National Petroleum Council

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

December 12, 2019

In September 2017

The Secretary of Energy requested the NPC conduct a study

- Define the potential pathways for integrating CCUS at scale into the energy and industrial marketplace.
- The Secretary asked the Council to consider:
  - Technology options and readiness
  - Market dynamics, economics and financing
  - Cross-industry integration and infrastructure
  - Policy, legal and regulatory issues
  - Environmental footprint
  - Public acceptance

The request asked five key questions

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?

Comprehensive report covering:

CCUS Energy and Emission Landscape
- Understanding the dual challenge and the role of CCUS

Economics
- Detailed CCUS cost and economic analyses

Enabling Factors
- Existing policy and regulatory landscape
- Current barriers and prioritized, actionable recommendations

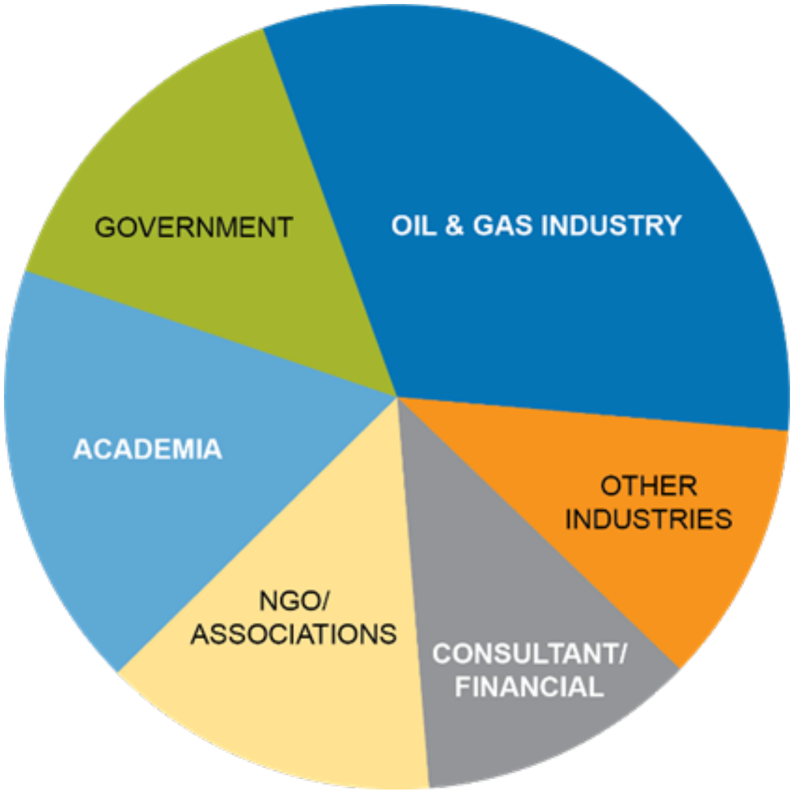
Technology
- Well written technology chapters covering entire supply chain
- Aggressive research and development recommendations

Roadmap
- Prioritized based on economics and ease of implementation
- Three phases of deployment
- Detailed plan – who, what, when, and why over 25 years

Study organization

Study participation

- The CSC has membership of 22 individuals representing upstream and downstream oil & gas, LNG, biofuels, power, EPC, NGO, and state and federal governments.
- The overall study team is currently composed of over 300 participants from more than 110 different organizations and includes 17 international members.
- National Coal Council participation is represented through overlap of 21 organizations.



CCUS deployment at scale

Will mean:

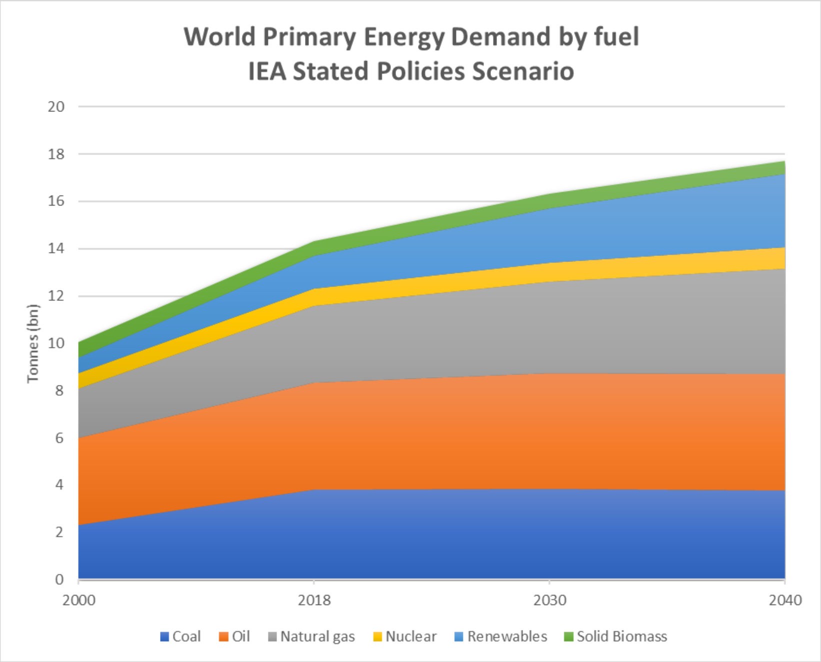
- Moving from 25 to **500 Million tonnes per annum** of CCUS capacity
- Infrastructure buildout equivalent of **13 million barrels per day** capacity
- Incremental investment of **$680 billion**
- Support for **236,000 U.S. jobs** and **GDP of $21 billion** annually

Will require:

