CARBON DIOXIDE REMOVAL
MISSION

Measurement, Reporting and Verification (MRV) for Carbon Dioxide Removal (CDR)

Issues and Opportunities for International Harmonization of National Governments' CDR MRV Methodologies

Disclaimer

This document is a government-sponsored study, funded by the Ministry of Economy, Trade and Industry (METI) as part of Japan's contributions to the Mission Innovation Carbon Dioxide Removal (CDR) Mission.

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Acknowledgements

Many individuals were involved in drafting and reviewing sections of this report, including: Renee Birchall (CSIRO, Australia), Asma Bouikni (NRCan, Canada), Samantha Bryson (NRCan, Canada), Ellen Handyside (NRCan, Canada), Saviz Mortazavi (NRCan, Canada), Jaber Shabanian (NRCan, Canada), Jennifer DeBruyn (ECCC, Canada), Daniel Jutzi (ECCC, Canada), Jackie Mercer (ECCC, Canada), Xian Zhang (Ministry of Science and Technology, China), Fabien Ramos (CLIMA, European Commission), Jeroen Schuppers (RTD, European Commission), Jørild Svalestuen (Gassnova, Norway), Baldur Pétursson (National Energy Authority, Iceland), Neelima Alam (Ministry of Science and Technology, India), Mamdouh S. Alajmi (KACST, Saudi Arabia), Abdullah M. Alkhedhair (KACST, Saudi Arabia), Faisal Al Qurooni (Ministry of Energy, Saudi Arabia), Sophie Wenger Hintz (BAFU, Switzerland), Samuel Adjei-Baah (DESNZ, United Kingdom), Matt Antes (Department of Energy, United States), Grant Faber (Department of Energy, United States), and Juho Lipponen (Carbon Dioxide Removal Mission).

Their comments and recommendations were of great value in developing this report.

A special thanks to Matt Antes (Department of Energy, United States) for the significant advice he provided throughout the development of this report.

Acronyms and Abbreviations

BECCS: Bioenergy with Carbon Capture and Storage

BiCRS: Biomass Carbon Removal and Storage

CCS: Carbon Capture and Storage

CCUS: Carbon Capture, Utilization and Storage

CDM: Clean Development Mechanism

CDR: Carbon Dioxide Removal

CMA: Conference of the Parties serving as the meeting of the Parties to the Paris Agreement

CO2: Carbon Dioxide

CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation

DAC: Direct Air Capture

DACCS: Direct Air Capture and Carbon Storage

DOE: US Department of Energy

ETS: Emissions Trading System

ERW: Enhanced Rock Weathering

EW: Enhanced Weathering

GGR: Greenhouse Gas Removals

GHGs: Greenhouse gases

ICROA: International Carbon Reduction and Offset Alliance

IPCC: Intergovernmental Panel on Climate Change

LCA: Life Cycle Analysis/Life Cycle Assessment

LCCO2: Life Cycle Carbon Dioxide

LULUCF: Land Use, Land-Use Change and Forestry

mCDR: Marine Carbon Dioxide Removal

MoU: Memorandum of Understanding

MMRV: Measurement, Monitoring, Reporting and Verification

MRV: Monitoring (or Measurement), Reporting, and Verification

NDC: Nationally Determined Contributions

OAE: Ocean Alkalinity Enhancement

TEA: Techno-Economic Analysis/Techno-Economic Assessment

TFI: Task Force on National Greenhouse Gas Inventories

Contents

Section 1 – Introduction

This report reviews the current state of national Carbon Dioxide Removal (CDR) policies and their development in measurement (monitoring), reporting, and verification (MRV) methodologies across the spectrum of technologies considered in the CDR Mission (Section 2). It provides the criteria factors for high-quality MRV and how national governments' CDR MRV methodologies are handling each factor (Section 3). This report proposes a strategy for the interoperability of CDR MRV protocols across platforms that could help enable global market development of cross-border carbon removal credits (Section 4), and is not intended to be an assessment of comparison of carbon removal effectiveness across various CDR methods nor comparison with methods for emissions avoidance.

Section 2 – Current State of CDR MRV Methodologies in National Context

Conduct a review of government policies and activities related to CDR MRV to better understand the current state of play, recent progress, gaps, and plans for CDR MRV protocols/standards from national governments. These policies and programs help shape how governments approach CDR. This section also outlines how countries account for CDR in their Nationally Determined Contributions (NDCs). Output: Summary of national government programs, policies, activities, and plans on CDR MRV protocols.

Section 2.1 – National Carbon Removal Policies and Related MRV Methodologies

Australia

(CDR Mission Core Member)

Australian Carbon Credit Unit (ACCU) Scheme

Market of CDR:

- The Clean Energy Regulator administers a national carbon market for Australian Carbon Credit Units (ACCUs), which can be issued, traded, transferred, surrendered, or cancelled on the Australian National Registry of Emissions Units (ANREU). A new Unit and Certificate Register called the Australian Carbon Exchange is being created for carbon credits.

- Under the Australian Carbon Credit Unit (ACCU) Scheme, a methodology determination (method) sets the requirements and rules for issued projects that are regulated and administered by the Clean Energy Regulator. Methods under the ACCU Scheme cover projects across agriculture, energy efficiency, landfill and waste, mining, oil and gas, transport, and vegetation. The methods vary between conventional CDR and emissions reductions/avoided emissions methods.

Applicable CDR methods:

- Afforestation/reforestation
- Coastal wetland restoration
- Soil carbon sequestration
- No novel CDR methods exist under the ACCU Scheme at present. However, industrial process emissions captured from plants (including for electricity generation) in the carbon capture and storage method are classified as an eligible activity. Therefore, BECCS could possibly be (indirectly) included as a novel CDR methodology under this method.
- Direct Air Capture and Storage projects are explicitly excluded under the carbon capture and storage method (https://cer.gov.au/schemes/australian-carbon-credit-unit-scheme/accu-scheme-methods/carbon-capture-and-storage-method).

Existing conventional (agricultural and vegetation) CDR methods (including MRV protocols) under the ACCU Scheme include:

- Estimating soil organic carbon sequestration using measurement and models method
- Estimating sequestration of carbon in soil using default values method
- Reforestation and afforestation method
- Plantation forestry method
- Tidal restoration of blue carbon ecosystems method

CDR roles and methodologies in NDC (June 2022 version)

- Australia will address emissions and subsequent removals from natural disturbances on managed lands in accounting for its NDC and will continue to provide information on its approach in its annual National Inventory Report.
- Australia will use a stock-change approach consistent with the IPCC 2006 Guidelines to account for emissions and removals for harvested wood products. The methodology will be described in detail in Australia's annual National Inventory Report.
- The estimates of emissions and removals used in accounting for the NDC will be those reported in the Inventory, which will apply the IPCC 2006 Guidelines, or subsequent

version or refinement as agreed by the CMA, and nationally appropriate methods consistent with that guidance and informed inter alia by the IPCC 2019 Refinement and IPCC 2013 Wetlands Supplement.
- No specific information regarding carbon dioxide removals is mentioned except for the above points.

Other activities and plans

- Australia attended an IPCC Expert Meeting on Carbon Dioxide Removal Technologies and Carbon Dioxide Capture Utilisation and Storage in preparation for a 2027 Methodology Report on *Carbon Dioxide Removal Technologies, Carbon Capture Utilisation and Storage* activities, produced by the Task Force on National Greenhouse Gas Inventories (TFI).
- The Climate Change Authority (The Authority) commissioned the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to report on Australia's sequestration potential and technology cost-reduction drivers to inform their advice to government on the role of carbon sequestration in supporting increasingly ambitious emissions reduction targets. The Authority's work program across 2023-24 includes providing advice to the Government on Australia's 2035 Emissions Reduction Targets, the 2023 Annual Progress Report to inform the Annual Climate Change Statement, and statutory reviews of the Carbon Credits (Carbon Farming Initiative) Amendments Act 2014 (the Emissions Reductions Fund) and the National Greenhouse and Energy Reporting Scheme Act 2007 (NGERs), including the Safeguard Mechanism.
- The Australian government funded two CDR projects involving DAC in their Carbon Capture Technologies Program (CCTP) in July 2024.

Canada
(CDR Mission Co-Lead)

Canada's Greenhouse Gas Offset Credit System

Market of CDR:

- Federal offset credits can be sold and used for compliance by facilities covered in the federal Output-Based Pricing System or sold and used by others who are looking to meet voluntary climate targets or commitments. The first federal offset credits are expected to be available in 2025.

Applicable CDR methods:

- Any type of CDR methods.

Existing CDR MRV protocols:

- Federal offset protocols are being developed on an ongoing basis. Only the protocol for the "Improved Forest Management on Private Land" has been published for CDR as of May 2024.

Current plans and activities:

- Environment and Climate Change Canada (ECCC) is currently developing the following federal offset protocols for CDR: Direct Air Carbon Dioxide Capture and Sequestration (DACCS), Enhanced Soil Organic Carbon, and Improved Forest Management on Public Land. Subsequent project types under consideration for future federal offset protocol development include Bioenergy Carbon Dioxide Capture and Sequestration (BECCS).

Carbon Capture, Utilization, and Storage Investment Tax Credit (CCUS ITC)

Market of CDR:

- Refundable Investment Tax credit on capital expenditures.

Applicable CDR methods:

- BECCS.
- DACCS.

  Projects that capture carbon directly from the ambient air (DAC) are eligible for a 60% tax credit on qualifying equipment (reduced to 30 for the period from 2031 through 2040). Projects that capture carbon that would otherwise be released into the atmosphere (e.g. BECCS) are eligible for a 50% tax credit on qualifying equipment. These rates are reduced by half after 2030 and to zero after 2040.

