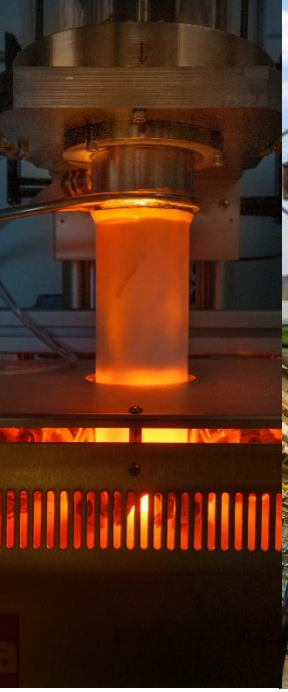
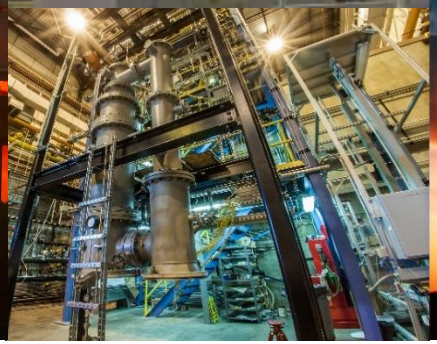
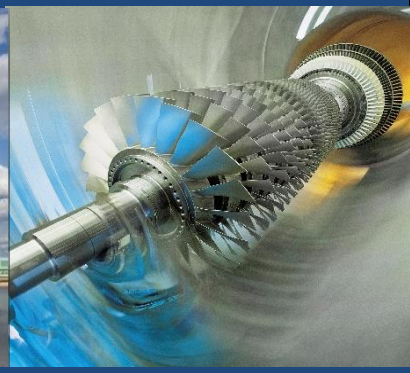




U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

The Future of Coal

"Carbon Free Fossil Energy"

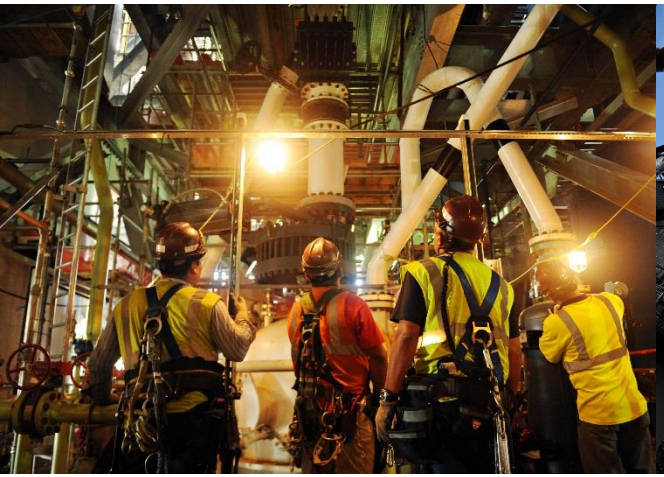
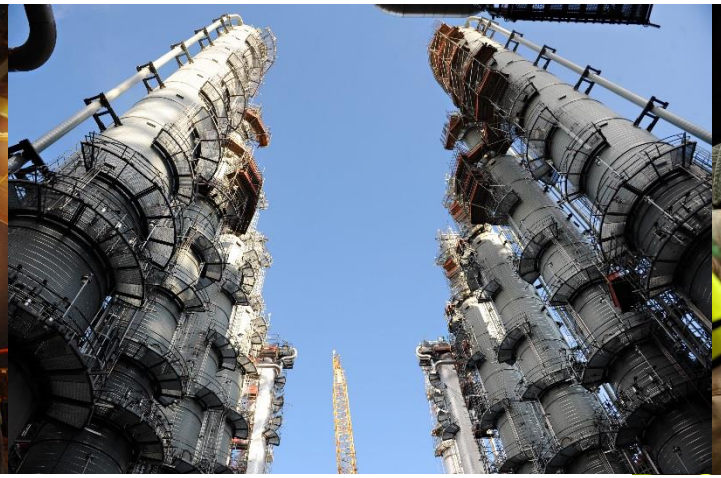
National Association of Regulatory Utility Commissioners
Winter Meeting
February 12th, 2019

Lou Hrkman

Deputy Assistant Secretary
Clean Coal and Carbon Management

Administration Energy Priorities

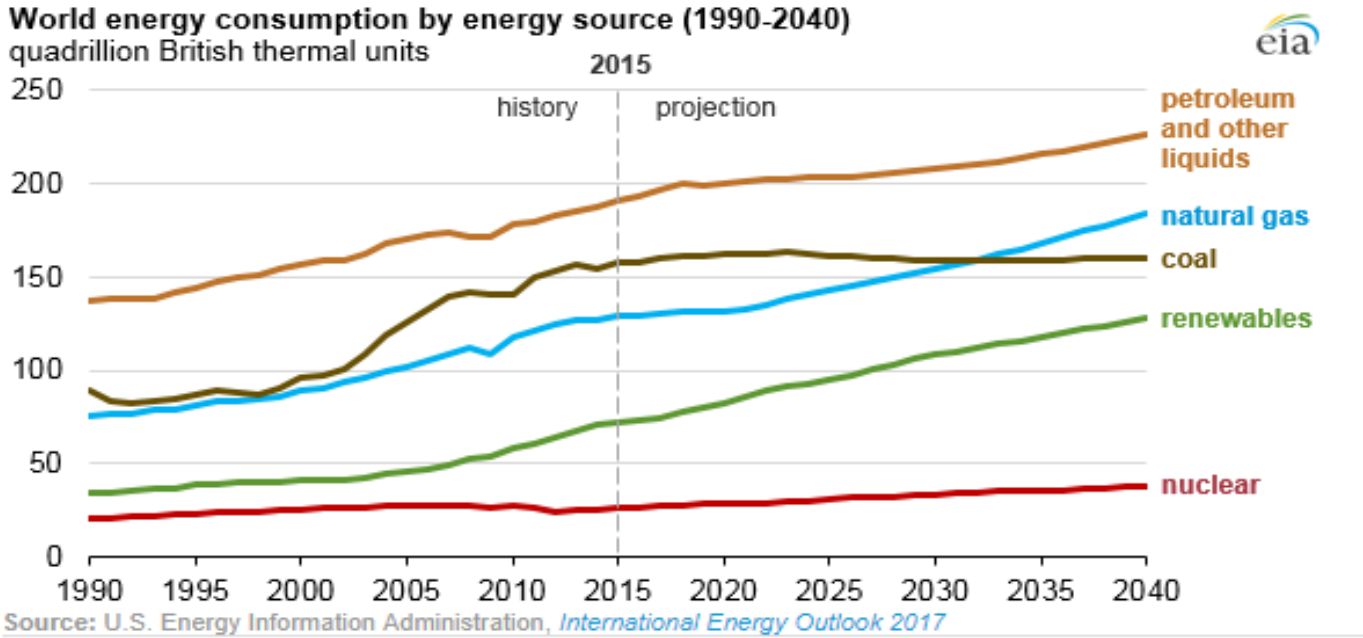
- Boosting Domestic Energy Production
- Grid Reliability and Resiliency
- Job Creation
- Energy Security


“All of The Above Strategy”