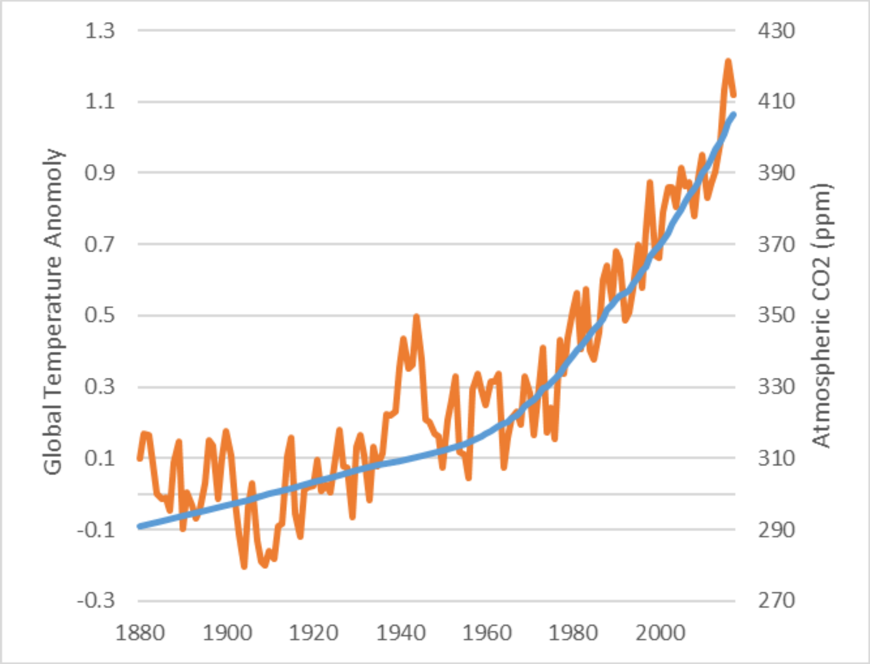
- Improved **policies**, **incentives**, **regulations** and **legislation**
- Broad-based **innovation** and **technology** development
- Strong **collaboration** between **industry** and **government**
- Increased **understanding** and **confidence** in CCUS

Understanding the dual challenge

The world faces a dual challenge of providing affordable, reliable energy while addressing the risks of climate change.



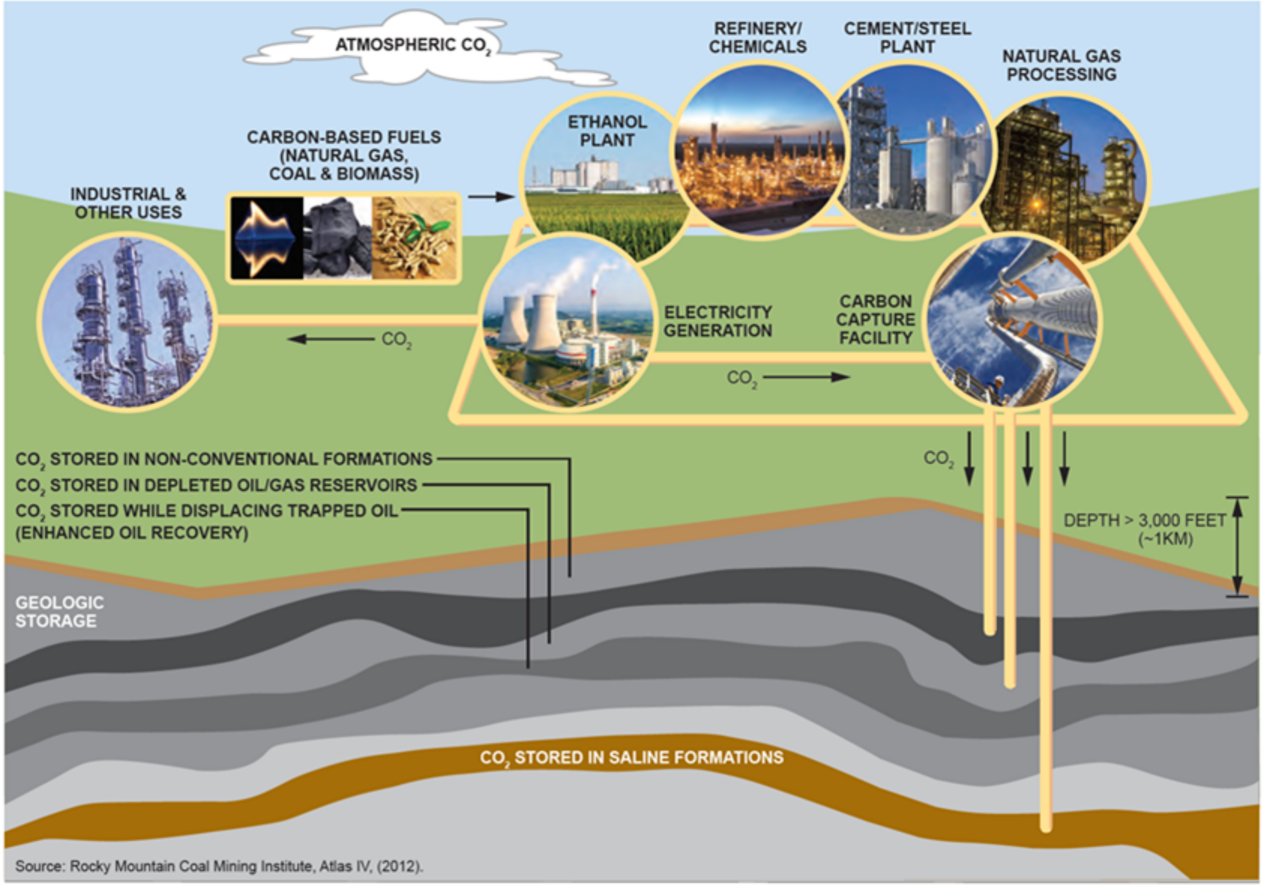
Over the next two decades, global population and GPD growth will drive continued increase in global energy demand



