



WVU Energy Research: Leveraging Our Strengths, Expanding Our Impact



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Governor Tomblin's

ENERGY *Summit*
West Virginia: A National Energy Resource

October 6, 2016



Energy Institute Vision and Mission

Vision

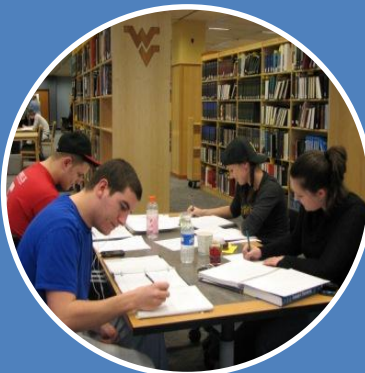
By *serving* WVU's colleges, energy researchers, administration and students as a **catalytic hub** for energy research, continually creating, nurturing and expanding research opportunities, industry partnerships, policy frameworks and curricular pathways in alignment with industry, state government and federal government needs, innovations and opportunities in the energy sector

Mission

To promote, coordinate and drive forward WVU excellence in discovery and innovation within the West Virginia, Appalachian, Mid-Atlantic Regional, National and International energy sectors, with particular emphases on fossil energy, sustainable energy, energy policy, environmental stewardship and economic development for the people of West Virginia



Energy Institute Pillars



Research

- Fossil
 - Coal, gas, oil
- Renewable
 - Biomass, solar
- Policy
 - Economic, regulatory
- Environment
 - Water, air

Education

- Energy graduate programs
- Energy minor and certificate programs
- General Education Curriculum
- Student energy club

Campus Sustainability

- Building efficiency
- Transportation services
- Campus energy services
- Student learning opportunities

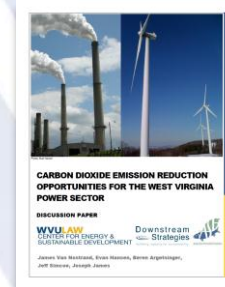


Broad Areas of Energy Research at WVU

- **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



Fossil Energy



Coal and Energy Systems:

- Bhattacharyya, Lima, Zitney, Celik, Sharma, Taylor, Tarka, Gemmen, Scime, Sun



Mining Technology:

- Dean, Herbst, Klinkachorn



Rare Earths:

- Granite, Hedrick, Moore, Noble, Black, Hohn, Ziemkiewicz



Shale Gas Utilization:

- Anderson, Dumitrescu, Fisher, Tian



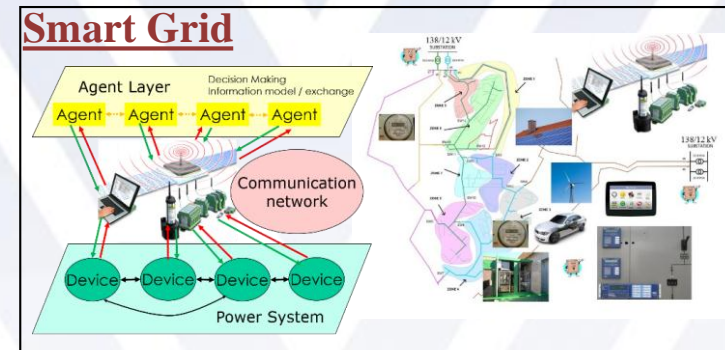
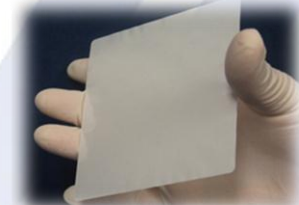
Shale Gas Production :

- Carr, Grushecky, Patchen, Yost



Sustainable Energy

- **Fuels & Vehicles:**
 - Carder, Davis, Israel
- **Energy Materials:**
 - Finklea, Sabolsky, Romanosky, Bingyun Li
- **Smart Grid:**
 - Brewer, Famouri, Saymansky
- **Energy Business Development:**
 - Biser, Irwin, Kirby, Nowak
- **Industrial Energy Programs:**
 - Gopalakrishnan, Means
- **Sustainable Energy:** Promote energy efficiency, alternative fuels, conservation, renewable energy sources, geothermal, and sustainable and responsible development
 - geothermal energy
 - biomass conversion and utilization
 - biomass/coal conversion and co-firing
 - energy efficiency and conservation
 - sustainable design and development



Environmental Stewardship



- **Biomass:**
 - Tarka, J. Wang, Wang



- **Remediation of Land and Water :**
 - Lin, O'Neal, Petty, Skousen



WEST VIRGINIA
WATER RESEARCH INSTITUTE

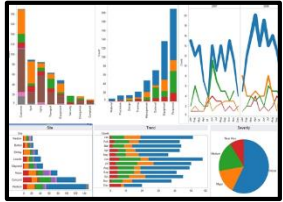
- **Environmental Stewardship:** Ensuring that energy production is balanced with minimizing negative impacts to our air and water resources
 - developing tools to lower the carbon footprint of our energy portfolio
 - development of efficient water usage methods in energy production
 - evaluation of impacts of energy systems on air and water quality
 - sustainable use of water in energy production
 - life cycle assessment of energy systems



Energy Policy



- **Sustainable Energy:**
 - Bowen, Fershee, Haley, Van Nostrand



- **Resource Economics:**
 - Deskins, Elbakidze, Jackson, Risch

- **Energy Policy:** Analyze energy policies and their impact on use of resources, carbon management, environmental, and infrastructure
 - analysis and modeling of energy and environmental policy issues
 - analysis for the development of strategies for the management of carbon
 - analysis of energy infrastructure systems
 - data-driven policy assessment
 - community impact evaluation



