



# Appalachian Storage Hub: What is needed to store and maximize the regional development and use of NGLs?

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# Energy Institute Vision and Mission

## Mission

To promote, coordinate and expand the vital impacts and value of West Virginia's energy assets and capabilities for the people of West Virginia, the mid-Appalachian region, the nation and world

## Vision

By serving as a catalytic hub, continually discovering and developing transformational pathways connecting WVU energy researchers, programs, facilities, capabilities and students/workforce entrants with the future of energy

## 2025 Goals

### (A) Expand the Portfolio

Strategically drive, enable and guide expansion of WVU's energy research portfolio to \$60m annually by 2025 in coordination with the needs of policy makers and industry

### (B) Promote Development

Promote economic development within West Virginia and the region by aligning West Virginia's energy assets with the emerging needs, directions, and challenges of the energy sector

### (C) Elevate the Workforce

Elevate West Virginia's workforce by aligning, coordinating, and expanding opportunities through interdisciplinary energy academic programs and initiatives



# Broad Areas of Energy Research

- **Fossil Energy:** Promote the efficient use of fossil resources, conversion, extraction, utilization, and environmental management



- **Energy Policy:** Analyze energy policies, and their impact on use of these resources, carbon management, environmental, and infrastructure



- **Sustainable Energy:** Promote energy efficiency, alternative fuels, conservation, renewable energy sources, geothermal, and sustainable and responsible development

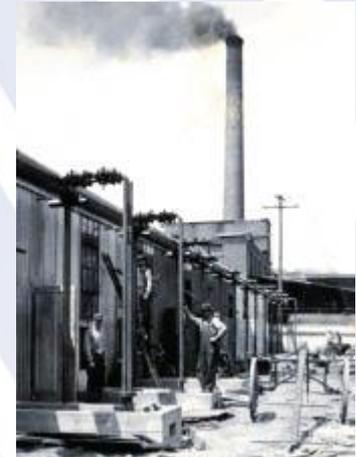


- **Environmental Stewardship:** Ensuring that energy production is balanced with minimizing negative impacts to our air and water resources



# WVU Mountain of Excellence in Natural Gas Utilization - Opportunities

- **WV – a long history in NG to chemicals**
  - Clendenin, WV: Site of the world's first commercial ethylene plant
- **Upstream:**
  - resource evaluation,
  - management, and
  - production
- **Downstream:**
  - use as an alternative transportation fuel
  - conversion to liquid fuels or chemicals
  - use in fuel cells

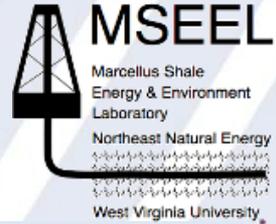


- Union Carbide 10,000 lb/day ethylene plant online in 1921
- Driven by access to raw materials



# MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY

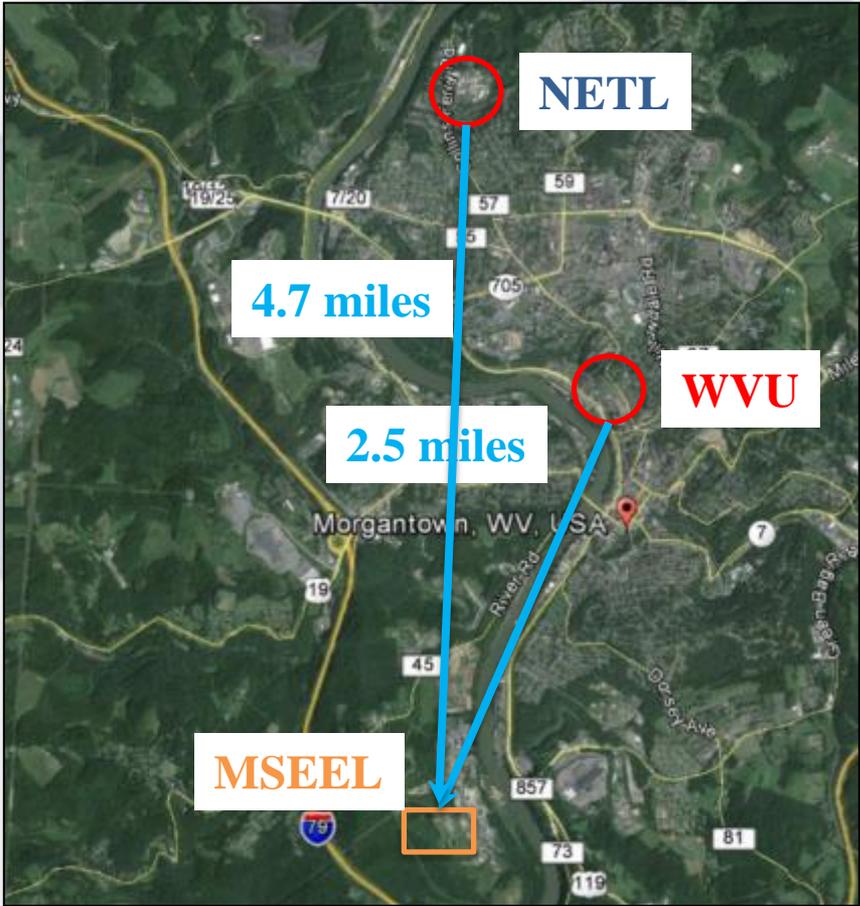
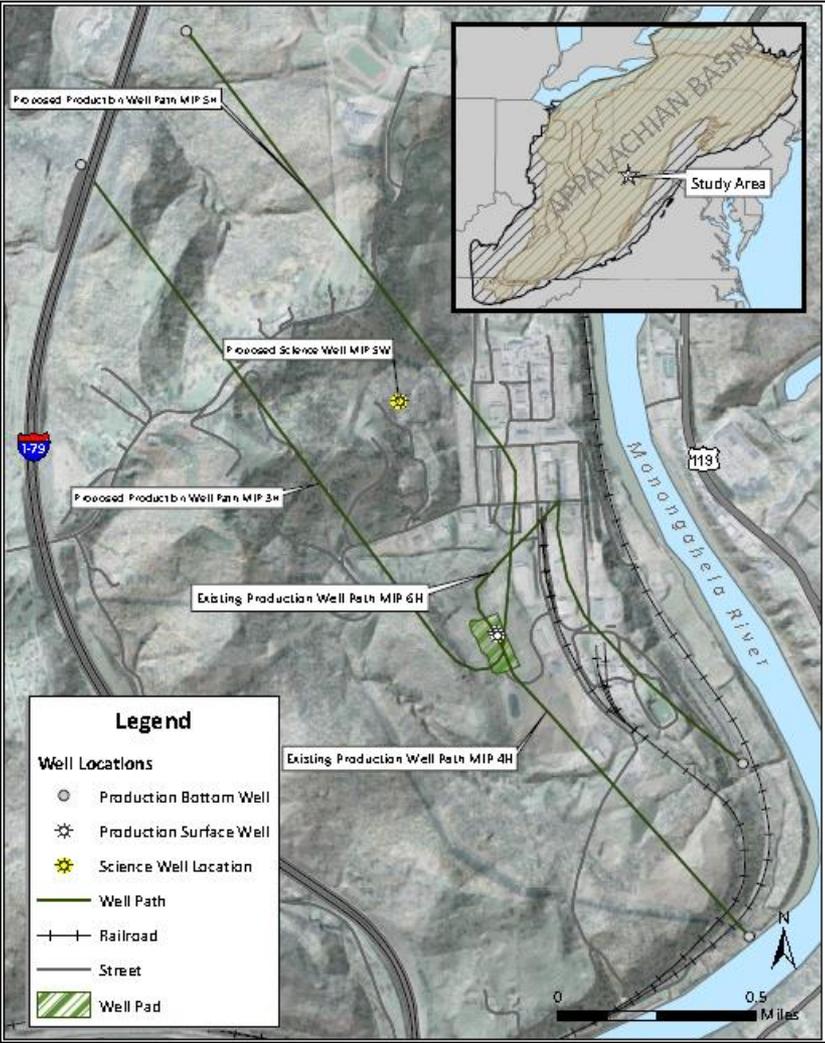
## MSEEL



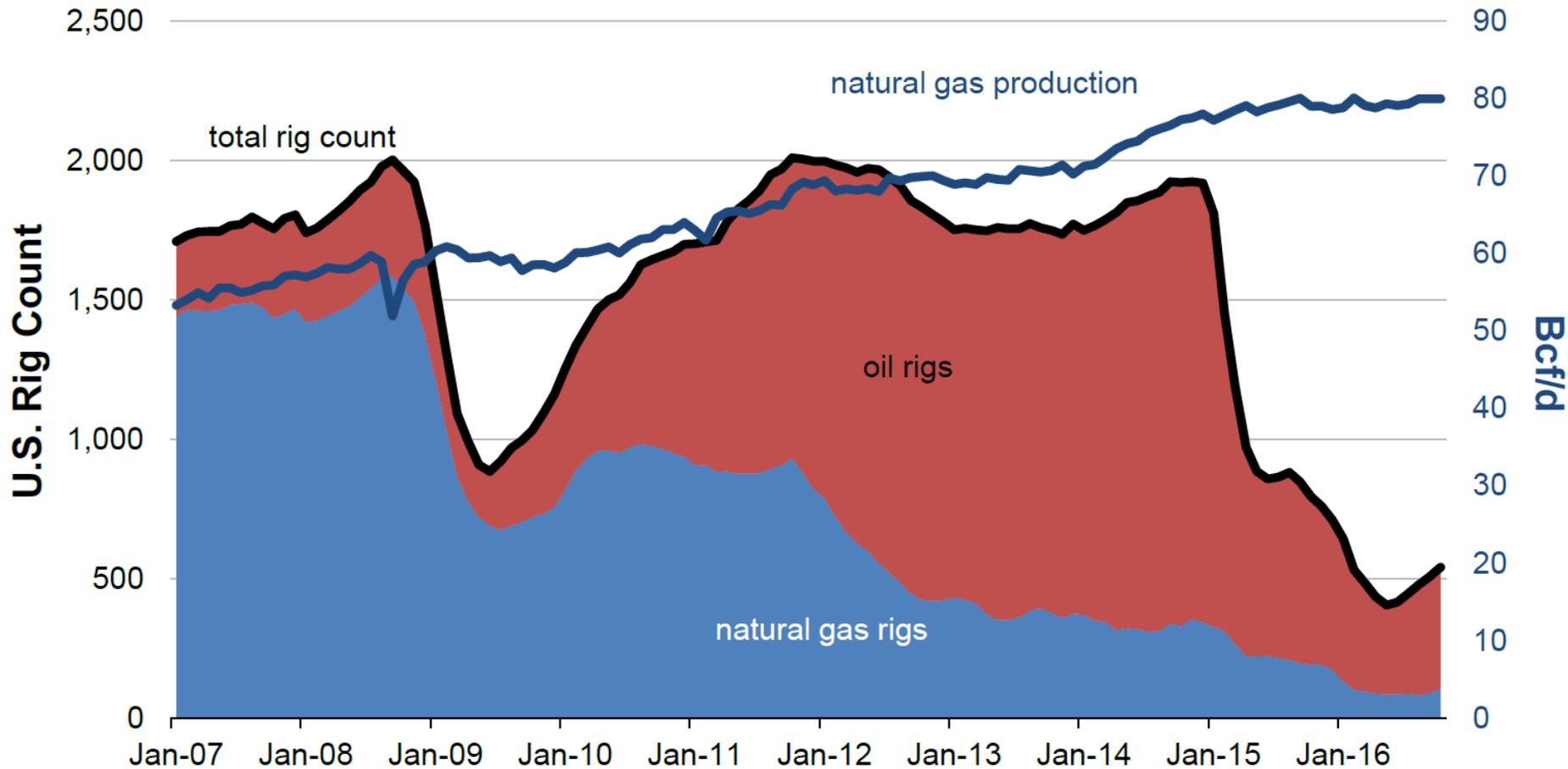
The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a **long-term collaborative field site** to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development



