A Vision for Regional Advanced Manufacturing

Solutions for Today | Options for Tomorrow

Presentation at the Marcellus & Manufacturing Development Conference

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NETL Director
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U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Mid-Atlantic Region

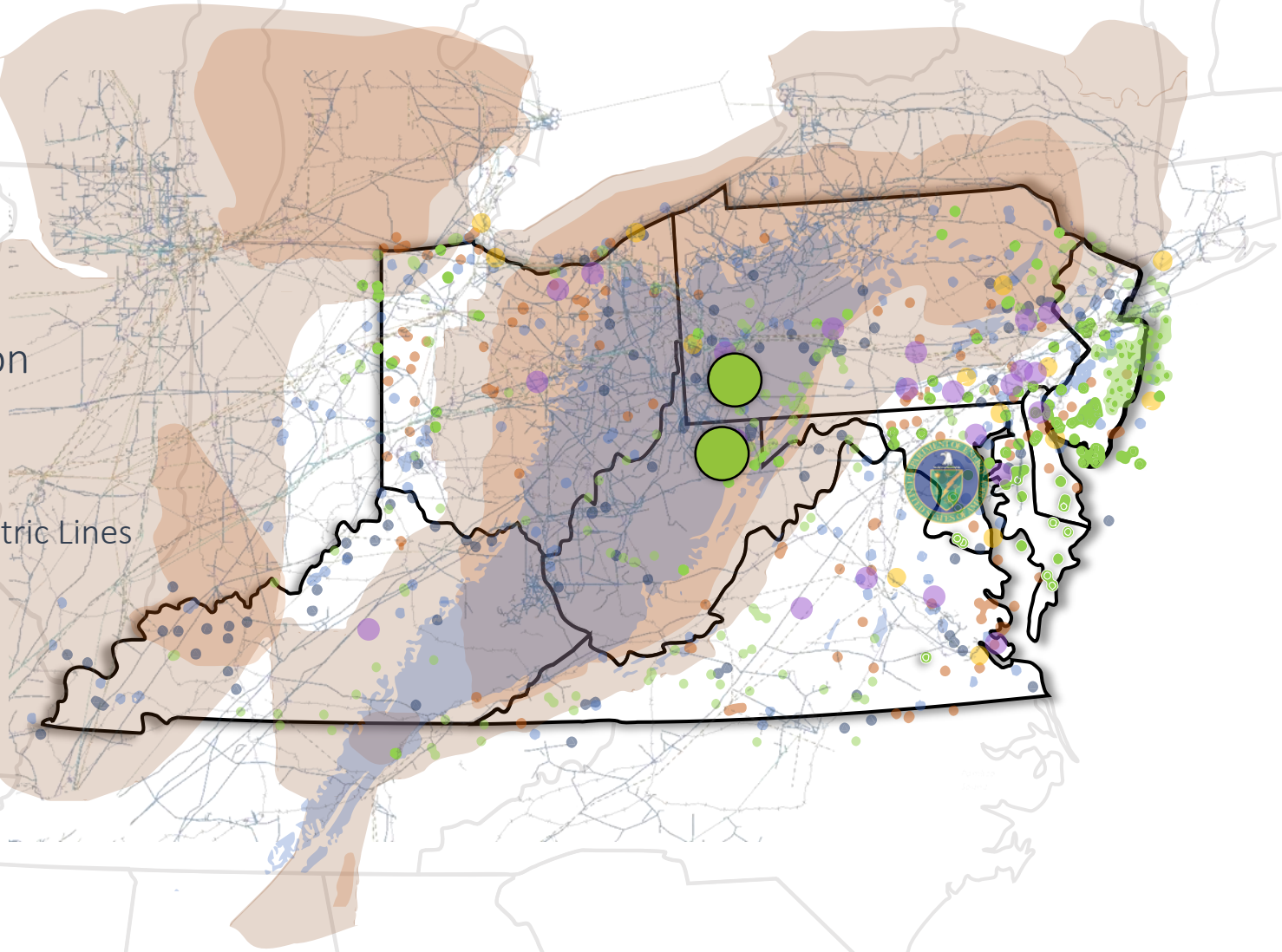
- Sedimentary Basins
- Tight Oil/Shale Gas Plays
- Coal Fields

- Coal Power Plants
- Natural Gas Power Plants
- Petroleum Power Plants
- Nuclear Power Plants
- Renewable Power Generation
  Wind Solar Hydro