Existing CDR MRV protocols:

- To claim the tax credit, projects must be issued an initial project evaluation for each qualified project. A project plan must be submitted to Natural Resources Canada, and this must include elements as described in the CCUS-ITC Technical Guidance Document. Large projects (more than $250 million in qualified expenditures) are also subject to knowledge sharing provisions which require reports be provided to be made public that includes information on Monitoring, Measurement and Verification (MMV) of storage such as: list and describe the monitoring techniques considered along with the screening and assessment process for the monitoring techniques and technologies, as well as justification for the ultimate selection based on cost-benefit analysis. It requires providing lessons learned from the assessment and selection

process. Summarize the verification plan and reporting plan, highlighting areas of higher risk and specific monitoring targets and techniques for those areas.

Regulation for carbon capture and storage is developed, implemented and enforced by provinces and territories. Those that have been declared a "designated jurisdiction" for the purposes of this tax credit – Alberta, British Columbia and Saskatchewan as of 2024 – each have their own MMV requirements. These regulations do not include guidance for CDR activities but do establish MMV requirements for geological storage of carbon.

- Alberta's Directive 065: Resources Applications for Oil and Gas Reservoirs – Appendix P: MMV Principles and Objectives for CO2 Sequestration Projects
- British Columbia's *Drilling and Production Regulation* refers to CSA Standard Z741 "Geological storage of carbon dioxide"
- Saskatchewan's *Disposal and Injection Well Requirements*, which is applicable to CO2 injection, refers to CSA Z341 "Storage of hydrocarbons in underground formations" for monitoring requirements.

Clean Fuel Regulations: quantification method for CO_2 capture and permanent storage

Applicable CDR methods:

- BECCS[1].

Existing CDR MRV protocols:

- Quantification Method for CO2 capture and permanent storage – Generation of credits under this quantification method is limited to CO2 capture and storage projects at a fossil fuel production facility or at a facility that generates hydrogen, electricity or heat for a fossil fuel production facility. The BECCS project would have to provide heat or electricity for a fossil fuel production facility (i.e. oil refinery or upgrader) to be eligible to generate credits under this quantification method.

[1] BECCS projects related to the production of low carbon fuels (e.g. ethanol) are also eligible under the CFR. They are quantified under the Life Cycle Assessment Model, not the Quantification Method. https://www.canada.ca/en/environment-climate-change/services/managing-pollution/fuel-life-cycle-assessment-model/methodology.html#toc18:~:text=4.2.2%20Modelling%20approach%20for%20CCS%20configurable%20processes

CDR roles and methodologies in NDC (August 2021 version)

- For the Land Use, Land-Use Change and Forestry (LULUCF) sector, emissions and removals from the following reporting categories are included: forest land, cropland, grassland, wetlands, settlements, harvested wood products, and other lands.
- Canada estimates the emissions and subsequent removals from natural disturbances on managed forest land in the LULUCF sector according to a Tier 3 country-specific method. Reported estimates for the net GHG emissions from managed forest land exclude the impacts (both emissions and subsequent removals) of non-anthropogenic natural disturbances (e.g., wildfires, windthrow and those insect infestations that cause significant (>20%) tree mortality).
- No specific information related to CDR other than LULUCF sector is mentioned.

European Union (EU)

(CDR Mission Supporting Member)

Carbon Removals and Carbon Farming (CRCF) Regulation[2]

Applicable CDR methods:

- Permanent carbon removals (DACCS, BiCRS including BECCS, chemically binding CO2 permanently into products, and other technological solutions that lead to permanent storage).
- Carbon farming (peatland and wetland restoration, agroforestry, soil, reforestation, forest management); Carbon storage in long-lasting products (bio-based construction products).

To implement the CRCF regulation, the Commission will take the following steps:

- Adoption of EU certification methodologies: The Commission, with support from the Expert Group on Carbon Removals, will establish tailored EU certification methodologies for different carbon removal activities through delegated acts. These acts involve standard procedures, engaging the European Parliament, the Council, and broader stakeholders.

[2] Council greenlights EU certification framework for permanent carbon removals, carbon farming and carbon storage in products - Consilium

- Adoption of third-party verification rules: The Commission will issue implementing acts to set technical rules for third-party verification requirements, specifying procedures for certification schemes, certification bodies, and audit processes.
- Recognition of certification schemes: The Commission will approve certification schemes able to apply CRCF rules through Decisions, following a comprehensive assessment of governance, rules, and procedures, typically granting recognition for five years.

Existing CDR MRV protocols:

- N/A

Current plans and activities:

- Work has started on detailed methodologies for different carbon removal activities that will be set out in separate Commission delegated acts. The first methodologies are expected to be ready in 2025 (including BECCS and biochar), while certification of the first units under the CRCF is expected in 2026/2027. The first draft methodologies have been presented to the Carbon Removal Expert Group in October 2024 (5th EU Carbon Removals Expert Group meeting - European Commission)
- An EU registry will be established to create a-high level of transparency about certified carbon removals with 4 years.[3]

Regulation on the land use, land use change and forestry (LULUCF) EU 2018/841

Applicable CDR methods:

- Carbon farming (peatland and wetland restoration, agroforestry, soil, reforestation, forest management).
- Carbon storage in long-lasting products (bio-based construction products).

Existing CDR MRV protocols:

- Handbook on the updated LULUCF Regulation EU 2018/841 Version 2

The intent of the LULUCF regulation is to provide a consistent set of methodological principles to help countries move to higher-resolution and more accurate calculations, which use available high-quality datasets, and can monitor LULUCF emissions and removals at a scale that reflects impacts of land management and policy implementation.

[3] https://ec.europa.eu/commission/presscorner/detail/en/ip_24_885

Industrial Carbon Management Strategy (COM/2024/62)[4] aligned with the 2040 Climate Target Plan announced in February 2024

Applicable CDR methods:

- Biogenic or atmospheric CO2 is captured by technological means and put into permanent storage (i.e. BECCS and DACCS).

Existing CDR MRV protocols:

- As a geological storage part of CDR, regulatory framework for the safe transport and storage of CO2 through the EU CCS Directive 2009/31/EC for long-term storage site. Revised guidance documents are published in July 2024 and the Monitoring and Reporting Regulation 2018/2066 (MRR) on EU ETS.

Current plans and activities:

- Assessment of overall objectives in line with the 2040 climate ambition.
- Develop policy options for supporting industrial carbon removals, including public-private finance.
- Boost research and innovation through Horizon Europe and the Innovation Fund (EU ETS Innovation Fund Methodology for GHG Emission Avoidance Calculation Version 3.1 March 2024).

CDR roles and methodologies in NDC (October 2023 version)

- In the LULUCF sector reported for all managed land, the EU adopted a Union net greenhouse gas removals target of 310 million tonnes of CO2 equivalent, as a sum of the reported greenhouse gas net emissions and removals in the sector in 2030.
- LULUCF Categories: Emissions and removals occurring on reported categories of forest land, cropland, grassland, wetlands, settlements, other land, harvested wood products, other, atmospheric deposition and nitrogen leaching and run-off, including land use change between these categories.
- LULUCF Pools: Living biomass, litter, deadwood, soil organic carbon in mineral soils, soil organic carbon in organic soils, harvested wood products.
- No specific information related to CDR other than LULUCF sector is mentioned.

[4] eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024DC0062

Iceland

(Non-CDR Mission Member)

Iceland's 2020 Climate Action Plan

Applicable CDR methods:

- LULUCF sector based on EU's Regulation on the LULUCF.
- There are no dedicated legal frameworks for CDR other than the LULUCF sector yet.

Existing CDR MRV protocols:

- Forest Carbon Code by the Icelandic Forest Service.
- EU Regulation on the LULUCF.

NOTE: Climeworks, Carbfix and Puro announced a collaboration targeting the certification of the DACCS services via in-situ carbon mineralization in Iceland under the Puro Standard.

CDR roles and methodologies in NDC (February 2021 version)

- LULUCF sector methodologies based on the EU Regulation on the LULUCF are documented.
- For carbon neutrality in 2040, increasing carbon removals from the atmosphere, including by restoration, revegetation, afforestation, and carbon capture and in-situ carbon mineralization in rock formations (Carbfix) are emphasized.
- For accounting methods for carbon removal, it is foreseen that the accounting framework for the carbon neutrality goal will be revised in a few years' time, when a more robust LULUCF accounting framework will be in place in Iceland.

India

(CDR mission Supporting Member)

India's Carbon Credit Trading Scheme (CCTS)

Market of Credit:

- Compliance mechanism with obligated entities, which aims at addressing the emissions from its energy use and industrial sectors.
- Offset mechanism with non-obligated entities that can voluntarily participate in the tradable carbon credits market.

Applicable CDR methods:

- "Agriculture", "Forestry", and "Carbon capture and storage and other removals" sector scopes are mentioned in the accreditation procedure (version 1.0 – July 2024) of the offset mechanism of the Indian Carbon Market, however, no detailed CDR methods are specified in the document.

Existing CDR MRV protocols:

- This is not yet described in the Detailed Procedure for Compliance Mechanism under CCTS, which was published in July 2024.

  NOTE: Mati Carbon is at the forefront of implementing Enhanced Rock Weathering (ERW) in India and its MRV, which are published in scientific literature (Reershemius et al. 2023).

Current plans and activities:

- The compliance segment is scheduled to commence in 2025-26.
- There is no set timeline for the launch of the voluntary carbon market.
- CCUS is listed as a category for the "removal activities" in decisions in regard to the type of projects that may take part in international carbon market under Article 6.2 mechanisms.

Green Credits Program

Applicable CDR methods:

- Afforestation.

Existing CDR MRV protocols:

- Methodology for Tree Plantation published on February 2024.
  - The green credit will be calculated at the rate of one green credit per tree grown through the tree plantation on such land parcel, subject to minimum density of 1100 trees per hectare, based on the local silvi-climatic and soil conditions.

CDR roles and methodologies in NDC (August 2022 version)

- Create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.
- No specific information related to CDR other than forest and tree cover is mentioned.

Japan

(CDR Mission Core Member)

J-Credit Scheme

Market of CDR:

- Domestic credit certified by the government.