# MSEEL Site



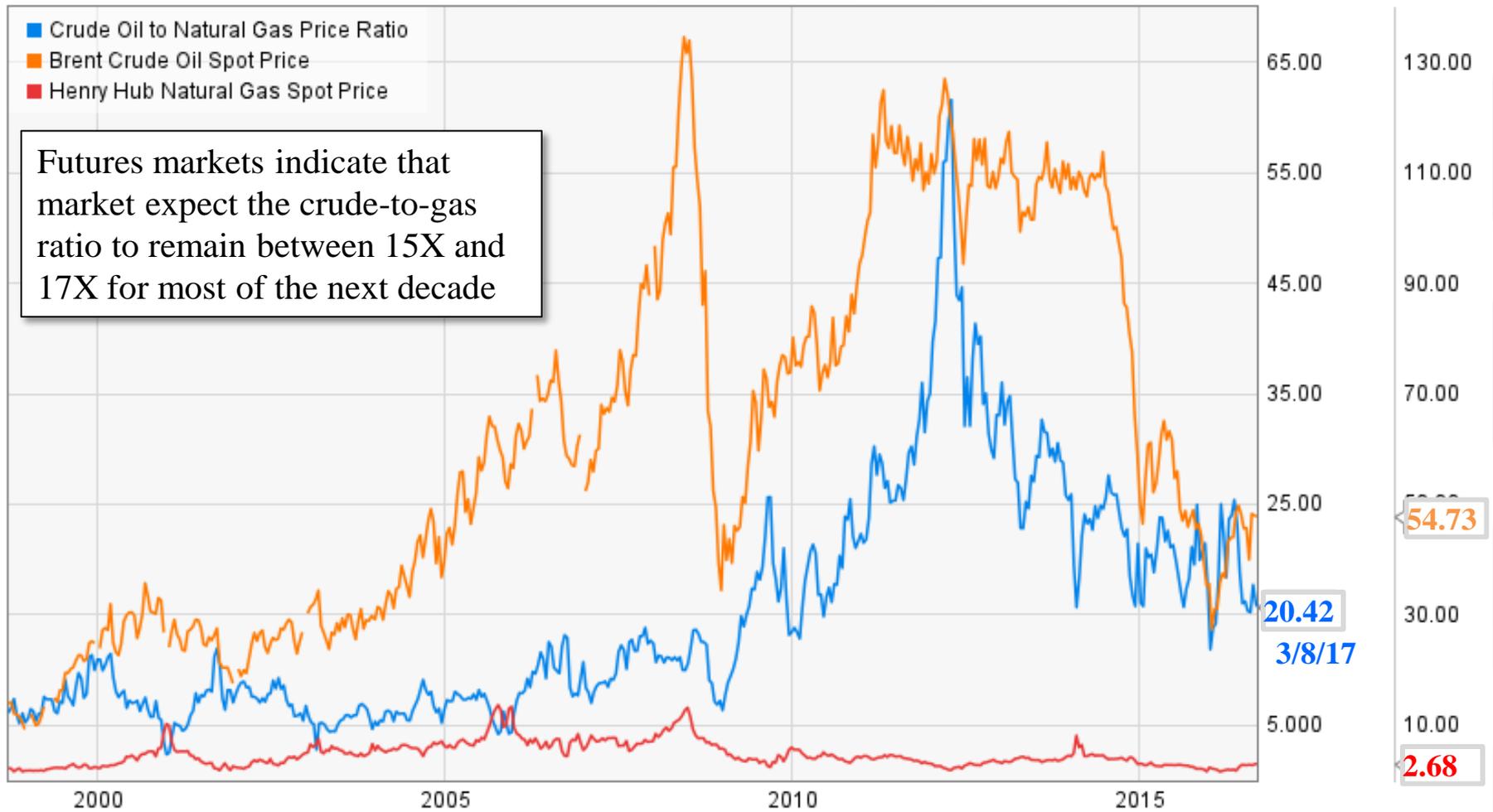
# U.S. Rig Count and Production



Source: Baker Hughes, Inc. rig count, EIA Monthly Total Marketed Production



# Natural gas advantage



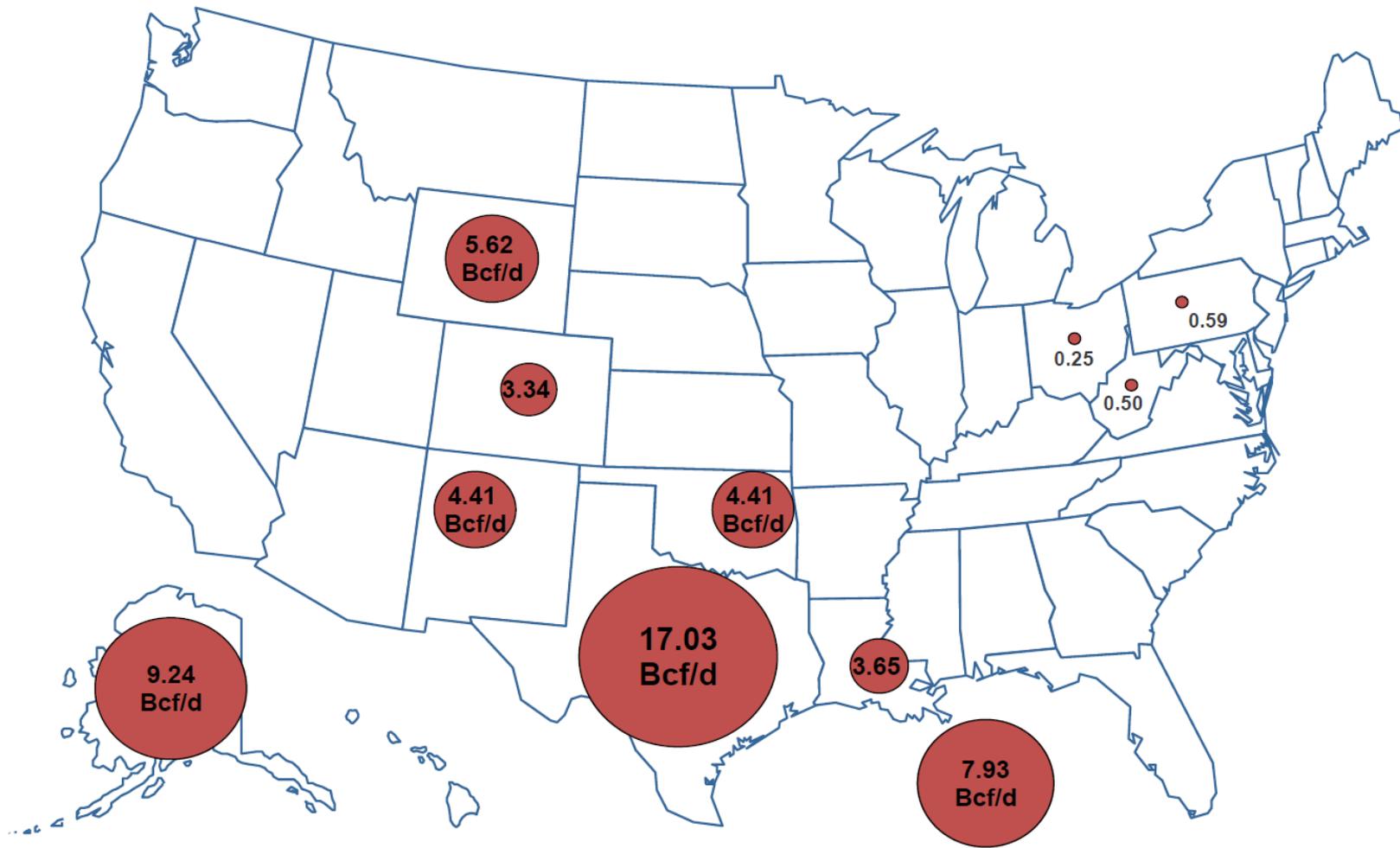
Source: EIA

The “true” BTU ratio of WTI crude to natural gas of 5.8 MMBtu/Bbl



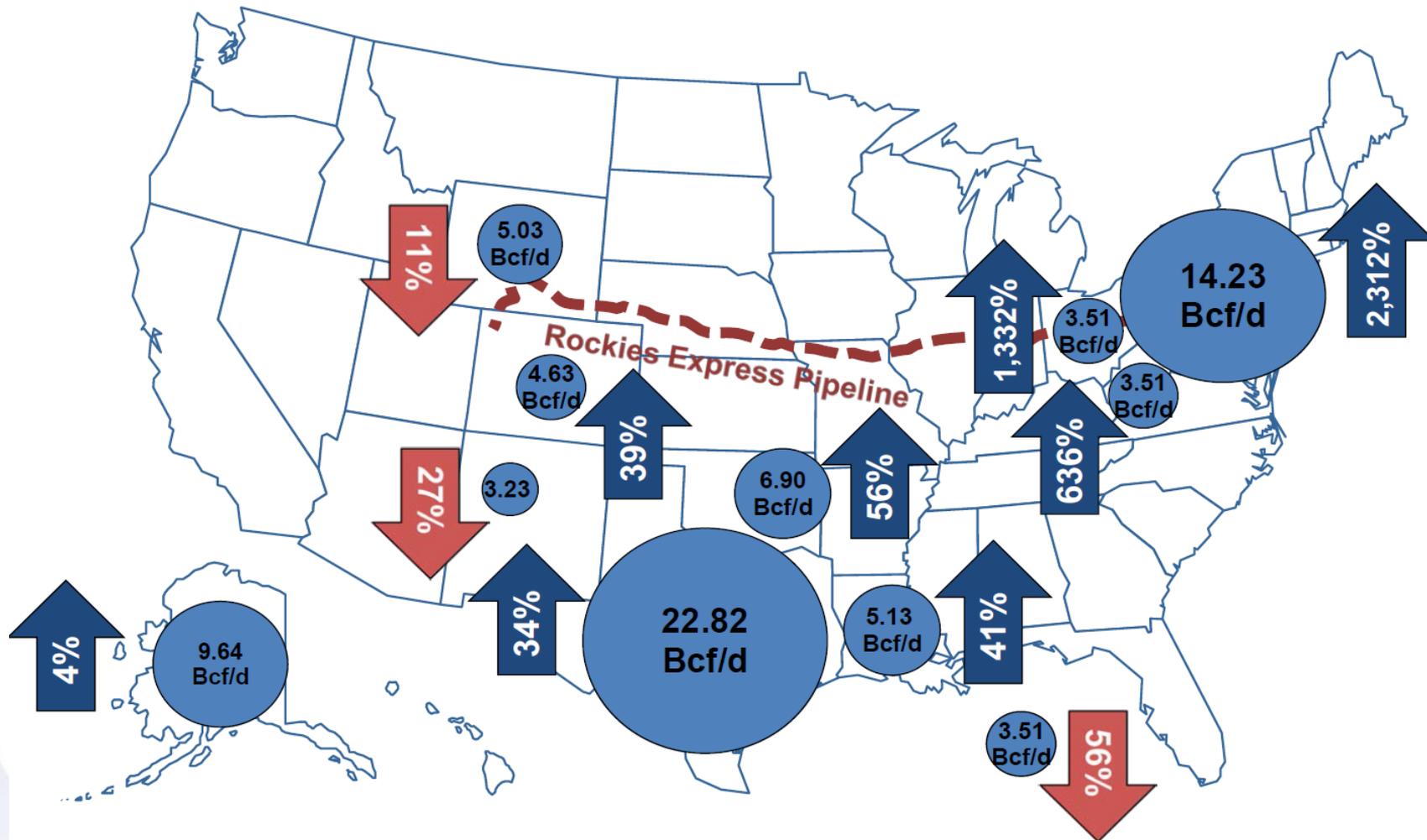
# Natural Gas Production Shifts

*U.S. Natural Gas Production in Jan. 2006, Bcf/d*



# Natural Gas Production Shifts

U.S. Natural Gas Production, Jan. 2006 compared to Jan. 2016, Bcf/d

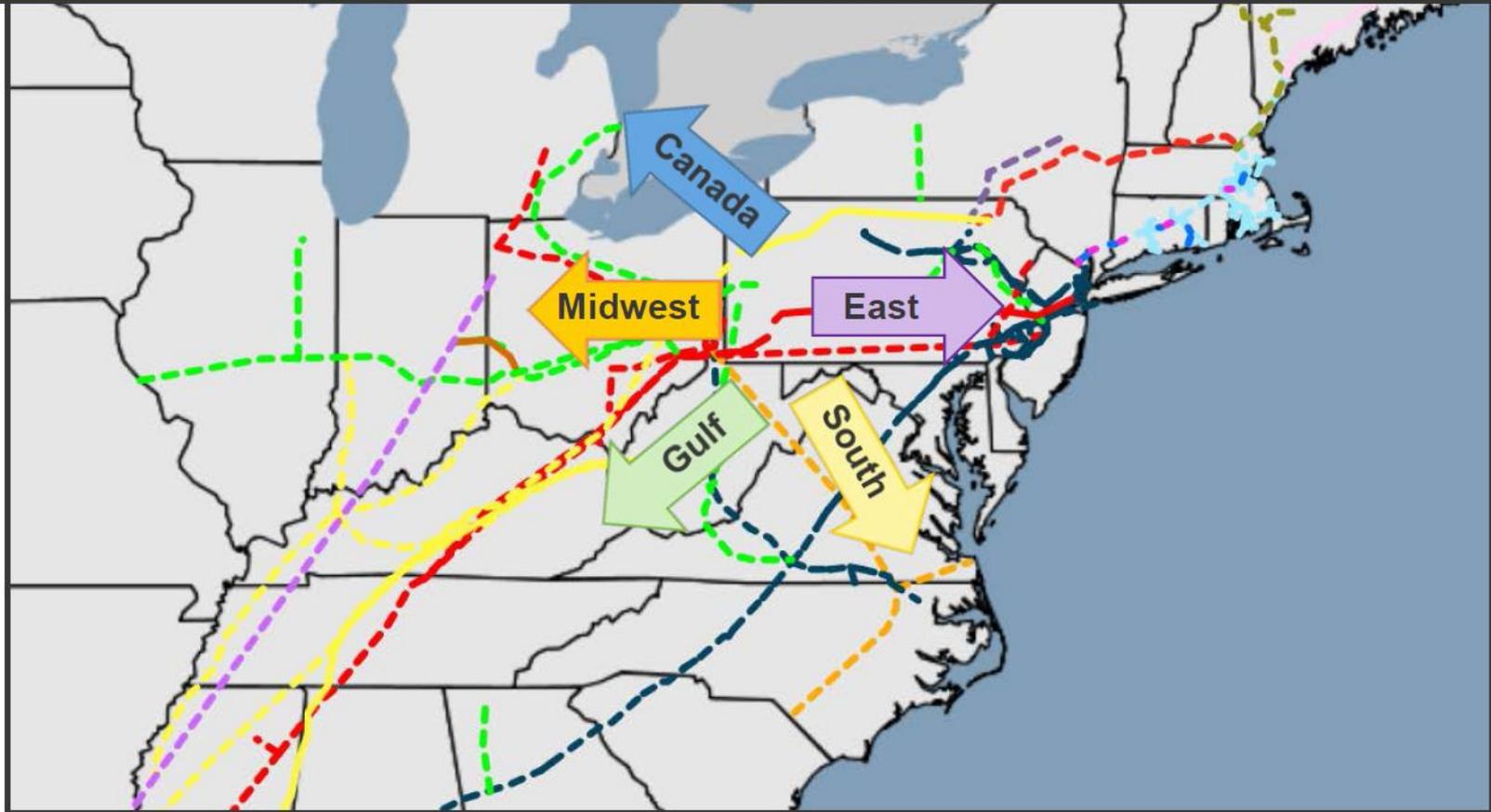


Source: EIA, January Monthly Natural Gas and Petroleum Report



# Natural Gas Infrastructure Development

~20 Bcf/d of new natural gas pipeline takeaway capacity from 30+ pipeline builds, expansions and reversals to move gas out of the Appalachian basin by 2019.



Source: RBN Energy and EIA



# Tri-State Shale Summit

- **WV, PA, and OH**
  - Governors signed collaboration agreement
    - Infrastructure
    - Research, Innovation, and Commercialization
    - Workforce Development
    - Publicity and Marketing
  - <http://www.tristateshalesummit.com/>



**TRI-STATE  
SHALE  
SUMMIT**

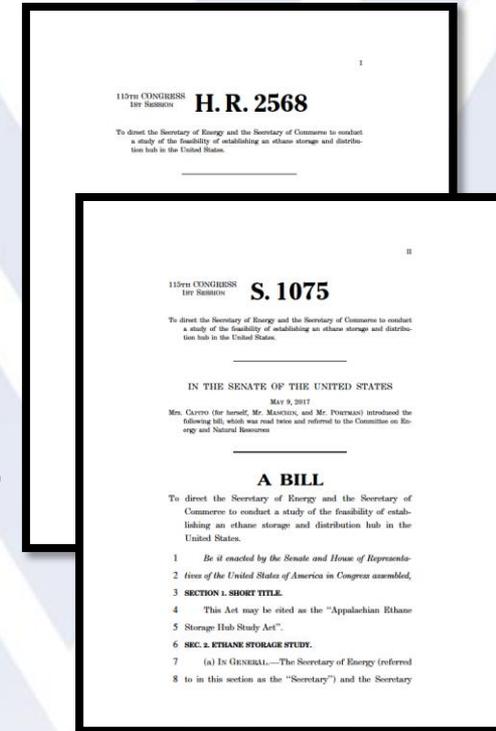


October 13, 2015



# Regional Cooperation – Congressional Action

- **H.R.2568 - Appalachian Ethane Storage Hub Study Act**