Major Initiatives and Partnerships



- Natural gas utilization
 - Shale gas Mountain of Excellence faculty hires
 - Shale Gas Center launched
 - Appalachian Storage Hub
 - National Academy of Science Roundtable on Unconventional Hydrocarbons



NATIONAL ACADEMY OF SCIENCES

- Coal utilization
 - U.S.-China Clean Energy Research Centers
 - Advanced Coal Technology Consortium
 - Rare earth and critical materials



- Sustainable energy pathways
 - The Nature Conservancy
 - NNMI Institutes
 - Smart Manufacturing Hub NNMI
 - Current DOE NNMI Opportunities



International MOUs

- China
- Paraguay
- Iceland
- Canada
- Middle East
 - Bahrain
 - Qatar
 - Kuwait



PENNSTATE



Tri-State University Energy Alliance
CMU, Pitt, CWRU, WVU



WORLD
RESOURCES
INSTITUTE



Partnerships



- **Industry**
 - Over 100 active industry partners – see: <http://energy.wvu.edu/partnerships>
- **Academic**
 - Tri-State University Energy Alliance (CMU, Pitt, CWRU, WVU)
 - Ohio State University (Shale Gas MOU)
- **NGO**
 - National Research Council and the National Academy of Sciences
 - Claude Worthington Benedum Foundation
 - The Nature Conservancy and the MacArthur Foundation
 - Allegheny Conference on Community Development
 - World Resources Institute
- **Government**
 - DOE (ARPA-E, Mission Innovation) – National Energy Technology Laboratory
 - State of West Virginia

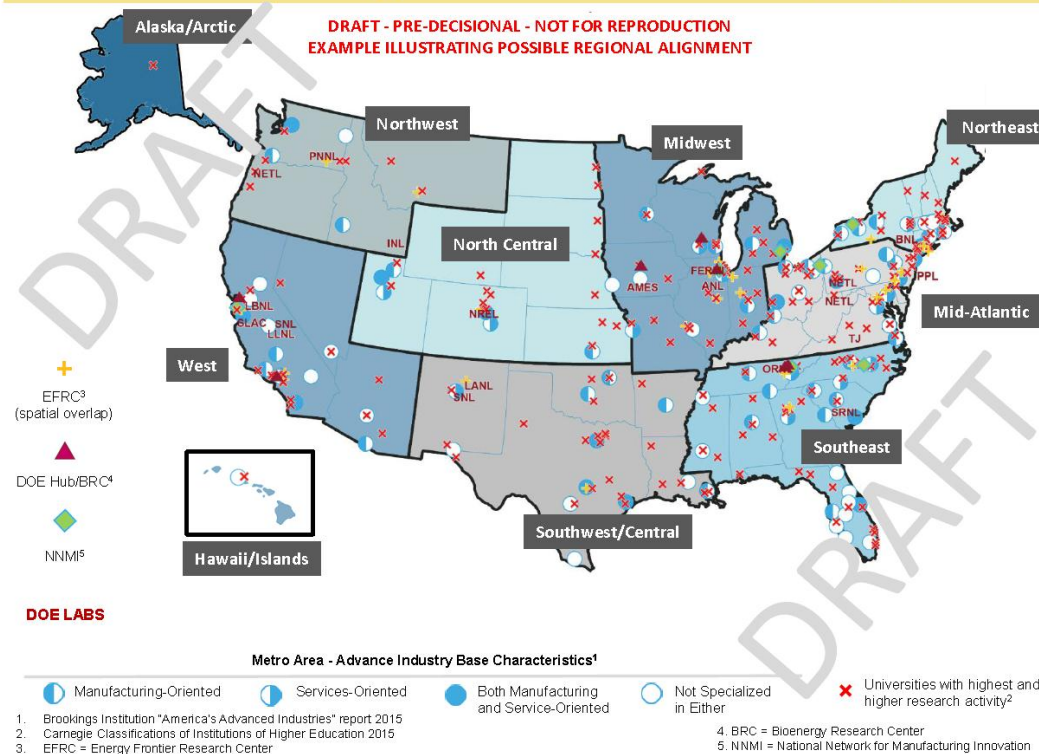


September 12 – Mid-Atlantic Region Energy Innovation Forum

In FY 2017, DOE will solicit and competitively select up to 10 Regional Partnerships that will:

- Competitively select RD&D projects for financial assistance based on technical merit and, generally, connecting innovators in their regions with RD&D funding.
- Provide analysis, data, access to federal RD&D facilities, and project management.
- Support development of early prototypes.
- Encourage and support collaborative RD&D, regional public-private partnerships, and consortia of innovative clean energy entities.
- Develop in collaboration with stakeholders regional energy innovation roadmaps to facilitate RD&D planning and inform annual plans submitted to DOE.
- Coordinate with other Regional Partnerships on best practices and technology projects relevant to multiple regions.

Notional Clean Energy Innovation Partnership Regions



MID-ATLANTIC REGION ENERGY INNOVATION FORUM HOSTED BY WEST VIRGINIA UNIVERSITY

SEPTEMBER 12, 2016
MORGANTOWN, WEST VIRGINIA



Brian Anderson

Director



Areas of Focus: Sustainable Energy Portfolio Development, Academic-Industry-Government Partnerships



The WVU Energy Institute | energy.wvu.edu

Major Takeaways: Mid-Atlantic Region Forum at West Virginia University

Event Overview

- 112 participants from 7 states (KY, OH, PA, VA, MD, NJ, WV) and DC from academia (32), national laboratories (8), industry (35), government (22), and non-governmental organizations (15).
- Keynotes from Secretary Moniz, Senator Joe Manchin, and Congressman David McKinley
- Regional cooperation panels:
 - Regional Challenges and Opportunities (NETL, CMU, Battelle, Benedum Foundation)
 - The Tri-State Governor's Regional Cooperation (WV, PA, OH)
- Topical Panels
 1. Innovation opportunities for fossil fuels in a future low carbon economy (ExxonMobil, Battelle, B&W, Siluria)
 2. Innovation opportunities in other clean energy technologies (GE, PPPL, SMLC, DOE NE)
 3. Policies Facilitating Sustainable Clean Energy Development (PJM, RFF, NRECA, Spilman Thomas & Battle)
 4. Regional Innovation Investment and Commercialization (InnovationWorks, HarbourVest Partners, DOE CFO)

