

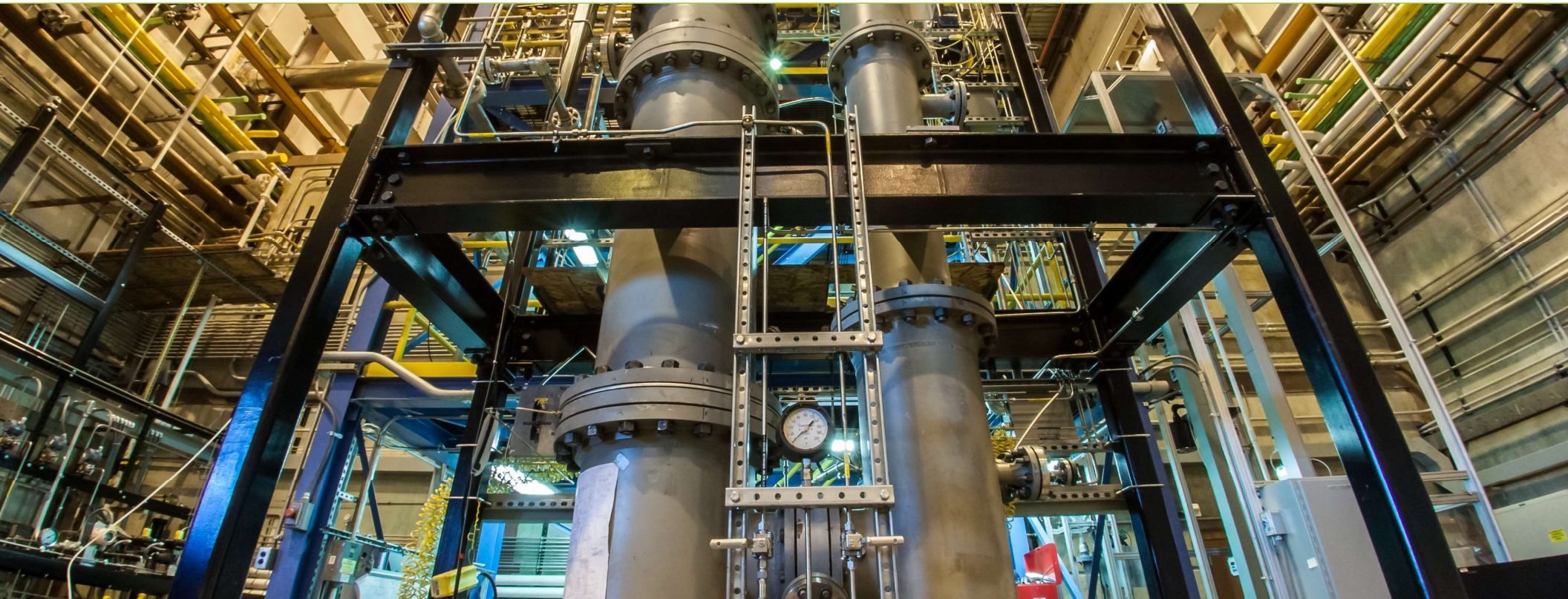
Overview of NETL Supported Topics in Transformative Power Generation



*Crosscutting Research and Advanced Energy Systems Project Review Meeting
Transformative Power Generation Virtual Session
May 11, 2021*

K. David Lyons

Technology Manager, Transformative Power Generation



MISSION

Driving innovation and delivering solutions for an environmentally sustainable and prosperous energy future:

- Ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while
- Developing technologies to manage carbon across the full life cycle, and
- Enabling Environmental Sustainability for all Americans

VISION

To be the nation's premier energy technology laboratory, delivering integrated solutions to enable transformation to a sustainable energy future.



U.S. DEPARTMENT OF
ENERGY



NATIONAL
ENERGY
TECHNOLOGY
LABORATORY

Program Relevance for the U.S. Electricity Sector



- **2021 Electricity Landscape**

- Renewable energy is increasing its market share
- Flexible power plants needed for a stable electric grid

“We have the tools to put America on an irreversible path to achieve net-zero carbon emissions by 2050.”

- **Administration Priorities**

- 50-52 percent reduction in economy-wide new greenhouse gas pollution from 2005 levels by 2030
- Zero-carbon electricity sector by 2035
- Zero-carbon economy by 2050

- **DOE-FE Approach**

- Clean, efficient, reliable, and cost competitive electricity
- Waste coal and biomass with carbon capture and storage to achieve environmental justice
- Assist environmental remediation for disadvantaged communities