  - McKinley (R-WV), Jenkins (R-WV), Mooney (R-WV), Murphy (R-PA), Johnson (R-OH)
- **S.1075 - Appalachian Ethane Storage Hub Study Act**
  - Capito (R-WV), Manchin (D-WV), Portman (R-OH)
- **S.1337 - A bill to amend the Energy Policy Act of 2005 to make certain strategic energy infrastructure projects eligible for certain loan guarantees, and for other purposes**
  - Manchin (D-WV), Capito (R-WV), Brown (D-OH)
- **S.1340 - A bill to provide for an expedited permitting process for critical energy infrastructure projects relating to the establishment of a regional energy hub in Appalachia, and for other purposes**
  - Capito (R-WV)



# Regional Cooperation – Congressional Action

## H.R.2568 and S.1075 - Appalachian Ethane Storage Hub Study Act

To direct the Secretary of Energy and the Secretary of Commerce to conduct a study of the feasibility of establishing an ethane storage and distribution hub in the United States.

In general.—The Secretary of Energy (referred to in this section as the “Secretary”) and the Secretary of Commerce, in consultation with other relevant Federal departments and agencies and stakeholders, shall conduct a study of the feasibility of establishing an ethane storage and distribution hub in the Marcellus, Utica, and Rogersville shale plays in the United States.