Key Takeaways

- Current Regional Innovation Ecosystem
 - The Mid-Atlantic Region is a tale of two halves, fewer population but energy resources in the west and population density in the east. As such, there are currently two disconnected innovation ecosystems. WV, PA, and OH have created the Tri-State Coalition and the Pittsburgh/Cleveland/N. WV region has the Power of 32.
- Building a Broader Ecosystem
 - Coordinating across the entire 8 state region and multiple sub-regional efforts.



Major Takeaways: Mid-Atlantic Region Forum at WVU (continued)



Key Takeaways (continued)

- Opportunities
 - Large (55 million ppl), diverse, energy-rich region with **engaged stakeholders from all sectors**
- Priority Innovation Focus Areas
 - **Clean fossil**: advanced power cycles, fuel cells, CCUS, and increased natural gas utilization
 - NETL, Industry partners (i.e. B&W, ExxonMobil, Siluria, Battelle), and Universities strong in this area (OSU, UK, WVU, PSU, Princeton, VT, etc)
 - Strong state-level support and momentum in the industry, e.g. current infrastructure developments underway
 - **Grid modernization** – smart grid and grid-scale electric storage (NEES EFRC, PJM, FirstEnergy, Exelon, AEP, NRG)
 - **Energy Efficiency** – building and industrial efficiency (CBEI Hub, Energy4P32)
 - **Nuclear Energy** – fission and fusion energy sciences (PPPL, WVU, Westinghouse, WastePD)
 - **Advanced and Smart Manufacturing** (NNMIs: America Makes, IACMI, SMLC-CESMII)
- Challenges
 - **Funding** for large-scale demonstration of technologies - CCUS, power cycles, NG conversion demonstrations cost \$100s of millions
 - Diverse region and **broad priority focus** areas
- Next Steps
 - **Five follow-on events** coordinated by the TrUE Alliance
 - **Grid**: EPIC Meeting Pittsburgh, 11/14-11/15; **Storage**: Center of Excellence in Ohio meeting on Energy Storage end of October in Cleveland;
 - **NG Utilization**: AIChE Natural Gas Utilization Workshop on November 1-3, 2016 in Morgantown and technical workshop Tri-State, November 30
 - **Efficiency**: CMU and Energy for the Power of 32
 - PJM Interconnect will be working with WVU on **regional planning and innovation efforts**
 - Coordinate with **sub-regional consortia** in developing a Mid-Atlantic Region Energy **Innovation Roadmap**



International Partnerships

China

- The WVU Energy Institute leads the US-China Clean Energy Research Center
 - 10-year, \$50 million US program
- Other US-China Energy Programs
 - Yanchang Petroleum CO₂ Sequestration Project
 - China NDRC partnership MOU
 - Shenhua Group Strategic Partnership
 - Synfuels Strategic Partnership
- Programs in multiple colleges
 - Business School, Statler, Davis, Creative Arts
- Multiple Chinese Universities working on MOUs with WVU
 - Guangdong University of Petroleum Technology (formerly run by Sinopec) on campus Monday, 9/21
 - Shanxi Higher Ed Commission signed MOU with WVU and WVHEPC





US-China Clean Energy Research Center – Advanced Coal Technology Consortium **CERC-ACTC**

The US-China Advanced Coal Technology Consortium (CERC-ACTC) was formed to serve as the leader in the area of advanced coal technology including carbon capture, utilization and storage in both China and the United States. The benefits for both nations include creation of environmentally-sound coal technologies for electricity, liquids and syngas; new US-China business-to-business relationships; and advances in US and Chinese energy technology and innovation.

JOINT RESEARCH IS CONDUCTED IN THE FOLLOWING AREAS:

- Advanced Power Generation
- Coal Conversion Technology
- Pre-Combustion CO₂ Capture
- Post-Combustion CO₂ Capture, Utilization and Storage Technology
- Oxy-Combustion Research, Development, and Demonstration of Oxy-Firing Combustion
- CO₂ Sequestration Capacity and Near-Term Opportunities
- CO₂ Algae BioFixation and Use
- Integrated Industrial Process Modeling and Additional Topics
- Communication and Integration



International Partnerships

Middle East

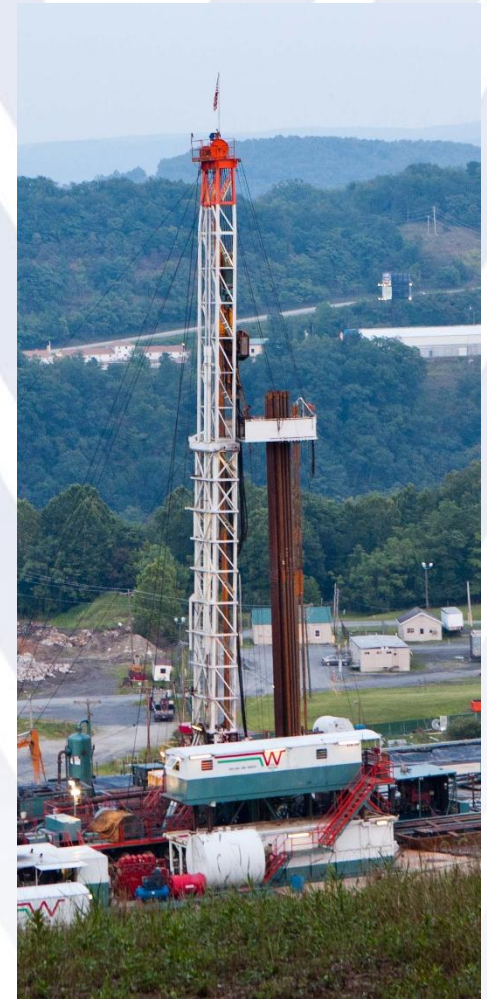
- WVU is a partner with the Royal University for Women, Bahrain
 - Extension of 5-year MOU signed November, 2015
 - WVU Launching Civil Engineering Program
- Qatar University
 - Business School and Engineering Partnerships
 - Research partnership to submit proposal to Qatar National Research Fund
 - Water and Energy



