Meeting the Dual Challenge:
A Roadmap to At-Scale Deployment of Carbon Capture, Use, and Storage

Post-Report Update

National Petroleum Council Annual Meeting

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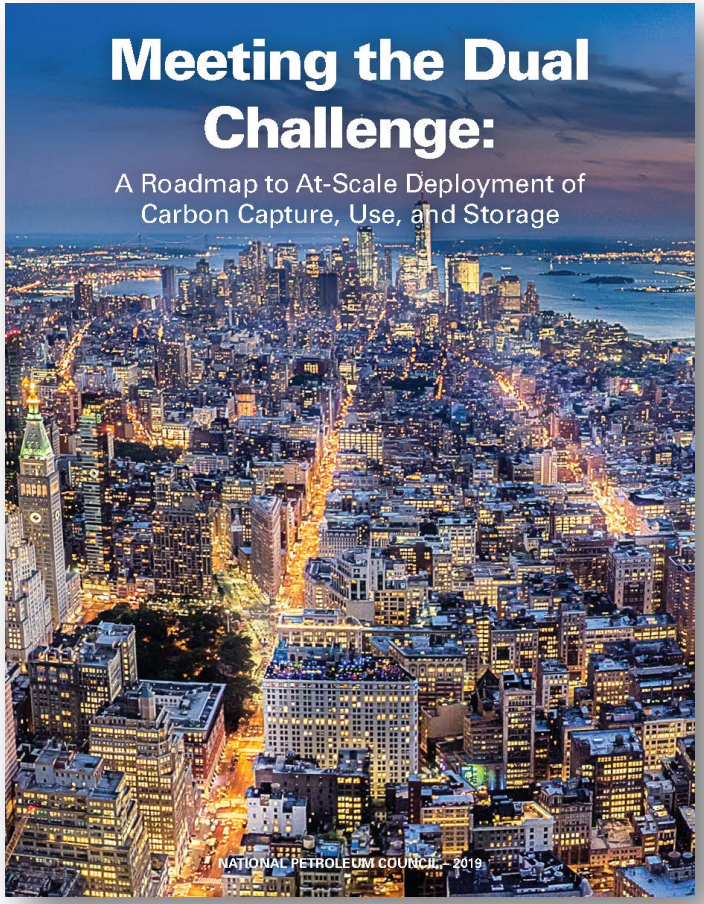


2017 Department of Energy request

Define the potential pathways for integrating carbon capture, use and storage (CCUS) at-scale into the energy and industrial marketplace

1. What are **U.S. and global future energy demand outlooks**, and the environmental benefits from the application of CCUS technologies?

2. What **R&D, technology, infrastructure, and economic barriers** must be overcome to deploy CCUS at scale?

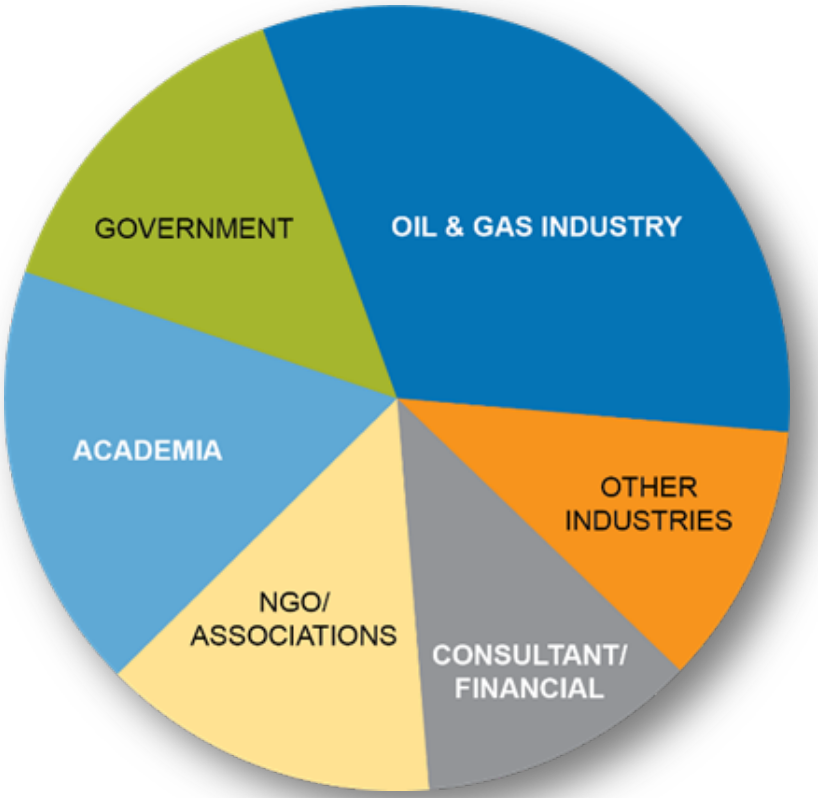
3. How should **success be defined**?

