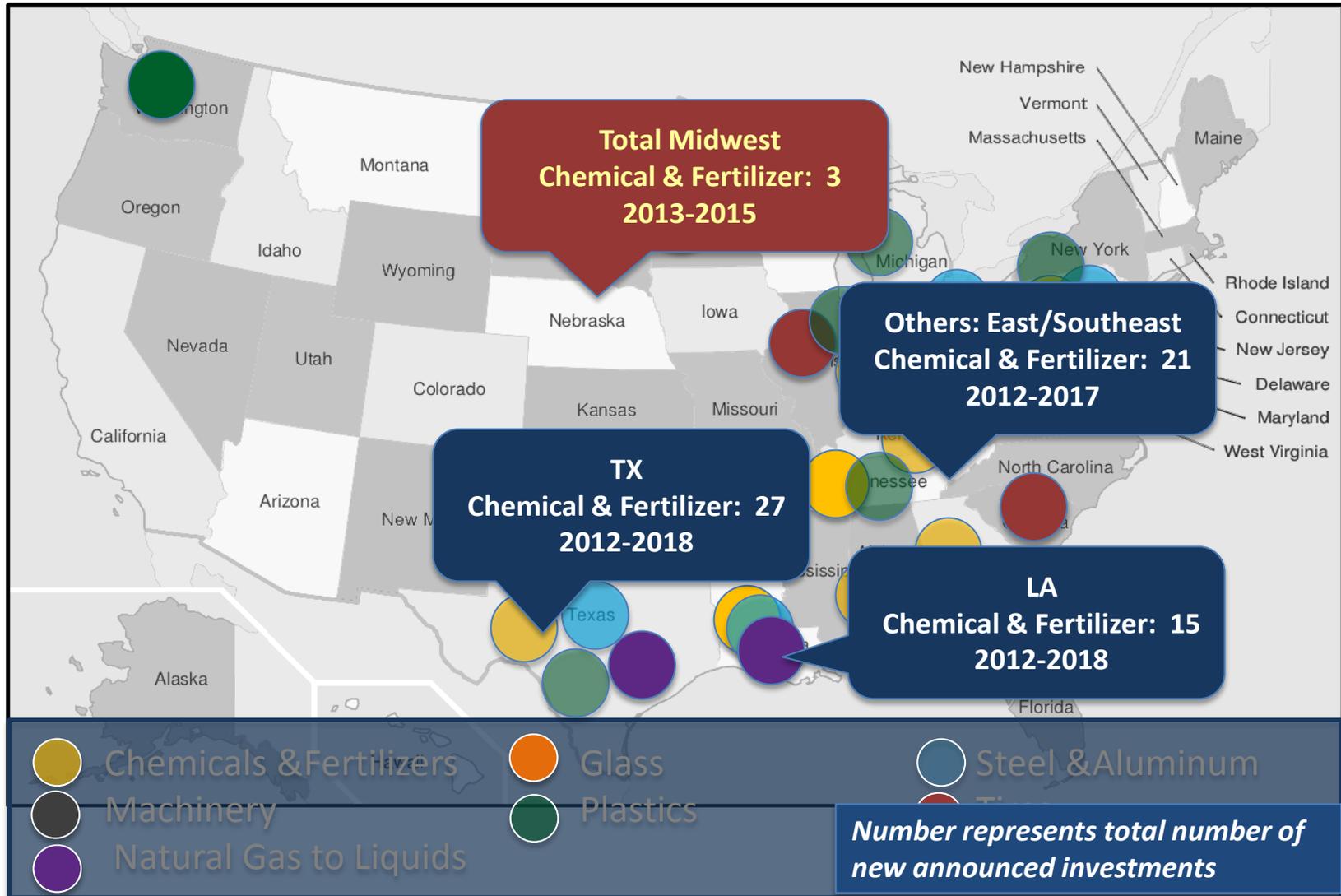
- Petro-Chemical Manufacturing Facility Announcements in Midwest is weak in comparison to other regions in US
 - Chemical & Fertilizer: 3
 - Steel & Aluminum: 7
 - Tires: 1
 - Plastics: 1



Agriculture	Oil	Finance, insurance, and real estate	Service
Manufacturing	Trade	Mining	Pipelines

