



## Moving West Virginia Forward via an Energy-Enabled Economy

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## ENERGY INNOVATION POWERING A NATION

October 9-11, 2018 Stonewall Resort

# **WV Energy Profile**





The WVU Energy Institute | energy.wvu.edu

# **WV Energy Profile**

## QUICK FACTS

- West Virginia ranked 4<sup>th</sup> among the states in total energy production in 2015, producing 4.7% of the nation's total.
- In 2016, West Virginia was the largest coal producer east of the Mississippi River and the second largest in the nation after Wyoming; the state accounted for 11% of the U.S. total coal production that year.
- In 2015, almost half of the 96 million short tons of coal mined in West Virginia was shipped to other states, and one-fourth was exported to foreign countries.
- Coal-fired electric power plants accounted for 94% of West Virginia's net electricity generation in 2016, natural gas contributed 1.6%, and renewable energy resources—primarily hydroelectric power and wind energy—contributed about 3.8%.
- In 2016, West Virginia was the ninth-largest natural gas-producing state in the nation, with gross withdrawals of almost 1.4 trillion cubic feet of natural gas.



## **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







# Major Initiatives and Partnerships ??

Conservancy

(

SMLC

- 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
- 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
    - AIChE RAPID Manufacturing •
- International MOUs
  - China
  - Paraguay
  - Iceland
  - Canada
  - Middle East
    - Bahrain
    - Qatar
    - Kuwait



CASE 💹

WESTERN RESERVE

NATIONAL

TECHNOLOGY



## **Deep Direct Use Geothermal**

Deep Direct Use (DDU) geothermal uses geothermal fluids (mainly water) for a spectrum of uses

- spectrum of uses
   District heating and cooling
- Industrial processes
- Can expand impact to wider areas of country.



Increasing Challenge



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**Geothermal Resource of the United States** 

## **Resource Potential – Direct-Use**

**Geothermal Resource of the United States** Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)

> "Hot Spot" Underlying North Central WV/Western MD = Opportunity?

> > Map does not include shallow EGS resources located near hydrothermal sites or USGS assessment of undiscovered hydrothermal resources. Source data for deep EGS includes temperature at depth from 3 to 10 km provided by Southern Methodist University Geothermal Laboratory (Blackwell & Richards, 2009) and analyses (for regions with temperatures ≥150°C) performed by Source data for identified hydrothermal sites from USGS Assessment of Moderate- and High-Temperature Geothermal Resources of the United States (2008). "N/A" regions have temperatures less than 150°C at 10 km depth and were not assessed for deep EGS potential.

NREL (2009)

 "Temperature at depth data for deep EGS in Alaska and Hawaii not available.



This map was produced by the National Renewable Energy Laboratory for the US Department of Energy. October 13, 2009 Author: Billy J. Roberts

Identified Hydrothermal Site (≥ 90°C)

Favorability of Deep EGS

Most Favorable

Least Favorable

N/A\* No Data\*\*

# Low-Temperature Energy Demand



U.S. thermal energy demand from 0-260°C (with electrical system losses)

Combined Risk Geological Factors; Play Fairways; Utilization Opportunities



## WVU Case Study

• AspenPlus models of the heating distribution system and absorption chilling system constructed and analyzed.

He, X., Anderson, B.J., "Low-Temperature Geothermal Resources for District Heating: An Energy-Economic Model of West Virginia University Case Study," SGW, 2012, SGP-TR-194



Case	Heating( MW <sub>tb</sub> )	Cooling (MW <sub>tb</sub> )	Levelized Energy Cost (\$/MMBtu <sub>th</sub> )
1	16.24	9.93	17.69~18.37
2	16.24	9.93	16.29~17.00
3	16.08	9.93	14.00~15.00

Case 1: Full costs, complete retrofit, no tax breaks

Case 2: Public entity bond rates, tax incentives

Case 3: Lower retrofit costs, using hot water not steam



#### Feasibility of Deep Direct Use Geothermal at West Virginia University

Prime Recipient:West Virginia University (WVU) Research Corporation - DE-EE0008105Key Participants:WVU, WVU Facilities Management, West Virginia Geological & Economic Survey, Lawrence<br/>Berkeley National Laboratory, Cornell UniversityPrincipal Investigator:Dr. Brian J. Anderson

