



U.S. DEPARTMENT OF
ENERGY

Office of
Fossil Energy



Overview of Carbon Capture, Utilization and Storage (CCUS) and Opportunities for Hydrogen

GCCSI Briefing: The Status of the Hydrogen Economy

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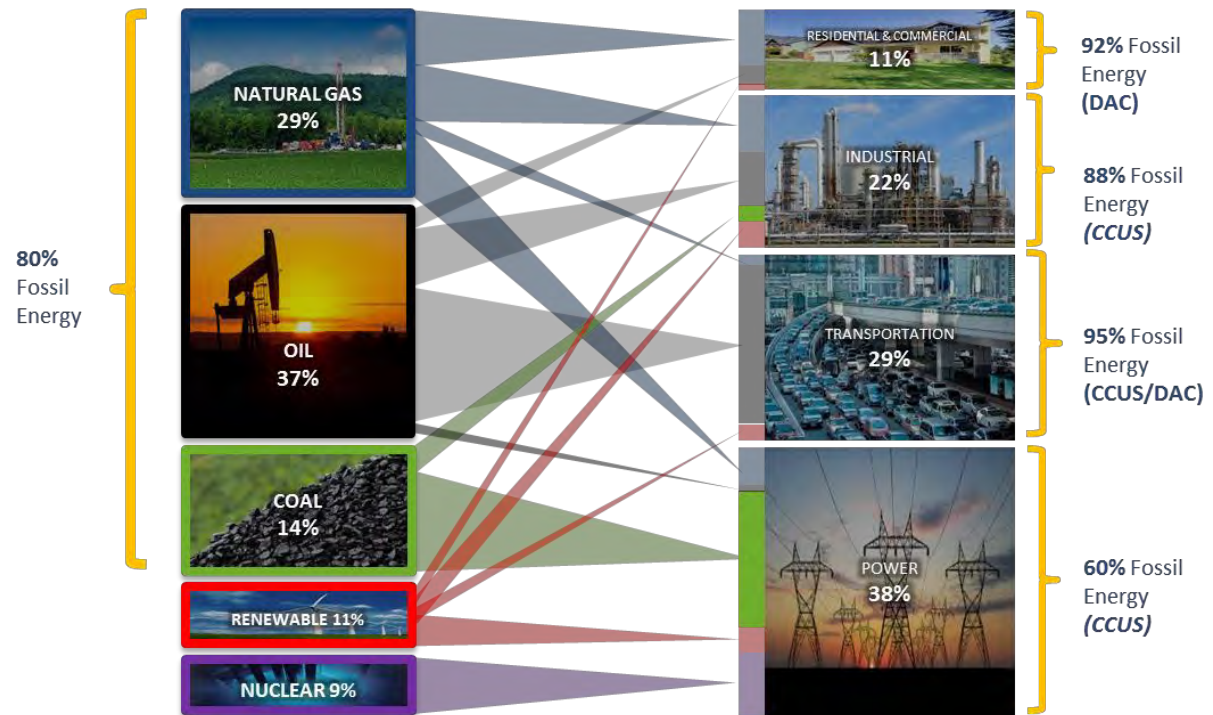
The US: A global leader on CCUS research, development, and deployment

- **40+ year history of CO₂ utilization for EOR**
- **Over 600 million tons of associated storage with EOR**
- **Over 4,000 miles of CO₂ pipelines in the United States**
- **Strong efforts in developing the human capital and enablers for CCUS deployment (scientists, engineers, trades)**
 - Broad R&D program engaging Private Industry, Universities, National Laboratories, small business, and the financial community.
- **Has successfully invested in major CCUS demonstrations**
- **Leading one of the most globally recognized and successful RD&D programs on CCUS....**
- **...And leveraging this technology, science, and knowledge with other agencies for sound policy development.**

EXCITING TIME FOR CCUS

CCUS is increasingly becoming widely accepted as a viable option for various point sources to lower their carbon dioxide (CO₂) emissions.

