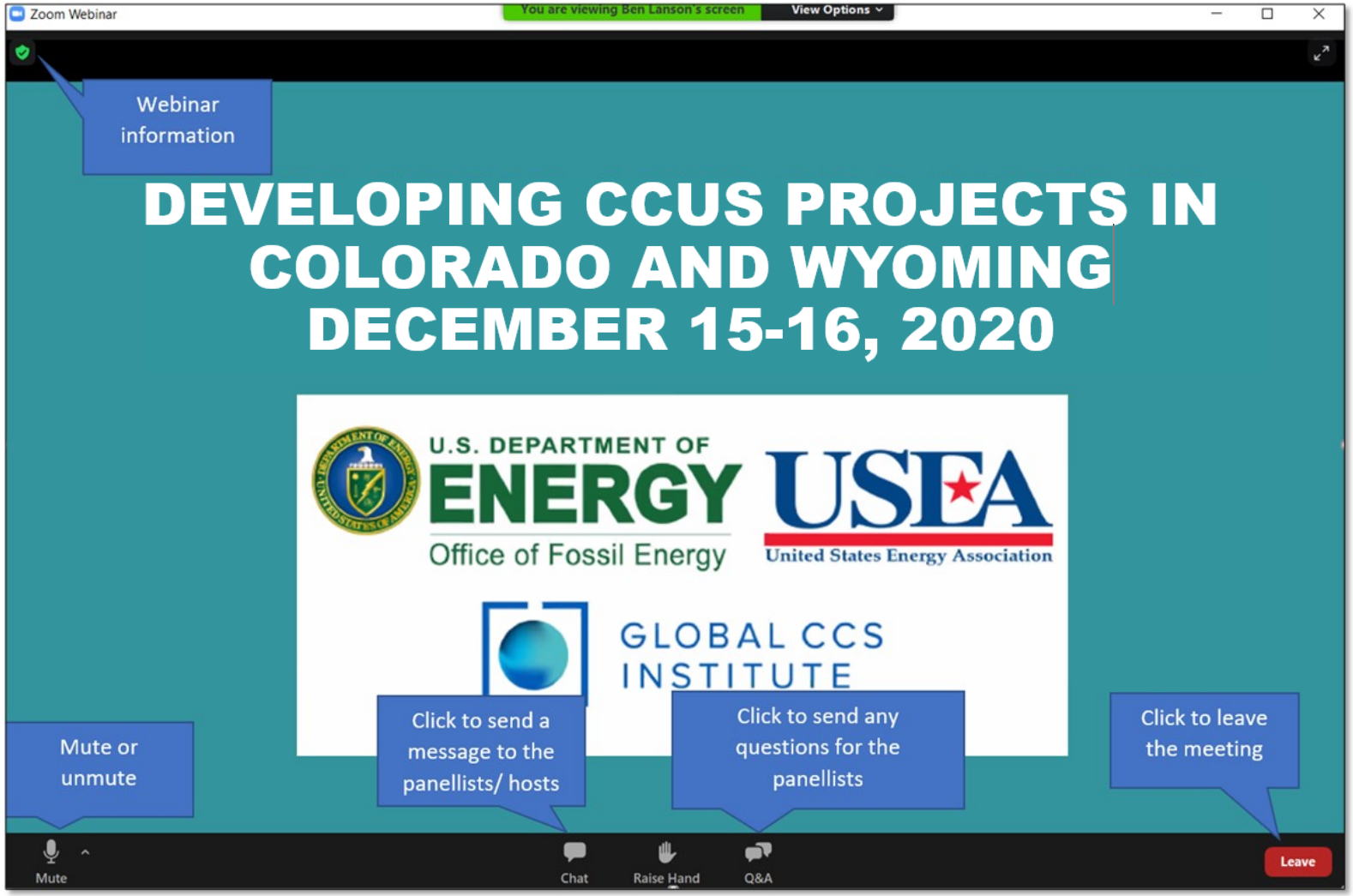
DEVELOPING CCUS PROJECTS IN COLORADO AND WYOMING
DECEMBER 15-16, 2020

ZOOM CONTROLS



THE GLOBAL CCS INSTITUTE

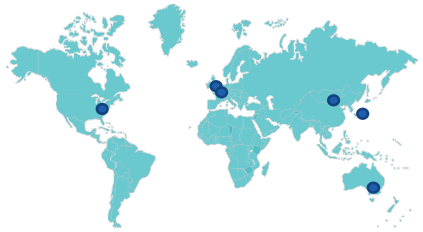
International think tank

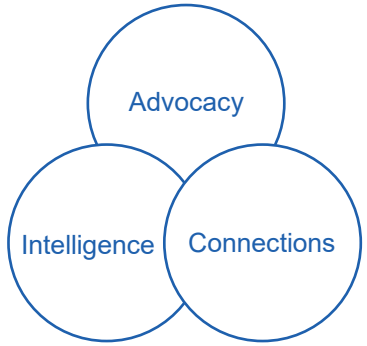
Backed by governments, businesses and NGOs

Mission: To accelerate deployment of CCS

83 MEMBERS

6 locations





AGENDA

Day 1

1:00 – 1:10 pm MT	Welcome
1:10 – 1:30	Commitment to Decarbonization: The States' Perspective
1:30 – 1:45	The Status of CCUS in the US and Around the World
1:45 – 2:15	How to Utilize 45Q on your CCUS Project
2:15 – 2:25	Break
2:25 – 3:30	Putting a Project Together: Capture, Transportation, and Storage
3:30 – 4:15	Innovation Applications to Drive Growth: hydrogen, biofuels, and more
4:15 – 4:20	Day 1 Wrap-up and Day 2 Preview

Day 2

9:00 – 9:20 am MT	Welcome & ESG Ratings – Are they Driving CCS Adoption?
9:20 – 10:10	Case Studies and New Technology Development in the Region
10:10 – 10:55	Challenges to Deployment and Strategies to Address Them
10:55 – 11:00	Wrap-up and Break-out Instructions
11:00 – 11:15	Break
Breakout Sessions – 11:15 to 12:00	
Breakout Session 1	Q&A and Broader Discussion on 45Q with Keith Tracy
Breakout Session 2	Putting together CCUS Projects
Breakout Session 3	Understanding the WY context regarding technology support, liability, permitting, etc. Jason Begger, Deputy Director, Wyoming Energy Authority and Kara Fornstrom

Patricia Loria, Senior Client Engagement Lead, GCCSI

COMMITMENT TO DECARBONIZATION: THE STATES' PERSPECTIVES

RANDALL LUTHI

CHIEF ENERGY ADVISOR, STATE OF WYOMING

DR. WILL TOOR

EXECUTIVE DIRECTOR, COLORADO ENERGY OFFICE

U.S. DEPARTMENT OF ENERGY
Office of Fossil Energy

USEA
United States Energy Association

GLOBAL CCS INSTITUTE

CCUS IN WYOMING

High Noon at the C02 Corral

Why CCUS will work in Wyoming

Existing coal fired power plants

Pore space available - Class VI Well permitting primacy

8th oil and gas producer in the US

C02 pipeline corridor initiative nearing completion by BLM

Integrated Test Center is available for testing

Closure of coal fired units and economic threat to communities

45Q for sequestration and use

Policy Support for CCUS

Governor Mark Gordon's Energy Strategy

- All the above energy state
- Maintain Wyoming's place as a major energy exporter
- Burning coal is not the issue, the release of C02 is the issue
- C02 capture and use a high priority
- Goal to be the next State to install a CCUS unit
- Federal Congressional Delegation united in support of CCUS

Legislative Support for CCUS

SF159 - Utilities must make good faith effort to sell coal fired units before closing

- Wyoming PSC just completed rules

The Wyoming Energy Authority established by merging the Wyoming Infrastructure Authority and the Wyoming Pipeline Authority

- Coordinate energy initiatives and policy - “transition” includes CCUS
- Exploring bonding capability

Continued Support for the School of Energy Resources and EORI

Legislative Support Continued

HB200 - mandates utilities meet a low level of C02 (650 pounds per megawatt hour of generated electricity over one calendar year through carbon capture) by 2030

Utilities must consider carbon capture in their integrated resource plans

Emphasis on “reliable” and “dispatchable”

PSC tasked with establishing goals and regulations to meet the mandate

Specifically provides the carbon capture unit can be “adjacent to” utility plant, could grant rate of recovery (2%), surcharge, return to shareholders

Rules being developed by PSC

Private Support for CCUS

Utility company evaluating CCUS in 2021 Integrated Resource Plan

Jupiter Oxygen will complete a FEED study related to Dave Johnston Power Plant in early 2021

Glenrock Petroleum continuing work on using C02 for EORI

Occidental and Microsoft have committed significant funds or services to C02 capture efforts elsewhere, both have facilities in Wyoming

Challenges

Utility companies hesitant about investing in CCUS, particularly in lieu of wind, solar and battery efforts - regional haze decisions slanted towards closing

Unlikely CC will be built without significant dollars from DOE. Still lack of private commitment

45Q needs to be extended

NGO’s now focused on skipping CC and go direct to wind, solar and sometimes nuclear

Oil Market conditions, slowly developing C02 market and TIME

Conclusion

No other state better situated than Wyoming for CCUS

CCUS may be the only life line to some coal communities

Need to move from “Why” to “Why Not?”

GLOBAL STATUS OF CCS 2020

Jeff Erikson

December 15, 2020

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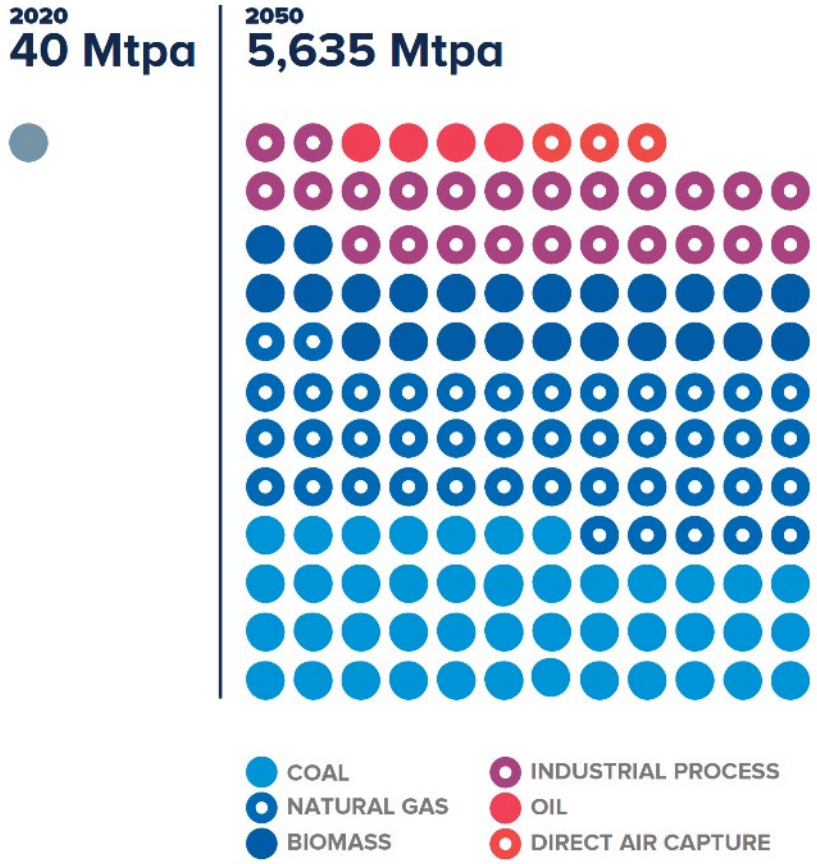
CCS. VITAL TO ACHIEVE NET-ZERO

MOMENTUM

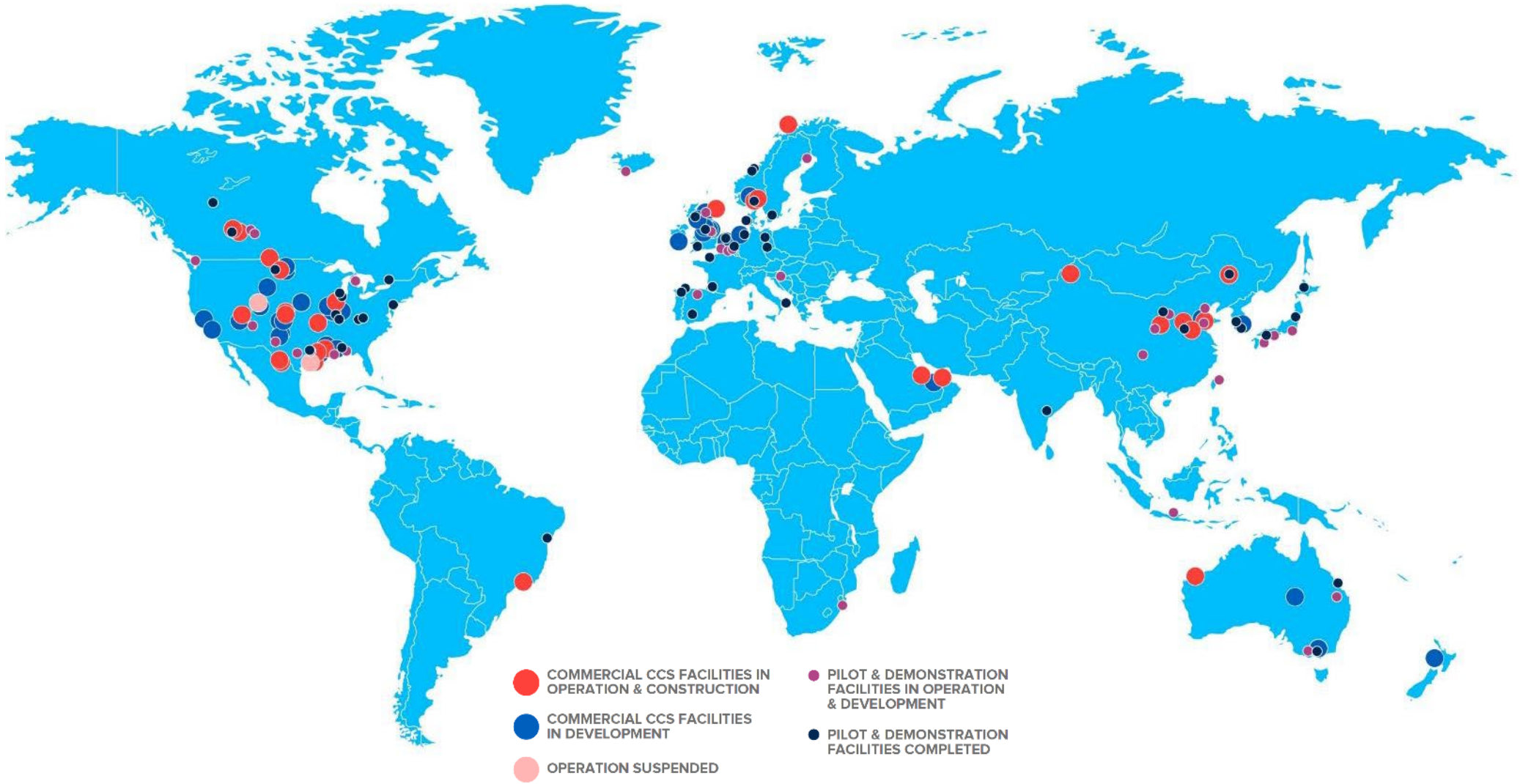
- CCS project pipeline continues to grow
- Net-zero emissions commitments driving interest and commitment
- Policy and funding support building, notably US, UK, Norway, EU, Japan, Australia
- Key developments
  - Enhanced tax credit in the US
  - Hubs and clusters
  - Hydrogen, as the fuel of the future

BUT… A STEEP HILL TO CLIMB

TO ACHIEVE NET-ZERO EMISSIONS, >100X INCREASE REQUIRED



CURRENT CCS FACILITIES AROUND THE WORLD



BY THE NUMBERS

MATURING INDUSTRY REQUIRES UPDATED CLASSIFICATION SYSTEM

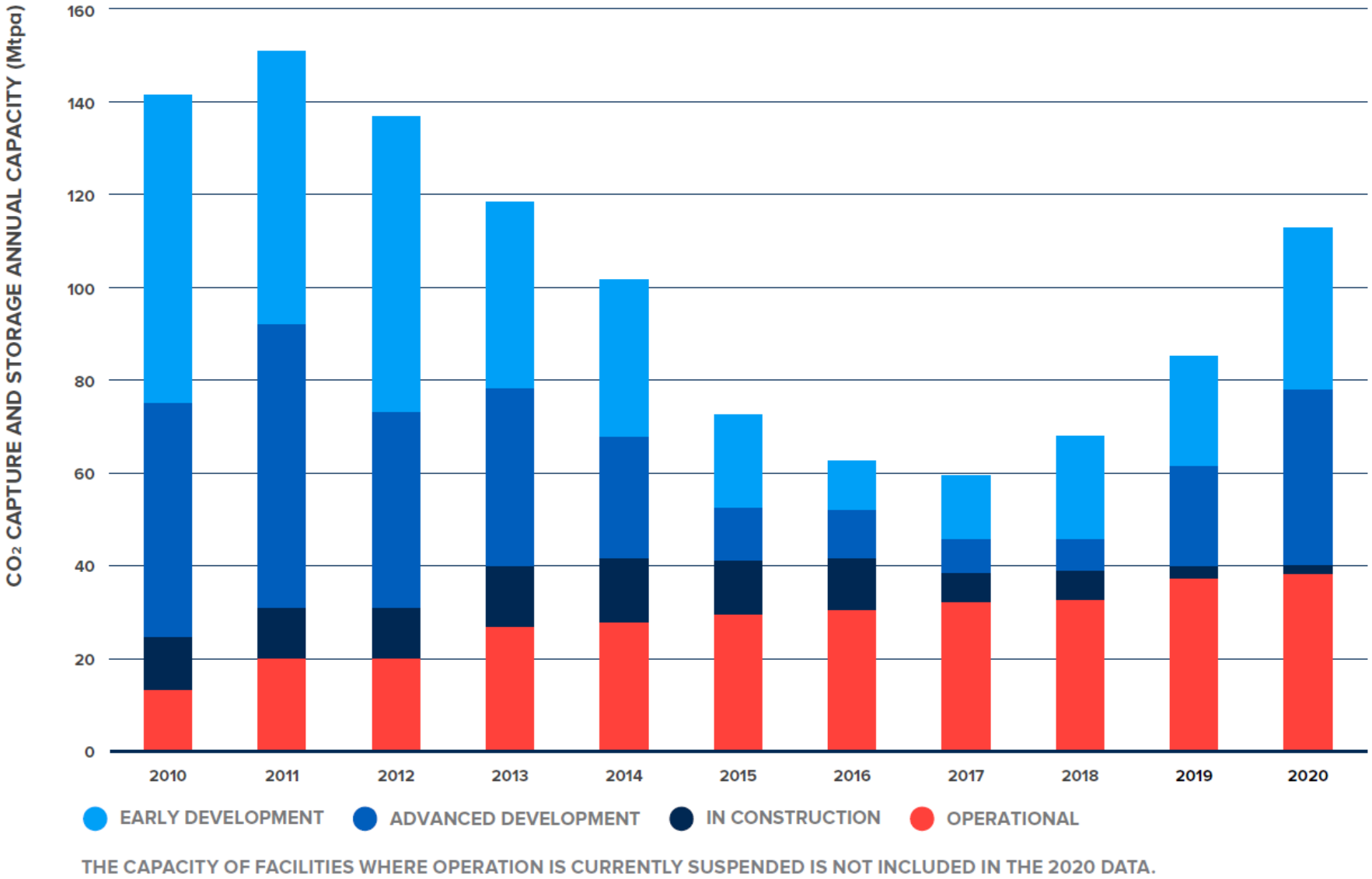
65 Commercial CCS facilities operating, under development, idle
26 Operating
3 In construction
34 Under development
2 Operations suspended

6 Reclassified as Commercial
2 Paired sources separated
6 Storage projects now Hubs

17 New commercial facilities added in 2020
12 New in US

115M Annual capture/storage capacity of all facilities (tonnes)
40M Annual tonnes CO_2 captured and stored by operating facilities

A GROWING CCS PROJECT PIPELINE



- 40 million tpa
- 260 million tonnes to date

40 MILLION TONNES PER YEAR

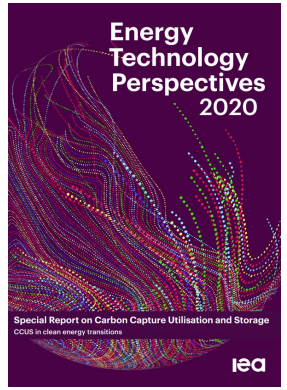
4.7 million houses

8.8 million cars

53 million acres of forest

100 Ivanpah Solar Farms

1/100th annual requirement from CCS by 2050 (IEA)