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

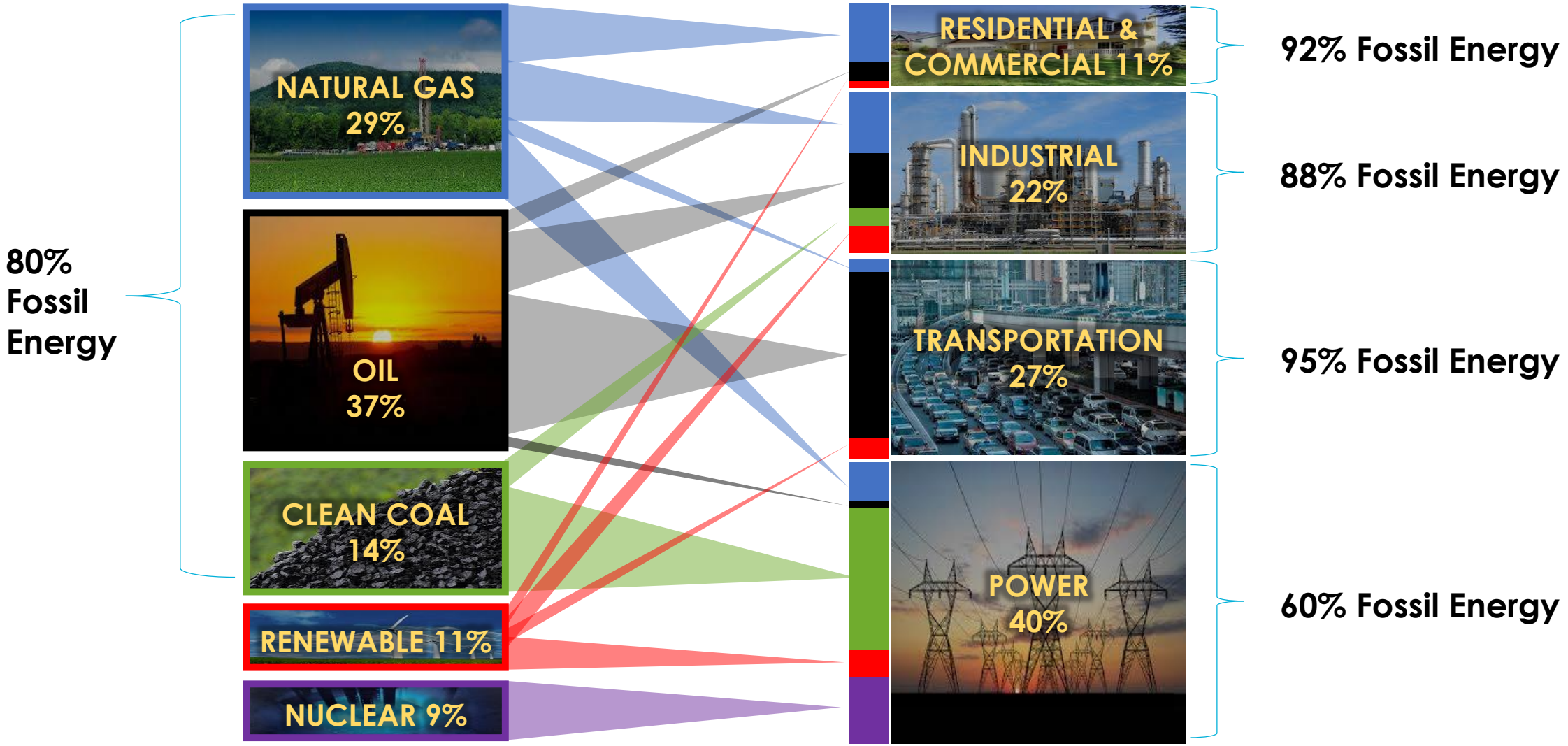
- Academia

- US DOE



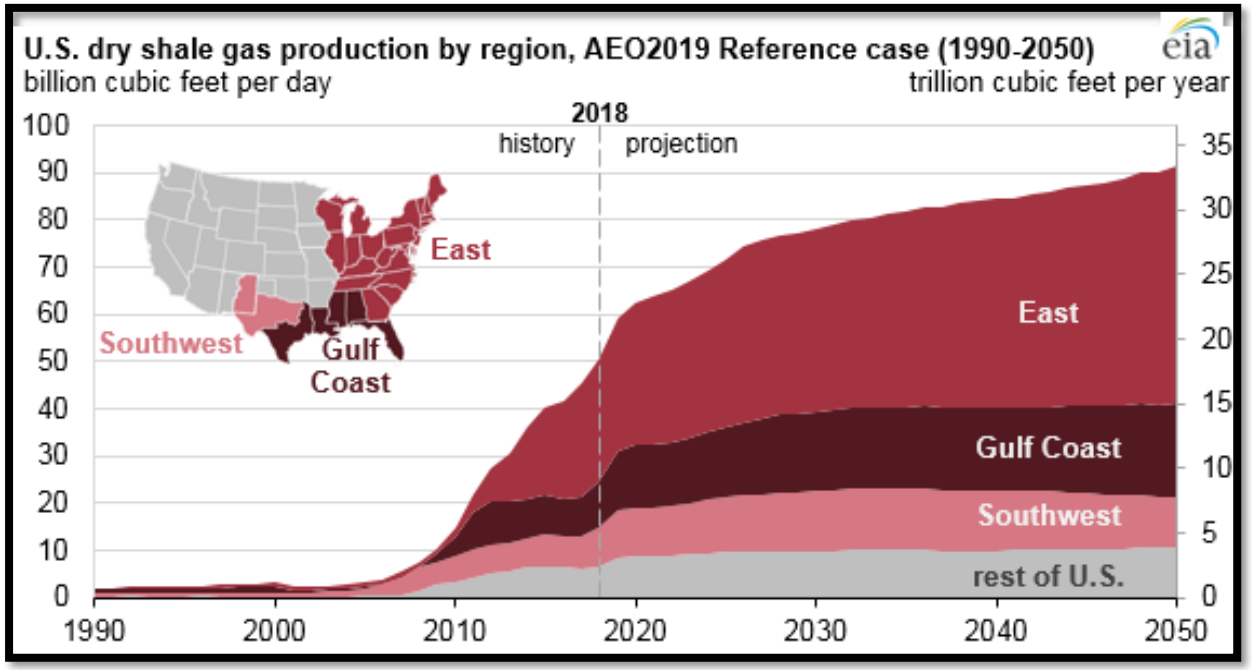
NETL
NATIONAL ENERGY TECHNOLOGY LABORATORY