Applicable CDR methods:

- Afforestation.
- Reforestation.
- Forest management.
- Biochar.
- Technology-based CDR methods (extended in March 2024).

Existing CDR MRV protocols:

- Forest management (FO-001).
- Afforestation (FO-002).
- Reforestation (FO-003).
- Biochar application to cropland (AG-004).

The Joint Crediting Mechanism (JCM)

Market of CDR:

- Facilitate diffusion of leading decarbonizing technologies and infrastructure, etc., through investment by Japanese entities, thereby contributing to GHG emission reductions or removals and sustainable development in partner countries.
- Contribute to the achievement of both countries' NDCs while ensuring the avoidance of double counting through corresponding adjustments.

Applicable CDR methods:

- Afforestation/reforestation.

Existing CDR MRV protocols

- Currently revisioning JCM-REDD+ guideline to include afforestation and reforestation.

DAC Working Group (WG) Methodology

Applicable CDR methods:

- Capture part of DACCS.

Existing CDR MRV protocols:

- DAC WG methodology (published in June 2024).

GX-ETS

Market of CDR:

- Domestic voluntary market (FY2023–FY2025).

Applicable CDR methods:

- CDR methods conforming J-Credit and JCM.
- Integrating removal credits other than J-Credit and JCM by Guidelines for the Use of Eligible Carbon Credits under GX-ETS (e.g. DAC or biogenic carbon with durable carbon products, coastal blue carbon, BECCS, and DACCS).

Existing CDR MRV protocols:

- DAC WG methodology.
- J Blue Credit methodology (v2.4) by Japan Blue Economy Association (JBE).

Current plans and activities:

- Biomass Sustainability WG is working on the sustainable criteria of biomass, including third-party verification and lifecycle GHG emissions of biomass feedstock.

JOGMEC CCS Guideline

Applicable CDR methods:

- BECCS.
- DACCS.

Existing CDR MRV protocols:

- Recommended guideline for the implementation of CCS projects (JOGMEC CCS guideline Version 1).

CDR roles and methodologies in NDC (October 2021 version)

- Removals by measures for forest and other carbon sinks sector are accounted for in line with approaches equivalent to those under the Kyoto Protocol.
- Japan aims to contribute to international emission reductions and removals at the level of a cumulative total of approximately 100 million t-CO2 by fiscal year 2030 through public-private collaborations through JCM. Japan will appropriately count the acquired credits to achieve its NDC.

Norway

(CDR Mission Core Member)

Norway's Climate Action Plan for 2021-2030

Applicable CDR methods:

- LULUCF (afforestation, forest management, grassland management, cropland management, and wetland management).

Existing CDR MRV protocols:

- EU Regulation on the LULUCF.

Current plans and activities:

- The Government and the agricultural organisations have signed a letter of intent with the aim of reducing emissions and enhancing removals by a total of 5 million tonnes CO2eq over the period 2021–2030 for agricultural activities.
- Consider new mitigation measures in managed forest land that offer a high potential for enhancing CO2 removals and are easy to implement. This applies specifically to improving practices for tending young-growth stands, treatment of stumps to control conifer root rot, and choosing suitable tree species for restocking after felling.
- Facilitate afforestation of new areas as a mitigation measure on the basis of clear environmental criteria.
- Norway is opening storage sites in the North Sea for storage of CO2 from CCS and CDR project in Europe. The Norwegian CCS demonstration project, "Longship", is starting up in 2025; CCS Norway - Sharing knowledge from the Norwegian CCS project Longship.

Other activities and plans

- Norwegian Environment Agency has assessed several economic support mechanisms for BECCS and DACCS (Norwegian Environment Agency, M-2735, 2024).
- Norway and Switzerland have signed a Declaration of Intent to bolster cooperation on CCS and CDR.

CDR roles and methodologies in NDC (November 2022 version)

- For the LULUCF sector, emissions and removals the following reporting categories are included: forest land, cropland, grassland, and wetland (wetland remaining wetland only from 2026), including land use changes between the categories, and between these categories and settlements and other land. The five carbon pools above-ground

biomass, below-ground biomass, litter, dead wood, and soil organic matters are included. In addition, the carbon pool harvested wood products is included.

- The LULUCF Regulation regulates emissions and removals for the land use, land use change and forestry sector. The regulation sets a national commitment to ensure that emissions do not exceed removals in this sector for the period 2021-2030.
- Within the climate cooperation with the European Union and Iceland emissions and removals from the land sector will be accounted for based on specific accounting rules for the different land categories in regulation (EU) 2018/841, Art 6-8 and Annex IV:
    - Zero is the baseline for afforested land and deforested land (gross-net accounting).
    - The average emissions between 2005-2009 is the baseline for managed cropland, managed grassland, and managed wetlands (net-net accounting).
    - A forest reference level based on the continuation of sustainable forest management practice in the period 2000-2009 is the baseline for managed forest land.

Saudi Arabia

(CDR Mission Co-Lead)

Saudi Green Initiative (SGI)

Applicable CDR methods:

- Afforestation, Reforestation.
    - Target of planting 10 billion trees and rehabilitating over 74 million hectares of land.
- Mangrove plantation.
    - Target of planting 100 million mangrove trees along Saudi Arabia's coastlines by 2030.
- Rangelands restoration.
- DAC.

Existing CDR MRV protocols:

- Not mentioned.

Current progress:

- Over 95 million trees planted across Saudi Arabia.
- 13 million mangrove seedlings planted in various regions of Saudi Arabia.

Middle East Green Initiative (MGI)

Applicable CDR methods:

- Afforestation, Reforestation.
    - Target of planting 50 billion trees across the Middle East.
- Degraded land restoration.
    - Target of restoring 200 million hectares of degraded land.

Existing CDR MRV protocols:

- Not mentioned.

Circular Carbon Economy (CCE) Approach

Applicable CDR methods:

- BECCS and DACCS.
- Nature-based solutions.
- In-situ carbon mineralisation.

Existing CDR MRV protocols:

- Not yet developed.

Current plans:

- King Abdullah Petroleum Studies and Research Center (KAPSARC), a think tank, is conducting a quantitative assessment of 125 countries, representing 96% of global greenhouse gas emissions to assess readiness and progress toward the energy transition. Using the CCE Index developed at KAPSARC, the organisation is evaluating these countries' progress and performance in adopting the circular carbon economy approach. This assessment has been conducted annually since 2021.

Greenhouse Gas Crediting & Offsetting Mechanism (GCOM)

Market of CDR:

- Voluntary market, aligning with Article 6 of the Paris Climate Agreement.

Applicable CDR methods:

- Afforestation and avoided deforestation.
- Sustainable forest management.
- Soil carbon sequestration (no-till and, grass cover).
- CO2 Curing.
- Biochar.

Existing CDR MRV protocols:

- No specific CDR protocol exists. However, the SA-DNA-M5 methodology for CCS/CCUS in the oil and gas sector might be applied to in-situ carbon mineralization, BECCS, and DACCS.
- Internationally recognized methodologies approved by the Designated National Authority (DNA), such as those under I-REC, Verra, and Gold Standards, are all acceptable.
- Afforestation and avoided deforestation.

Green Financing Framework (GFF)

Market of CDR:

- Green Bonds/Sukuks.

Applicable CDR methods:

- DAC.
- Sustainable management of natural resources and land use.

Existing CDR MRV protocols:

- The Ministry of Finance's Green Financing Framework (GFF), released in March 2024, adheres to the International Capital Market Association's (ICMA) Green Bond Principles (GBP). It aligns with the four core components of the 2021 ICMA GBP. This framework provides a solid foundation for the MRV of CDR projects.

Current plans:

- The government has established a transparent decision-making process to assess project eligibility, and it is made public. An independent external reviewer will verify fund allocation to eligible projects and conduct an impact assessment of the environmental benefits and potential externalities of the financed projects.

Regional Voluntary Carbon Market (RVCM)

Market of CDR:

- Voluntary market, aligning with Article 6 of the Paris Climate Agreement.

Applicable CDR methods:

- All CDR methods.

Existing CDR MRV protocols:

- The RVCMC prioritizes high-quality carbon credits, adhering to international standards and protocols such as Verra and Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).

Current plans:

- In June 2023, the RVCM held the largest-ever carbon credit auction in Nairobi, Kenya, selling 2.2 million tons of voluntary carbon credits. The credits met CORSIA standards and were registered with Verra.
- RVCM has recently partnered with Xpansiv, a global market infrastructure provider, to build the digital platform for its carbon credit exchange, set to launch by the end of 2024.
- Contracts will be developed to align with market best practices, including a gradual transition towards carbon removals initiatives.

CDR roles and methodologies in NDC (Mar 2022 version)

- Nature-based solutions: This includes tree planting and land rehabilitation over the next decade as part of the SGI and MGI. These initiatives impact will be estimated using approved methodologies.
- Integrated coastal zone management: This approach focuses on protecting, restoring and enhancing Saudi Arabia's coastal blue carbon ecosystems, with a particular focus on mangroves due to their significant climate benefits. The planting of mangrove seedlings is documented, and plans are in place for more accurate estimates of blue carbon sinks.
- DAC: Identified as a critical CDR technology for innovation and large-scale deployment.
- CCE framework: Relevant technologies include BECCS and DACCS.
- Geological carbon storage: Promoting the advancement of geological carbon storage technologies.
- CCS hub: Plans to establish a CCS hub to support both CCS approaches and CDR solutions dependent on geological carbon storage (BECCS and DACCS).

Switzerland

(Outside of the EU and active in removals and cross-border exchanges)

2050 target under the Long-Term Climate Strategy

Considered CDR methods:

- Plant-based CDR (afforestation, reforestation, forest management, wood use, soil management, and introduction of biochar).
- Technology-based CDR (BECCS, DACCS, and Enhanced Weathering (EW)).

Existing CDR MRV protocols:

- No detailed CDR methodologies in CO2 Act and CO2 Ordinance.