4. What actions can be taken to **establish a framework that guides public policy and stimulates private-sector investment** to advance the deployment of CCUS?

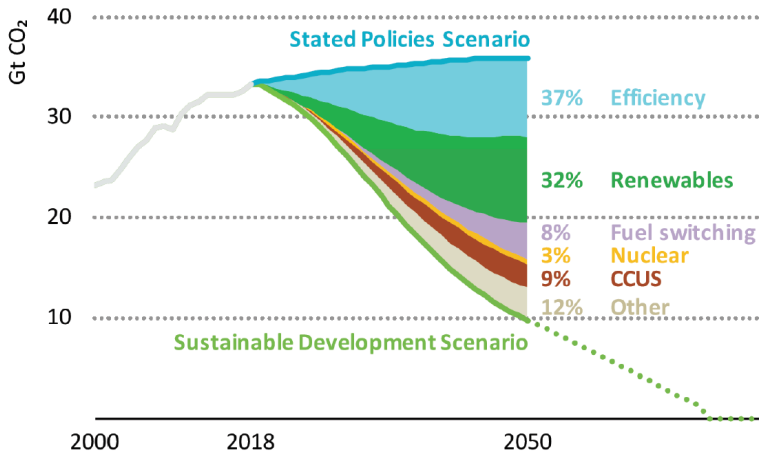
5. What **regulatory, legal, liability or other issues should be addressed** to progress CCUS investment and to enable the U.S. to be global technology leaders?

CCUS study participation

- Overall study team composed of over 300 participants from more than 110 different organizations and includes 17 international members.
- The Coordinating Subcommittee (CSC) had membership of 22 individuals representing oil & gas, LNG, biofuels, power, NGOs, engineering/construction and state and federal governments



CCUS deployment at-scale



Analysis demonstrates the critical role of CCUS in a clean energy technology portfolio (IEA, 2019)

The United States is the world leader in CCUS and is uniquely positioned to deploy the technologies at-scale.

***"At-scale" in the U.S. means*:**

- Moving from 25 million tonnes of CCUS capacity per annum to **500 Million tonnes of CO_2 removed** per annum
- Infrastructure buildout equivalent of **13 million barrels per day** capacity
- Incremental investment of **$680 billion**
- Support for **236,000 U.S. jobs** and **GDP of $21 billion** annually

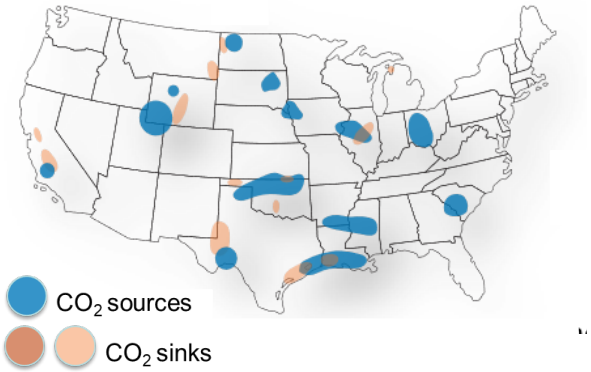
Key messages

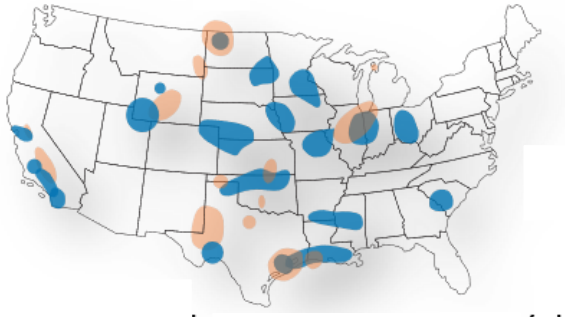
CCUS is essential to addressing the dual challenge of providing affordable, reliable energy to meet the world's growing demand while addressing the risks of climate change.

