

U.S. DEPARTMENT OF ENERGY

Carbon Capture Utilization and Storage: Outlook & Activities

National Coal Council
2016 Annual Fall Meeting

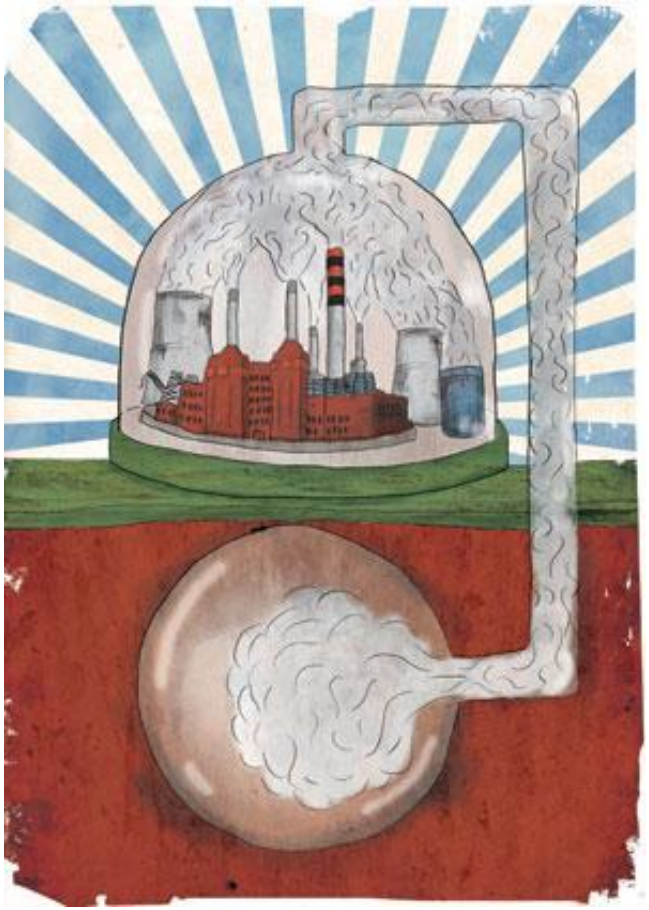
October 5, 2016

Dr. Darren Mollot

Associate Deputy Assistant Secretary

Office of Fossil Energy

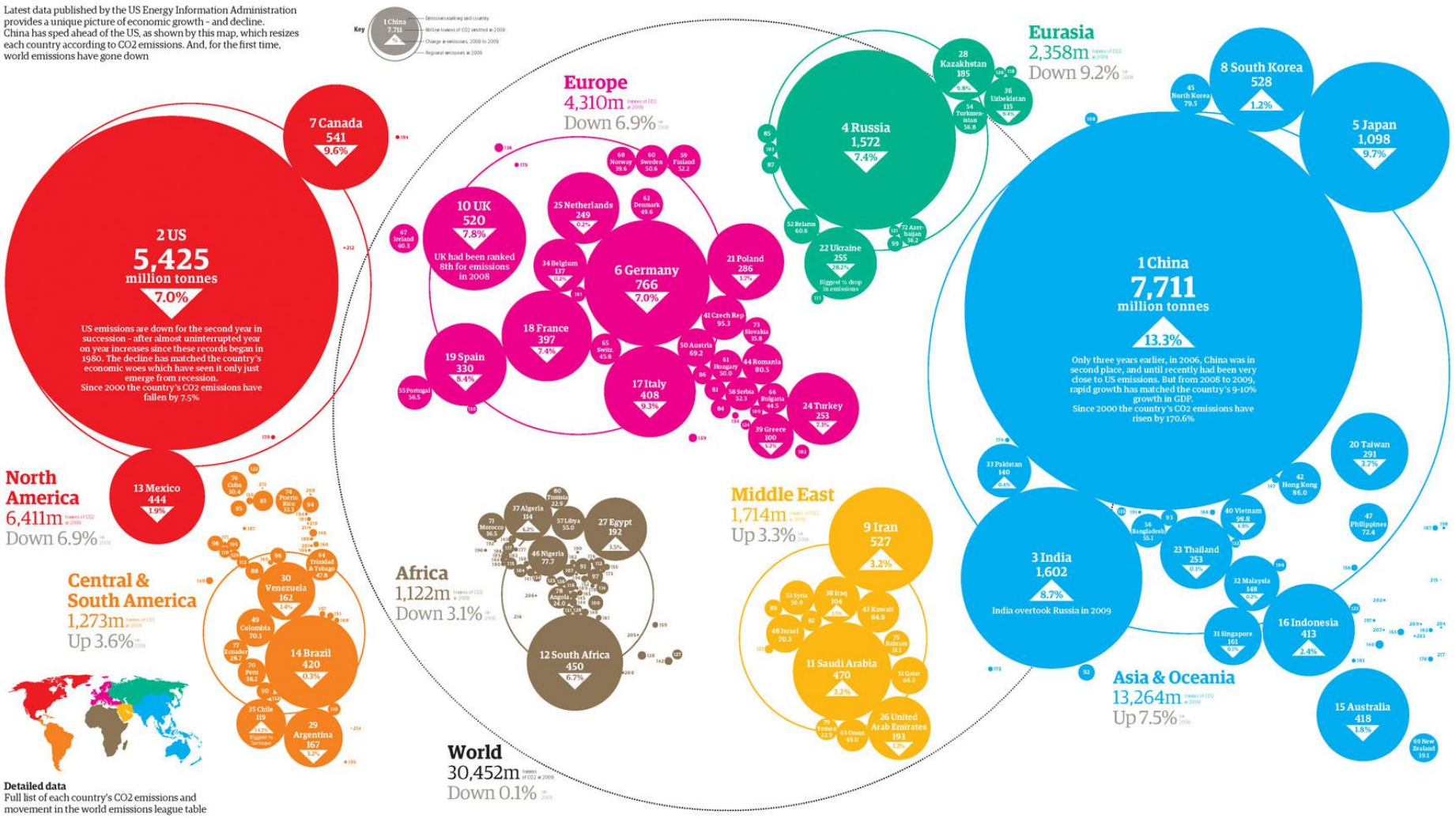
The Punchline, Upfront



Source: Schiermeier *et al*. 2008, Illustrator Jay Taylor, *Nature*

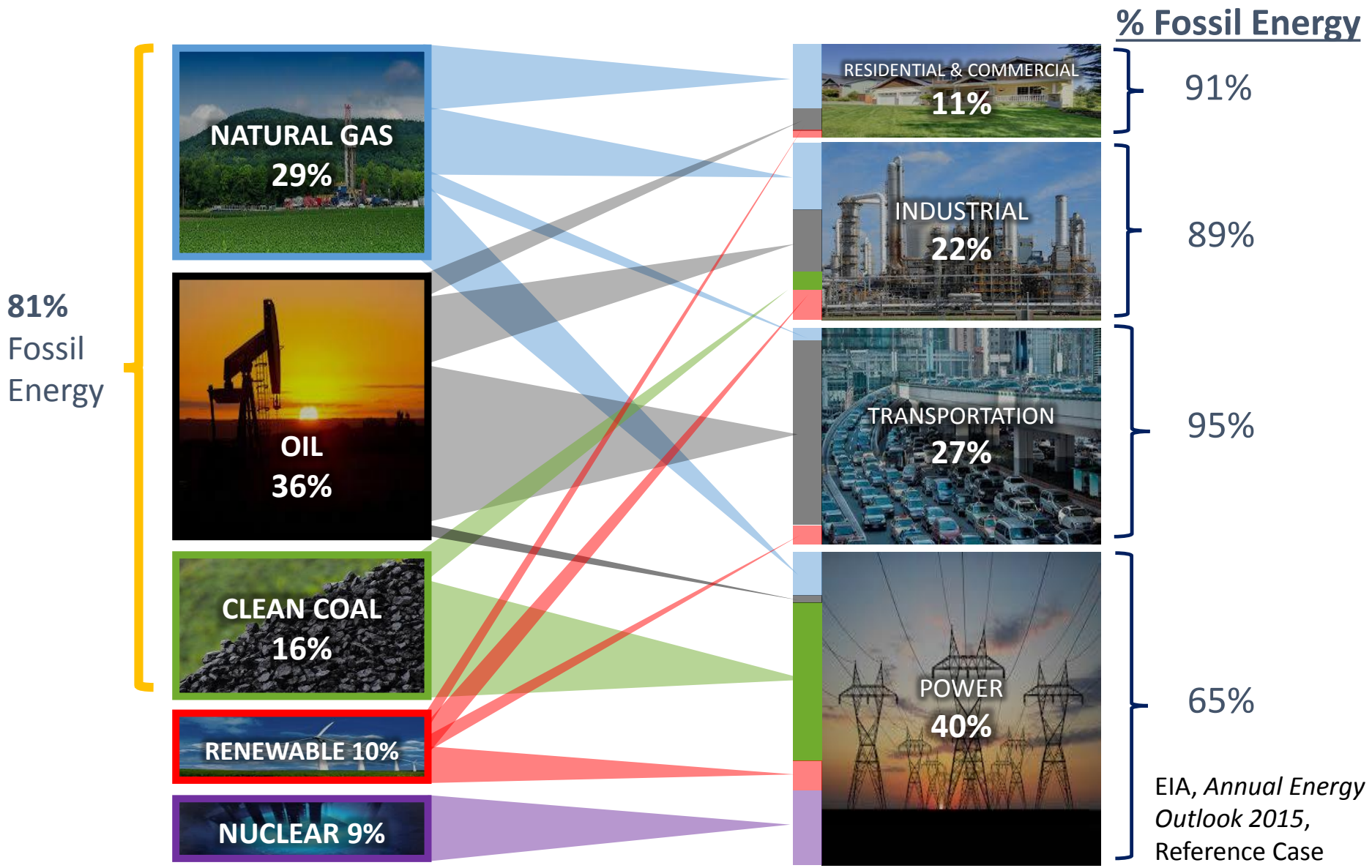
1. Carbon capture is a domestic and global necessity
2. CCUS will play a critical role in cutting emissions needed to limit global warming to 2°C
   - Limiting warming to less than a 2°C may not be possible without CCUS
3. CCUS is demonstrated and possible today, with today's technologies
4. Transformational technologies in the pipeline will enable reducing the cost of capture
5. CCUS deployment will require a combination of policy support and technological innovation
   - DOE analysis found that Federal RDD&D combined with tax credits could drive significant CCUS deployment