International Forum on Unconventional Gas Sustainability and the Environment **INFUSE**

WVU in partnership with the US State Department, will increase foreign governments' understanding of issues and best practices related to sound unconventional gas sector management.

- The overall goal is to increase international understanding of how proper drilling, hydraulic fracturing and water management reduces environmental risks and leads to sustainable resource development.
- Beneficiary government officials will better understand the unique safety, environmental, and social challenges and best practices associated with the development of unconventional resources.



WVU Mountain of Excellence in Shale Gas - Opportunities

- WV – a long history in NG to chemicals
 - Clendenin, WV: Site of the world's first commercial ethylene plant



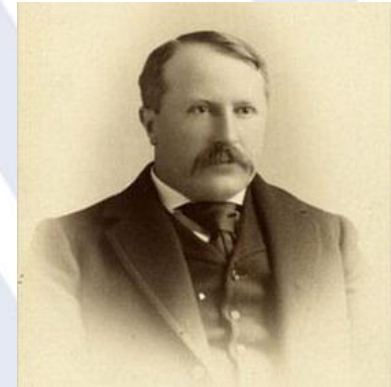
- Union Carbide 10,000 lb/day ethylene plant online in 1921
- Driven by access to raw materials

- Upstream:
 - resource evaluation,
 - management, and
 - production
- Downstream:
 - use as an alternative transportation fuel
 - conversion to liquid fuels or chemicals
 - use in fuel cells



Shale Gas: From Supply to Demand

- Research at WVU spans the full range from upstream to downstream
- We have entered a strategic partnership with Ohio State University in five areas of shale-related activities
 - Subsurface
 - Utilization
 - Environment
 - Policy
 - Economics




"Father of Geology" *Israel C. White.*



POWERSOURCE ENERGY NEWS. IN CONTEXT. *Pittsburgh Post-Gazette*

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NETL developing working lab to improve shale drilling

October 14, 2014 2:00 AM

By Anya Litvak / Pittsburgh Post-Gazette

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It's not easy to convince an oil and gas operator to experiment with a \$30 million well pad, to put a different kind of sand into a well that has been responding just fine to the status quo or to try fracking it with liquefied natural gas instead of the cheap, available and proven water mixture used today.

It takes some finesse and the promise of much greater yields in the future, even if that future is more than a decade away.

That's the uneasy task of Jared Ciferro, the Pittsburgh-based director of the strategic center for natural gas and oil at the National Energy Technology Laboratory that serves as the fossil fuel research arm of the Department of Energy.

"We'll pay you to do it," he tells companies.

But government funding isn't really the draw.

It's this: Even with all the millions of dollars spent tapping a single shale well, the hundreds of trucks and webs of pipelines and millions of tons of water and sand, only between 5 percent and 30 percent of the fuel trapped in the ground

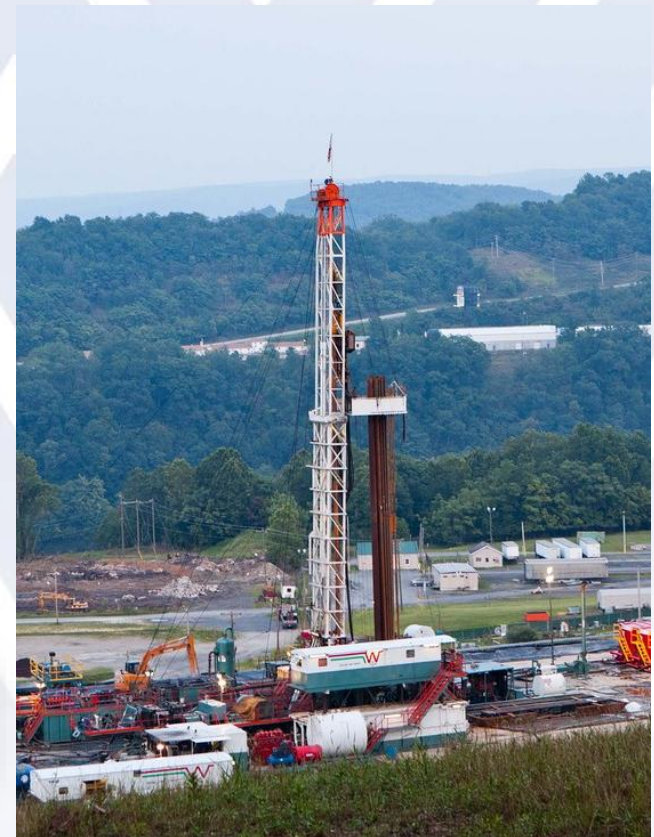
Most Read

1. Why is a warmer winter in the Northeast not likely to hit natural gas demand?
2. West Virginia company finds paths for Marcellus pipeline projects
3. Washington County drilling hearing raises conflicts over contamination
4. With safety standard, energy storage could see growth
5. Targa to acquire Atlas midstream assets for \$7.7 billion
6. Dilemma in the Marcellus Shale: How to dispose of radioactive oil and gas waste?