Dr. Brian J. Anderson brian.anderson@mail.wvu.edu, 304-293-6631

EERE funds: **\$720,000** Applicant Cost Share: **\$113,517** 

WestVirginiaUniversity,

**Technology Summary:** Morgantown's elevated geothermal temperature profile, combined with a retrofit of an existing 12-month steam loop, affords an optimal opportunity to use geothermal heating at the WVU campus



#### Research Objective 3 – Create Subsurface Model & Design





#### Research Objective 2 – Characterize Existing Infrastructure



#### <u>Research Objective 4 – Develop</u> and Optimize the System



**Project Result/Goal:** Design of a Geothermal District Heating and Cooling system providing heat to the WVU campus and replacing the current coal-fired system



- Advancement of WVU's efforts to achieve a reliable and clean energy source for its central steam generation system, as
  part of its <u>Sustainability Plan</u> managed under the Office of Sustainability and the WVU Energy Institute.
- Year-round utilization of the DDU system, significantly lowering the annually levelized cost of heat, thus providing <u>the first</u> <u>demonstration in the eastern U.S.</u> of the practical feasibility and effectiveness of geothermal technologies and systems as a component of sustainable practices for large public and private sector organizations.

## **Deep Direct Use Geothermal**

- Design of a Geothermal District Heating and Cooling (GDHC) system providing heat to the WVU campus and replacing the current coal-fired system.
- Year-round utilization of the DDU system, significantly lowering the annually levelized cost of heat, thus providing <u>the first demonstration in the eastern U.S.</u> of the practical feasibility and effectiveness of geothermal technologies and systems.

Start Date	October 2017	Fall 2019	Spring 2020	Spring 2021	Summer 2022	Summer 2023	Summer 2025	September 2026	March 2027
Task	Feasibility Project Start	Exploratory Well Planning	Exploratory Well Drilling and Evaluation	Injection Well Drilling and Formation Evaluation	Production Well Drilling and Flow Testing	Distribution System Upgrading	Building Integration	Commission- ing	New System Start

#### WVU GDHC System Development Timeline

# **Project Objectives**

#### Technical Challenges

The two critical subsurface risk factors are:

- the achievable flowrate of geofluid through target formations in the Appalachian Sedimentary Basin,
- 2. the temperature of the produced geothermal brine.



The location of the WVU campus in Morgantown, WV, provides a unique combination of factors necessary to develop deep direct use geothermal.

The proposed system will allow for utilization of the geothermal heat as both heating and an energy source for absorption cooling, thus amortizing system costs across a full, 12-month year.



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

#### **SEPTEMBER 12, 2016 MORGANTOWN, WEST VIRGINIA**



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![](_page_16_Picture_1.jpeg)

![](_page_17_Picture_1.jpeg)

Tight Oil/Shale Gas Plays

![](_page_18_Picture_2.jpeg)

![](_page_19_Picture_1.jpeg)

![](_page_19_Picture_2.jpeg)

- Tight Oil/Shale Gas PlaysCoal Fields
- Coal Power Plants

![](_page_20_Picture_3.jpeg)

- Tight Oil/Shale Gas PlaysCoal Fields
- Coal Power Plants
   Natural Gas Power Plants

![](_page_21_Picture_3.jpeg)

Tight Oil/Shale Gas Plays
 Coal Fields

Coal Power Plants
 Natural Gas Power Plants
 Nuclear Power Plants

![](_page_22_Picture_3.jpeg)

- Tight Oil/Shale Gas Plays
   Coal Fields
- Coal Power Plants
   Natural Gas Power Plants
   Nuclear Power Plants
   Renewable Power Generation

![](_page_23_Picture_3.jpeg)

- Tight Oil/Shale Gas Plays
   Coal Fields
- Coal Power Plants
   Natural Gas Power Plants
   Nuclear Power Plants
   Renewable Power Generation
  - Energy Transmission Natural Gas, Crude Oil, HGL, & Electric Lines