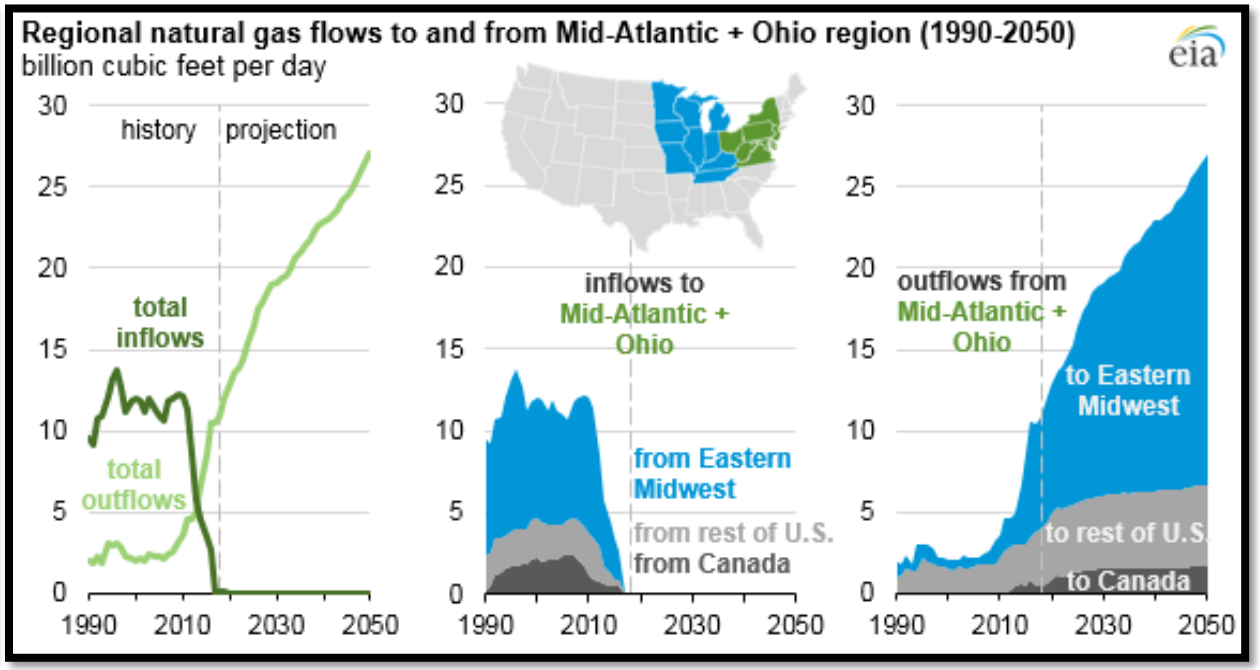
Fossil Energy Is Critical In All Sectors



EIA, Annual Energy Outlook 2017, Reference Case
https://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2017_energy.pdf

Increase in Regional Natural Gas Production





Natural gas production in the Mid-Atlantic and Ohio regions from the Marcellus and Utica formations results in increases of natural gas being transported to the Eastern Midwest and into the South Central regions, which includes the Gulf Coast and Texas.

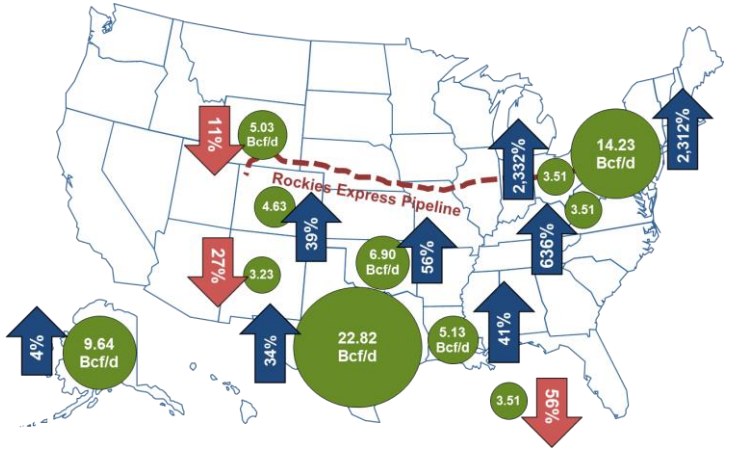
- Emergence of the downstream market has the potential to add nearly $200B of economic growth over the next decades.
- FE contributes approximately $500B to our economy and this is expected to double within the next few decades.

https://www.eia.gov/todayinenergy/detail.php?id=38652

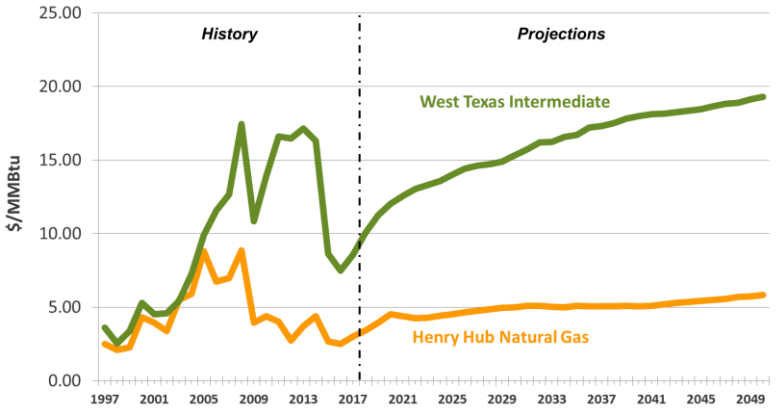
Shale Gas: "A Generational Opportunity"

Define the energy future

ABUNDANT



ECONOMICS



NATIONAL ALIGNMENT

- ✓ Increase national security
- ✓ Increase domestic jobs
- ✓ Increase GDP
- ✓ Energy independence

Pivot Towards Natural Gas

Growing Domestic Natural Gas and NGL Production Capacity

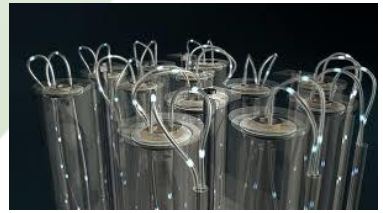
- 30 year supply of natural gas at $4/mcf or less
- Ethane supply to quadruple by 2025

Growing Chemical Production Capacity

- Announced chemical industry production capacity investments driven by shale gas and NGLs top $160 billion for 264 projects, 40% of which completed or underway as of April 2016
- Increased investment expected to generate more than $100 billion per year in new chemical industry shipments by 2023
- Also will generate 738,000 new jobs and $300 billion in permanent economic output by 2023

Growing Natural Gas Fueled Manufacturing

- Industries that have seen increased domestic investment and/or improved profitability driven by expected long-term supply of low cost natural gas include: steel, aluminum, fertilizer, glass, paper