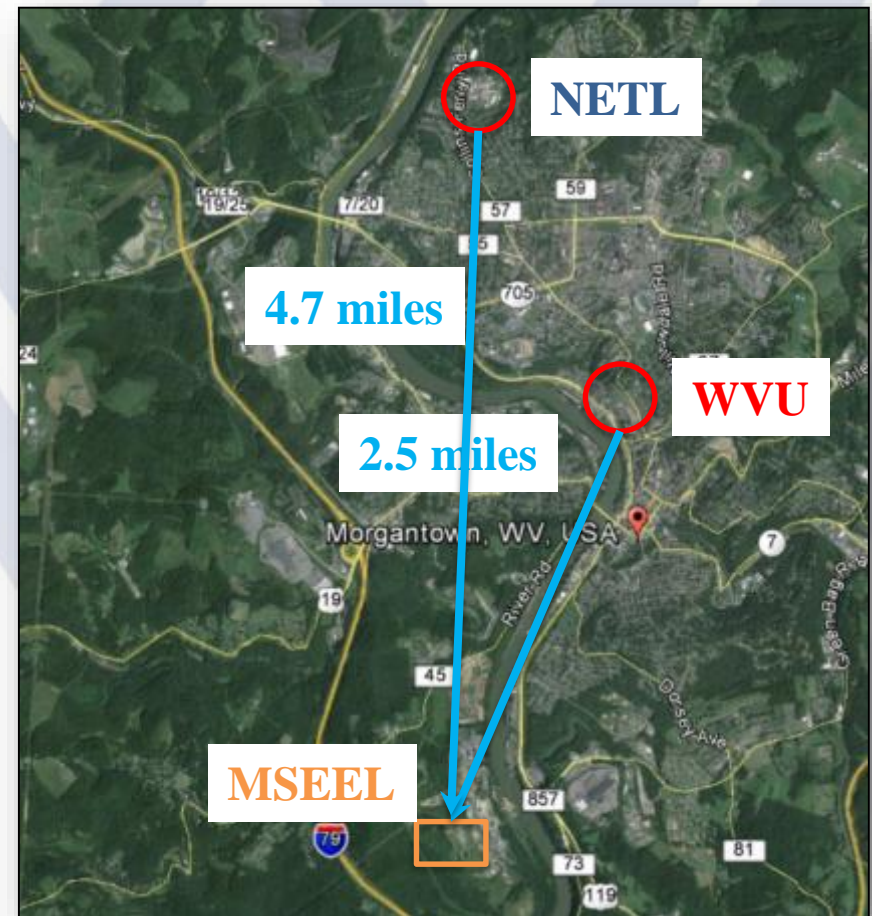
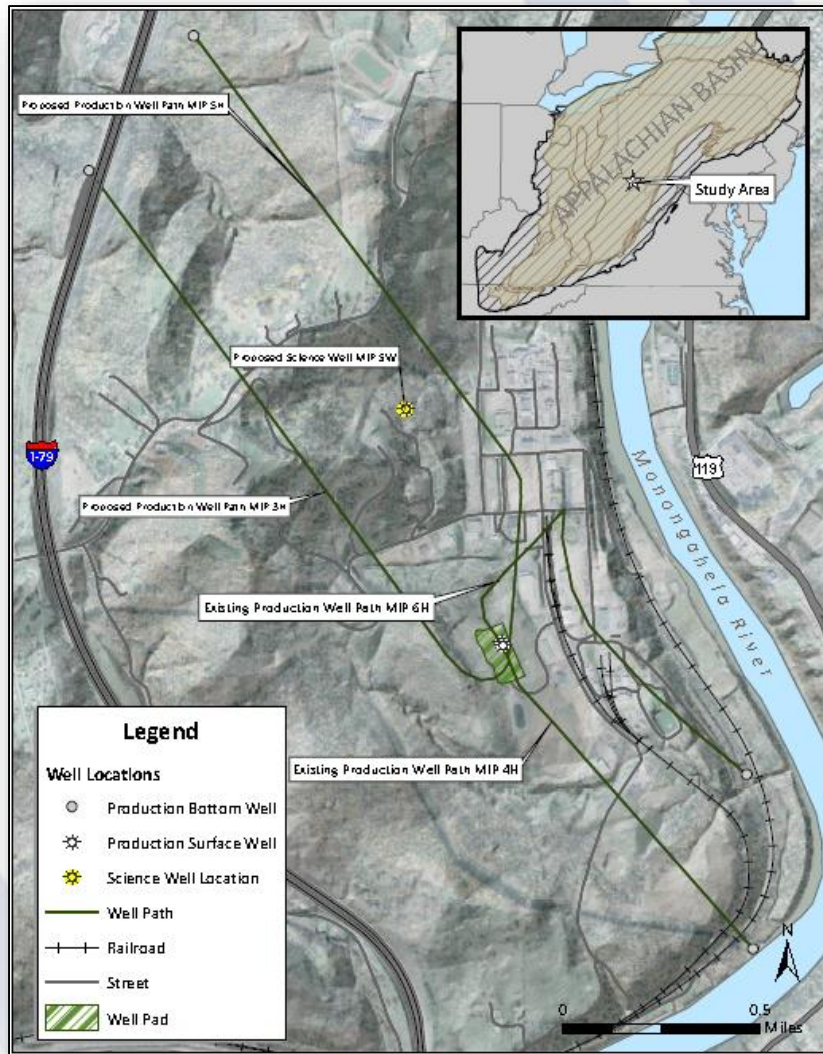


MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY MSEEL

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

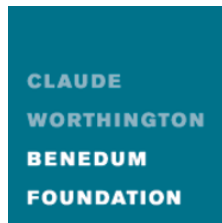


MSEEL Site



Tri-State Shale Summit

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



TRI-STATE
SHALE
SUMMIT

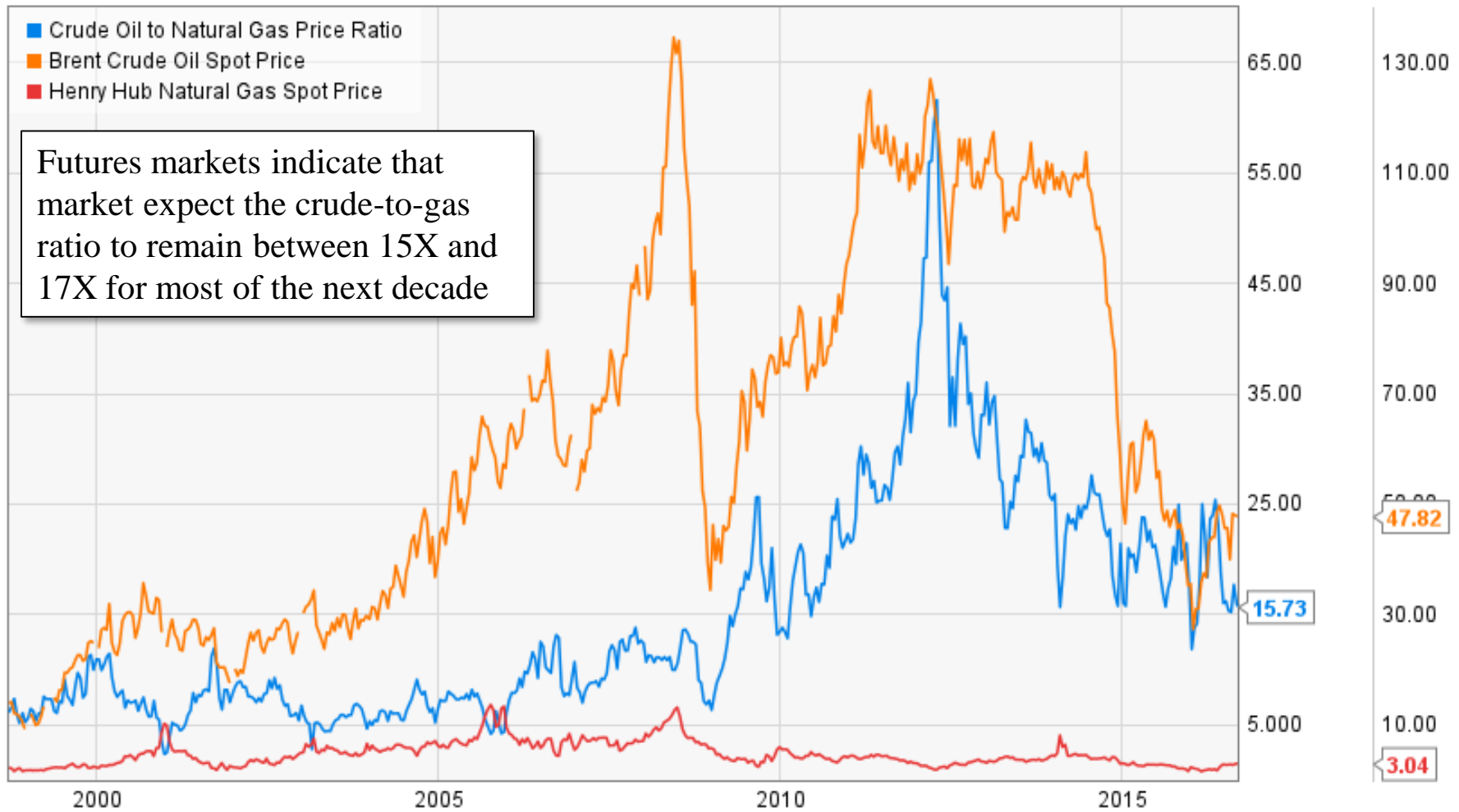


October 13, 2015



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Natural gas utilization: around to stay?