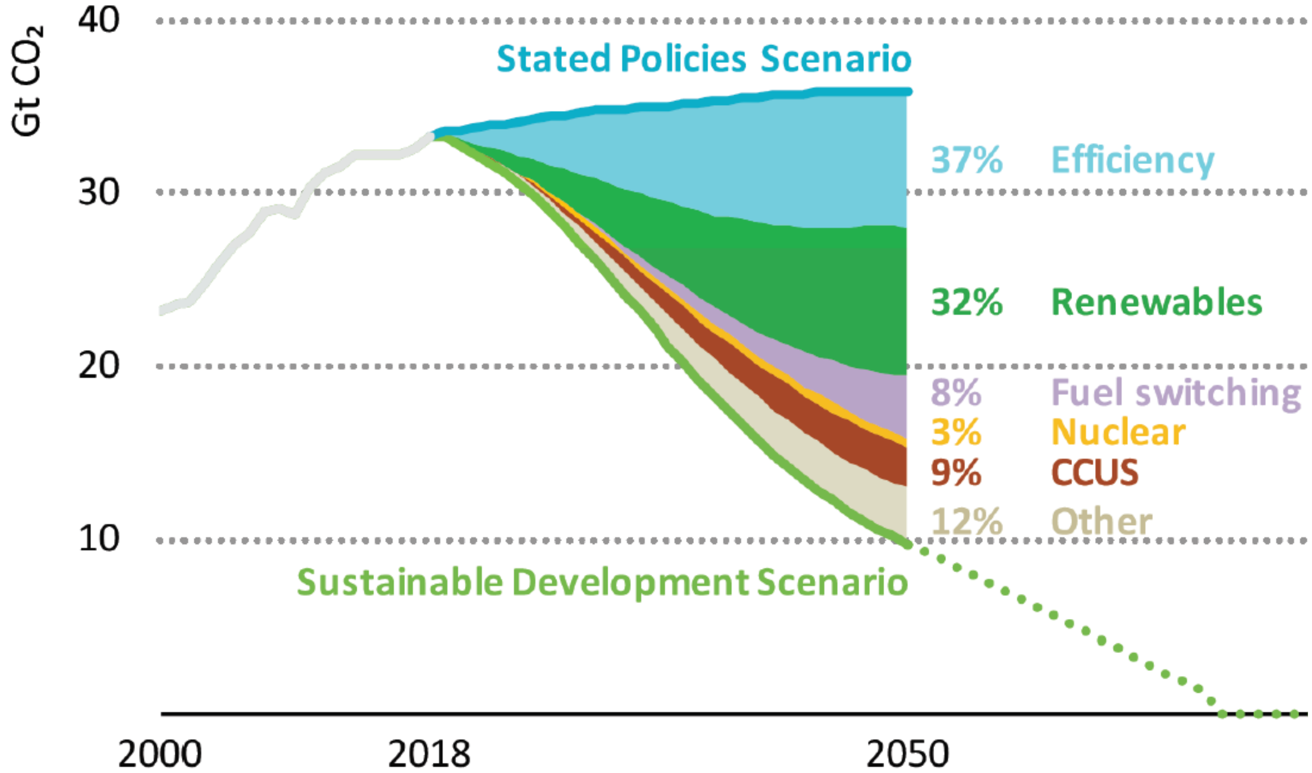
At the same time, the need to address rising carbon dioxide (CO_2) emissions continues to grow

The CCUS supply chain

CCUS technologies combine to reduce the level of CO_2 emitted to or remove CO_2 from the atmosphere to be transported to and converted into useful products or injected underground for safe, secure and permanent storage.



CCUS as part of a clean energy portfolio



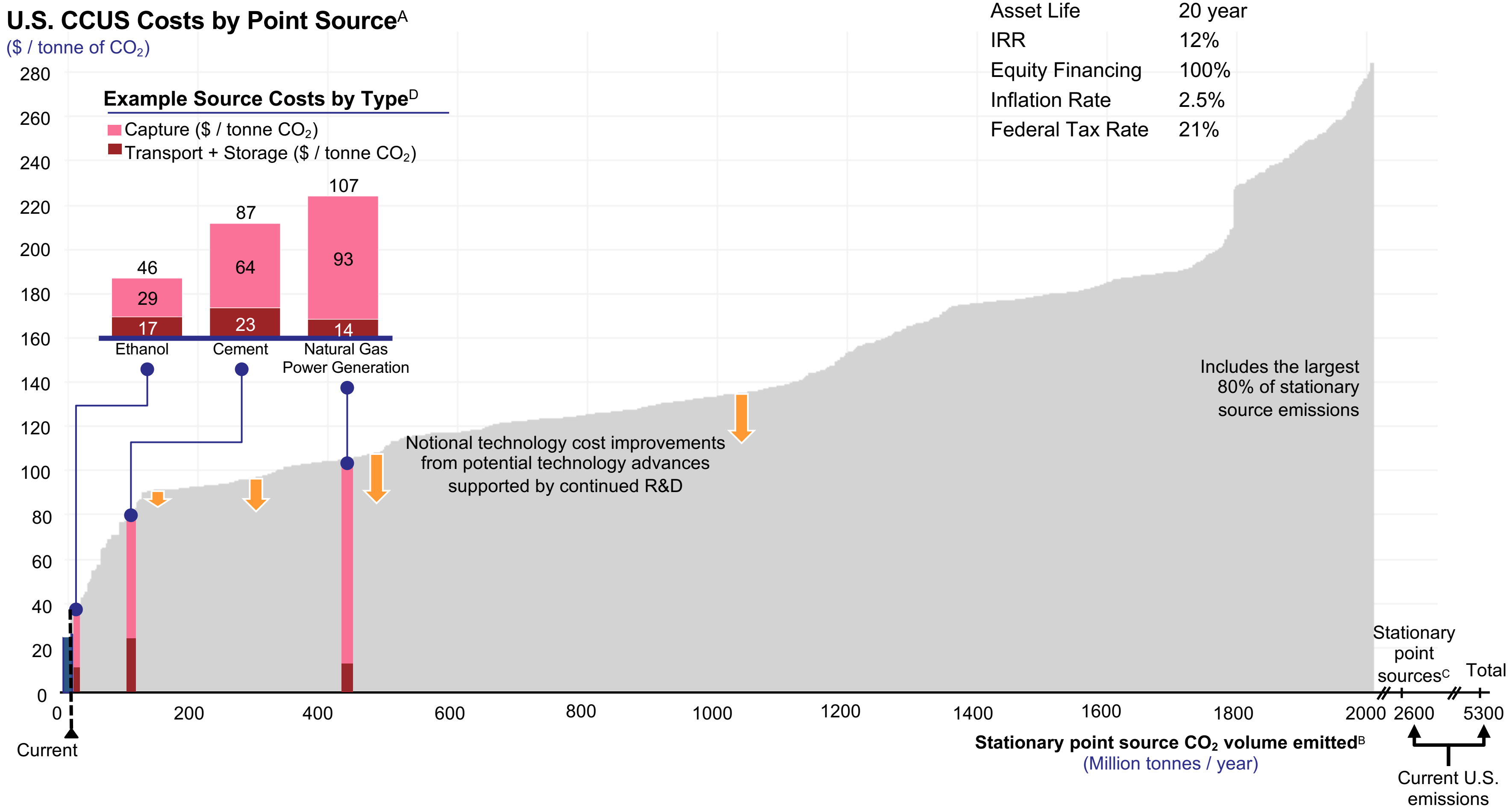
IEA analysis demonstrates the critical role of CCUS in a clean energy technology portfolio (IEA, 2019)