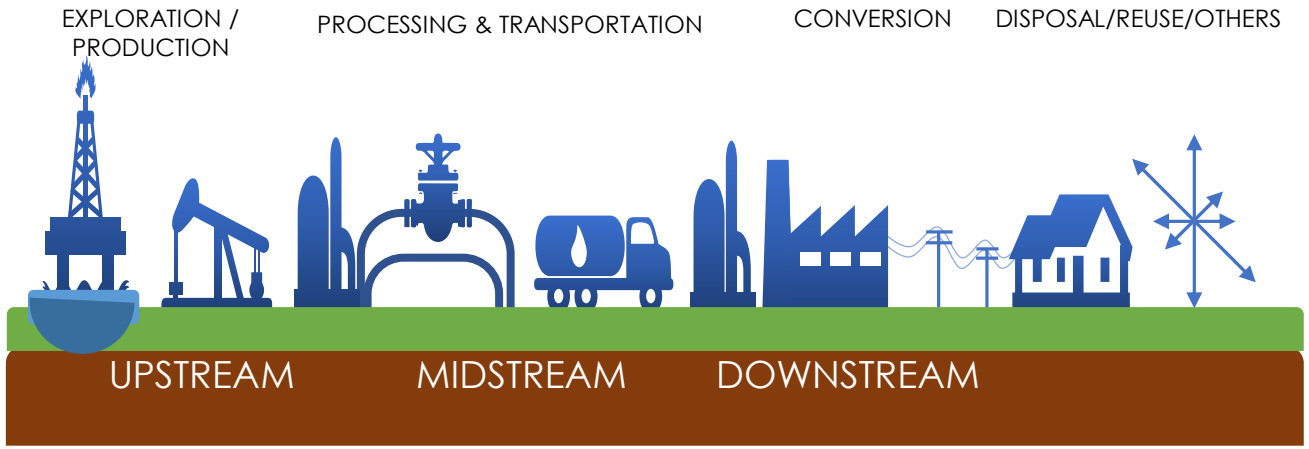


Source: American Chemical Council

NETL Mission & Vision

MISSION

Discover, integrate, and mature technology solutions to enhance the nation's energy foundation and protect the environment for future generations



VISION

Be the nation's renowned fossil-energy science and engineering resource, delivering world-class technology solutions…today and tomorrow

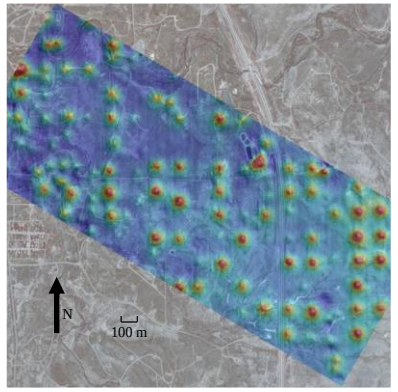
ENDURING MISSION ELEMENTS:

Effective Resource Development
Efficient Energy Conversion
Environmental Sustainability

NETL Core Competencies

NATIONAL ENERGY TECHNOLOGY LABORATORY

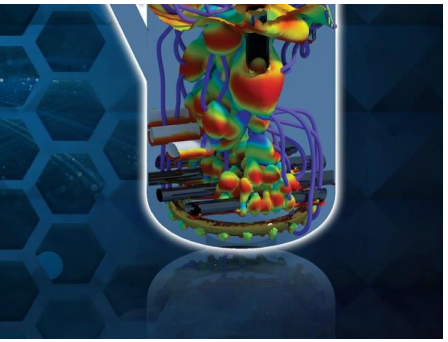
EFFECTIVE RESOURCE DEVELOPMENT • EFFICIENT ENERGY CONVERSION • ENVIRONMENTAL SUSTAINABILITY



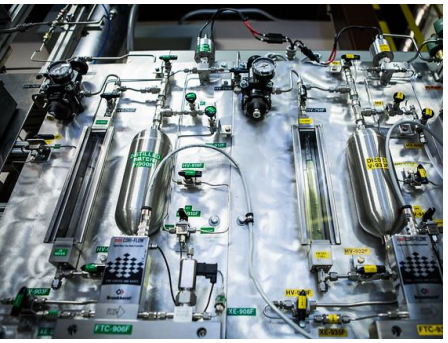
COMPUTATIONAL SCIENCE & ENGINEERING	MATERIALS ENGINEERING & MANUFACTURING	GEOLOGICAL & ENVIRONMENTAL SYSTEMS	ENERGY CONVERSION ENGINEERING	SYSTEMS ENGINEERING & ANALYSIS	PROGRAM EXECUTION & INTEGRATION
High Performance Computing	Structural & Functional	Geo-Analysis & Monitoring	Reaction Engineering	Process & System	Technical Project Management
Data Analytics	Design, Synthesis, & Performance	Data Storage, Management, & Analysis	Design & Validation	Multi-scale Modeling, Simulations & Optimization	Market & Regulatory Analysis
Machine Learning	Characterization	Geochemistry	Innovative Energy & Water Processes	Energy Markets Analysis	