- DOE Major Demonstration Program
- 45Q tax credit
- Responses to DOE funding opportunities – broader R&D portfolio
- Increased investment interest
- Cost reductions



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



MAJOR CCUS DEMONSTRATION PROJECTS

Air Products Facility (Port Arthur, TX) – operations began in 2013



- Built and operated by Air Products and Chemicals Inc. at Valero Oil Refinery
- State-of-the-art system to capture CO₂ from two large **steam methane reformers**
- **Over 5.0 million metric tons of CO₂** captured and transported via pipeline to oil fields in eastern Texas for **enhanced oil recovery (EOR)** since March 2013

Petra Nova CCS (Thompsons, TX) – operations began in 2017



- Joint venture by NRG Energy, Inc. (USA) and JX Nippon Oil and Gas Exploration (Japan)
- Demonstrating Mitsubishi Heavy Industries' solvent technology to **capture 90% of CO₂ from 240-MW flue gas stream** (designed to capture/store 1.4 million metric tons of CO₂ per year)
- **Nearly 3.3 million metric tons of CO₂** used for **EOR** in West Ranch Oil Field in Jackson County, Texas since January 2017

ADM Ethanol Facility (Decatur, IL) – operations began in 2017



- Built and operated by Archer Daniels Midland (ADM) at its existing biofuel plant
- CO₂ from **ethanol biofuels production** captured and stored in **deep saline reservoir**
- **First-ever CCS project** to use new U.S. Environmental Protection Agency (EPA) Underground Injection **Class VI well permit**, specifically for CO₂ storage
- **1.3 million metric tons of CO₂** stored, since April 2017



Policy Incentives for CCUS - 45Q tax credits

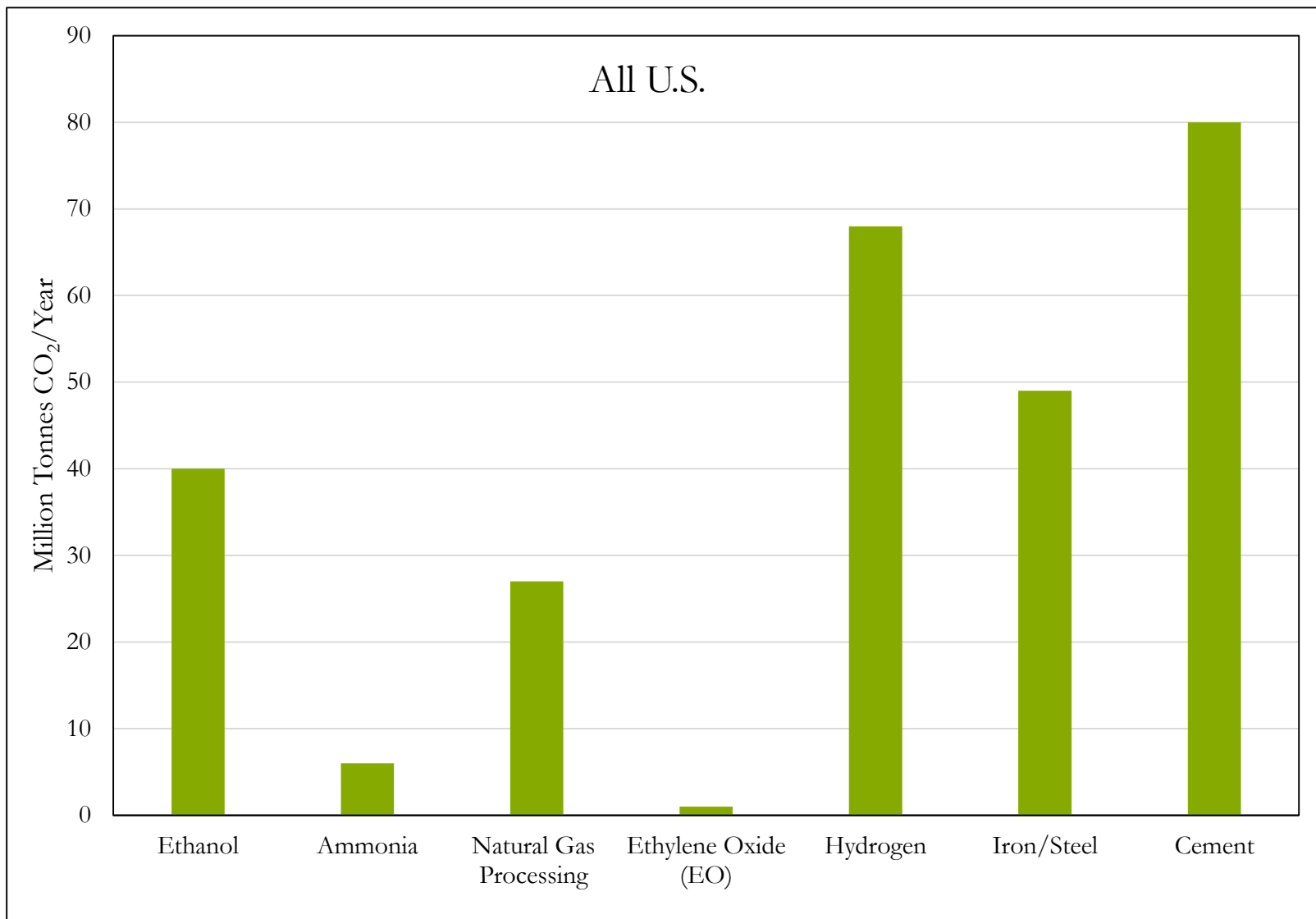
“Technology push” through R&D is matched with “market pull” through financial incentives