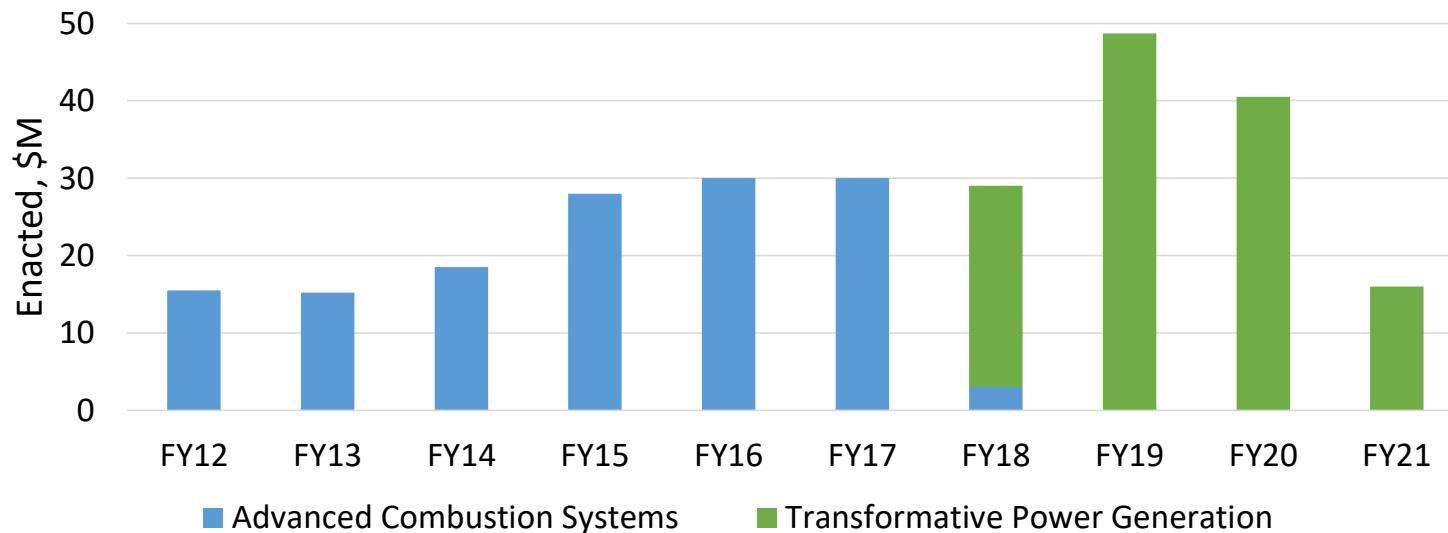


-Jennifer M. Granholm
Secretary of the U.S. Department of Energy

Transformative Power Generation and Advanced Combustion Systems Program Budget History

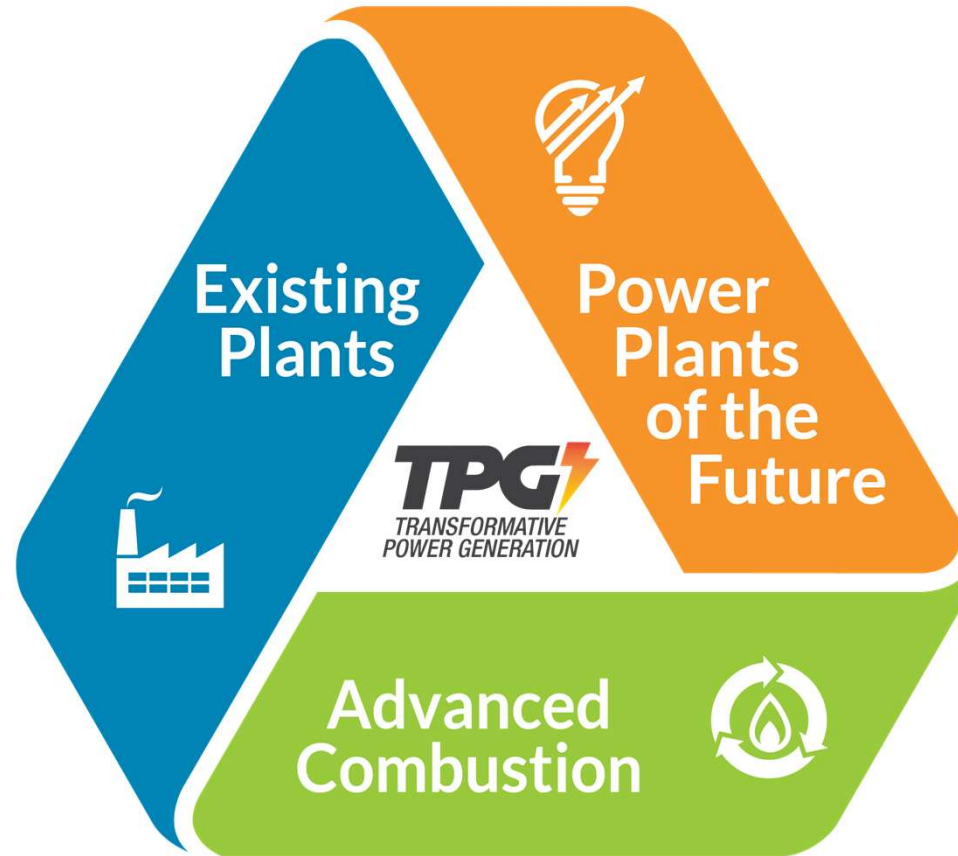


TPG Program Funding (\$M)				
	FY 18	FY 19	FY 20	FY21
Request	\$30	\$77	\$145	\$216.5
Enacted	\$26	\$48.7	\$40.5	\$16