An Innovative Approach to Advanced Manufacturing

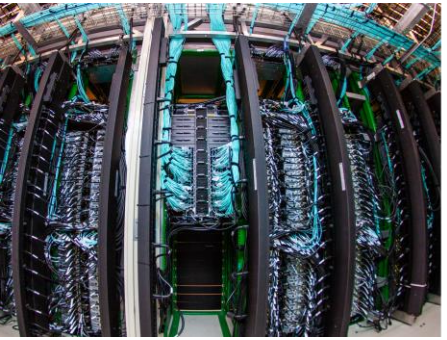
NATIONAL ENERGY TECHNOLOGY LABORATORY



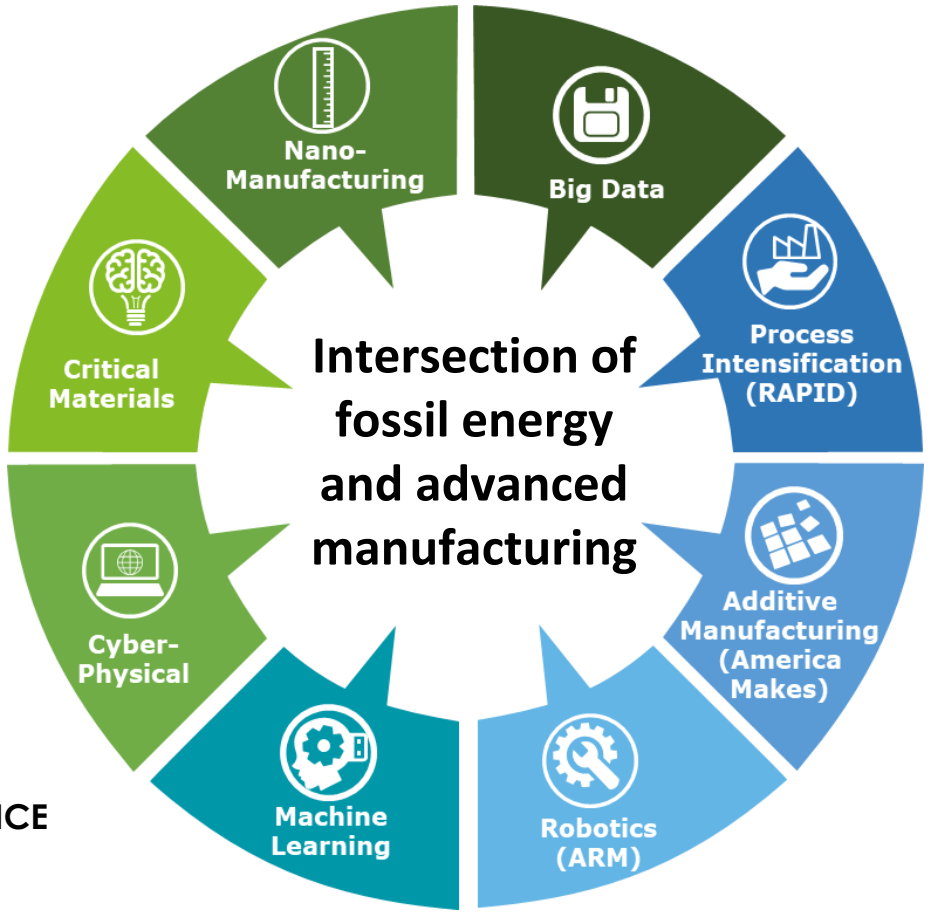
PROCESS INTENSIFICATION



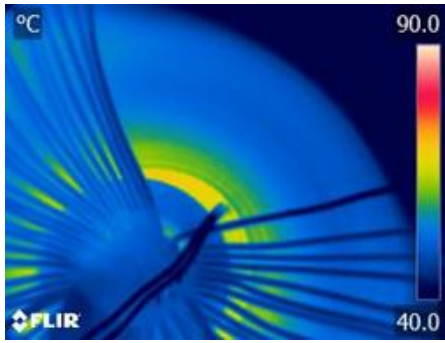
ENERGY CONVERSION TECHNOLOGIES



HIGH PERFORMANCE COMPUTING, SIMULATION, & MODELING

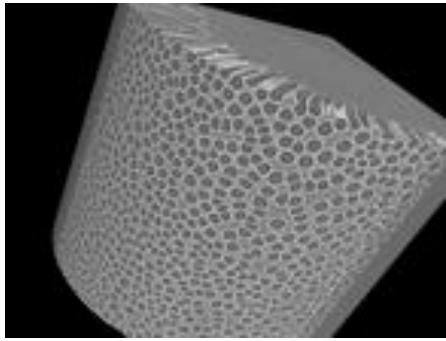


ADVANCED POWER ELECTRONICS



NEXT GENERATION MATERIALS FOR HARSH ENVIRONMENTS

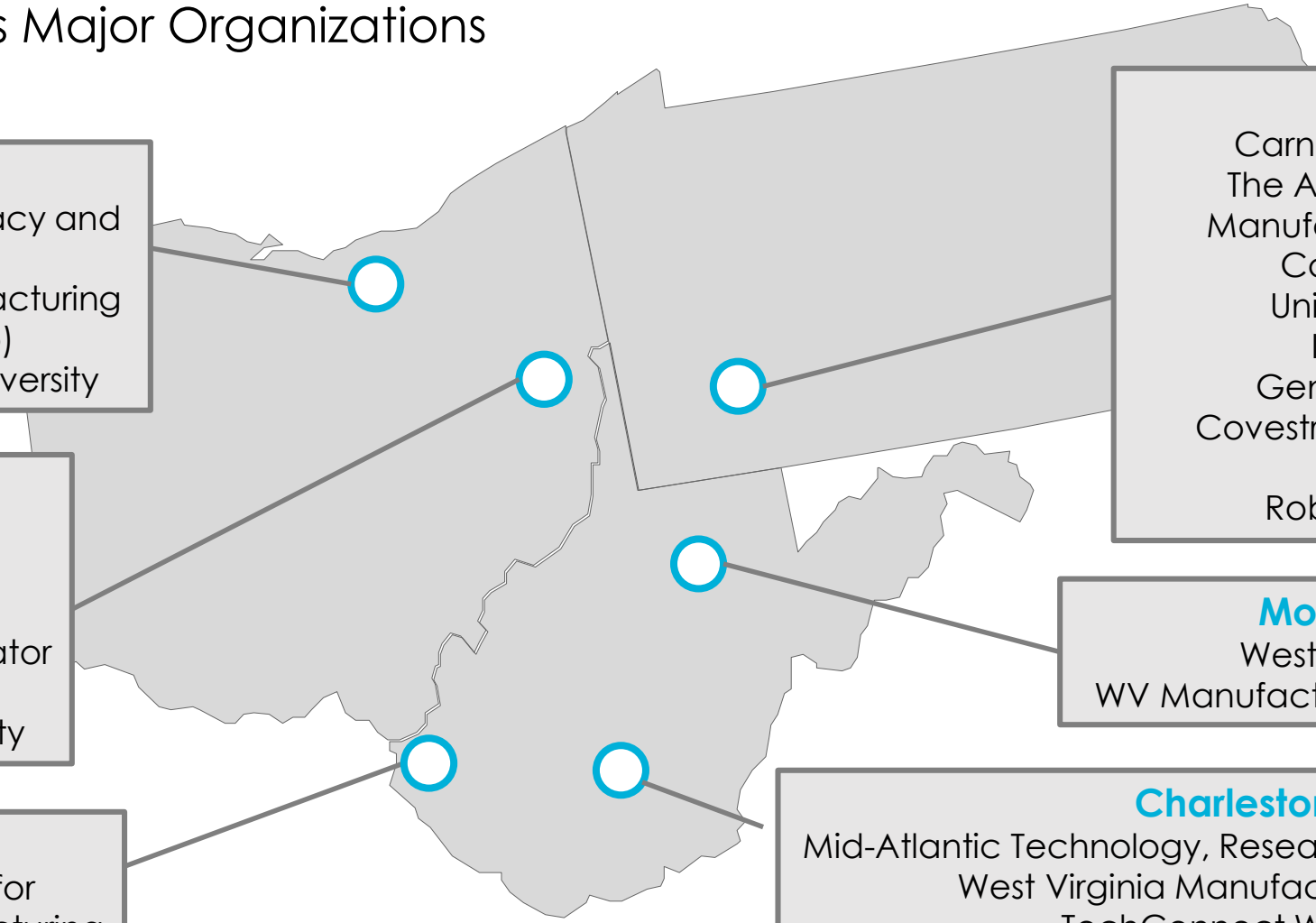
FUNCTIONAL MATERIALS



Advanced Manufacturing: A Regional View

NATIONAL ENERGY TECHNOLOGY LABORATORY

The Tri-State Area's Major Organizations



Cleveland, OH:
The Manufacturing Advocacy and Growth Network
(MAGNET, the Ohio Manufacturing Extension Partnership)
Case Western Reserve University

Youngstown, OH:
America Makes
Northeast Ohio Additive Manufacturing Cluster
Youngstown Business Incubator
Team NEO/Jobs Ohio
Youngstown State University

Huntington, WV:
Robert C. Byrd Institute for Advanced Flexible Manufacturing
Marshall University

Pittsburgh, PA:
Carnegie Mellon University
The Advanced Robotics for Manufacturing (ARM) Institute
Catalyst Connection
University of Pittsburgh
Innovation Works
General Electric, Alcoa, Covestro, Westinghouse, Ansys, Arconic, ExOne,
Robert Morris University

Morgantown, WV:
West Virginia University
WV Manufacturing Extension Partnership

Charleston, WV:
Mid-Atlantic Technology, Research, and Innovation Center
West Virginia Manufacturers Association
TechConnect West Virginia

RAPID Manufacturing Institute

$70M
Federal over
5 years
(2016-2020)

$140M
expected total
Industrial cost share

RAPID
Transforming Process Industries

Six Focus Areas

Primary Focus Spanning All Areas is Process Intensification

4-7
Technology Readiness Levels

75+