CCUS cost assessment

Study has assessed the costs to capture, transport and store 850 point sources of emissions comprising 80% (~2Gt) of all U.S. stationary sources:

- Cost to capture, transport, and store one tonne of CO_2 plotted against the volume of CO_2 abatement possible
- Source, industry and location specific
- Costs based on N^{th} of a kind technology currently available and deployed
- Transparent assumptions, leveraging existing studies combined with industry experience
- Identifies level of value (incentives, revenue, etc.) necessary to enable deployment
- Builds the case for ongoing RD&D across entire CCUS supply chain
- Economic impacts assessment (e.g., jobs, GDP)

CCUS cost assessment: methodology



Assumptions

Asset Life	20 year
IRR	12%
Equity Financing	100%
Inflation Rate	2.5%
Federal Tax Rate	21%

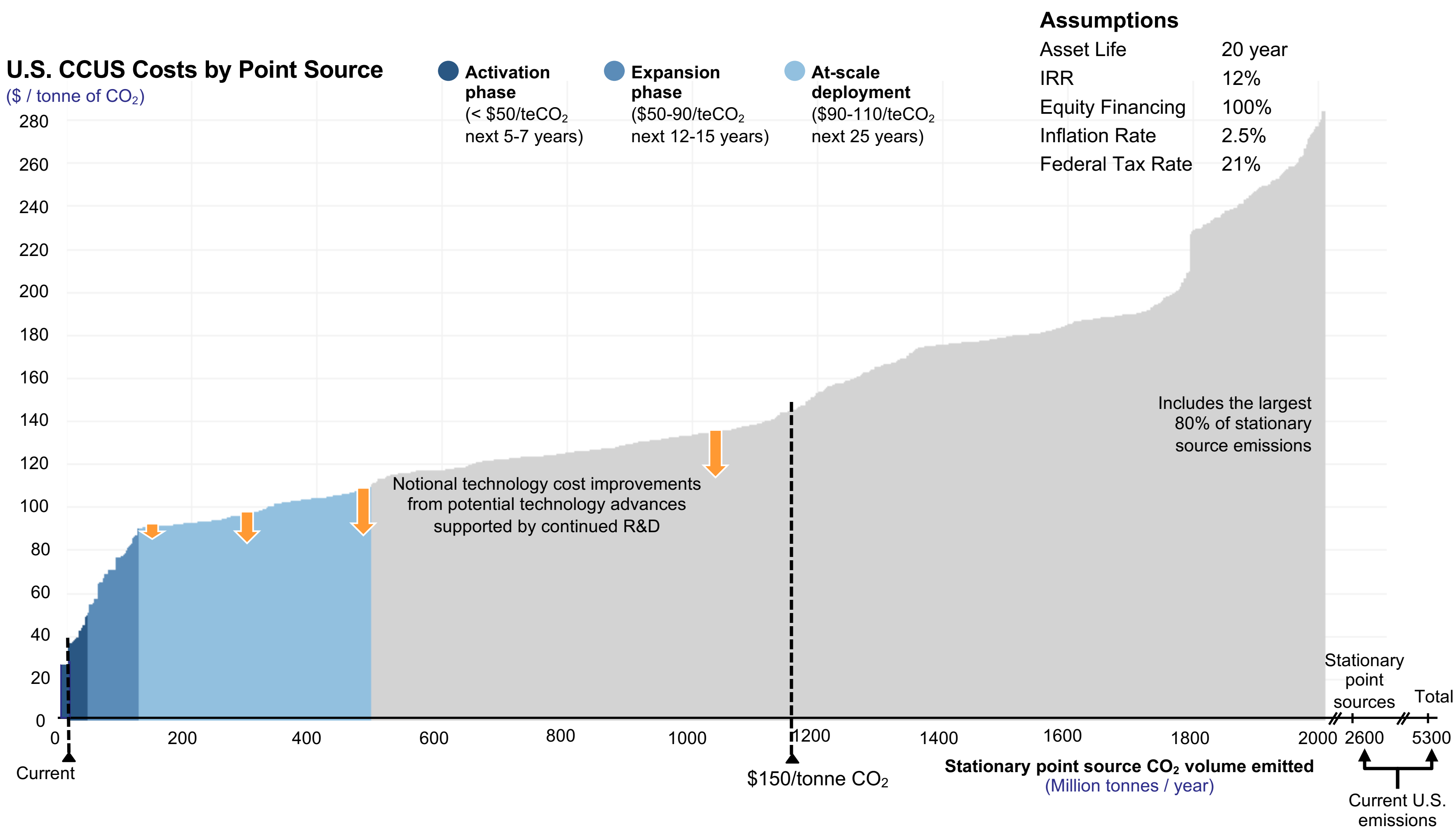
A Includes project capture costs, transportation costs to defined use or storage location, and use/storage costs; does not include direct air capture

B This curve is built from bars that each represent an individual point source with a width corresponding to the total CO_2 emitted from that individual source

C Total point sources include ~600 MTPA of point sources emissions without characterized CCUS costs

D Widths of bars are illustrative and not indicative of volumes associated with each source