![](_page_24_Picture_4.jpeg)

- Tight Oil/Shale Gas Plays
   Coal Fields
- Coal Power Plants
   Natural Gas Power Plants
   Nuclear Power Plants
   Renewable Power Generation
- Energy Transmission Natural Gas, Crude Oil, HGL, & Electric Lines
- Academia

![](_page_25_Picture_5.jpeg)

- Tight Oil/Shale Gas Plays
   Coal Fields
- Coal Power Plants
   Natural Gas Power Plants
   Nuclear Power Plants
   Renewable Power Generation
- Energy Transmission Natural Gas, Crude Oil, HGL, & Electric Lines
- Academia
- National Laboratories

![](_page_26_Picture_6.jpeg)

Tight Oil/Shale Gas Plays
 Coal Fields

Coal Power Plants
 Natural Gas Power Plants
 Nuclear Power Plants
 Renewable Power Generation

Energy Transmission Natural Gas, Crude Oil, HGL, & Electric Lines

Academia

National Laboratories

![](_page_27_Picture_6.jpeg)

At the epicenter of the driving force for energy research

### Major Takeaways: Mid-Atlantic Region Forum at WVU

#### Key Takeaways

- Opportunities
  - Large (55 million ppl), diverse, energy-rich region with engaged stakeholders from all sector
- Priority Innovation Focus Areas
  - Clean fossil: advanced power cycles, fuel cells, CCUS, and
    - NETL, Industry partners (i.e. B&W, ExxonMobil, Siluria, Battelle), and Universities strong in this area (OSU, UK, WVU, PSU, Princeton, VT, etc) increased natural gas utilization
    - 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

![](_page_28_Picture_22.jpeg)

#### Techbelt Region Energy Ecosystem Characterization (TREEC): Analyzing Energy Innovation's Opportunities and Challenges in Western Pennsylvania, Northeast Ohio, and Northern West Virginia

#### Cost Share DOE Funded Effort **Objective 1 Objective 2 Objective 3 Quantify Existing** Conduct SWOT Analysis **Develop Regional Regional Energy** & Perform Strategic **Ecosystem Development** Ecosystem Assessment Roadmap State Univers Task 6 Conduct Input-Output Task 10 Create and Document Task 1a Conduct Sector Ecosystem Development Roundtables (phase 1) Analysis Task 7 Analyze Data and Roadmap Task 2 Perform Regional Document Findings Task 1c Obtain Review and Investment Mapping by Task 1b Conduct Sector Comment From Sector Roundtables (phase 2) Roundtable Participants Task 3 Conduct Regional Patent Conduct SWOT Task 8 Task 10 Identify next steps for & IP Mapping by Sector Analysis and Strategic further analysis, Task 4 Perform Industrial Planning Analysis refinement and Mapping by Sector West Virginia University Carnegie Mellon University Task 9 Review and Comment Task 5 Assess and Package Data coordination of strategy by Sector Participants Task 11 Disseminate Roadmap INTERIM REPORT FINAL REPORT STRATEGIC ROADMAP Empirical snapshot of the **Documented analysis** Strategic roadmap for regional region's current existing challenges and opportunities ecosystem development regional energy ecosystem around apparent regional representing resources, economic and industrial trends, ecosystem development paths sector interests, natural comparative advantages & TRL1 TRL2 TRL3 TRL4 TRL5 TRL6 Roadmap to be provided to DOE for review horizon next steps and comment prior to dissemination Vorkforce and Ideas **Business Climate** SBA Analysis, New Business Startups State Development Offices -Business and Tax Receipts

![](_page_29_Picture_2.jpeg)

## US-China <u>Clean Energy Research Center</u> – <u>Advanced Coal Technology Consortium</u> <u>CERC-ACTC</u>

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

#### **US ACTC Partners**

#### Core Technical Partners

U.S. Universities West Virginia University University of Wyoming University of Kentucky Washington University in Saint Louis Indiana University Illinois State Geological Survey National Laboratories Lawrence Livermore National Lab Los Alamos National Lab National Energy Technology Lab NGOs World Resources Institute