Member institutions


CHEMICAL COMMODITY PROCESSES


MODELING AND SIMULATION


NATURAL GAS UPGRADING


MODULE MANUFACTURING


INTENSIFIED PROCESS FUNDAMENTALS


RENEWABLE BIO PRODUCTS

Clean Energy Smart Manufacturing Innovation Institute

$70M
Federal over
5 years
(2016-2020)

$70M
Cost Share industry, consortium members, & partners

95+
Member institutions

CESMII
THE SMART MANUFACTURING INSTITUTE

PHASED IMPLEMENTATION APPROACH


TRAIN & EDUCATE


TEST & EVALUATE


DEVELOP & VALIDATE


DEPLOY & COMMERCIALIZE

TECHNOLOGY FOCUS AREAS:
- Advanced sensors
- Real-time big data analytics and control systems
- Standardized open software and communication platforms
- Advanced high fidelity modeling
- First-of-kind application toolkits for smart manufacturing

Region of Great Opportunity

Drivers

Abundant Natural Resources

- Rich variety of energy resources
- Natural gas feedstock
- Water availability
- Liquid Rich

Manufacturing makes up 8.5% of U.S. employment and 11.4% of U.S. GDP, yet drives 60% of exports and an astounding 70% of private-sector R&D

U.S. Senate Testimony
Michael Molnar
Office of Advanced Manufacturing
National Institute of Standards and Technology

Economic

- Domestic jobs
- Projected economic growth
- Location and demand of U.S. manufacturing facilities
- Proximity to markets
- Transportation cost advantage

Pennsylvania Petrochemicals Complex, Shell Chemical Appalachia LLC

Innovation Ecosystem

- Advanced Manufacturing Institutes
- National Labs
- Academia
- Industry
- Start-ups
- Private Investors

Accelerating Regional Advanced Manufacturing

NETL's Role

Innovate

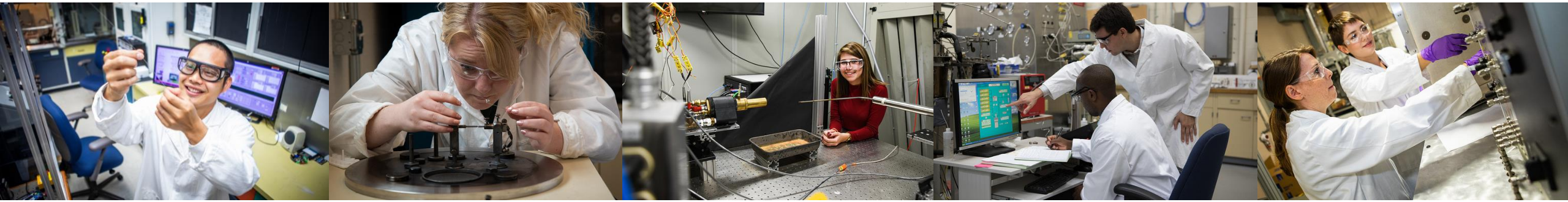
- Innovating, maturing, and deploying technologies
- Designing new standards and research procedures
- Advancing technologies to market readiness