	Threshold by Facility Type (ktCO ₂ /y)			Credit in 2026 (\$/t)
	Power Plant	Industrial Facility	Direct Air Capture	
Dedicated Storage	500	100	100	50
EOR	500	100	100	35
Utilization	25	25	25	35

Source: McCoy, 2018

- Credit available to qualified facilities for 12 year period
- Defines qualified Carbon Oxides (CO or CO₂)
- Measured at point of capture and verified at the point of disposal/injection/use
- Qualified facilities:
 - 1) Construction must begin by Jan 1, 2024;
 - 2) Original planning and design includes carbon capture equipment
- Credit can be claimed by owner of capture equipment or transferred to disposal/use entity

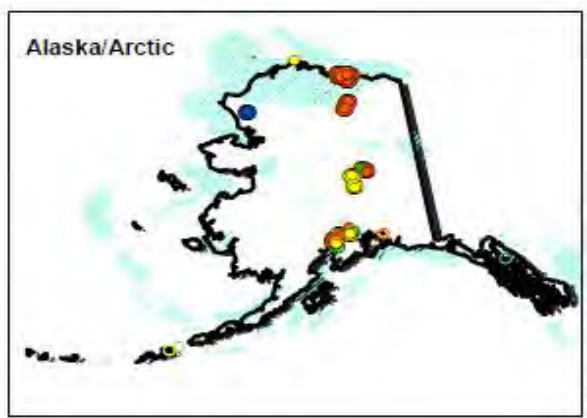
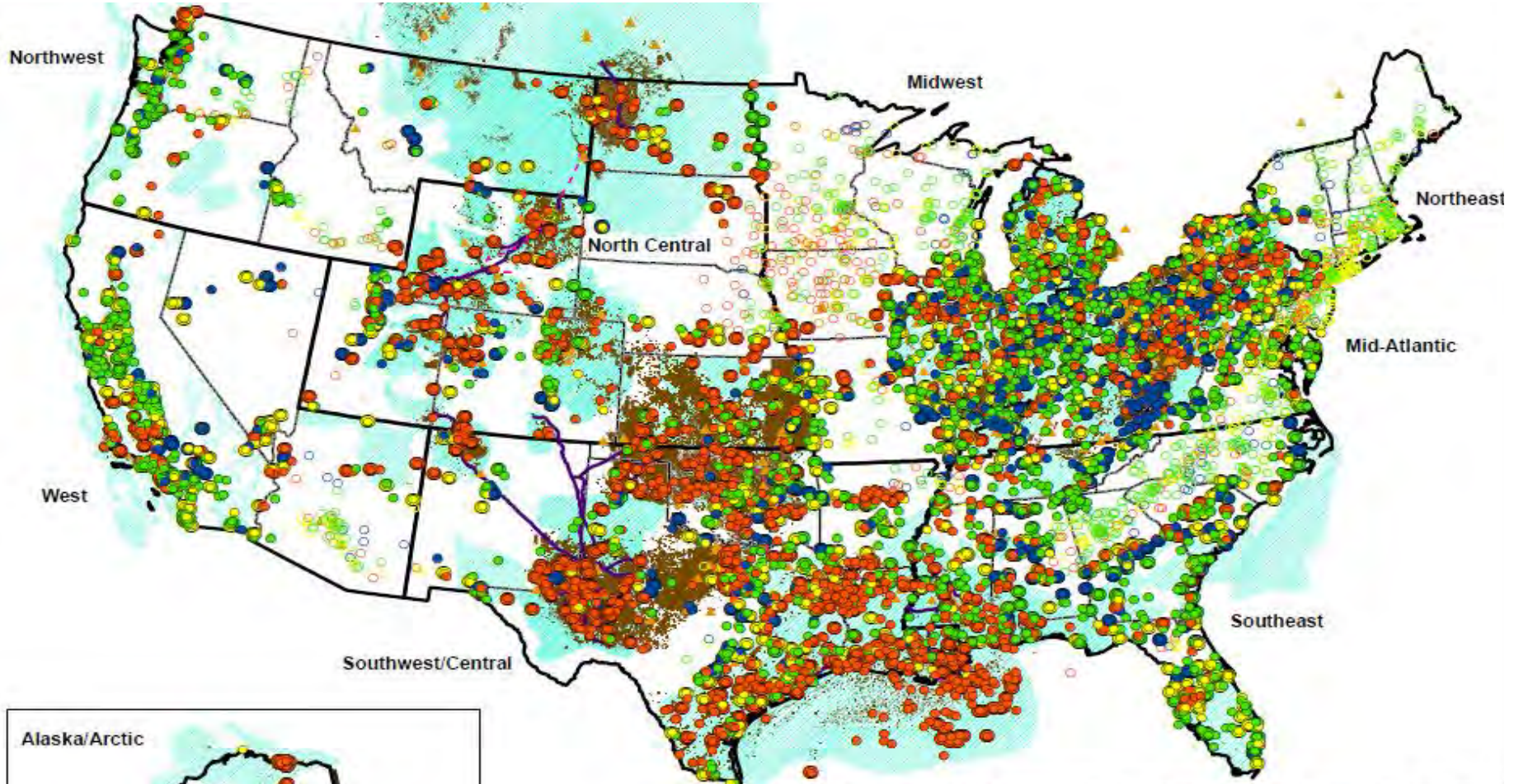
INDUSTRIAL PROCESSES: CO₂ AVAILABLE FOR CAPTURE IN THE US



Cost of Capturing CO₂ from Industrial Sources, January 10, 2014, DOE/NETL-2013/1602; <https://www.netl.doe.gov/energy-analysis/details?id=1836>