CCUS cost assessment: phases of deployment

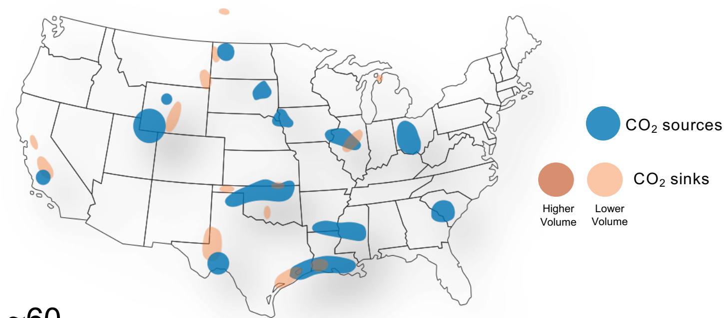


Findings 1 - 4: CCUS landscape and outlooks

1. As global economies and populations continue to grow and prosper, the world faces the dual challenge to provide affordable, reliable energy while addressing the risks of climate change.
2. Widespread CCUS deployment is essential to meeting the dual challenge at the lowest cost.
3. Increasing deployment of CCUS can deliver benefits and favorably position the United States to participate in new market opportunities as the world transitions to a lower CO_2 intensive energy system.
4. The United States is uniquely positioned as the world leader in CCUS and has substantial capability to drive widespread deployment:
   - ~80% of the world's CCUS capacity (10 of 19 projects) is deployed in the U.S.
   - ~85% of global CO_2 pipeline infrastructure is in the U.S.
   - Cutting edge RD&D - $4.5bn DOE investment over last 20 years
   - Supportive policy framework – but insufficient for widescale deployment

Finding 5: activation phase

5. 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.



Recommendations

Agency Action & Rulemaking:

- IRS/Treasury to clarify Section 45Q
- DOI and states to establish a process for access to and use of pore space
- EPA should shorten period of Class VI permit process
- EPA to review Class VI permit process to be site-specific risk and performance-based

~60 Mtpa — Cumulative annual CCUS Volume

~$50 B investment (cumulative)

~$2 B pipeline infrastructure investment

~10K annual jobs

9% of US oil system by volume

* note: 25-40 mtpa is likely overstated based on current 12 year life of 45Q tax credit – the increase to 20 years does not come until Expansion phase

Finding 6: expansion phase

6. 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.

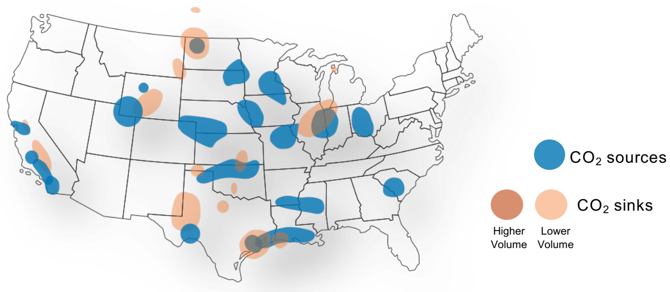
<u>Recommendations</u>

Congress to:

- Amend 45Q
- Expand access to Section 48 tax credits
- Expand use of MLPs, private activity bonds, and TIFIA eligibility/funding
- Increase funding to support well permitting and timely reviews
- Allow geologic storage in federal waters from all CO_2 sources

Agencies to:

- DOE & DOI to implement process for pore space access
- DOE to create CO_2 pipeline working group for development of large scale CO_2 pipeline infrastructure
- DOE to convene stakeholder forum to address geologic storage long-term liabilities
- State policymakers enable access to pore space on private lands



~150 Mtpa — Cumulative annual CCUS Volume

~$175 B investment (cumulative)

~$9 B pipeline infrastructure investment (cumulative)

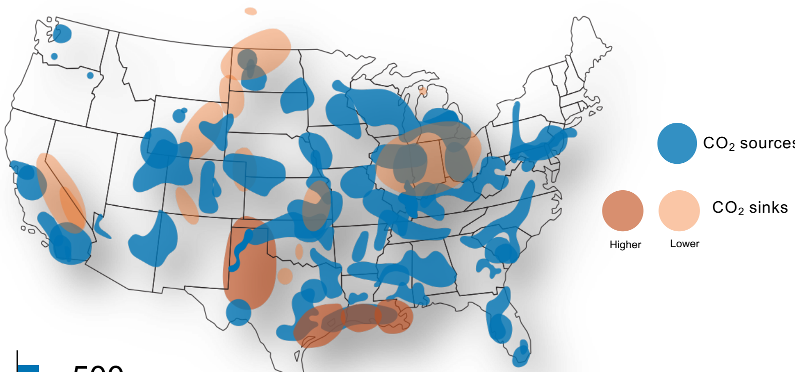
~40K annual jobs (cumulative)

23% of US oil system by volume

Finding 7: at-scale deployment phase

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

<u>Recommendation</u>:
To achieve at-scale deployment, congressional action should be taken to implement economic policies amounting to about $110/tonne. The evaluation of those policies should occur concurrently with the expansion phase.



~500 Mtpa — Cumulative annual CCUS Volume

~$680 B investment (cumulative)