#### U.S. Industrial Partners

Arch Coal Duke EPRI\* Gas Technology Inst General Electric/Alstom Jupiter Oxygen LP Amina Peabody Energy Stock Equipment Southern JOINT RESEARCH IS CONDUCTED IN THE FOLLOWING AREAS:

- Advanced Power Generation
- Collaborations and Knowledge Sharing on Large Projects and Demonstrations
- CO2 Utilization and Storage
- Advanced Coal Conversion
- Systems Analysis and Modeling

ACTC is an example WVU's long standing relationships in China

10-years, \$50M in US cooperative funding.

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![](_page_30_Picture_16.jpeg)

## 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

![](_page_31_Picture_2.jpeg)

![](_page_31_Picture_3.jpeg)

![](_page_31_Picture_4.jpeg)

PI: Tim Carr Phone: 304.293.9660 Email: tim.carr@mail.wvu.edu

## **U.S. Rig Count and Production**

![](_page_32_Figure_1.jpeg)

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

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# **Natural Gas Production Shifts**

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

![](_page_33_Figure_2.jpeg)

![](_page_33_Picture_3.jpeg)

Source: EIA, Annual Energy Outlook 2012 and Monthly Natural Gas and Petroleum Report, July 31, 2012

# Natural Gas Production Shifts

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

![](_page_34_Figure_2.jpeg)

![](_page_34_Picture_3.jpeg)

Source: EIA, January Monthly Natural Gas and Petroleum Report

## Natural Gas Infrastructure

~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.

![](_page_35_Figure_2.jpeg)

![](_page_35_Picture_3.jpeg)

Source: RBN Energy and EIA

## The Electricity Fuel Mix is Changing – Generation through Q2 2017

![](_page_36_Figure_1.jpeg)

![](_page_36_Picture_2.jpeg)

## PJM

## Eastern Interconnection

21% of U.S. GDP produced in PJM

![](_page_37_Picture_3.jpeg)

## **Capacity Market Managing Change**

![](_page_38_Figure_1.jpeg)

![](_page_38_Picture_2.jpeg)

## Capacity Market Additions Since 2007/08

![](_page_39_Figure_1.jpeg)

![](_page_39_Picture_2.jpeg)

## **Tri-State Shale Coalition**

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

![](_page_40_Picture_8.jpeg)

![](_page_40_Picture_9.jpeg)

Paul Boulie Team NEO PRoulier@TeamNEO.org

![](_page_40_Picture_11.jpeg)

Ken Zapinsk Allegheny Conference kzapinski@alleghenyconference.org

![](_page_40_Picture_13.jpeg)

Chemical Manufacturers (purple):<u>6.371</u> Com Plastic Converters (blue): <u>8.147</u> Companies Mfg. & Conv. (brown): 1.812 C Plastics Mfg. (green): 1.147 Com

![](_page_40_Picture_15.jpeg)

Vision Shared president@visionshared.org

Tri-State

Ohio, Pennsylvania, and West Virginia.

edge of market- and technology-advances

"Global Petrochemical Hub,"

**Shale Coal** Ohio, Pennsylvania, and West Virginia workin together, building on their shale assets

If your company is looking to expand in petrochemicals, plastics, or converted products, you should be considering the tri-state region of

We have customers, suppliers, a globally competitive technical workforce, and a leading educational/innovation ecosystem to help your company stay on the leading

The Tri-State Shale Coalition represents the three states working together to

We have the largest concentration of end-use customers in the United

States, giving you unprecedented access to help you effectively service and supply the strongest economy in the globe. We have a globally-competitive supply chain that serves both U.S. and international markets

Petrochemical & Downstream Manufacturers within 400 Miles: 17,477 Companies

build a global petrochemical hub. This "super-region" is on the verse of game-changing petrochemical, plastics fabrication and advanced manufacturing jobs and investments Public and private partners representing workforce development, academia, and onomic development in the tri-state region recognize this opportunity and are visibly and strategically aligned to promote the super region as the new

Cory Denniso

![](_page_40_Picture_20.jpeg)