Transformative Power Generation Program

Key Technology R&D Areas

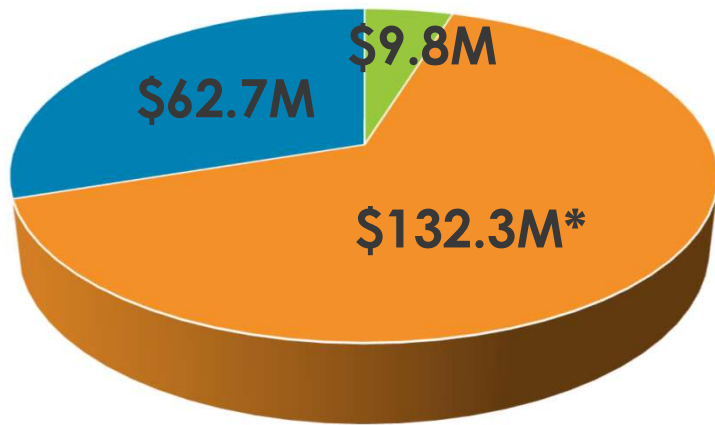


Key Technology R&D Areas



Transformative Power Generation

Active Project Value

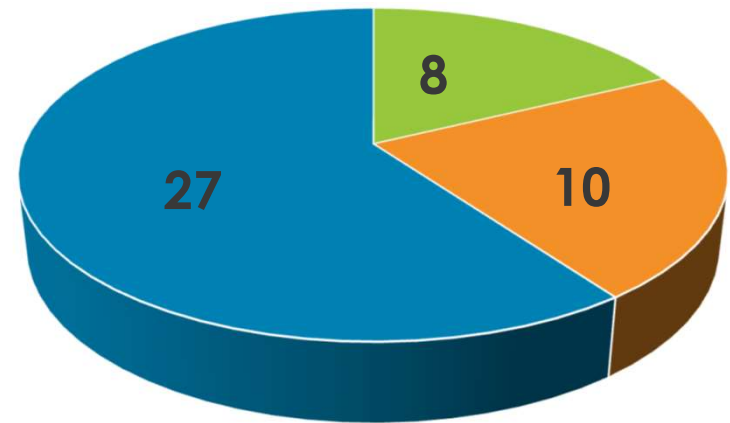


\$204.7M total portfolio

Power Plants of the Future Projects

- * Co-funded w/ other NETL Programs
- * \$75.9M in mortgages remain

Active Project Count



45 projects in portfolio

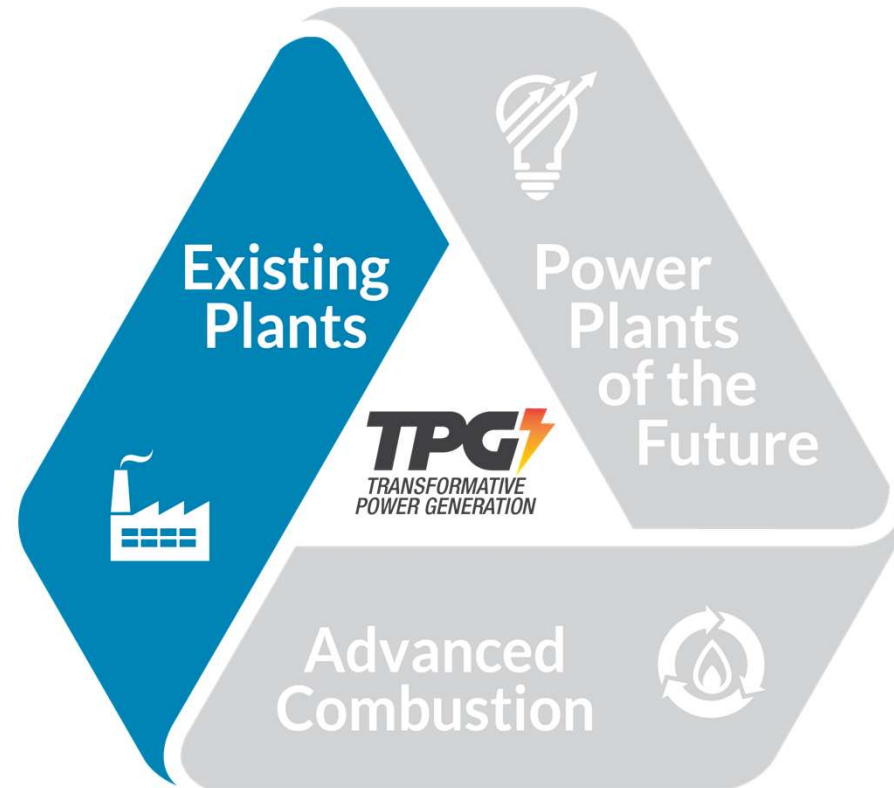
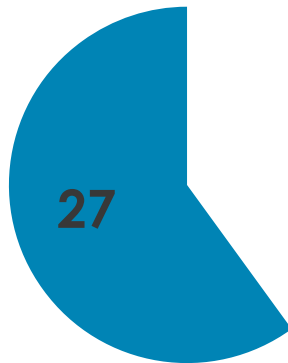
- Advanced Combustion
- Power Plants of the Future
- Improvements for Existing Plants

Improvements for Existing Plants

Active Project Value



Active Project Count



Coal Fleet R&D – Challenges and Focus



Mid 2000s – Baseload coal plants began being deployed as load-following units



2010s – Performance and equipment degradation acceleration results in increased forced outages



2020s – Assist plants with improving:

- Increased flexibility
- Improved reliability
- Optimized efficiency



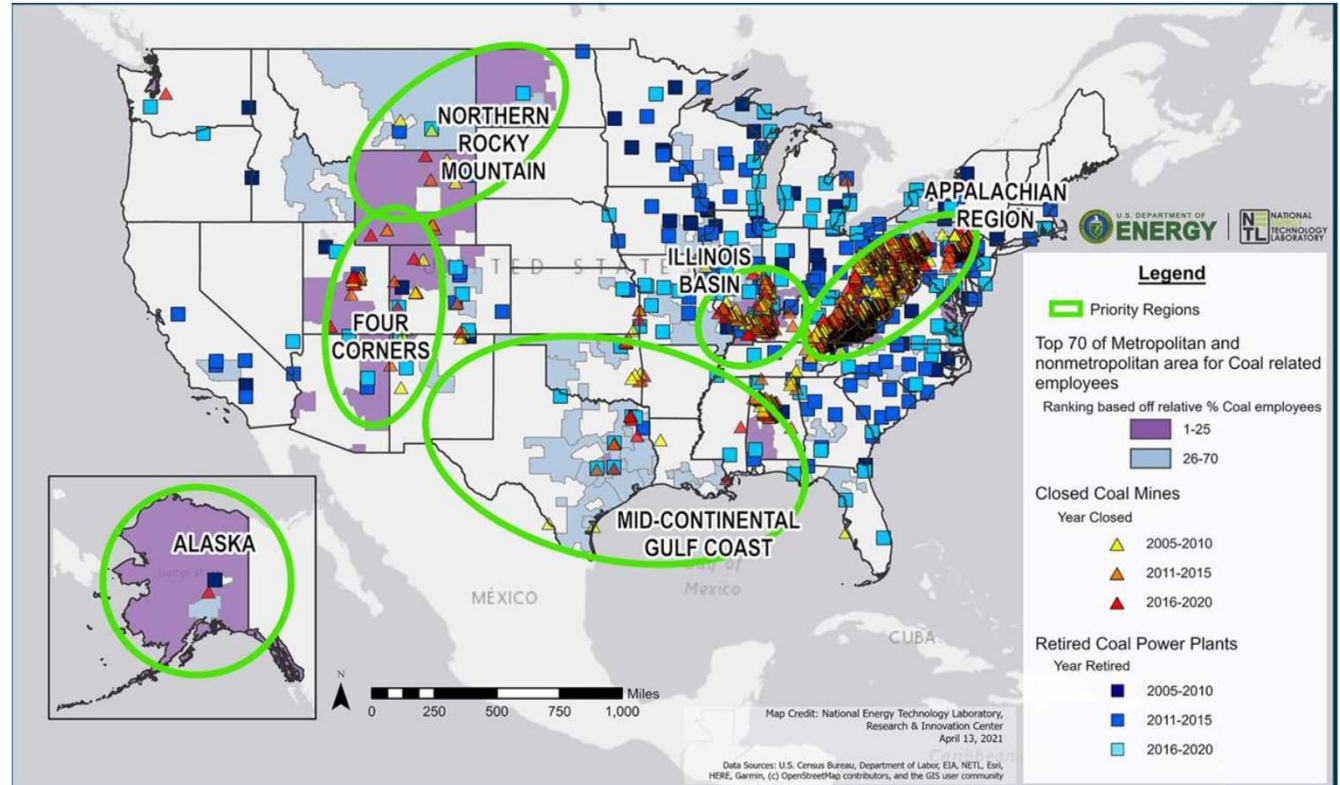
Priority Energy Communities

Empowering Workers Through Revitalizing Energy Communities



- **Initial Report Highlights Priority Regions:**

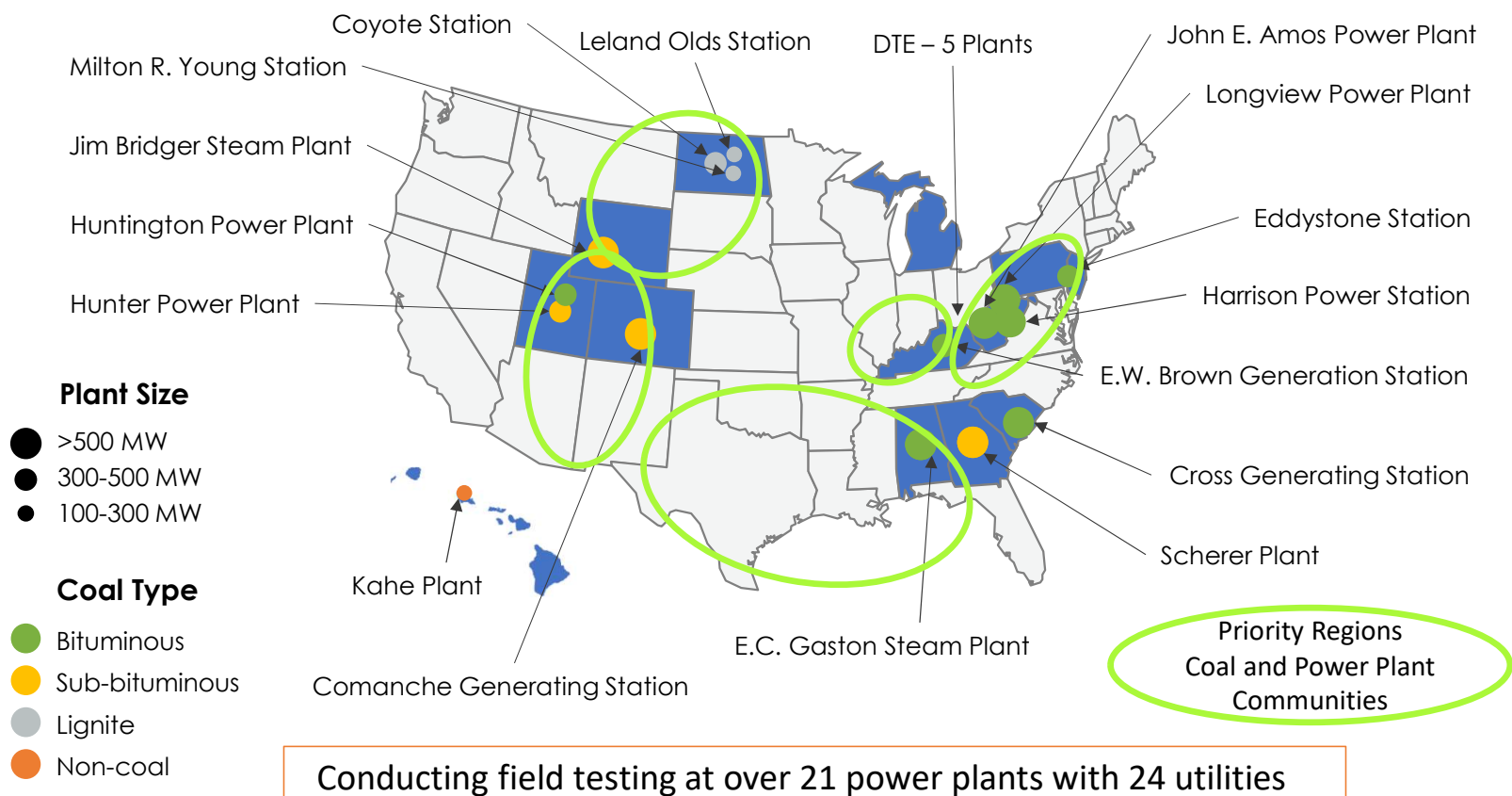
- Areas Impacted by coal mine & power plant closures
- Opportunities for job-creating investments



