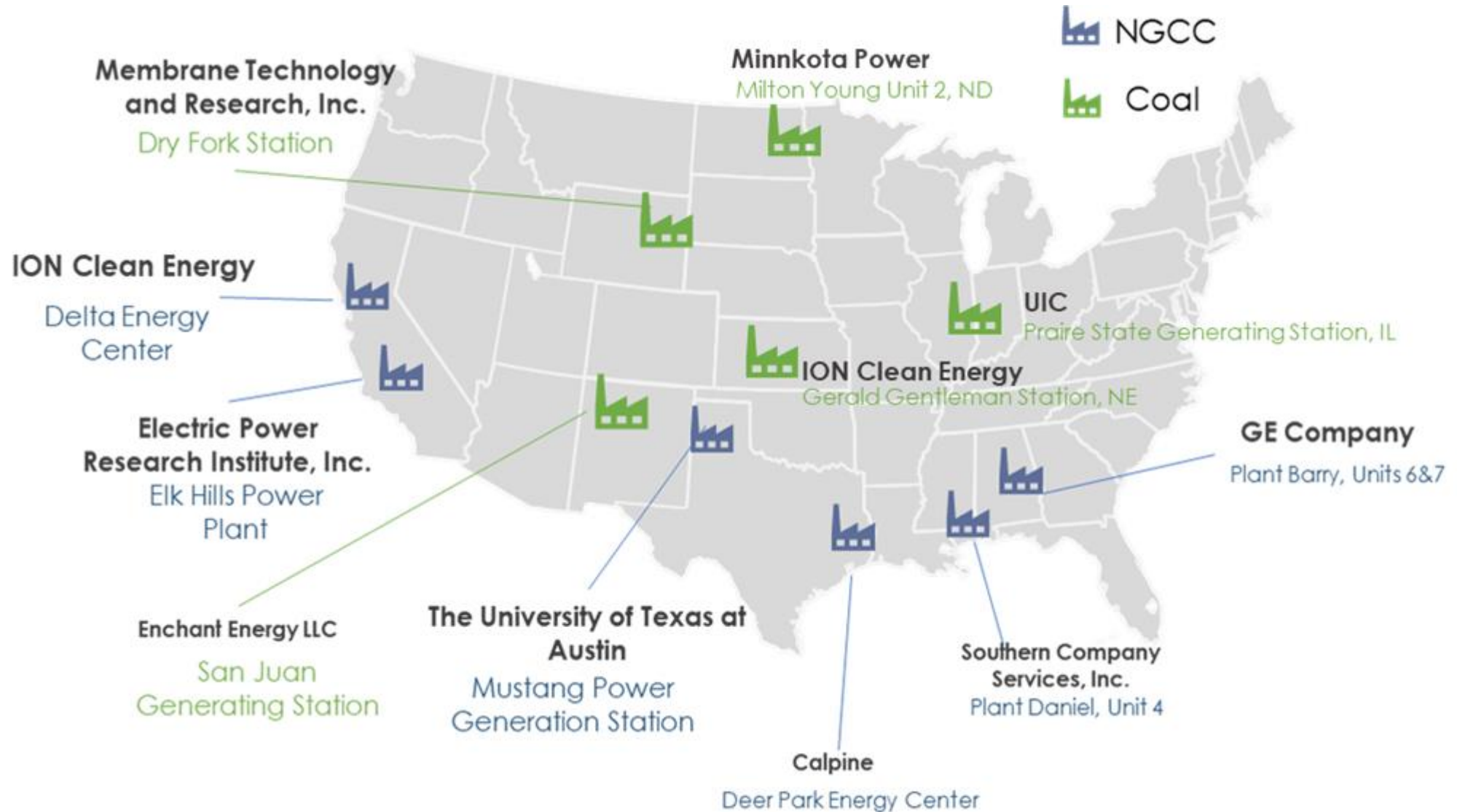