65 COMMERCIAL CCS FACILITIES

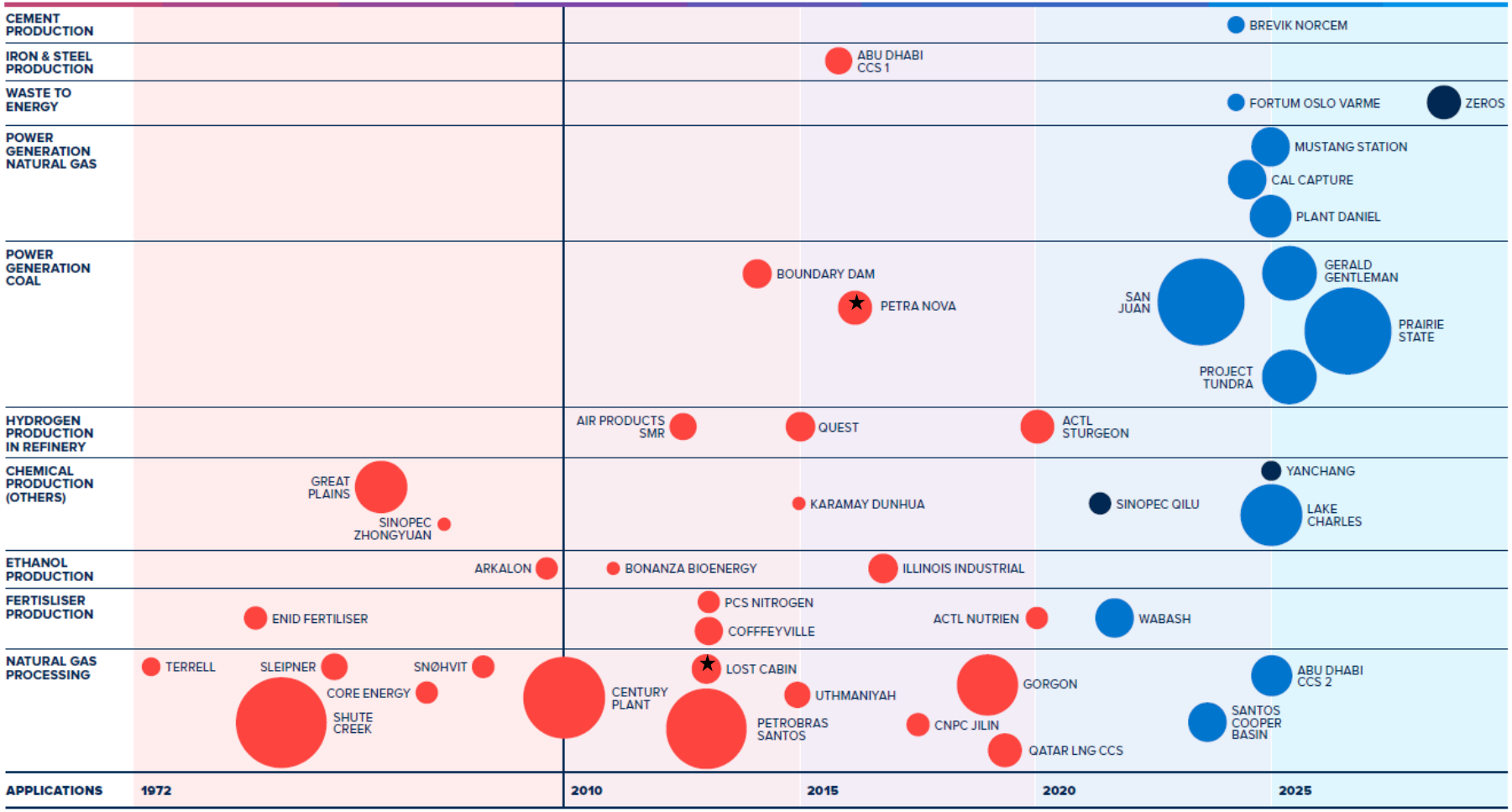


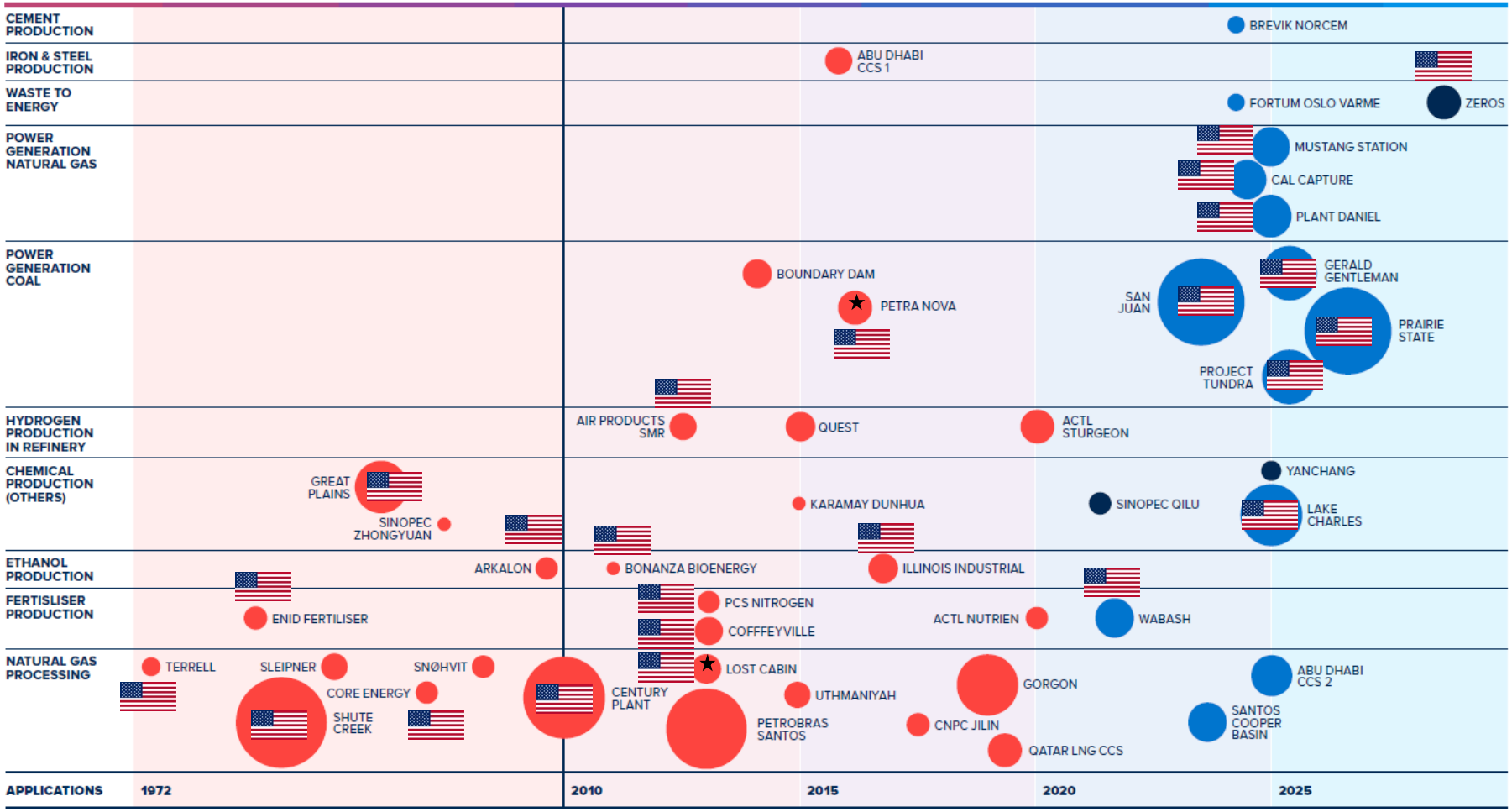
Chart indicates the primary industry type of each facility among various options.

- IN OPERATION
- IN CONSTRUCTION
- ADVANCED DEVELOPMENT
- ★ OPERATION SUSPENDED

Size of the circle is proportionate to the capture capacity of the facility.

0.2 Mtpa OF CO_2 · 1.0 Mtpa OF CO_2 · 5.0 Mtpa OF CO_2

USA REMAINS THE LEADER



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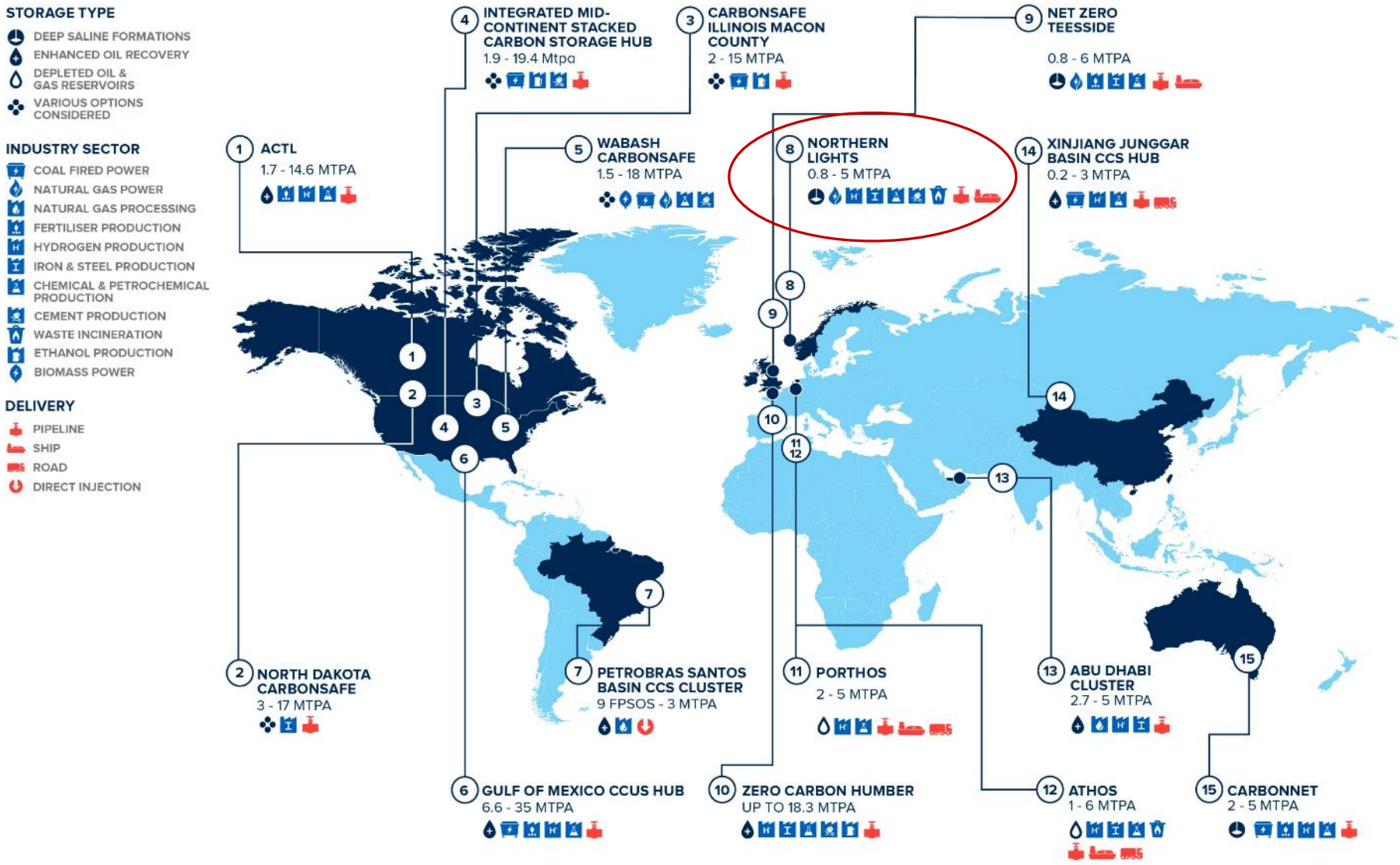
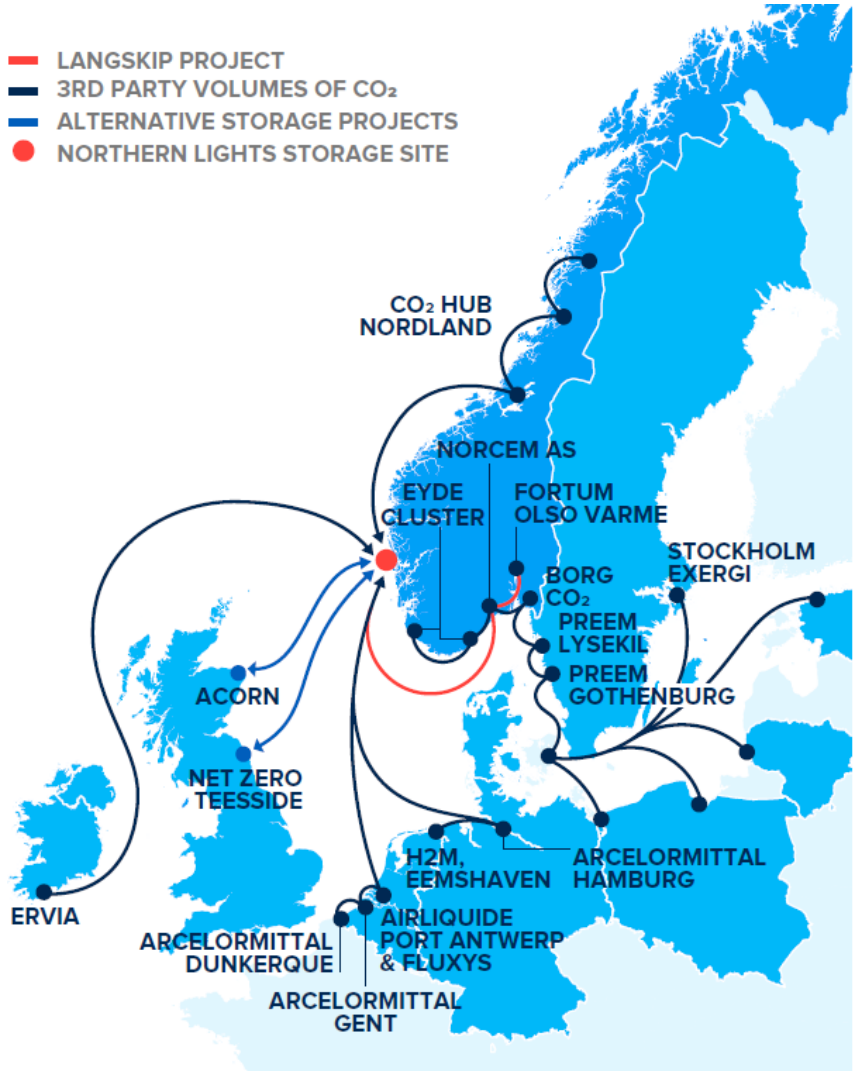
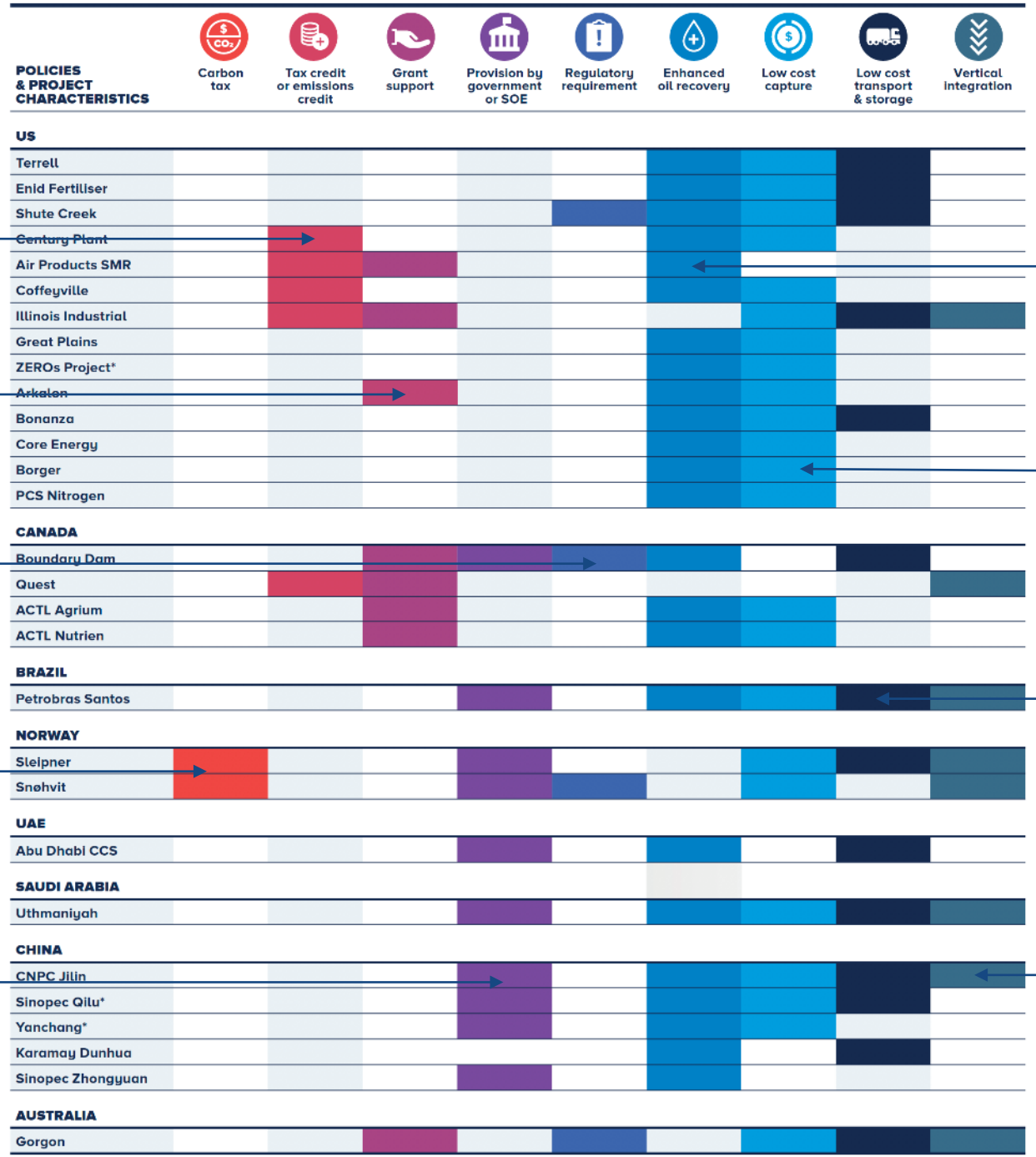
CCS HUBS/CLUSTERS



CCS HUBS/CLUSTERS – NORTHERN LIGHTS





Tax credit or emissions credit

Grant support

Regulatory requirement

Carbon tax

Provision by government or SOE

Enhanced oil recovery

Low-cost capture

Low-cost transport and storage

Vertical Integration

Source: Global CCS Institute

LOOKING AHEAD

Trends	Tea Leaves
Climate change awareness	Impact of Covid/Economy
Net Zero Emissions	The future of fossil fuels
ESG	Geopolitics
Hydrogen	The color of hydrogen
Continued US leadership on CCUS	Revenue model?

RESOURCES

- The Global Status of CCS 2020 Report can be downloaded from: https://www.globalccsinstitute.com
- Webinar recordings available through Institute website: https://www.globalccsinstitute.com/resources/audio-and-visual-library/
- Follow us on Social media: Global CCS Institute @GlobalCCS
- To learn more about Institute membership or our consultancy capabilities please e-mail: info@globalccsinstitute.com
- Jeff.Erikson@GlobalCCSInstitute.com

45Q Overview

Keith Tracy

December 2020

Overview

45Q is a carbon capture, utilization and storage (CCUS) incentive

US federal income tax credit for physically capturing CO_2 and storing it underground or in products

Tax credits are claimed on a per metric ton basis

- The more CO_2 is captured and stored, the greater the tax credit benefits

12-year tax credit for new capture operations

Value of the credit increases each year (generally)

45Q effectively puts a price on carbon

General Checklist

The following requirements are critical to qualify for 45Q credits:

- ❑ What is captured: Must capture Qualified Carbon Oxide (essentially carbon monoxide or carbon dioxide)
- ❑ How is it captured: Must use Carbon Capture Equipment to perform the capture function
- ❑ Where is it captured: Carbon Capture Equipment must be placed in service at a Qualified Facility
- ❑ When are the timing deadlines: Must satisfy Beginning of Construction deadline for Carbon Capture Equipment/Qualified Facility
- ❑ How is it stored: captured carbon oxide must be sequestered or stored using one of the following methods:
  - Utilized – non-underground storage such as algae and cement
  - Injected – stored in Secure Geologic Storage and used as a tertiary injectant in a Qualified EOR/EGR Project, or
  - Disposed of – stored in Secure Geologic Storage and not used as a tertiary injectant in a Qualified EOR/EGR Project (i.e. saline aquifer)
- ❑ Who claims the credit: either the Taxpayer to whom the credit is attributable, or the Credit Claimant (if election is made)
  - How: Option to satisfy Tax Equity Partnership safe harbor
- ❑ What to avoid: avoid having the credit Recaptured by the IRS
- ❑ How Much is the credit: new Credit Value amounts for Carbon Capture Equipment placed in service on or after Feb 9, 2018

Other Considerations

What is captured

Qualified Carbon Oxide

45Q credit is limited to capture of CO_2 or CO ("carbon oxide")

- Was only CO_2 prior to February 9, 2018

Must be either an emission captured from an Industrial Facility, or direct air capture (DAC)

- Absent capture of the emission, it would have otherwise been released to the atmosphere

Must be measured at the source of capture

Must be verified where it is Utilized, Injected, or Disposed

No credit allowed for Recycle CO_2 at an EOR/EGR project

Carbon Capture

How is it captured

Carbon Capture Equipment

Must use Carbon Capture Equipment to perform the capture function

Broad definition of "Carbon Capture Equipment" in the Proposed Regulations issued in June 2020

- All components of property needed to separate, purify, dry, compress, treat, process, liquefy, pump, capture, or perform some other physical action to capture CO_2 – or to remove it from the atmosphere through DAC
- Includes all components of property used to capture or process the CO_2 until it is transported for storage
- Does not include pipelines or transport vessels to transport CO_2 to its storage location
- May include a gathering and distribution system upstream of a pipeline

Similar but not identical definition of Carbon Capture Equipment in Notice 2020-12

- Beginning of Construction guidance from Feb 2020 contains slightly different definition

Anticipate more harmonized definitions in the Final Regulations and a possible revision to Beginning of Construction guidance

Where is it captured

Qualified Facility

- Carbon Capture Equipment must be placed in service at a Qualified Facility
- Qualified Facility must be one of the following:
  1. Industrial Facility is a facility that produces CO_2 from
     - a fuel combustion source or fuel cell, or
     - a fugitive CO_2 emission source, or
     - a manufacturing process (manufacture of any product other than CO_2 that is intended to be sold at a profit or used for a commercial purpose)
     - Excludes a CO_2 production well that produces from a natural CO_2-bearing formation
  2. Electricity Generating Facility is a facility subject to MACRS Asset Class 49.11, 49.13 or 49.15 (i.e. generating power for sale)
  3. Direct Air Capture (DAC) Plant is a facility that uses Carbon Capture Equipment to remove CO_2 directly from ambient air or atmosphere
- Must capture minimum amount of CO_2 to qualify (annual threshold):
  - Power plant selling power on the grid: 500,000 metric tons/year
  - Special rule for utilization: 25,000 metric tons/year, if Qualified Facility emits ≤500,000 metric tons/year
  - Any other facility: 100,000 metric tons/year
  - Annualization is permitted for first year of operations

Applicable Facility

- Qualified Facility placed in service before Feb 9, 2018, and
- No 45Q was claimed for any captured CO2 prior to 2018