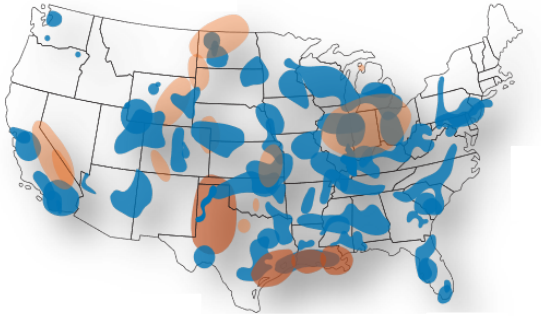
To achieve CCUS deployment at scale,

- The U.S. government will need **to reduce uncertainty** on **existing incentives**, **establish adequate additional incentives**, and implement a **durable regulatory** and **legal environment** that drives industry investment.
- A commitment to CCUS must include a commitment to continued **research, development, and demonstration.**
- At-scale CCUS deployment could create a **new industry, driving job creation** and **economic growth** across the nation.
- Increasing understanding and confidence in CCUS as **safe and reliable** is essential for **public and policy stakeholder support**.

Phases of CCUS deployment using existing technology







Activation: 5-7 years

~60 mtpa total CO_2

Clarifying existing tax policy and regulations could activate an additional 25 to 40 million tons per annum (Mtpa) of CCUS, doubling existing U.S. capacity within the next 5 to 7 years.

Expansion: 15 years

~150 mtpa total CO_2

Extending and expanding current policies and developing a durable legal and regulatory framework could enable the next phase of CCUS projects (an additional 75-85 Mtpa) within the next 15 years.

At-scale: 25 years

~500 mtpa total CO_2

Achieving CCUS deployment at scale, an additional 350-400 Mtpa, in the next 25 years will require substantially increased support driven by national policies.