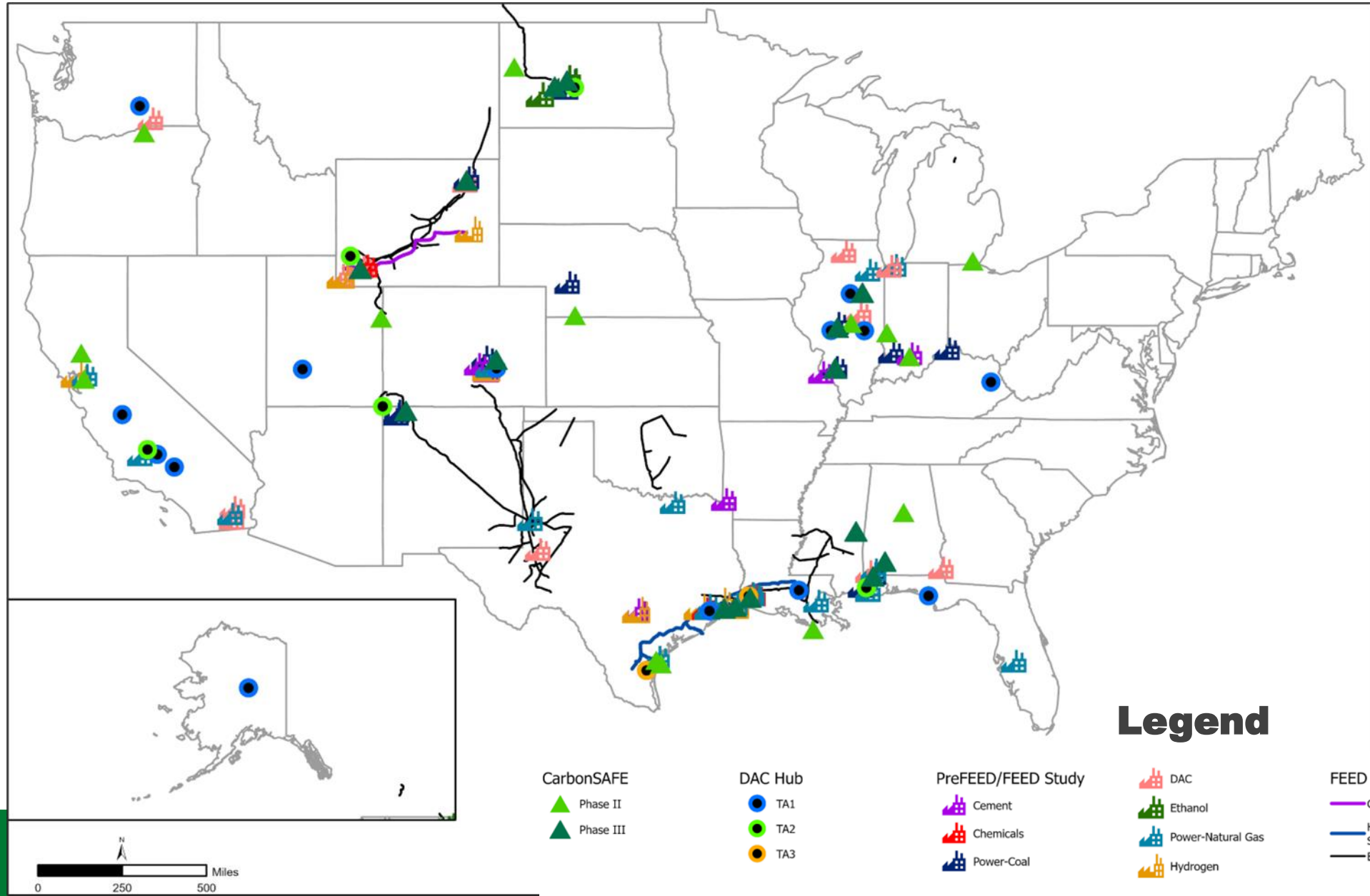




