# Monitoring, Reporting and Verification of CDR and CCUS: US Experiences and Lessons Learned for National GHG Inventories

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IPCC Expert Meeting on CDR Technologies and CCUS

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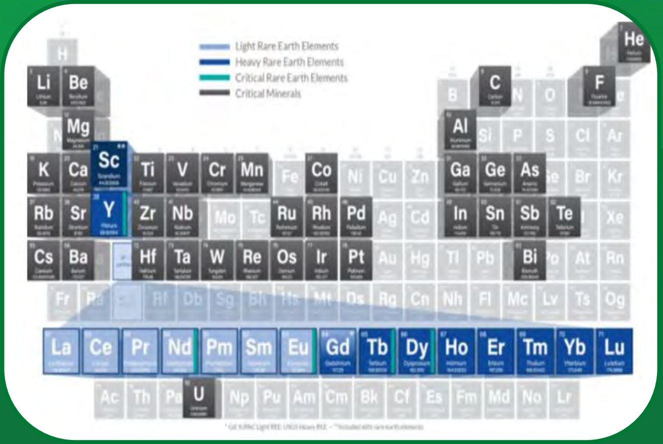
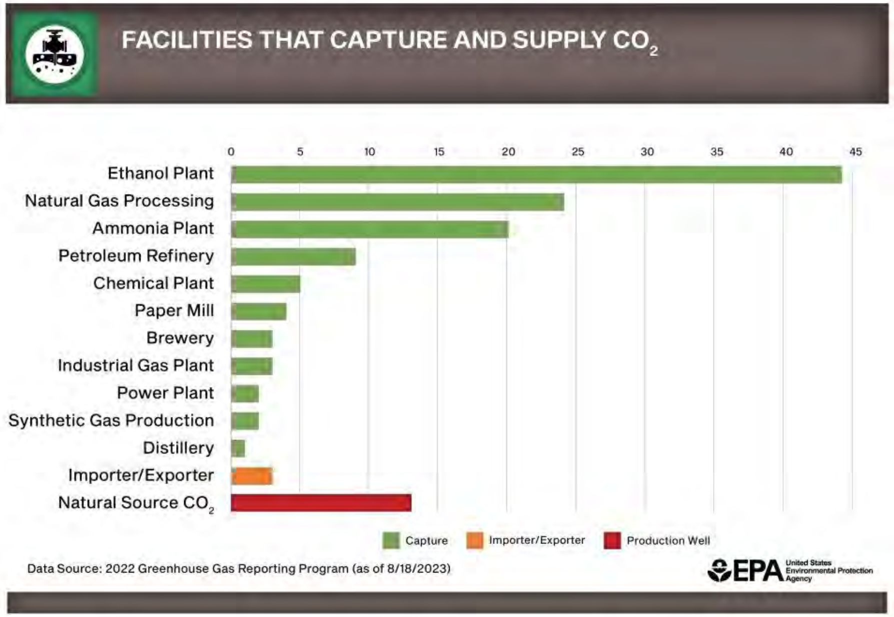
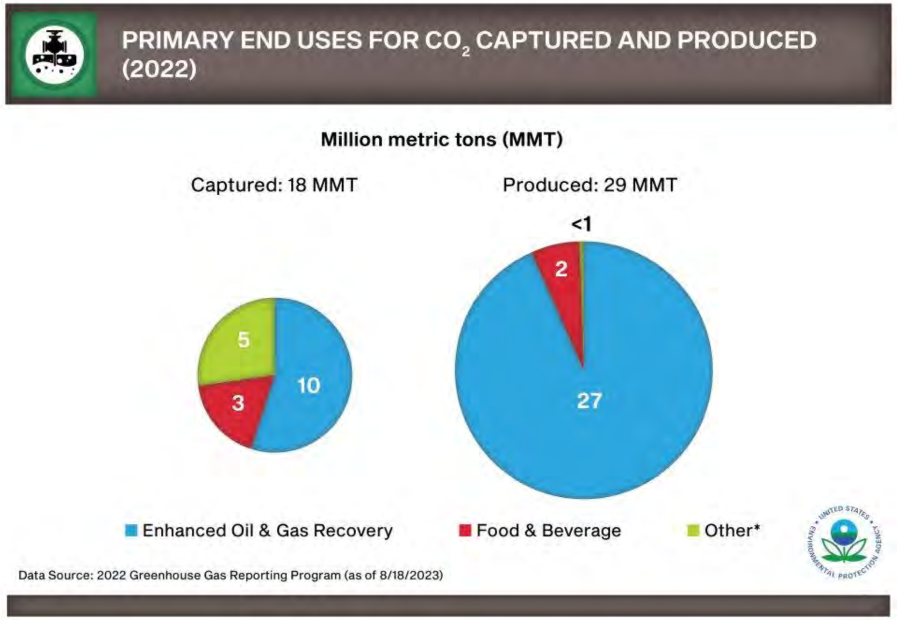