Applicable Facility Election

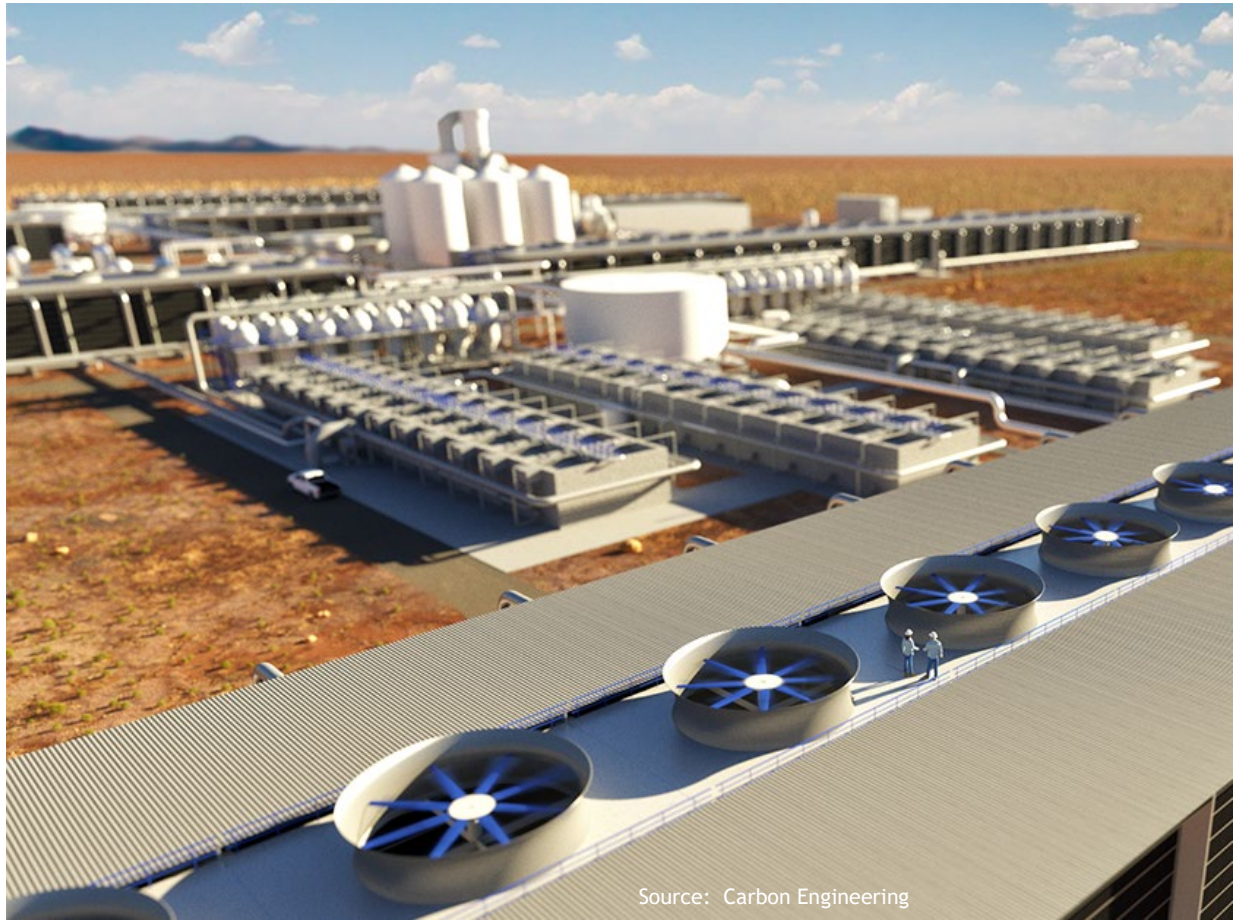
- In any tax year where facility captures ≥500,000 metric tons, election can be made to deem facility as placed in service on Feb 9, 2018 (effectively qualifying for high value tax credits)

Source: NRG

Where is it captured

45Q and Direct Air Capture (DAC) Plants

Direct Air Capture Facility



- DAC Plant must use Carbon Capture Equipment to remove CO_2 directly from ambient air or atmosphere
  - Must exclude facilities that capture CO_2 using natural photosynthesis or CO_2 that was deliberately released from the subsurface
- Must meet the requirements of a Qualified Facility
- Must capture at least 100,000 metric tons/year
- CO_2 must be measured at the source of capture
- CO_2 must be verified where it is Utilized, Injected, or Disposed

When are the timing deadlines

Beginning of Construction Requirement

Construction must begin on the Qualified Facility before Jan 1, 2024

Construction must begin on the Carbon Capture Equipment before Jan 1, 2024 – unless the original planning/design of that Qualified Facility includes installation of Carbon Capture Equipment

IRS Notice 2020-12 contains many details on "beginning of construction" requirements, and answers 3 important questions:

1. What must be done to "begin" construction?
   - Construction can begin by doing physical work of a significant nature (Physical Work Test), or by paying/incurring 5% or more of the total cost of the Qualified Facility or Carbon Capture Equipment (5% Safe Harbor)
2. Once construction is commenced, what is the deadline by which the equipment/facility must be operational?
   - Construction must continue to completion with limited excusable disruptions, or the facility/equipment must be placed in service within the "6 Year Safe Harbor"
3. Can multiple units of equipment or facilities be combined as a "single project" for purposes of beginning of construction? Can they later be disaggregated so that at least some can meet the 6 Year Safe Harbor?
   - Yes, and yes

Carbon Capture Equipment

Source: Bloomberg

How is it stored – Option 1

Utilization

- 45Q credits are available if the minimum amount of captured CO_2 is stored through Utilization
- Utilization – Captured CO_2 must be utilized in one of the following ways:
  - Growing of algae or bacteria or other fixation through photosynthesis or chemosynthesis
  - Chemically converting CO_2 to a material or chemical compound where the CO_2 is securely stored
  - Use of the CO_2 for any other purpose for which a commercial market exists

Utilization Process

Source: SkyMine

How is it stored – Option 1

Utilization - LCA

- Amount of CO_2 utilized is determined based on a lifecycle GHG analysis (LCA) of CO_2 isolated or displaced
- LCA report requirements:
  1. Performed by or verified by a 3rd party
  2. Be consistent with ISO 14044:2006
  3. Technical review by DOE
  4. Must be approved by the IRS, in consultation with DOE and EPA
  5. Full product lifecycle analysis required (proposed regulations)
- What remains to be clarified by the IRS:
  - Whether the LCA requirement implies an extension of "utilization" to GHGs other than CO_2
  - Whether utilization allows for 45Q credits when CO_2 is used to make a product but is not captured or stored
  - More definition concerning the "commercial market" catchall provision, such as (a) whether it includes transportation fuels, (b) whether it is limited to a product (instead of a service); and (c) the process for commercial markets to be approved by IRS
  - Whether the LCA requirement only serves the function of verifying the amount of capture CO_2, and only serves to ensure the utilization process does not emit more GHGs than the amount of CO_2 captured in the first place
  - Details regarding the LCA report: whether approved LCA reports will be made public, whether LCA reports of others can be relied upon, and what are the baselines and boundaries of the LCA
  - How is additional Carbon Capture Equipment capacity determined in the utilization context

How is it stored – Option 2

Injection or Disposal

- 45Q credits are available if captured CO_2 is stored through Injection or Disposal
  - Approved locations include oil and gas reservoirs, deep saline formations, and unminable coal seams
- Both Injection and Disposal require CO_2 to be placed in Secure Geologic Storage so that CO_2 does not escape into the atmosphere
  - Injection:
    - Use the captured CO_2 as a tertiary injectant in a qualified EOR/EGR Project and disposing of it in secure geologic storage
    - Secure Geologic Storage Requirement: Must comply with EPA GHGRP Subpart RR, or ISO Standard 27916:19
  - Disposal:
    - Dispose of the captured CO_2 in secure geologic storage and not using it as a tertiary injectant in a qualified EOR/EGR Project
    - Secure Geologic Storage Requirement: Must comply with EPA GHGRP Subpart RR
- Annual certification and documentation:
  - If using Subpart RR, taxpayer may self-certify amount of CO_2 claimed
  - If using ISO Standard 27916:19, documentation must be certified by independent qualified engineer or geologist
  - Complete documentation and certification must be provided to the IRS annually

CO_2 Injection Well

Source: Houston Chronicle

Who claims the credit – Part 1

Taxpayer or Credit Claimant

- Credits are claimed by the Owner of the Carbon Capture Equipment
  - Exception: if Carbon Capture Equipment was placed in service before Feb 9, 2018, then credit is claimed by the person who performs the capture (and that Capture Operator might be different than the Owner)

- Owner (or Capture Operator) must physically or contractually ensure the capture and the Utilization, Injection or Disposal of the CO_2
  - A contract ensuring Utilization, Injection or Disposal must be a "binding written contract", which must:
    - Provide for enforcement of other party's obligation of Utilization, Injection or Disposal
    - Obligate the Injector/Disposer to comply with applicable Regulations regarding Secure Geologic Storage
    - Obligate the Injector/Disposer to promptly inform Owner (or Capture Operator) of all information pertinent to any recapture event
  - Whether contract can include liquidated damages provision will likely be clarified
  - Contract information must be reported to IRS

- OPTION: Credit Claimant Election – 45Q(b)(3)
  - Owner (or Capture Operator) may elect to allow the credit be claimed by the "Credit Claimant" – the person who does the Utilization, Injection or Disposal (storage company operator)
  - Election may be partial or full amount of the credit, and may involve multiple Credit Claimants
  - New elections required annually, using Form 8933
  - Reporting Requirements

Who claims the credit - Part 2

Tax Equity Partnerships

- Significant tax credit amounts require an investor that has large tax appetite to take advantage of the tax credit
- Tax Equity Partnership Flip Structure – highlights:
  - Revenue Procedure 2020-12 “safe harbor”, like wind energy production credits but more favorable in some areas
  - Investor/Partner needs to be an equity holder rather than secured lender or credit purchaser
  - Project Company (or Partnership) would own the Carbon Capture Equipment and claim the credits
  - Tax items (including 45Q tax credits) may (and will) be allocated different than cash
  - Investor must make up-front Unconditional Investment of at least 20% of total expected investment
  - Up to 50% of Investor’s consideration may be contingent (“Pay-Go”)
    - Operating expenses are not treated as part of contingent investments
  - Developer cannot have Call/Purchase Rights
  - Investor may have Put/Sale Rights at FMV
  - Many guarantees are permitted, including:
    - Performance of any act necessary to claim the credit, such as guarantee of Injection or Disposal
    - Avoiding any act that would result in Recapture
  - Long-term take-or-pay, take all, supply-or-pay, supply all, and store-or-pay contracts are allowed
  - Allocation guidance appears to authorize (for the first time ever) a Project Company to operate without revenue other than receipt/distribution of the tax credits (ie Disposal)

	Developer		Investor	
	Cash	Income/Loss, and 45Q Credits	Cash	Income/Loss, and 45Q Credits
Period 1	100%	≥1%	0%	≤99%
Period 2	0%	≥1%	100%	≤99%
Period 3	≤95%	≤95%	≥5%	≥5%

- Period 1 lasts until date certain, or date Developer receives $x cash return
- Period 2 lasts until “Flip Point”, when Investor has achieved agreed-upon IRR (after-tax). Flip Point could possibly occur before Period 1 ends

Elysian VENTURES

What to avoid

Recapture

- "Recapture" is where Qualified CO_2 is Captured, Injected or Disposed and 45Q credits are claimed as a result, but then the Qualified CO_2 later leaks or ceases to be Captured, Injected or Disposed
  - "Leaked Amount of Qualified CO_2" is the amount of CO_2 that ceases to be Captured, Injected or Disposed, and the quantity is the amount that leaked to the atmosphere as determined by how Secure Geologic Storage is demonstrated (i.e. MRV Plan)
- "Recapture Event" only occurs if there is an instance of Recapture Qualified CO_2 in a tax year during the Recapture Period
  - "Recapture Qualified CO_2" is the amount by which the Leaked Amount of Qualified CO_2 that year exceeds the Qualified CO_2 Injected or Disposed that year
  - *Current Year Offset Principle* prevents some potential recapture instances because potential for Recapture only emerges if the Leaked Amount of Qualified CO_2 in a tax year exceeds the amount of Qualified CO_2 Injected or Disposed in that same year
  - The "Recapture Period" is the time period between (a) the date of first injection or disposal of the Qualified CO_2 and (b) the earlier of (i) the date the monitoring period ends under the secure geologic storage rules (i.e. the MRV Plan) and (ii) 5 years after the last taxable year in which a 45Q credit was claimed
- "Recapture Amount" is the value of the 45Q credit recaptured, calculated on a last-in-first-out (LIFO) basis
- Recapture Amount is taken into account in the tax year when the leak is identified and reported
  - Exception: Recapture Event occurs in the year Qualified CO_2 is deliberately removed from a Secure Geologic Storage Site
- Recapture Amount is allocated pro rata if there are multiple taxpayers or multiples units of Carbon Capture Equipment involved

How Much is the Credit

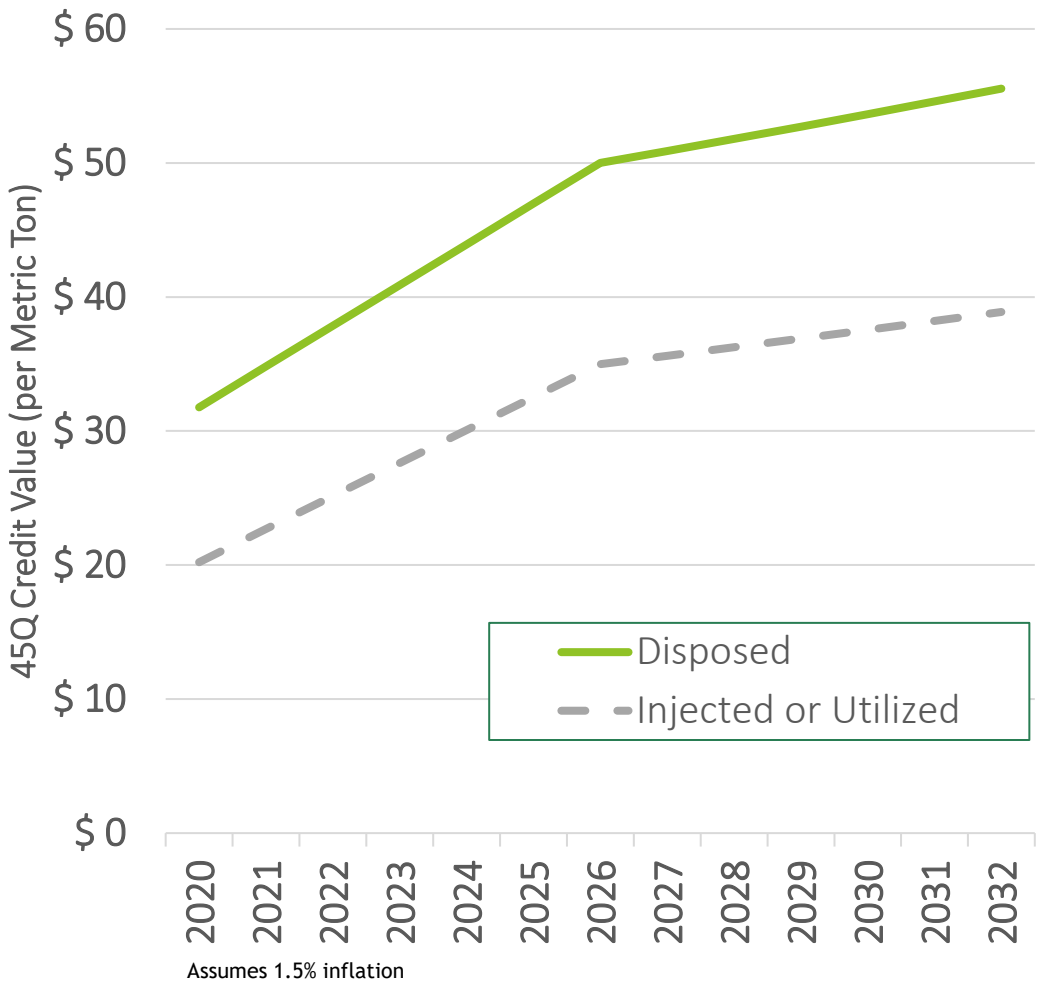
45Q Tax Credit Value

- Value of 45Q tax credit increases annually (per metric ton)
  - $20.22 (in 2020) up to $35 (in 2026) if Injected or Utilized
  - $31.77 (in 2020) up to $50 (in 2026) if Disposed
- Values in 2027 and beyond are inflation adjusted

Examples:

- 100,000 metric ton/yr capture project placed in service in 2021, tax credits over 12 years totaling:
  - ~$40 million, if Injected or Utilized
  - ~$57 million, if Disposed
- 500,000 metric ton/yr capture project placed in service in 2021, tax credits over 12 years totaling:
  - ~$198 million, if Injected or Utilized
  - ~$287 million, if Disposed

Projected 45Q Credit Values



Assumes 1.5% inflation

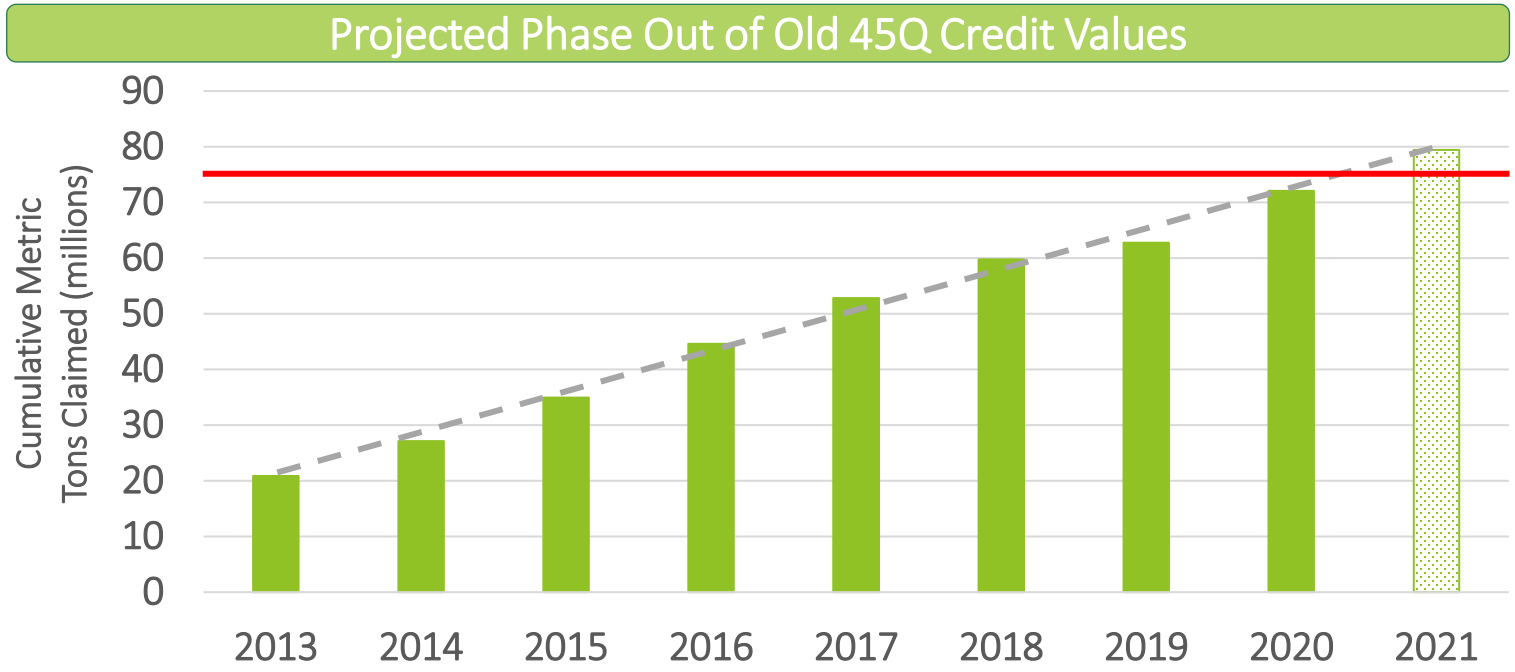
Older Facilities

At an older facility, if additional Carbon Capture Equipment is installed on or after Feb 9, 2018:

- The newer values apply ($35/50), but only to the extent the total amount of Qualified CO_2 exceeds the CO_2 capture capacity of the older Carbon Capture Equipment
- 80/20 Rule applies to a retrofit of the older Carbon Capture Equipment
  - Retrofit qualifies if Fair Market Value of used components does not exceed 20% of the total value

Credits for Carbon Capture Equipment placed in service before Feb 9, 2018 are at lower values ($10/20)

- Credits will phase out when a total of 75 million metric tons of Qualified CO_2 have been taken into account
- Current projection: phase out at end of 2021



Reporting Requirements

Proposed Regulations contain numerous reporting requirements. Examples include:

- The taxpayer who claims the 45Q credit must report the name and location of each Qualified Facility at which the Qualified CO_2 was captured
- Each party to a binding written contract must report the existence of the contract, the names and tax ID numbers of the parties involved, the amount of Qualified CO_2 involved with each party, EPA GHGRP e-GGRT ID number of the storage site, etc.
- Credit Claimant, and electing taxpayer who transfers credit to Credit Claimant, must both report significant details of their actions to allow IRS to trace the transfers
- Any taxpayer who claims the 45Q credit must report a recapture event that occurs during a project's recapture period, along with the recapture amount, the quantity of leaked Qualified CO_2, the credit rates involved and a statement providing details regarding the leak

45Q credits will not be allowed to a taxpayer that fails to timely provide all required information, documentation and certifications

45Q Proposed Regulations

34050 Federal Register / Vol. 85, No. 106 / Tuesday, June 2, 2020 / Proposed Rules

DEPARTMENT OF THE TREASURY

Internal Revenue Service

26 CFR Part 1

[REG–112339–19]

RIN 1545–BP42

Credit for Carbon Oxide Sequestration

AGENCY: Internal Revenue Service (IRS), Treasury.

ACTION: Notice of proposed rulemaking.

SUMMARY: This document contains proposed regulations regarding the credit for carbon oxide sequestration under section 45Q of the Internal Revenue Code (Code). These proposed regulations will affect persons who physically or contractually ensure the capture and disposal of qualified carbon oxide, use of qualified carbon oxide as a tertiary injectant in a qualified enhanced oil or natural gas recovery project, or utilization of qualified carbon oxide in a manner that qualifies for the credit.

DATES: Written or electronic comments and requests for a public hearing must be received by August 3, 2020. Requests for a public hearing must be submitted as prescribed in the "Comments and Requests for a Public Hearing" section.

ADDRESSES: Commenters are strongly encouraged to submit public comments electronically. Submit electronic submissions via the Federal eRulemaking Portal at *www.regulations.gov* (indicate IRS and REG–112339–19) by following the online instructions for submitting comments. Once submitted to the Federal eRulemaking Portal, comments cannot be edited or withdrawn. The IRS expects to have limited personnel available to process public comments that are submitted on paper through mail. Until further notice, any comments submitted on paper will be considered to the extent practicable. The Department of the Treasury (Treasury Department) and the IRS will publish for public availability any comment submitted electronically, and to the extent practicable on paper, to its public docket.

Send paper submissions to: CC:PA:LPD:PR (REG–112339–19), Room 5203, Internal Revenue Service, P.O. Box 7604, Ben Franklin Station, Washington, DC 20044.