“Initial Report to the President on Empowering Workers Through Revitalizing Energy Communities,” April 2021.

https://netl.doe.gov/sites/default/files/2021-04/Initial%20Report%20on%20Energy%20Communities_Apr2021.pdf

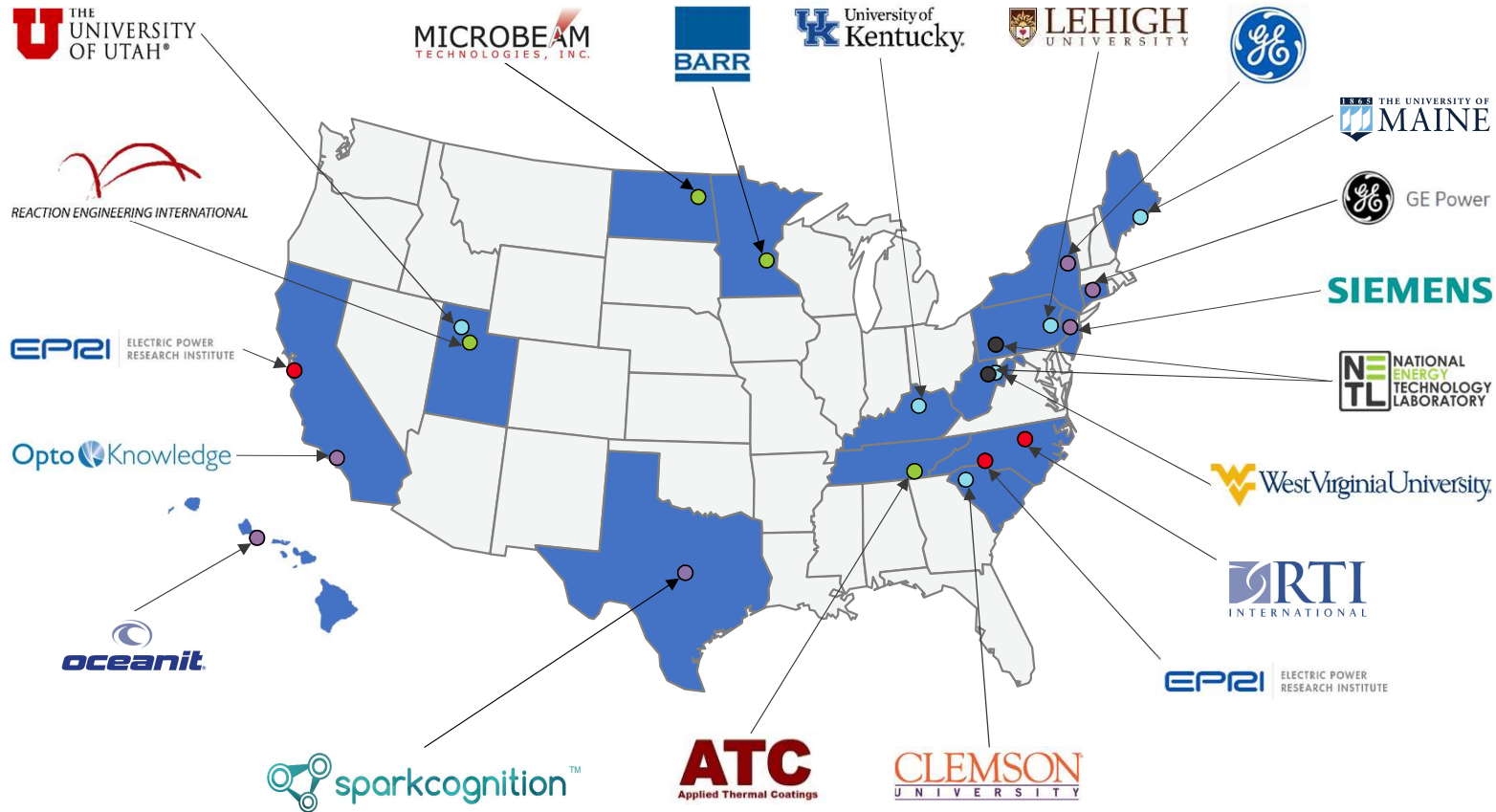
Improvements for Existing Plants Projects Plant Test Sites