# $CO_2$ Supply and End Uses in US

- CCUS activity has increased due to recent changes in the US tax code (45Q)
- $CO_2$ is supplied to US economy from different sources
  - Captured: industrial sources
    - Fossil sources
    - Biogenic sources
  - Produced: natural sources ($CO_2$ domes)
- $CO_2$ has a number of end uses
  - Geologic storage (sequestration)
  - Enhanced oil recovery (EOR)
  - Food and beverage
  - Other*

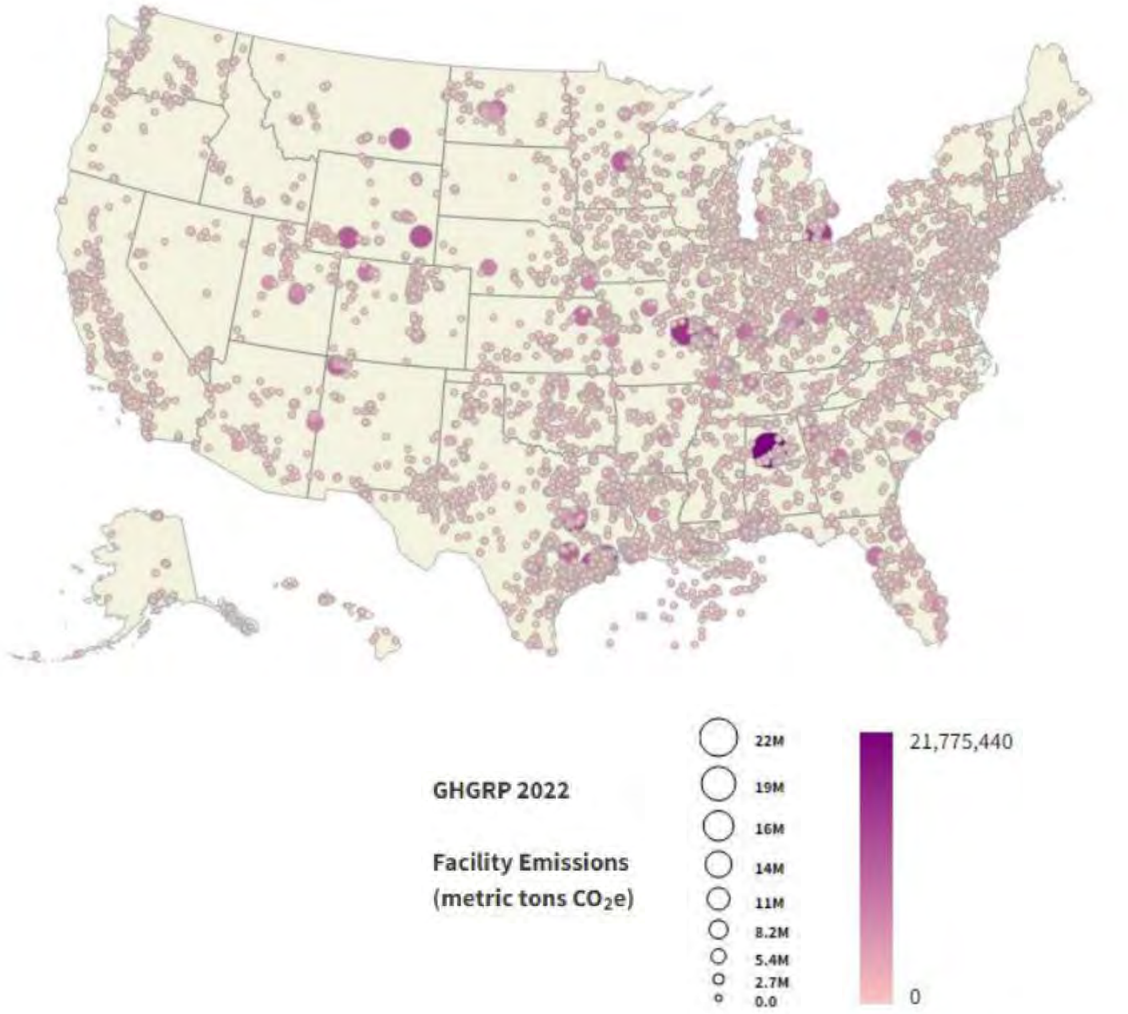


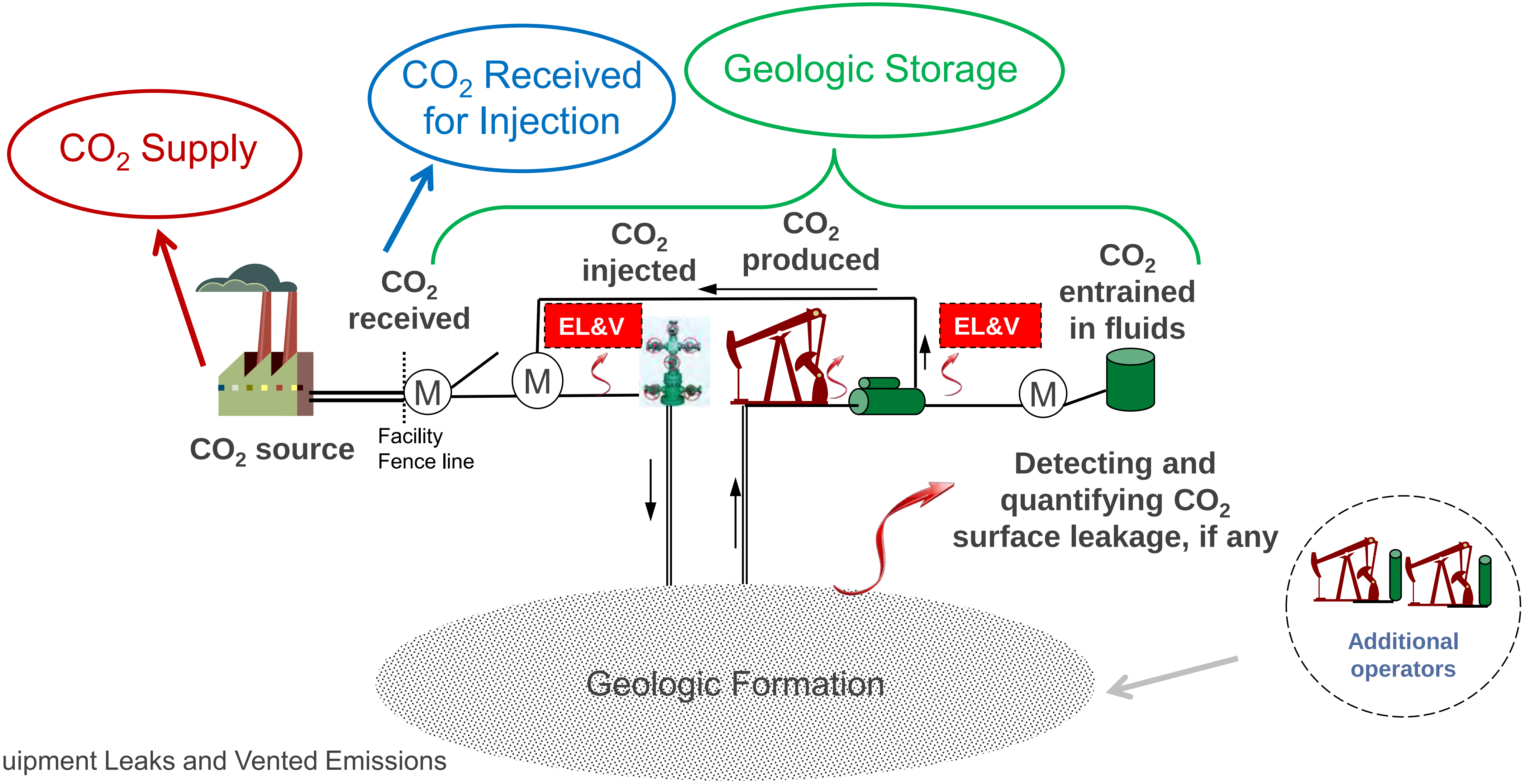

* Includes cleaning and solvent use, fumigants and herbicides, transportation and storage of explosives, firefighting equipment, industrial and municipal water/wastewater treatment, pulp and paper, metal fabrication and greenhouse plant growth

# US Facility-Level Data on GHG Emissions

- US Environmental Protection Agency (EPA) GHG Reporting Program (GHGRP) collects GHG data under Clean Air Act authority
- GHGRP collects, verifies and publishes detailed annual GHG data from over 8,000 US facilities and suppliers across 41 industrial source categories
- This data supports and improves the Inventory of US GHG Emissions and Sinks, supports policy development, and informs industry, state and local governments, the research community, and the public
- GHGRP includes coverage of CCS
- Methodologies used in the GHGRP are consistent with 2006 IPCC Guidelines, Tier 3 methods