The study conducted shall include—

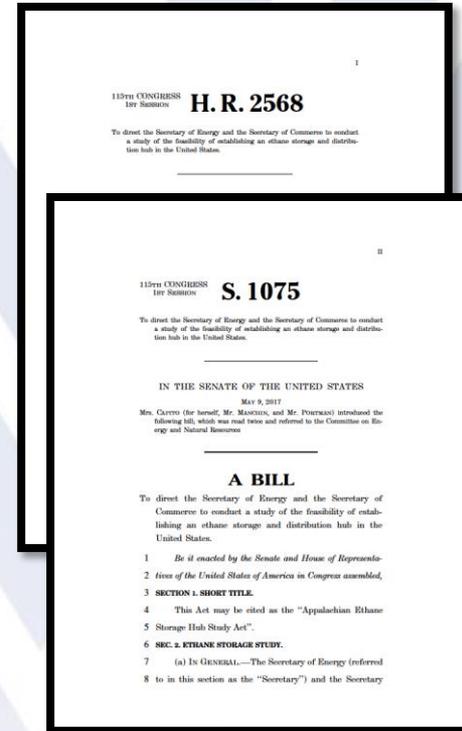
(1) an examination of, with respect to the proposed ethane storage and distribution hub—

- (A) potential locations;
- (B) economic feasibility;
- (C) economic benefits;
- (D) geological storage capacity capabilities;
- (E) above-ground storage capabilities;
- (F) infrastructure needs; and
- (G) other markets and trading hubs, particularly hubs relating to ethane; and

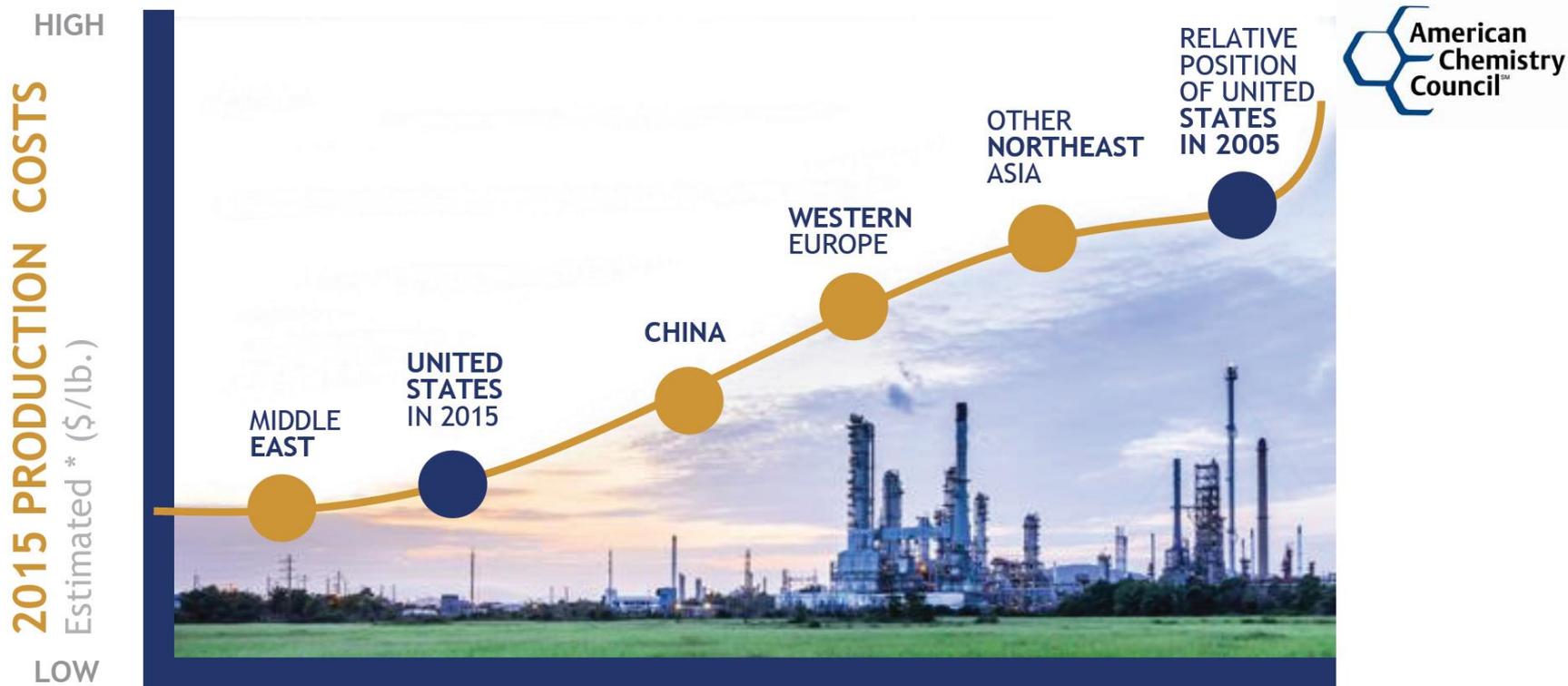
(2) the identification of potential additional benefits of the proposed hub to energy security.

Publication of results.—Not later than 2 years after the date of enactment of this Act, the Secretary and the Secretary of Commerce shall—

- (1) submit to the Committee on Energy and Commerce of the House of Representatives and the Committees on Energy and Natural Resources and Commerce, Science, and Transportation of the Senate a report describing the results of the study under subsection (a); and
- (2) publish those results on the Internet websites of the Departments of Energy and Commerce, respectively.



# U.S. Petrochemical Production Costs

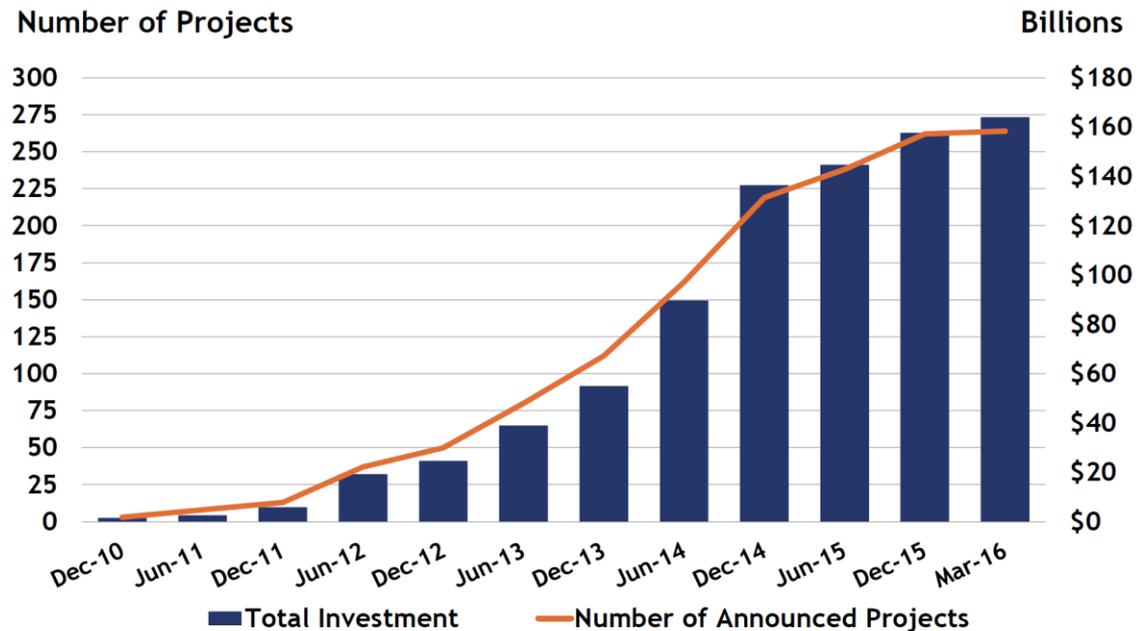


Source: American Chemistry Council, 2016



# Impact of Shale Production on the Chemical Industry

- According to American Chemistry Council (ACC) estimates, as of September 2015 companies from around the world have announced 246 projects and \$153 billion in potential capital investments in U.S. chemical-processing facilities (ACC, 2016), up from 97 projects and \$72 billion as of March 2013 (ACC, 2013).
- Largely as a result of the shale gas boom, U.S. jobs related to plastics manufacturing alone are expected to grow by 462,000, or more than 20 percent over the next decade (ACC, 2015a).

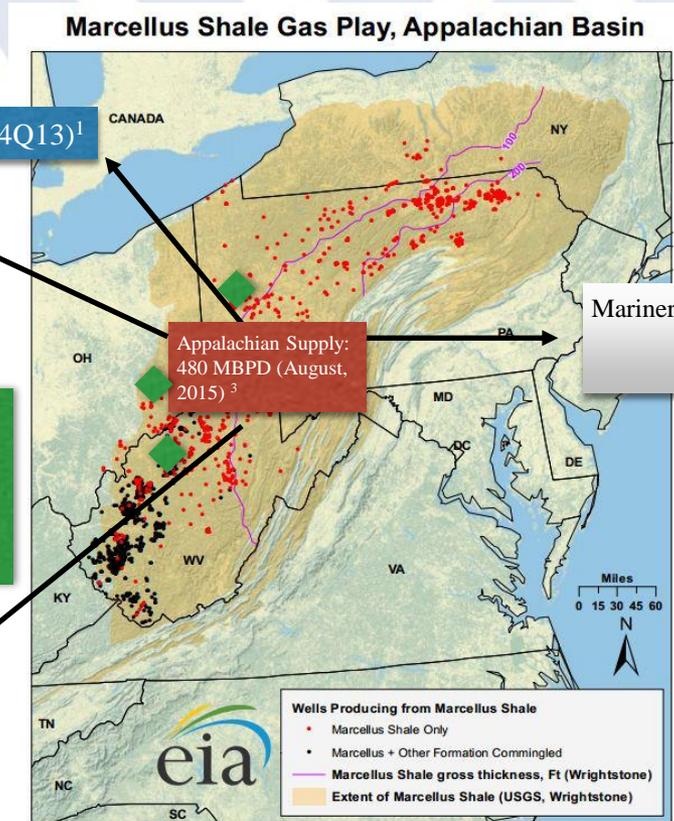


Source: ACC analysis, Dec. 2010 - March 2016

Source: American Chemistry Council, 2016



# Estimated Ethane Supply and Announced Demand



Mariner West (MW): 50 MBPD (4Q13)<sup>1</sup>

KM Utopia (MW): 18 MBPD (1Q18)<sup>1</sup>

Steam Crackers<sup>5</sup>  
 Shell: 105 MBPD (2019)  
 PTTGC: 65 MBPD (2020)  
 Braskem: 65 MBPD (2021)  
 Total: 235 MBPD