CLAUDE WORTHINGTON BENEDUM FOUNDATION

## **TRI-STATE** SHALE SUMMIT

![](_page_40_Picture_23.jpeg)

October 13, 2015

![](_page_40_Picture_25.jpeg)

# **Petrochemical & Downstream Manufacturers**

within 400 Miles: <u>17,477</u> Companies

![](_page_41_Figure_2.jpeg)

Plastics Mfg. (green): <u>1,147</u> Companies

![](_page_41_Picture_4.jpeg)

### Central Appalachia Is Key to Over 50% of the US Population

![](_page_42_Picture_1.jpeg)

![](_page_42_Figure_2.jpeg)

### **DOE Appalachian Basin NGL Primer**

The US Department of Energy released an NGL Primer in Decerr

![](_page_43_Figure_2.jpeg)

![](_page_43_Picture_3.jpeg)

Natural Gas Liquids Primer With a Focus on the Appalachian Region

December 2017

United States Department of Energy Washington, DC 20585

## Estimated Ethane Supply and Announced Demand

![](_page_44_Figure_1.jpeg)

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)

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### Marcellus and Utica Ethane Growth Scenario Supply/Demand, 2013-2022

![](_page_45_Figure_1.jpeg)

![](_page_45_Picture_2.jpeg)

#### EXHIBIT 9

![](_page_46_Figure_1.jpeg)

MTA

Even if gas prices increases beyond \$4/mmbtu, we still expect U.S. producers to retain cost advantage at a low crude oil price market

- 1 Effective capacity assumes 93% of nameplate capacity
- 2 Based on weighted average cost

3 Plant gate costs; based on prices in US, WE, NEA, SEA, and ME netbacks (S. America costs based primarily on WE prices); each cracker's cost based on estimated feed mix, scale, byproduct recovery (e.g., extract vs sell CC4s), and estimated yield efficiency

3 Brent crude price

SOURCE: ICIS Italia, ICIS, CMAI, McKinsey cost curve models

![](_page_46_Picture_9.jpeg)

![](_page_46_Picture_10.jpeg)

## **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

Chevron

FirstEnergy

Goal of this project: to provide essential data to support of the development the chemical manufacturing industry, promoting economic development

![](_page_47_Figure_7.jpeg)

# **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
  FIG. 2

![](_page_48_Picture_5.jpeg)

Schultz and Vereide, O&G Journal, 2017

![](_page_48_Figure_7.jpeg)

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

## Appalachian Storage Hub – Summary

![](_page_49_Figure_1.jpeg)

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# The Appalachia Storage and Trading Hub

- January 3, 2018 Appalachia Development Group, LLC, (ADG) invited to submit a Part II Application for a loan guarantee under the U.S. Department of Energy (DOE) Title XVII Loan Guarantee Program.
  - The invitation for the Part II application is for a \$1.9 billion loan guarantee from the DOE to support the development of infrastructure for the Appalachia Storage & Trading Hub (ASTH).
  - ADG submitted Part I application on September 13, 2017 and working to secure a \$1.4 billion equity position.

![](_page_50_Picture_4.jpeg)

![](_page_50_Picture_5.jpeg)

### Chemical and Other Manufacturing from Marcellus Shale

![](_page_51_Picture_1.jpeg)

#### POTENTIAL ECONOMIC IMPACTS OF CHEMICAL AND PLASTICS MANUFACTURING IN APPALACHIA

Martha Gilchrist Moore, Sr. Director – Policy Analysis and Economics

### The Scenario and Opportunity

- 350,000-400,000 bpd ethane by 2025
- \$35.8 billion in new investment
- 5 ethane crackers + other facilities
- Storage and pipeline infrastructure built

#### **Four-State Economic Impact**

- 25,664 Direct Jobs
- 100,818 Total Jobs
- \$6.2 Billon Total Payroll
- \$2.9 Billion Taxes

## Workforce Development and Entrepreneurship

- The "biggest bang" outcome is going all the way up the value chain with WV BASED companies
- Understanding that "entrepreneurship" occurs all across the sector!
  - Innovations in environmental technology are just as valuable as innovations in production or conversion technology

#### Higher Ed Attainment Directly Relates to Innovation

- 23% of working age population had a bachelors degree of more (7% less than US average)
- New Inventions, Patents, Development of New Sectors
- Labor Force to Support Innovative Industries

![](_page_52_Figure_8.jpeg)

Map Title: Percent of Persons Ages 25 and Over in the Appalachian Region With a Bachelor's Degree or More, 2006-2010 Data Source: U.S. Census Bureau, 2006-2010 American Community Survey.