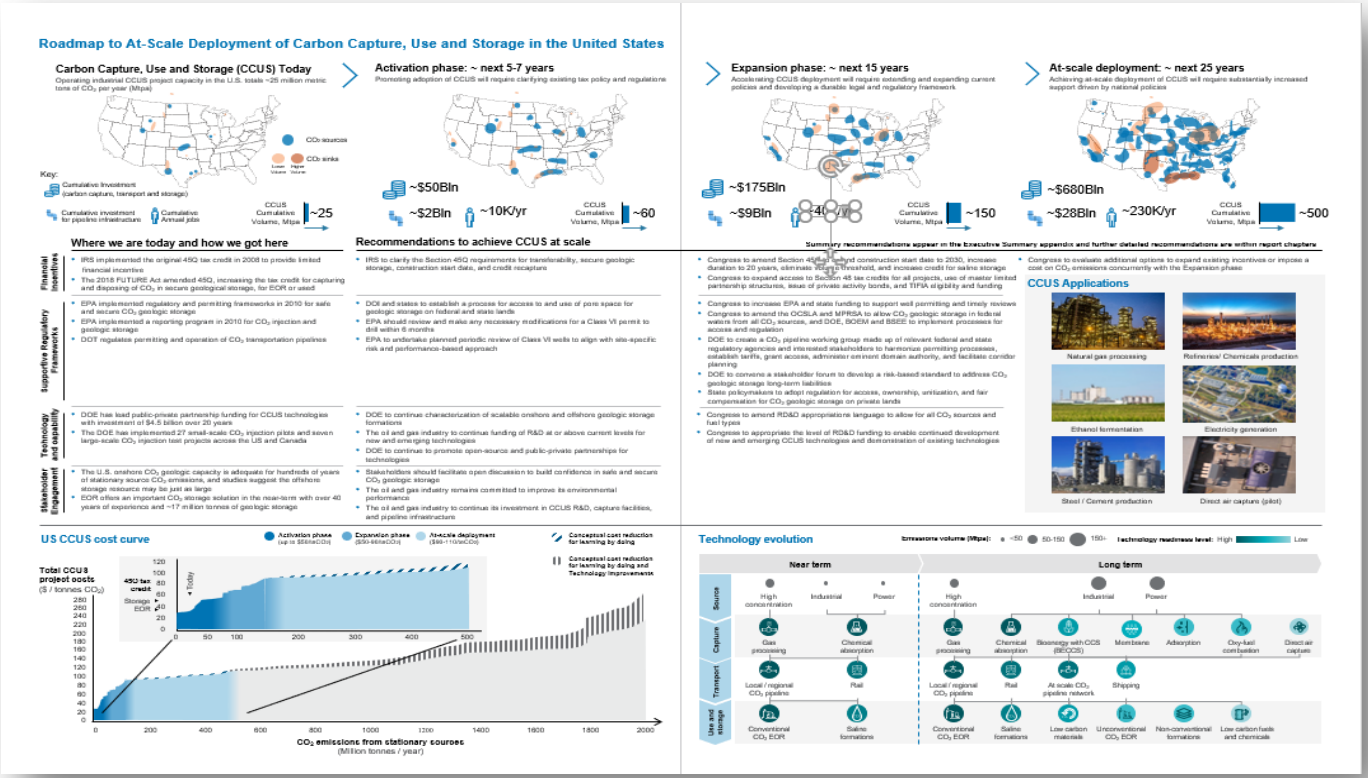
Research, development and demonstration

Increased government and private research, development, and demonstration is needed to improve performance, reduce costs, and advance alternatives beyond currently deployed technology.

Study recommends that Congress should appropriate **$15 billion of RD&D** funding over the next **10 years** to enable the continued development of new and emerging CCUS technologies and demonstration of existing technologies.

Technology	R&D (including pilot programs)	Demonstrations	Total	10-Year Total
Capture (including negative emissions technologies)	$500 million/year	$500 million/year	$1.0 billion/year (over 10 years)	$10 billion
Geologic Storage	$400 million/year		$400 million/year (over 10 years)	$4 billion
Nonconventional Storage (including EOR)	$50 million/year		$50 million/year (over 10 years)	$500 million
Use	$50million/year		$50 million/year (over 10 years)	$500 million
Total	**$1.0 billion/year**	**$500 million/year**	**$1.5 billion/year**	**$15 billion**

Roadmap and cost curve



To frame the roadmap, a CCUS cost curve was developed:

- Assessed the costs to capture, transport and store the largest 80% of U.S. stationary source CO_2 emissions – source, industry, and location specific and use transparent assumptions
- Plotted the cost to capture, store and transport one tonne of CO_2 against the volume of CO_2 abatement possible – identifies the level of value (incentives, revenue, etc.) needed to enable deployment.

Report publication

The 3-volume, 600+ page study report includes:

- Volume 1 - **Report Summary**

(*includes study request, Executive Summary: findings and recommendations, Roadmap to At-Scale Deployment, study team*).

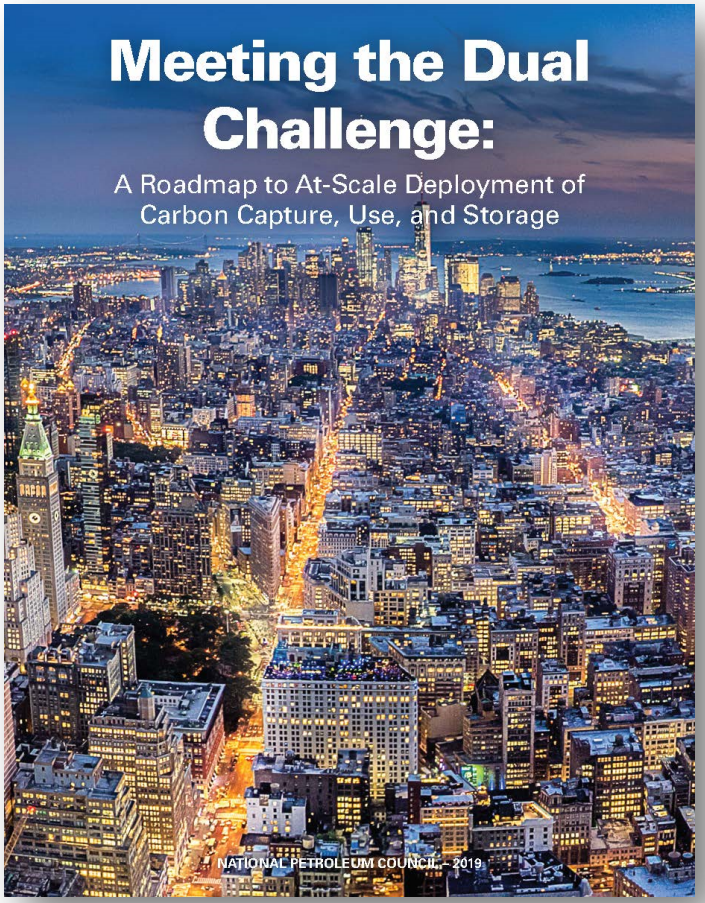
- Volume II - **Analysis of CCUS Deployment At-Scale**

(*includes energy outlook, supply chain and economics, policy, regulatory and legal enablers, stakeholder engagement*).