# Completed Power Plant FEED Studies



# Industrial Decarbonization FEEDs & CarbonSAFE



# Seven Regional Hydrogen Hubs Selected

## Bipartisan Infrastructure Law

- Two Hubs in regions with large natural gas resources.
  - Gulf Coast, Appalachian
- Four Hubs with large Carbon Management Component
  - Gulf Coast, Appalachian, Midwest, Heartland



# Current OCED Power CCS Demo Awards

	Sector	Fuel	Host Site	Capacity	CO2 Technology
Duke Energy Indiana, LLC	Electricity Generation	Coal/NG	Duke Energy Edwardsport	3.6 MTA CO2	Honeywell, UOP
Entergy Services, LLC	Electricity Generation	NG	Lake Charles Power Station	2.5 MTA CO2	MHI, KS-21
Navajo Transitional Energy Company, LLC (NTEC)	Electricity Generation	Coal	Four Corners Power Plant (FCPP)	10+ MTA CO2	MHI, KS-21
Taft Carbon Capture, LLC	CHP	NG	Taft cogeneration power plant	3 MTA CO2	Post combustion capture, solvent
Tampa Electric Company	Electricity Generation	NG	Polk Power Station in Mulberry, Florida	3.7 MTA CO2	ION, post combustion capture
University of Illinois at Urbana-Champaign	Electricity Generation	Coal	Dallman 4, PC coal power plant at City Water, Light and Power in Springfield, Illinois	2 MTA CO2	Linde-BASF

# Pre-Commercial – H<sub>2</sub> FEEDS

## Steam Methane Reforming



Linde-BASF technology using OASE® blue solvent

## Advanced CCS Systems for SMR



*Svante VeloxoTherm™ solid adsorbent at Linde SMR H<sub>2</sub> plant*

- ▶ ~1,100,000 tonnes/year net CO<sub>2</sub> capture
- ▶ **90% Capture Efficiency**
- ▶ **Production of “blue” H<sub>2</sub> with 99.97% purity**



*Gen 1 CCS technology at Phillips 66 refinery in Rodeo, California*

- ▶ **Separate & store ~190,000 tons/year net CO<sub>2</sub> from hydrogen production unit with >90% carbon capture efficiency**

## Advanced CCUS +for ATR



*CO<sub>2</sub> Capture Unit at Tallgrass MLP Operations LLC's Planned Blue Bison ATR Plant*

- ▶ **Separate and store 1.66 million tonnes/year of 95% pure CO<sub>2</sub> with >97% carbon capture efficiency**
- ▶ **System combining carbon capture, H<sub>2</sub> production (220 MMSCFD at 99.97% purity), and H<sub>2</sub> combustion in auxiliary burners**



*CCS system at the Painter Gas Complex, WY*

- **100 million SCF per day of 99.97%-pure hydrogen**
- **Capture 90–99% of CO<sub>2</sub> emissions.**
- **Three design cases implementing the subsystems and equipment of the 8RH2 ATR technology and a CO<sub>2</sub> separation unit, are being evaluated.**

# FEED Studies on Existing Energy Assets

## Electric Power Research Institute, Inc. (Palo Alto, CA)

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

Integrated design study on an oxygen-blown gasification system coupled with water-gas shift, pre-combustion CO<sub>2</sub> capture, and pressure-swing adsorption working off a waste coal/biomass mix to yield high-purity hydrogen and a fuel off-gas that can generate power.

- Nebraska Public Power District Sheldon Station coal fired plant
- CO<sub>2</sub> Storage: enhanced oil recovery and saline sequestration
- Co-feed corn stover, possibly other biomass and waste plastics



## Wabash Valley Resources, LLC (West Terre Haute, IN)

### *Wabash Hydrogen Negative Emissions Technology*

Complete system integrated design study for redeveloping the existing Wabash Valley Resources coal gasification site in West Terre Haute, Indiana, into a 21<sup>st</sup> century power plant for flexible fuel gasification-based carbon-negative power and carbon-free hydrogen co-production.