Compensation projects in Switzerland

Eligible CDR methods:

- Biological carbon sink (Long-term increase in carbon storage in soils, agroforestry systems and forests by means of active measures).
- CDR methods with geological carbon storage (including inorganic building materials).

Existing CDR MRV protocols:

- Offsetting CO2 emissions
    - General requirements of monitoring and reporting for offsetting projects are described in UV-1315-E (FOEN, 2024).
    - Carbon storage projects must offer sufficient guarantees of the permanence of the carbon storage. The applicant must demonstrate conclusively that the CO2 emissions stored in biological carbon sinks (only authorised in Switzerland) or geological carbon sinks will be there for at least 30 years, regardless of the project duration.
    - The applicant must demonstrate the permanence of CO2 emissions stored in carbon sinks. It may do this by, in particular, including in their project or programme description:
        - the modelling of the theoretical development of the storage over time;
        - a list of the parameters that must be monitored to ensure the storage develops in such a way that there is no reversal of the carbon sink effect (i.e. the carbon sink becomes a carbon source);
        - the monitoring that will have to be put in place as a result; and
    - the range of expected values for each of these parameters over time.
    - In each monitoring report, the applicant presents the data measured in accordance with the monitoring plan detailed in the project or programme description and compares these values with those expected according to the model depicting storage development over time, thereby demonstrating that a reversal of the carbon sink effect is precluded.
    - Registered projects and relevant documentation, e.g. for the category “biological sequestration: harvested wood products” are reported here.

- Five projects, which aim to store CO2 from biogas upgrader plants in concrete in Switzerland or in underground storage abroad from 2025 to 2030, intend to register these projects under the Swiss compensation scheme (see press release). The authorisation process is ongoing.

Compensation projects abroad through the bilateral climate agreements

Eligible CDR methods:

- Only CDR methods with geological carbon storage through active measures is accepted as an offsetting project or programme abroad.

Existing MRV protocols potentially applicable to CDR:

- UV-1315-E describes general requirements of monitoring and reporting for offsetting projects abroad.
- The validation and verification (VV) must be approved by the competent authority in the partner country, in accordance with the requirements of the bilateral agreement between Switzerland and that country.
- Validation also ensures the conditions set out in the bilateral agreements with partner countries are met. The VV also verifies compliance with the legal requirements of partner states.
- For the development of reference scenario, the existing Clean Development Mechanism (CDM) or Gold Standard methodologies can be used as a reference.
- Registered projects and relevant documentation are reported here.
- Switzerland is currently exploring options to pilot international transfers of industrial carbon removals under Article 6 of the Paris Agreement at a small scale with Sweden (see MoU) and Norway (see MoU).

CDR roles and methodologies in NDC (December 2021 version)

- Removals from LULUCF will be reported and accounted for on a land-based approach.
- Switzerland will develop a forest reference level (FRL) for managed forest lands. This reference level will draw on Kyoto Protocol methodologies for developing what the Kyoto Protocol referred to as a forest management reference level (FMRL).
- For forest land, elements like the calculation method of harvested wood products (HWP), the calculation of the background level and margin for the exclusion of natural disturbances and the basic principles of the FMRL are used from the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

- Emissions and removals resulting from afforested and deforested land will be accounted for as being the total emissions and total removals for each of the years (gross-net).
- Non-forest lands (cropland, grassland, wetland, settlements, other land) will be accounted for by comparing emissions/removals to a reference period that presents a long-term historic average preceding 2020.
- No specific information related to CDR other than LULUCF is mentioned.

UK

(CDR Mission Supporting Member)

Net Zero Strategy

Applicable CDR methods:

- Nature-based approaches (afforestation and soil carbon sequestration).
- Engineering-based approaches (BECCS, DACCS, wood in construction, biochar, and EW).

Existing CDR MRV protocols:

- Protocols are being developed in collaboration with British Standards Institution (BSI) for BECCS and DACCS. Methodological 'Minimum Quality Thresholds' are expected to be published in 2025, and full protocols in a series of Publicly Available Specifications (PASs) to follow in 2027.
- The Department for Environment, Food & Rural Affairs (Defra) sponsored BSI Nature Investment Standards (NIS) Programme was launched in March 2023. The initial and primary focus of the programme was to develop operational standards for the supply of high integrity units. The NIS is intended to:
    a) establish an overarching framework to drive actions to create the conditions for consistency and high integrity across all nature markets.
    b) support high integrity of units traded in nature markets.
    c) support nature markets to deliver positive environmental outcomes.
    d) protect against the risks of activity in nature markets leading to negative, unintended consequences for the environment.
    e) act as a specification, and a basis for standards on specific aspects of nature markets, against which market participants can seek certification to signal their high integrity; and

f) support the provision of information from nature markets that deters, and/or helps detect greenwashing

- The NIS work programme includes:
  - Overarching Principles & Framework
  - Certification scheme for the supply of Biodiversity Benefits
  - Certification scheme for the supply of Nature-based Carbon Benefits
  - Certification scheme for the supply of Nutrient reduction benefits
  - Community Benefits and Engagement
  - Operation and Governance procedures
  - Standards Navigation Tool Minimum viable product
  - Assurance framework

Current plans and activities:

- Developing a robust approach to the MRV of negative emissions is essential to the deployment of CDR at scale. Future markets in which negative emissions are traded, whether voluntary or otherwise, will require careful regulation to ensure that capital is being invested into permanent, verifiable carbon removal.
- In 2021, the UK established a Greenhouse Gas Removals (GGR) MRV Task and Finish Group, comprised of experts across government, industry, academia, and regulatory services and published the final report (DESNZ and BEIS 2023) with key recommendations.
- An MRV regime will be required to ensure that the amount and permanence of removals are quantified, robustly and transparently, with tolerable uncertainty.
- In 2023, the UK updated the proposed commercial frameworks for the GGR business model and related policy. In the updates, The UK government announced its intention to design methodologies for the quantification of engineered removals. In the same publication, ERM released an independent review of engineered GGR standards and methodologies (ERM 2023), commissioned by the Department for Energy Security and Net Zero to understand the potential applicability of existing standards and methodologies to UK business models.
- In September 2024, the UK Government commissioned the BSI to develop an engineered GGR Standard, focusing on DACCS and BECCS initially. Under the first phases of the contract, BSI will define and publish methodological Minimum Quality Thresholds for early GGR projects seeking support from the Government's Business Model. BSI will use feedback from the Minimum Quality Thresholds to support the development of subsequent detailed methodologies for DACCS and BECCS, in the form of a series of PASs.

Climate Change Act 2008

Applicable CDR methods:

- Removals of GHGs from the atmosphere due to processes, mechanisms or activities (engineered removals are added in the amendment of October 2023).

Existing CDR MRV protocols:

- Not specified at present.

The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010

Applicable CDR methods:

- BECCS.
- DACCS.
- Direct ocean carbon capture with geological storage.

Existing MRV protocols applicable to CDR:

- Monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council
- Monitoring must include (where possible) the monitoring of the CO2 plume, and (where appropriate) of the surrounding environment.
- The monitoring plan must be updated in accordance with Annex II to the Directive, and in any event within five years of the approval of the original plan, in order to take account of
    - changes to the assessed risk of leakage;
    - changes to the assessed risks to the environment and human health;
    - new scientific knowledge; and
    - improvements in best available technology.

UK Emissions Trading Scheme (ETS)

Applicable CDR methods:

- None at present.

Existing CDR MRV protocols:

- None at present.

Current plans and activities:

- Integrating GGRs in the UK ETS

- In July 2023 the government confirmed its position that the UK ETS will be an appropriate long-term market for GGRs. The UK ETS Authority opened a further consultation on 23 May 2024 on GGR inclusion in the UK ETS, which considers principles for policy design when integrating GGRs into the UK ETS and several other elements. It closed on 15 August 2024.

CDR roles and methodologies in NDC (September 2022 version)

- No specific portfolio of CDR is documented.
- The 2006 IPCC Guidelines for National Greenhouse Gas Inventories, 2013 IPCC Kyoto Protocol Supplement and 2013 IPCC Wetlands Supplement will be used for estimating GHG emissions and removals for the UK's NDC.
- For harvested wood products, the UK will reflect emissions and removals resulting from changes in the carbon pool of harvested wood products using a production approach.
- Right to use of voluntary cooperation under Article 6 of the Paris Agreement is mentioned with potentially linking of the UK emissions trading scheme to another emissions trading system or using emissions reductions or removals units.

USA
(CDR Mission Co-Lead)

Carbon Negative Shot, supported by Bipartisan Infrastructure Law and Inflation Reduction Act

Applicable CDR methods:

- DACCS.
- Soil carbon sequestration.
- BiCRS.
- Enhanced Carbon Mineralization.
- Ocean-based CDR.
- Afforestation/ reforestation.

Existing schemes applicable to CDR MRV:

- 45Q tax credit
  - Biogenic carbon captured and stored from industrial facilities or power plants (BECCS), and direct air capture facilities (DACCS) are eligible.

    - Biogenic and DAC CO2 utilization for conversion to securely stored products. Verification with Life Cycle Analysis (LCA) is required for them to be approved by Notice 2024-60 (IRS 2024).
- Best practices for Life Cycle Assessment (LCA) of Direct Air Capture with Storage (DACS) (U.S DOE 2022).
- UIC Class VI for geologic carbon storage.
    - Subpart RR of Greenhouse Gas Reporting Program (U.S. EPA 2016).
    - BEST PRACTICES: Monitoring, Verification, and Accounting (MVA) for Geologic Storage Projects DOE/NET-2017/1847 (U.S. DOE 2017).