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



Growth Since 2008

197 CNG Stations & 8 LNG Stations
Total Capital ~\$500 Million

Industry Announcements

Station Infrastructure

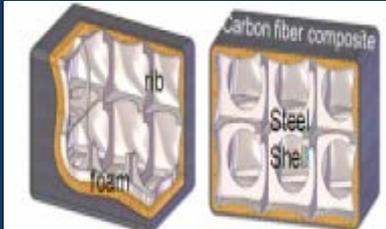
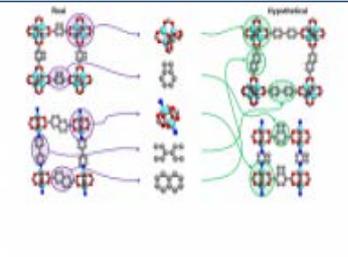
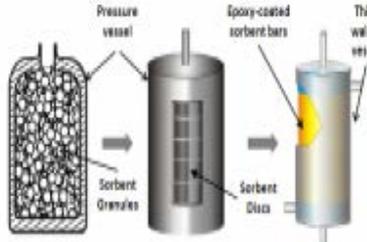
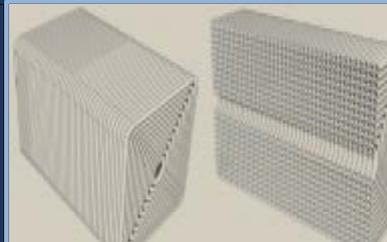
- Shell/Travel Centers of America
 - 100 LNG stations planned
- Clean Energy LNG station expansion
 - “America’s Natural Gas Highway”
- Encana/Heckmann
 - Mobile and fixed stations
- Over 100 new CNG stations planned

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

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

NG Downstream Technology Innovation

 <p>Proposed At-Home Refueling System</p>	<p><i>Chilled Natural Gas for At-Home Refueling</i></p>	 <p>Cross section of tank showing the steel liner design</p>	<p><i>Modular Natural Gas Tank</i></p>
<p><i>Conformable Core Gas Tank</i></p>	 <p>Conformable Core Building Final Interconnected Tank Structure</p>	<p><i>Gas-Compressing Engine</i></p>	
	<p><i>Low-Pressure Conformable Natural Gas Vehicle Tank</i></p>		<p><i>Low Pressure Material-Based Natural Gas Fuel System</i></p>
<p><i>Sorbent-Based Natural Gas Tank</i></p>		<p><i>Intestinal Natural Gas Storage</i></p>	

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

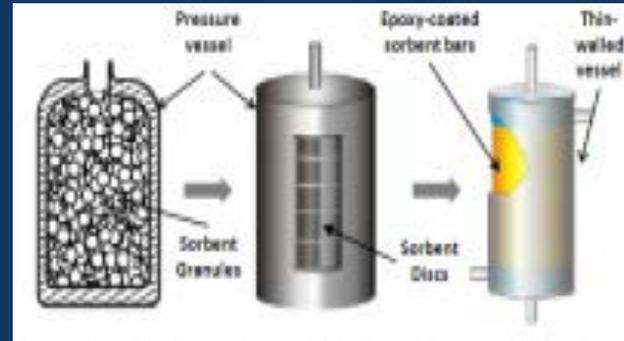
Partners: Lincoln Composites



Low Pressure Material-Based NG Fuel System

Developer: Ford Motors

*Partners: BASF, University of Quebec Trois Rivieres
University of California-Berkeley*