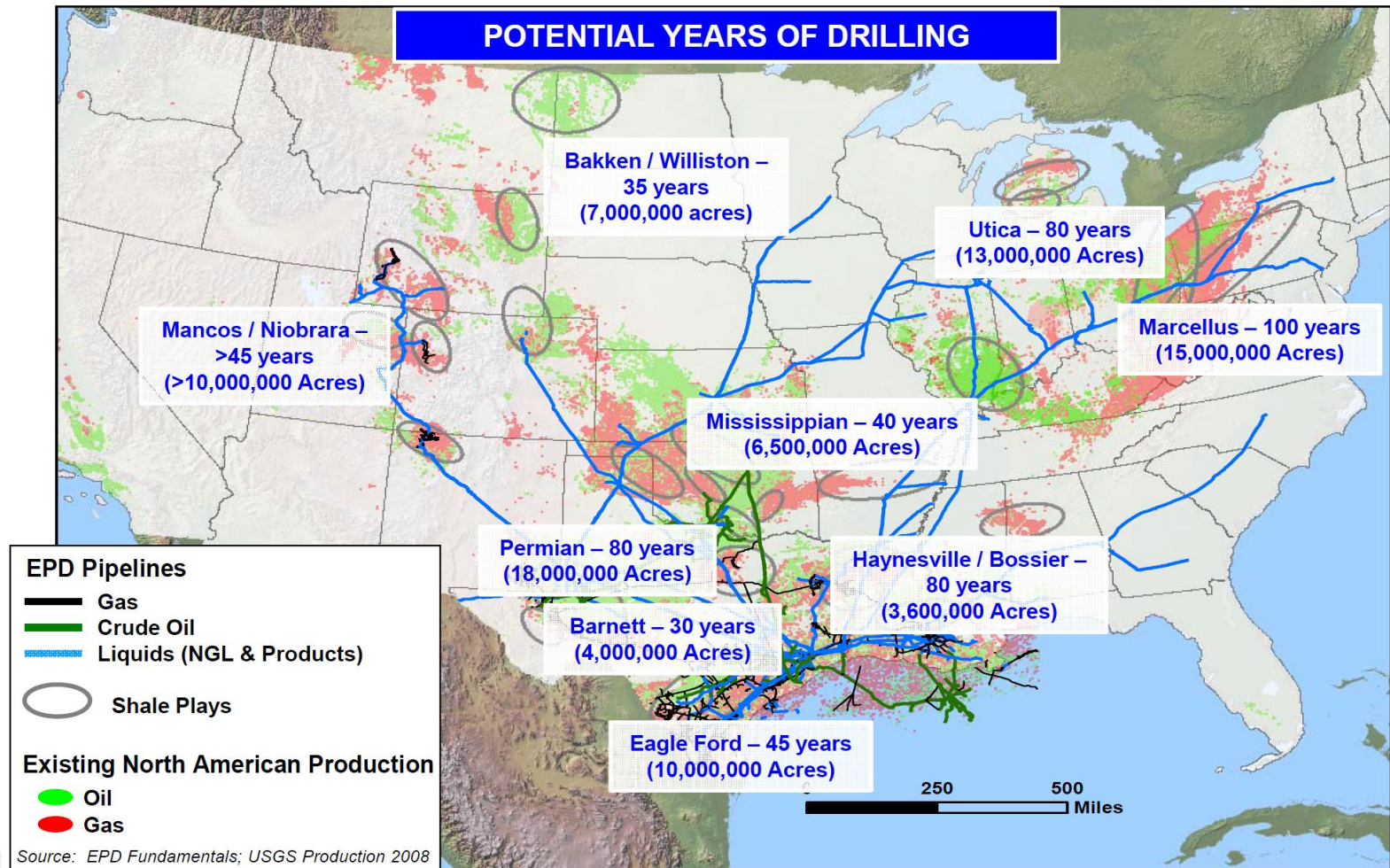


Source: EIA

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



Potential lifetime of North American Gas

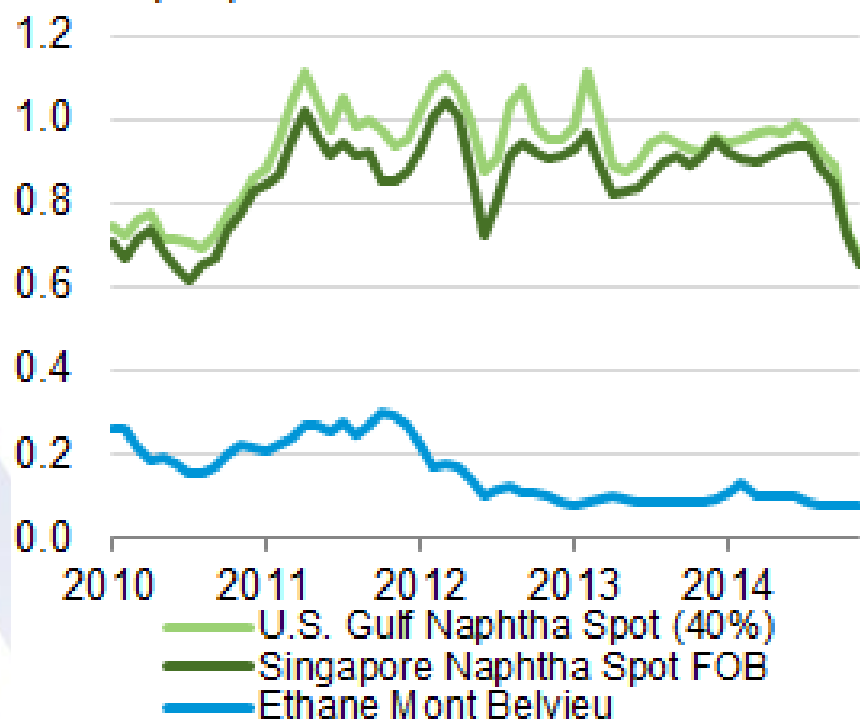


The U.S. has become long on ethane

Average monthly ethane and naphtha spot prices

January 2010-November 2014

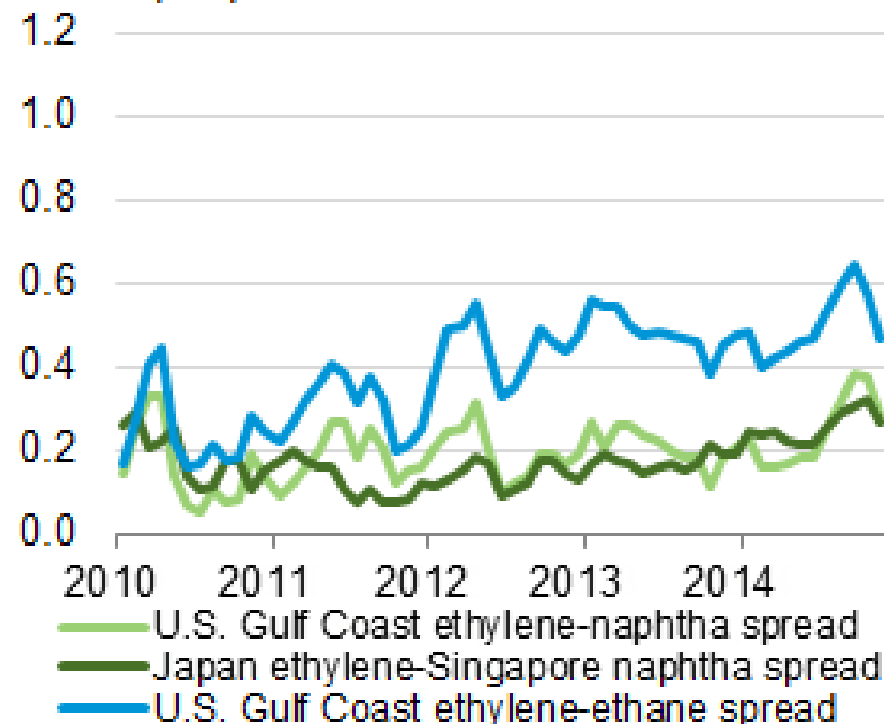
dollars per pound



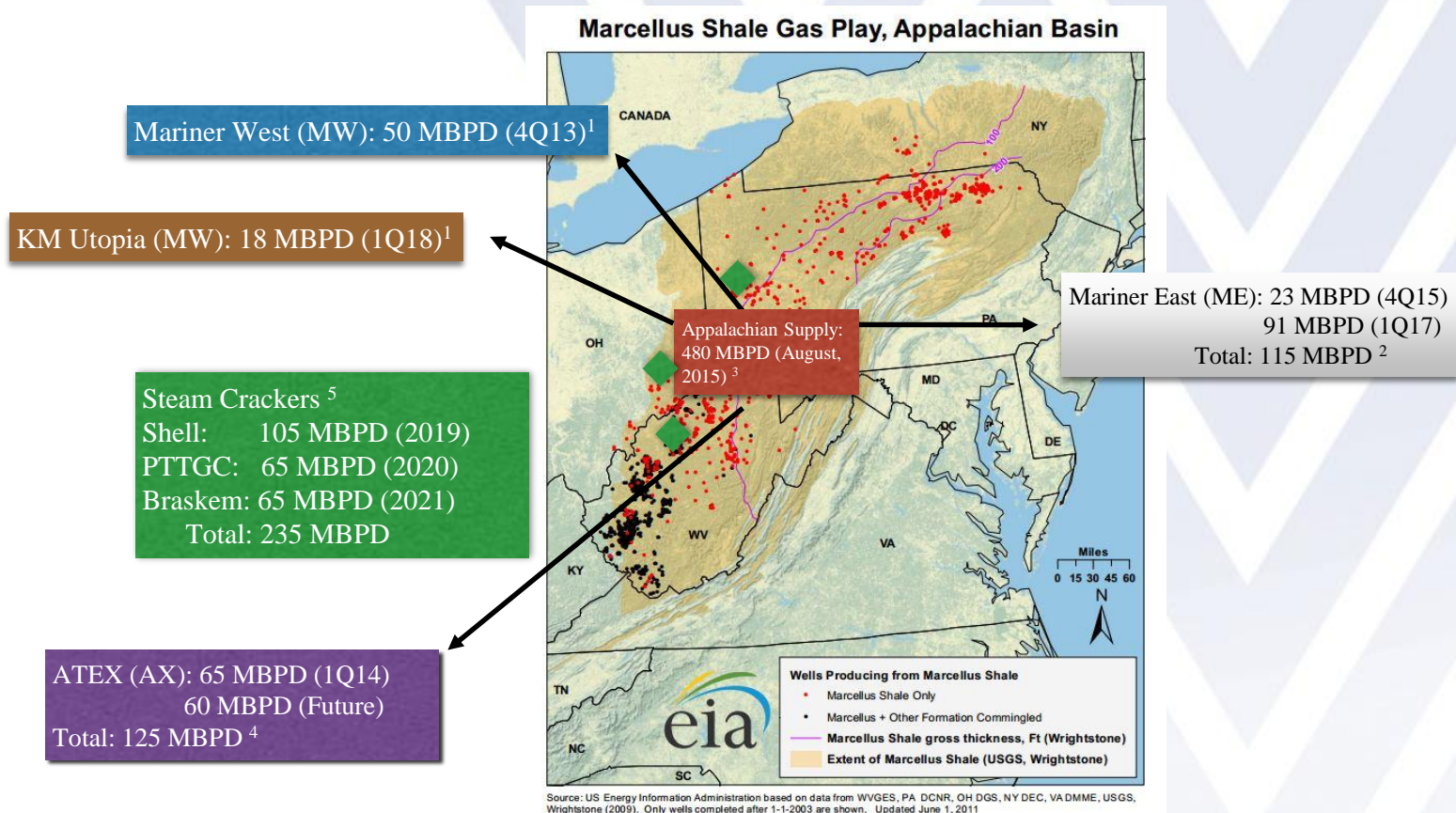
Average monthly ethylene spot price spreads over ethane and naphtha spot prices

January 2010-November 2014

dollars per pound



Estimated Ethane Supply and Announced Demand



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)



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

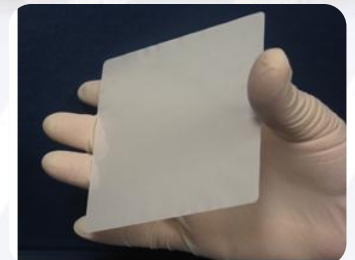


- Industry Consortium:
 - Chevron
 - Southwestern
 - EQT
 - AEP
 - First Energy
 - XTO
 - Mountaineer NGL
 - ANTERO
 - WVONGA
 - Noble
 - Dominion
 - Blue Racer



Strategies for Excellence

- Recruit, support, and retain exceptional faculty
 - New, strategic faculty hires
 - Cost-sharing on center proposals
 - Proposal development center and implement proposal capture process
- Support core research facilities
 - Build WVU Energy Institute Shared Research Facilities that act as a hub for integrated research activities
- Encourage innovation
 - Seed innovative ideas for preliminary studies
 - Graduate fellowship program
- Transform the curriculum
 - Integrate energy studies into GECs





The WVU Energy Institute

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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