Current plans and activities:

- Setting key performance elements:
    - Robust accounting of full life cycle emissions.
    - High-quality, durable storage with costs demonstrated for MRV for at least 100 years.
- Regional DAC Hubs
    - The first-round awardees to discuss plans for MRV at their Hubs.
    - The Notice of Intent of second-round of DAC Hubs indicates that robust MRV will be required.
- DOE Voucher Program
    - Voucher Opportunity 5 – Commercialization Support addresses key adoption risk areas faced by companies working in carbon management, including independent assessment and validation of MRV technologies/practices and performance validation.
- CDR Purchase Pilot Prize in 2024
    - Competition for companies to compete for the opportunity to deliver carbon dioxide removal credits directly to DOE.
    - GHG accounting and MRV methodologies or protocols used to calculate the net removals produced and durably stored by the proposal's CDR project(s) using a cradle-to-grave accounting framework (Appendix 12 of official rules of the prize).
    - Rigorous monitoring, measurement, reporting, and verification (MMRV) practices through third-party scientific validation.
    - Four technology pathways are considered (DAC, BiCRS, enhanced geological weathering and enhanced carbon mineralization, and planned and managed carbon sinks).

    - Launch a Voluntary CDR Purchase Challenge, which encourages non-DOE entities - including companies and other governments - to purchase high quality removal credits from the Pilot Prize awarded companies.
- Carbon Negative Shot Pilots funding in 2024
    - Integrated pilot-scale testing of biomass carbon removal and storage or conversion with appropriate MRV.
    - Integrated pilot-scale testing of enhanced carbon mineralization technologies with appropriate MRV.
    - A LCA is required for both technological facilities (Appendix E of the DOE's Funding Opportunity Announcement).
- Research projects at the US DOE National Labs to accelerate commercialization of CDR technologies
    - Lawrence Livermore National Laboratory will develop an umbrella CDR 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.
    - Pacific Northwest National Laboratory will develop an adaptive MRV framework for mineralization-based CDR pathways in collaboration with Lawrence Livermore National Laboratory and 22 industry partners.
    - National Renewable Energy Laboratory will develop and validate best practices for cement and concrete CDR pathways in collaboration with Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, and nine industry partners.
    - National Renewable Energy Laboratory will address critical MRV challenges for BiCRS pathways in collaboration with Lawrence Livermore National Laboratory and eight industry partners.

CDR roles and methodologies in NDC (April 2021 version)

- Enhancing carbon sinks through a range of programs and measures for ecosystems ranging from forests and agricultural soils to rivers and coasts are documented.
- The US intends to use the IPCC 2006 guidelines (or any updated IPCC guidelines that may be agreed upon by the CMA in the future).
- The US intends to use a production approach consistent with the IPCC 2006 Guidelines to estimate emissions and removals from Harvested Wood Products.

Section 3 – Critical Factors for High-Quality MRV of CDR

Identify the criteria factors for high-quality MRV (e.g., durability, additionality, liability, monitoring, etc.), and how national governments CDR MRV methodologies are handling each factor. Output: MRV matrix populated with details for each country's methodologies/definitions for each criterion.

Section 3.1 – General

Consistent and credible MRV is critical to provide transparency and accountability of CDR methods. Robust MRV function would need to manage quantification uncertainty and reversal risk associated with CDR approaches. MRV involves layered and tailored activities, such as quantifying CO2 drawdown and storage based on collected measurements of carbon (and other greenhouse gas, as applicable) stocks and flows, analyzing and/or modeling the effective CDR permanence duration and risk of reversal in response to realistic external stimuli, reliably providing CO2 measurement data and information, including methods for sampling, collection, and harmonization, in a usable and transparent format to enable ongoing auditing throughout the project lifetime, and obtaining a scientific validation of the CO2 removal methodology and project.

The principal objective of MRV is to assess the amount of CO2 removed by the implementation of a specific CDR method over time. The ability to accurately quantify how much CO2 has been removed from the atmosphere is fundamental to assessing the performance of CDR into climate change mitigation strategies. At the core of this is designing MRV systems that are based on the best available scientific evidence (Schulte et al. 2024).

Criteria for high-quality MRV of CDR at project level should consider the following, based on Core Carbon Principles from the Integrity Council for the Voluntary Carbon Market (ICVCM; see Section 4.3), ERM (2023), Lebling et al. (2024), Mitchell-Larson et al. (2022), and Schulte et al. (2024).

- **Additionality**: A CDR activity is additional when it can prove that it would not have otherwise happened (baseline or counterfactual scenario).
- **Durability**: Duration for which carbon is safely sequestered, and the corresponding reversal risk of that sequestration with appropriate monitoring and modelling approaches. The criteria may be used for the assurance of credits with durable net-zero concept of balancing emissions and removals from biosphere and geosphere separately (Carbon Gap 2023; Allen et al. 2024).

- **Quantification and uncertainty assessment**: Quantification of carbon removed must be done with the best available science to prove and quantify net negativity on a life cycle basis of a project or technology.
- **No double counting**: Carbon removals activity shall not be double counted. Double counting covers double issuance, double claiming, and double use.
- **Transparency**: The way data are measured, collected, reported, and verified must be publicly accessible to the amount practicable, so project developers and others can be held accountable and trust can be built. Strong tracking capabilities, independent/third-party oversight, and enough temporal and geographic resolution to do meaningful auditing and analysis to be wanted.
- **Environmental impacts**: Beyond carbon accounting (i.e. carbon MRV), impacts on the environment should also be measured and monitored to account for and minimize potential negative impacts (environmental MRV: eMRV).
- **Co-benefits and Synergies:** MRV should also show the benefit beyond CO2 removal to biodiversity enhancement, soil health improvements, or local economic development. These co-benefits strengthen the case for broader adoption of CDR projects while contributing to sustainable development.
- **Scalability:** The CDR-MRV system should reflect how scalable and technologically innovative to meet future carbon removal targets and projects.

Section 3.2 – Technology-specific Considerations for the Criteria

CDR methods involving geological carbon storage

(e.g., The storage component of BECCS and DACCS, and in-situ carbon mineralization)

- Long-term containment of CO_2 in subsurface geological formations (e.g., saline aquifers or depleted oil reservoirs) must be safe, effective, quantified, and verified.
    - Baseline assessment and characterisation of storage sites to assess geological suitability.
    - Monitoring of CO_2 behaviour during and after injection (e.g., well pressure monitoring), including delineation of the post-injection monitoring area and identification of potential surface leakage pathways.
    - Comprehensive risk management strategy, including detecting and quantifying any surface leakage of CO_2 as well as establishing baselines for monitoring CO_2 surface leakage.

  - Injection and operational strategy including injection rate control which can impact reservoir pressure and containment risks (Kelemen et al. 2019).
  - Transparent reporting, data sharing, and verification of storage integrity via a third party to regulators.
  - Ensure regulatory compliance (e.g., ISO 27914: International standard for geological storage of CO_2).
  - Environmental impact assessment and ongoing environmental monitoring (e.g., groundwater monitoring).

- For in-situ carbon mineralization, additional requirements include, but not limited to:
  - Comprehensive fracture mapping during site characterisation to understand fracture network and permeability (reducing risk of fluid moving into low-pressure zones where the CO2 can leave the solution as a free gas phase).
  - Transparency around the water consumption requirement and source of water used in the carbon mineralization process (and any associated trade-offs).

Note: Data sharing from existing projects towards the development of a standard workflow for in-situ mineral carbonation is a necessary step to fast-track scaling in-situ carbon mineralization projects globally.

BiCRS: BECCS

- Choice of system boundary strongly influences the net GHG emissions attributable to BECCS (Galik et al. 2023).
  - Inclusion of both upstream (i.e., land use and land-use change) and downstream (i.e., energy displacement) emissions emerge as particularly important determinants of net BECCS GHG balance.
- The origin and type of feedstock used are key sensitivities that will vary with each project for quantification of net CO2 removed (ERM 2023).
  - DRAX and Stockholm exergy (2024)'s methodology requires use of only sustainable biomass feedstocks, verified appropriately against the conditions laid out in their criteria for forest biomass.
- Process, feedstock transport, and feedstock storage emissions, while potentially still in need of further study, are fairly well-understood and have a history of being accounted for in both research and practice.

BiCRS: Biochar

- Feedstock sustainability as BECCS.

- Biomass processing and transport needed to be monitored (Fajardy et al. 2019).
- The higher temperatures used in fast pyrolysis leads to greater biochar stability and permanence of carbon sequestration. However, the lower temperatures and slower heating rates of slow pyrolysis result in higher biochar yield (ERM 2023).
- Biochar decomposition and behaviour in soils are difficult to predict due to multiple influencing parameters (ERM 2023).
    - Puro Earth's methodology (Puro.earth 2024) calculates the permanence factor based on soil temperature values from literature or statistics, and the molar hydrogen to organic carbon ratio, which must be determined by laboratory analyses of produced biochar with a representative sampling methodology.
- Potential yield increase and stabilization of soil organic carbon in the land from biochar could be added benefit of the deployment of biochar.

DAC

- Consideration of the direct and indirect effects from increased demand on renewable energy is key (Schulte et al. 2024).
    - Analysis of environmental burdens other than GHG emissions shows some trade-offs associated with CO2 removal, especially land transformation for system layouts with photovoltaics (PV) electricity supply (Terlouw et al. 2021).
- Source of energy (electricity and/or heat) used in the capture stage is the dominant factor in determining lifecycle emissions (Erans et al. 2022).
- Carbon intensity of consumable materials (e.g., liquid solvents, absorbents, adsorbents) and carbon intensity of infrastructure's construction materials are also important due to being capital intensive (ERM 2023).
    - As an emerging and proprietary technology, with minimal process transparency, LCA datasets on (novel) chemicals remain incomplete on key data, such as consumption rate, degradation, and lifetime.
- DAC publications often lack full transparency on the CO2 capture stage due to the competitive, nascent technological market (ERM 2023).

Enhanced Carbon Mineralization

Enhanced mineralization techniques typically fall into two categories (MI CDR 2023): ex-situ or in-situ:

- Ex-situ applications typically include combining atmospheric CO2 with crushed silicate materials (i.e., ultramafic tailings or industrial wastes) or applying crushed mafic silicate rock (i.e., basalt) to the soil to interact passively with atmospheric CO2.