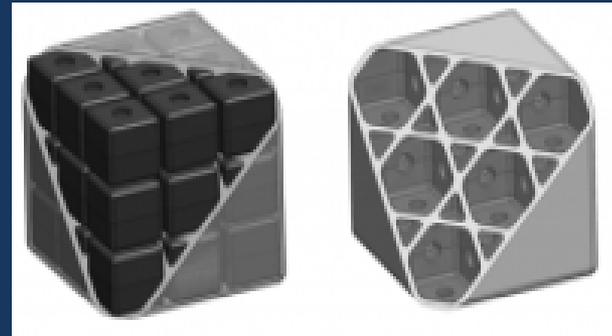
Sorbent-Based Natural Gas Tank

Developer: SRI International

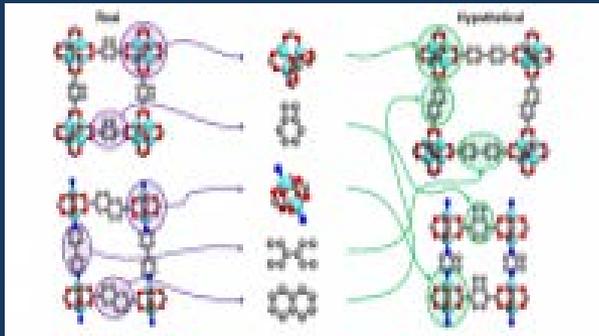
NG Downstream Technology Innovation (2/2)



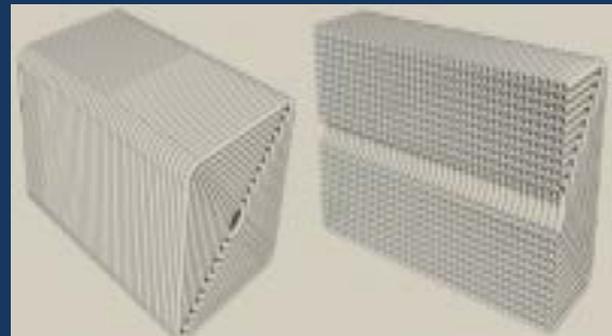
Gas-Compressing Engine
Developer: Oregon State University
Partners: Colorado State University



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.

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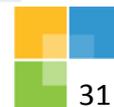
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Midwest Impact of US Shale Gas Development

Upstream & Midstream

Value Chain Opportunity	Technology/ Opportunity	Who Benefits	Investment Potential	Economic Impact (Jobs)
Recovery / Production (including Fracking and Drilling Equipment)	<ul style="list-style-type: none"> - Hydraulic Fracturing - High-tech Drilling Technology 	Land owners, Steel, Rigs, Cement, Equipment, Large mfg./fab. Suppliers	High	High Longer Term
Pipeline Infrastructure	<ul style="list-style-type: none"> - Lateral pipelines - Compressor additions - Composites and lining technology - O&M Techniques 	<ul style="list-style-type: none"> - Construction firms - Pipeline mfg's - Utilities 	High	High Shorter Term
Storage Capacity	<ul style="list-style-type: none"> - On site LNG - Battery compression 	<ul style="list-style-type: none"> - Utilities - Storage Asset Owners 	High	Low Longer Term
Gathering / Distribution	<ul style="list-style-type: none"> - New pipeline lining - Maintenance technologies 	Machinery, Construction firms, Utilities	Medium	Medium Shorter Term

Source: MIT, HIS Global Insight, KKR, PWC, US EIA, Chatham House, Forbes, Dow Chemicals



Midwest Impact of US Shale Gas Development Downstream (1/2)

Value Chain Opportunity	Technology/ Opportunity	Who Benefits	Investment Potential	Economic Impact (Jobs)
LNG Export	<ul style="list-style-type: none"> - Floating LNG Plants 	<ul style="list-style-type: none"> - Large Oil & Gas - US Trade 	Low	Low Longer Term
NG Power gen plants and components	<ul style="list-style-type: none"> - More efficient combined cycle technology - Turbine component design 	<ul style="list-style-type: none"> - NG turbine OEM's and component suppliers - Large mfg./fab. suppliers 	Medium	Medium Longer Term
NG Vehicles	<ul style="list-style-type: none"> - NGV Infrastructure - On board low pressure NG tank tech 	<ul style="list-style-type: none"> - Vehicle OEM's - Component Suppliers - Fleets 	Medium	Medium Longer Term
NG use related products (e.g., CNG engines)	<ul style="list-style-type: none"> - Transportation and stationary power applications 	<ul style="list-style-type: none"> - OEMs/Tier 1s (Cummins, CAT, Roush) 	Medium	Medium Longer Term

Source: MIT, HIS Global Insight, KKR, PWC, US EIA, Chatham House, Forbes, Dow Chemicals



Midwest Impact of US Shale Gas Development Downstream (2/2)

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