The World is Hungry for Energy

EIA projects 28% increase in world energy use by 2040

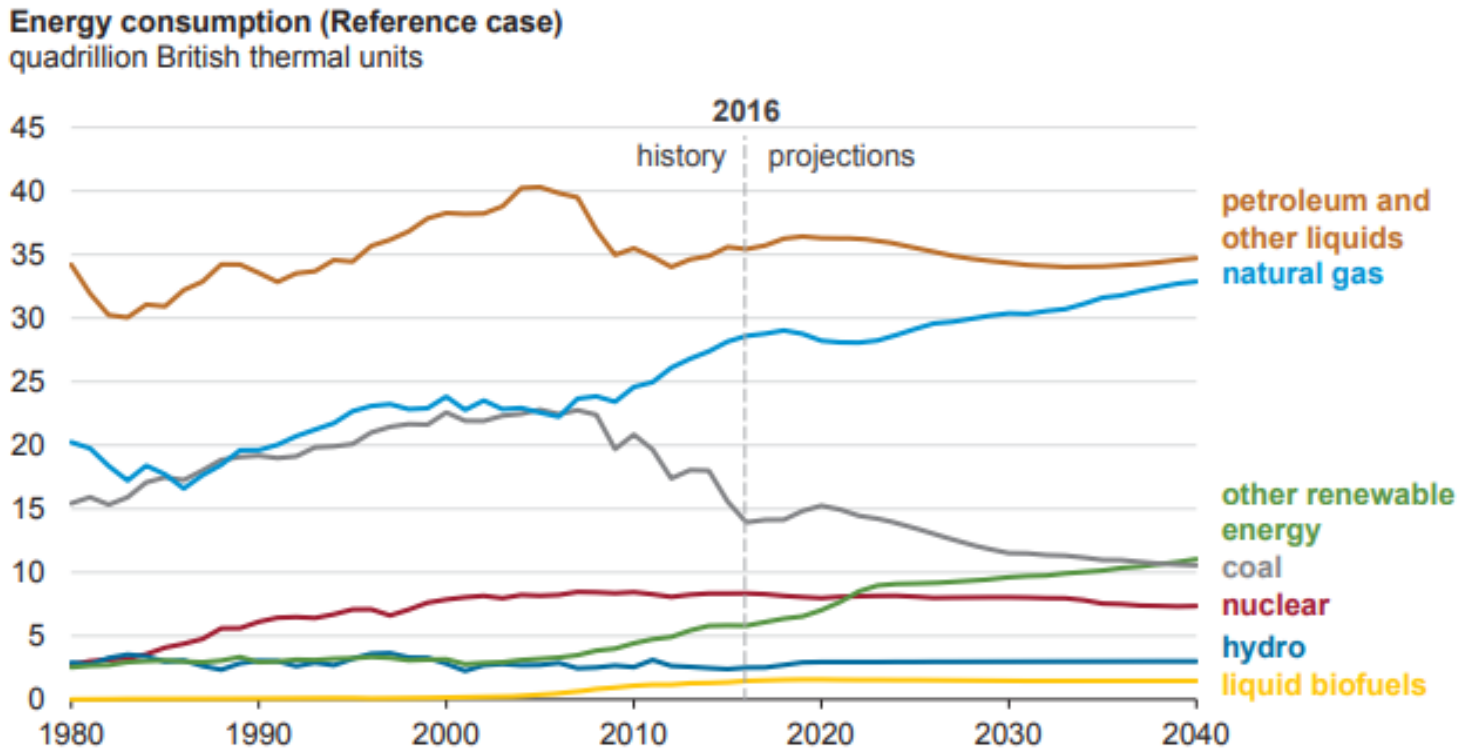


Asia (which includes China and India) accounts for more than 60% of the world's total increase in energy consumption from 2015 through 2040.

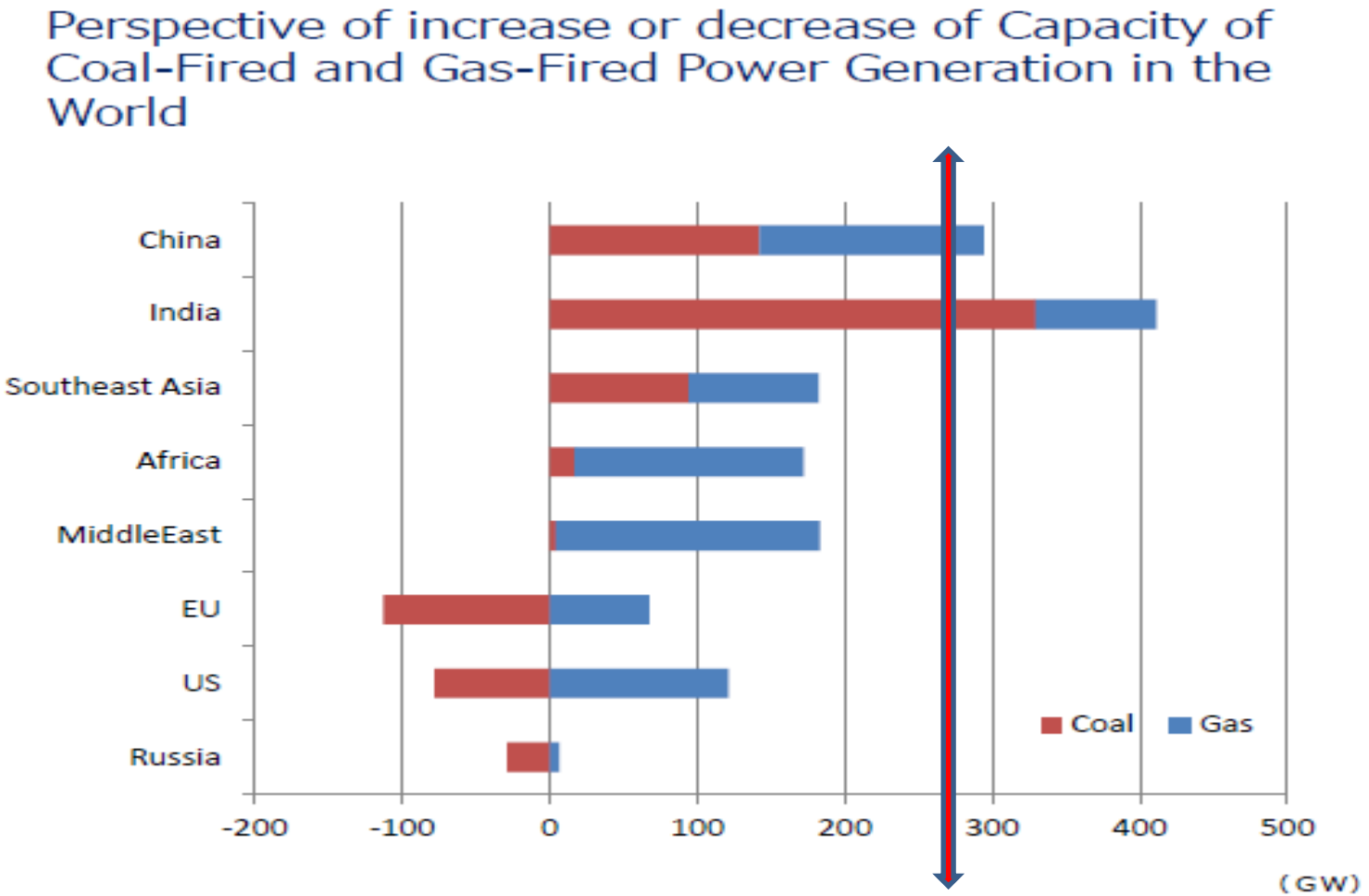
"Fossil fuels will still account for more than 3/4ths of the world's energy consumption through 2040"