ATEX (AX): 65 MBPD (1Q14)  
 60 MBPD (Future)  
 Total: 125 MBPD<sup>4</sup>

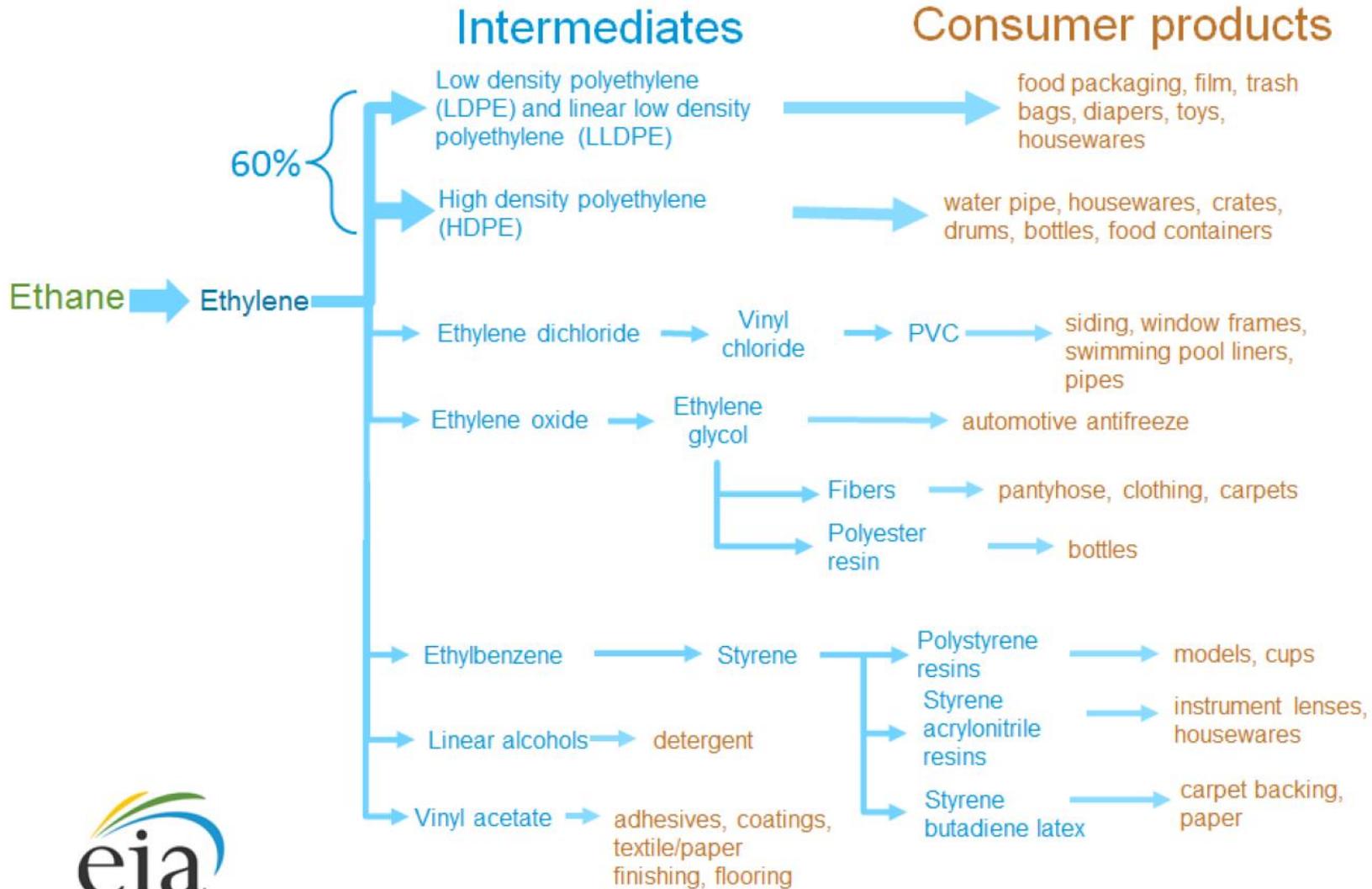
Appalachian Supply:  
 480 MBPD (August, 2015)<sup>3</sup>

Mariner East (ME): 23 MBPD (4Q15)  
 91 MBPD (1Q17)  
 Total: 115 MBPD<sup>2</sup>

Source: US Energy Information Administration based on data from WVGES, PA DCNR, OH DGS, NY DEC, VA DMMME, USGS, Wrightstone (2009). Only wells completed after 1-1-2003 are shown. Updated June 1, 2011

August 2015 it is estimated that 350 MBPD was rejected — the announced demands/off takes will provide a relevant “frac” spread for the Appalachian Basin with the majority of ethane leaving the region (Europe, Texas, Canada)

# Ethane Product Streams



# Appalachian Basin NGL Storage Study

- Geologic investigation of subsurface storage potential for NGLs in a broad geographic area
- Study area is along the Ohio River, from PA to southern WV and eastern KY
- Project is a critical step in the process of infrastructure development
- Subsurface storage facilities with adjacent
- Surface NGL transportation
- Goal of this project: to provide essential data to support of the development the chemical manufacturing industry, promoting economic development

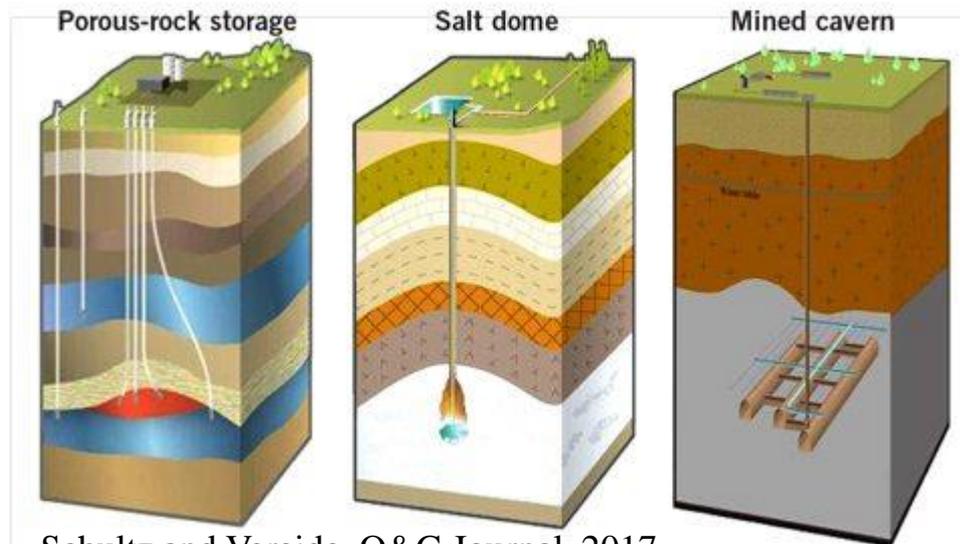




# Types of Potential NGL Storage

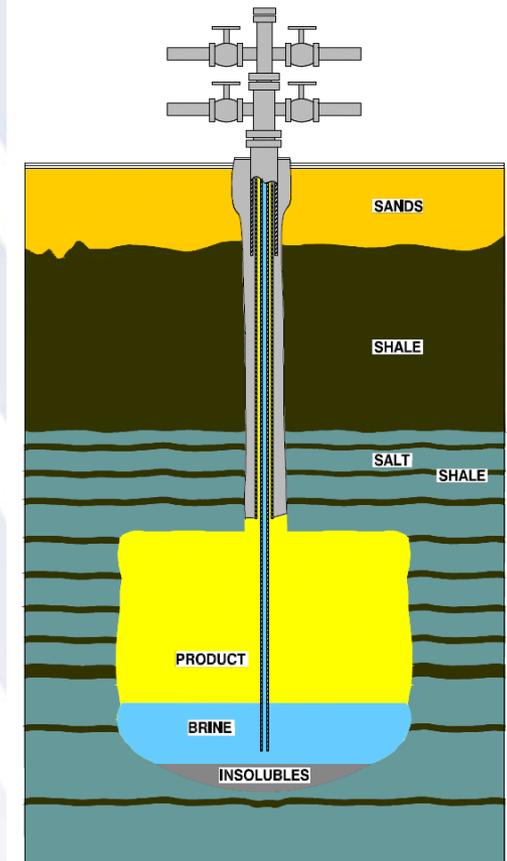
- Solution mining to create large cavities in Salina salt beds
- Subsurface excavation to create large mines in Greenbrier Limestone
- Injection into depleted gas fields with good porosity & permeability
- Vertical & lateral seals essential for each option