FOR FURTHER INFORMATION CONTACT: Concerning the proposed regulations, Maggie Stehn of the Office of Associate Chief Counsel (Passthroughs & Special Industries) at (202) 317–6853; concerning submissions of comments and/or requests for a public hearing, Regina L. Johnson at (202) 317–5177 (not toll-free numbers).

SUPPLEMENTARY INFORMATION:

Background

This document contains proposed amendments to the Income Tax Regulations (26 CFR part 1) under section 45Q of the Code (proposed regulations).

Section 45Q was enacted on October 3, 2008, by section 115 of Division B of the Energy Improvement and Extension Act of 2008, Public Law 110–343, 122 Stat. 3765, 3829, to provide a credit for the sequestration of carbon oxide. On February 17, 2009, section 45Q was amended by section 1131 of Division B of the American Recovery and Reinvestment Tax Act of 2009, Public Law 111–5, 123 Stat. 115, 325. Section 45Q was further amended on December 19, 2014, by section 209(j)(1) of Division A of the Tax Increase Prevention Act of 2014, Public Law 113–295, 128 Stat. 4010, 4030, and most recently on February 9, 2018, by section 41119 of Division D of the Bipartisan Budget Act of 2018 (BBA), Public Law 115–123, 132 Stat. 64, 162, to encourage the construction and use of carbon capture and sequestration projects.

On May 20, 2019, the IRS published Notice 2019–32, 2019–21 I.R.B. 1187. The notice requested general comments on issues arising under section 45Q, as well as specific comments concerning secure geological storage, the measurement of qualified carbon oxide, the recapture of the benefit of the credit for carbon oxide sequestration, the types of utilization that qualify for the credit, the beginning of construction, partnership arrangements, definitions of terms, and other issues related to the credit. The IRS received 116 comments from industry participants, environmental groups, and other stakeholders.

In response to comments submitted pursuant to Notice 2019–32, on March 9, 2020, the Treasury Department and the IRS published Revenue Procedure 2020–12, 2020–11 I.R.B. 511, and Notice 2020–12, 2020–11 I.R.B. 495. Revenue Procedure 2020–12 provides a safe harbor under which the IRS will treat partnerships as properly allocating the section 45Q credit in accordance with section 704(b). Notice 2020–12 provides guidance on the determination of when construction has begun on a qualified facility or on carbon capture equipment that may be eligible for the section 45Q credit. As requested by commenters, the safe harbor in Revenue Procedure 2020–12 and the rules in Notice 2020–12 are similar to those provided in prior guidance.

Pursuant to section 45Q(h), the Secretary of the Treasury or his delegate (Secretary) may prescribe such regulations and other guidance as may be necessary or appropriate to carry out section 45Q, including regulations or other guidance to (i) ensure proper allocation under section 45Q(a) for qualified carbon oxide captured by a taxpayer during the taxable year ending after the date of the enactment of the BBA, and (ii) determine whether a facility satisfies the requirements under section 45Q(d)(1).

Summary of Comments and Explanation of Provisions

1. General Credit Provisions

a. Credit Amount in General

Section 45Q(a)(1) allows a credit of $20 per metric ton of qualified carbon oxide (i) captured by the taxpayer using carbon capture equipment which is originally placed in service at a qualified facility before the date of the enactment of the BBA (February 9, 2018); (ii) disposed of by the taxpayer in secure geological storage; and (iii) neither used by the taxpayer as a tertiary injectant in a qualified enhanced oil or natural gas recovery project nor utilized in a manner described in section 45Q(f)(5).

Section 45Q(a)(2) allows a credit of $10 per metric ton of qualified carbon oxide (i) captured by the taxpayer using carbon capture equipment which is originally placed in service at a qualified facility before February 9, 2018; and (ii) either (A) used by the taxpayer as a tertiary injectant in a qualified enhanced oil or natural gas recovery project and disposed of by the taxpayer in secure geological storage; or (B) utilized by the taxpayer in a manner described in section 45Q(f)(5).

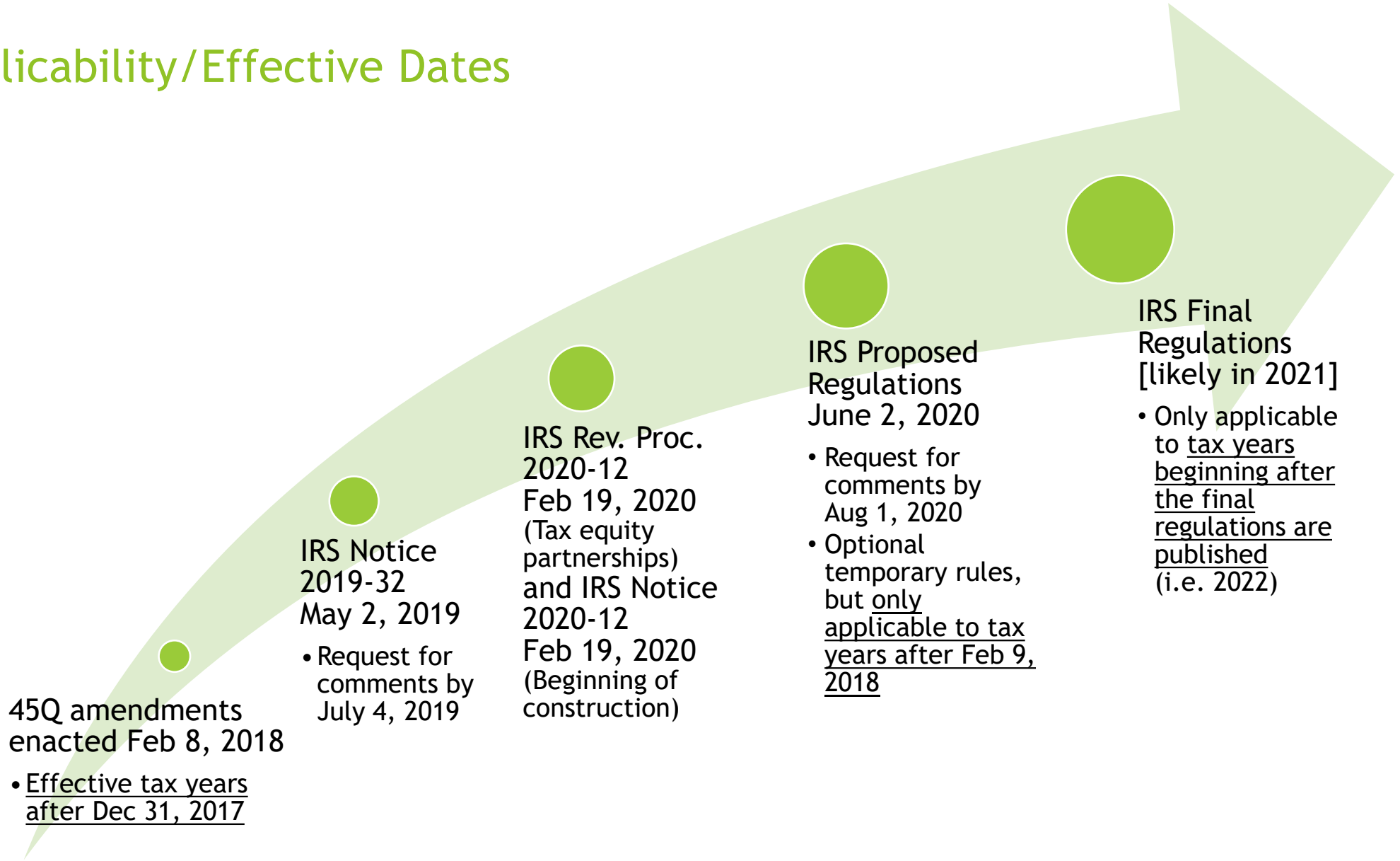
Section 45Q(a)(3) allows a credit of the applicable dollar amount (as determined under section 45Q(b)(1)) per metric ton of qualified carbon oxide (i) captured by the taxpayer using carbon capture equipment which is originally placed in service at a qualified facility on or after February 9, 2018, during the 12-year period beginning on the date the equipment was originally placed in service; (ii) disposed of by the taxpayer in secure geological storage; and (iii) neither used by the taxpayer as a tertiary injectant in a qualified enhanced oil or natural gas recovery project nor utilized in a manner described in section 45Q(f)(5).

Section 45Q(a)(4) allows a credit of the applicable dollar amount (as determined under section 45Q(b)(1)) per

Potential Business Relationships Needed for Carbon Capture Projects

- Equity investor and debt
- Tax equity investor
- Law Firm
  - Tax Opinion
  - Transaction documents
  - Environmental permitting
- EPC Contractor
- O&M Provider
- CO_2 Transporter
- CO_2 Offtaker (for Utilization, Injection or Disposal)
- Secure Geologic Storage Consultant
  - For MRV Plan development and EPA approval process
  - For ISO Standard certifications
- Insurance for 45Q qualification, recapture insurance, etc
- Developer to put the whole carbon capture project together
- Possibly others

Applicability/Effective Dates



45Q amendments enacted Feb 8, 2018

- Effective tax years after Dec 31, 2017

IRS Notice 2019-32
May 2, 2019

- Request for comments by July 4, 2019

IRS Rev. Proc. 2020-12
Feb 19, 2020
(Tax equity partnerships)
and IRS Notice 2020-12
Feb 19, 2020
(Beginning of construction)

IRS Proposed Regulations
June 2, 2020

- Request for comments by Aug 1, 2020
- Optional temporary rules, but only applicable to tax years after Feb 9, 2018

IRS Final Regulations [likely in 2021]

- Only applicable to tax years beginning after the final regulations are published (i.e. 2022)

45Q Legislative History

- Originally enacted on October 3, 2008:
  - $10/metric ton for EOR (now increased)
  - $20/metric ton for non-EOR (now increased)
  - Had to capture at least 500,000 metric tons/year (now reduced)
  - Expired once 75 mm metric tons of CO_2 were stored
  - Effective for CO_2 captured after October 3, 2008
- Amended on February 17, 2009:
  - CO_2 injected for EOR must go into "secure geologic storage"
  - Effective for CO_2 captured after February 17, 2009
- Amended on February 9, 2018:
  - "FUTURE Act" amendments were in Bipartisan Budget Act of 2018
  - Increased credit values, reduced minimum volume threshold, expanded to include CO and "utilization", eliminated nationwide aggregate limit of tax credits available going forward, etc
  - Effective to tax years beginning after December 31, 2017

45Q Legislative Proposals (2019-2020)

- Direct Pay or increased efficiency by providing option to treat the 45Q credit as estimated tax:
  - At 85% level: HR 7330 (Thompson – GREEN Act); HR 2 (DeFazio – Moving Forward Act)
  - At 100% level (no discount): HR 8858 (McKinley – ACCESS Act); S 4966 (Capito – 45Q CCUS Amendments Act)
    - NOTE – Elections for 85% and 100% levels are made by regulations that IRS must later adopt
  - At 90% level: HR 7896 (Bergman - RECOUPS Act): NOTE - Election is made by statute, not regulation
- Adjust minimum annual thresholds:
  - Decrease minimum threshold level from 100,000 to 50,000 metric tons/yr (& increase credit values for DAC plants): HR 5883 (Schweikert)
  - Eliminate all annual minimum threshold amounts of carbon oxide: HR xxxx [anticipated]
- Extend 45Q beginning of construction deadline:
  - 1 year: HR 5156 (Sewell); HR 7579 (Burgess); S 4041 (Cornyn)
  - 2 years: HR 2 (DeFazio – Moving Forward Act); HR 7330 (Thompson – GREEN Act of 2020)
  - 5 years: HR 7516 (DeGette); S 4966 (Capito – 45Q CCUS Amendments Act)
  - 10 years: HR 8858 (McKinley – ACCESS Act)
  - Eliminate deadline: HR 5883 (Schweikert)
- Other:
  - Relax EOR/EGR and Secure Geologic Storage definitions: S 2263 (Hoeven – CO_2 Regulatory Certainty Act)
  - Enhanced transferability of 45Q credit to numerous parties: S 3032 (Bennet – Renewable Energy Transferability Act)
  - Eliminate the 45Q program by not allowing credits for Qualified CO_2 captured after the date the bill is enacted: HR 7781 (Omar)
  - Adopt exemption to taxpayer privacy rules and require IRS to report who received how much 45Q credits: HR 7781 (Omar)
  - Erase power plants from 45Q, eliminate sections 43 and 48A and 48B, and establish new production and investment credits under new 45T and 48D as well as Clean Energy Bonds: S 1288 (Wyden - Clean Energy for America Act)

Elysian VENTURES

Table of Contents of 45Q statute, IRS regulations, and IRS guidance

Significant 45Q-Related Topics	45Q statute section	IRS regulation section (or guidance)
Qualified Carbon Oxide	45Q(c)	1.45Q-2(a) and (b)
Carbon Capture Equipment	45Q(b)(2)	1.45Q-2(c) and 1.45Q-1(g)
Qualified Facility	45Q(d) and (f)(6)	1.45Q-2(d), (e), (f), and (g)
Beginning of Construction		See IRS Notice 2020-12
Utilization	45Q(f)(5)	1.45Q-4
Secure Geologic Storage	45Q(f)(2)	1.45Q-3
Tertiary Injectant and Qualified EOR/EGR Project	45Q(e)	1.45Q-2(h)
Who can claim the credit	45Q(f)(3)	1.45Q-1(h)
Tax Equity Partnership safe harbor		See IRS Rev. Proc. 2020-12
Recapture	45Q(f)(4)	1.45Q-5
Amount of Credit	45Q(a), (b)(1), and (f)(7)	1.45Q-1(a), (b), (c), (d), and (e)
Phase out of old credits	45Q(g)	1.45Q-1(f)

Contact.

ktracy@elysian.cc

Developing and operating carbon capture projects that decarbonize power and industrial facilities

Elysian VENTURES

BREAK

PUTTING A PROJECT TOGETHER: THE MAIN ELEMENTS AND PROJECT PARTICIPANTS

JASON BEGGER, *DEPUTY DIRECTOR, WYOMING ENERGY AUTHORITY*
SCOTT QUILLINAN, *DIRECTOR OF RESOURCES & COMMUNICATIONS, UNIVERSITY OF WYOMING*
KEVIN LAUZZE, *VP AND PROJECT DIRECTOR, SARGENT & LUNDY*

INNOVATION APPLICATIONS TO DRIVE BUSINESS GROWTH: HYDROGEN, BIOFUELS, AND MORE

ROBERT SCHRECENGOST, *SENIOR PROGRAM MANAGER, ADVANCED TURBINES, HYDROGEN, AND ADVANCED ENERGY MATERIALS, DOE*
HOLLY KRUTKA, *EXECUTIVE DIRECTOR OF THE SCHOOL OF ENERGY RESOURCES, UNIVERSITY OF WYOMING*
JAMES SORENSEN, *DIRECTOR OF SUBSURFACE R&D, EERC*

U.S. DEPARTMENT OF ENERGY
Office of Fossil Energy
USEA United States Energy Association
GLOBAL CCS INSTITUTE

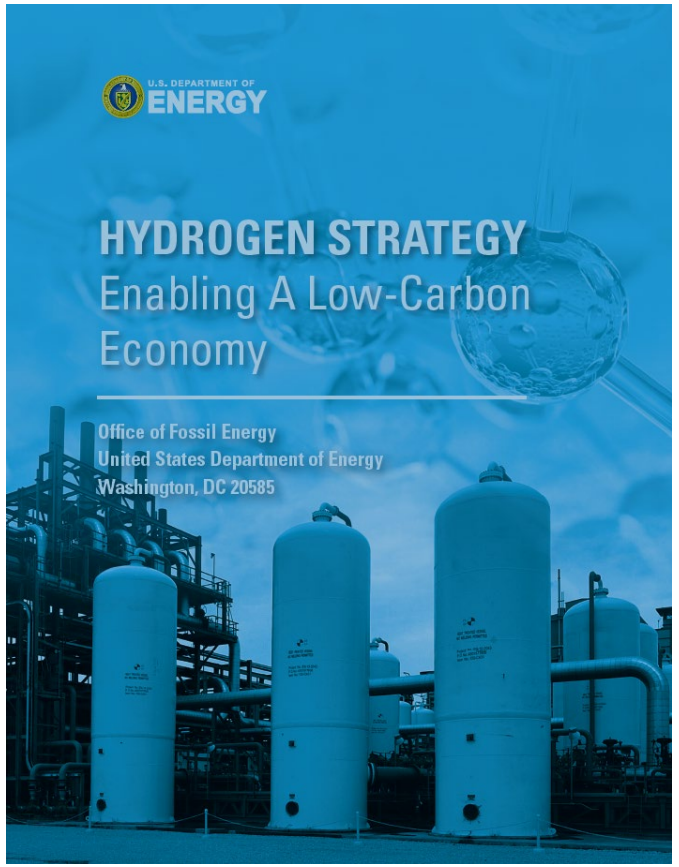
U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

Fossil Energy Hydrogen Strategy

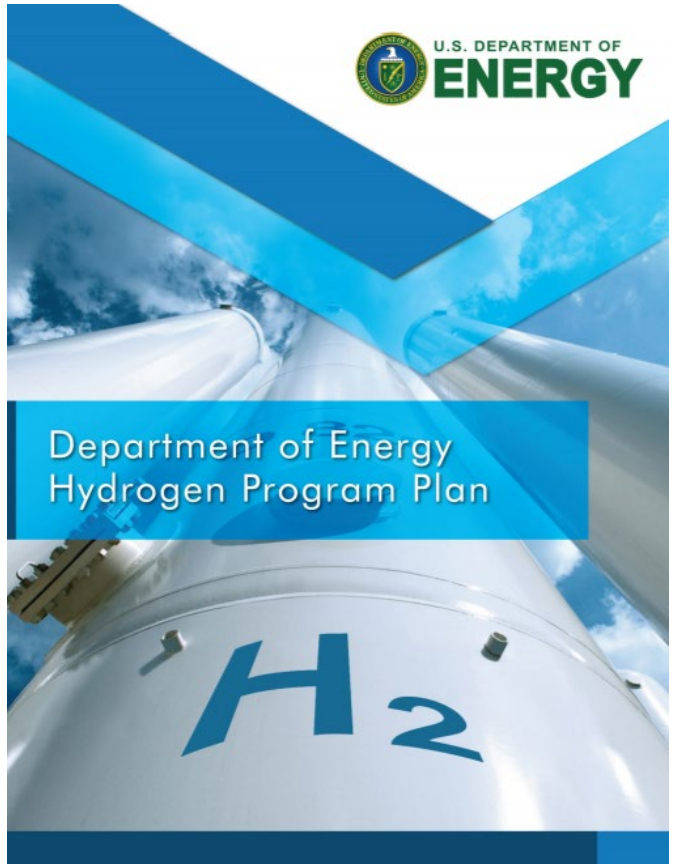
Bob Schrecengost
Hydrogen Program Manager
Advanced Energy and Hydrogen Systems Division

December 15, 2020 | GCCSI – Developing CCUS Projects in Colorado & Wyoming

DOE Publishes FE Hydrogen Strategy, DOE Hydrogen Program Plan



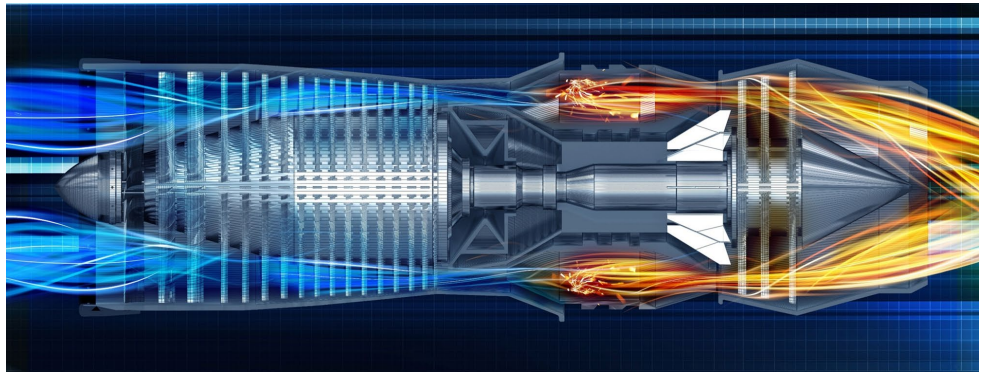
https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf

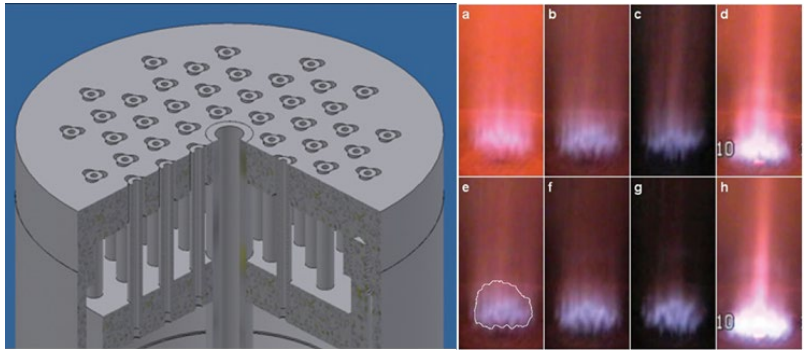


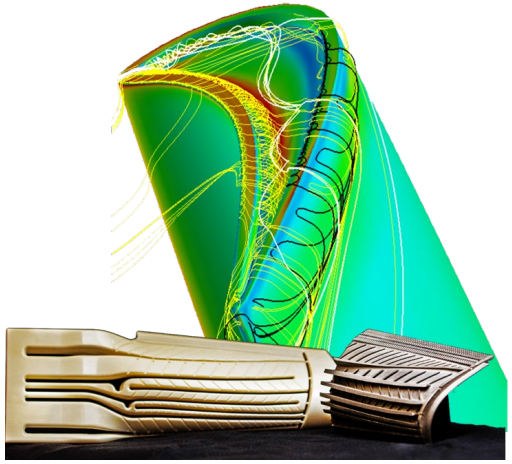
https://www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf

FE Investments in Hydrogen R&D

- ❑ Carbon-Negative Hydrogen Production Using Gasification and Reforming Technologies
- ❑ Hydrogen Use for Electricity Generation, Fuels, and Manufacturing.
- ❑ Large Scale On-site and Geological Hydrogen Storage for Energy Storage
- ❑ Large Scale Hydrogen Transport Infrastructure

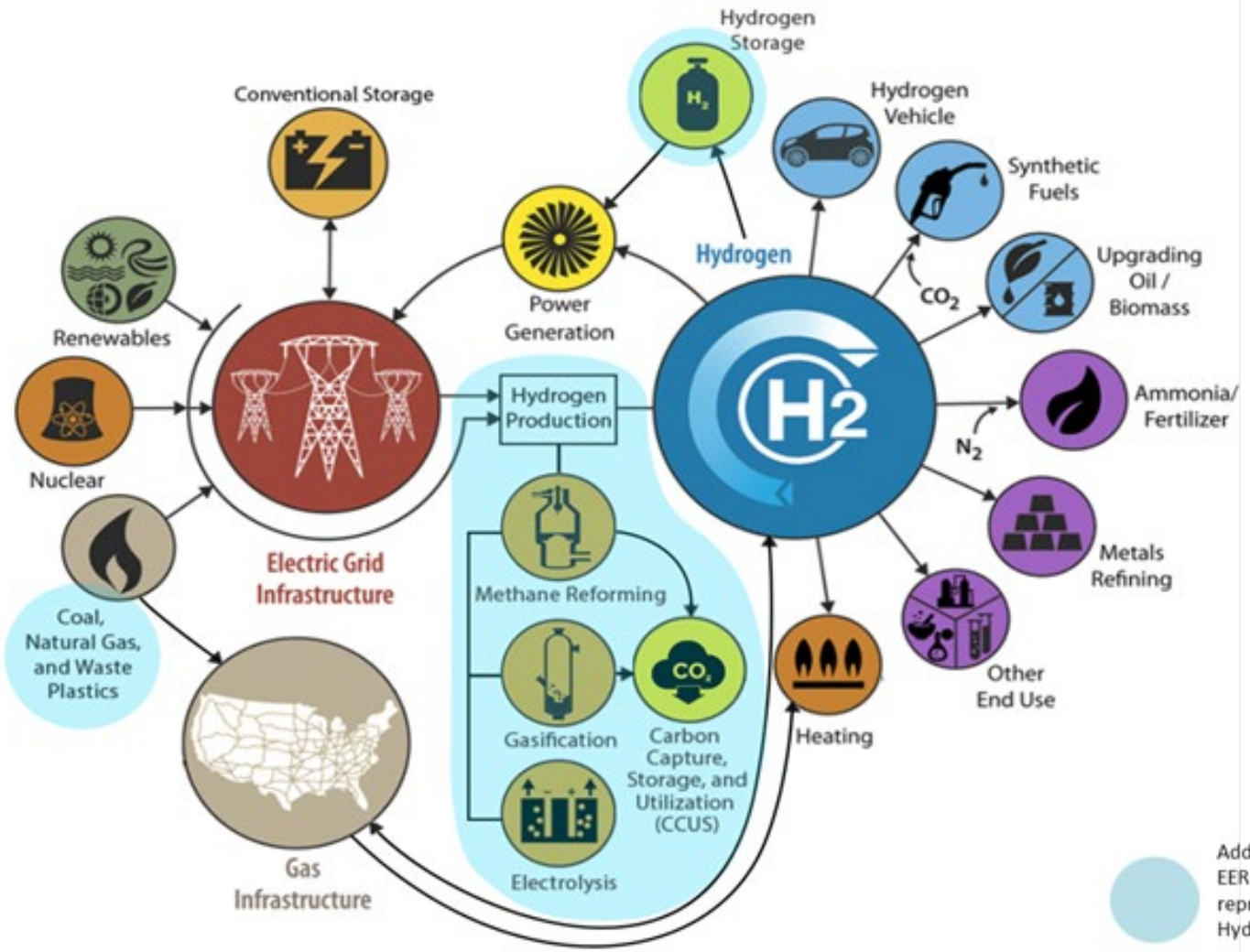






State of Hydrogen Production Today

- ❑ Currently 99% of 10 MMT in the U.S. supplied by fossil fuels – least cost
  - 96% by SMR
  - 3% by gasification
  - 1% by electrolysis
- ❑ 70 MMT generated globally
  - 76% by SMR
  - 22% by gasification
  - 2% by electrolysis
- ❑ Small fraction includes CCUS
- ❑ Economics dominates generation mix



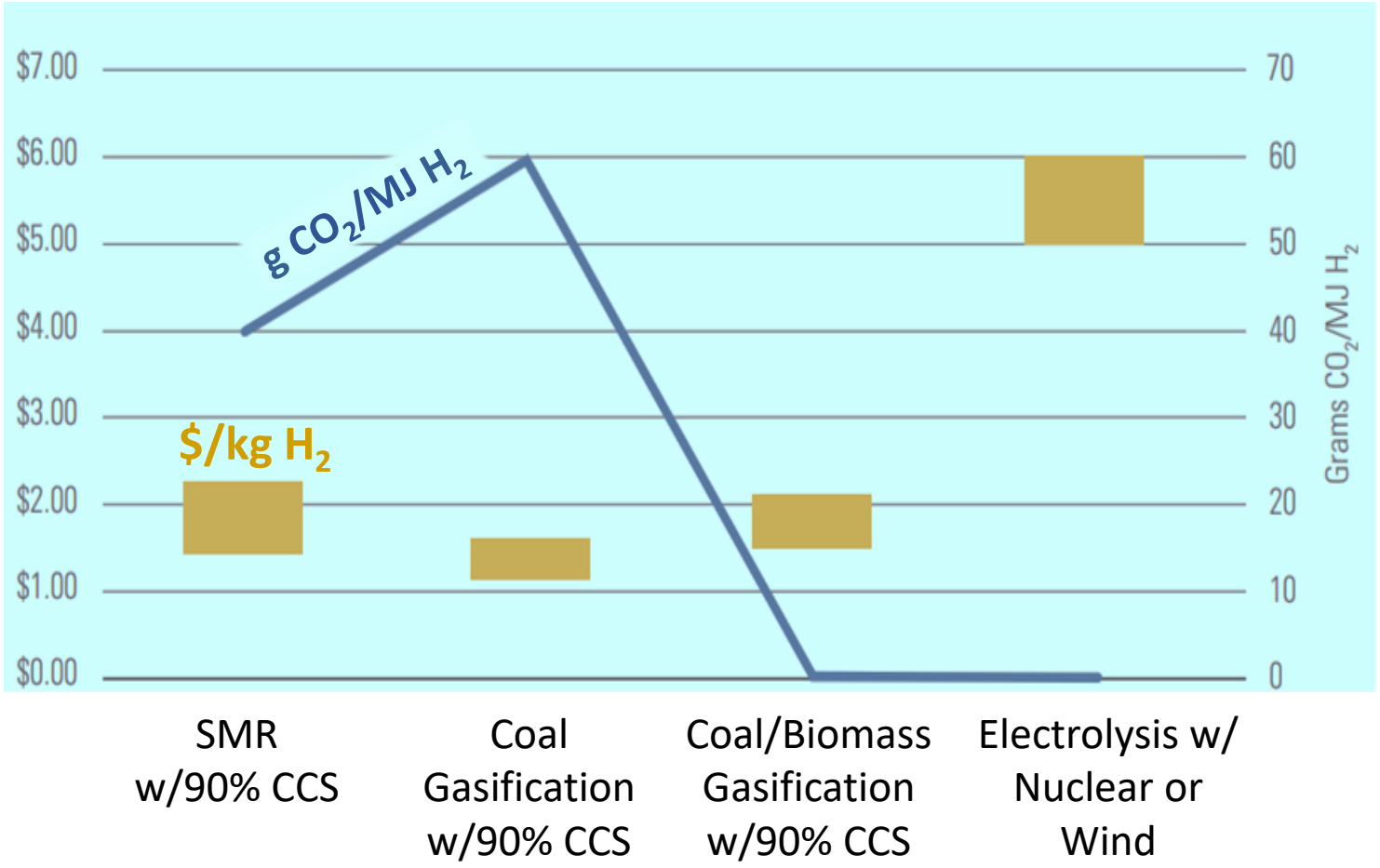
Transforming Fossil Energy Systems for the Future

Producing Hydrogen (H_2)

- Enable low-carbon economy.
- Serve transport, industry, and power generation markets.
- Improve poly-generation pathways to H_2.
- Create secure, utility-scale storage.

- **2030:** Develop turbines capable of 100% hydrogen combustion.
- **2035:** Produce H_2 from blends of coal, biomass, or MSW at commercial scale.

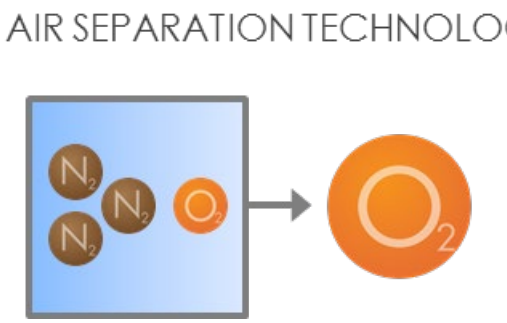
Current Cost of Hydrogen Production and CO_2 Intensity

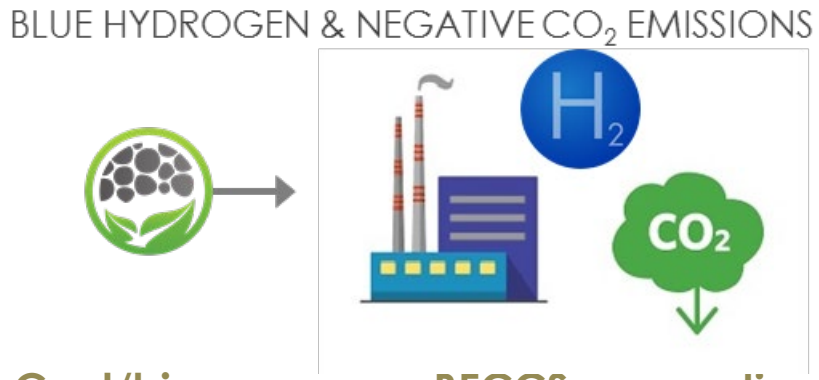


Source: DOE Hydrogen Strategy, July 2020, based on IEA Roadmap for Hydrogen and Fuel Cell and DOE Baseline Studies

Gasification Key Technology Areas

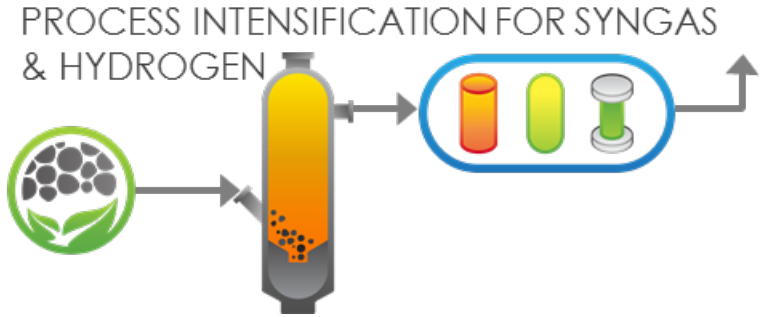
Modular ASUs for small-scale power systems



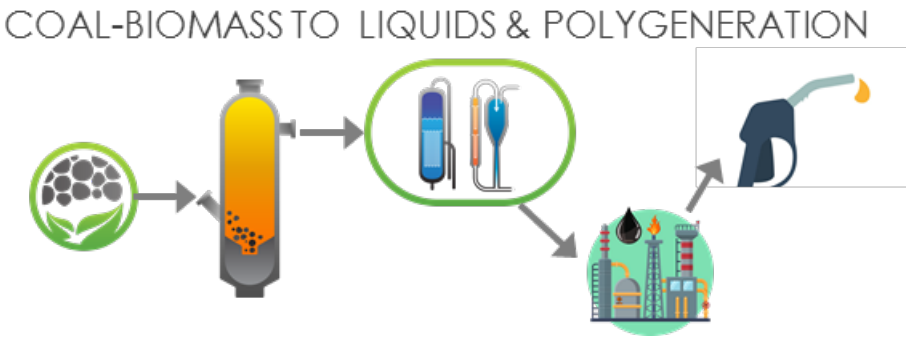


Coal/biomass use – BECCS connection

Gasifiers for small-scale power systems



Accommodate limited supply characteristics of biomass & MSW



Access higher value markets

Gasification with Plastics

Alternative feedstock & blending possibilities

- Low-cost localized sources

Syngas can:

- Produce heat and/or power
- Provide higher value products

Environmental Benefits

- Reduce landfill burdens
- Sustainable waste to energy

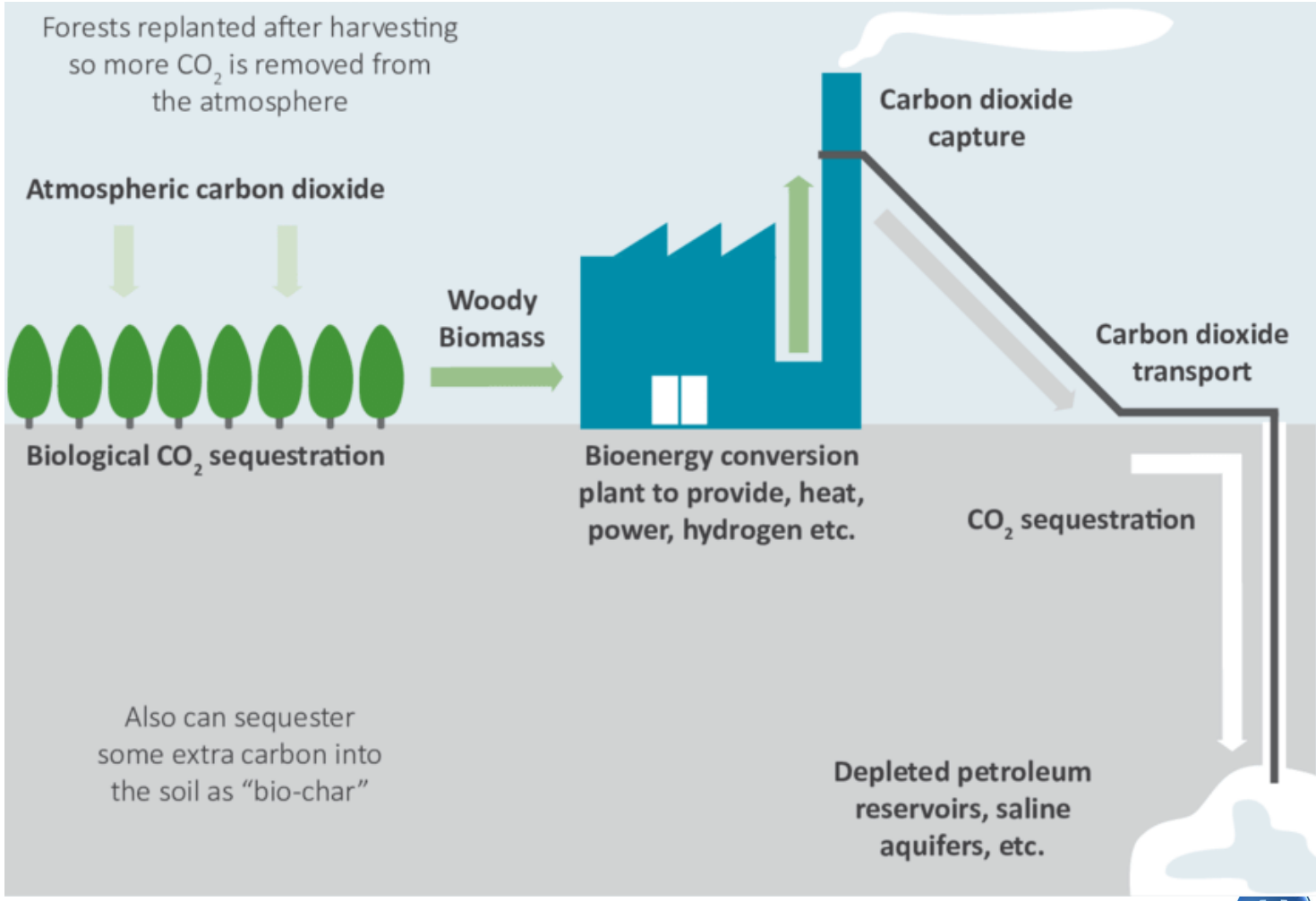
Transforming Fossil Energy Systems for the Future

Gasification of coal/biomass – pathway for negative carbon

- Integrated w/ CCUS – potential for negative emissions

Technology Gaps

- Affordable small-scale gasifier at location
- Affordable CCS integration



Hydrogen Storage Technologies – Leverage CCUS Experience

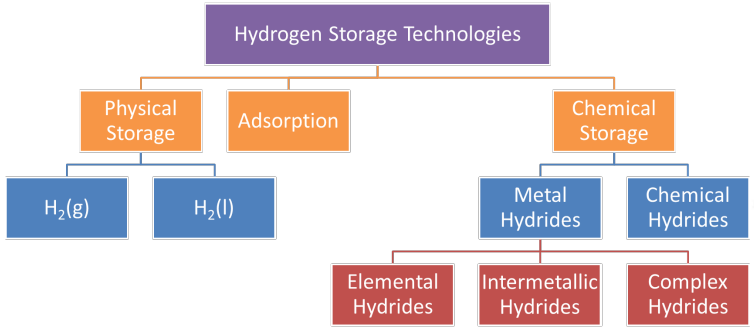
SOTA - High pressure tanks and as a liquid requires cryogenic temperatures (-423°F) – physical storage

Hydrogen infrastructure could require geologic bulk storage to handle variations in demand throughout the year
And bulk onsite storage for emergency fuel supply during extreme events

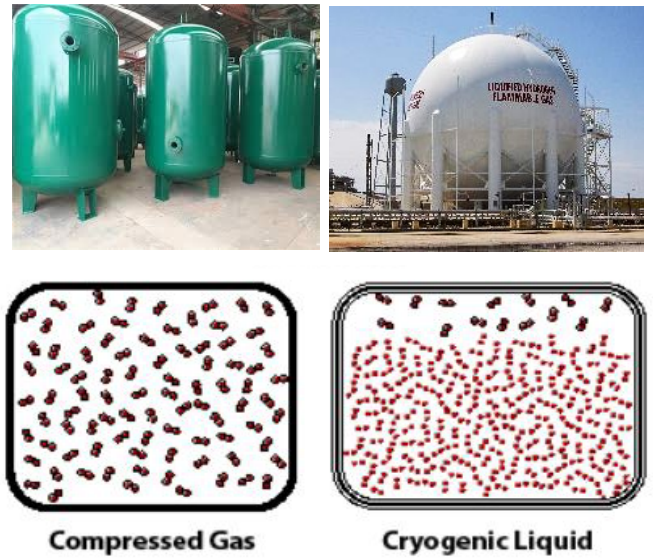
Technology Advancement necessary in physical and chemical storage

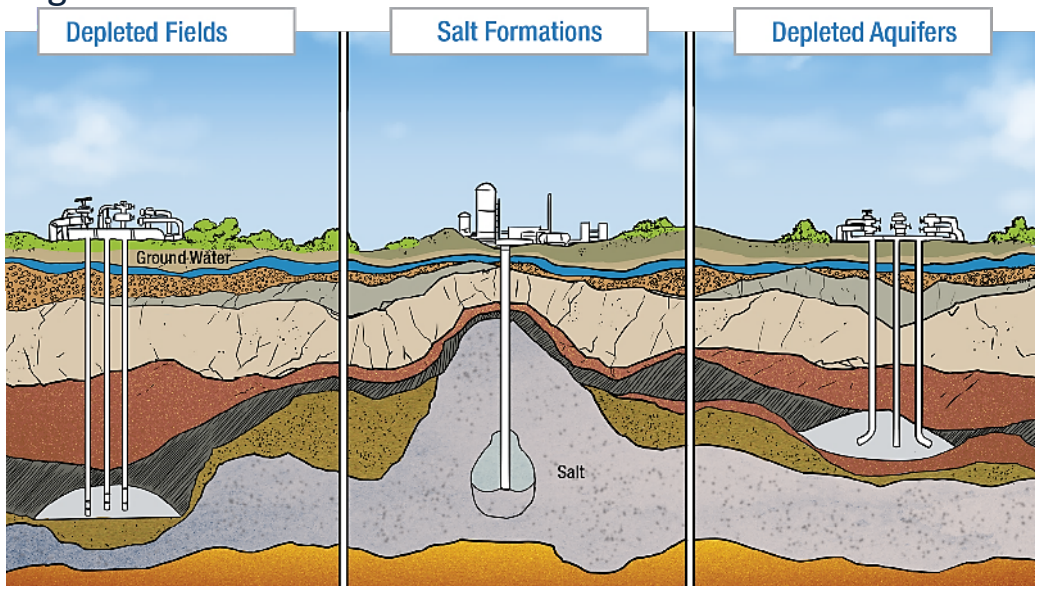
Underground geologic storage of low-pressure gaseous hydrogen necessary

- Salt caverns, depleted oil and gas reservoirs, aquifers, and hard rock caverns.
- Regional characterization and field laboratories to validate geologic storage



Ref: Andersson, J. and S. Gronkvist, 2019, "Large-scale storage of hydrogen." International Journal of Hydrogen Energy, Vol. 44.





Hydrogen Production Gasification Project FEED Studies – Net Negative Emissions Goal

Electric Power Research Institute, Inc. (Palo Alto, CA)

- *Gasification of Coal and Biomass: The Route to Net-Negative-Carbon Power and Hydrogen* – Integrated design study on an oxygen-blown gasification system coupled with water-gas shift, pre-combustion CO_2 capture, and pressure-swing adsorption working off a coal/biomass mix to yield high-purity hydrogen and a fuel off-gas that can generate power.
- Nebraska Public Power District
- CO_2 Storage: enhanced oil recovery and saline sequestration
- Co-feed corn stover and possibly other biomass and waste plastics

Wabash Valley Resources, LLC (West Terre Haute, IN) - *Wabash Hydrogen Negative Emissions Technology* –

Complete System integrated design study for redeveloping the existing Wabash Valley Resources coal gasification site in West Terre Haute, Indiana, into a Coal FIRST power plant for flexible fuel gasification-based carbon-negative power and carbon-free hydrogen co-production.

- Facility: Wabash Gasification Facility
- CO_2 Storage: Saline sequestration
- Co-feed woody biomass and/or agricultural residue and petroleum waste plastics

Examples of DOE Collaboration – Upcoming FOAs and Awards, DOE Loan Office

Project Awards

- FE announced the selection of 12 projects to receive approximately $34 million in DOE funding to develop small-scale solid oxide fuel cell systems.
- This month, FE will select projects for up to $6 million for cost-shared R&D on system-integrated, energy storage solutions (many of which will utilize hydrogen) for fossil assets.

Upcoming Hydrogen-related FOAs

FE released a $2 million funding opportunity announcement for cost-shared R&D on gasification of blended coal, biomass, and plastic waste to produce hydrogen with carbon capture, utilization, and storage (CCUS) and will announce the selections in February 2021.

FE released an $8 million funding opportunity announcement under its University Turbines System Research program to develop full hydrogen firing capability and research ammonia combustion fundamentals for gas turbines.

FE is developing a large, office-wide FOA for hydrogen production, utilization, transport and storage.

- Programs participating include Gasification, Natural Gas-based H_2 Production, SOEC, Carbon Capture, H_2 Turbines, Subsurface Storage, H_2 Pipelines and Infrastructure

https://www.fedconnect.net/FedConnect/Default.htm for FOA notifications, to search for opportunities

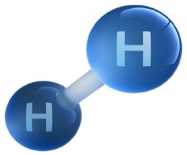
DOE Loan Guarantee Office

- https://www.energy.gov/lpo/services/solicitations/advanced-fossil-energy-projects-solicitation

Questions?

Robert Schrecengost
Hydrogen Program Manager
Office of Fossil Energy
Advanced Energy and Hydrogen Systems division

Robert.schrecengost@hq.doe.gov



END OF DAY 1

U.S. DEPARTMENT OF
ENERGY
Office of Fossil Energy
USEA
United States Energy Association
GLOBAL CCS
INSTITUTE

DEVELOPING CCUS PROJECTS IN COLORADO AND WYOMING
DECEMBER 15-16, 2020

AGENDA

Day 1

1:00 – 1:10 pm MT	Welcome
1:10 – 1:30	Commitment to Decarbonization: The States' Perspective
1:30 – 1:45	The Status of CCUS in the US and Around the World
1:45 – 2:15	How to Utilize 45Q on your CCUS Project
2:15 – 2:25	Break
2:25 – 3:30	Putting a Project Together: Capture, Transportation, and Storage
3:30 – 4:15	Innovation Applications to Drive Growth: hydrogen, biofuels, and more
4:15 – 4:20	Day 1 Wrap-up and Day 2 Preview

Day 2

9:00 – 9:20 am MT	Welcome & ESG Ratings – Are they Driving CCS Adoption?
9:20 – 10:10	Case Studies and New Technology Development in the Region
10:10 – 10:55	Challenges to Deployment and Strategies to Address Them
10:55 – 11:00	Wrap-up and Break-out Instructions
11:00 – 11:15	Break
Breakout Sessions – 11:15 to 12:00	
Breakout Session 1	Q&A and Broader Discussion on 45Q with Keith Tracy
Breakout Session 2	Putting together CCUS Projects with Emily Kunkel, Project Associate, Sargent & Lundy
Breakout Session 3	Understanding the WY context regarding technology support, liability, permitting, etc. Jason Begger and Kara Fornstrom

Patricia Loria, Senior Client Engagement Lead, GCCSI

ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) ASSESSMENTS AND CCS

GLOBAL CCS INSTITUTE

AIM AND SCOPE OF STUDY

- Examine the significance and the extent of the influence of Environmental, Social and Governance (ESG) ratings in supporting investment in CCS project deployment

- Addressed five key questions:
  - How does a company's ESG rating impact the company?
  - How does a company's CO_2 footprint or exposure impact its ESG rating?
  - How is CCS considered when the ESG performance of a company with a large CO_2 footprint or exposure is rated?
  - Do the positive impacts of CCS (if any) on a company's ESG rating support the business case for investing in or financing CCS?
  - How does climate litigation and public policy impact corporate risk and ESG ratings?

IMPACT OF ESG RATINGS UPON A COMPANY

- Reporting and scrutiny of Environmental, Social and Governance (ESG) factors has emerged as a critical aspect of commercial behaviour in recent years
- Significant rise in the number of ESG-related schemes – both voluntary and proprietary
- Definitive shift towards more mandatory forms of reporting, with governments, market regulators, stock exchanges introducing new requirements
- Closer scrutiny of the links between ESG performance, the allocation of capital and an organization's commercial performance
- Moving beyond the traditional shareholder primacy model

THE SIGNIFICANCE OF A CO_2 FOOTPRINT

- Climate has become "front and foremost" in the consideration of 'E' ratings
- The 'materiality' of an organization's GHG emissions are increasingly considered
- Rising expectations around more detailed disclosure, particularly the use of voluntary schemes such those developed under the TCFD
- An important aspect of commercial ratings assessments, however, caution urged as to methodologies employed

IMPACT OF CCS OPERATIONS

- With an increasing focus upon GHG emissions and the CO_2 footprint, CCS should play a positive role in an ESG assessment
  - Demonstrating awareness of market and policy risks
  - Directly reduces emissions
  - Provides an opportunity as a low-carbon investment
- Technology has received little direct attention within ratings schemes to-date
- May contribute to an organization's rating, where reported as part of efforts to address GHG emissions

A BUSINESS CASE FOR INVESTING IN CCS

- The link between investment and ESG ratings is becoming clearer
- Considerable potential offered by CCS to address the critical climate element of many rating assessments
- More widespread deployment of the technology may encourage greater review and ratings performance
- Improvement in ratings performance alone, however, is unlikely to drive investment – merely one aspect of a wider investment strategy

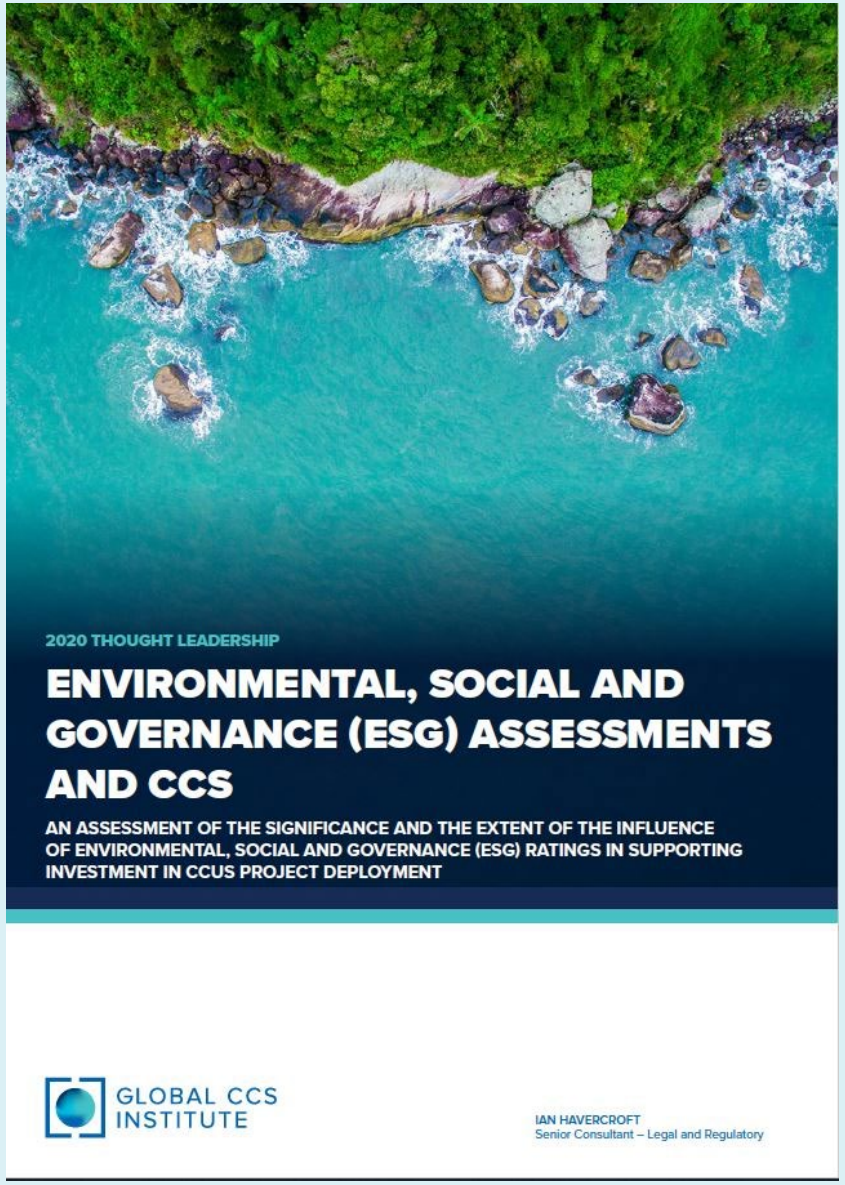
IMPACT OF CLIMATE LITIGATION

- New and emerging consideration for companies and investors alike, with several noteworthy examples of litigation underway
- Largely unaddressed by ratings, however, clearly the subject of 'controversy' factors
- All parties interviewed accepted that is remained a largely unexplored area, but:
  - "likely to be very significant going forward"
  - "bubbling under the surface"
  - "Proposed threat or ongoing litigation would likely weigh upon a particular company's scoring"

CONCLUSIONS

- ESG ratings playing an increasingly significant role, with investors, companies and the public scrutinizing performance
- Climate change related performance is an intrinsic element of many ratings schemes
- Growing expectation for companies to both disclose their performance and in a manner that is readily accessible
- CCS remains largely unaddressed by many schemes, but more widespread scrutiny of emissions reduction activities, greater deployment and financial commitment, may change this

- Final Thought Leadership report published in October 2020
- Available now in the Publications section on the Institute's website



CASE STUDIES AND NEW TECHNOLOGY DEVELOPMENT IN THE REGION

DERICK DREYER, *DIRECTOR OF CORPORATE MANUFACTURING AND SLAG OPERATIONS, LAFARGEHOLCIM ON HOLCIM PORTLAND CEMENT PLANT*

BRICE FREEMAN, *MEMBRANE TECHNOLOGY AND RESEARCH ON DRY FORK GENERATING STATION*

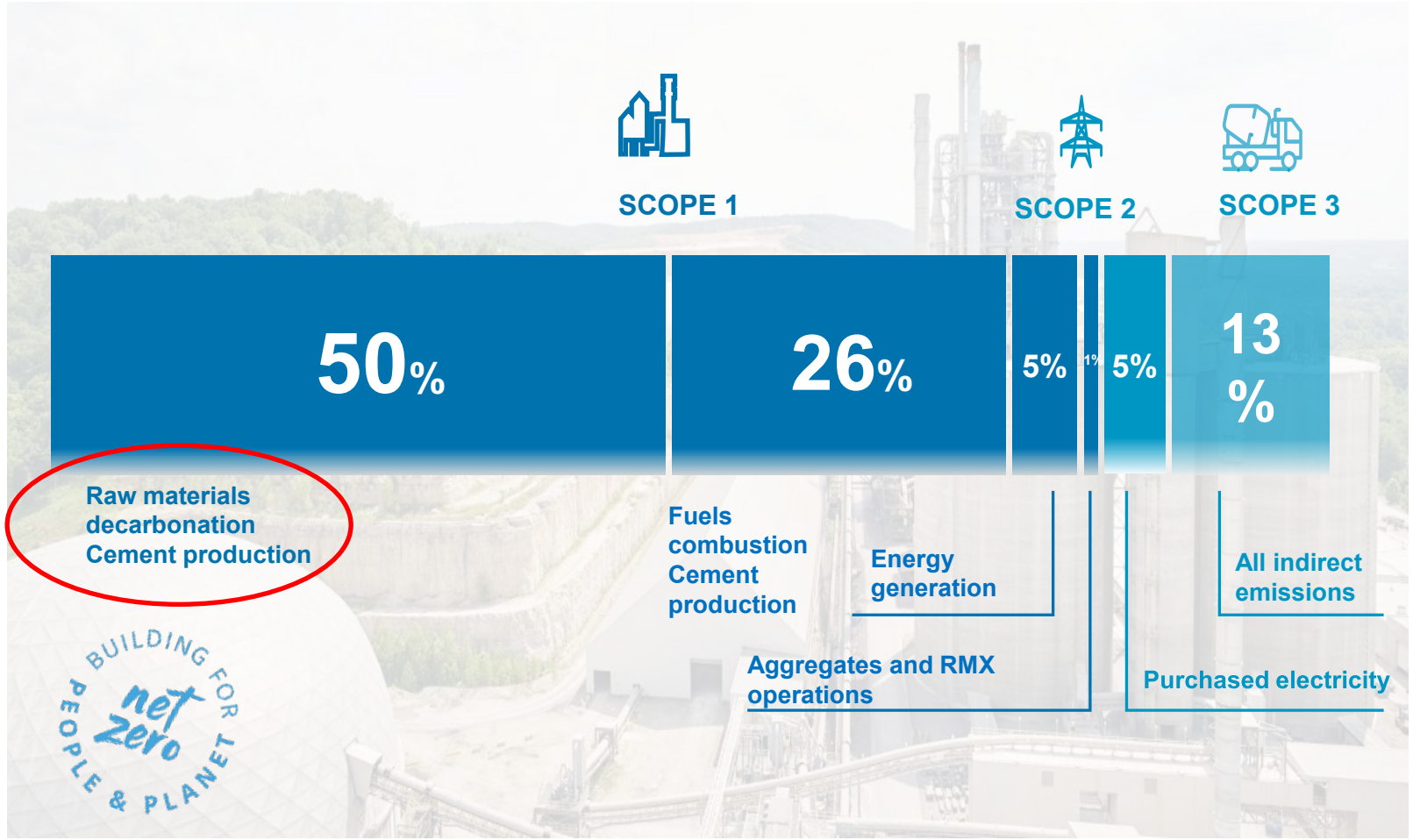
MARKUS LESEMANN, *DIRECTOR, BUSINESS DEVELOPMENT – ENERGY SUPPLY & CONVERSION, GAS TECHNOLOGY INSTITUTE ON WYOMING INTEGRATED TEST CENTER*

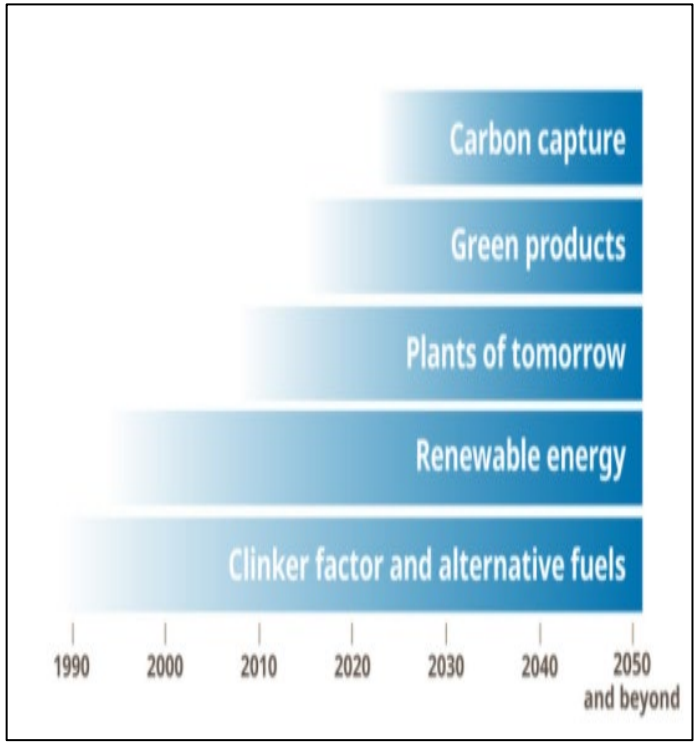
LafargeHolcim

CO2ment Project- Florence, Colorado

LafargeHolcim

LafargeHolcim- Committed to Net Zero



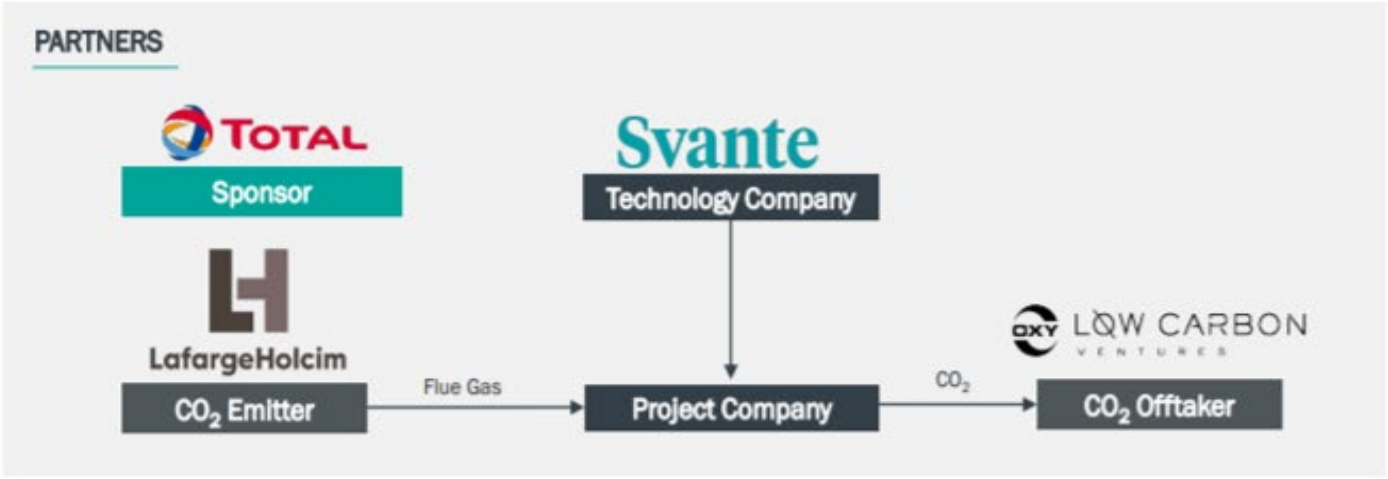


LafargeHolcim

CO2ment Project Overview

Joint study to assess the viability and design of a commercial-scale carbon capture facility

Plant Scale:	~5000 tonnes/day ~1,500,000 tonnes/yr
Source & Location:	Cement Kiln flue gas, LH Portland Plant Florence, Colorado, US
Scope:	Capture Plant, utilities, compression and product tie-in, pipeline



TECHNOLOGY COMPANY
SVANTE

Role Developer of the second generation carbon capture technology Project Delivery

SPONSOR
TOTAL S.A.

Role The learnings from this study will help pursue their commitment to the commercial development of CCUS

CO_2 EMITTER
LAFARGEHOLCIM

Role As the CO_2 emitter, the project will reduce CO_2 emission from its cement plant

CO_2 OFFTAKER
OXY LOW CARBON VENTURES

Role The industry leader in CO_2 management and storage. Transport and sequester the CO_2.

CO2ment Project Overview

The scoping study completed in 2020 delivered on 3 key tasks

TASK 1

Scoping Study & Class IV TEA

with Dense Phase Compression (including pipeline transport).

Includes

- Block Flow Diagram & Tie-in Points/Utilities
- Utilities & Chemicals Summary Emissions & Effluent Summary
- Process Flow Diagram & Stream Tables
- List Of Major Equipment
- Site Layout
- CAPEX, OPEX
- Preliminary 3D Model – *not essential*
- Process Description

TASK 2

Project Financial model with Sensitivity Analysis

Includes

- Project Profitability & Investment Metrics
- Net Present Value (NPV)
- Internal Rate Of Return (IRR)
- Cash Flow Pro Forma Project Financial Model

45Q

TASK 3

Plan for a FEED Study and further project development

Includes

- Deliverables
- EPC Schedule
- Resources
- Cost
- Engineering Consultant Candidates
- potential funding mechanisms

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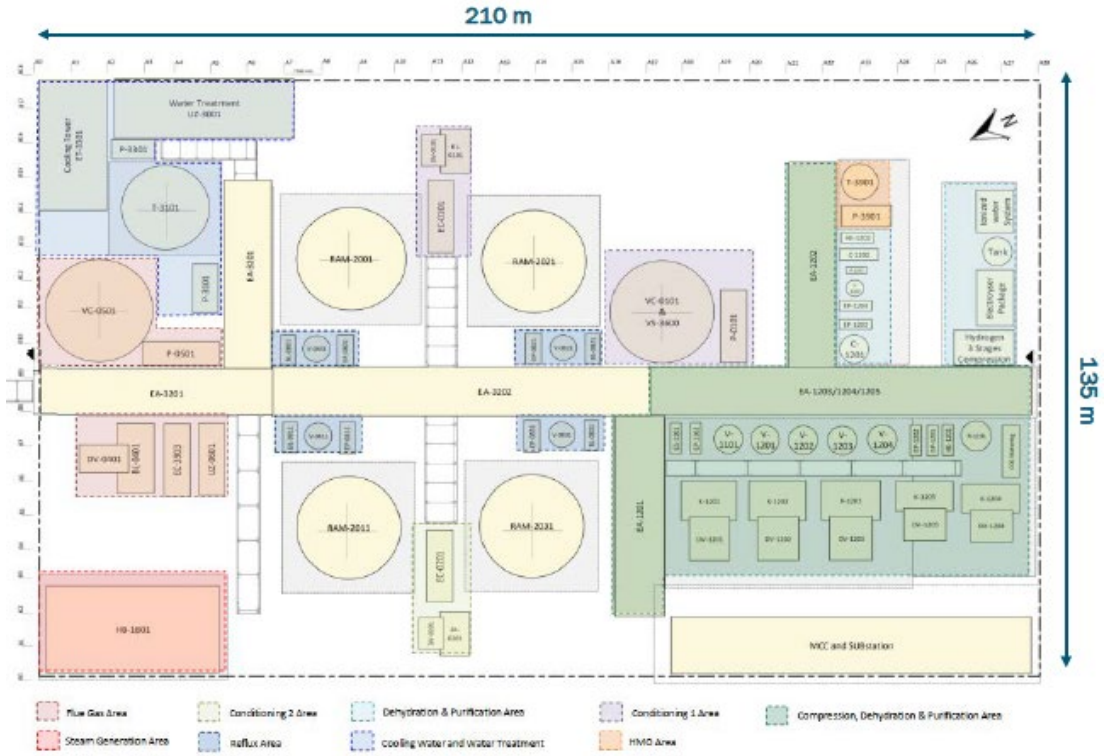
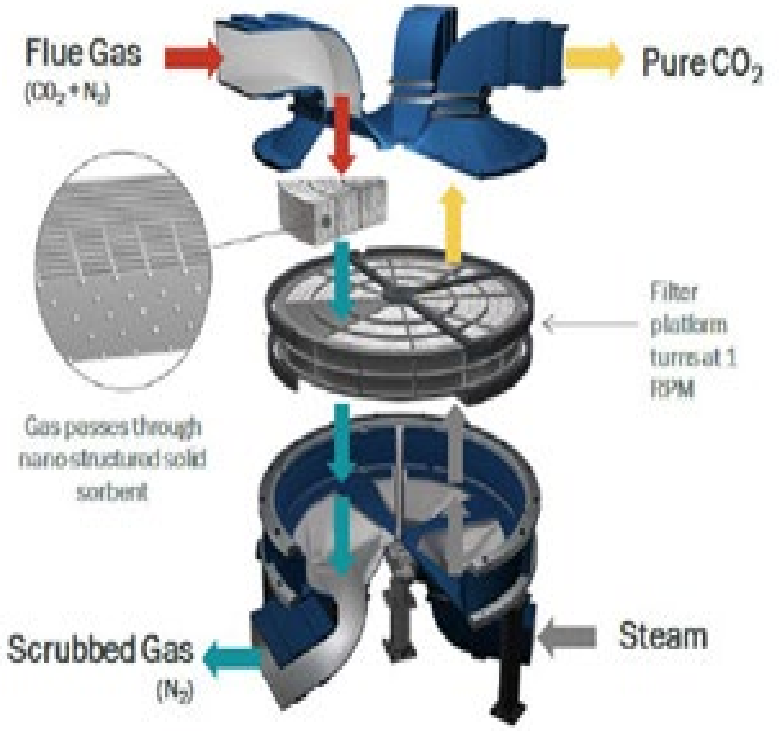
CO2ment Project Overview





Portland (Colorado, USA)

- Next steps are project phase FEL-1 / FEL-2 being supported with DOE NETL Funding Support
- Support from State

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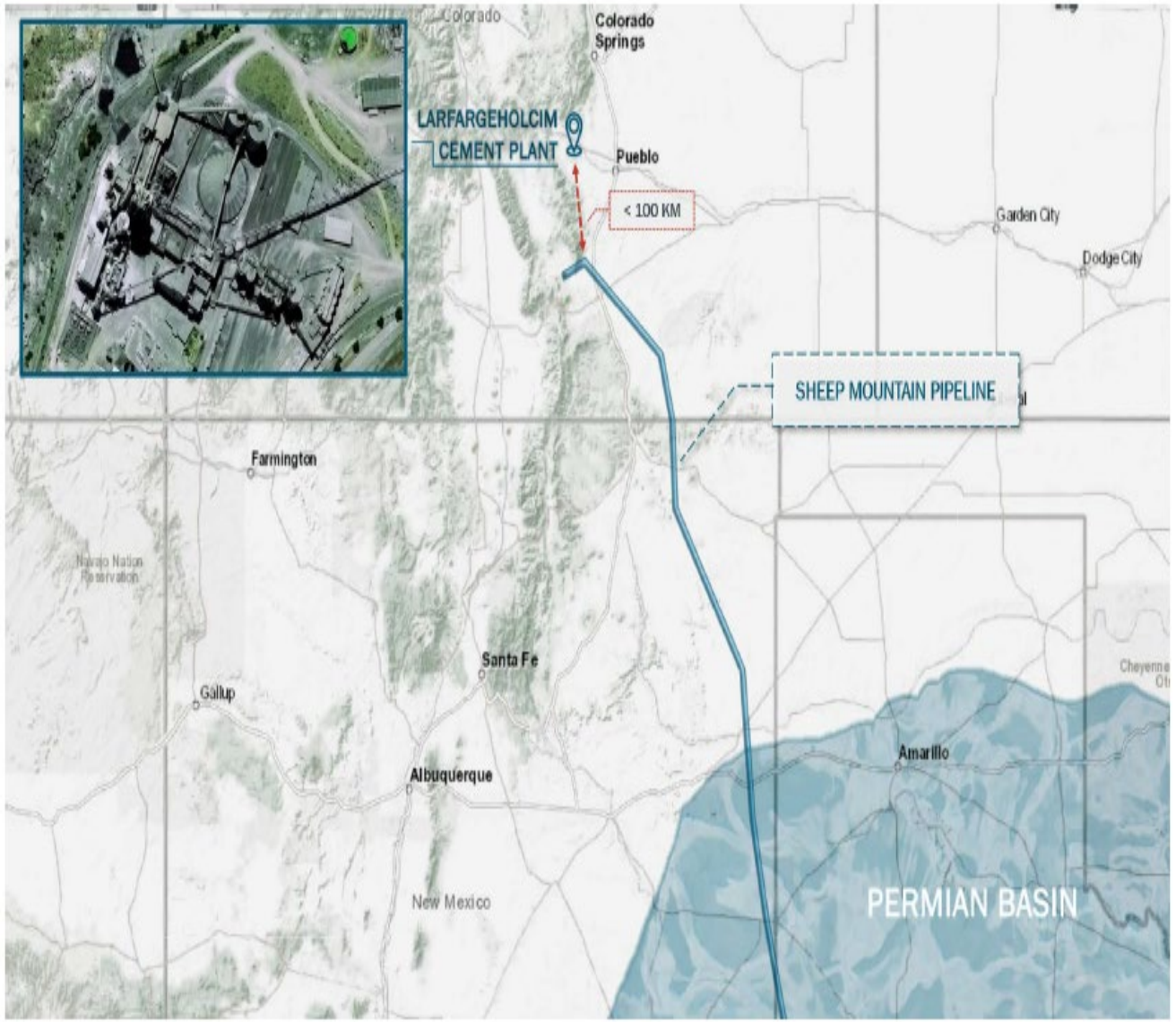
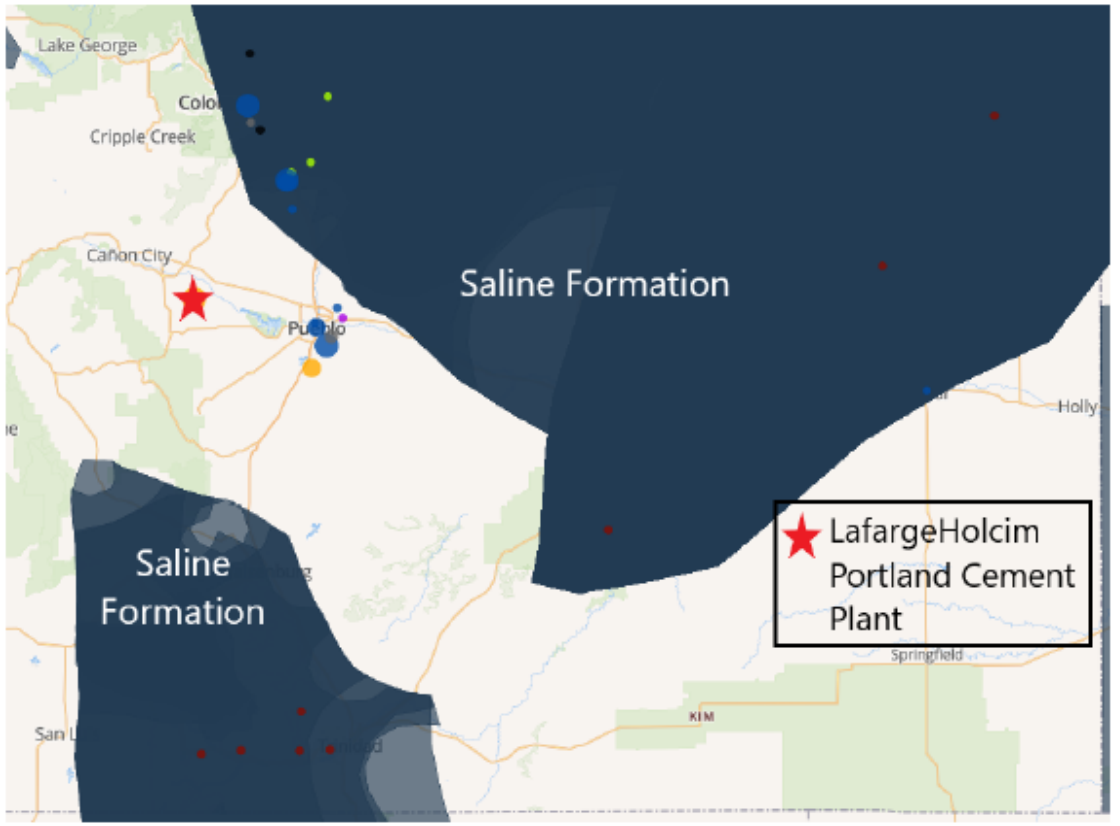
CO2ment – 45Q EOR /Sequestration options





Source: Picture taken from NATCARB Viwer 2.0

Table 4. CO_2 Sequestration Capacities Estimated for Colorado (in Million Metric Tonnes)

Pilot Study Regions	Geologic			Mineralization		Total CO_2 Capacity
	Oil & Gas	CBM	Saline Aquifers	Silicates	Produced Waters	
Cañon City	0	447	20,300	1,950	---	22,697

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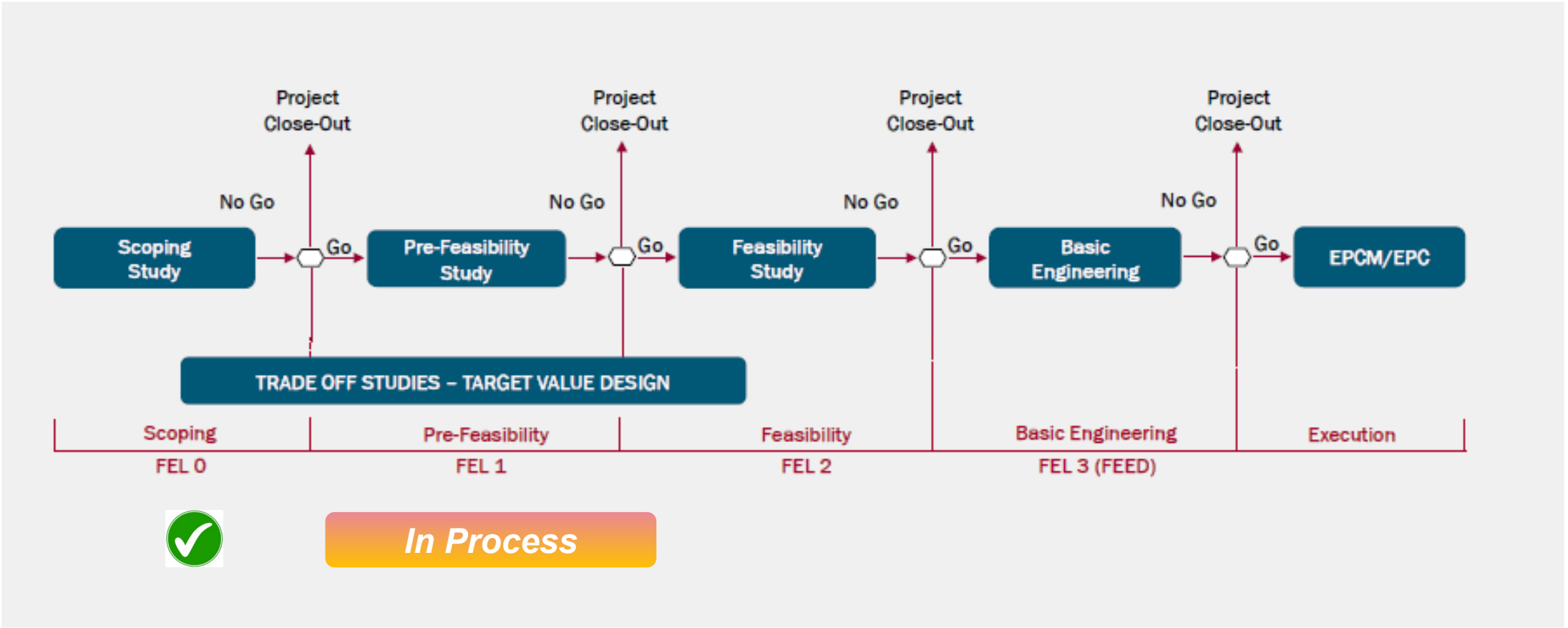
CO2ment Project Overview



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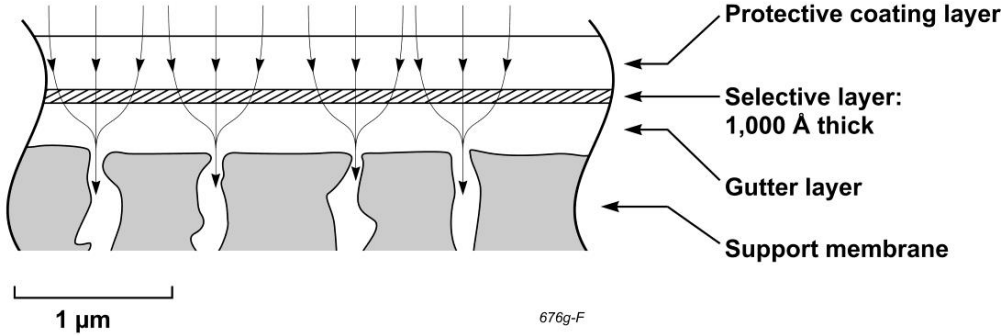
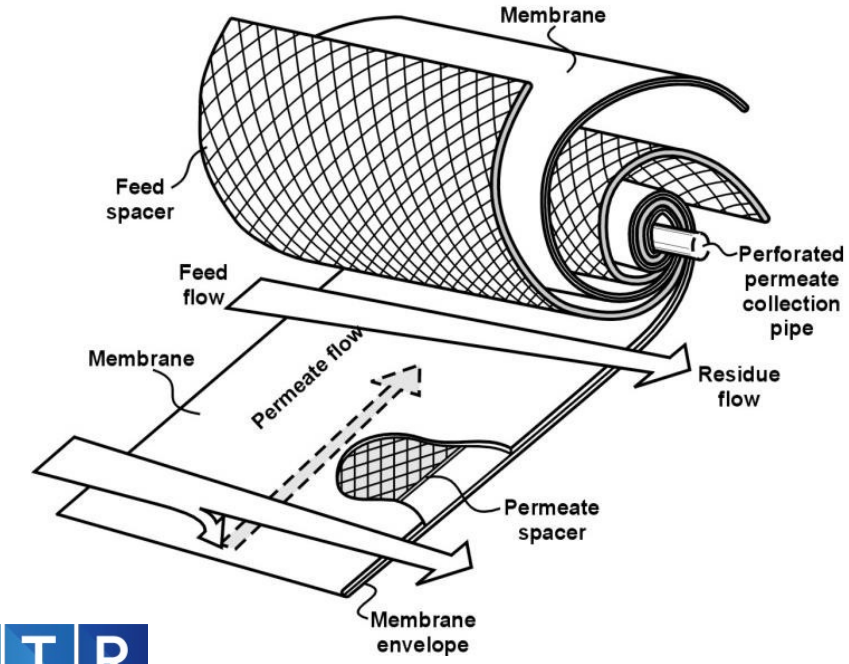
MTR's CO_2 Capture Projects at Dry Fork Station

Brice Freeman
Membrane Technology and Research, Inc.

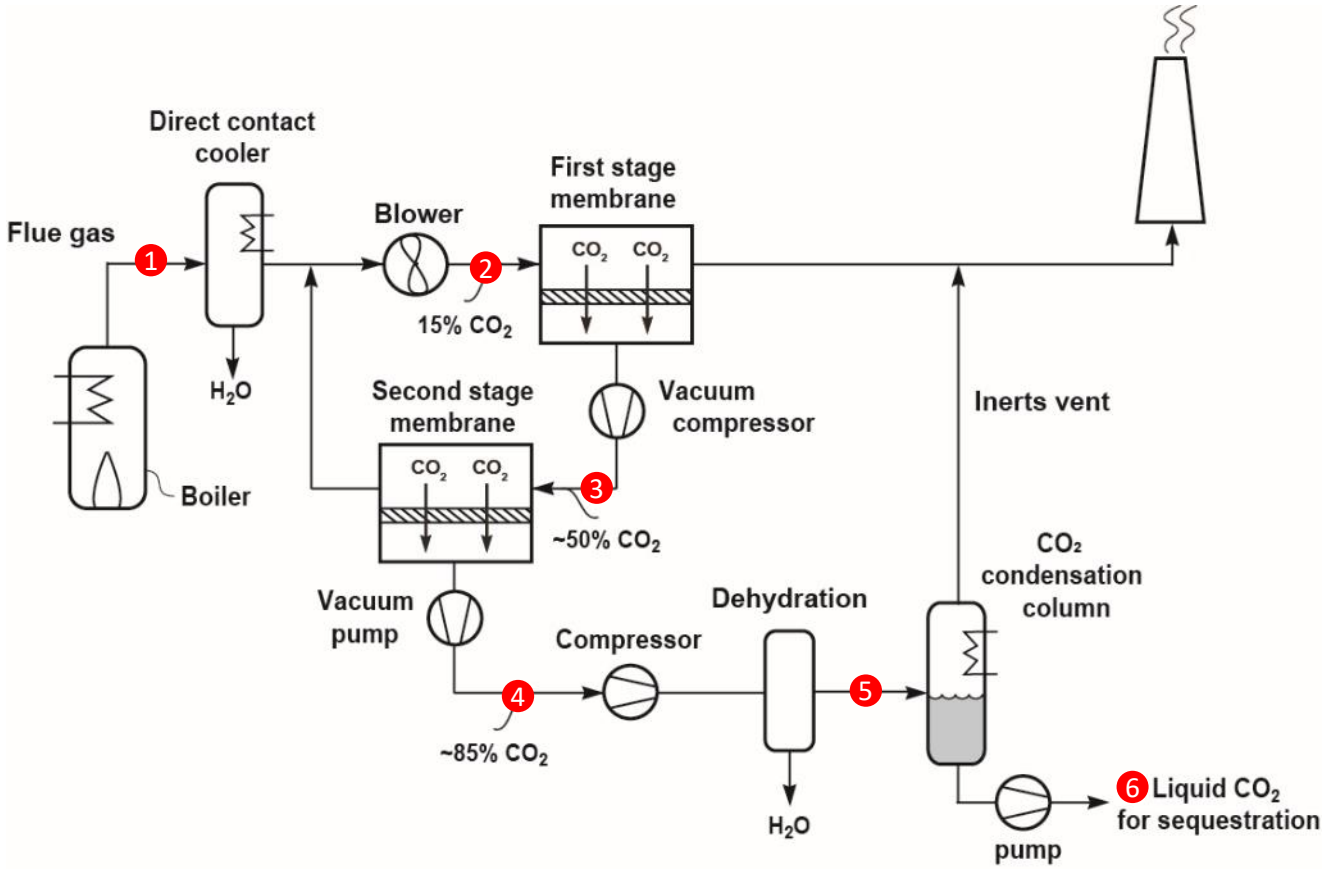
GCCSI: Developing CCUS Projects in Colorado & Wyoming
December 16, 2020

Membrane Anatomy



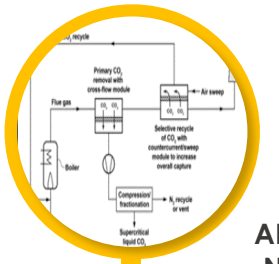


Process Design



MTR's CO_2 Capture Development Timeline

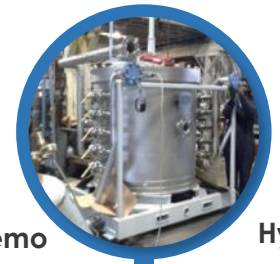
Feasibility Study
(NT43085)
- Sweep concept proposed
- Polaris membrane conceived



APS Cholla Demo
(NT0005312)
- First Polaris coal flue gas test
- 1TPD CO_2 captured (50 kWe)

APS Red Hawk NGCC Demo
- First Polaris flue gas test
- 250 lb/d CO_2 for algae farm

Low Pressure Mega Module
(FE0007553)
- Design/build 500 m^2 module



NCCC 1 MWe Demo
(FE0005795)
- 11,000 hrs of 1 TPD system operation
- 1 MWe (20 TPD) system operation

Hybrid Capture
(FE0013118)
- Membrane solvent hybrids with UT, Austin

B&W Integrated
(FE0026414)
- Integrated operation of 1 MWe system with B&W's 0.6 MWe coal-fired boiler

10 MWe Large Pilot
(FE0031587)
- Phase II – FEED Study, Permitting
- Phase III -- construction/operation

Full Scale FEED
(FE0031846)
- Retrofit study for Dry Fork Station
- Partial capture conditions
- Coordination with CarbonSAFE

2006 2008 2010 2012 2014 2016 2018 2020

Unit #1 - Dry Fork Station

- 400 MWe power plant in Gillette, WY
- Owned by Basin Electric (92.9%) and the Wyoming Municipal Power Agency (7.1%)
- Commissioned in 2011
- Low sulfur, PRB coal from Dry Fork Mine
- Low NOx burners w/ OFA, SCR, dry lime fluidized bed FGD, fabric filter
- Zero liquid discharge plant
- Cooling via an air-cooled condenser (one of the largest in N. America)
- Home to the Wyoming Integrated CO_2 Test Center (WITC)
- Home to the Dry Fork CarbonSAFE CO_2 storage project

Large Pilot CO_2 Capture Project (DE-FE0031587)

- Three phase project to build, install and operate a 10 MWe Large Pilot capture plant.
- Completed the FEED study. Permit issued.
- If selected for Phase III, project would start next summer
- Phase III activities:
  - Detailed design / procurement
  - Membrane manufacturing / BOP fabrication
  - Site construction
  - Installation and commissioning
  - Operation of large pilot capture plant

Sargent & Lundy

MTR

ITC WYOMING INTEGRATED TEST CENTER

TRIMERIC CORPORATION

Full-Scale FEED of MTR's Capture Process (DE-FE0031846)

- FEED of MTR's membrane-based CO_2 capture process applied to Dry Fork Station
- Study lead by Sargent & Lundy
- Designed for a 70%+ capture rate which exceeds the CarbonSAFE threshold of 50 million tonnes of CO_2 in a 30 year period
- Coordination with CarbonSAFE Wyoming

BASIN ELECTRIC POWER COOPERATIVE
A Touchstone Energy® Cooperative

Sargent & Lundy

EPRI ELECTRIC POWER RESEARCH INSTITUTE

MTR

TRIMERIC CORPORATION

Engineering Scale Design and Testing of Transformational Membrane Technology for CO_2 Capture

GTI – Ohio State University – Wyoming ITC Collaboration

Markus Lesemann

Director, Business Development

December 16, 2020

75-year History of Turning Raw Technology into Practical Energy Solutions

FOR A BETTER ECONOMY AND A BETTER ENVIRONMENT

SUPPLY ▶ CONVERSION ▶ DELIVERY ▶ UTILIZATION

RESEARCH & DEVELOPMENT

PROGRAM MANAGEMENT

TECHNICAL/ ANALYTICAL

CONSULTING

TRAINING

COMMERCIALIZATION

400+ EMPLOYEES

World-class piloting facilities headquartered in Chicago area

Project Overview

- Objectives
  - Design and build an engineering-scale CO_2 capture system (1 MW_e) using OSU's transformational membrane in commercial-size, spiral-wound (SW) membrane modules
  - Conduct tests on coal flue gas, and demonstrate a continuous, steady-state operation for a minimum of two months
- Performance targets
  - CO_2 capture with 95% CO_2 purity at a cost of $30/tonne of CO_2 captured
  - Cost of electricity (COE) at least 30% less than baseline CO_2 capture approaches by 2030
- Funding: $13 MM DOE + $3.25 MM partner cost share over 4-year project

Team Member	Project Roles
gti	• Prime contractor to DOE. Lead on project management and planning • Lead on skid design, selection of skid constructor, skid installation, and field testing • Support TEA and EH&S assessment
OHIO STATE UNIVERSITY 1870	• Co-PI on DOE award • Lead on commercial-sized membrane and module fabrication and QA/QC testing • Participate in design, inspection, and installation of the skid, and field testing • Support TEA and EH&S assessment
ITC	• Site host, lead on testing site preparation. Support TEA and EH&S assessment • Support engineering scale design, installation of the skid, and field testing
TRIMERIC CORPORATION	• Lead on TEA and EH&S assessment

OHIO STATE UNIVERSITY 1870
gti

ITC

WYOMING INTEGRATED TEST CENTER

- 22+ MW of coal derived flue gas from the Dry Fork Power Station.
- Completed flue gas system commissioning Q3, 2019
- Simple design minimizes costs, provides flexibility & quick turnaround times.
- Designed for maximum flexibility and scalability for testing.
- Focused on larger scales to compliment NCCC and create a space for further scale up.

ITC

WYOMING INTEGRATED TEST CENTER

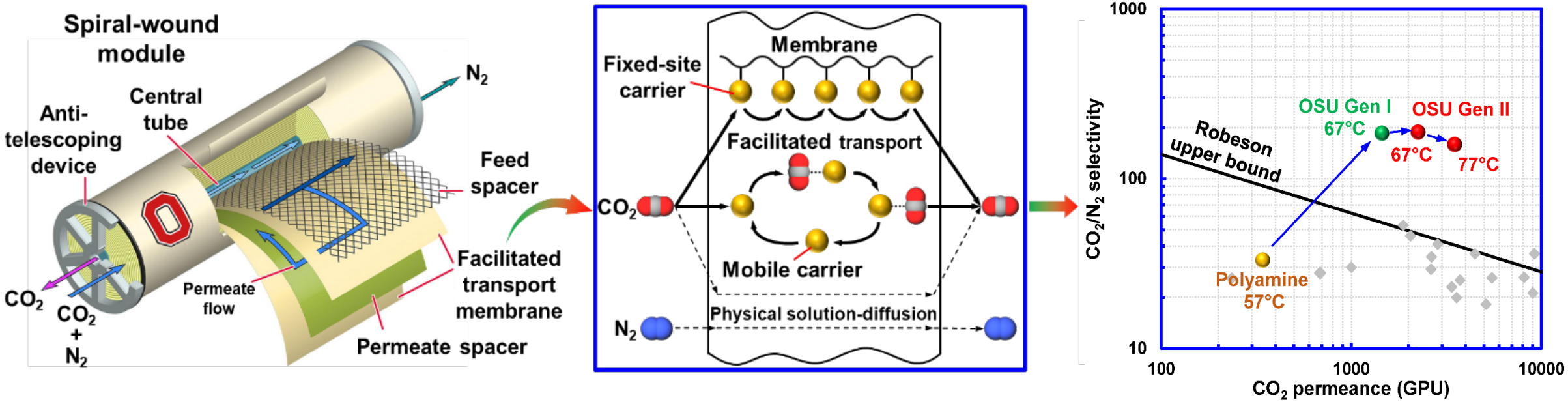
Who is invested in the ITC?

- State of Wyoming - $15 million
- Basin Electric – Host at Dry Fork Station
- Tri-State G&T - $5 million
- National Rural Electric Cooperatives Association - $1 million
- Wyoming Infrastructure Authority – Managing Entity
- Black Hills Corp. and Rocky Mountain Power providing technical expertise and in-kind contributions

OSU high-permeance and high-selectivity membranes

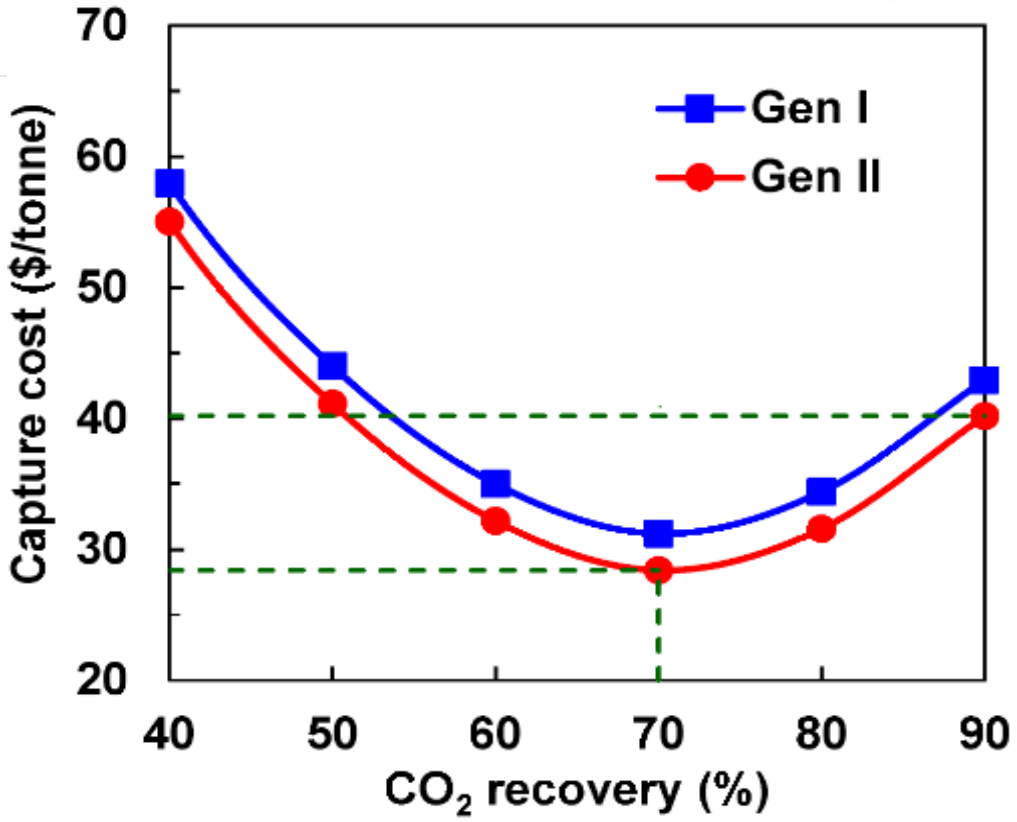
Simplicity of membrane for low cost: thin selective amine polymer layer on polymer support

High-selectivity due to facilitated transport mechanism



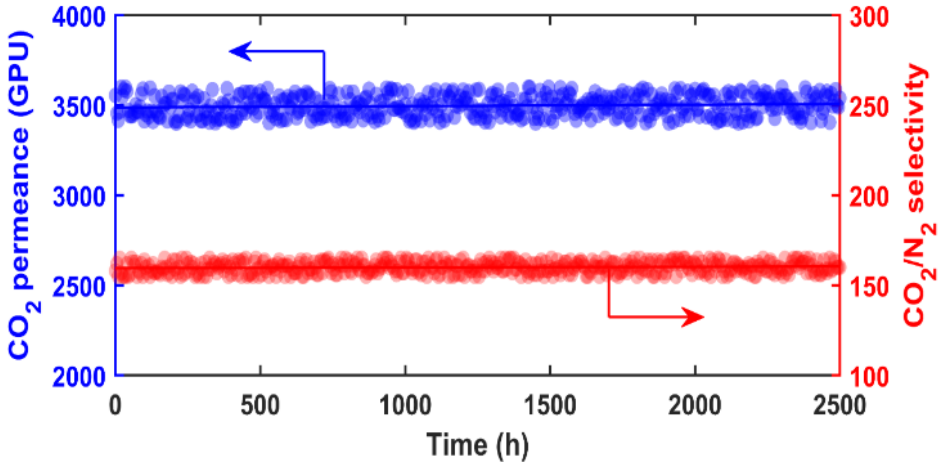
Economic Potential

- Preliminary TEA indicates:
  - Capture cost can be as low as <$30/tonne at 70% CO_2 capture
  - At 90% capture, <$40/tonne is achievable

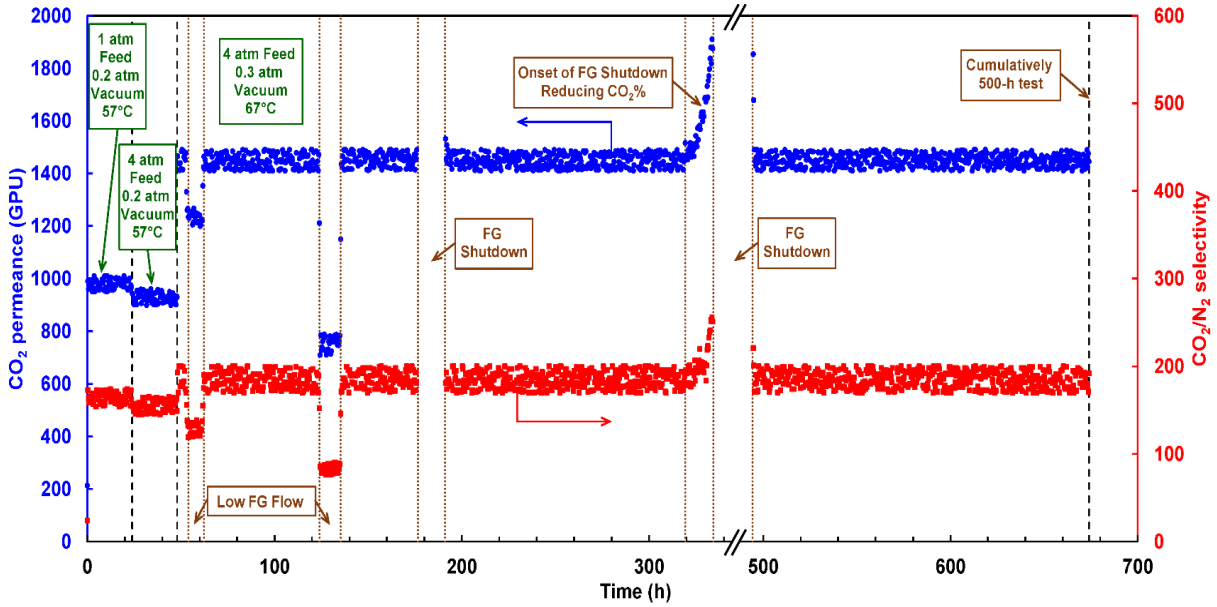


Long-term membrane performance confirmed on simulated and actual flue gas (NCCC)

- 2,500-h lab testing with simulated flue gas containing SO_2, O_2, H_2O (Gen II)

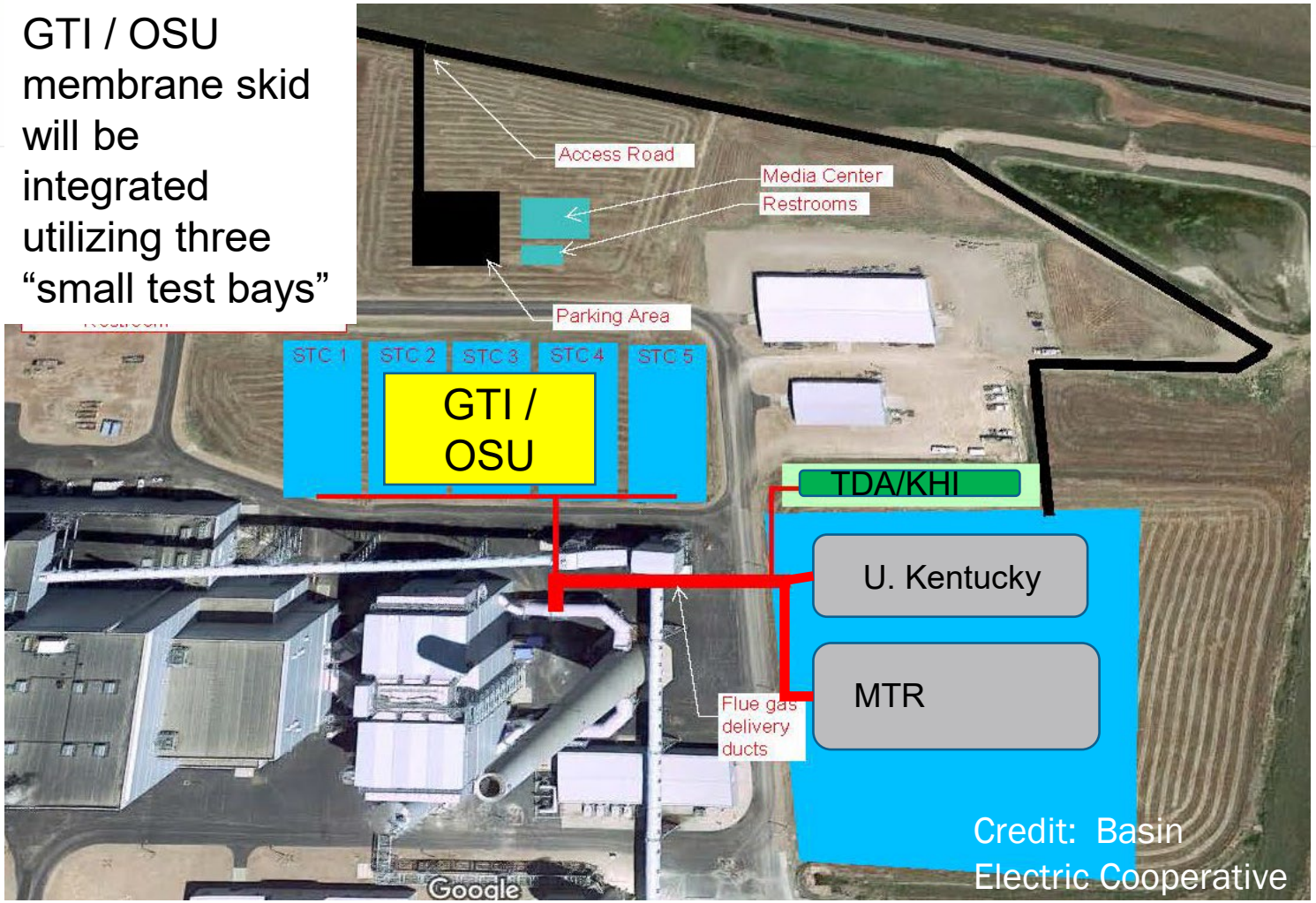


- Gen I: 500-h testing with actual flue gas at National Carbon Capture Center (NCCC)

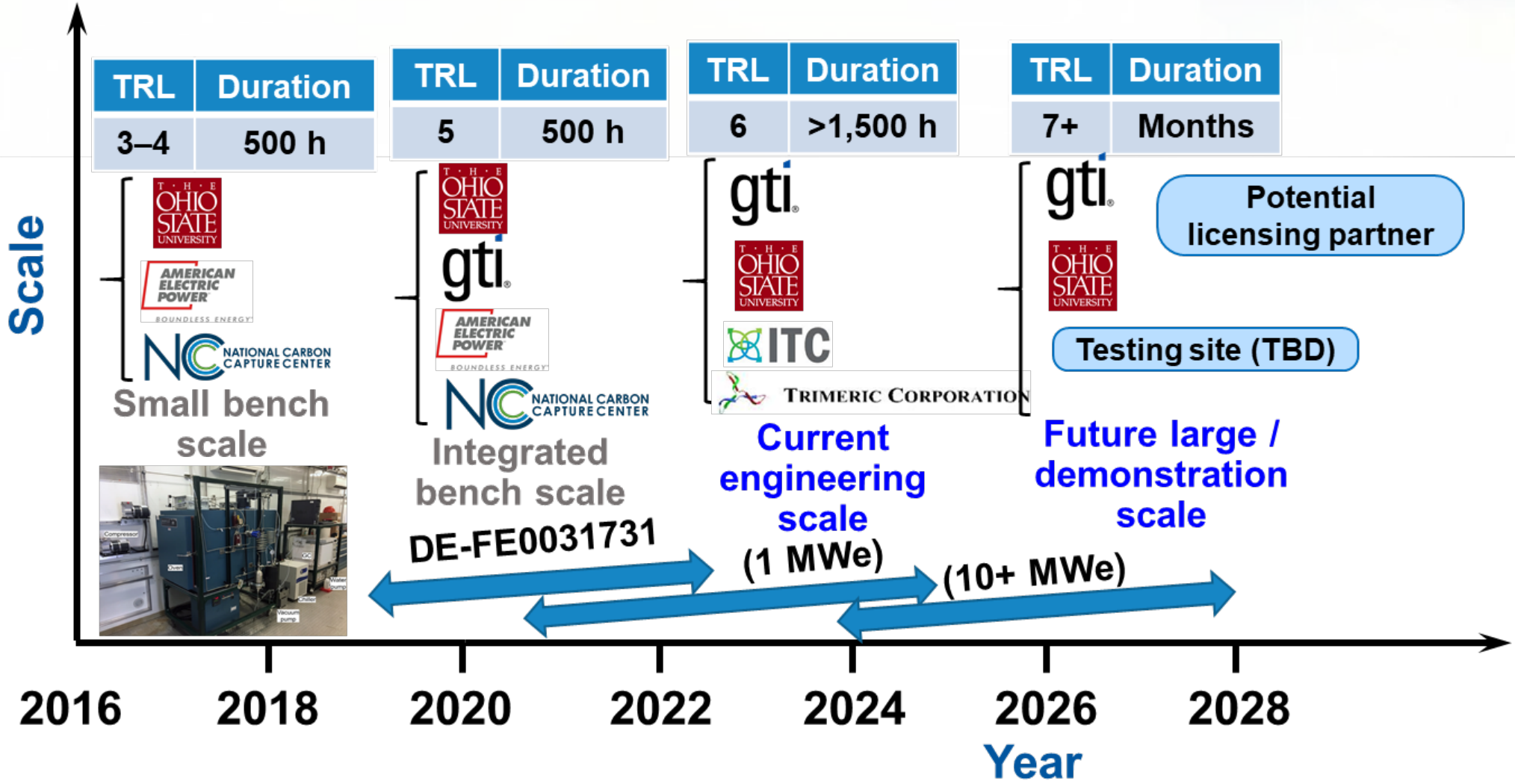


Integration into WITC

GTI / OSU membrane skid will be integrated utilizing three “small test bays”

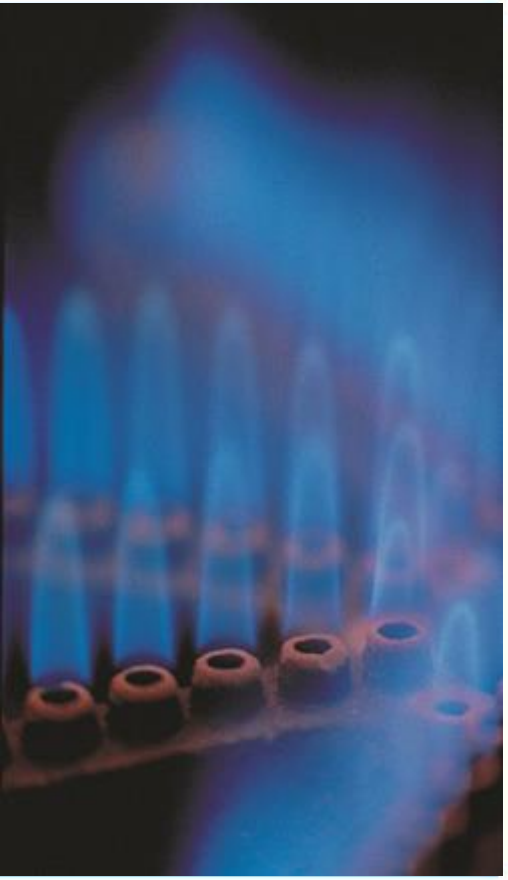


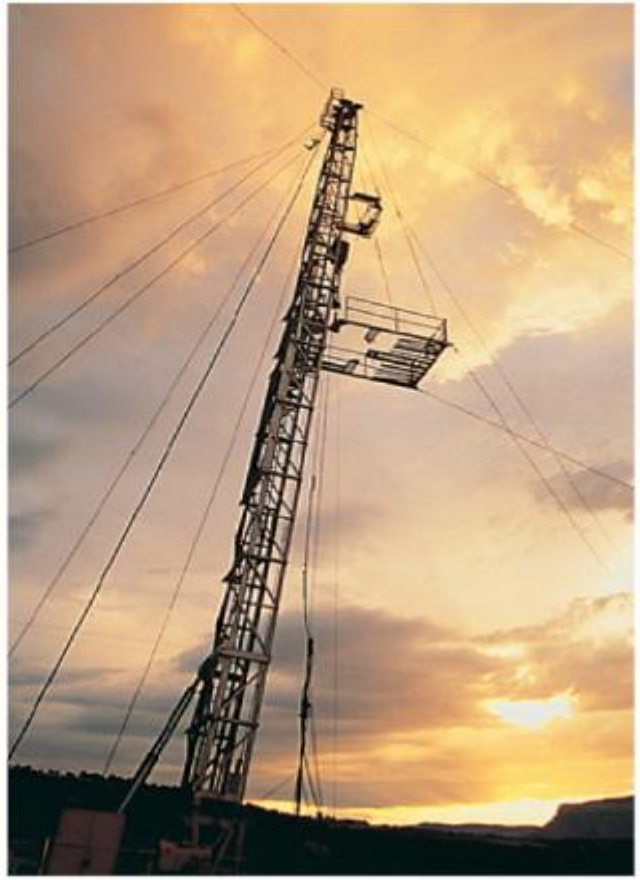
Technology Maturation Path



Turning Raw Technology into Practical Solutions

www.gti.energy | **@gastechnology**





CHALLENGES TO DEPLOYMENT AND STRATEGIES TO ADDRESSING THEM

KARA FORNSTROM, *CHAIRMAN, WYOMING PUBLIC SERVICE COMMISSION*
LEE BECK, *CCUS POLICY INNOVATION DIRECTOR, CLEAN AIR TASK FORCE*
WILL SHIMER, *BUSINESS DEVELOPMENT MANAGER/ PROJECTS, OGCI CLIMATE INVESTMENTS*

BREAKOUT SESSIONS

BREAKOUT 1: Q&A AND BROADER DISCUSSION ON 45Q WITH KEITH TRACY

BREAKOUT 2: PUTTING TOGETHER CCUS PROJECTS WITH EMILY KUNKEL, *PROJECT ASSOCIATE, SARGENT & LUNDY*

BREAKOUT 3: UNDERSTANDING THE WY CONTEXT REGARDING TECHNOLOGY SUPPORT, LIABILITY, PERMITTING, ETC. JASON BEGGER AND KARA FORNSTROM