Global atlas of CO_2 emissions



Source: US Energy Information Administration

Fossil Energy Is Critical in All Domestic Sectors



U.S. and global need to accelerate development of reliable low-cost, low-carbon energy sources and products

COP-21 Outcome pursues aspirational goal of 1.5°C

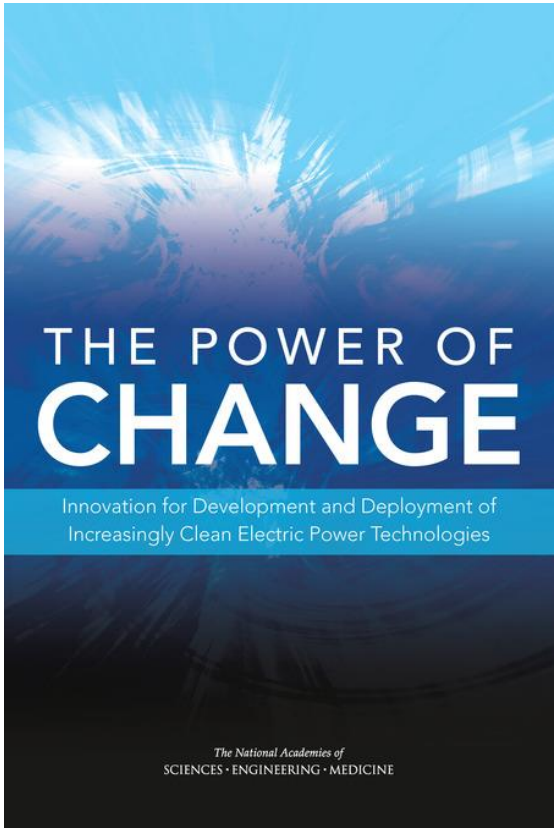
- Unachievable without CCUS on **all sources**, and eventually **negative emissions**
- Requires **Advanced Energy System** technologies to increase efficiency, reduce costs
- Future fossil-based systems must be **designed and built for grid and market of future**
- Need to **optimize value** from feedstocks, products, and CO_2

Carbon Capture and Storage (CCS): Needed to Meet Climate Goals

"Credible forecasts also suggest that fossil fuels…will continue to be available in high quantities and at low prices for decades, and thus will make up a significant fraction of the fuels used to generate electric power for years to come.

Coupled with the dramatic reductions in GHGs that can be realized through CCS technologies, the development, demonstration, and deployment of these technologies for both coal and natural gas generators remain critical."

National Academy of Engineering



Innovation for Development and Deployment of Increasingly Clean Electric Power Technologies

CCUS is Possible and Demonstrated Today

Operational:

Air Products, Port Arthur TX – Since 2014, approaching 3 million tons CO_2 stored with EOR

Boundary Dam, Saskpower, Saskatchewan – Since October 2014, capturing 1.1 million tonnes CO_2 / Year for EOR and geologic storage

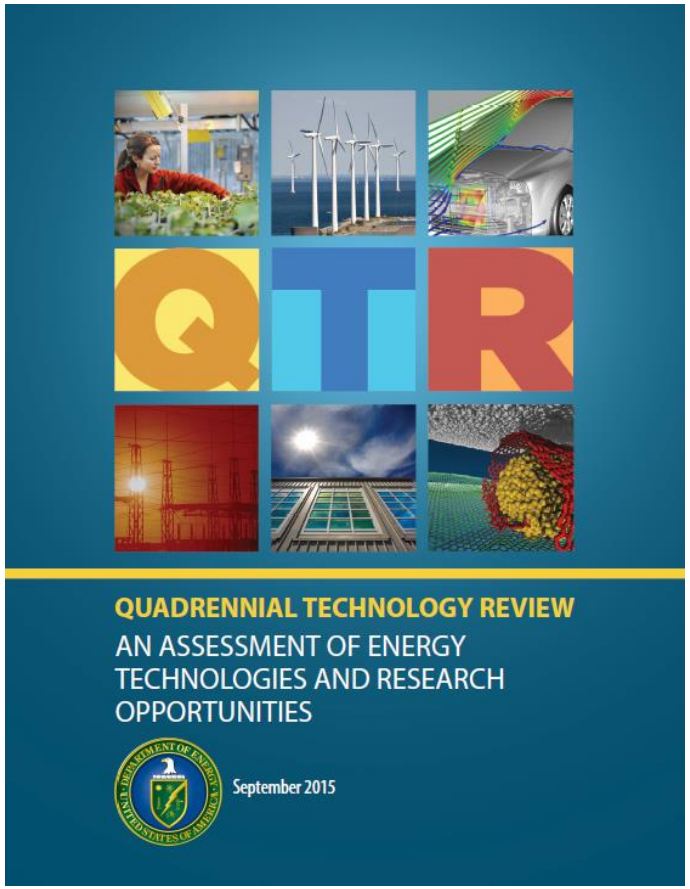
Soon to be Operational:

Southern Company Kemper Project, Operational fall of 2016, will capture 3 million tonnes CO_2 / Year for EOR and potentially geologic storage

Petra Nova, Thompsons, TX – Full capacity operation January 2017, will capture ~1.6 million tonnes CO_2 / Year post combustion for EOR storage

Archer Daniels Midland Company, Decatur, IL – Full capacity operation first quarter 2017, 900,000 tonnes CO_2 / Year for saline storage

Opportunities in Carbon Capture and Storage



www.energy.gov/qtr

- **Pilot:** Build *2nd-generation* pilots of carbon capture/advanced energy systems for *new* and *existing* plants*; field test* to solve key challenges (e.g., manage pressures, induced seismicity, storage permanence).
- **Demonstrate:** *Retrofit* CCS technologies on *fossil fuel* burning plants.
- **Expand uses:** Apply CCS to natural gas and industrial plants; address differences in CO2 and O2 concentrations and the impacts.
- **Partner:** Expand international knowledge *sharing, demonstrations, and impacts.*
- **Crosscut:** Combine *CCS with utility-scale biopower* to boost power production efficiency and cost-effectively reduce GHGs.

FE Goals and Priorities

Accelerate a Commercial Pathway to CCS

- Innovation CCS
- Advanced Carbon Technologies R&D
- Domestic and international partnerships
- Reduce deployment barriers

Advance Safe and Environmentally Prudent Oil & Gas Resource Production and Transport

- R&D on water and air quality, induced seismicity
- Emissions mitigation and quantification
- Gas hydrates

Modernize the Strategic Petroleum Reserves Program

Natural Gas Trade Regulation

Address challenges across the energy spectrum

- Intra-agency crosscut efforts:
  - Subsurface Technology and Engineering (SubTER)
  - Supercritical CO2
  - Energy Water
  - Advanced Materials
  - Grid Modernization

FE Goals and Priorities

Accelerate a Commercial Pathway to CCS

- Innovation CCS
- Advanced Carbon Technologies R&D
- Domestic and international partnerships
- Reduce deployment barriers

Advance Safe and Environmentally Prudent Oil & Gas Resource Production and Transport

- R&D on water and air quality, induced seismicity
- Emissions mitigation and quantification
- Gas hydrates

Modernize the Strategic Petroleum Reserves Program

Natural Gas Trade Regulation

Address challenges across the energy spectrum

- Intra-agency crosscut efforts:
  - Subsurface Technology and Engineering (SubTER)
  - Supercritical CO2
  - Energy Water
  - Advanced Materials
  - Grid Modernization

FE Office of Coal and Carbon Management Mission

Ensure that the nation can continue to rely on traditional resources for clean, secure, and affordable energy while enhancing environmental protection.

Clean Coal R&D:

Help coal remain a strategic fuel for the nation while enhancing environmental protection.

- Develop and demonstrate advanced power generation and carbon capture
- Develop utilization and storage technologies for existing and new power plants
  - Increase overall system efficiencies and reduce capital costs

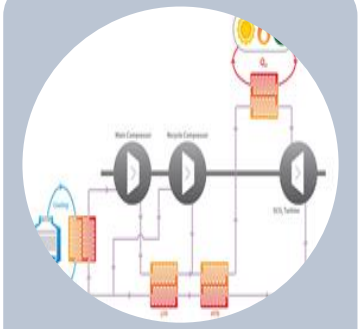
Department of Energy Crosscuts

Leveraging Investments Across the Enterprise

Subsurface Technology & Engineering (SubTER)

Energy Water

- Produced water treatment
- Desalination



Supercritical CO_2

- Develop technologies and next-gen components
- 10MWe pilot

Grid Modernization

- Solid oxide fuel cells
- Fast ramping and peaking gas generators

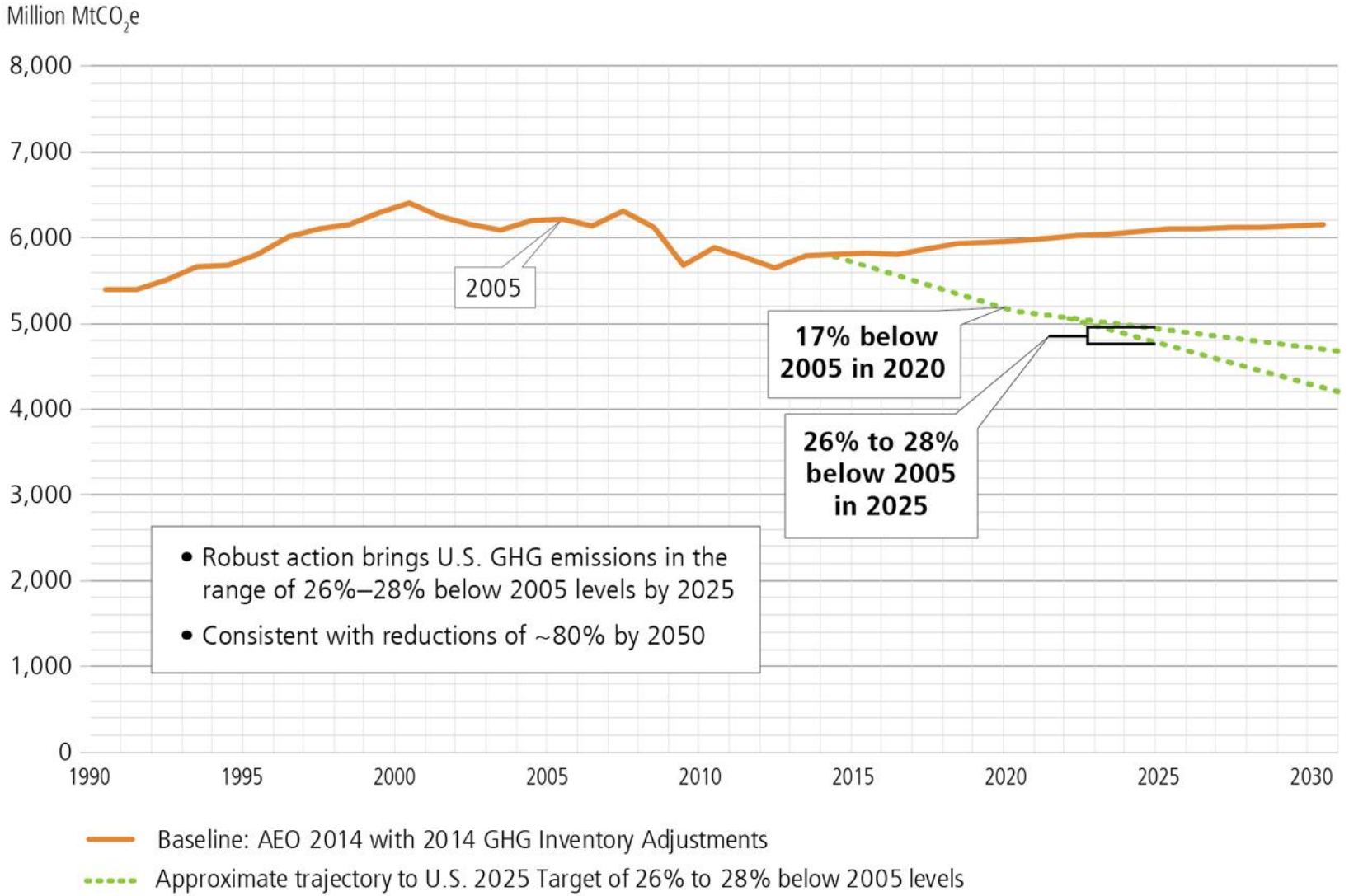
Advanced Materials

- Materials for extreme environments

Departmental Crosscutting RD&D

U.S. Climate Targets

Greenhouse Gas Reduction



CCS Is Too Costly Today

Today, the cost per ton is economically prohibitive. We need public-private partnerships where the government takes commercial exposure and some of the risks."

Olav Skalmeraas
Statoil vice president for carbon capture and storage, Norway

CCS technologies are still at the pilot and demonstration phase. Paradoxically, it is primarily the costs of these early demonstration projects that have hampered further deployment.

David M. Reiner
Judge Business School, University of Cambridge, UK

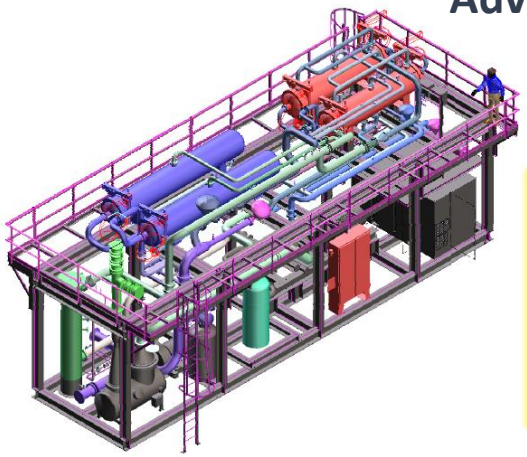
Smokestack scrubbers were once saddled with the same debilitating cost problems as CCS. Since 1990, improvements have enabled them to reduce sulfur-dioxide emissions more than fivefold, and nitrogen-oxide emissions threefold.

John Thompson
Director, Fossil-fuel transition program, Clean Air Task Force, St. Louis, MO

Technology: Transformational Carbon Capture and Compression

Advanced CO_2 capture technologies: Many pathways to success

Advanced Membranes



Solid Sorbents

Opportunity: Concentrated CO2 from Industrial Sources

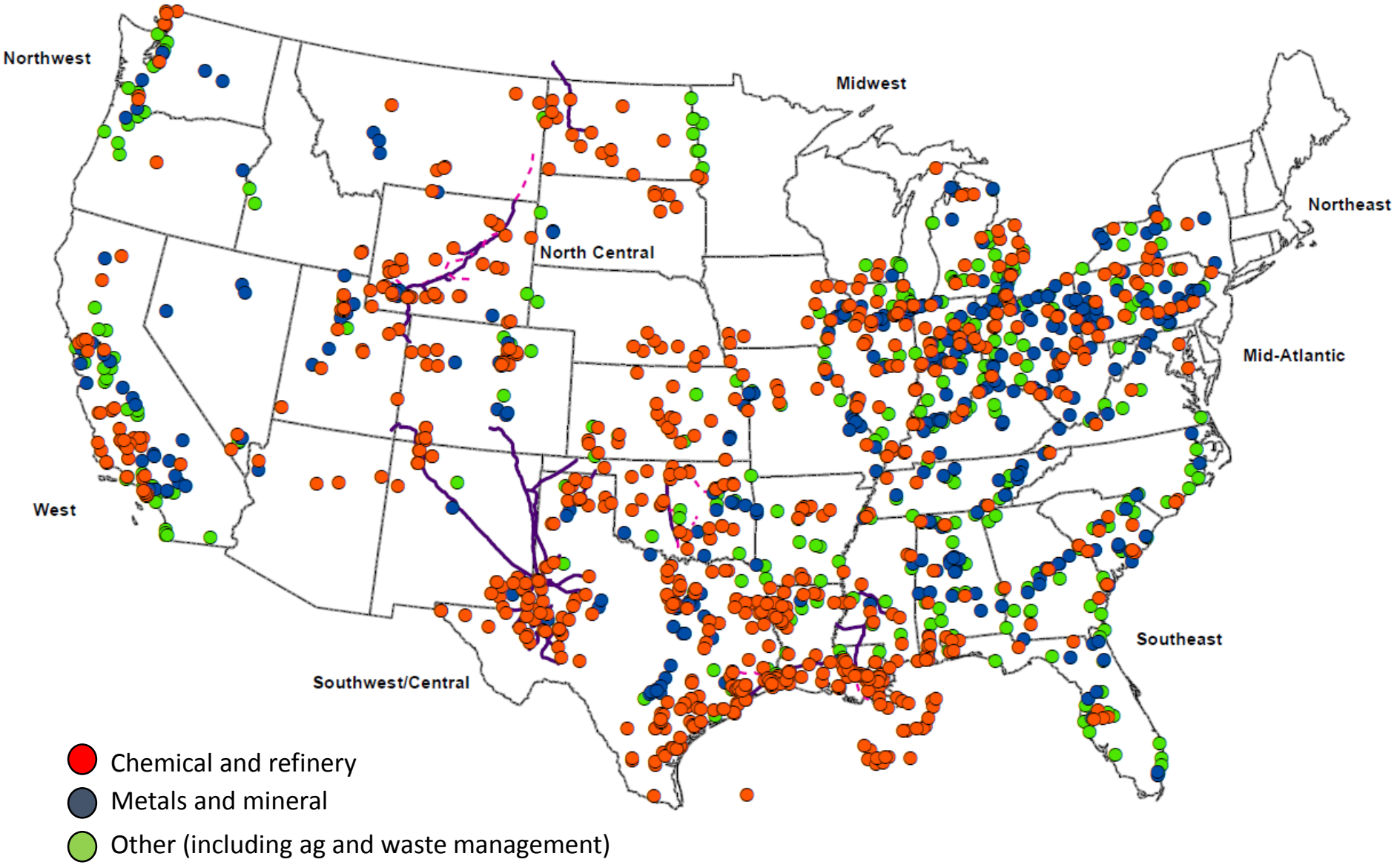
Objective: Rapidly advance U.S. CCS development and deployment.

- Enable **widespread deployment of industrial CCS**
  - Catalyze construction of the pipeline and storage infra-structure
  - **Capture 30 million tonnes of CO_2** from opportune industrial point sources, **below $30/tonne, by 2025**.

Southern Company Kemper Project (*Credit: Mississippi Power*)

- Reduce capture costs for power sector sources to **$30/tonne by 2025**, enabling **~400 million tonnes/yr CO_2 capture to deploy between 2025 and 2050**.
- Develop and implement **supporting policies and financial incentives** to support global deployment of CCS.

Industrial Resources



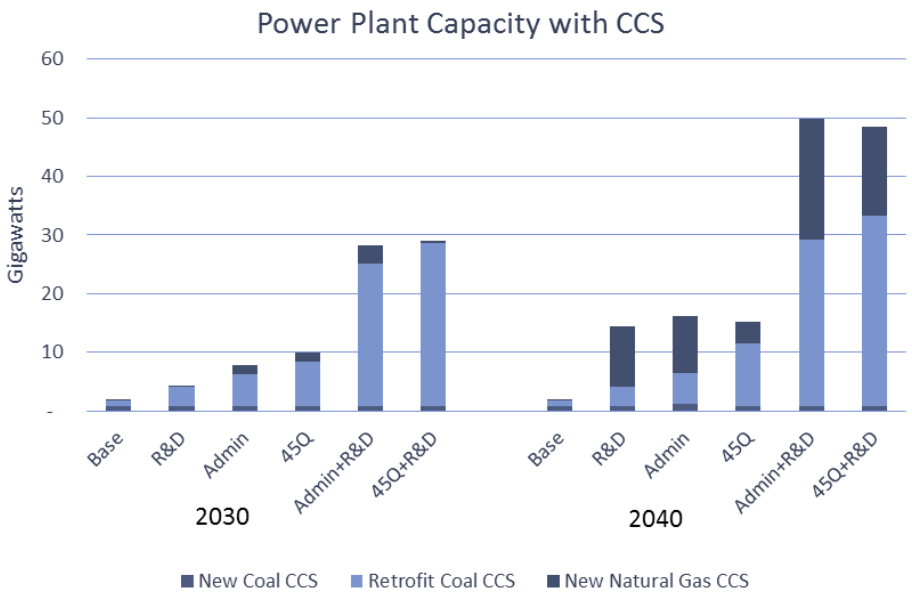
Utilization: Increase Revenue, Decrease Storage

DOE's CO_2 use and reuse efforts focus on converting CO_2 to useful products and fuels—cutting CO_2 emissions where geologic storage is not feasible.

- **Enhanced Oil/Gas Recovery (EOR)**
- **CO_2 as Feedstock**: Use CO_2 to produce chemicals, fuels, and polymers
- **Non-Geologic Storage of CO_2**: Produce stable, solid materials
- **Indirect Storage**: Store carbon by removing CO_2 from the air (e.g., enhanced photosynthesis) or enhancing carbon intake by terrestrial vegetation and soils
- **Beneficial Use of Produced Water**: Find uses for water produced from CO_2 storage in saline formations
- **Breakthrough Concepts**: Develop novel applications for CO_2; use microbes that consume CO_2 to produce useful products or fuels

Increasing CCUS Deployment

The combination R&D and tax credits significantly increase CCUS capacity, generation, and the associated CO_2 sequestered from power plants, in comparison to business as usual.



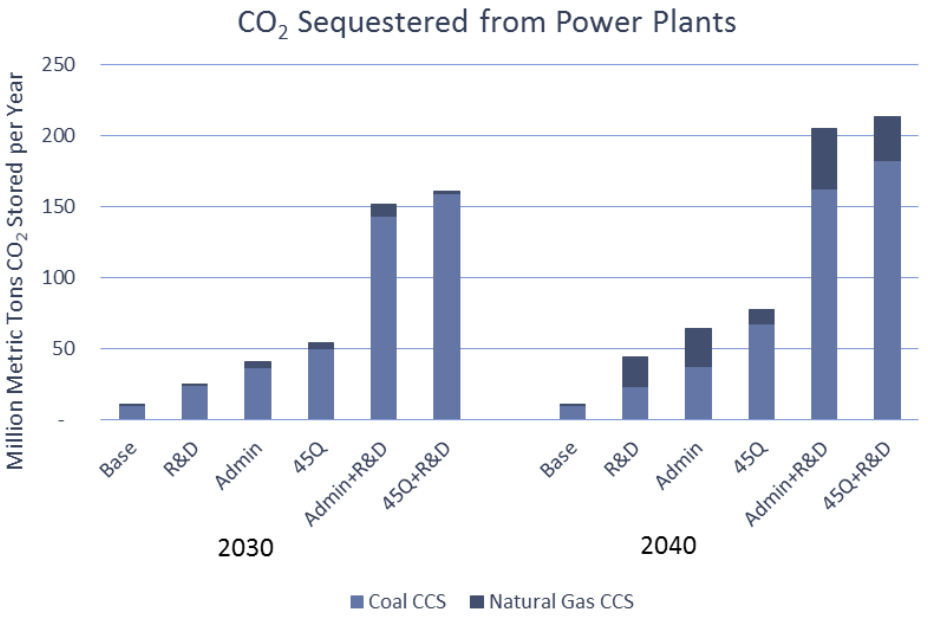


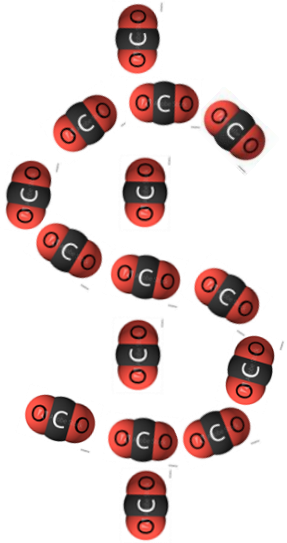
Figure source: DOE Issue Brief "Carbon Capture, Utilization, and Storage: Climate Change, Economic Competitiveness, and Energy Security", August 2016

CCUS Incentives: Tax and Other Financial

CCUS is difficult to deploy when oil prices are low.

Tax and financial incentives for CCUS under consideration:

- Incentives for CO_2 storage and EOR, including expansions of the existing 45Q provisions
- CO_2 price stabilization
- Master limited partnerships (MLPs)
- Private activity bonds (PABs)
- Investment tax credits (ITCs)



CCUS incentives in the President's FY2017 Budget Request:

- A refundable investment tax credit (ITC) for CCUS projects and supporting infrastructure
- A 20-year, refundable sequestration tax credit (STC) for captured CO_2; $10/metric ton EOR and $50/metric ton saline
- Many incentives under consideration are consistent with the Administration's proposal.

Leveraging: International Collaboration Drives RDD&D

Policy Efforts

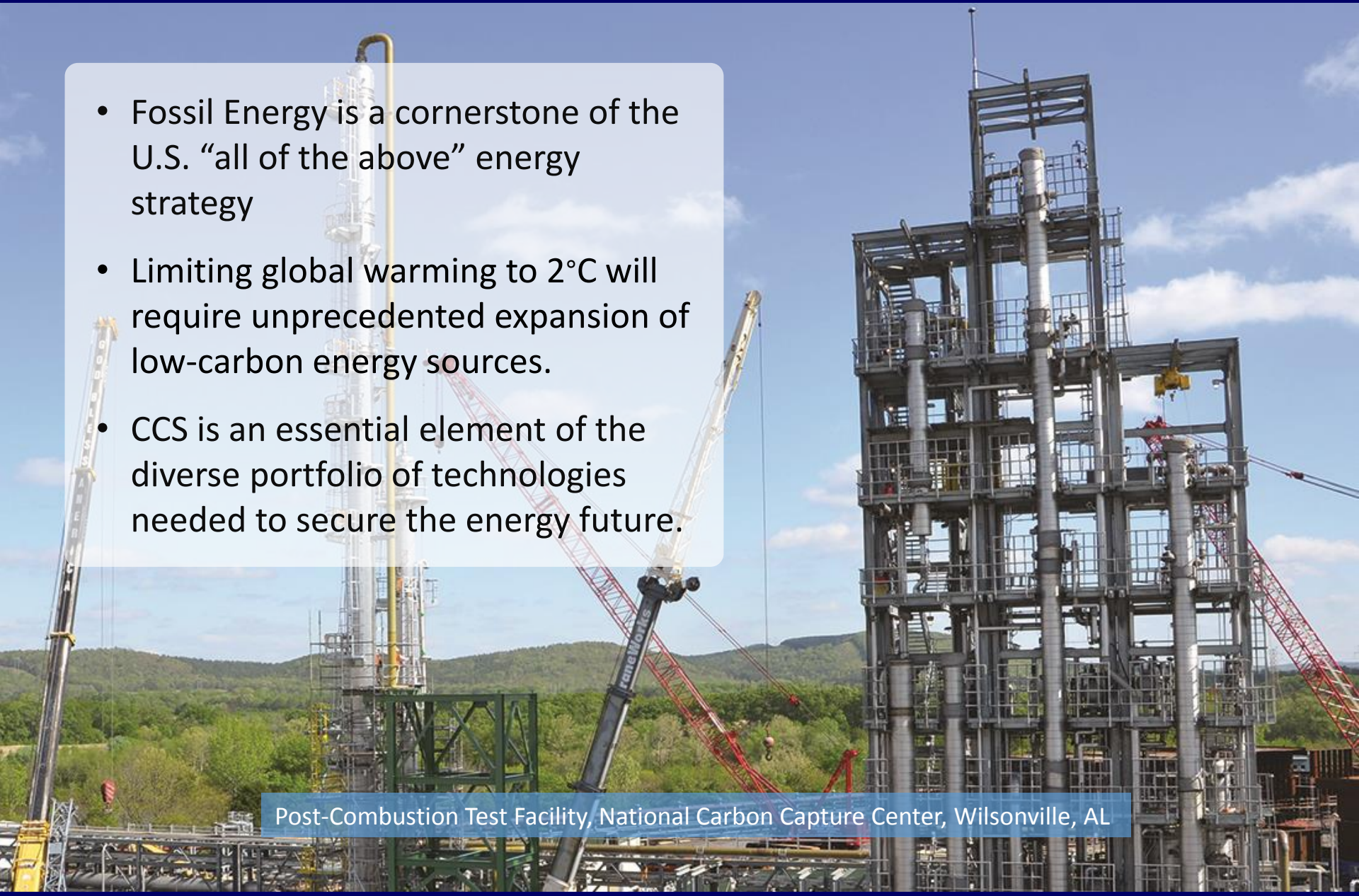
- International Energy Agency (IEA)
- United Nations Economic Commission for Europe (UNECE)
- Asia Pacific Economic Cooperation (APEC)
- Carbon Sequestration Leadership Forum (CSLF)
- Clean Energy Ministerial (CEM)

Technical Efforts

- Multi-Lateral
  - Asia Pacific Economic Cooperation (APEC)
  - IEA Greenhouse Gas R&D Programme (IEAGHG)
  - IEA Clean Coal Centre (IEA CCC)
  - Carbon Sequestration Leadership Forum (CSLF)
  - Mission Innovation
- Bi-Lateral Technical Efforts
  - China, Japan, Korea, Canada, Mexico, Norway, UK, KSA, UAE, etc.

Advanced Fossil Technologies = Low Carbon, Affordable, Accessible Energy

- Fossil Energy is a cornerstone of the U.S. “all of the above” energy strategy
- Limiting global warming to 2°C will require unprecedented expansion of low-carbon energy sources.
- CCS is an essential element of the diverse portfolio of technologies needed to secure the energy future.



Post-Combustion Test Facility, National Carbon Capture Center, Wilsonville, AL

Thank You