## STORAGE TYPES



Schultz and Vereide, O&G Journal, 2017

FIG. 2

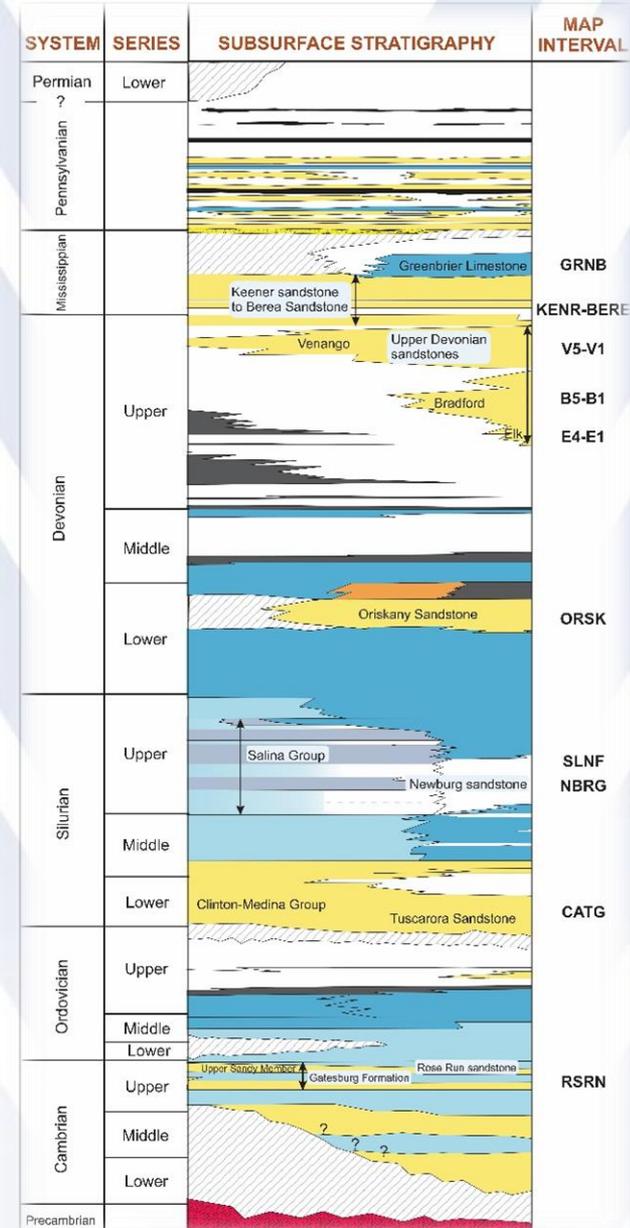


Schematic Illustration of a Solution-Mined Storage Cavern in Bedded Salt

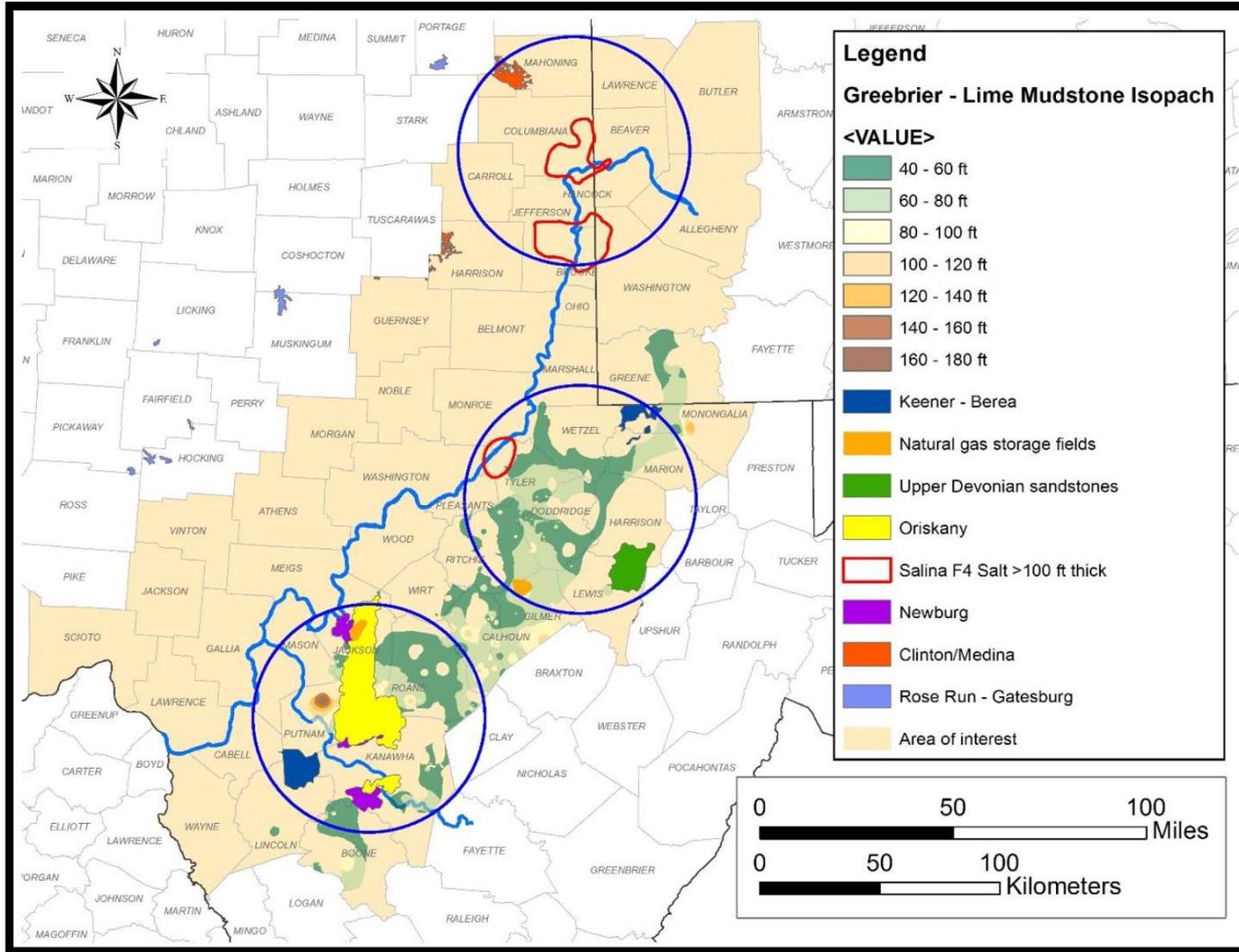


# Evaluating our Prospects

- Mined-rock cavern
  - depth, thickness, extent (facies changes)
- Salt cavern
  - location, thickness, extent
  - create your storage container
  - F salt ~100 ft thick in Ohio River Valley corridor
  - Manage produced brine
- Gas reservoirs
  - multiple sandstone reservoirs at various depths in AOI
  - porosity/permeability characteristics are important
  - productivity gives insight into potential storage potential
  - stacked storage opportunities

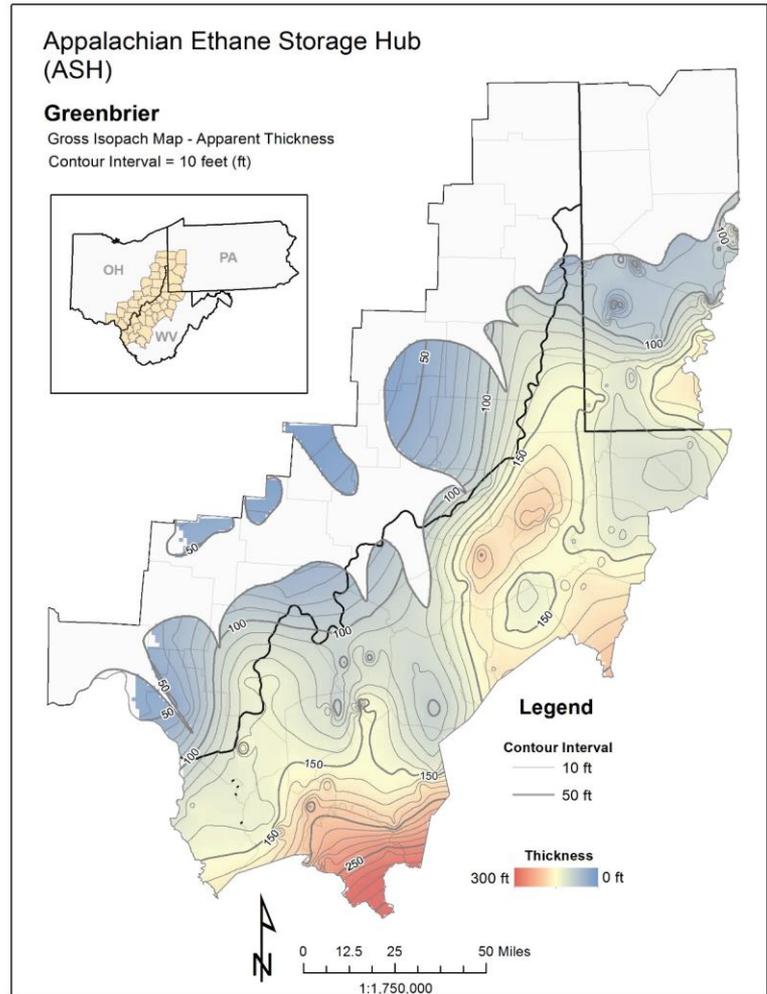
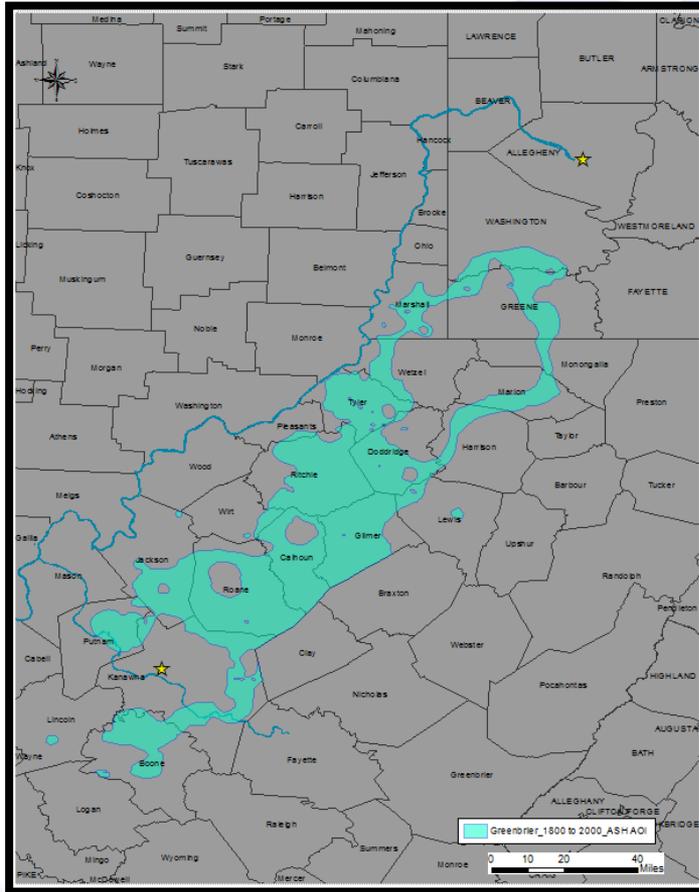


# Appalachian Storage Hub – Summary



# Appalachian Storage Hub – Greenbrier

Areas within the AOI where the top of the Greenbrier is at depths from 1,800-2,000 ft below ground surface