Convene

- Bringing complementary organizations together – industry, academia, government, NGO
- Connecting technology with workforce development needs

Implement

- Systematic decision-making techniques
- Addressing market and policy drivers
- Technology systems integration

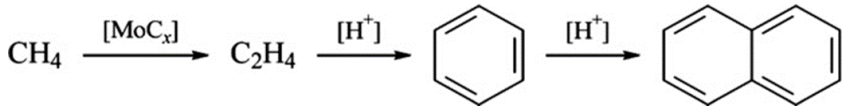


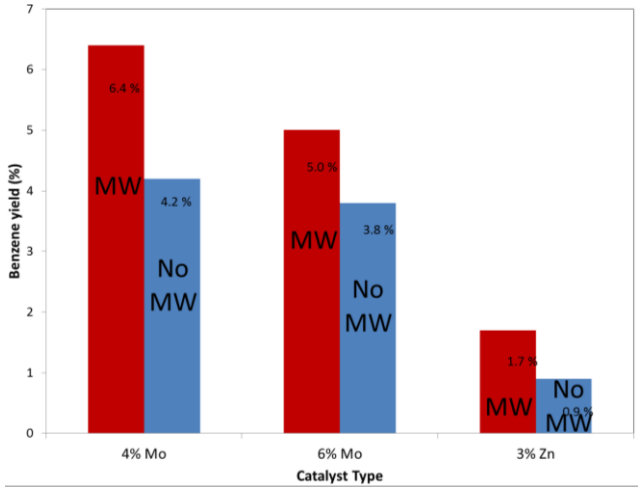
Enabling Valued-Added Chemicals from NG

RAPID Manufacturing Institute Project

Microwave-assisted Catalysis for Process Intensified Modular Production of Value-Added Chemicals from Natural Gas

Funding Agency: DOE Advanced Manufacturing Office (AMO) thru AIChE's RAPID Institute
Partners: NETL, WVU, University of Pittsburgh, and Shell
Duration: 2018-2021 (4 Year)





ReACT Facility Features

Fuel flexible – gaseous hydrocarbon fuels, coal, liquid hydrocarbon fuels, biomass, coal and biomass mixtures, and syngas

Equipped with advanced diagnostics – high-speed imaging, thermal imaging and online gas analysis

Wide range of Temperature & Pressure (1000°C/600 psi)

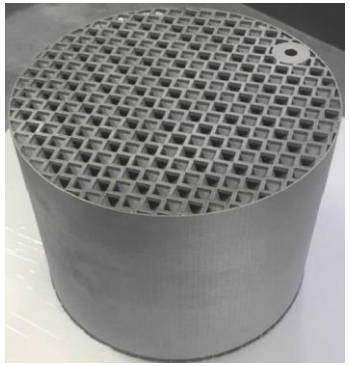
Fully automated 24/7 unattended operations

- Increase power cycle efficiency
- More power generation for less fuel
- Fewer emissions
- Optimize chemical reactor designs for specific chemical transformations

No other known facility in the world has this capability

Advanced Manufacturing for Carbon Capture Technologies

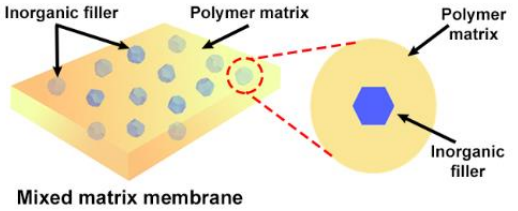
- Intensify thermodynamic operations
- Improve process performance
- Reduce equipment size
- Lowers capital and operating costs



ORNL prints intensified devices with heat exchanger integrated into pack

ION ENGINEERING

ION uses 3D Printing to develop internal absorber mass transfer and heat exchange



Using HPC, NETL predicted properties for over a million possible mixed matrix membranes

Domestic Coal for Materials Manufacturing

NETL Current Research

COAL FEEDSTOCKS
$30-60/ton

Domestic Char
(Sample from Virginia Carbonite)