NATIONAL MAP OF CO₂ SOURCES AND STORAGE OPPORTUNITIES



U.S. CO₂ Sources within 50 miles of Saline Aq., EOR or In Service CO₂ Pipeline

CO₂ sources within 50 miles		CO₂ sources outside 50 miles	Saline Aquifer
● Power Generation	○ Chemical and Refinery Industry	○ Power Generation	Oil or Oil/Gas Field
● Chemical and Refinery Industry	○ Metals and Mineral Industry	○ Chemical and Refinery Industry	CO₂ Pipeline
● Metals and Mineral Industry	○ Other Industry	○ Metals and Mineral Industry	Status
● Other Industry	○ >50Kmt CO ₂ Emissions Per Yr	○ Other Industry	— In Service
● >50Kmt CO ₂ Emissions Per Yr		▲ Natural Gas Storage Facility	- - - Proposed

Map data source credits:
 ABB Velocity CO₂ Pipelines, NG Storage Fac., March 2016
 NATCARB v1502 Shapefiles CO₂ Sources,
 OIIGas Fields, Saline Aquifers
 Basemap credit: ESRI

0 62.5 125 250 375 500 Miles

CARBON CAPTURE, UTILIZATION AND STORAGE

Program Areas

\$200M per Year Investment focused on:

Carbon Capture – Reduce the cost of capture

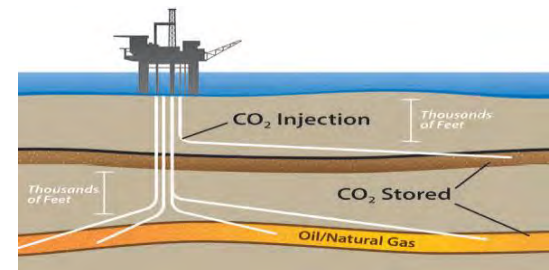
- Capital cost
- Energy penalty
- Integration

CO₂ Use and Reuse/Utilization – Develop viable carbon utilization alternatives – *opportunity for hydrogen?*

- Capital cost
- Energy requirements
- Lifecycle assessment

Carbon Storage – Improve the reliability and operations

- Higher resolution and quantification
- Geomechanics (pressure and state of stress)
- Cost



GROWING INDUSTRIAL INTEREST ON CCUS – NOT JUST FOR POWER

OIL AND GAS CLIMATE INITIATIVE (OGCI)



ExxonMobil



- **13 member companies**



- **Focused on three objectives:**
 - Reducing Energy Value Chain Footprint
 - Accelerating Low-Carbon Solutions
 - Enabling a Circular Carbon Model
- **\$1+ billion climate investment fund focused on:**
 - Reducing methane leakage
 - Reducing carbon dioxide (efficiency)
 - Recycling carbon dioxide (CCUS)

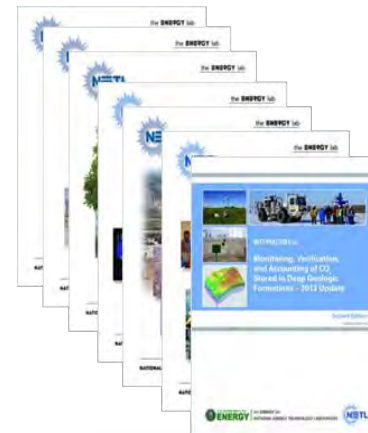
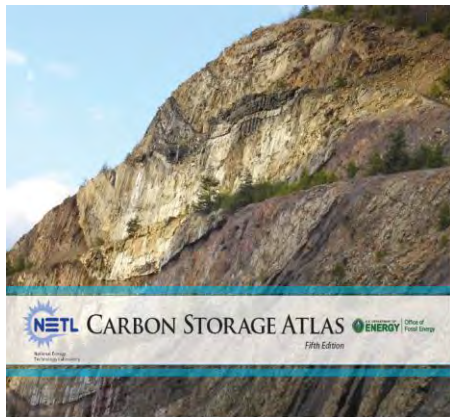


U.S. role in multilateral CCUS partnerships

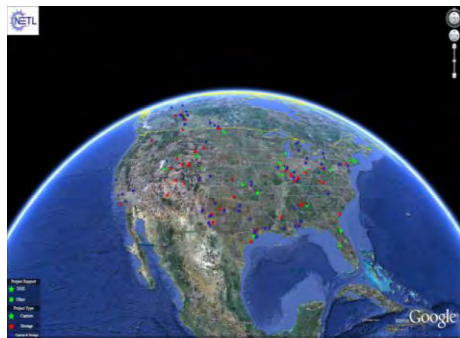
- ❑ **International Energy Agency (IEA)**
 - Working Party on Fossil Fuels (Chair)
 - Greenhouse Gas R&D Programme (GHG) *ExCo member*
 - Clean Coal Centre (CCC) *ExCo Chair*
 - CCS Unit – CCS Roadmap and International CCS Regulatory Network
- ❑ **Carbon Sequestration Leadership Forum (CSLF)**
 - *Secretariat and Policy Group Chair*
- ❑ **Clean Energy Ministerial (CEM) - CCUS Initiative**
 - *CCUS Initiative Lead*
- ❑ **Accelerating CCUS Technologies (ACT) Initiative**
- ❑ **Mission Innovation CCUS Initiative**
- ❑ **Asia Pacific Economic Cooperation Expert Group on Clean Fossil Energy (APEC EGCFE)**
 - *EGCFE Chair*
- ❑ **UN Economic Commission for Europe (UNECE)**
 - *Sustainable Energy Bureau Vice Chair*
- ❑ **Global CCS Institute**



KNOWLEDGE SHARING PRODUCTS



Worldwide CCS Project Database



A global leader on CCUS research, development, and deployment



Thank You

Questions?

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