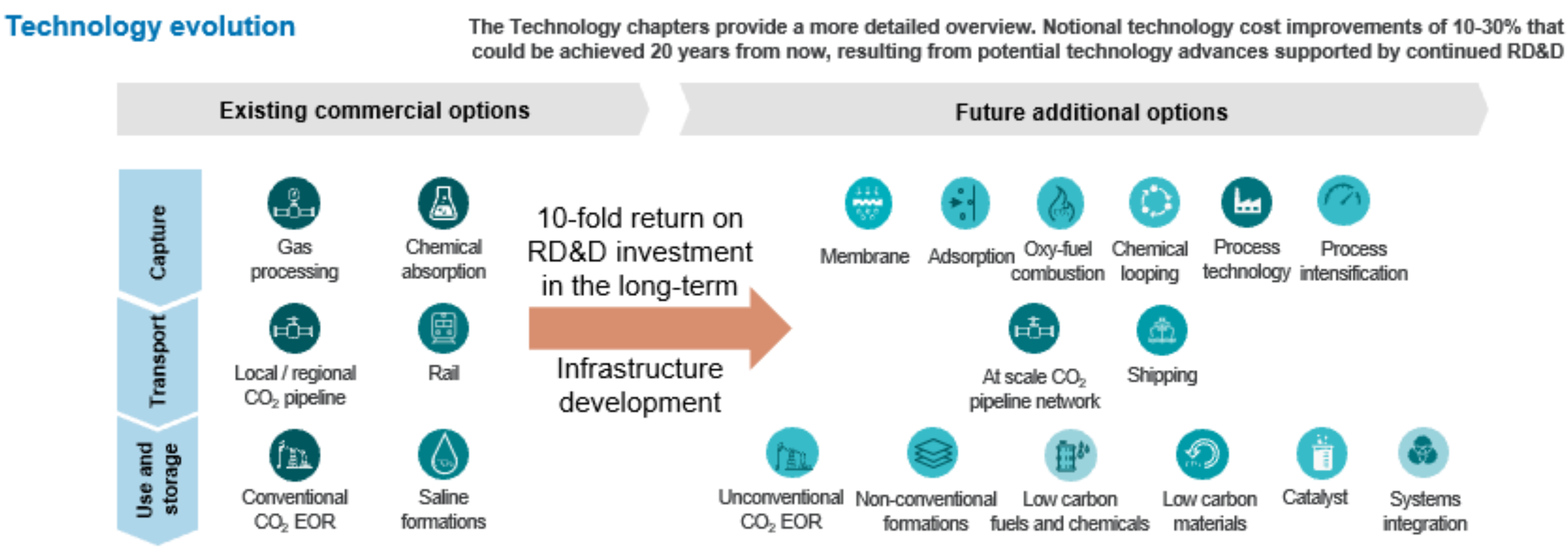
~$28 B pipeline infrastructure investment (cumulative)

~230K annual jobs (cumulative)

76% of US oil system by volume

Critical role of RD&D investment

Study describes the evolution of CCUS technologies across the supply chain and builds the case for continued investment in research and development to achieve long-term cost and performance improvements.



Finding 8: research and development

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

Recommendation: 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**

Findings 9 and 10: public and industry engagement

9. Increasing understanding and confidence in CCUS as a safe and reliable technology is essential for public and policy stakeholder support.

Recommendations:

- Simplify terminology and build confidence that CCUS is safe, secure, and critical to managing emissions.
- Oil and natural gas industry remain committed to improving its environmental performance.

10. The oil and natural gas industry is uniquely positioned to lead CCUS deployment due to its relevant expertise, capability, and resources.

Recommendation:

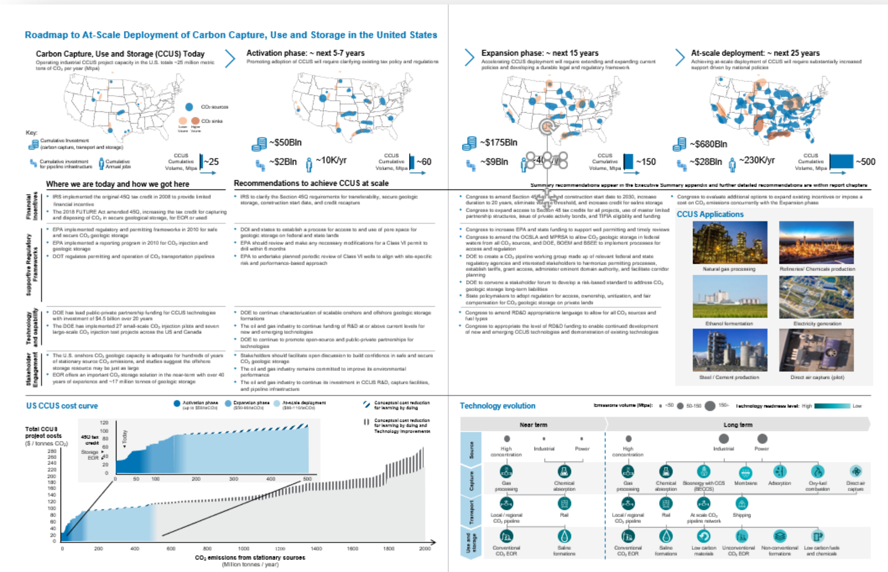
- The oil and natural gas industry continue investment in CCUS, specifically:
  - Current and next generation capture facilities
  - Development of new technologies
  - CO_2 pipeline infrastructure needed for EOR and saline storage
  - R&D for advancing CCUS technologies

Key messages

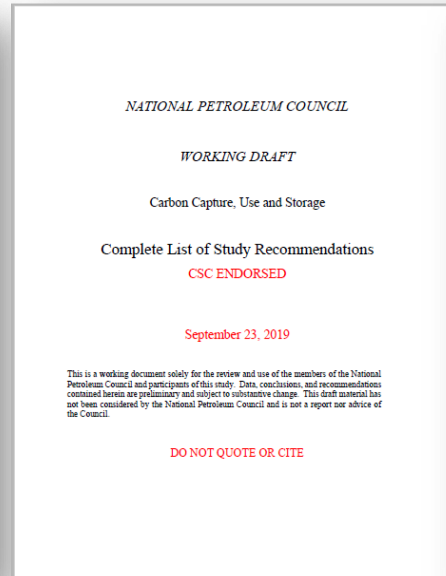
- CCUS refers to the complete supply chain needed to capture, transport and permanently use or store CO_2, eliminating it from the atmosphere.
- CCUS is essential to addressing the dual challenge of providing affordable, reliable energy to meet the world's growing demand while addressing the risks of climate change.
- The United States is the world leader in CCUS and uniquely positioned to deploy the technologies at scale.
- 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.

Roadmap and full list of recommendations

Roadmap to At-Scale CCUS Deployment



All Study Recommendations



NATIONAL PETROLEUM COUNCIL

WORKING DRAFT

Carbon Capture, Use and Storage

Complete List of Study Recommendations

CSC ENDORSED

September 23, 2019

This is a working document solely for the review and use of the members of the National Petroleum Council and participants of this study. Data, conclusions, and recommendations contained herein are preliminary and subject to substantive change. This draft material has not been considered by the National Petroleum Council and is not a report nor advice of the Council.