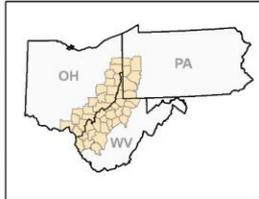


# Appalachian Storage Hub – Salina F4

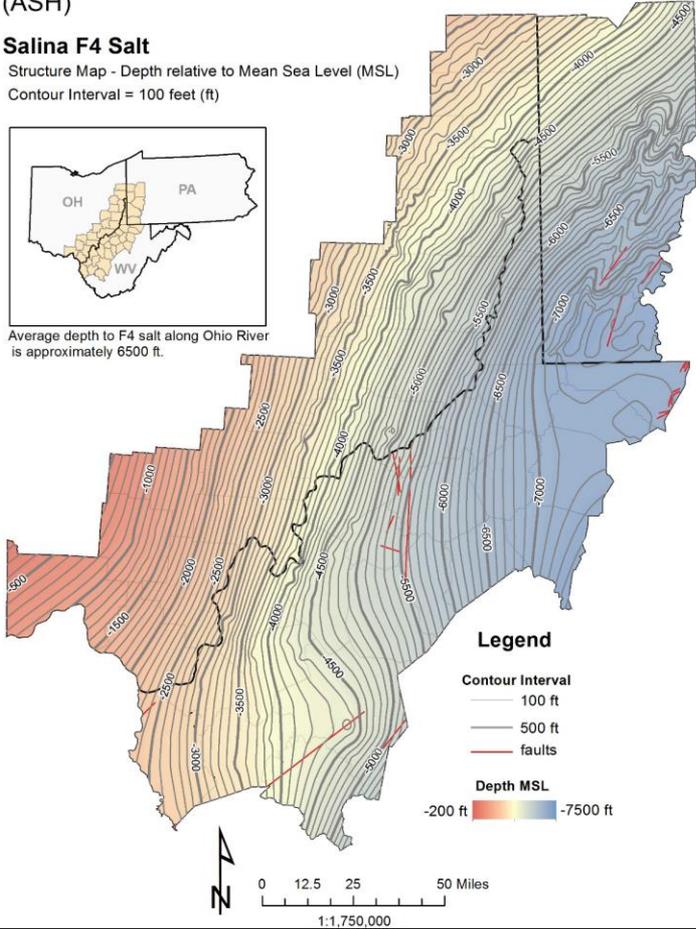
## Appalachian Ethane Storage Hub (ASH)

### Salina F4 Salt

Structure Map - Depth relative to Mean Sea Level (MSL)  
Contour Interval = 100 feet (ft)



Average depth to F4 salt along Ohio River is approximately 6500 ft.



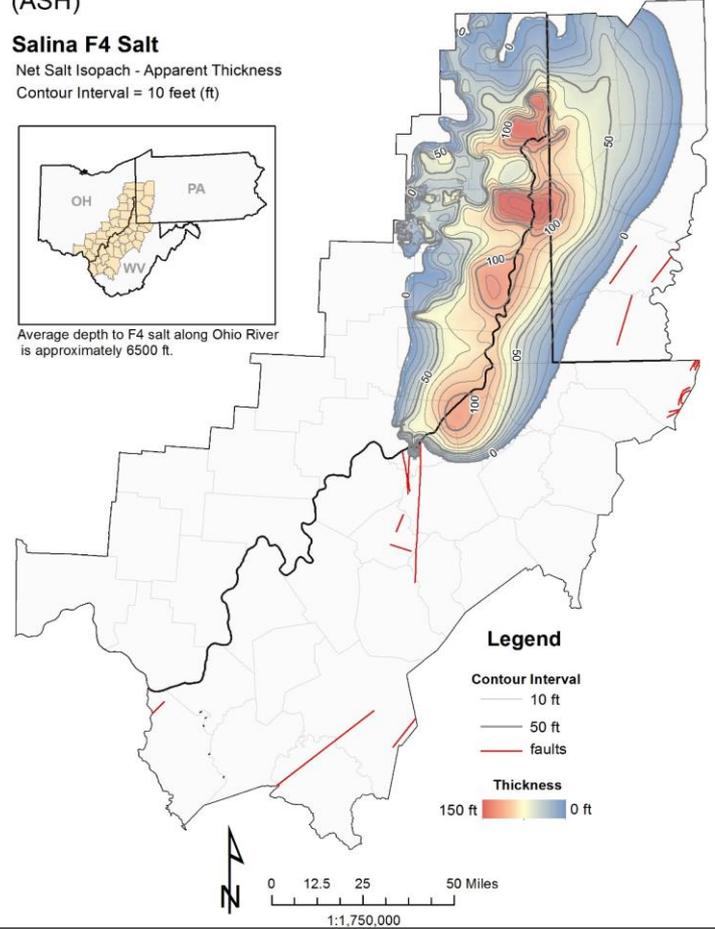
## Appalachian Ethane Storage Hub (ASH)

### Salina F4 Salt

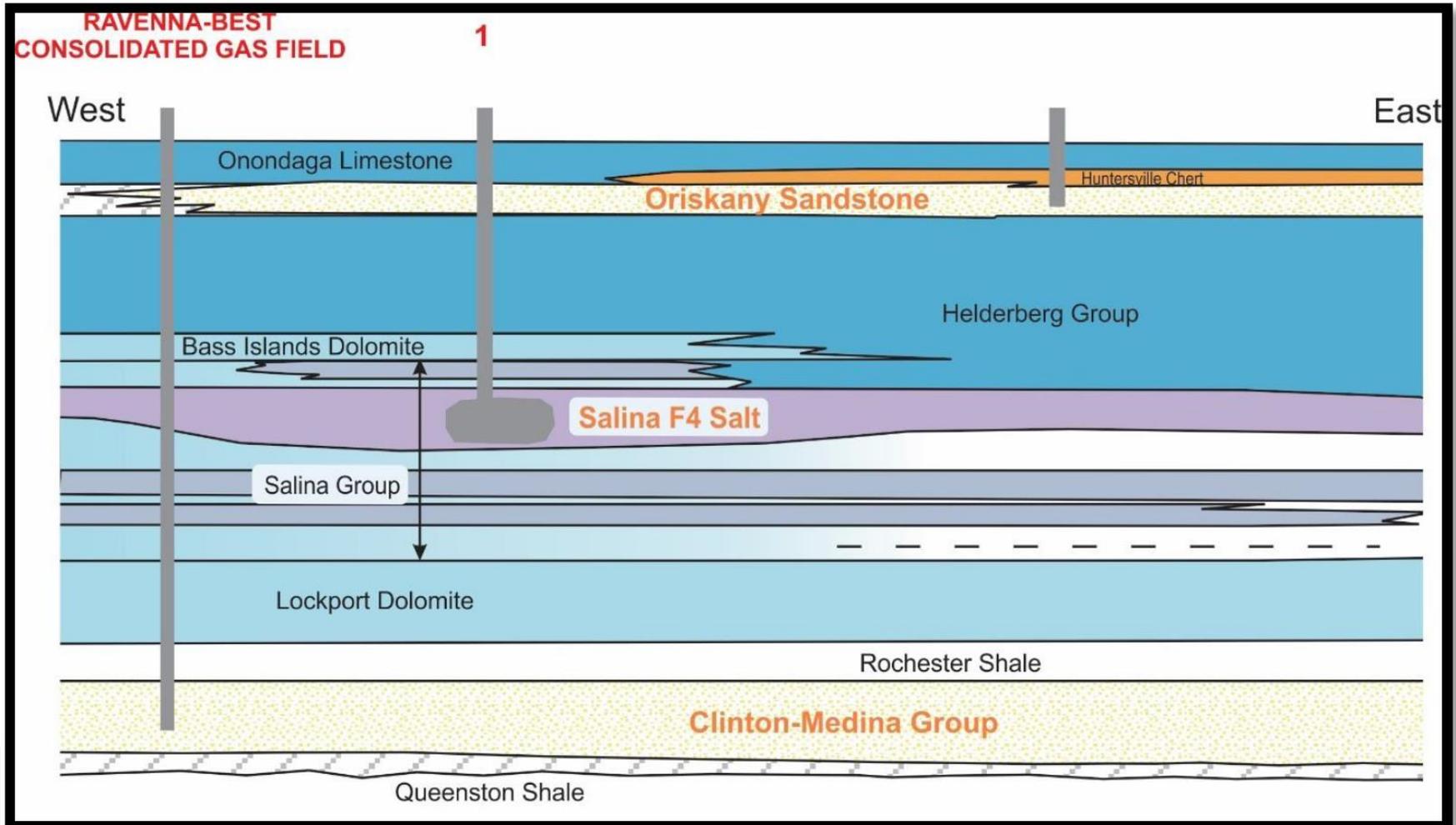
Net Salt Isopach - Apparent Thickness  
Contour Interval = 10 feet (ft)