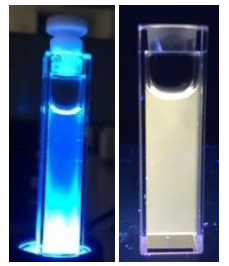
Coal Processing Technology

Graphene-Enhanced Cement

NEW ECONOMIC OPPORTUNITIES
$100,000/ton - $100,000,000/ton

Engineered Plastics

Low Cost Graphene Inks/Fluids



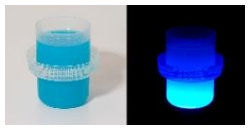
Carbon Quantum Dots

Other Possible Modern Applications for Coal-derived Carbon Materials

Stain & Water Resistant Textiles

Electronic Displays

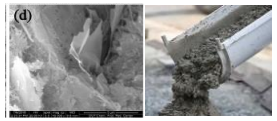
Pigments, Dyes, & Paints



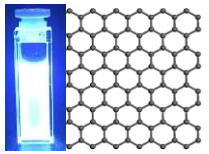
Optical Brighteners

Photovoltaics & LEDs

Carbon Fiber



Additives For Construction Materials



Carbon Nanomaterials

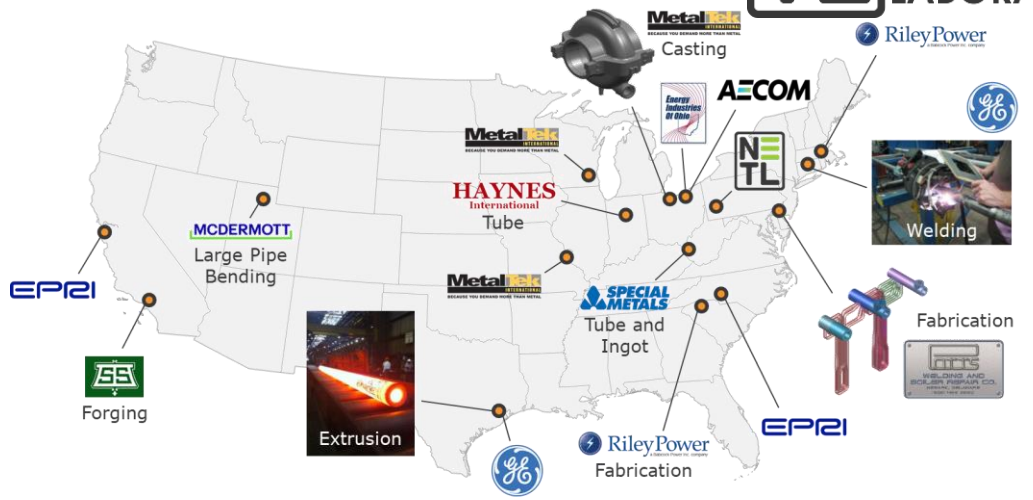
3D Printing Materials

Advanced Ultra-supercritical Technology

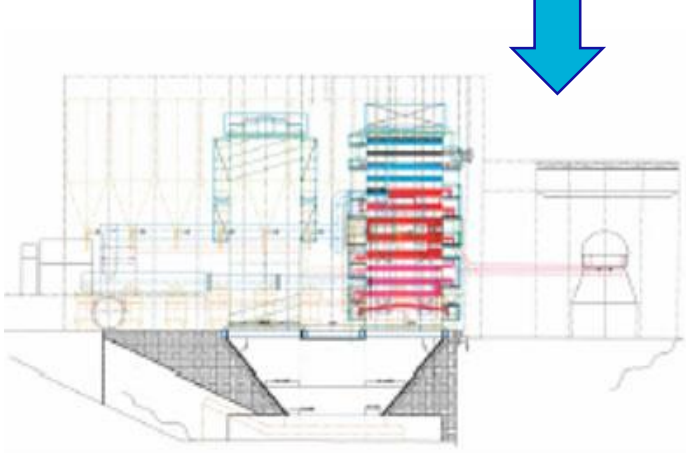
Component Demonstration

A-USC ComTest Project will lead to:

- Accelerated development of domestic supply chain for advanced materials and components
- Higher efficiency for new and existing fossil fuel plants
- Lower emissions (NO_x, SO_x, CO_2)
- Minimized risk for utilities desiring to build A-USC plants
- Design of world's first integrated A-USC steam turbine at 760°C
- Validation of technology applicable to multiple fossil, nuclear, and renewable power generation options



15 years



ComTest

Energizing Regional Innovation Through Partnerships

NATIONAL ENERGY TECHNOLOGY LABORATORY

INDUSTRY PARTNERSHIPS

covestro
RANGE RESOURCES
EQT
LG
Chevron
EATON
FirstEnergy
LONGVIEW POWER
Battelle
GE
Dominion
Shell
UES Excellence in Science & Technology
PPG
AIR PRODUCTS
AEP AMERICAN ELECTRIC POWER

GOVERNMENTAL PARTNERSHIPS

Association of Regulatory Utility Commissioners – Dedicated to Public Service – 1889
National Governors Association
National Association of Counties NACo
NASEO National Association of State Energy Officials
Oak Ridge National Laboratory
National Conference of State Legislatures – The Forum for America's Ideas
The Seal of the City of Pittsburgh – 1816 – Benigno Numine
Tri-State Shale Coalition
COAL Pennsylvania Coal Alliance

ACADEMIC PARTNERSHIPS

Tri-State University Energy (TrUE) Alliance
Case Western Reserve University
Frostburg State University
Virginia Tech
Carnegie Mellon University
The Ohio State University
Penn State
University of Maryland
Tennessee State University
West Virginia University
Tennessee Tech Golden Eagles
Marshall
University of Cincinnati
Ohio University
UK University of Kentucky
University of Pittsburgh

NONGOVERNMENT PARTNERSHIPS

Appalachia Storage & Trading HUB
Allegheny Conference on Community Development
United Mine Workers of America UMWA
America Makes
TECHCONNECT West Virginia
ShaleNET Educate, Collaborate, Succeed.
CURC Carbon Utilization Research Council – Advancing Fossil Energy Solutions
SOAR
MATRIC Market-Driven Innovation
Claude Worthington Benedum Foundation
gti
RAPID Manufacturing Institute
Marcellus Shale Coalition
ARC Appalachian Regional Commission
RAND Corporation
NRECA America's Electric Cooperatives
Southern States Energy Board
RCBI Robert C. Byrd Institute – Advancing Manufacturing Technologies

How to work with NETL

The TOOLBOX

- Cooperative Research and Development Agreement (CRADA)
- Contributed Funds-In Agreement (CFA)
- Memorandums of Understanding (MOU)/ Memorandums of Agreement (MOA)

- Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) Programs
- Unsolicited Proposals (USP)
- Non-disclosure Agreement (NDA)
- Funding Opportunity Announcement (FOA)

Available Technologies

- NETL's technology portfolio contains a broad range of innovations that have resulted from research
- Technologies and IP available for licensing on NETL's website.

Available Technologies: https://www.netl.doe.gov/business/tech-transfer/available-technologies

Funding Opportunity Announcement (FOA)

- NETL uses FedConnect.net, Grants.gov and FedBizOpps.gov to post FOAs
- Proposals and applications are only accepted electronically through FedConnect.net or Grants.gov

Funding Opportunities:

https://www.netl.doe.gov/business/solicitations

Thank You

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Director