The World Will Require CCUS technologies

Domestic Energy Consumption to 2040



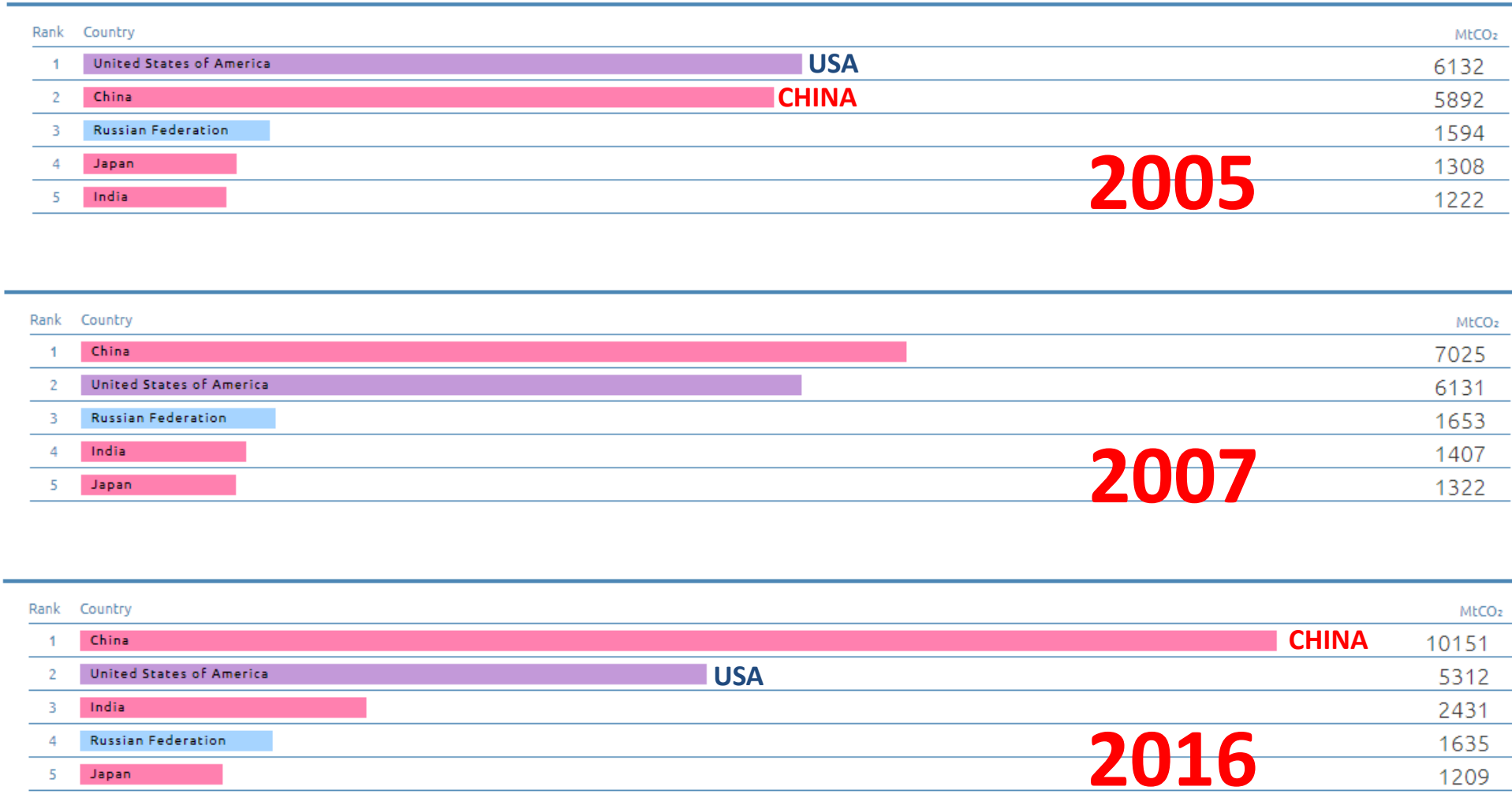
2040 Outlook



Point of Comparison
Today-US ~260 GW

(Source: IEA World Energy Outlook 2017)