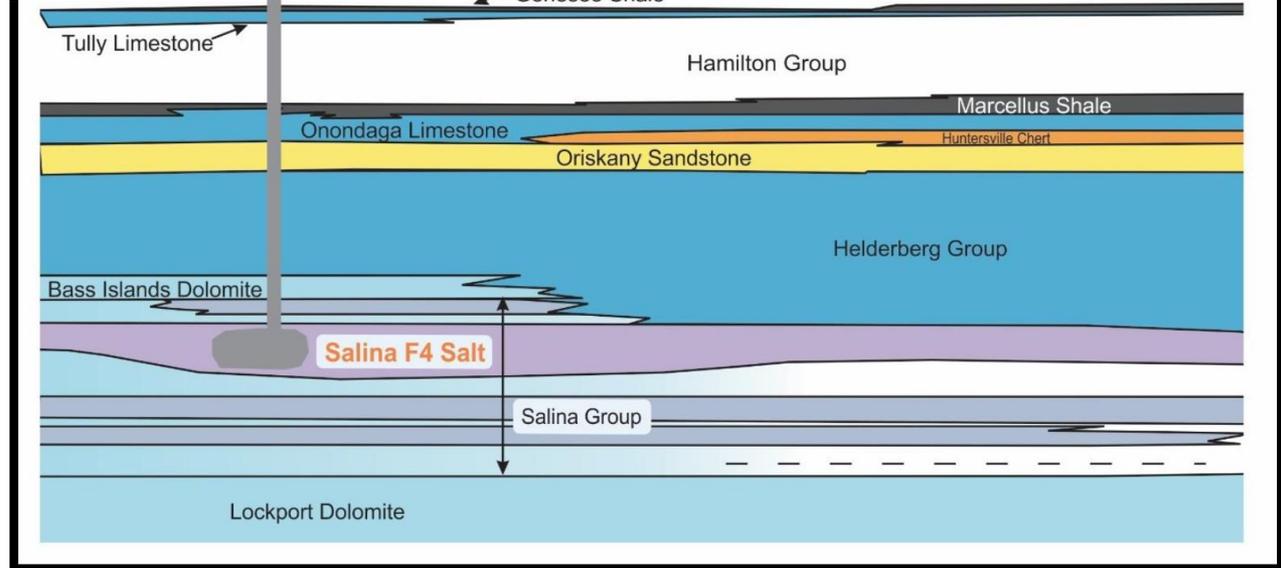
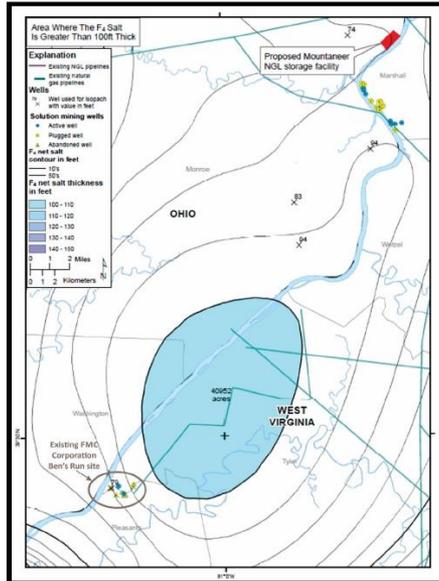
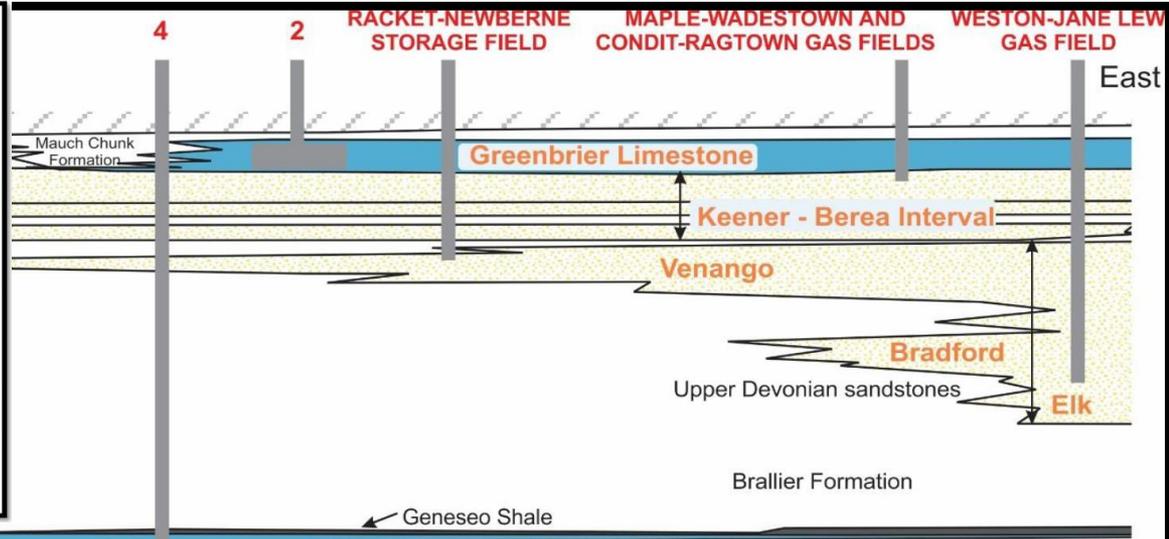
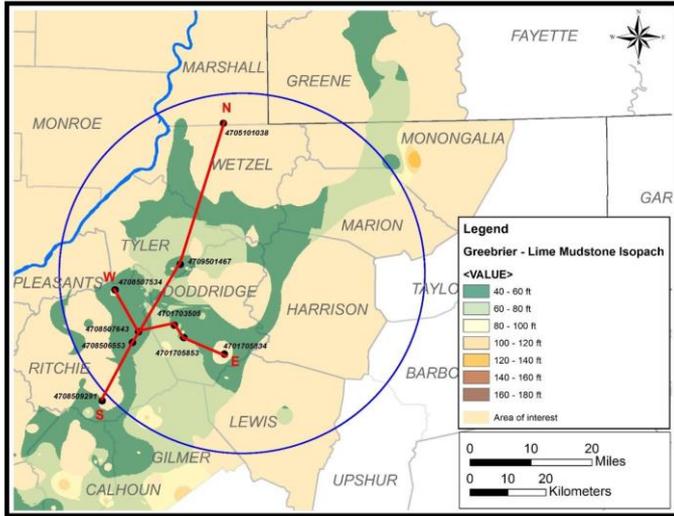
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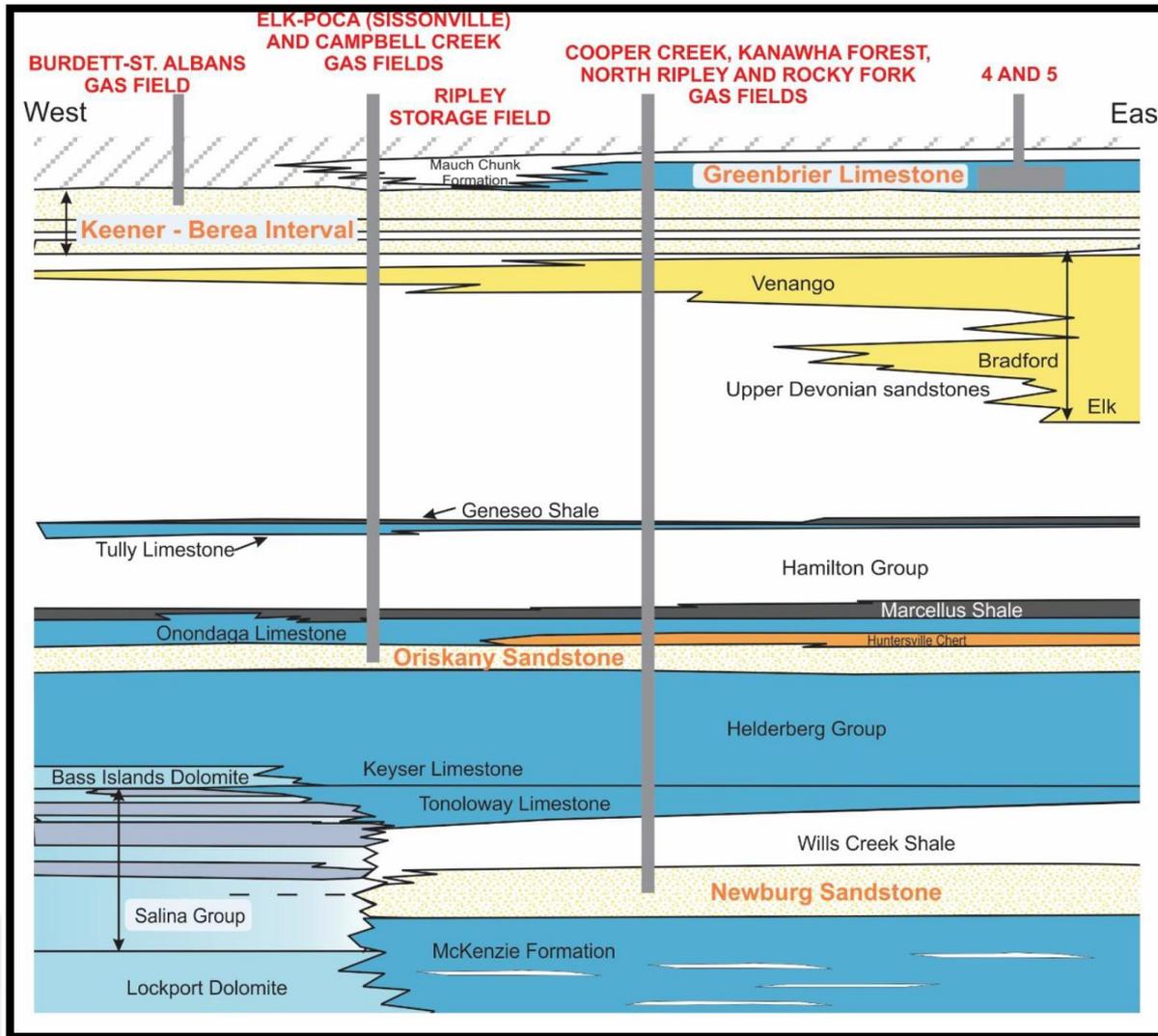
# Appalachian Storage Hub – North Prospect



# Appalachian Storage Hub – Central Prospect



# Appalachian Storage Hub – South Prospect



# Conclusion

- There is an abundance of natural gas (containing NGLs) in the shales of the U.S.
  - NGL production from the Appalachian Basin has increased tenfold over this time, from a baseline of under 30,000 bbl/day to nearly 400,000 bbl/day in 2016.
- The Appalachian Basin provides 1) access to markets, and 2) a competitive pricing advantage due to the abundance of valuable (yet currently underpriced) hydrocarbons
  - Transportation costs for transporting ethane via pipe from the Appalachian Basin to Mont Belvieu is approximately \$0.16/gal, while the cost for rail transportation of propane is \$0.30/gal. The current Mont Belvieu prices for ethane and propane are \$0.21/gal and \$0.43/gal
- Ethane storage is key to the development of a robust NGLs trading post, i.e. a spot market essential to further development of the chemical manufacturing industry in this region
- A storage facility will be tied into the overall play via massive piping infrastructure
- The U.S. and Mid-Atlantic Region would benefit from infrastructure development to satisfy the feedstock and offtake requirements for world scale and/or distributed manufacturing elements





# The WVU Energy Institute

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The Institute's mission is to coordinate and promote University-wide energy research in engineering, science, technology, and policy.

With an emphasis on

## **Fossil Energy**

Coal, Oil, and Natural Gas

## **Sustainable Energy**

Biomass, Geothermal, Wind, and Solar

## **Energy Policy**

Energy and Environmental Policy

## **Environmental Stewardship**

Protecting our Air and Water Resources



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