#### What Are Our Barriers?

- Labor Force Training
- Educational Attainment
- Financing (and how this relates to
  - entrepreneurship)
- Regional Perceptions
- Time Scales for Commercialization

#### What Are Our Advantages?

- Labor Force Availability
- Geography
- Resource Availability
- IP

Development/Research Capability

![](_page_52_Figure_23.jpeg)

# Natural gas utilization

The focus is on responsible demand-side research that emphasizes the technology needs to promote responsible growth of the shale gas industry and economic development in the State.

The focus must include economic, legal, and policy needs to inform the State and legislative decision makers.

The emergence of significant national natural gas plays, coupled with thermocatalyic pathways, provides the potential to decrease dependence on conventional petrochemical routes towards a variety of products, including gasoline, diesel, methanol, ethanol, ammonia, hydrogen, and a variety of oligomers and polymers.

![](_page_53_Figure_4.jpeg)

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![](_page_54_Picture_0.jpeg)

CENTER FOR INNOVATION IN GAS RESEARCH AND UTILIZATION

![](_page_54_Picture_2.jpeg)

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## **There's Power in Partnership**

#### Thanks to CIGRU's partners

![](_page_55_Picture_2.jpeg)

![](_page_55_Picture_3.jpeg)

![](_page_55_Picture_4.jpeg)

![](_page_55_Picture_5.jpeg)

![](_page_55_Picture_6.jpeg)

![](_page_55_Picture_7.jpeg)

![](_page_55_Picture_8.jpeg)

![](_page_55_Picture_9.jpeg)

![](_page_55_Picture_10.jpeg)

![](_page_55_Picture_11.jpeg)

![](_page_55_Picture_12.jpeg)

![](_page_55_Picture_13.jpeg)

![](_page_55_Picture_14.jpeg)

# CENTER FOR INNOVATION IN GAS RESEARCH AND UTILIZATION

WVU, NETL TO COLLABORATE WITH PITT, SHELL TO DEVELOP PROCESS TO TRANSFORM STRANDED NATURAL GAS INTO MARKETABLE

#### WVU PARTNERS WITH START-UP ON NATURAL GAS TO HYDROGEN AND CARBON FIBER TECHNOLOGY

MORGANTOWN, W.Va.-

esearchers from West Virginia University will partner with colleagues from Southern California Gas Company and Pacific Northwest National Laboratory on technology that converts natural gas to hydrogen and value-added forms of carbon.

![](_page_56_Picture_4.jpeg)

John Hu, Hanjing Tian and Debangsu Bhattacharyya

### WVU AWARDED \$1.25 MILLION FROM ARPA-E FOR TRANSFORMATIONAL ENERGY TECHNOLOGY

![](_page_56_Figure_7.jpeg)

The Department of Energy's Advanced Research Projects Agency-Energy launched a new program that will use components from renewable sources to produce high-energy liquid fuels for transportation and other uses. WVU engineers will use ammonia to "transport" electricity across distances and then convert it back to electricity or hydrogen. Source: Image courtesy of The Advanced Research Projects Agency-Energy.

![](_page_57_Picture_0.jpeg)

# West Virginia Forward:

Summary of Findings

We are focused on understanding West Virginia's strengths and opportunities and identifying initiatives that will provide the collaboration to achieve both short- and longterm success in revitalizing the economy, creating jobs and priming the state for success in our changing economic and technological landscape.