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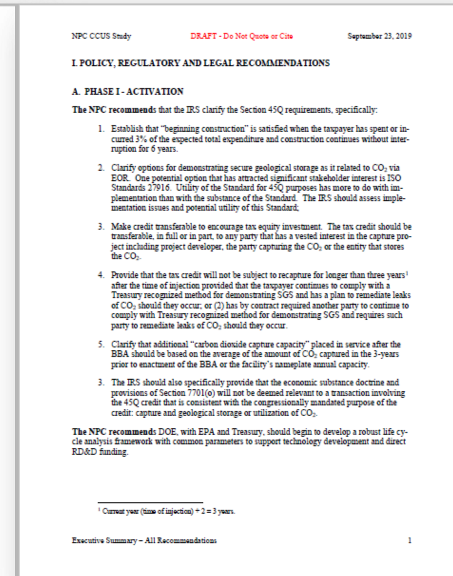


NPC CCUS Study DRAFT - Do Not Quote or Cite September 23, 2019

I. POLICY, REGULATORY AND LEGAL RECOMMENDATIONS

A. PHASE I - ACTIVATION

The NPC recommends that the IRS clarify the Section 45Q requirements, specifically:

1. Establish that "beginning construction" is satisfied when the taxpayer has spent or incurred 3% of the expected total expenditure and construction continues without interruption for 6 years.
2. Clarify options for demonstrating secure geological storage as it related to CO_2 via EOR. One potential option that has attracted significant stakeholder interest is ISO Standards 27916. Utility of the Standard for 45Q purposes has more to do with implementation than with the substance of the Standard. The IRS should assess implementation issues and potential utility of this Standard;
3. Make credit transferable to encourage tax equity investment. The tax credit should be transferable, in full or in part, to any party that has a vested interest in the capture project including project developer, the party capturing the CO_2 or the entity that stores the CO_2.
4. Provide that the tax credit will not be subject to recapture for longer than three years[1] after the time of injection provided that the taxpayer continues to comply with a Treasury recognized method for demonstrating SGS and has a plan to remediate leaks of CO_2 should they occur; or (2) has by contract required another party to continue to comply with Treasury recognized method for demonstrating SGS and requires such party to remediate leaks of CO_2 should they occur.
5. Clarify that additional "carbon dioxide capture capacity" placed in service after the BBA should be based on the average of the amount of CO_2 captured in the 3-years prior to enactment of the BBA or the facility's nameplate annual capacity.
3. The IRS should also specifically provide that the economic substance doctrine and provisions of Section 7701(o) will not be deemed relevant to a transaction involving the 45Q credit that is consistent with the congressionally mandated purpose of the credit: capture and geological storage or utilization of CO_2.

The NPC recommends DOE, with EPA and Treasury, should begin to develop a robust life cycle analysis framework with common parameters to support technology development and direct RD&D funding.

[1] Current year (time of injection) + 2 = 3 years.

Executive Summary – All Recommendations 1

NPC study report

Executive Summary

- Transmittal letter
- Report outline
- Preface
- Executive Summary, Roadmap and Recommendations

Appendices

A. Request Letter and NPC Description
B. Study Group Rosters

CCUS Deployment At-Scale (Volume 1)

- **Chapter 1:** The Role of CCUS in Future Energy Mix
- **Chapter 2:** CCUS Supply Chains & Economics
- **Chapter 3:** Policy, Regulatory & Legal Enablers
- **Chapter 4:** Stakeholder Engagement

Appendices

C. CCUS Project Summaries
H. Integrated Economic Analysis (ERM Memo)

CCUS Technologies (Volume 2)

- **Technology Introduction**
- **Chapter 5:** CO_2 Capture
- **Chapter 6:** CO_2 Transport
- **Chapter 7:** CO_2 Geologic Storage
- **Chapter 8:** Enhanced Oil Recovery
- **Chapter 9:** CO_2 Use

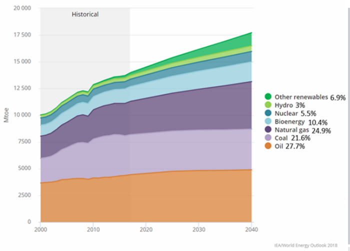
Appendices

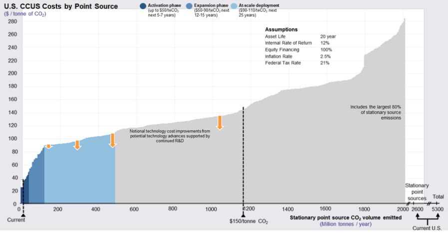
D. Mature CO_2 Capture Technologies
E. Emerging CO_2 Capture Technologies
F. CO_2 EOR Case Studies
G. CO_2 EOR Economic Factors and Considerations
List of Topic Papers
Abbreviations, Units, Glossary

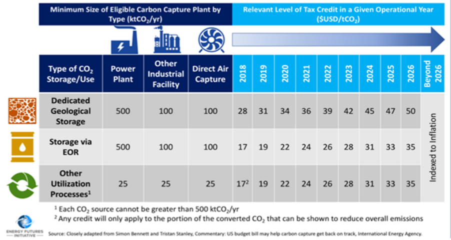
Findings and Recommendations — *Full Report*

CCUS deployment at-scale: chapters 1 - 4

Title	Lead Authors	Key Sections
The Role of CCUS in a Future Energy Mix	Jason Bordoff Julio Friedmann	• Global & U.S. energy demand forecasts • Role of CCUS • U.S. CO_2 emissions profile • Benefits of CCUS – environmental, economic, US leadership
CCUS Supply Chains and Economics	Nigel Jenvey Guy Powell Rick Callahan	• Complexity of supply chain • Description of existing projects • Supply chain enablers • Cost to deploy CCUS • Enablers for future projects
Policy, Regulatory and Legal Enablers	Leslie Savage Susan Blevins	• Existing policy and regulatory framework • Activation phase actions • Expansion phase actions • At-Scale phase actions • Research and development priorities
Building Stakeholder Confidence	Sallie Greenberg	• Spheres of public engagement • Public perception of CCUS • Defining and understanding stakeholders • Strategic engagement





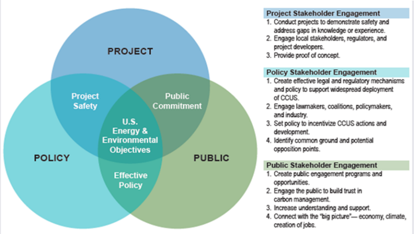


Type of CO_2 Storage/Use	Power Plant	Other Industrial Facility	Direct Air Capture	2018	2019	2020	2021	2022	2023	2024	2025	2026	Beyond 2026
Minimum Size of Eligible Carbon Capture Plant by Type ($ktCO_2/yr$)				Relevant Level of Tax Credit in a Given Operational Year ($\$USD/tCO_2$)									
Dedicated Geological Storage	500	100	100	28	31	34	36	39	42	45	47	50	Indexed to Inflation
Storage via EOR	500	100	100	17	19	22	24	26	28	31	33	35	Indexed to Inflation
Other Utilization Processes[1]	25	25	25	17[2]	19	22	24	26	28	31	33	35	Indexed to Inflation

[1] Each CO_2 source cannot be greater than 500 $ktCO_2/yr$
[2] Any credit will only apply to the portion of the converted CO_2 that can be shown to reduce overall emissions

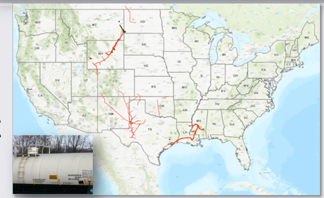
ENERGY FUTURES INITIATIVE

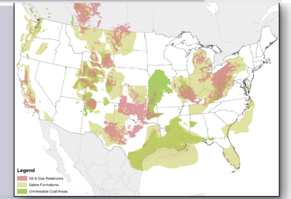
Source: Closely adapted from Simon Bennett and Tristan Stanley, Commentary: US budget bill may help carbon capture get back on track, International Energy Agency.

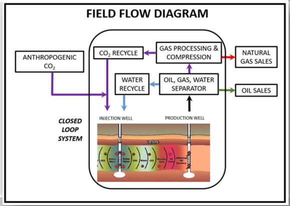


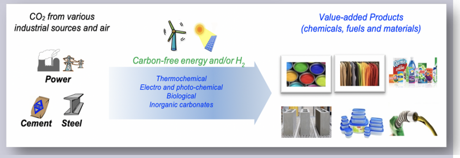
CCUS technologies: chapters 5 – 9

Title	Lead Authors	Key Sections
CO_2 Capture	John Northington Jennifer Wilcox	• Capture process • Technology types and maturity • Opportunities by sector • Capture cost drivers • Research and development priorities
CO_2 Transport	Dan Cole	• Current transport technologies • Existing U.S. CO_2 pipeline network • Role of transport in widespread CCUS deployment
CO_2 Geologic Storage	Richard Esposito Sally Benson	• Description of CO_2 geologic storage • Commercial scale experience and enablers • Options for CO_2 storage and capacity potential • Research and development priorities
CO_2 Enhanced Oil Recovery	William Barrett	• EOR technology experience and maturity • Conventional vs. non-conventional EOR • EOR capacity potential, near- and long-term • Research and development priorities
CO_2 Use	Will Morris Alissa Park	• CO_2 use technologies, pathways and products • Relative experience and maturity • Opportunities and challenges • Research and development priorities









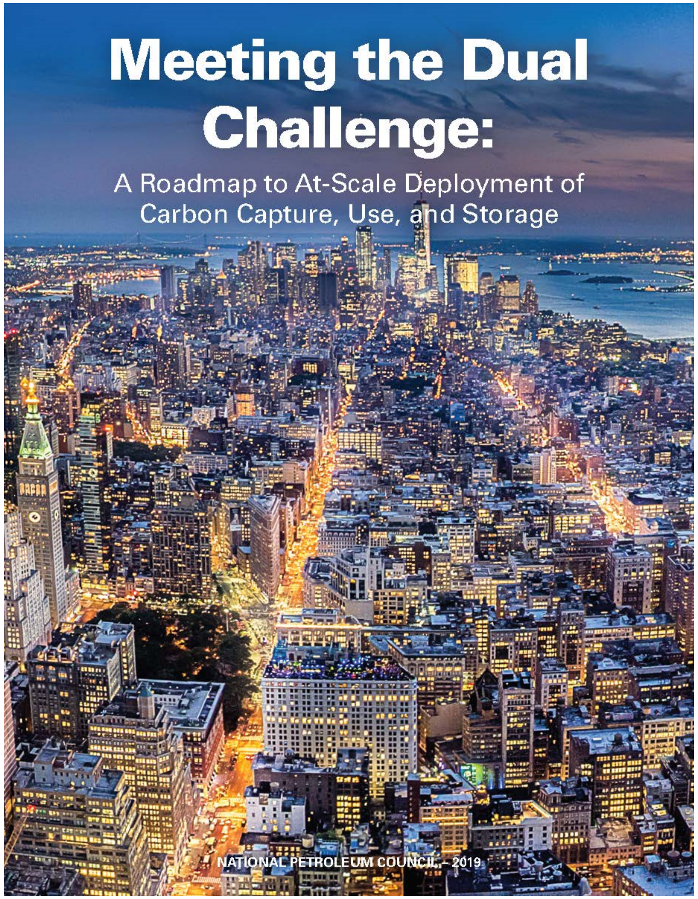
Forward plans

Digital publications and communications

- Report website will go live this afternoon
- Digital copy of executive summary and related materials
- Council webcast
- Social media friendly
- Other useful links

Printed Report Publication

- Executive Summary volume available mid-January
- Full report available end 1Q 2020



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Communications

Communications

- The study will be communicated in 2020 as requested by policymakers, governments, academia, research organizations, trade associations, technical societies and other interested groups.
- To request a presentation, please contact the National Petroleum Council

Protocol for ongoing communications

- Any individual or organization may use the NPC CCUS report in expressing their own views, provided that it is properly cited
- If the request did not originate from the NPC, please inform the NPC staff, and provide the name of the presenter, the audience, and a copy of the presentation or report
- Presenters are to be mindful of the purpose of the Council, and the prohibition against lobbying

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 over the last 18 months.