GHG Emissions by Country 2005-2017



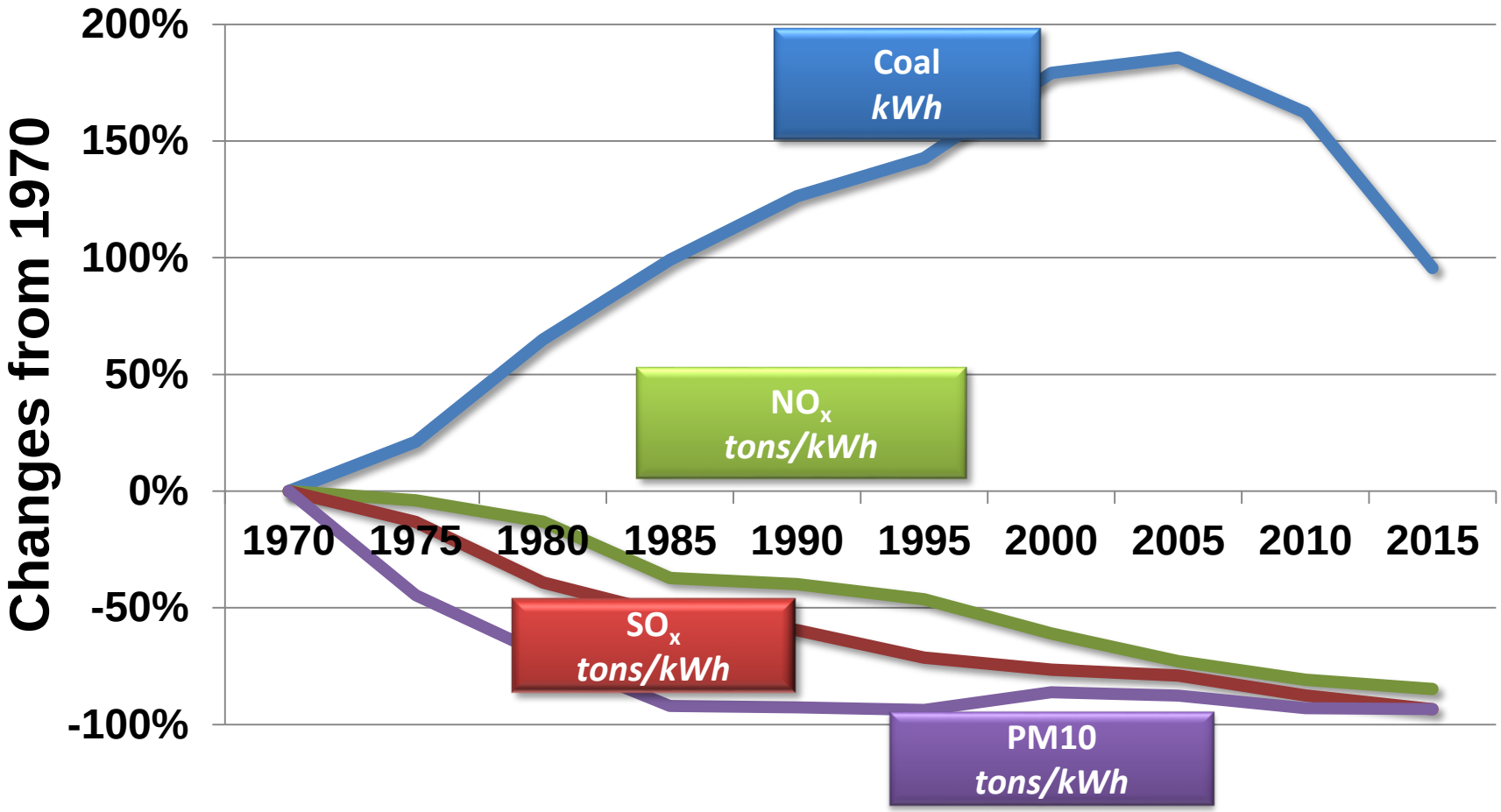
Source—Global Carbon Atlas

History of Successful DOE R&D to Advance Emission Controls

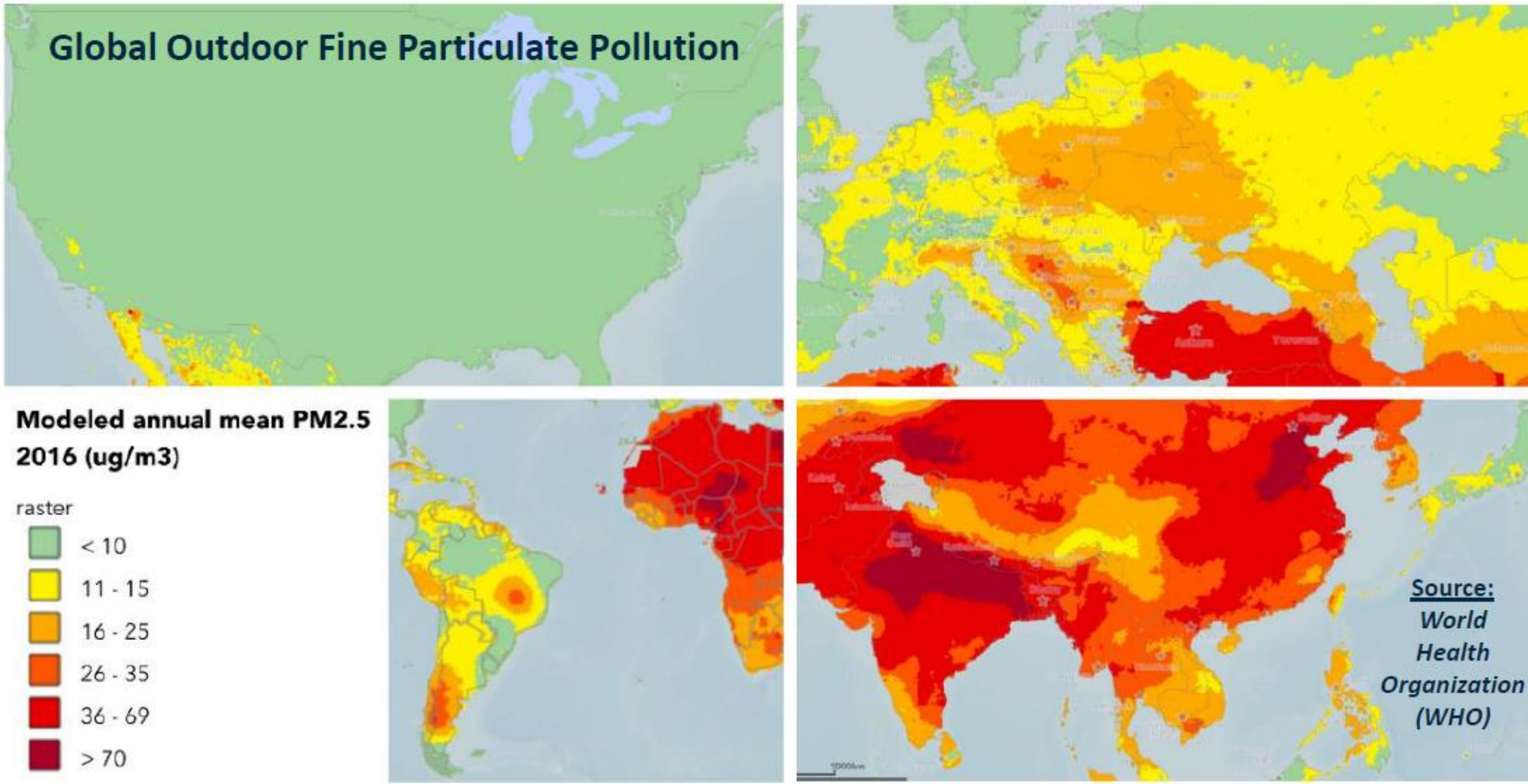
DOE has a history of advancing commercially successful R&D, with national economic and environmental benefits. For example:

- Low NOx burners developed by DOE are installed commercially on about 75% of U.S. coal-fired power plants;
- Selective Catalytic Reduction (SCR) technologies developed through DOE programs are now commercially installed on about half our nation's coal fleet;
- Multi-pollutant control technologies including mercury have experienced significant sales in the commercial market; and
- Technologies to help recycle coal combustion products (Coal Ash) were developed through DOE programs and a large commercial recycling industry exists today in the U.S.

Coal Power: Emissions fell as Coal generation grew

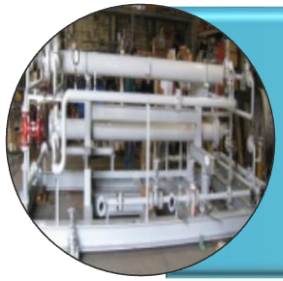


Particulate Matter- USA The World Leader

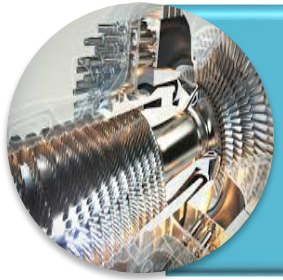


Department of Energy Investments Clean Coal and Carbon Management

Office of Clean Coal and Carbon Management – What we do



Carbon Capture, Utilization and Storage
R&D and scale-up technologies for capturing and using or storing CO_2 from new and existing industrial and power-producing plants



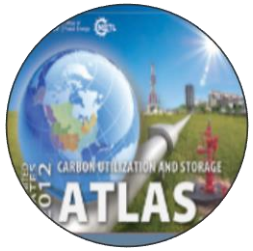
Advanced Energy Systems
Technologies that improve plant efficiency and performance, increase plant availability, and maintain the highest environmental standards

Cross Cutting Research and Systems Integration
Materials, sensors, and advanced computer systems for future power plants and energy systems, as well as testing and validating technologies into integrated systems

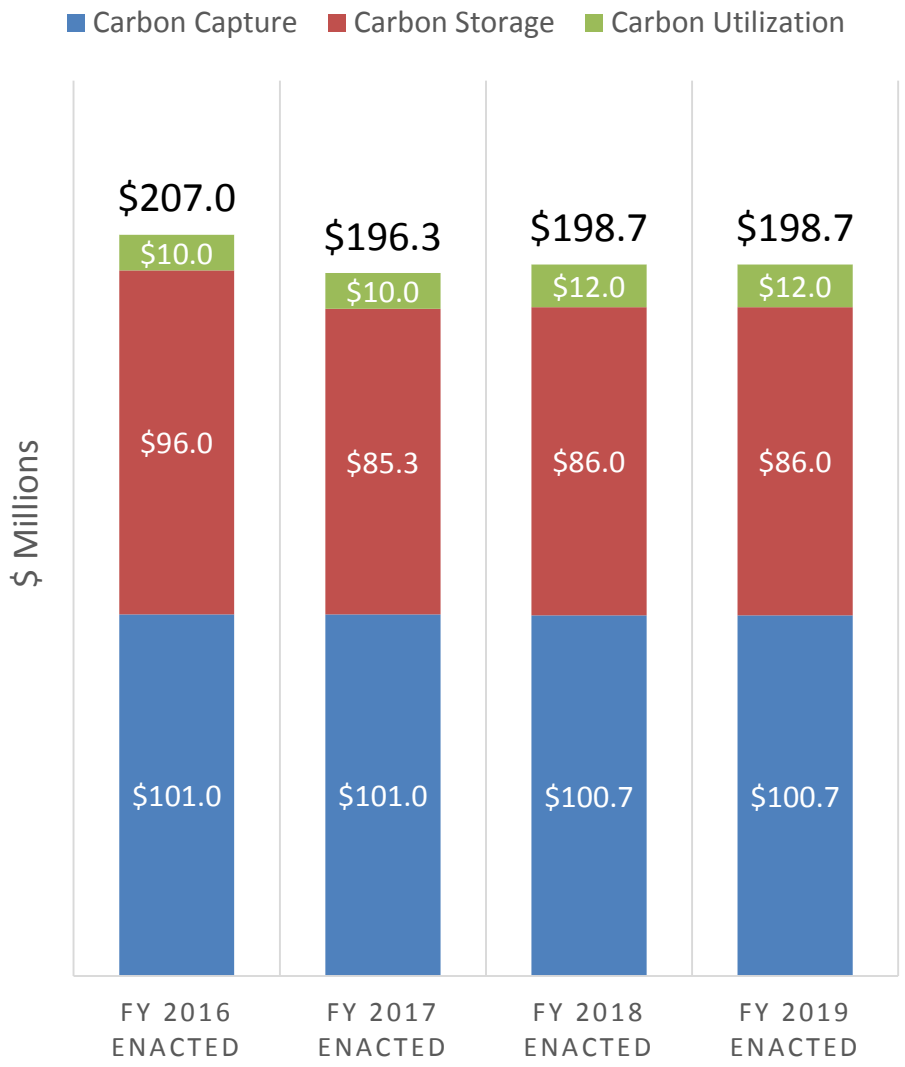
Federal Investment in Carbon Capture, Utilization and Storage R&D