- Facility: Wabash Gasification Facility
- CO<sub>2</sub> Storage: Saline sequestration
- Co-feed woody biomass and/or agricultural residue and waste plastics





# Financing to Enable Deployment at Scale

## Loan Programs Office (LPO) has \$40 Billion in Available Debt Capital

LPO announced loan guarantee conditional commitments for 2 clean hydrogen projects

**MONOLITH**

HALLAM, NEBRASKA

Employing innovative carbon black reactor technology, Monolith is a pioneering clean hydrogen and carbon utilization project.

**LOAN GUARANTEE: CONDITIONAL COMMITMENT**

FINANCED BY U.S. DEPARTMENT OF ENERGY

**LPO** Loan Programs Office

**ADVANCED CLEAN ENERGY STORAGE**

DELTA, UTAH

First-of-its-kind hydrogen production and storage facility capable of providing long-term seasonal energy storage.

**LOAN GUARANTEE: CONDITIONAL COMMITMENT**

FINANCED BY U.S. DEPARTMENT OF ENERGY

**LPO** Loan Programs Office

**\$1.04B** for the first-ever commercial-scale project to deploy methane pyrolysis technology. Will enable 1,000 construction jobs and 75 operations jobs. (December 2021)

**\$504.4M** for large-scale hydrogen energy storage, 220 MW electrolysis and turbine. Will enable up to 400 construction jobs and 25 operations jobs. (April 2022)

[LPO@hq.doe.gov](mailto:LPO@hq.doe.gov)



# Previous Industry Advanced Turbine Awards

## FY 22 Industry Awards (\$28 M) – Hydrogen Combustion Focus

- Develop combustion modules for F-class, aeroderivative and industrial scale turbines
- Develop retrofit technologies
- Apply to 100% hydrogen & natural gas / hydrogen blends
- Assess ammonia fuels
- Advance application of rotating detonation combustion systems for power generation
- Advance hydrogen combustor technology to next stage of testing & demonstration

Performer	Title	Total Funding (\$M)
Solar Turbines	Development of a Retrofittable Dry Low Emissions Industrial Gas Turbine Combustion System for 100% Hydrogen and Natural Gas Blends	5.6
GTI	Investigation of Ammonia Combustion for Turbines (IACT)	4.1
General Electric Company	Advanced Mixed Mode Combustors for Hydrogen F-Class Retrofit	15.0
GE Research	Demonstration of a Gas Turbine-Scale RDC Integrated with Compressor and Turbine Components at 7FA Cycle Conditions	8.7
Raytheon Technologies	Development of Hydrogen Burner for FT4000 Aeroderivative Engine	6.0
Raytheon Technologies	Low-NOx, Operable Ammonia Combustor Development for Zero-Carbon Power (LOAD-Z)	4.2

# Previous UTSR Advanced Turbine Awards

## FY 21 UTSR Awards (\$6.2 M) – Hydrogen Combustion Focus

- Hydrogen Combustion Fundamentals for Gas Turbines
  - *Georgia Tech Research Corporation*
  - *The University of Central Florida*
  - *San Diego State University*
- Hydrogen Combustion Applications for Gas Turbines
  - *Purdue University*
  - *The Ohio State University*
  - *University of California, Irvine*
- Hydrogen-Air RDE
  - *The University of Alabama*
  - *Purdue University*

### What will be done:

- Explore chemical kinetics
- Investigate NO<sub>x</sub> & flame strain rate
- Investigate ignition delay times
- Measure flame speed
- Evaluate existing fuel injectors
- Flame structure and combustion dynamics for H<sub>2</sub> & NH<sub>3</sub> fuels
- Assess RDE combustion modes
- Develop design rules for micromixer injectors
- Develop CFD design tools



U.S. DEPARTMENT OF  
**ENERGY**

Fossil Energy and  
Carbon Management

# Thank You!

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