- Volume III – **Analysis of CCUS Technologies**

(*includes technology overviews of capture, transport, storage and use, RD&D recommendations*).

Report volumes and supporting information available on NPC website at https://dualchallenge.npc.org



Outreach: engagements

Full study briefings include:

- **Press briefing**, 12/11/19
- **Trade Association briefing**, 12/11/19
- **ESG and Energy anti-conference**, 1/13/20
- **Clean Energy Ministerial,** 1/21/20*
- **SPE National Chapter**, 1/22/20
- **DOE agency staff**, 1/23/20
- **DOE and state officials**, 1/24/20
- **USEA/DOE CCUS Roadshow**, 1/28/20
- **UT CCUS Policy/Technology**, 1/28/20*
- **SPE CCUS Technical Section**, 1/29/20
- **OGCI CCS Working Group**, 1/29/20
- **GHP Energy Policy Committee**, 2/20
- **IEA Energy Technology Perspectives**, 2/5/20
- **NARUC Staff Subcommittee**, 2/9/20
- **LA Industry Engagement on CCUS**, 2/10/20
- **Georgetown podcast**, 2/20
- **Texas Governor's office** brief, 2/17/20
- **ENGO** brief, 2/18/20
- **Groundwater Protection Council,** 2/18/20
- **House Committee on Science, Space, Tech**, 2/19/20
- **House Committee on Energy & Commerce**, 2/25/20
- **House Select Committee on Climate**, 2/26/20
- **Senate Environment & Public Works**, 2/26/20
- **CURC** member briefing, 2/26/20
- **House minority leader** staff, 2/27/20
- **Senate Energy & Natural Resources**, 2/27/20
- **iCCUS conference-** Saudi, 2/27/20
- **Representing CCUS Cost workshop**, 3/920
- **National Academies of Science**, 5/13/20*
- **Energy Industries Council**, 6/4/20
- **IOGCC** meeting, 6/24/20*
- **USGS** webinar, 8/10/20
- **SPE** Annual Conference, 10/5/20
- **UH Energy** Symposium, 10/9/20
- **UK CCS** Research Center, 11/5/20
- **U of Tulsa** energy class, 11/19/20
- **OGUK Decommissioning** Conference, 11/25/20

Study references and weblinks distributed include:

- **GCCSI CCS forum**, 3/3/20
- **Atlantic Council Green Stimulus**, 8/12/20
- **Houston Energy dialogs**, 8/18/20
- **Upstream magazine panel**, 10/7/20
- **CHF Future Innovation Summit**, 108/20

Engagements to continue into 2021

Outreach: references and impact

Recordings of representative events and presentation materials available on the NPC website @ Meeting the Dual Challenge - Report Downloads (npc.org)

Study overview:

- Proposed Final Report of the NPC Committee on CCUS *(12/12/19)*
- National Academies of Science Committee on Earth Resources *(5/13/20)*

Roadmap: Clean Energy Ministerial *(1/21/20)*

Cost assessment and economics: UT 5th Conference on CCS *(1/28/20)*

Interstate Oil and Gas Compact Commission *(6/24/20):* study findings and recommendations, *yielded supporting resolution from OIGCC.*

CCUS Cost Assessment Tools: Carbon Capture Use and Storage (CCUS) project evaluations | GaffneyCline

- Integrated cash flow model calculates revenue to fund installation and operation of capture, transport and storage
- 400 users to date
- Applications include cost assessments of:
  - Port of Houston area (U of Houston/CHF)
  - Southeastern US (Georgia Tech)

Policy and economic foundation integrated into studies and recommendations including:

- Helped frame priority issues and diverse stakeholder views on 45Q recommendations
- Baker Institute/Rice developing paper on "Expanding Carbon Capture in Texas"
- EFI/Stanford study, leveraged work in NPC study to evaluate plan for CCUS in California
- Planned integration in future studies

Acknowledgements

- U.S. Department of Energy
- The National Petroleum Council leadership and staff
- Members of the National Petroleum Council
- The NPC Infrastructure Study leadership and team

… and to the 300+ participants who helped to develop and deliver this comprehensive study on carbon capture, use, and storage, thank you for your contributions!