# CCS in US GHG Reporting Program (GHGRP)



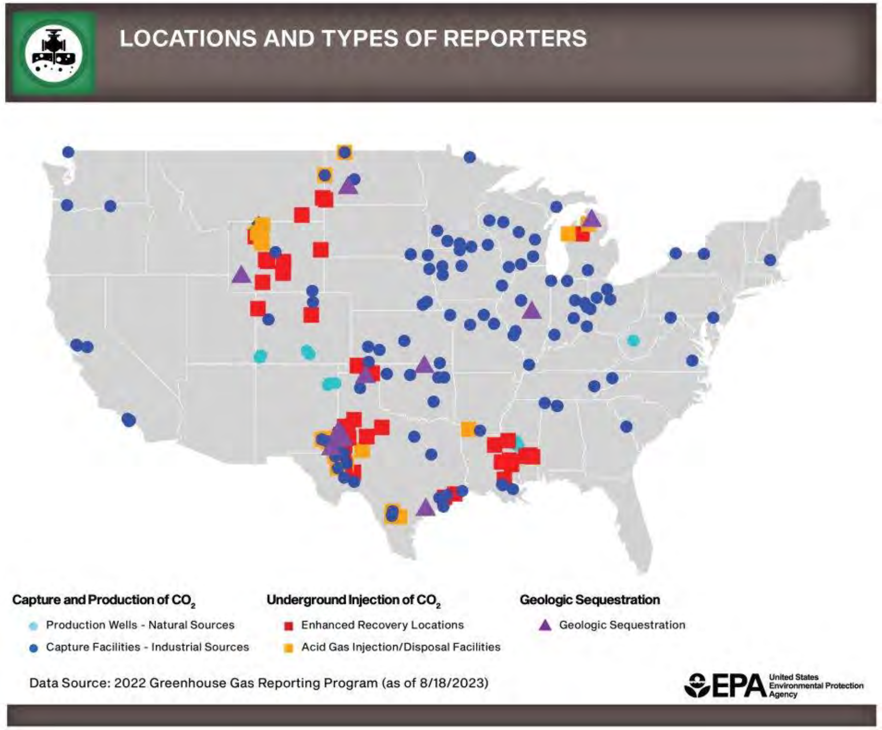

M = Meter
EL&V = Equipment Leaks and Vented Emissions

# Geologic Storage (GHGRP Subpart RR)

- Provides monitoring and reporting mechanisms to quantify $CO_2$ storage and to identify and quantify potential leakage, if any
- Requirements include:
  - Report information on the mass of $CO_2$ received for injection
  - Develop and implement EPA-approved monitoring MRV plan
  - Report mass of $CO_2$ stored using a mass balance approach
  - Report annual monitoring activities
- MRV plan process is consistent with requirements outlined in 2006 IPCC Guidelines
- Elements of MRV plan
  - Delineation of monitoring areas based on the $CO_2$ plume location
  - Identification and evaluation of the potential surface leakage pathways and assessment of likelihood, magnitude, and timing, of surface leakage of $CO_2$through these pathways
  - Strategy for detecting and quantifying any surface leakage of $CO_2$ in the event leakage occurs
  - Approach for establishing the expected baselines for monitoring $CO_2$ surface leakage
  - Summary of considerations made to calculate site-specific variables for the mass balance equation
- Over 25 facilities with approved MRV plans

# Implementing IPCC Methodology (1)

- Some considerations are potentially unique to the United States
- Determining if the source of the supplied $CO_2$ is from industrial sources or natural domes
  - IPCC guidelines require assigning reductions to the proper source category
  - Because $CO_2$ pipelines often transport $CO_2$ from a mix of sources, it can be difficult to determine the source category of captured and stored $CO_2$ (e.g., Permian Basin has several geologic storage sites with multiple $CO_2$ sources connected to the system including natural $CO_2$ and industrial $CO_2$ sources)
- Aligning end uses to the IPCC source category used in the Inventory for the industrial source $CO_2$
  - Once the source of the captured carbon and the end use are identified, the use of the $CO_2$ must be categorized and aligned with IPCC source categories as best as possible
  - It must be determined if the captured carbon should be removed (or it is already removed) and if so, from which source category
- Confidential business information