Carbon Capture
R&D and scale-up technologies for capturing CO_2 from new and existing industrial and power-producing plants

CO_2 Utilization
R&D and technologies to convert CO_2 to value-added products



Carbon Storage
Safe, cost- effective, and permanent geologic storage of CO_2



Coal FIRST Technologies to Meet Opportunity

Flexible, Innovative, Resilient, Small, Transformative

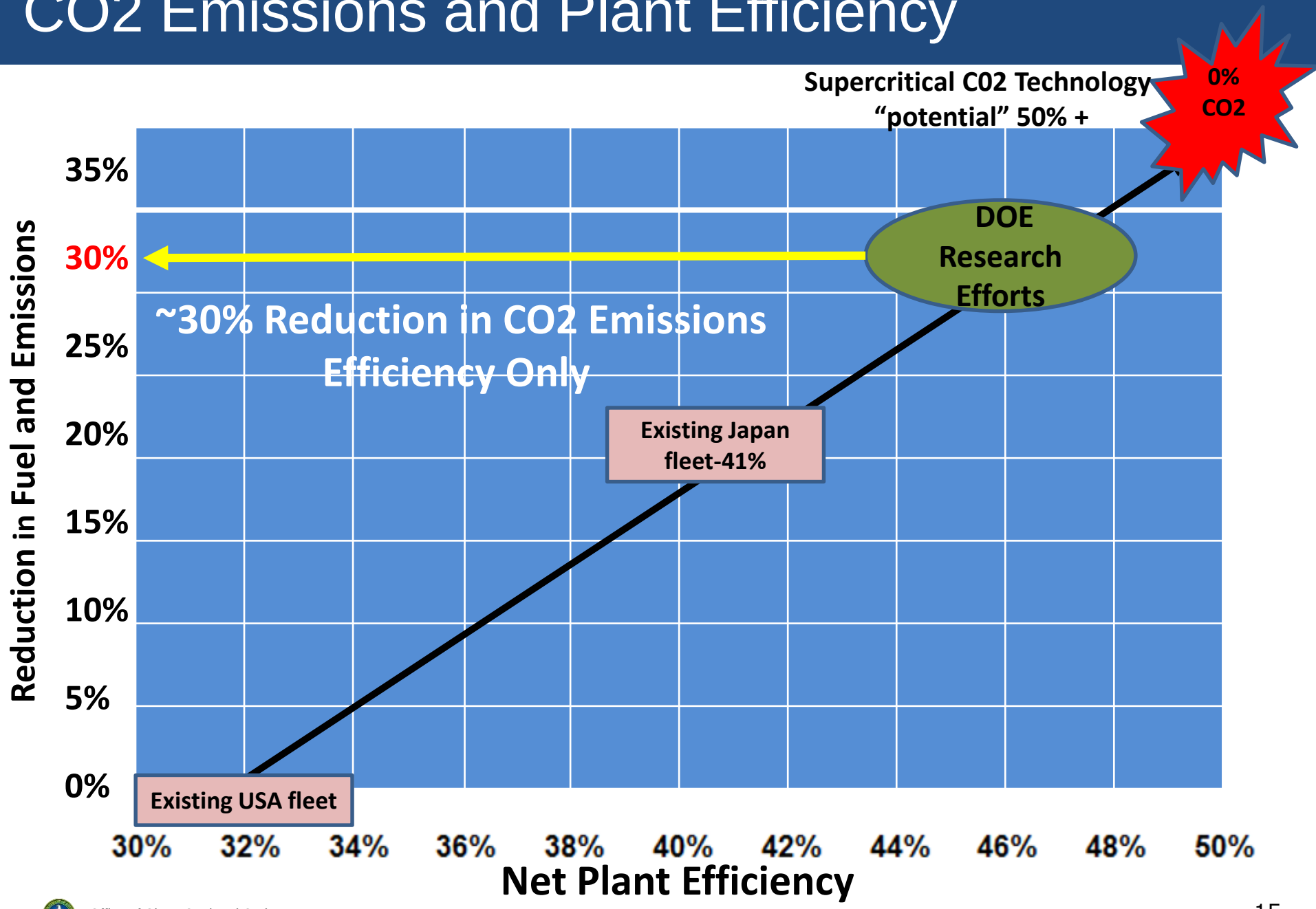
Goal: *Develop the coal plant of the future needed to provide secure, stable, and reliable power*

- capable of *flexible* operations to meet the needs of the grid;
- use *innovative* and cutting-edge components that improve efficiency and reduce emissions;
- provide *resilient* power to Americans;
- are *small* compared *to* today's conventional utility-scale coal;
- and will *transform* how coal technologies are designed and manufactured.

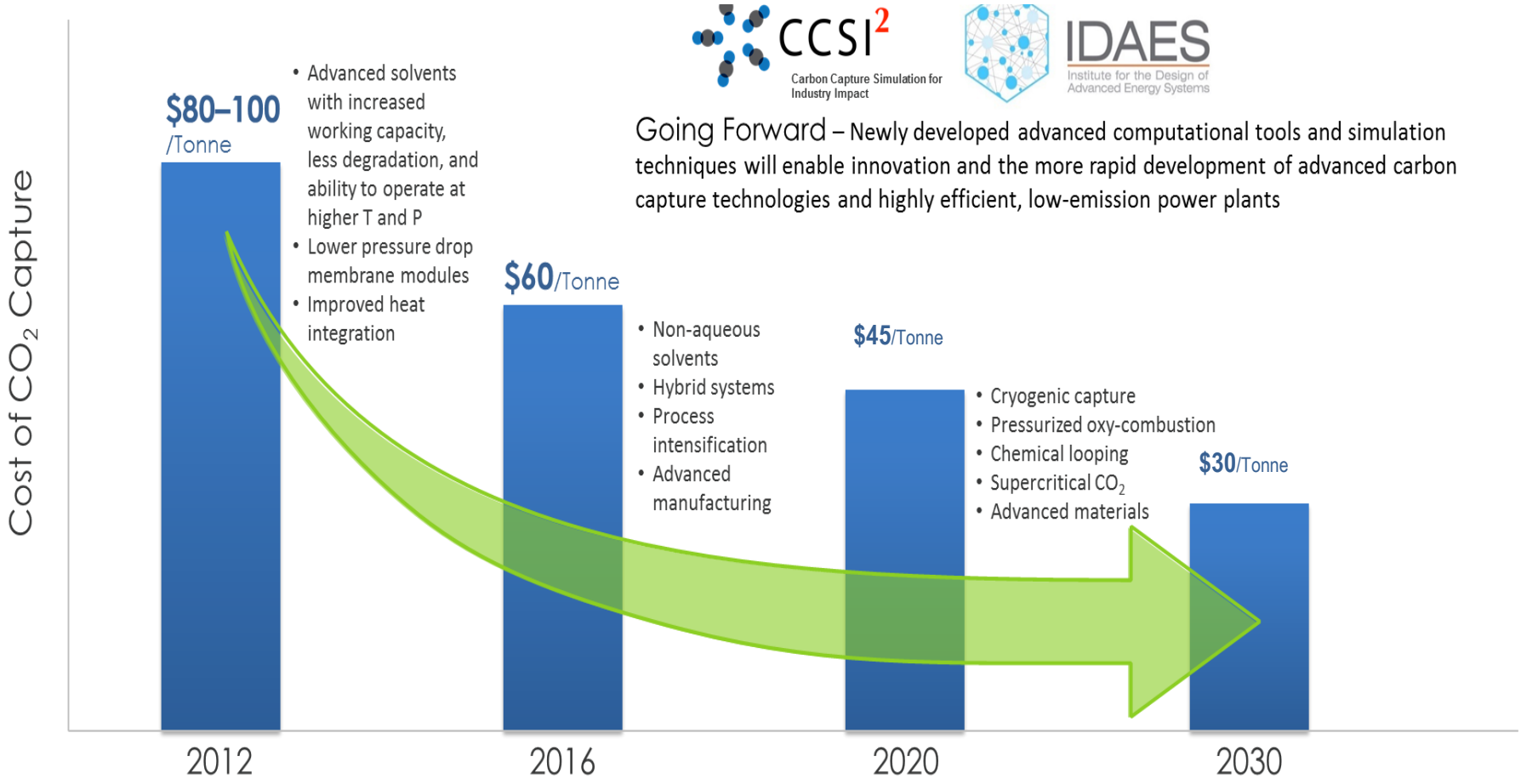
Coal FIRST Technologies to Meet Opportunity

Flexible, Innovative, Resilient, Small, Transformative

CO2 Emissions and Plant Efficiency



Need to Reduce the Cost of CCUS

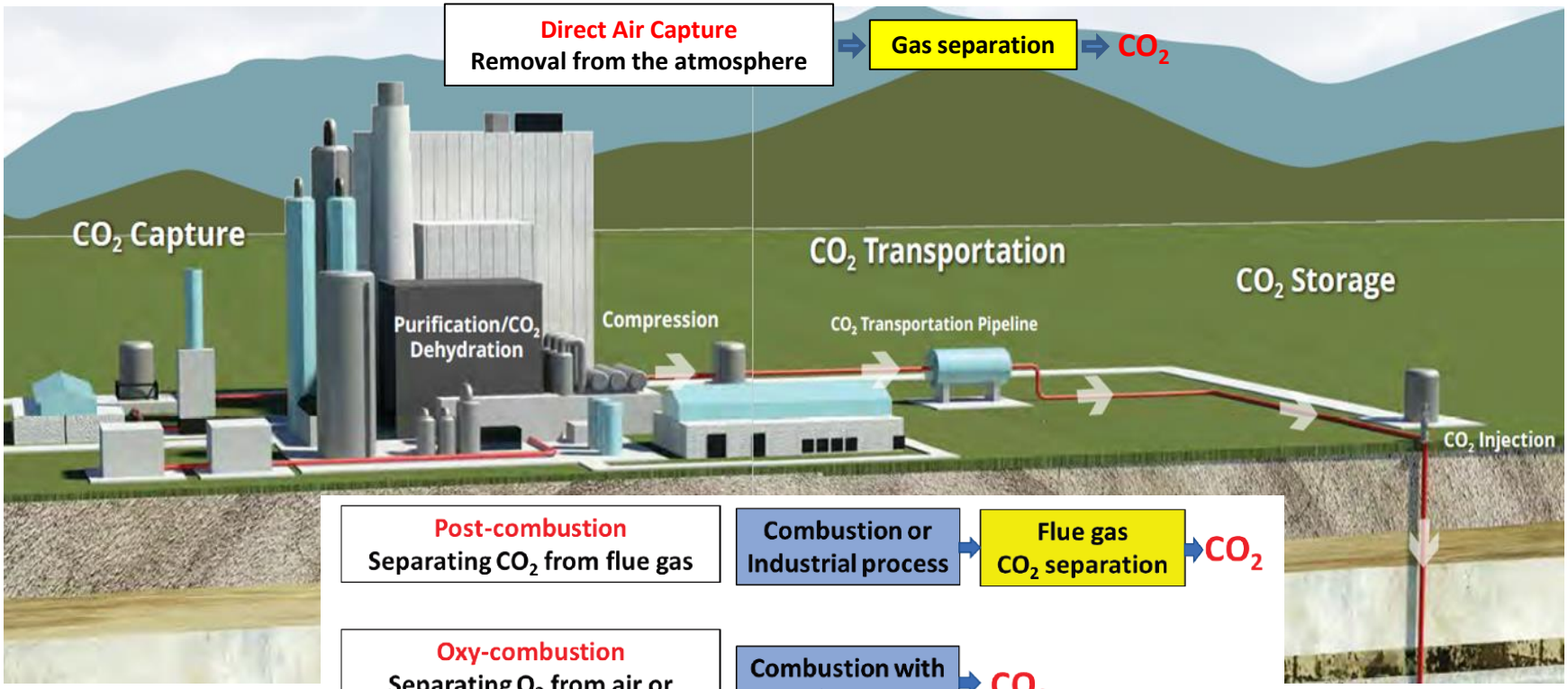


CCSI² Carbon Capture Simulation for Industry Impact

IDAES Institute for the Design of Advanced Energy Systems

Going Forward – Newly developed advanced computational tools and simulation techniques will enable innovation and the more rapid development of advanced carbon capture technologies and highly efficient, low-emission power plants

What is Carbon Capture ?



Petra Nova-NRG Energy
Advanced Post Combustion CO2 capture

- Project at NRG's W.A. Parish power plant near Houston TX
- Retrofit of Existing Coal Plant to process flue gas from W.A. Parish Unit 8 - Post-Combustion CO_2 capture
- World's largest post-combustion CO_2 capture system
- Project was completed On-Budget and On-Schedule
- Delivering and permanently storing around 1.4 million metric tons of CO_2 per year for EOR.
- 240 MWe slipstream scaled up to improve project economics
- Technology applicable to retrofit of existing coal plants
- EOR at the Hilcorp West Ranch oil field.
- Total Project Cost: ~$1 billion (DOE Cost Share: $190 MM)
  - NRG Equity - $300 million
  - JX Nippon Equity – $300 million
  - JBIC Project Financing - $250 million
  - MHI – Technology Provider

Key Events:

- **Project Awarded: May 2010**
- **Completed Construction (on Schedule and Within Budget): December 2016**
- **Started Operations: January 10, 2017**
- **Ribbon Cutting Ceremony: April 13, 2017**
- **2017 Plant of the Year (Power Magazine)**
- **2017 Coal Project of the Year (Power Engineering Magazine)**
- **First 1 Million Tons of CO_2 Captured: Nov. 2017**
- **2 Million Tons of CO_2 Captured: Oct 2018**

Petra Nova project " …demonstrates that clean coal technologies can have a meaningful and positive impact on the Nation's energy security and economic growth."

U.S. DOE Secretary Rick Perry, April 13, 2017

Major CCUS Demonstration Projects

Air Products Facility (Port Arthur, TX) – Began Operations 2013

- Built and operated by Air Products and Chemicals Inc. and located at Valero Oil Refinery in Port Arthur, TX
- State-of-the-art system to capture the CO_2 from two large steam methane reformers
- Captured gas transported via pipeline to oil fields in eastern Texas where it is used for EOR.
- Since 2013, the project has captured over three million metric tons of CO_2.

Petra Nova CCS (Thompsons, TX) – Began Operations 2017

- Joint venture by NRG Energy, Inc. and JX Nippon Oil and Gas Exploration
- Demonstrate the Mitsubishi Heavy Industries CO_2 capture technology ability to capture 90% of the CO_2 emitted from a 240-megawatt flue gas stream. (designed to capture/store 1.4 million tonnes of CO_2 per year)
- Captured CO_2 used for EOR at the West Ranch Oil Field in Jackson County, Texas, where it will remain sequestered underground

ADM Ethanol Facility (Decatur, IL) – Began Operations 2017

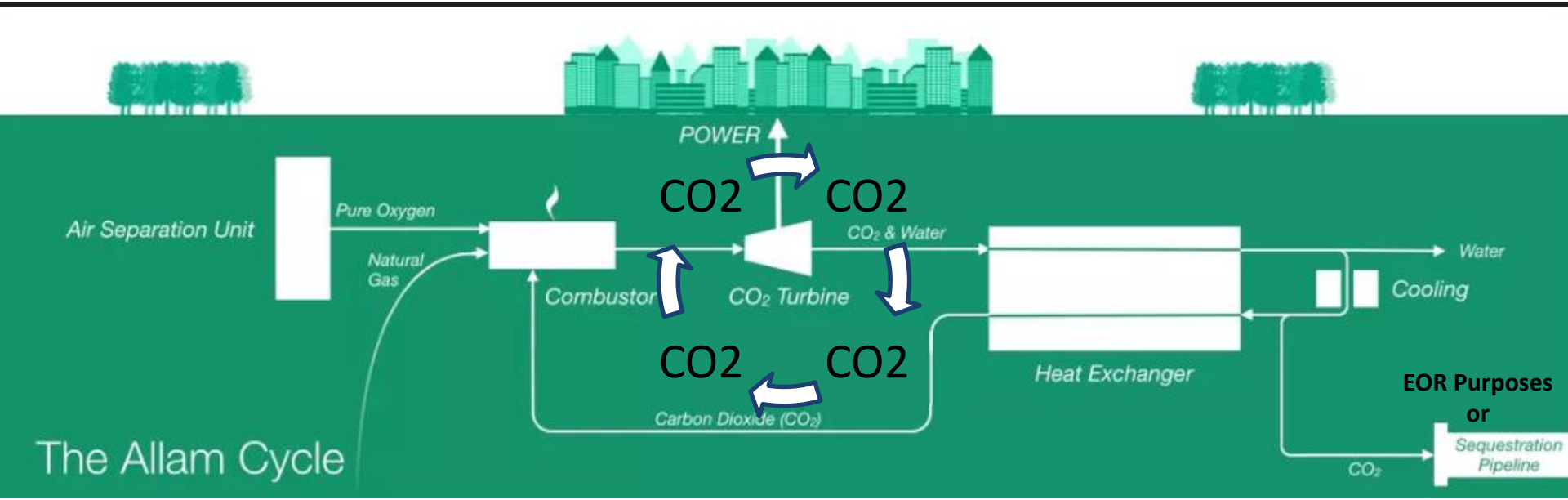
- Built and operated by Archer Daniels Midland (ADM) at their existing biofuel plant located in Decatur, IL
- **1 million metric tons of CO_2** as a by-product of the ethanol biofuels production process and store it in a deep saline reservoir
- First ever CCS project to use the EPA Underground Injection Class VI well permit in the United States that is specifically designed for CO_2 storage

The Allam Cycle

The Allam cycle uses a single turbine, driven by a working fluid consisting of only water and carbon dioxide, ***NO STEAM***.

This is achieved by using pure oxygen instead of air to burn the fuel. Similarly to combined-cycle plants, the ***intended fuel is natural gas or gasified coal***

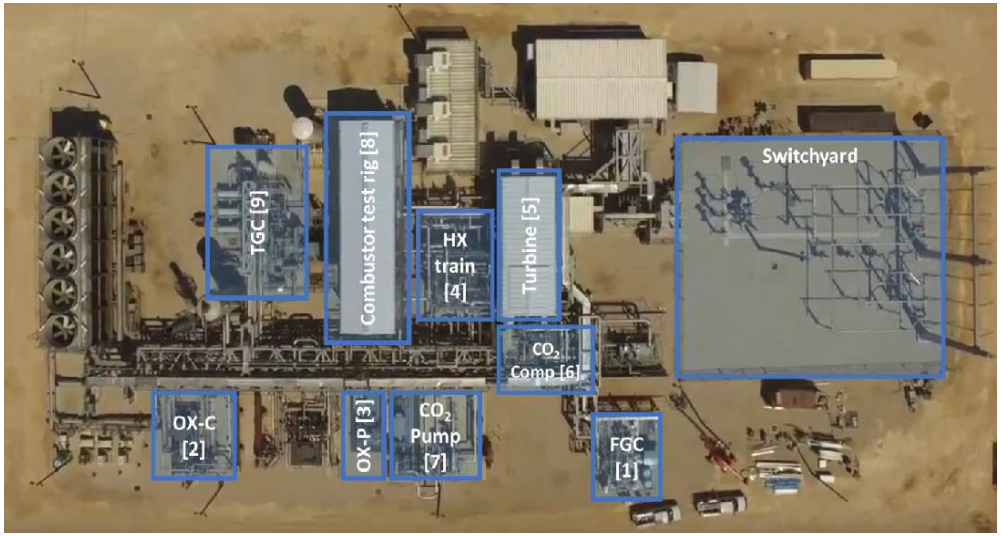
Near Zero CO2 Emissions



By VOX

NetPower Demo Plant---La Porte, Texas

- PRIVATE SECTOR FUNDED
- PRODUCES ELECTRICITY FROM NATURAL GAS (future coal gasification w/ DOE)
- NEAR-ZERO ATMOSPHERIC EMISSIONS
- NO ADDITIONAL COST OF CAPTURE
- LOW OR ZERO WATER USAGE
- HIGH EFFICIENCY
- 50 MW GRID-CONNECTED PLANT
- $160M+ DESIGN, CONSTRUCTION, AND TESTING PROGRAM
- ADDITIONAL VALUE STREAMS (CO2, 45Q, INDUSTRIAL GASES)



La Porte, TX Demonstration Plant

Exelon MCDERMOTT 8 RIVERS OXY Oxy Low Carbon Ventures, LLC A subsidiary of Occidental Petroleum Corporation

National Carbon Capture Center (NCCC) Wilsonville, AL

Goal

Develop technologies under realistic conditions that will reduce the cost of advanced coal-fueled power plants with CO_2 capture

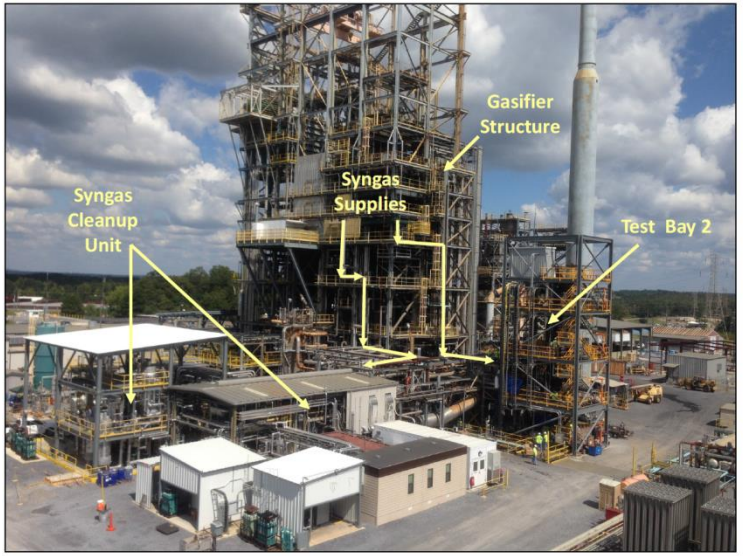
Advantages

- National resource for industry and academia to validate performance and operations of advanced capture
- Consistent testing procedures and data collection allow comparison
- Stellar safety and environmental record

Status

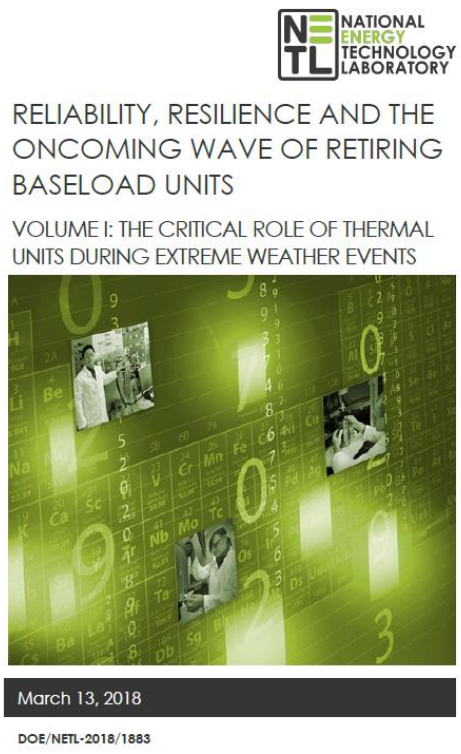
- Over 30 technologies tested from laboratory to small scale pilot
- Hundreds of technologies screened
- Opportunities to test technologies using NG

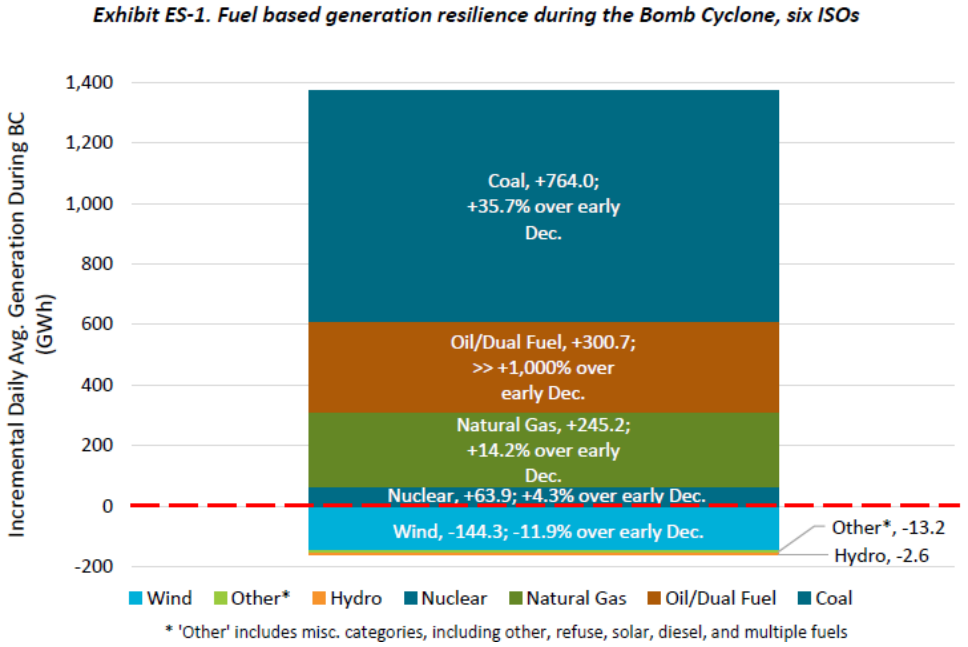
NCCC Pilot Solvent Test Unit (PSTU)



TRIG Pre-combustion Capture Center

DOE –NETL Conclusion "Bomb Cyclone"





"During the worst of the storm from **January 5-6, 2018**, actual U.S. electricity market experience demonstrated that without the resilience of coal- and fuel oil/dual-firing plants—its ability to add 24-hour baseload capacity— ***the eastern United States would have suffered severe electricity shortages, likely leading to widespread blackouts***. "

Whole Sale Market Recognizes There is a Problem

ISO new england

"the possibility that power plants won't have or be able to get the fuel they need to run, particularly in winter—is the ***foremost challenge to a reliable power grid in New England***."

ISO New England

pjm

Fuel Security

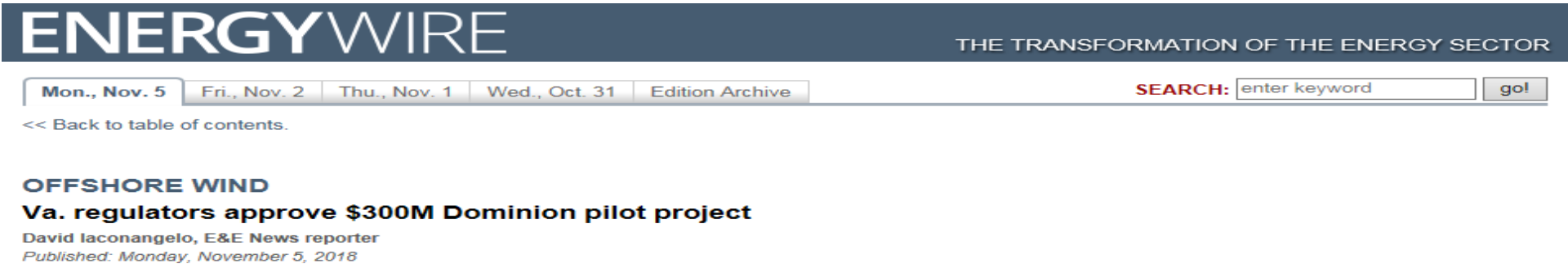
Analyzing Fuel Supply Resilience in the PJM Region

"While there is **NO** imminent threat, **Fuel Security is an important component of ensuring reliability** – especially if multiple risks come to fruition."

FERC Chairman Chatterjee:

"There are consequences to the current market pressures that we're facing, and if the end result of that is baseload units retiring prematurely because of the short-term pressures they're facing in the marketplace, we need to understand what the long-term implications of that would be."

Typical of Actions Around The Country



ENERGYWIRE

THE TRANSFORMATION OF THE ENERGY SECTOR

Mon., Nov. 5 | Fri., Nov. 2 | Thu., Nov. 1 | Wed., Oct. 31 | Edition Archive

SEARCH: enter keyword go!

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OFFSHORE WIND

Va. regulators approve $300M Dominion pilot project

David Iaconangelo, E&E News reporter

Published: Monday, November 5, 2018

- Virginia regulators approved Dominion Energy's plans for what could be the nation's second offshore wind farm Friday but said ***they would not have done so if the state Legislature hadn't created a mandate for the project.***
- In its decision Friday, the SCC said the company ***had not justified the expense of the project*** relative to other types of renewables, or even compared to the nation's other offshore wind project in Massachusetts
- **"Dominion's customers bear essentially all of the risk, including cost overruns and lack of performance.**"
- But the policy preferences expressed in the energy law, wrote the SCC, took precedence over the regulatory analysis.
- If not for that, the pilot ***"would not be deemed prudent as that term has been applied by this Commission in its long history of public utility regulation*** or under any common application of the term," it said.

Questions?