Technologies in Development

- Advanced Sensors (incl. temperature, corrosion, wireless, real-time, combustible gases, ash deposition)
- Reduced Low-load Technology
- Online Coal Analyzer
- Advanced Ash Management
- Dynamic Plant Control Systems for Improved Transient Operation
- Coatings for Reliability and Efficiency
- Condition-based Monitoring Systems
- Energy Storage
- Dynamic Plant Models
- Online System Identification
- Energy Systems & Market Analysis

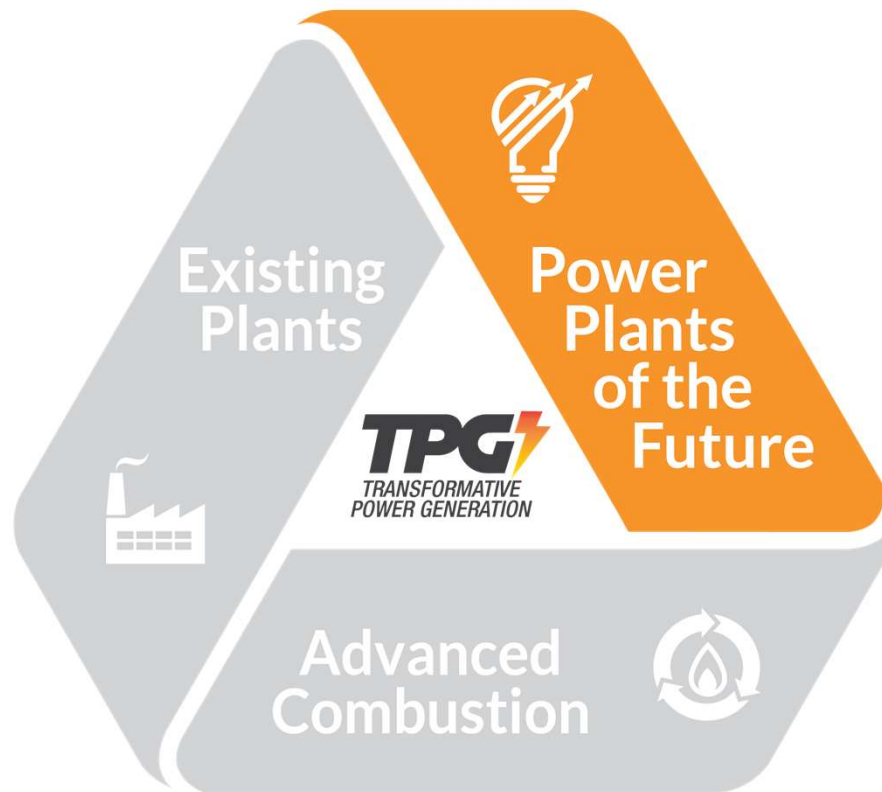
Improvements for Existing Plants Projects



ORGANIZATION TYPE (# includes partners)

- Service Provider (26)
- Equipment Manufacturer (15)
- Coal Company (1)
- Research Institute (4)
- University (18)
- National Laboratory (3)
- Utilities (24)

Power Plants of the Future



Active Project Count



Active Project Value



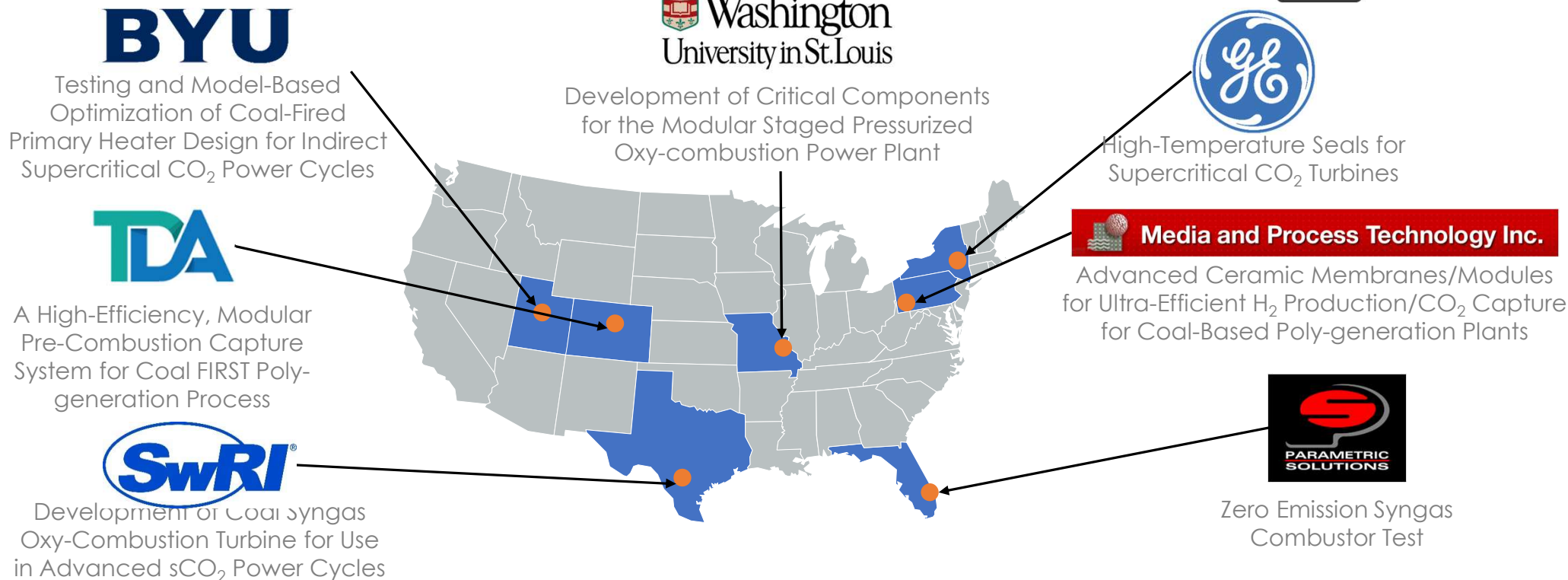
Recent Financial Assistance and Acquisition Activities



Power Plants of the Future

Title	Objective	Funding (DOE/Total)	Issued	Closed
RFP No. 89243319RFE000015 "Coal-Based Power Plants of the Future"	Develop the program's conceptual design with an option to conduct preliminary front-end engineering design (Pre-FEED) studies.	\$9.8M/ \$9.8M	Nov 12, 2018	Jan 25, 2019
FOA-2057 "Critical Components for Coal FIRST Power Plants of the Future"	Development of critical components that will support potential designs for coal-based power plants of the future.	\$36M/\$46M	Feb 7, 2020	Apr 13, 2020
FOA-0002180 "Design Development and FEED Studies for Coal FIRST Systems"	To make available up to ~\$81 million for cost-shared R&D projects focused on performing Front End Engineering Design (FEED) studies for the Coal FIRST plant with allowances for limited design development.	\$83M/\$104M	DRAFT: May 18, 2020 FINAL: July 17, 2020	Aug 26, 2020

Critical Components R&D



Brigham Young University and Washington University in St. Louis are in the TPG Portfolio.
Other five are supported by other FE programs.

Design Development and FEED Studies



Front-End Engineering Design Study for Hybrid Gas Turbine and USC Coal Boiler Concept (HGCC) Plant with Post Combustion Carbon Capture and Energy Storage System at City, Water, Light and Power Plant



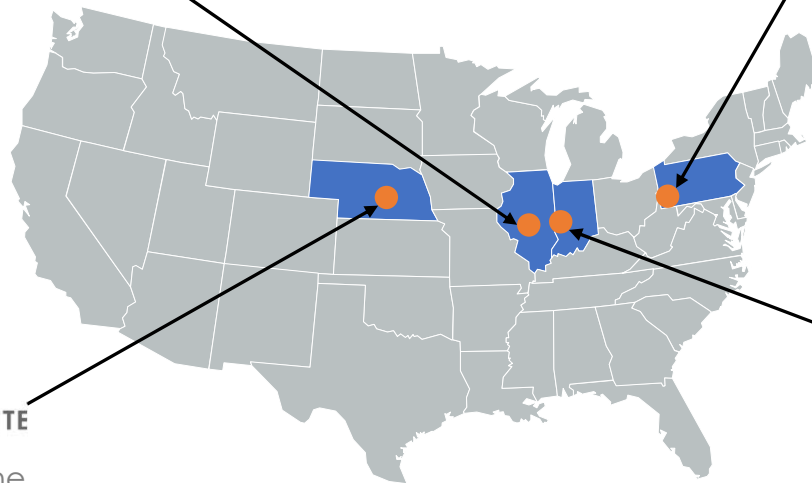
Design Development and System Integration Design Study for an Advanced Pressurized Fluidized Bed Combustion Power Plant with Carbon Capture



Gasification of Coal and Biomass: The Route to Net-Negative-Carbon Power and Hydrogen



Wabash Hydrogen Negative Emissions Technology Demonstration



All four are co-funded with other FE programs.

Transformative Power Generation

Advanced Combustion R&D



Active Project Count



Active Project Value



Advanced Combustion Technologies

Chemical Looping Combustion



Magnesium oxide (MgO)-promoted
Hematite Oxygen Carrier
NETL Research and Innovation Center

Pressurized Oxy-combustion



100 kW Prototype Staged
Pressurized Oxy-combustor
Washington University in St. Louis

Pressure Gain Combustion



Coal RDE test fire
University of Central Florida

Environmental Justice and Remediation



Current TPG Projects

- **Consol** – FEED Study for an Advanced Pressurized Fluidized Bed Combustion Power Plant with Carbon Capture
 - Wide range of solid fuels, including biomass and waste coal
 - Potential for 7% net-negative with 10% biomass co-firing
- **EPRI** - Gasification of Coal and Biomass FEED Study
 - Evaluating use of multiple forms of biomass and waste plastics
 - Potential for up to 9-12% net-negative CO₂ emissions
 - Produces syngas and “blue” hydrogen
- **Wabash** – Hydrogen Negative Emissions Technology Demonstration FEED Study
 - Co-firing woody biomass, agriculture residue and petroleum waste (plastics)
 - Potential for up to 3.2% net-negative CO₂ emissions
 - Produces “blue” hydrogen
- **TDA Research** – Direct Combustion of Fine Coal from Coal Waste
 - Uses discarded coal waste generated by washing the coal at the mines
 - Over 2.5 billion tons of currently unusable fuel can be turned into electricity while remediating abandoned coal waste sites

TPG is developing technologies for...



- Flexible power plants needed for a stable electric grid
- Clean, efficient, reliable, and cost competitive electricity
- Carbon capture and storage to achieve Administration priorities
- Environmental remediation for disadvantaged communities



Questions?

VISIT US AT: www.NETL.DOE.gov

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 <https://netl.doe.gov/coal/tpg>

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Improvements for Existing Plants Accomplishments



- ✓ Conducting field testing at over 21 power plants with 24 utilities
- ✓ Installed extended low-load boiler system
- ✓ Tested online coal tracker with combustion system performance prediction
- ✓ Tested wireless temperature and corrosion sensors
- ✓ Tested ultrasonic sensors for real-time temperature profiles
- ✓ Detected and diagnosed pre-mature equipment failure using machine learning
- ✓ Tested improved condenser coating technology

Biomass and Coal Wastes Combustion with Carbon Capture



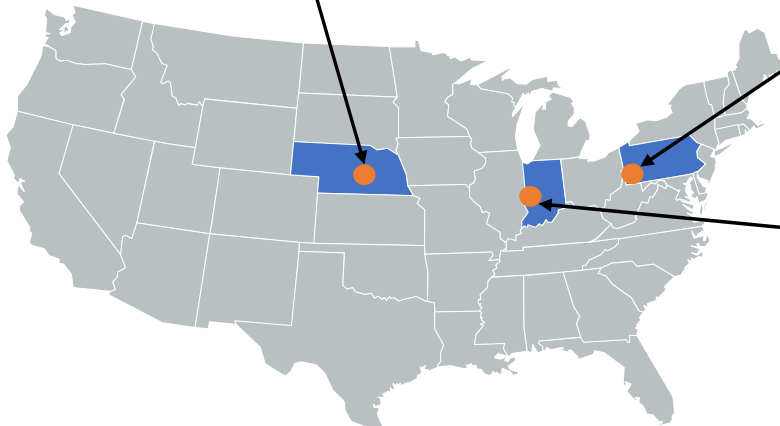
Current FEED studies



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Wabash Hydrogen Negative Emissions Technology Demonstration

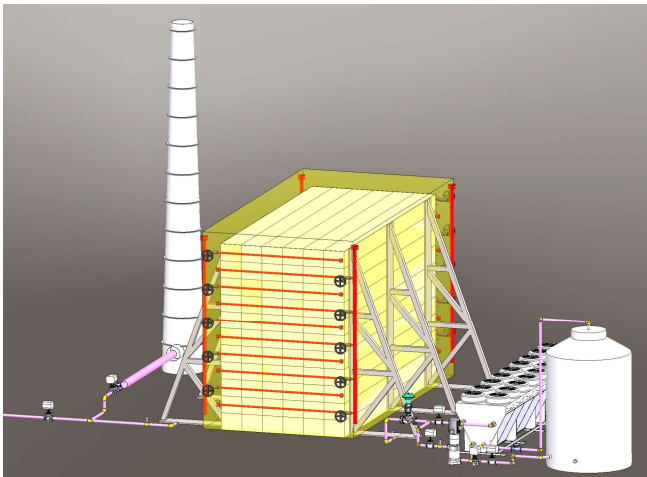
Green Infrastructure

Energy Storage



EPRI

Application: Concrete Thermal Energy Storage
Enabling Flexible Operation Without Coal
Plant Cycling



Initial 3D Model of the Concrete Thermal Energy
Storage Pilot Unit

Lehigh University

Thermal Energy Storage Utilizing Thermosiphons
and Cementitious Materials



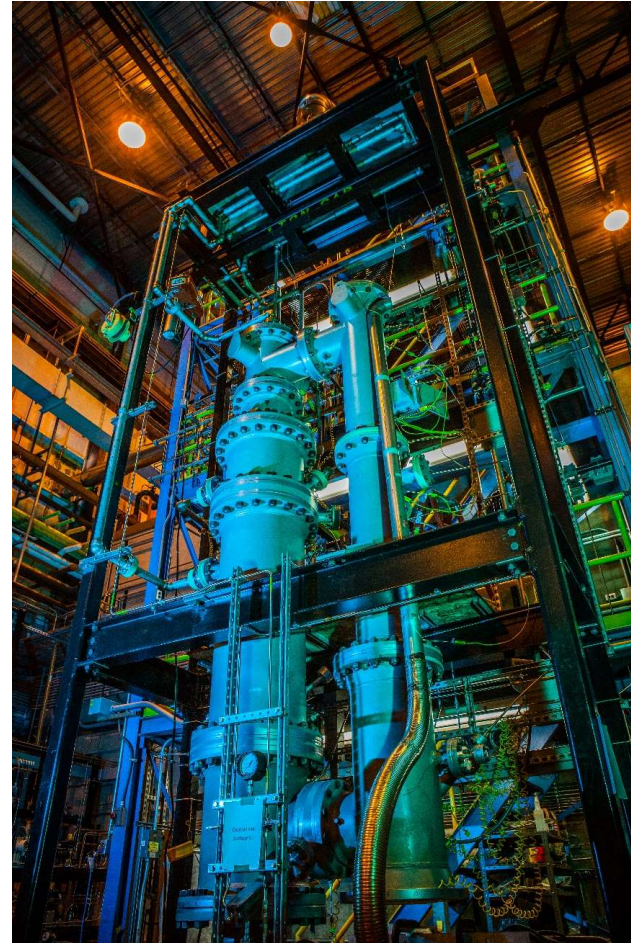
Significant combustion pilot facilities in past work



Alstom 5-MWe Oxy-Combustion Pilot



Alstom 1-MWe CLC Pilot



NETL CLC Reactor