  - GHGRP classifies the amount of $CO_2$ captured by a specific facility as confidential business information and therefore only aggregated data are available for use within the Inventory



# Implementing IPCC Methodology (2)

- GHGRP data can be used to allocate $CO_2$ to its source and quantify $CO_2$ injection and geologic storage emissions, if any
- Allocate geologically stored $CO_2$ to the source directly if known based on data from geologic storage source category (GHGRP Subpart RR)
    - If unknown or if multiple sources are listed in geologic storage source category, allocate geologically stored $CO_2$ across sources based on data from $CO_2$ supply source category (GHGRP Subpart PP)
- For the most part, even though some facilities vary the source of $CO_2$, geologic storage can be directly allocated to an Inventory source category
    - For several facilities, geologically stored $CO_2$ needs to be allocated across natural domes and natural gas processing sources.
- National emissions associated with $CO_2$ injection and geologic storage can be calculated using data reported to geologic storage source category

# Future Data

- In April 2024, several updates were finalized to GHGRP regulations
- New reporting pathway for EOR operators that use ISO 27916:2019 standard to quantify $CO_2$ stored as a result of their operations (GHGRP Subpart VV)
  - Data could be treated in the Inventory in the same way as data from geologic storage category (GHGRP Subpart RR)
- $CO_2$ suppliers including capture facilities will be required to report facility identification numbers and annual quantities of $CO_2$ transferred to geologic storage
- Reporting requirements for direct air capture (DAC) facilities, including amount of $CO_2$ captured and energy use

# Creating Robust, Transparent, and Workable MRV Frameworks for Carbon Dioxide Removal

| Area | Key Activities |
| --- | --- |
| Develop tools and methods | • FECM: National Lab consortia supporting CDR MRV tool and standards development<br>• ARPA-E: Program supporting ocean CDR MRV |
| Issue best practices for life cycle assessment (LCA) | • FECM: DAC best practices + forthcoming analysis from CDR purchase pilot<br>• FECM + Bioenergy Technology Office: Biomass CDR best practices |

DOE: United States Department of Energy
FECM: DOE Office of Fossil Energy and Carbon Management
ARPA-E: DOE Advanced Research Projects Agency for Energy