## **ECONOMIC SECTORS & ECONOMIC ENABLERS**

		Maintain current industries	) ',	Auto parts manufacturing Metals manufacturing	<ul><li>/ Fulfillment distribution</li><li>/ Building products</li></ul>
WV economic development	Diversify economic sectors	Differentiate in growing sectors where WV has a presence	/	Carbon fiber reinforced plastics Fine chemicals	
		Capture new sectors that have high growth prospects	;	Higher-end tourism Cyber security and cloud services	
		Keep an eye on potential opportunities	;	Life sciences Vehicle assembly plants	
		Business climate	/,	Ease of doing business Cost of doing business Quality of life	/ Regulatory environment
		Innovation and business development	//	Attract businesses Support small-businesses Foster development of new busines	sses
		Infrastructure	//	Transportation Broadband Sites	/ Utilities to infrastructure
		Human capital	//	Talent pool Workforce participation Talent attraction	/ Population health

![](_page_59_Picture_2.jpeg)

#### **Economic Enablers:** Summary of Findings

Enablers:	Dimensions:	Diagnostic:	
Business Climate	Cost of Doing Business Regulatory Environment Quality of Life	<ul> <li>/ Top 15 states for cost of doing business, but energy costs are rising</li> <li>/ 18th on State Business Tax Climate Index, ahead of peers</li> <li>/ Has taken measures to improve legal climate</li> <li>/ Ranks last in quality of life</li> </ul>	
Innovation and Business Development	Starting new businesses Growing Existing Businesses Attracting Businesses	<ul> <li>/ Business exits higher than startups, ranking #49 on business birth rate and #47 on patent creation</li> <li>/ Fewer small business innovation research awards (\$20 per \$1M of GDP), lesser seed/angel funding</li> <li>/ Limited discretionary funds available to close deals</li> </ul>	
Infrastructure	Transport IT Sites	<ul> <li>#43 on bridge quality, and #37 on road quality</li> <li>Bottom ten on access to broadband, with internet backbone missing WV entirely</li> <li>Opportunity to certify more sites for business attraction</li> </ul>	
Human Capital	Foster Talent Pipeline Improve Health and Skills of Workforce Attract Talend from outside WV	<ul> <li>Fewer STEM and college grads than all peers (14% and 20% respectively)</li> <li>Net population loss of ~5K/year</li> <li>Declining labor force participation (ranks worse in women and disabled people participation vs. peers)</li> </ul>	

Outperform peers

i peers

On par with peers

Underperform peers

![](_page_60_Picture_6.jpeg)

#### Implementation: Action items can be broken down into six initiatives

![](_page_61_Figure_1.jpeg)

![](_page_61_Picture_2.jpeg)

![](_page_62_Figure_0.jpeg)

![](_page_62_Picture_1.jpeg)

## WV DOES NOT CERTIFY SITES AND COULD LEARN FROM PEER STATES

#### What is a certified site?

- / A certified site is a development-ready industrial site that has completed a rigorous review process by the State and an independent, third-party engineering firm
- / Specific site details, such as zoning restrictions, title work, environmental studies, soil analysis and surveys, are assessed for compliance and authenticity

![](_page_63_Picture_4.jpeg)

#### **Best practice example - OH**

- / WV's peers (OH, KY, etc.) have certified sites available to speed up development
- / OH launched SiteOhio to help companies find the best location in OH
- / SiteOhio puts properties through comprehensive review and analysis
- / OH shows a site is ready for immediate development with all utilities, adequate capacities, and all due diligence studies
- / OH also ensures the site is free of incompatible uses, with no limitations or insurance liability based on surrounding property

![](_page_63_Picture_11.jpeg)

# **IMPLEMENTATION STRUCTURE**

- / MOU between WVU, the Commerce Department and Marshall University
- / Will create a structure of accountability
- / Engage stakeholders
- / Steering committee
- / Implementation working groups

![](_page_64_Picture_6.jpeg)

# **IMPLEMENTATION WORKING GROUPS**

- / Energy
- / Business Climate
- **/** Human Capital
- / Entrepreneurship

![](_page_65_Picture_5.jpeg)

![](_page_66_Picture_0.jpeg)

![](_page_66_Picture_1.jpeg)

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

![](_page_66_Picture_4.jpeg)

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