- In-situ applications involve injecting CO2 into onshore or offshore mafic or ultramafic rock formations.

This section addresses MRV for ex-situ carbon mineralization as enhanced rock weathering. MRV criteria for in-situ carbon mineralization applications are described in the "CDR methods involving geological carbon storage" section above.

Enhanced Rock Weathering (ERW)

Optimisation of CDR by ERW can be achieved by choosing locations, feedstocks, and geological settings favouring rock weathering (Campbell et al. 2022; Haque et al. 2023). Understanding these parameters is necessary as they influence the rate of weathering and, therefore, the fate of CO2. Both geochemical and biogeochemical processes control rock weathering and heavily depends on the mineral dissolution rate, which is influenced by:

- Climate (e.g., rainfall, humidity, temperature, wind speed, etc., Baek et al. 2023; Cipolla et al. 2021)
- Bedrock geology (e.g., soil pH and soil type)
- Rock flour mineralogy (including composition, particle size, surface area, and application rate (tonnes per hectare))
- Secondary mineral formation (e.g., silicate or clay formation can slow mineral dissolution rates)
- Inorganic amendments (e.g., the presence of inorganic ligands can speed up mineral dissolution)
- Agricultural practices (e.g., type of farming and management practices such as irrigation, tilling and fertiliser use, Cipolla et al. 2022)
- Plants and organisms (e.g., organic acids speed up mineral dissolution, silicate-weathering microbes)

MRV Considerations for ERW Projects

- Open system CDR technologies such as ERW are complex, and verification of CDR requires multiple and varied analytical methods (e.g., combinations of solid, liquid, and gas phase analyses); intricate, temporally varying processes occurring between organic and inorganic carbon pools (and resultant fluxes of CO_2 and other GHGs) underpin these complexities (Clarkson et al. 2024).
- Analytical methods used to verify CDR by ERW must be underpinned by robust, location- and feedstock-specific experimental design that considers the open system spatially and temporally and includes changes in both inorganic and organic carbon

pools and resultant fluxes, and accurate baselining must also occur to ensure a project's CDR calculations are additional (Sutherland et al. 2024).

- Medium-term climate changes and impacts on ERW projects need to be considered, as well as environmental risks (e.g., land contamination) and social risks. Farmers/landholders must demand ERW; therefore, demonstrating co-benefits for farm productivity by soil, crop, and rock type must occur alongside MRV development to ensure buy-in from critical stakeholders.
- Transparency around experimental design and analytical methods is critical; project data should be provided to and verified by credible third parties to allow for accurate CDR accounting. Life cycle analyses (LCAs) and total environmental footprint must be included (Foteinis et al. 2023; Jerden et al. 2024); consistent system boundaries between project LCAs are also necessary for accurate CDR accounting.

Other Emerging Technologies

- Marine carbon dioxide removal (mCDR) or ocean-based CDR methods are emerging technologies, which could significantly help mitigate climate change by capturing anthropogenic CO2 and storing it in the ocean for extended periods at large scales. However, development of MRV precision and market maturity are very low at this stage for open-ocean CDR and may be impacted by limitations of mCDR activities under the London Protocol. The development and deployment of advanced MRV technologies will be crucial for the success of the mCDR industry, as these technologies provide the necessary data to quantify the effectiveness of mCDR projects, assess their long-term viability, and enable the accurate valuation of carbon removal and sequestration (Boyd et al. 2023). Ocean Alkalinity Enhancement (OAE) is shown here as an example of mCDR's MRV considerations.

Ocean Alkalinity Enhancement (OAE)

- The complexity of ocean geochemistry has created difficulties in isolating the effects of Ocean Alkalinity Enhancement (OAE) from natural processes through observation methods alone (Mu et al. 2023; Ho et al. 2023).
    - Observational approaches during field trials should aim to quantify the delivery of alkalinity to seawater and monitor for secondary precipitation, biotic calcification, and other ecosystem changes that can feed back on sources or sinks of greenhouse gases where alkalinity is measurably elevated.
    - Resultant shifts in the partial pressure of CO2 (pCO2) and ocean pH can help determine the efficacy of OAE.

- Empirical models can estimate CDR through OAE, but not with the precision necessary to develop monitoring and verification standards that would enable the sale of GGR credits (Mercer and Burke 2023).
    - The development of fit-for-purpose models, carefully validated against observational data, will be a critical part of MRV for OAE.
- Closed-system approaches (e.g., Eisaman 2024) have the advantage of more straightforward MRV.

Section 3.3 – Existing National Criteria Matrix for BiCRS (BECCS and biochar), DACCS, and Enhanced Carbon Mineralization

General matrix for CDR storage (mostly involving geological carbon storage)

	Canada	EU (CRCF)	Japan	UK	USA
Baseline scenario	• Reporting against baseline monitoring results and tests for geological storage sites are required (CCUS-ITC when knowledge sharing applies). • The baseline scenario for projects using the Quantification Method is defined as the continued emission of CO2 to the atmosphere that is captured and injected in the project (Clean Fuel Regulations).	• Standardised baselines will be developed to reflect the statutory and market conditions in the geographical context in which the carbon removal activity takes place. This will take into account carbon removal performance of comparable activities in similar social, economic, environmental, and technological circumstances. Inclusion of existing carbon removals in the baseline (mostly for carbon farming activities) is expected to simplify the additionality tests (ERM 2023). • The proposal suggest that baselines need to be periodically updated but the details are yet to be determined (ERM 2023).	• N/A (JOGMEC CCS guideline)	• A baseline assessment may be initially determined through an appraisal period, in which the licensee measures key reservoir characteristics to include in a storage permit, and how they would potentially be affected by CO2 storage activities. This contributes to a “baseline assessment” from which modelling make predict future injected CO2 behaviour. Should real-time CO2 behaviour be assessed to be deviating from the model (supported by the baseline assessment), then a corrective action plan may be implemented (ERM 2023).	• The MRV plan must specify a strategy for detecting and quantifying surface release of CO2 and an approach for establishing baselines for monitoring CO2 surface releases (MVA for geologic storage). • Competitors should provide evidence supporting a presumed common practice or “business as usual” outcome, had the CDR project not occurred, to both demonstrate the additionality of the CDR credits generated from the project and to establish an emissions baseline (CDR Purchase Pilot).

	Canada	EU (CRCF)	Japan	UK	USA
Durability (Long-term containment monitoring)	• List and describe the monitoring techniques considered along with the screening and assessment process for the monitoring techniques and technologies, as well as justification for the ultimate selection based on cost-benefit analysis (CCUS-ITC when knowledge sharing applies). • Provide lessons learned from the assessment and selection process (CCUS-ITC when knowledge sharing applies). • Summarize the verification plan and reporting plan, highlighting areas of higher risk and specific monitoring targets and techniques for those areas (CCUS-ITC when knowledge sharing applies). • For use of CO2 in concrete, 3rd party inspection and certification of the concrete process against ISO 14034:2016 (CCUS-ITC).	• Projects will be required to monitor the storage sites throughout the monitoring period and take measures to mitigate risk of leakage. • For carbon farming and carbon storage in long lasting products, carbon is assumed to be released back at the end of the monitoring period. For GGRs with permanent storage and carbon permanently chemically bound in products, removal is assumed to be permanent after liability is transferred to the relative public authorities in line with the EU CCS Directive (2009/31/EC) (ERM 2023). • For activities falling outside of the EU CCS Directive, other liability measures should be employed, such as discounting, buffer pools or up-front insurance. There must always be a liable party at any time for the reversal of stored carbon. Further detail on liability provisions is to be determined (ERM 2023).	• Although the post-closure stage is not covered in the CCS guideline, it recommends obtaining confirmation of the long-term storage site transfer, post-closure, to a local authority, including the monitoring of CO2 storage to ensure long-term safe storage (JOGMEC CCS guideline).	• Permanence is assumed through continuous monitoring and verification. Post-closure, the private operator is expected to hold liability for monitoring the storage site for at least 20 years, after which it might transfer long-term liability to the state with a financial contribution covering another 30 years of monitoring.	• Monitoring techniques that address well integrity, groundwater monitoring, subsurface plume tracking, long-term containment of the injected plume, and soil-gas and surface-air monitoring are all applicable to UIC Class VI Rule requirements (MVA for geologic storage). • MRV plan should describe the activities that will be performed to directly measure, model, and monitor the carbon removal during the entirety of project operation as well as ensure the secure storage after the CDR credit delivery and project operations have been concluded, for at least 50 years (CDR Purchase Pilot).

	Canada	EU (CRCF)	Japan	UK	USA
Quantification and the uncertainty	• Provide an overview of the assessment of the reservoir chemistry and its impact on injection, including reactivity of impurities and their impact on phase behaviour, as well as any risk or uncertainty in regard to the CO2 stream composition and the subsurface (CCUS-ITC when knowledge sharing applies). • Outline the required pressure and temperature, as well as the pressure management and operation strategy for the reservoir (CCUS-ITC when knowledge sharing applies). • For use of CO2 in concrete, 3rd party inspection and certification of the concrete process against ISO 14034:2016 (CCUS-ITC) • For the quantification of emission from subsurface to atmosphere, the quantity of emissions leaked from the subsurface equipment or CCS Subsurface operations to atmosphere for each of the leakage events must be estimated with a maximum	CRCF requires quantification of carbon removals to account for and report uncertainties in accordance with recognised statistical approaches to limit the risk of over crediting. This accounting must be done in a conservative manner and be proportional to the level of uncertainty. Specific rules for addressing these uncertainties will be set in the specific methodologies (ERM 2023).	• Set rules based on ISO 14064-2 and ISO14064-3 (JOGMEC CCS guideline). • Continuous measurement of CO2 stream (at least with several minutes intervals) should be conducted (JOGMEC CCS guideline). • Monitoring and verification are performed against the potential risks identified in the risk management process, and it is performed as a part of the process. The results of monitoring and verification is used to ensure the effectiveness of CO2 storage, i.e., it provides technical justification to ensure the amount of CO2 reduction by the project (JOGMEC CCS guideline).	• There is limited discussion of uncertainty within the UK storage regulations themselves. In the CCS Directive, a discussion of uncertainty is contained to the models associated with predicting CO2 behaviour: "The uncertainty associated with each of the parameters used to build the model shall be assessed by developing a range of scenarios for each parameter and calculating the appropriate confidence limits. Any uncertainty associated with the model itself shall also be assessed." • While this does recognise that there is a certain degree of uncertainty associated with model development, and that this should be quantified and continuously improved, there is no explicit uncertainty limit required by the Directive.	• All flow meters must be operated continuously except as necessary for maintenance and calibration (subpart RR). • Operator must determine a quarterly concentration of the CO2 received that is representative of all CO2 received in that quarter (subpart RR). • Given the uncertainty concerning the nature and characteristics of any leaks that may be encountered, operator will determine the most appropriate method to quantify the volume of CO2 using an event-driven process to assess, address, track, and (if applicable) quantify any potential CO2 Surface Leakage (Monitoring, Reporting and Verification (MRV) Plan for Denver Unit). • Whenever possible, multiple physical quantification tools and sensors should be employed to monitor relevant CO2 fluxes (e.g., gaseous, aqueous, and/or solid), with confirmations provided

	Canada	EU (CRCF)	Japan	UK	USA
	overall uncertainty of ±7.5% over the reporting period (Clean Fuel Regulation).				through the incorporation of relevant models (CDR Purchase Pilot).
Transparency	• For large projects (more than $250 million) public knowledge sharing reports are required (CCUS-ITC) as a compliance requirement. • For use of CO2 in concrete, 3rd party inspection and certification of the concrete process against ISO 14034:2016 (CCUS-ITC)	• Sets out rules for the independent verification of carbon removals, as well as rules to recognise certification schemes that can be used to demonstrate compliance with the EU framework (ICF 2023).	• Data management, documentation and reporting methods: Operators must have in place systems for appropriate data management, documentation and reporting that are transparent and enable verification of changes over time throughout the lifecycle of the CCS project (JOGMEC CCS guideline).	• Monitoring must be based on a monitoring plan, which is updated every five years. This takes into account changes to the assessed risk of leakage, changes to the assessed risks to the environment and human health, new scientific knowledge and improvements in best available technology.	• Competitors should identify a specific MMRV methodology or protocol, under which the competitors CDR credits will be quantified and verified, as well as CDR credit verifier, that will oversee implementation of the MMRV methodology and testify to the accuracy of credits generated (CDR Purchase Pilot).
Environmental impacts	• Provide a description of the potential impacts of the CCUS project on the environment, specifying non-CO2 emissions and substances released to the air, soil, and water (CCUS-ITC when knowledge sharing applies). • Summarize the measurement, monitoring, and verification approach for the CCUS project, the potential risks, and the preventative measures taken to mitigate those risks (CCUS-ITC when knowledge sharing applies).	• GGR activities must have, at least, a neutral impact on climate change mitigation / adaptation, pollution prevention, circular economy, water / marine resources, food security, protection and restoration of biodiversity and ecosystems. Specific requirements will be determined by the methodologies. The requirements are expected to follow the technical screening criteria for Do Not Significant Harm, as laid under	• N/A (JOGMEC CCS guideline)	• CO2 storage applicants are required to include in their initial impact assessment proof that “there is no significant risk of leakage or of harm to the environment or human health”.	• Consideration of broader environmental and social impacts and legal, regulatory, or permitting requirements (CDR Purchase Pilot).

	Canada	EU (CRCF)	Japan	UK	USA
		Commission Delegated Regulation 2021/2139 and biomass sustainability criteria laid down in Article 29 of Directive 2018/2001. • Methodologies will encourage activities to provide additional co-benefits beyond the minimum sustainability requirements, which will be reported transparently on the certificates. The exact measurement and reporting requirements will be laid out in specific methodologies.			
System boundary	• The boundary used to determine on-site versus off-site sources and sinks at each project location should be indicated (Clean Fuel Regulation).	• N/A	• Project boundary of CCS includes CO2 capture, transportation, and storage systems (JOGMEC CCS guideline).	• N/A	• N/A

BiCRS: BECCS specific matrix

	Canada	EU (CRCF)	Japan	UK	USA
Baseline scenario	• N/A	• N/A	• N/A	• N/A	• N/A
Durability	• N/A	• N/A	• N/A	• N/A	• N/A
Quantification & uncertainty	• N/A	• N/A	• N/A	• N/A	• N/A
Transparency	• N/A	• N/A	• N/A	• Sustainable biomass auditing should be prioritised over certification and the use of more transparent methodologies and modern technologies (e.g., satellite, public datasets) (biomass strategy 2023).	• N/A
Environmental impacts	• N/A	• N/A	• N/A	• N/A	• N/A
System boundary	• N/A	• N/A	• Lifecycle GHG should be considered (Biomass sustainability WG).	• Look to include Indirect Land Use Change (ILUC) in the cross-sectoral sustainability framework based on up-to-date scientific evidence on ILUC (Biomass strategy 2023).	• BiCRS pathways must demonstrate net-negative greenhouse gas (GHG) emissions on a cradle-to-grave life cycle basis (CDR Purchase Pilot).
Feedstock sustainability	• BiCRS approaches follow a set of “do no harm” principles to value food security, rural livelihoods, and biodiversity conservation (Canada’s Carbon Management Strategy).	• The Renewable Energy Directive includes a set of sustainability criteria for bioenergy, which are implemented by either national competent authorities or private certification schemes recognised by the Commission.	• Feedstock which does not compete with other purpose/usage should be employed (Biomass sustainability WG). • Need for third party verification for imported feedstock (Biomass sustainability WG).	• The development and implementation of a cross-sectoral sustainability framework will require consideration of the current international certification landscape, established voluntary certification schemes in use, and various government support schemes (Biomass strategy 2023).	• N/A

BiCRS: Biochar specific matrix

	Canada	EU (CRCF)	Japan (J-Credit)	UK	USA
Baseline scenario	• N/A	• N/A	• Amount of soil carbon sequestration without the biochar project.	• N/A	• N/A
Durability (decomposition rate)	• N/A	• Draft methodology is anticipated in H1 2025.	• Feedstock types are restricted to the materials applicable to the default values of decomposition rate of 100 years for National GHG Inventory or IPCC guideline.	• N/A	• N/A
Quantification and the uncertainty	• N/A	• Draft methodology is anticipated in H1 2025)	• Default value of decomposition rate and carbon content is applied. • Emissions from transportation of feedstock, production of biochar, transportation of biochar, and the application of biochar shall be accounted if they are more than 1% of net removals.	• N/A	• N/A
Transparency	• N/A	• N/A	• Project operator is required to obtain documentation from the biochar supplier that guarantees that the biochar used is of the specified type or origin based on the raw material, biochar production process, etc., and to submit this documentation at each verification.	• N/A	• N/A
Environmental and social impacts	• N/A	• N/A	• Compliance with domestic environmental laws.	• N/A	• N/A
Feedstock sustainability	• Same as BECCS.	• Same as BECCS.	• Domestic biomass feedstock which does not compete with other purpose/usage shall be employed (J-Credit).	• Same as BECCS	• N/A
Co-benefits and Synergies	• N/A	• N/A	• N/A	• N/A	• N/A

DACCS specific matrix

	Canada	EU (CRCF)	Japan	UK	USA
Baseline scenario	• N/A	• N/A	• N/A	• N/A	• Baselines should be clearly identified, and displacive impacts should be identified as such in LCA/TEA (DACS LCA).
Durability (Long-term containment monitoring)	• N/A	• N/A	• N/A	• N/A	• N/A
Quantification and the uncertainty	• N/A	• N/A	• N/A	• N/A	• Separately report and account for any captured fossil or other non-atmospheric CO2 (e.g., from on-site fossil fuel combustion) from the captured atmospheric CO2 for consistency with the functional unit (DACS LCA). • Define LCA scenarios with a direct tie to process and cost engineering model (i.e., TEA) scenarios such that they characterize the underlying facility operating envelope (DACS LCA). • Coordinate with process and cost engineering modeling (e.g., TEA) team to capture data necessary for LCA (DACS LCA). • Clearly identify degree of uncertainty and variability, in particular, for modeled rather than empirical inputs (DACS LCA).
Transparency	• N/A	• N/A	• Emissions from activity of the project shall be monitored and accounted if they are more than 5% of net removals. Also, emissions from the activity with 1–5% of net removals should be	• N/A	• N/A

	Canada	EU (CRCF)	Japan	UK	USA
			accounted, although explicit monitoring is not a requirement (DAC WG methodology).		
Environmental impacts	• N/A	• N/A	• N/A	• N/A	• N/A
LCCO2 of consumable materials and infrastructure's construction materials	• N/A	• Accounting for energy/chemical consumption & transportation of CO2 based on LCA literature.	• Direct and indirect emissions only considered in the CCS value chain (JOGMEC CCS guideline and DAC WG methodology). • Accounting the emissions from consumable materials are in discussion (DAC WG methodology).	• N/A	• Report physical quantities for process inputs and outputs (e.g., MJ energy and, kg materials) in addition to the associated inventory of emissions (e.g., kg emission) (DACS LCA).

Enhanced Carbon Mineralization: ERW

	Canada	EU	Japan	Saudi Arabia	UK	USA
Baseline scenario	• N/A	• N/A	• N/A	• Lessons learned from current operational projects can be adapted for **baseline monitoring** in enhanced mineralization projects.	• N/A	• N/A
Durability (decomposition rate)	• N/A	• N/A	• N/A	• N/A	• N/A	• N/A
Quantification and the uncertainty	• N/A	• N/A	• N/A	• N/A	• N/A	• N/A
Transparency	• N/A	• N/A	• N/A	• N/A	• N/A	• N/A
Environmental and social impacts	• N/A	• N/A	• N/A	• N/A	• N/A	• N/A
LCCO2 of Energy input	• N/A	• N/A	• N/A	• N/A	• N/A	• N/A
Co-benefits and Synergies	• N/A	• N/A	• N/A	• N/A	• N/A	• N/A

Section 4 – International Harmonization of the MRV Protocols of CDR

Propose options/methods for reviewing and approving CDR MRV protocols for purposes of international harmonization. In other words, propose a strategy for interoperability of CDR MRV protocols across platforms that could help enable global market development of cross-border removal credits by exploring alignment with international standards (e.g., Paris Agreement Crediting Mechanism, IPCC Guidelines for National Greenhouse Gas Inventories, International Standardization Organization) and guidelines for the certification and the verification procedure in voluntary carbon markets.

Section 4.1 – Harmonized Requirements and Recommendation of Measurement, Monitoring, and Reporting

Policymakers in jurisdictions developing CDR strategies can develop minimum standards for MRV to help enable interoperability across platforms. Minimum standards could be differentiated from preferred methodologies. This could begin with identifying where in the MRV ecosystem there is duplication, low credibility, and unnecessary complexity among MRV providers (Mercer and Burke 2023).

4.1.1 Essential/most important items

- Setting minimum criteria to provide a commonly accepted global standard for following items, then allowing project developers to follow and develop any MRV methodologies and protocols. This should apply CDR methods which have relatively matured MRV methodologies (e.g. BECCS, DACCS, and biochar).
    - Baseline scenario.
    - Durability.
    - Quantification procedure (equations, system boundary, and LCCO2).)
- To conduct partnership with standard(s) to develop joint methodologies, the following items are also important:
    - No double counting (ensuring each credit is only counted once across the market).
    - Transparency.
    - Environmental impacts.

4.1.2 recommended items (for enhancement of interoperability)

- Endorsement of a single standard for global interoperability.
- Development of an independent new CDR MRV standard for emerging technologies (Enhanced Carbon Mineralization, open-system mCDR, etc.).

Section 4.2 – Standards developed by the Supervisory Body of the Paris Agreement Article 6.4

Two standards developed by the Supervisory Body enter into force in October 9th 2024, describing following requirements:

- Requirements for the development and assessment of Article 6.4 mechanism methodologies (A6.4-STAN-METH-001) for generating Article 6.4 credits.
- Requirements for activities involving CDR by the Supervisory Body regarding their use under the Article 6.4 mechanism (A6.4-STAN-METH-002).

A6.4-STAN-METH-001 standard describes the principles for the methodology to provide the basis for claim and assessment of creditable emission reductions or removals, satisfying additionality requirements, rules, modalities, and procedures. They include:

- Baseline-setting;
- Avoidance of leakage: leakage here refers to emissions that occur outside the activity boundary which are attributable to the Article 6.4 activity;
- Demonstration of additionality of activities;
- Additional requirements including with respect to policies, national circumstances and reversals; and
- Basic procedures for the development of methodologies.

A6.4-STAN-METH-002 standard describes the recommendations on requirements for activities involving removals under the Article 6.4 mechanism. The requirements include:

- Monitoring of removals: monitoring approaches, flexibility in monitoring, conservative manner in net removal calculations, quality assurance and quality control measures, monitoring plan and risk assessment plan;
- Reporting: monitoring activities and methods used, estimated net removals with the associated uncertainty, records and logs of the observed events of GHG release, how the risks of reversal were addressed, negative environmental and social impacts, frequency of submission of the report, submission following the observation of an event of GHG release, providing a transparent and verifiable justification etc.;
- Post-crediting period monitoring and reporting and their termination criteria;

- Accounting for removals: determination of net removal calculations;
- Methodologies applicable for a renewed crediting period;
- Addressing reversals: reversal risk assessment, reversal-related notifications and actions, remediation of reversals;
- Avoidance of leakage set out in A6.4-STAN-METH-001; and
- Avoidance of other negative environmental and social impacts and respecting human rights and the rights of Indigenous Peoples.

Section 4.3 – International Alignment for the Certification of the Verification Procedure

In the voluntary carbon market (VCM), the ICVCM and the Voluntary Carbon Markets Integrity Initiative (VCMI) are two established bodies that are developing guidance to advance quality considerations and best practice within the VCM. The ICVCM's Core Carbon Principle establish a global benchmark for high-integrity carbon credits that set rigorous thresholds on disclosure and sustainable development and unlock urgently needed finance for CDR suppliers in VCM. The VCMI is providing guidance on how to make a meaningful impact on climate action through voluntary use of carbon credits. The ICROA within International Emissions Trading Association (IETA) also sets Code of Best Practice, which aims to define international best practice in carbon crediting and represents the minimum requirements that all ICROA accredited organisations must meet. As a high-level standard, the International Civil Aviation Organization's CORSIA has CORSIA Emissions Unit Eligibility Criteria, setting of principles by which the programmes are assessed for the eligibility to supply emissions units to CORSIA.

In the absence of clear rule sets for Article 6.4 of the Paris Agreement until COP29 in November 2024, the ICVCM, VCMI, ICROA, and CORSIA guidelines might provide a foundation for national regulation for the certification and the verification procedure of CDR (Schulte et al. 2024), although the current size of the VCM is very limited compared to the ultimate government procurement and compliance markets for CDR.

For CDR specific criteria for high-quality MRV, Frontier and CarbonPlan published Verification Confidence Levels for carbon dioxide removal. It is an interactive tool that maps out the key uncertainties associated with quantifying net carbon removal and storage durability outcomes for six CDR pathways (DAC, BiCRS, EW, OAE, terrestrial biomass sinking, and ocean biomass sinking). In addition to the uncertainty mapping, they developed the Verification Confidence Level (VCL) metric, which assesses the extent to which net carbon removal and durability can be confidently be quantified using the best approaches available

today. These two metrics may be incorporated to align tracking the performance of different CDR approaches.

Section 4.4 – Potential Way for Harmonization with Upcoming IPCC Guidelines for National GHG Inventories

The IPCC, in early 2024, agreed on the scientific work programme for its seventh assessment cycle. The IPCC Panel at its 60th session, in January 2024, requested the Task Force on National Greenhouse Gas Inventories (TFI) to develop a methodology report on Carbon Dioxide Removal (CDR) technologies, Carbon Capture Utilization and Storage (CCUS) beyond land use, land-use change, and forestry. Expert meeting was held in July 2024, then the scoping meeting was held in October 2024.

The methodology report is expected to outline a framework for including novel CDR methods in national inventories and will be published by the end of 2027. Even existing IPCC Guidelines already provide for inventory compilers to estimate and report on anthropogenic sinks from any process, activity or mechanism which removes a greenhouse gas from the atmosphere in their national GHG inventories (NGHGI), new methods will broaden the base of sinks and sources that inventory compilers should routinely monitor and facilitate their estimation and reporting in future national inventories. In the expert meeting, broad range of CDR methods were discussed with three break-out groups (Group 1: Engineered capture, utilisation & geological storage, e.g. DACCS, BECCS, bio-oil injection/biomass burial; Group 2: Inorganic processes and storage, e.g. rock weathering, OAE, and concrete carbonation; Group 3: Biogenic processes and storage, e.g. afforestation/reforestation, agroforestry, improved forest management, blue carbon management in coastal wetlands, soil carbon sequestration, peatland and wetland restoration, and biochar).

Both activities of MI CDR MRV and upcoming IPCC CDR Guidelines by TFI share common targets of novel CDR methods in its scope of the development of MRV protocols. Since there are still issue in terminology and categorization/taxonomy of emerging CDR methods (e.g. enhance carbon mineralization, and mCDR methods), both activities can benefit from harmonization of the concept of them. Also, MI CDR experience in innovative pilot and commercial scale CDR MRV knowledge may be transferrable to the upcoming IPCC CDR Guidelines.

Section 4.5 – Engagement with the International Standard Organization (ISO)

Higher level standards from ISO can be used to determine the minimum and internationally consistent criteria for national CDR MRVs.

- ISO 14040:2006, ISO 14044:2006 by ISO/TC207 for general principle of LCA.
- ISO 14064-2:2019 by ISO/TC207 for project level quantification, monitoring, and reporting.
- ISO 14065:2020 and ISO 14066:2023 by ISO/TC207 for verification body.
- ISO 27914 (in revision) by ISO/TC265 for quantification and verification of geologically stored CO2.
- ISO 14046:2014 by ISO/TC207 for water footprint assessment — Principles, requirements, and guidelines.

Development of quantification standard for DAC methodologies would be addressed in ISO/TC265 WG1. Also, currently incorporating carbon mineralisation storage to the scope of ISO/TC265 and possible development of Technical Report are discussed.

Section 4.6 – Recommendations

1. Establish a scientifically informed minimum standard covering key elements of CDR MRV such as additionality, durability, transparency, double counting, and third-party verification that are robust and consistent with expected UNFCCC and IPCC developments to provide guidance to individual CDR methodologies/protocols being developed around the world.
2. Provide clarity on complex, vague, and even controversial topics such as clean energy procurement, system boundaries, additionality of CDR processes with co-products, like-for-like CDR credit matching, and social impact assessment.
3. Provide information for high-quality data collection and verification to enhance the credibility of CDR project assessments, ensuring that all MRV activities adhere to strict quality control procedures to help strengthen the reliability of the results.
4. Create expectations for transparency and public CDR data tracking to enhance quality, integrity, international emissions tracking, and trust (e.g. establishment of an independent oversight committee or the adoption of a multi-stakeholder governance model that would support fairness and technological diversity in CDR projects).

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CARBON DIOXIDE REMOVAL
MISSION

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