# MRV Technology Commercialization Lab Call

| Lead Lab | Key Activities |
|---|---|
| Lawrence Livermore National Laboratory | Develop an umbrella carbon dioxide removal MRV framework in collaboration with National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, and a leading group of five industry partners headed up by CarbonPlan. Lawrence Livermore National Laboratory will also play a coordination role for the cohort of carbon dioxide removal MRV projects. |
| Pacific Northwest National Laboratory | Develop an adaptive MRV framework for mineralization-based carbon dioxide removal pathways in collaboration with Lawrence Livermore National Laboratory and 22 industry partners. The team will work closely with communities, especially often disadvantaged mining towns and coastal communities that would be prime candidates for mineralization-based carbon dioxide removal, to understand how MRV can be used to address their needs and concerns. |
| National Renewable Energy Laboratory | Develop and validate best practices for cement and concrete carbon dioxide removal pathways in collaboration with Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, and nine industry partners. The cement and concrete industries present a nearly unparalleled opportunity for direct air capture coupled with permanent sequestration and provides a value-added end use for captured carbon dioxide. |
| National Renewable Energy Laboratory | Address critical MRV challenges for biomass carbon removal and storage pathways in collaboration with Lawrence Livermore National Laboratory and eight industry partners. The project seeks to address a scientific knowledge gap regarding the durability of various bio-derived products and a lack of best practices and protocols needed. |

# CDR Purchase Pilot Prize

- CDR Purchase Pilot Prize is a three-phase competition that awards innovative technology developers
- Technology areas
  - Direct air capture with storage
  - Biomass with carbon removal and storage
  - Enhanced rock weathering and mineralization
  - Planned or managed carbon sinks
- 24 semi-finalists for first phase announced in May 2024
- Demonstration of rigorous MRV practices through third-party scientific validation could inform IPCC process

**Catalyze development of national CDR market**

**Validate high-quality CDR and measurement, monitoring, reporting and verification**

**Standardize appropriate technical rigor, workforce, and community benefits for high-quality CDR**

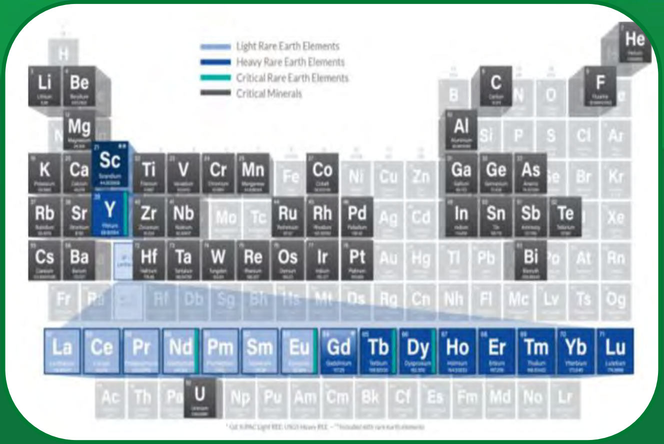
# International Context

- Carbon management is a **global challenge** that requires international collaboration
- Several **multilateral partnerships** are undertaking activities that **complement** IPCC process
- IPCC process can in turn help **inform** these partnerships

## Key multilateral partnerships

| Carbon Management Challenge | Clean Energy Ministerial CCUS Initiative | Mission Innovation CDR | CETPartnership | IEAGHG R&D Programme |
|---|---|---|---|---|
| • 21 countries and the EU<br>• Commitment to scale carbon management capacity to 1 gigatonne per year by 2030 | • 15 countries<br>• Convenes public and private sectors to accelerate carbon management | • 9 members<br>• Goal to enable CDR capacity of 100 million tonnes per year by 2030 | • 30 countries<br>• Fosters international carbon management research and innovation | • 37 members<br>• Funds carbon management R&D to reduce GHG emissions |

# Thank You


Light Rare Earth Elements
Heavy Rare Earth Elements
Critical Rare Earth Elements
Critical Minerals
H He
Li Be B C N O F
Mg Al Si P S Cl Ar
K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Br Kr
Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te Xe
Cs Ba Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi At Rn
Fr Rf Db Sg Bh Hs Mt Ds Rg Cn Nh Fl Mc Lv Ts Og
La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr