GEOSTORAGE AND CARBON CREDITING

A COMPREHENSIVE HANDBOOK FOR METHODOLOGICAL DESIGN AND SAFEGUARDING

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EXECUTIVE SUMMARY

IN 2021, THE INTERNATIONAL EMISSIONS TRADING ASSOCIATION (IETA) WITH PARTNERS SET OUT TO DEVELOP BEST PRACTICE GUIDANCE FOR CREDITING CARBON GEOLOGICAL STORAGE ACTIVITIES WITHIN CARBON MARKETS. TO INFORM THE DEBATE, AN INITIAL REVIEW OF EXPERIENCES WITH CARBON CAPTURE AND STORAGE AND ENGINEERED CARBON REMOVALS IN CARBON MARKETS WAS PREPARED. THE HIGH-LEVEL CRITERIA WERE LAUNCHED IN DECEMBER 2022.

Since that time, new methodologies and updates to existing methodologies have been produced. This handbook seeks to capture and synthesize the current state of play for carbon geostorage methodologies, drawing upon the initial review underpinning the high-level criteria.

Safeguarding principles, precedents and practice for geological storage established under the UNFCCC and Kyoto Protocol are also reviewed and discussed.

Collectively, these experiences provide a robust foundational basis to inform methodological design elements and safeguarding principles for undertaking and crediting carbon geostorage activities in today's carbon markets.

THE FOLLOWING STANDARDS ARE COVERED:

- Clean Development Mechanism
- ACR
- Verra (CCS+)
- Puro.earth
- Gold Standard
- Global Carbon Council
- Isometric
- Alberta
- British Columbia [draft]

METHODOLOGIES AND PROTOCOLS UNDER THESE STANDARDS ARE REVIEWED IN THE FOLLOWING CONTEXTS:

- Applicability conditions
- Project boundary
- Baseline scenario and baseline emissions
- Determination of additionality
- Project and leakage emissions
- Non-permanence and carbon reversal, covering:
  - Upfront quality assurance and quality control
  - Liability for short-term (operational) and longer-term (post injection) leaks
- Environmental and social impacts and sustainability.

THIS HANDBOOK SEEKS TO CAPTURE AND SYNTHESIZE THE CURRENT STATE OF PLAY FOR CARBON GEOSTORAGE METHODOLOGIES

TECHNICAL SUMMARY

BACKGROUND

The International Emissions Trading Association (IETA) with partners set out to establish common principles and high level criteria for the treatment of mitigation methods involving geological storage of carbon dioxide (CO2) within carbon markets. The principles and criteria aim for widespread applicability, covering CO2 captured from any of fossil/industrial point sources ("CCS"), biogenic point sources (bioenergy with carbon capture and storage; BECCS) or directly from the air (direct air capture; DAC).

Development of the principles and criteria was structured around addressing the following questions:

1. How do existing protocols address various methodological aspects relating to geological CO2 storage (GCS)?
2. What priorities could be established through common principles for crediting of GCS activities?
3. What additional safeguards are needed in GCS methodologies relative to existing crediting standards?
4. What high-level criteria can guide the development of these safeguards?

The first two questions were explored through a synthesized review of GCS methodologies and protocols, and principles and precedents established over the period 2005-2012 (e.g. the 2006 IPCC Guidelines and clean development mechanism).

The second two questions were the main outputs from the investigations into questions 1 and 2, as well as the outcome of extensive dialogue with stakeholders and other experts. These were synthesized into high-level criteria for crediting carbon geostorage activities, published in December 2022.

The foundational basis contained in the initial methodology review has been updated to reflect more recent developments including new methodologies and updates to existing methodologies (to April 2024). The synthesized summary provides an up-to-date handbook for practitioners and policymakers seeking to understand current best practice for methodological design and long-established principles and precedents that can safeguard deployment of climate-critical GCS technologies.

The handbook is split in two parts, reflecting the high-level criteria launched by IETA in December 2022: (i) a synthesized review of protocols and standards, which are used to inform common methodological design components for crediting GCS activities and (ii) a review of safeguarding principles, precedents and practice that offer a robust basis for sound deployment of GCS solutions.

THE HANDBOOK IS SPLIT IN TWO PARTS: (1) A REVIEW OF PROTOCOLS AND STANDARDS, (2) AND A REVIEW OF SAFEGUARDING PRINCIPLES

PROTOCOLS AND STANDARDS: A SYNTHESIS

The current suite of protocols and standards share many similarities in methodological design, but also contain some subtle differences and divergence of approaches.

Only minor differences exist across methodological components such as boundary, baseline, and additionality, and few if any unique issues are posed for GCS technology in these respects. Conversely, wider differences can be seen that stem from both technical and geographical applicability conditions used across the methodologies. These act to restrict both (i) the types of GCS activities that are eligible to apply the methodology and (ii) the geography (i.e. prevailing jurisdictional controls) in which an eligible GCS project activity may be developed, operated and closed.

Technical applicability: boundary, baseline and additionality

Puro.earth and Gold Standard are unique in applying exclusively to engineered carbon removals (BECCS, DAC with geological carbon storage). ACR is unique in covering fossil CCS, DAC, and currently only storage in conjunction with active injection of CO2 for enhanced oil recovery (EOR; although ACR is in the process of further expanding the scope in a forthcoming methodology update, v2.0). Verra, in conjunction with the CCS+ Initiative, takes a modular approach that aims to cover a wide array of GCS applications (but has so far only published draft standards for capture from DAC and bioenergy, and storage in saline aquifers and depleted hydrocarbon reservoirs). Isometric has published a DAC protocol and a module for storage in saline aquifers (and is working on a bioenergy protocol). The Global Carbon Council (GCC) methodology applies to variety of potential CO2 sources (fossil, bio, DAC) and storage types, but excludes EOR. Both Alberta and British Columbia [draft] protocols are fairly agnostic to the source of CO2 streams sent for storage, and Alberta allows for adaptions to be proposed by applicants wishing to use sources outside of the initial scope.

Notably, broader technical applicability can pose challenges for boundary setting and baseline considerations. Methodologies applicable to BECCS, for example, seek to address upstream emissions associated with the source of the biomass (especially sustainability and indirect land use aspects). Some standards applicable to fossil CCS and DAC also require upstream emissions from fuel production to be included (e.g. Alberta and Verra). Baseline selection complexity also increases as the technical scope of a methodology expands, driven by the wider array of potential alternative technologies that could be used to deliver the same underlying service. ACR, for example, applies either performance- or standards-based approaches to baselines to accommodate a wide set of situations, whereas Verra, Puro.earth and Isometric – with their limitation to carbon removals – assumes all captured and stored (i.e. removed) carbon is additional with a baseline of zero (i.e. there would be no removals in the absence of the registered activity). In all cases, variations also exist depending on whether a BECCS project is a new build or retrofit at an existing facility.

Nearly all methodologies require additionality demonstration. Most use variations upon the regulatory surplus test, financial additionality test and the common practice test, drawing from existing methods such as CDM tools.

THE HANDLING OF NON-PERMANENCE AND THE ALLOCATION LIABILITY IN THE EVENT OF A CARBON REVERSAL, ESPECIALLY LONG-TERM LIABILITY BEYOND THE END OF CREDITING, IS THE MOST CHALLENGING ASPECT FOR GCS METHODOLOGY DESIGN.

Geographical applicability: site selection QA/QC and long-term reversal liability

The handling of non-permanence and the allocation of liability in the event of a carbon reversal, especially long-term liability beyond the end of crediting, is the most challenging aspect for GCS methodology design. Standard setters need assurances that the environmental integrity of the credits that they issue for GCS projects today do not become compromised by the reversal of the emission reduction or removal effect due to future leakage of stored CO2. In all cases, there is a need to decouple that residual risk from the issued credits to ensure equivalence and fungibility with other units in carbon markets. Most standard setters therefore apply a combination of quality assurance and quality control (QA/QC) requirements on GCS site selection and management and long-term liability, alongside measures that can address short-term liability for any carbon reversal.

The presence of a dedicated host country legal and regulatory framework for GCS is the most common way in which standard setters apply QA/QC requirements for site selection, operation, closure and long-term liability. Such a regime (primarily in OECD countries today) offers assurances that effective systems are in place to oversee site selection, design, responsible operation, effective closure, longer term monitoring and allocation of liability for the GCS site. Usually this a managed through a local permitting process implemented by a government or its mandated agency/authority.

At the methodological level, such QA/QC requirements are practically implemented by restricting the geographical applicability of GCS methodologies. Some standard setters apply explicit restrictions (e.g. Alberta CCS Offset Protocol applies only to Alberta; British Columbia [draft] Protocol applies only to BC; the ACR is only applicable in the U.S and Canada). Others (e.g. Isometric) imply de facto restrictions by only allowing projects permitted under "EU or US laws and authorised or following similar requirements as set out by those legislations".[1]

Verra (CCS+ Initiative), Gold Standard and Puro.earth methodologies offer a hybrid approach to QA/QC requirements. These methodologies provide substantial technical guidance in respect of matters such as site selection, well design, operation, post-injection and closure. However, instead of directly imposing these requirements on project developers that use the methodology, they are rather established as an expected benchmark for host country national laws and regulations in which the GCS site is to be located. These standards also require, inter alia, evidence of government/government agency regulatory oversight, evidence of access and tenure rights to the pore space in the GCS site, and the need for operators to maintain dedicated permits for their GCS operations.

The GCC methodology sets similar requirements to those of Verra (CCS+), Gold Standard and Puro.earth, although it allows for greater discretion in the precise form of the permit. Guidance is also provided for GCS selection, operation and closure etc. to help fill gaps in local host country permitting regimes and accommodate situations where dedicated GCS laws and regulations are locally absent.

The UN's Clean Development Mechanism (CDM) modalities and procedures (M&Ps) for CCS, alongside the 2006 IPCC Guidelines, are the only standards under the UNFCCC that define monitoring, reporting and verification (MRV) expectations for countries wishing to host GCS activities (in, respectively, Appendix B to Decision 10/CMP.7 and 2006 IPCC, Volume 2, Chapter 5). Both lay down quasi-regulatory frameworks that must be followed by countries reporting on hosted/credited GCS operations. Both frameworks can therefore provide safeguards to the environmental efficacy of GCS activities in delivering long-term, permanent, climate change mitigation and to control the risk of future CO2 leaks (carbon reversal).

THE SIZE OF INDIVIDUAL PROJECT CONTRIBUTIONS TO THE BUFFER POOL IS GENERALLY DETERMINED THROUGH A NON-PERMANENCE RISK ASSESSMENT PROCEDURE/TOOL

SAFEGUARDS FOR DEPLOYMENT: A REVIEW

Parties to the Kyoto Protocol established various safeguards for undertaking CCS as CDM project activities in developing countries, primarily because host countries faced no direct liabilities in the event that a GCS site leaked. In addition, the desire to ensure high quality, permanent, GCS and to allocate liability in the event of reversal, led Parties to establish specific rules and standards for CCS project activities relative to other types of emission reduction project activities. The alignment of standards for CCS deployment between CDM countries and developed countries (e.g. the European Union) also supported the fungibility of any resulting units.

Under the Paris Agreement, the situation is different to that of the Kyoto Protocol, since the Paris Agreement requires all Parties to pledge ambitious climate action meaning that host countries face liabilities for any leaks of CO2 in respect of their NDC targets. However, concerns still persist in respect of ensuring that crediting is limited to only high quality, permanent, GCS activities.

Drawing upon principles, precedents and practice from the CDM, IPCC and voluntary carbon market (VCM) standards, robust safeguarding requirements that can underpin crediting of GCS are considered. Such precedents offer a foundational basis for how similar safeguards can be integrated into mechanisms under Article 6 of the Paris Agreement.

A combination of methodological guidance and standards, backstopped by UNFCCC requirements for Parties to apply the methods contained in the 2006 IPCC Guidelines, can provide a safeguard for GCS activities operating under Article 6.2 cooperative approaches.

For the Article 6.4 mechanism, similar centralised standards as applied under the CDM could possibly be developed for project activities involving GCS. Further analysis and consultation is likely to be needed to achieve widespread agreement among parties. In the absence of integrated safeguards at the mechanism level, alternative restrictions would ultimately need to be applied. For example: limiting to jurisdictions where GCS laws and regulations are in place; through use of government-to-government bilateral agreements (e.g. under Article 6.2); or through establishing new forms of safeguards within yet-to-be-developed methodologies (under Article 6.4).

If VCM mechanisms are unable to effectively apply such safeguards, the options for crediting CCS activities under Article 6 are:

1. Only allow Article 6.2 crediting in jurisdictions:
   a. Where CCS laws and regulations are in place (although the quality of these would be difficult to assess and may require some minimal standards); or
   b. Where the activity is backed by a government-to-government bilateral agreement that acknowledges CCS risks and safeguards; or,
2. Only allow Article 6.4 crediting in jurisdictions without national GCS laws, regulations and standards, by using yet-to-be-established Article 6.4 methodologies that contain appropriate safeguards.

HIGH-LEVEL CRITERIA FOR CREDITED GCS ACTIVITIES

A set of high-level criteria are proposed to guide the development of international standards for crediting of GCS activities. These draw from the methodological components set out in international GCS-related standards and protocols and the safeguards applied in the CDM CCS M&Ps and other sources. The charts below provide descriptions of the high-level criteria alongside examples of evidence / checkpoints for each safeguard area for three core safeguarding areas: (1) political acceptability (2) legal and regulatory frameworks for safe storage (3) environmental and social safeguards.

IETA's high-level criteria can be directly accessed at:
https://www.ieta.org/initiatives/high-level-criteria-for-carbon-geostorage-activities

HIGH LEVEL GUIDE TO GCS METHODOLOGICAL COMPONENTS

METHODOLOGICAL COMPONENT		DESCRIPTION
01.	APPLICABILITY CONDITIONS	Defines the specific circumstances, attributes and other conditions that apply to eligible geological CO2 storage activities. These can include the eligible sources of captured CO2 (e.g. which types of CO2, and from which sectors, both of which have implications for baseline selection; see below), the modes of transport, and the allowable storage media. Geographical and technical restrictions can also be applied (e.g. only countries with CCS laws; conditions on geostorage development/operations).
02.	PROJECT BOUNDARY & LEAKAGE	Defines the emissions by sources and removals by sinks that must be measured and accounted for across the capture, transport and storage (project boundary). Includes emissions occurring outside of the immediate control of the project operator (e.g. upstream emissions), but which are measurable and attributable to the project activity (i.e. 'leakage').
03.	BASELINE	Describes procedures and options to establish the *baseline scenario* and a methodology for calculating *baseline emissions*. The emissions from the project activity must be compared to the baseline to quantify the net emission reductions or carbon removals. Options include projection-based approaches (e.g. historical emissions, or estimated future emissions, without CO2 capture) or standards-based approaches (e.g. using benchmark emissions of a comparable activity without CO2 capture).
04.	ADDITIONALITY	Demonstration that the activity delivers emissions reductions/removals that would not have occurred absent of the incentive created by carbon credit revenues. Different approaches and tests exist for demonstrating additionality (e.g. first-of-a-kind (FOAK); regulatory surplus; financial additionality). The primary purpose of CO2 capture is climate mitigation, which generally means that most projects will be additional. Novelty also means that FOAK or technology penetration rates can be used to rapidly demonstrate project additionality. Financial additionality testing may also be used to discern the value of crediting where other incentives (e.g. tax breaks) or benefits also exist (e.g. commercial CO2 utilization).
05.	NON-PERMANENCE & LIABILITY	Methodologies should ensure that geological storage sites are appropriately characterized, selected, developed, managed and level to mitigate against the risk of carbon reversals (quality assurance). Liability to remedy the impacts of any carbon reversals must also be allocated (*liability allocation*). These safeguards can be implemented either by applying geographical applicability conditions (i.e. relying on local laws and regulations) and/or through other effective safeguards (**see safeguard criteria 05, 06, 07**).
06.	MONITORING	Robust monitoring is needed to measure flows and emissions related to aboveground features of the activity and to check for CO2 leaks in around the storage site. Results of monitoring are used to (i) quantify creditable reductions or removals and (ii) protect natural ecosystems and human health. The latter safeguard can be implemented either by applying geographical applicability conditions (i.e. relying on safety monitoring under local laws and regulations) and/or through other effective safeguards (**see safeguard criteria 08, 09**).

HIGH-LEVEL CRITERIA FOR CREDITED GEOLOGICAL CO2 STORAGE ACTIVITIES (SUMMARY)

SAFEGUARD AREA	HIGH LEVEL CRITERIA	
POLITICAL ACCEPTABILITY	01.	SIGNIFICANT AND COST-EFFECTIVE FOR NATIONAL CLIMATE MITIGATION
	02.	ALIGNED WITH NATIONAL DEVELOPMENT PRIORITIES AND POLICY AIMS
	03.	WIDESPREAD PUBLIC ACCEPTANCE
LEGAL AND REGULATORY FRAMEWORK FOR SAFE STORAGE	04.	LEGAL BASIS FOR INJECTION AND STORAGE
	05.	EFFECTIVE SITE SELECTION AND DEVELOPMENT
	06.	ROBUST OVERSIGHT OF SITE OPERATION AND CLOSURE
	07.	LONG-TERM LIABILITY
ENVIRONMENTAL AND SOCIAL SAFEGUARDS	08.	RISK AND SAFETY ASSESSMENT
	09.	ENVIRONMENTAL AND SOCIAL IMPACTS
	10.	SUSTAINABILITY

SAFEGUARD AREA	HIGH LEVEL CRITERIA		DESCRIPTION	EXAMPLES OF EVIDENCE / CHECKPOINTS
POLITICAL ACCEPTABILITY	01.	SIGNIFICANT AND COST-EFFECTIVE FOR NATIONAL CLIMATE MITIGATION	Technologies involving geostorage should be part of a host country's cost-optimized and Paris-aligned national mitigation pathway. The host country mitigation scenarios must have been developed cognizant of the UN Sustainable Development Goals (SDGs).	• Nationally Determined Contributions (i.e. inclusion of geostorage within mitigation scenarios and plans) • Long-term Low Emissions Development Strategies (i.e. inclusion of geostorage) • Techno-economic mitigation studies etc
	02.	ALIGNED WITH NATIONAL DEVELOPMENT PRIORITIES AND POLICY AIMS	Technologies involving geostorage should be well aligned with the host country's national development plans, policies and sectoral programmes (e.g. economic development plans, energy sector development, industrial development strategy).	• Nationally Determined Contributions (i.e. demonstration of alignment with broader aims) • National development plans and strategies (e.g. economic development plans, energy sector development, industrial development strategy)
	03.	PUBLIC ACCEPTANCE	Activities should only be credited where the host country government and political stakeholders accept the need for geostorage (e.g. undertaking of robust stakeholder consultation as part of national climate policy development).	• Nationally Determined Contributions (i.e. developed with broad public input) • Normal host country public consultation processes and procedures • *OECD Best Practice Principles on Stakeholder Engagement in Regulatory Policy*

SAFEGUARD AREA	HIGH LEVEL CRITERIA		DESCRIPTION	EXAMPLES OF EVIDENCE / CHECKPOINTS
LEGAL AND REGULATORY FRAMEWORK FOR SAFE STORAGE	04.	LEGAL BASIS FOR INJECTION AND STORAGE	Activities credited under international standards should be compliant with host country laws and regulations. The responsibility for governing the geological pore space into which CO_2 is injected and stored is typically vested into government (but sometimes the surface property owner). In some situations, protection of sub- surface resources may also trigger government permitting and oversight (e.g. groundwater protection). Appropriate permission must therefore be obtained to access and use geologic pore space for the purpose of storing CO_2.	• National laws (e.g. constitution; mineral laws etc that indicate ownership of geological pore space and procedure(s) by which access is conferred to economic operators/private entities). • CDM CCS Modalities and Procedures (requirements outlined in Appendix B)
	05.	EFFECTIVE SITE SELECTION AND DEVELOPMENT	In permitting the use of geological pore space for CO_2 stor- age, the pore space owner should ensure protection of natural resources and public health and safety. The safety and security of storage in a proposed geological storage site must be appropriately demonstrated prior to the granting of access and use permission (through e.g. robust site characterisation and selection reports and development, operation and closure plans).	• National laws and regulations (e.g. mineral or petroleum development laws; environmental protection laws; dedicated geological storage law) • 2006 IPCC Guidelines Volume 2, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage (Requirements in Section 5.10 include reporting of site characterisation and selection, modeling, monitoring plan design, monitoring etc.) • CDM CCS Modalities and Procedures (Appendix B) • ISO Standard 27914:2017 - Geological Storage
	06.	ROBUST OVERSIGHT OF SITE OPERATION AND CLOSURE	Geological storage activities must be operated respecting the conditions specified in storage site permits with appropriate oversight of a competent body (i.e. modes of development, operation and closure).	• National laws and regulations (clarifying the competent authority and their regulatory powers)
	07.	LIABILITY FOR CARBON REVERSAL DESCRIPTION	Responsibility for CO_2 stored in geological formations must be appropriately allocated to ensure that remedial measures are implemented in the event of a leak/carbon reversal from a geological storage site.	• Liability arrangements (e.g. national laws on environmental liability; mineral/petroleum laws; geological CO_2 storage law) • Liability transfer arrangements (e.g. aligned with the cessation of monitoring described in the 2006 IPCC Guidelines Volume 2, Chapter 5) • Non-permanence risk tool (NPRT) applied by registry operator

SAFEGUARD AREA	HIGH LEVEL CRITERIA		DESCRIPTION	EXAMPLES OF EVIDENCE / CHECKPOINTS
ENVIRONMENTAL AND SOCIAL SAFEGUARDS	08.	RISK AND SAFETY ASSESSMENT	Geological domains are inherently heterogeneous, each having unique characteristics that influence the safety, durability and non- permanence risk of storage. Risks from CO2 leaks therefore need to be suitably assessed and managed on the basis of site-specific characteristics within a proposed geological storage site, its surrounding domains and the proposed modes of development and operation. Inherent uncertainty in geological analysis means that this must be based on scenarios of specific features and potential events and processes that could occur at the specific site in order to understand the scale and magnitude of potential impacts (i.e. risks).	• National laws and regulations • ISO Standard 27914:2017 - Geological Storage (Section 6: Risk Assessment) • CDM CCS Modalities and Procedures (Appendix B)
	09.	ENVIRONMENTAL AND SOCIAL IMPACTS	The nature of the impacts of leaking CO2 of an individual project needs to be understood in the context of the scenarios identified in the risk and safety assessment (e.g. communities, natural ecosystems). Measures must be taken to mitigate and mange such risks and impacts.	• National laws and regulations • ISO Standard 27914:2017 - Geological Storage (Section 6: Risk Assessment) • IFC Performance Standards on Environmental and Social Sustainability (Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts)
	10.	SUSTAINABILITY	Sustainability impacts and benefits of an individual project must be appropriately demonstrated (e.g. tangible co-benefits and/or contributing towards multiple United Nations SDGs). Corporate social responsibility should be part of project deployment (as appropriate to the project setting). For example, implementation could be accompanied by community support programmes and knowledge sharing, education and engagement actions relating to climate change and its mitigation through geologic CO2 storage.	• CDM Sustainable Development co-Benefits Tool • ISO Standard 37101:2016 - Sustainable development in communities • Project-level standard requirements for sustainability (e.g. The Gold Standard requirement to deliver on at least 3 SDGs, including climate action (SDG 13))

01 INTRODUCTION

1.1 BACKGROUND

In 2021 the International Emissions Trading Association (IETA) and partners[3] launched a process to establish common principles, criteria and accounting standards for the treatment of geological storage of carbon dioxide (CO2; hereafter, "GCS") within carbon markets, covering CO2 captured from any of fossil ("CCS"), biogenic ("BECCS") or direct air ("DACCS") sources.

The initiative used IETA's global reach and market convening power to bring together key actors into a discussion around the levels of assurance needed to consider GCS methods as effective climate mitigation technologies. Stakeholders engaged in the IETA dialogues included:

- Governments (especially those with significant interests in GCS)
- Carbon market actors (e.g. ACR, Global Carbon Council (GCC), Climate Action Reserve (CAR), Voluntary Carbon Standard (VCS))
- CCS-related initiatives (e.g. the CCS+ Initiative, Global CCS Institute (GCCSI), IEA Greenhouse Gas R&D Programme, Oil & Gas Climate Initiative (OGCI), and International CCS Knowledge Centre)

The intention and expected outcomes were primarily the establishment of key methodological requirements and guardrails that could guide development of future common standards.

Key questions addressed included:

1. How do existing protocols address various methodological aspects relating to GCS?
2. What priorities could be established through common principles for GCS crediting?
3. What unique safeguards are needed in GCS methodologies in addition to existing generic crediting standards?
4. What high-level criteria can guide the development of these safeguards?

The work programme concluded with the launch, in December 2022, of IETA's High Level Criteria for Crediting Carbon Geostorage.[4]

1.2 REPORT OUTLINE

This report describes and updates (to April 2024) the findings of analysis that provided the foundational basis for the high-level criteria for GCS. The findings are structed as follows:

- **Section 2** presents a synthesis of how existing standards and protocols for GCS address various methodological components and summarises the key issues and priorities to address in the development of new GCS crediting standards and protocols.
- **Section 3** reviews the unique risks associated with crediting of GCS activities relative to other types of mitigation activities, and describes the principles, precedents, and practice that evolved over many years of international negotiations to safeguard against such risks. These provide important guidance for future methodological development and featured significantly in establishing IETA's high level criteria for crediting GCS.

THIS REPORT DESCRIBES AND UPDATES THE FINDINGS OF ANALYSIS THAT PROVIDED THE FOUNDATIONAL BASIS FOR THE HIGH-LEVEL CRITERIA FOR GCS.

02 PROTOCOLS AND STANDARDS: A SYNTHESIS

2.1 GEOSTORAGE AND CARBON CREDITING

Capture and geological storage of CO_2 presents some unique methodological features compared to other types of project-based activities and methodologies: principally, most types of climate mitigation technologies avoid the formation of CO_2 by replacing emissive activities with substitutes performing a similar function. Conversely, activities involving GCS reduce the CO_2 emissions (or atmospheric stocks of CO_2) by the engineered capture and injection of CO_2 to enhance geological carbon sinks and reservoirs. Such activities can lead to increases in the formation of CO_2 due to the energy and materials requirements for capture, transport and storage. Thus, it remains vital that:

1. Monitoring and accounting boundaries are appropriately drawn so as to include the full range of GHG effects arising from a specific GCS activity (i.e. to avoid leakage effects that can arise when emissions attributable to the activity occur outside the activity boundary and are not appropriately recorded), and
2. The captured CO_2 injected into an enhanced geo-sink remains in place for a significant (permanent) period of time in order not to reverse the ongoing effectiveness of the initial climate change mitigation effect (i.e. the risk of non-permanence and carbon reversal; see Section 3).

Standard setters, in establishing methodologies, must therefore seek reasonable assurance (hereafter referred to as Quality Assurance and Quality Control or "QA/QC") that the environmental integrity of any credits that they issue to GCS project operators today are not, or will not become, compromised by leakage effects or the future reversal of the reduction or removal effect. Furthermore, the residual risk of carbon reversal in an underlying project activity must be decoupled from issued credits in order to allow for equivalence and fungibility with other units in carbon markets.

This section outlines how the unique methodological components relating to non-permanence and liability, alongside more conventional aspects of project-based methodologies (e.g. boundaries, baselines, additionality etc), are managed under existing protocols and methodologies.

A range of relevant protocols, standards and other sources have been reviewed and synthesized to provide a foundational basis for methodological components to be applied to the crediting of project activities involving GCS (Table 1).

2.2 METHODOLOGICAL COMPONENTS

Key terms and definitions. The unique nature of GCS activities gives rise to some specific terms and definitions that need to be clearly and carefully formulated to ensure their use is consistent and aligned with international standards and other best practice. Existing methodologies, protocols and rules provide significant guidance to draw upon in this respect.

Applicability/eligibility conditions. These set out the specific circumstances, attributes and other conditions that apply to activities wishing to apply a given methodology. For GCS related activities, these can include the eligible sources of CO_2 being captured (e.g. which types of CO_2 and from which sectors, both of which have implications for baseline selection; see below), the modes of transport, the allowable geological storage media (e.g. deep saline formations; depleted hydrocarbon fields; eligibility for enhanced oil recovery) and restrictions on the utilisation/beneficial use of CO_2 for purposes other than geological storage (e.g. CO_2 for manufacture of chemicals). Specific restrictions on the geographical setting can also be applied.

In addition, 'conditions of use' may be established that impose certain technical requirements on project operators applying the methodology.[5]

Project boundary. Describes all the emission sources to be included across the project chain (capture, transport, storage) deemed to be under the control of the project participant(s) and that are significant and reasonably attributable to the project activity. May include temporal as well as physical boundaries.

Storage site characterisation and selection. Outlines the steps required to characterise and select the proposed GCS site in order to demonstrate, among others, that there is sufficient capacity to store the intended mass/volume of CO_2 over the lifetime of the operation, injectivity to accept CO_2 at the required rate, and containment to ensure that the CO_2 will not leak from the storage unit.

Baseline emissions. Sets out the procedures and options to establish the baseline scenario, and the methodology for calculating baseline emissions against which reductions and/or removals arising from the activity are quantified. Options include projection-based approaches (e.g. historical or estimated future emissions from the activity) and/or standards-based approaches (e.g. using performance benchmarks for the activity where the CO_2 is captured from). The latter can make use of existing methodological tools (e.g. CDM TOOL07).[6]

Additionality. A project is deemed additional only if it delivers emission reductions or removals over and above what would have occurred in the absence of the incentive offered by crediting the activity. Protocols make use of different approaches and tests to demonstrate the additionality of projects. Unlike some other mitigation technologies, GCS projects generally only impose financial costs to operators and are undertaken for the sole purpose of climate mitigation; however, the presence of relevant CCS or carbon removal regulation, economic incentives and/or potential revenue generation from use of captured CO_2 may warrant that candidate project activities be subject to an assessment of their additionality.

Project emissions. Describes the methods for measuring and quantifying the emissions sources occurring inside the project boundary that shall be compared to the baseline. For GCS related activities

STANDARD SETTERS NEED REASONABLE ASSURANCES THAT THE INTEGRITY OF CREDITS WILL NOT BE COMPROMISED BY FUTURE REVERSAL OF THE REDUCTION OR REMOVAL EFFECT

TABLE 1: PROJECT-BASED METHODOLOGICAL STANDARDS COVERED IN THE REVIEW (AT 04/2024)

STANDARDS BODY	METHODOLOGY/STANDARD/PROTOCOL	VERSION	SOURCE
Alberta Emission Offset System	Quantification protocol for CO_2 capture and permanent storage in deep saline aquifers	06/2015	https://open.alberta.ca/publications/9780778572213
ACR	Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals from Carbon Capture and Storage Projects	v.1.1 (v2.0 coming soon)	https://acrcarbon.org/wp-content/uploads/2023/03/ACR-CCS-v1.1.pdf
British Columbia Offset Programme	Carbon Capture and Sequestration (CCS) Protocol (draft)	10/2023	https://www2.gov.bc.ca/assets/gov/environment/climate-change/offsets/offsets-portfolio/draft_ccs_protocol.pdf
Gold Standard	Methodology for Biomass Fermentation with Carbon Capture and Geologic Storage	10/2023	https://www.goldstandard.org/sites/default/files/documents/bfccgs_methodology_draft_for_tac_review.pdf
Puro.earth	Draft Geologically Stored Carbon Methodology	Draft 2024 edition	https://puro.earth/blog/our-blog/geologically-stored-carbon-call-for-public-consultation
Verra - Verified Carbon Standard (VCS)	**1.** Methodology for Carbon Capture and Storage **2.** Module for CO_2 Capture from Air (Direct Air Capture) **3.** Module for CO_2 Storage in Saline Aquifers **4.** Module for CO_2 Transport **5.** Module for CO_2 Capture from Bioenergy Combustion **6.** Module for CO_2 Storage in Saline Aquifers and Depleted Hydrocarbon Reservoirs **7.** Geologic Carbon Storage (GCS) Requirements, v.4.0 **8.** Geologic Carbon Storage Non-Permanence Risk Tool, v4.0	06/2023 to 03/2024	https://verra.org/methodologies/methodology-for-carbon-capture-and-storage/
Global Carbon Council	**1.** Methodology for Project Activities Involving the Capture, Transport and Geological Storage of Carbon Dioxide **2.** GCC Guidance for Geological Storage V01	04/2024	https://www.globalcarboncouncil.com/standards/baseline-monitoring-methodologies/#methodologies-for-public-call
Isometric	**1.** Direct Air Capture (v1.0) [Protocol] **2.** CO_2 Storage in Saline Aquifers (v1.0) [Storage Module]	02/2024 03/2024	https://registry.isometric.com/protocols
UNFCCC	Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities (CDM CCS M&Ps) Decision 10/CMP.7	2011	https://unfccc.int/files/meetings/durban_nov_2011/decisions/application/pdf/cmp7_carbon_storage_.pdf
IPCC	2006 IPCC Guidelines (Volume 2, Chapter 5)	2006	https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

project emissions include combustion emissions sources inside the project boundary, emissions relating to any bought in heat and/or electricity, CO2 leaks across the chain of activities, including any potential 'seepage'[7] from the storage site.

Leakage. Describes the methods for measuring the net change in GHG that occur outside of the project boundary and that are measurable and attributable to the project activity. Leakage associated with GCS activities can include emissions from incremental fossil fuel production that is needed to cover the energy requirements for CO2 capture, transport and injection, or any land use change effects resulting from the demand for biomass as a source of energy (for BECCS). Some protocols may also refer to leakage in the context of the movement of CO2 outside of the pre-defined limits of a subsurface store and its potential release to the atmosphere.

Monitoring. Sets out the requirements for project monitoring. For GCS activities this includes both the operational and post-injection phases, and various surface and sub-surface aspects including the provision of QA/QC over the security of storage, early warning of irregularities and the risk of leaks, and the quantification of leaks if they are detected. Unlike conventional emission reduction or removal activities, a more complex stepwise procedure can be expected to be required involving the design of a sub-surface monitoring plan with appropriate QA/QC aspects and a range of details specific to the proposed storage site (e.g. technology types, locations, frequency of application).

Non-permanence and liability for CO2 reversal. GCS projects could in some cases experience a reversal of storage (a leak or seep) of stored CO2 back to the atmosphere at some point in time either during or after project operation. If leaks occur during the crediting period, liability generally lies with the project operator to make good the damage caused (e.g. by drawing down on a buffer account or buying recognised credits from elsewhere)[8]. If a leak occurs after the crediting period, then liability for the emissions needs to be effectively allocated to maintain the environmental integrity of the issued credits.

Environmental and social impacts. Describes any requirements for undertaking environmental and socio-economic impact assessments across the project chain and relevant environmental media (e.g. air emissions, solid waste generation, water use), and including plans in the event of any foreseen negative environmental or community impacts.

Sustainability. Describes any requirements for demonstrating the sustainability of proposed CCS projects based on contributions made towards achieving the United Nations Sustainable Development Goals (SDGs) or other specified sustainability goals/criteria (e.g. in relation to biomass fuels).

2.3 SYNTHESIS OF EXISTING METHODOLOGIES

A detailed breakdown of each reviewed methodology is presented in Annex A.

In Annex B, a review of the relevant parts of the 2006 IPCC Guidelines is provided. This IPCC guidance does not relate directly to specific methodological components of project-based standards, but rather indicates the measurement, reporting and verification (MRV) requirements for countries to follow when hosting GCS projects activities. As such, they offer valuable guidance on the design of project-level standards that can ensure that such activities can be counted towards the host country's climate mitigation goals (e.g. in pursuit of nationally determined contributions; NDCs).

Thefollowing sections provide a synopsis of the key methodological features arising from the review and reflects on potential best practice for the design of methodological components for mechanisms that can be used under Article 6 of the Paris Agreement.

2.3.1 Applicability conditions

Existing protocols vary considerably in terms of applicability conditions and eligible activities.

The Alberta protocol and ACR adopt broad scopes of application covering industrial (hydrogen production, gas sweetening, cement production) and non-industrial CO2 sources (e.g. electric generating facilities), with ACR also including direct air capture (DAC). The British Columbia [draft] Protocol is seemingly agnostic to the source of CO2, suggesting widespread applicability.

Puro.earth, Gold Standard and Isometric methodologies apply only to removals. Puro.earth includes biogenic CO2, DAC and potentially also waste-to-energy emissions.[9] Gold Standard is limited to the capture and storage of CO2 in fermentation off-gas from biomass refining. Isometric has so far published a DAC Protocol and has a Biogenic Carbon Capture and Storage Protocol under development. Verra (CCS+) seeks to establish a modular approach covering a wide array of configu-rations – various capture sources, transport modes, and storage types – but has so far published specific guidance only for DAC and a module for bioenergy combustion.

In respect of storage, some methodologies do not constrain the allowable storage media types (e.g. GCC, British Columbia). The Alberta CCS Protocol requires the use of deep saline aquifers capable of permanently storing CO2 gases.[10] ACR is unique in being only applicable to operational EOR activities (but is in the process of expanding its scope in a forthcoming methodology v2.0). The other methodologies do not presently allow for EOR, and Gold Standard does not allow for storage in depleted oil and gas reservoirs. Verra (CCS+) has so far published storage modules for saline aquifers and depleted hydrocarbon reservoirs.

The Alberta, British Columbia [draft] and ACR methodologies are geographically limited to Alberta, British Columbia and the U.S. and Canada, respectively. Puro.earth and Isometric imply global applicability, but also set expectations regarding the site permitting and prevailing legal regime for the geological

storage. Similarly, Verra (CCS+) and Gold Standard do not impose specific geographical restrictions, but both require that projects be (i) located in a jurisdiction where regulatory oversight is provided by the government or a government-appointed agency and (ii) established under a regulatory program that meets certain minimum criteria specified therein.[11] As such, Puro.earth, Isometric, Verra and Gold Standard establish partial or de facto geographical restrictions (because of the low number of countries worldwide that have established dedicated GCS regulatory programs). The GCC methodology implements a slightly different hybrid by providing guidance on procedures and documentation for GCS that could help local regulators to permit a site in the absence of dedicated regulatory frameworks (see Section 2.3.5). The approach of Verra and Gold Standard could also be interpreted to offer similar latitude, depending on how the term 'regulatory program' is interpreted, while Puro.earth also allows projects in jurisdictions where the local regulatory framework meets its "robustness" requirements.

These conditions have implications for the extent to which lessons can be learned for guiding principles for GCS, not only in respect of applicability, but also in respect of the following:

- **Baselines.** Any limitations on the scope of eligible CO2 capture sources under a methodology will determine the extent to which baseline choices must be elaborated. For example, because the Puro.earth standard applies only to removals, it avoids complex baseline considerations by assuming all injected CO2 would otherwise remain in the atmosphere (see Section 2.3.3 below).[12] Conversely, both ACR and GCC contain more complex procedures for determining the baselines for various types of CO2 emitting activities, including grid-connected electric generating facilities. More complex formulations may also apply where the underlying activity from which CO2 is captured could be replaced by alternative processes that do not generate any CO2.
- **Non-permanence and longer-term liability in case of carbon reversals.** Applying geographical limitations significantly simplifies methodological requirements for the management of non-permanence and long-term liability for carbon reversal. This is because laws, regulations and permitting requirements in the jurisdictions to which the limitation applies allows aspects such as site selection and regulatory monitoring to be excluded from the scope of the methodological framework. Global application, by contrast, requires such aspects to either be addressed in the methodology itself or else through reference to specific jurisdictions (as in the case of Isometric, which cites EU and US laws). As noted above, Verra (CCS+), Gold Standard, GCC and Puro.earth establish a hybrid approach to GCS regulation by setting de minimus requirements for oversight by a government regulator or agencyt appointed by government.

The CDM CCS M&Ps also contains several limitations (e.g. exclusion of projects from international waters) and perhaps most critically, a 'conditions of use' term, which can be employed in the applicability conditions to trigger various obligations within a methodological framework.

LIMITING TECHNICAL APPLICABILITY OF METHODOLOGIES CAN SIMPLIFY BASELINE APPROACHES

Many registry operators restrict the applicability of their GCS methodologies, both technically and geographically. The second mainly relates to the quality of the regulatory program in place, which acts to manage the QA/QC requirements for managing non-permanence risk and liability for carbon reversal over the long term.

Following in the footsteps of CDM, registry operators seeking to set standards today are increasingly providing guidance on the expectations for regulatory approvals of GCS activities (e.g. Verra (CCS+), Gold Standard, GCC and Puro.earth).

These systems have yet to be tested, and some open questions remain as to whether the hybrid approaches can result in robust oversight systems that provide sufficient assurance to registry operators and validation and verification bodies (VVBs) regarding the quality of CO2 storage, especially in the post-injection phase.

2.3.2 Project/activity boundary

Project or activity boundary and covered emission sources are generally straightforward to define for GCS projects. Some variations exist in the way certain emissions sources are included or excluded by standard setters, however. For example:

- The Alberta protocol includes the embodied carbon in the chemicals used for CO2 capture (e.g. amines) as an emissions source in the project activity, whereas ACR doesn't mention this.
- Puro.earth adopts a lifecycle type approach in the quantification methodology, requiring consideration of lifecycle emissions following the biomass supply-chain emission quantification.[13]
- Verra (CCS+) and Gold Standard take a narrow perspective of the boundary, encompassing the project site where CO2 is captured, transported and stored. Any emissions attributable to the project outside of this boundary (e.g. upstream, relating to emissions embodied in bought in energy and materials) are treated as leakage emissions. GCC and CDM exclude embodied emissions relating to bought-in materials, but also treat biomass sourcing as leakage in a similar way to Verra and Gold Standard.
- Isometric requires many detailed life-cycle GHG effects to be measured across the project during implementation, following the wide of suite modules prepared under the standard.[14]

Methodological choices therefore arise in respect of how to treat lifecycle GHG effects.

All reviewed protocols include the subsurface geological CO2 storage site boundary within the project boundaries.

The ACR protocol describes a temporal boundary, and places obligations for post closure monitoring therein, whereas the Alberta protocol relies on the site permit to handle longer-term liability.

Protocols vary in terms of how they manage the broader lifecycle aspects related to matters such as embodied carbon in products and equipment used within the project boundary. Several standards include external emission sources as leakage.

Protocols also vary in terms of temporal boundaries, which is a key issue for GCS activities given ongoing residual risks of carbon reversal. Post-injection monitoring is therefore needed to limit the risk of non-permanence and carbon reversal (see below). These longer-term risks can either be managed through separate obligations imposed through monitoring, or through explicit inclusion of temporal boundaries in the methodology.

2.3.3 Baseline scenario and baseline emissions

The ACR protocol is unique in allowing for baseline emissions to be calculated using either projection-based or standards-based approaches. The GCC methodology also applies similar approaches, depending on various factors (e.g. the source of CO2 and the age of plant in respect of whether it is new build or retrofit etc). Most other methodologies apply only a projection-based approach (e.g. based on a forward projection of historical emissions).

Projection-based approaches use historical or actual data to determine the baseline emissions based on the assumption that everything injected would otherwise be emitted to or remain in the atmosphere. In the Alberta CCS Protocol and the British Columbia Protocol, the baseline is established according to the mass of CO2 injected into the reservoir irrespective of CO2 source. In the case of Puro.earth, Isometric, Verra (CCS+; DAC module) and Gold Standard, because they apply to removals only, the amount of CO2 injected is also applied as the baseline emissions with the assumption that this is equal to the amount of CO2 that would otherwise remain in the atmosphere in the absence of the project activity. In addition, Puro.earth and Verra (CCS+; bioenergy module) explicitly or implicitly include variations on the baseline scenario for BECCS projects depending on whether the activity applies to an existing or new-build facility. This affects the treatment of upstream emissions from biomass supply in the project emissions calculation (e.g. excluded for existing facilities).

Standards-based approaches use a benchmark to determine the baseline emissions. The benchmark is based upon an activity providing an equivalent service or function as the source of CO2 in the underlying activity (e.g. a standard emission factor for a cement plant as opposed to the actual mass of CO2 captured from the plant in the project activity). These methods can be used to address concerns over the possibility of incentivising inefficient and/or carbon

USING ONLY A PROJECTION-BASED APPROACH, OR LIMITING APPLICABILITY TO REMOVALS ONLY, SIGNIFICANTLY SIMPLIFIES METHODOLOGICAL ASPECTS OF GCS STANDARDS.

intensive activities instead or promoting alternative forms of production. A standards-based approach can be considered more conservative: it can avoid over-crediting inefficient plant because the baseline is set according to a benchmark for CO2 generation in the underlying (CO2 source) activity, rather than the actual amount of CO2 generated. Baselines emissions determined through benchmarks can also better accommodate situations where the energy penalty of retrofitting CO2 capture to an existing plant has impacts upon the efficiency of the underlying activity (e.g. fuel boilers in electric power plants).

Using only a projection-based approach, or limiting applicability to removals only, significantly simplifies methodological aspects of GCS standards. In contrast, including a standards-based approach can support wider applicability across multiple activities and sectors, but increases the complexity and poses some issues. For example, the ACR protocol draws upon U.S. State and Federal proposals for emissions performance standards to guide the standards-based (benchmark) for CCS in electric generating facilities. This benchmark may not be relevant to other jurisdictions. Under the CDM, for example, the combined margin approach was rather used to determine the baseline for CO2 capture when applied to electric generating facilities, an approach also adopted in the GCC methodology for grid-connected power plants.

A baseline established using a standards-based benchmark, in being conservative, may significantly reduce the level of credits compared to projection-based methods, which could prove problematic. Reducing the baseline for CCS activities and therefore the number of credits that project could generate, could undermine the economic viability of a GCS activity. Such effects will generally be jurisdiction-specific, according to the regionally relevant benchmark for a given activity (e.g. emissions intensity of cement or power generation). Such effects will also have impacts on any financial additionality assessment (see below).

Notably, ACR recommends that the most conservative of either a projection- or standards-based approaches should be adopted.

There are important interactions between baseline approaches and applicability conditions, whereby the more technologies that can apply the methodology, the greater the complexity of baseline methodology design.

Standards-based approaches can widen applicability but can be complex to set in many sectors and create challenges for determining an appropriate standard. They can also significantly influence and erode the potential amount of credits that could be issued to some CCS activities.

Protocols focused on removals only generally avoid the need for baseline considerations and associated challenges (e.g. Isometic, Verra (CCS+; as published so far), Puro.earth).

2.3.4 Additionality

Current methodologies and standards show some minor variations in their approach to additionality demonstration. However, they generally all tend towards following methods established within the CDM framework, for example:

1. Does the activity exceed regulatory requirements? The so-called regulatory surplus test.
2. Is the activity the most economically attractive course of action, taking into account barriers? The financial additionality test.
3. Is the activity common practice in the local and regional context? The common practice test.

ACR's methodology draws upon the typical 'regulatory surplus' test and a type of 'best in class' or 'front runner' type test (e.g. environmental additionality based on common practice analysis).[15] Verra (CCS+), Gold Standard, British Columbia [draft] and Isometric varyingly apply regulatory surplus testing, financial additionality and common practice analysis. Most standards draw directly or indirectly upon principles and approaches established under the CDM (e.g. TOOL01[16] and TOOL02[17]). For example, GCC applies a CDM-based approach following the TOOL01. The Puro.earth Standard applies a general requirement for additionality assessment for all projects on the registry, based on proof of both financial and regulatory additionality in a similar way as the CDM.

The Alberta Protocol is unique in making only limited reference to additionality, and rather suggests this aspect to be part of any future evaluation of the protocol. Therefore all projects registered under the protocol are implicitly assumed to be additional.

Different approaches are adopted within existing protocols ranging from an implicit assumption of additionality to more bespoke, project-specific, additionality assessments.

2.3.5 Project and leakage emissions

Project emissions and leakage emissions are the emission sources that are measured during project implementation and counted against the baseline (or measured removals) so as to estimate the net GHG effectiveness of a GCS activity. The covered sources are determined by the project or activity boundary.

Most of the methodologies cover the same emissions sources, including fossil emissions relating to heat and/or electricity used to capture, transport and inject CO2. However, other variations exist across the suite of methodologies. For example, both CDM and GCC exclude upstream GHG effects (e.g. embodied emissions) associated with the supply of materials for a project, and generally do not require the upstream emissions associated with the extraction and supply of fuel or energy imported to a project site to be in-

THE RESIDUAL RISK OF CARBON REVERSAL IN AN UNDERLYING PROJECT ACTIVITY MUST BE DECOUPLED FROM ISSUED CREDITS IN ORDER TO ALLOW FOR EQUIVALENCE AND FUNGIBILITY WITH OTHER UNITS IN CARBON MARKETS.

cluded. However, most methodologies require GHG effects such upstream emissions and emissions embodied in bought-in goods (e.g. capture chemicals) to be included. Both Puro.earth and Isometric also include emissions arising from energy used during geological storage site monitoring.

All methodologies covering BECCS consider leakage effects such as land use change potentially driven by biomass use.

The GCC methodology takes a different approach to storage site monitoring than the other methodologies. It specifies three components of storage site monitoring that could lead to project emissions, namely: conditions of use; CO2 migration analysis; storage site architecture.

> There is an emerging trend within methodologies towards increasingly stringent environmental accounting, such as including the emissions from storage site monitoring, seemingly drawing from lifecycle analysis type frameworks. Accurately estimating the full lifecycle of potential project emissions can be challenging and may lead to overlaps and double counting across different regulatory and reporting systems.

2.3.6 Non-permanence and liability for carbon reversals

Standard setters need assurances that the environmental integrity of the credits that they issue to GCS project operators today do not become compromised by the future leaks of stored CO2 that reverse the emission reduction or removal effect.

The methodologies reviewed indicate that standard setters are managing this risk through various methodological approaches, including (i) upfront QA/QC requirements on the selection, operation, closure and post-closure of GCS sites, and (ii) the establishment of mechanisms for the ongoing management of short- and long-term liability for remediating climate impacts in the event of carbon reversal.

General QA/QC requirements

All standards generally set the following QA/QC requirements:

- Appropriate GCS site selection.
- Effective oversight of GCS site operations, including post-injection requirements and site closure standards so as to reduce the risk of leaks occurring (in particular, effective monitoring of site performance).
- Allocation of liability for the GCS site, especially over the longer term.

Variations exist in the way methodologies are implementing these QA/QC requirements.

In the case of ACR, Alberta and British Columbia [draft] the protocols do not offer significant guidance on QA/QC for GCS site selection and operation. They instead rely on Canadian and U.S. federal and provincial/state regulations to backstop such requirements. As such, QA/QC aspects largely fall outside of the direct scope of the methodology. These methodologies therefore also apply geographical limitations in the applicability conditions, as noted above. Similarly, the Isometric DAC Protocol refers to application of EU or U.S. regulation in respect of storage site selection and management and reiterates these QA/QC requirements.

Under the CDM CCS M&Ps, Parties to the Kyoto Protocol agreed that non-Annex I parties wishing to host GCS activities under the CDM may only do so if they had established laws or regulations that, inter alia:

- Set procedures for appropriate selection, characterization and development of GCS sites
- Define means by which to confer rights to store CO2 in, and gain access to, subsurface pore space,
- Provide for timely and effective redress for affected entities and remedial measures in the event of leaks, and
- Establish means for addressing liability arrangements for GCS sites.

Technical guidance on these matters is also provided in Appendix B of the CDM CCS M&Ps.

The more recent methodologies from Verra (CCS+), Gold Standard and Puro.earth (draft, 2024 edition), in contrast to earlier VCM standards, offer a something of a hybrid approach that is more reflective of the CDM. Their methodologies provide substantial technical QA/QC guidance in respect of matters such as site selection, well design, operation, post-injection and closure. The QA/QC benchmark is not presented as direct requirements for project developers applying the methodology, but rather framed as a benchmark for laws, regulations and regulatory oversight that is expected to be implemented and undertaken by any country wishing to host a project applying the methodology. Thus, in applying these methodologies, entities will also require, inter alia, evidence of government/government agency regulatory oversight, evidence of access and tenure rights to the pore space in the GCS site, and the need for operators to maintain dedicated permits for their GCS operations. Some uncertainty persists over who is responsible for judging the robustness of national laws and regulations relative to the benchmark. Puro.earth (draft) is explicit in reserving the right to “determine the eligibility of a legal framework”.

HYBRID APPROACHES TO LOCAL REGULATORY REQUIREMENTS ARE AN EMERGING FEATURE FOR GCS METHODOLOGIES

THE 2006 IPCC GUIDELINES CAN HELP TO BUILD THE CASE WITH LOCAL STAKEHOLDERS TO ESTABLISH SOLID STANDARDS TO ADDRESS NON-PERMANENCE RISKS.

The GCC methodology also adopts a similar hybrid QA/QC approach, but with modifications. The methodology proposes technical QA/QC requirements as tasks to be implemented by a project developer but leaves discretion regarding the specific type of permit that could be issued by a local authority (i.e. the permit would not necessarily need to be issued under dedicated GCS laws and regulations). To support the more flexible approach, the GCC provides technical guidance for GCS selection, operation, closure and monitoring etc. and also specific reporting protocols and templates for project developers to follow. The templates serve to fill potential gaps in local permitting regimes in host countries where dedicated GCS laws and regulations are locally absent. In such situations, GCS operations could be permitted under parallel, analogous, regulatory frameworks while following the technical guidance provided.

The variation in QA/QC requirements across methodologies suggests that wider deployment and accelerated scale-up of GCS technologies will require standard setters to continue seeking a good balance between ensuring sufficiently high environmental quality standards while maintaining widespread applicability to a range of potential host country circumstances.

The 2006 IPCC Guidelines can help to build the case with local stakeholders to establish solid standards to address non-permanence risks. Therein, good practice for GHG inventory compilers includes determining whether 'an adequate geological site characterization report has been produced for each storage site', whether 'the operator has assessed the potential for leakage at the storage site' and whether 'each site has a suitable monitoring plan' (Annex B). As such, crediting methodologies should seek to dovetail QA/QC requirements with national GHG inventory reporting approaches to allow for GCS related activities to be accounted for appropriately in national GHG reports. In particular, alignment of methods will be critical in supporting robust international transfers of mitigation outcomes (see below).

Short-term liability for reversals (operational phase)

If CO2 leaks from a GCS site during a crediting period (i.e. in the operational phase), all methodologies require those leaks to be measured and reported as project emissions.

In circumstances where the scale of a leak exceeds the level of reduction or removals occurring within a monitoring period, a reversal, a carbon reversal, or a net reversal of storage can be considered to have occurred (i.e. emissions were higher than reductions or removals for that same period, leading to net climate change impacts). Aside from requirements to suspend any ongoing injection operations until the leak is repaired or corrected, methodologies typically require a carbon reversal to be remediated by acquiring and retiring reduction or removal credits.

To support remediation requirements, some standards apply a buffer pool; namely Verra, Gold Standard, British Columbia [draft], the CDM, GCC and Isometric. The buffer pool is a withheld credit reserve taken from all GCS projects registered with particular registry, which can be called upon to remediate carbon reversals. The size of individual project contributions to the buffer pool are either fixed (e.g. CDM at 5%) or determined through a risk assessment procedure/tool (e.g. Verra, Gold Standard and British Columbia [draft], the latter by reference to the California LCFS CCS Protocol). The buffer pools are typically applied at the registry level for all similar projects, rather than being a project specific buffer (which would otherwise not be a risk pooling instrument). The GCC proposes to apply a buffer but has yet to define how it will function.

Neither Alberta nor Puro.Earth employ a buffer pool for GCS activities, while ACR applies a reserve account to address the risk of reversal.

Long-term liability for reversals (post-injection phase)

Establishing arrangements for long-term stewardship of GCS sites relates to allocating liability for carbon reversals in the post-injection phase, as well as any other impacts of CO2 leaks. The matter is handled somewhat unevenly across the current suite of GCS methodologies.

Both Verra and Gold Standard require a site closure plan to be established but refrain from prescribing precise conditions for continuing and/or terminating monitoring activities in the post-injection phase. The expectation seems to be that these conditions will be defined by the local permitting regime and through the approaches prescribed in the site closure plan. GCC similarly requires the preparation of a site closure plan, and also requires a preliminary plan to be part of the documentation prepared for registration. Puro.earth requires that post-closure monitoring be undertaken until the transfer of responsibility to a national entity. Isometric notes the conditions for long-term liability under U.S. and EU laws and regulations.

Both ACR and GCC propose a minimum of 5 years post closure monitoring by the project owner (with attendant liability for any carbon reversal), and, in addition, variously require either/or:

- An extension of 5 years' post-closure monitoring if "no leakage" cannot be assured after the first five years (ACR). ACR is updating its methodology to a "plume stability" assessment rather than "no leakage" demonstration (forthcoming in methodology v2.0).
- Extension by a further 2 years thereafter on a rotational basis until "no leakage" assurance is achieved (ACR and GCC).

Alberta, GCC and Puro.earth methodologies are explicit in stating that the host jurisdiction/country is expected to take on long-term liability for the project GCS site. The former two also explicitly mention that the requirement for remediation in the event of any carbon reversals will fall upon the host jurisdiction/country government:

- Alberta states that liability will be assumed by the Government of Alberta after the issuance of the Closure Certificate to the operator.
- GCC proposes that, once monitoring indicates that the risk of seepage is sufficiently low and that permanent storage is highly likely to be achieved, site closure can occur and monitoring can be discontinued. Thereafter, in line with 2006 IPCC Guidelines, the host country shall be liable for undertaking any future monitoring (as per paragraph 4(v) of Volume 2, Chapter, 5, Section 5.7.1 in line with Paris Agreement requirements).[18]

The accounting of any GCS site leakage as emissions in national GHG inventories ensures that a trigger for remediation exists and environmental integrity is maintained (i.e. in respect of the accounting of emissions against the host country emission reduction targets set out in its NDC). In other words, reductions, removals, and also any subsequent re-emissions of CO2 from storage all need to be counted by host countries in respect of accounting for progress against NDCs.

The Paris Agreement rulebook re¬quires that 2006 IPCC methods be followed applied in the following relevant ways:

1. Guidance on cooperative approaches under Article 6.2[19] requires that mitigation outcomes be measured using the methodologies and metrics assessed by the IPCC.
2. The modalities, procedures and guidelines for action and support under Article 13[20] obliges parties to follow 2006 IPCC Guidelines in their national GHG reporting from 2024.

Consequently, host governments wishing to report and count GCS related activities towards their NDCs, or to transfer such mitigation outcomes to other Parties for them to count towards their NDCs, will need to follow the best practice under 2006 IPCC and relevant updates. As such, a de facto host country liability backstop for carbon reversals exists within the Paris Agreement architecture.

GCS methodologies have tended to rely on local laws and regulations to backstop the liability for non-permanence and carbon reversal through geographical restrictions in applicability conditions.

In contrast, the CDM CCS M&Ps adopted regulatory safeguards to be followed by host countries, although these were never implemented at the methodological level. Verra, Gold Standard, GCC and Puro.earth have taken cues from the CDM CCS M&Ps to propose more hybrid approaches that set expectations for host country laws and regulations or prescribe best practice to support permitting.

Greater alignment across methodologies, including in relation to existing legal precedents, for the conditions under which liability transfer may occur could help enhance confidence in the environmental integrity of GCS standards.

Any methodology needs to strike a balance between integrity/quality, complexity, and administrative burden.

2.3.7 Environmental and social impacts, and sustainability

Most standards include general requirements for environmental and social safeguards, as well as sustainable development requirements, although there is some variation across the methodologies.

Verra, Gold Standard and Puro.earth indicate various requirements to safeguard against environmental, social and sustainability impacts. Gold Standard, for example, proposes a 9-point sustainability assessment approach. GCC sets out specific environmental and social risk assessment and reporting procedures in the accompanying GCC Guidance for Geological CO2 Storage v1.0.

Both Puro.earth and Verra (CCS+) set requirements for ensuring the sustainability of biomass, covering sustainability principles and traceability requirements. Both standards provide significant guidance on the sourcing of biomass.

The CDM CCS M&Ps specifically require that a comprehensive and thorough risk and safety assessment be carried out in order to assess the integrity of the GCS site and potential impacts on local communities and ecosystems in proximity to the proposed project activity. They outline the environmental media and specific risks to be included, alongside a requirement to employ best available techniques.

Neither the Alberta nor British Columbia [draft] use the protocols to directly address environmental and social impacts. However, projects developed under these protocols are subject to the relevant assessment requirements/regulations in place in the respective jurisdictions.

Similarly, ACR refers to Federal and/or State level requirements for EIA and obliges project participants to make these documents available upon request. ACR also requires project proponents to document a mitigation plan for any foreseen negative community or environmental impacts and to disclose any negative environmental or community impacts made during the reporting year. ACR also has a public comment process for all projects.

COUNTING GCS RELATED ACTIVITIES TOWARDS NDCs WILL REQUIRE PARTIES TO FOLLOW BEST PRACTICE UNDER THE 2006 IPCC GUIDELINES AND RELEVANT UPDATES

As with permanence, Alberta, British Columbia [draft] and ACR rely on local regulations to address the need for environmental and social impact assessment and impact mitigation.

Puro.earth and the CDM CCS M&Ps address environmental and social impacts at the methodological level, with details of the impacts to be assessed.

Gold Standard and GCC both set detailed environmental and social risk and impact assessment requirements.

2.3.8 Double counting

The risk of double counting, or double claiming, may be possible where a GCS project involves more than one Paris Agreement country Party, and may be complicated particularly in the case of transboundary projects. However, double counting is not an issue specific to CCS or engineered carbon removals and is rather addressed through the 'corresponding adjustments' requirement under Article 6 of the Paris Agreement.

In circumstances where credits from a GCS project activity are acquired by a corporation to make certain claims, and the same associated reductions or removals are also recorded in the national GHG inventory of the host jurisdiction/country, this is nesting rather than double counting or claiming. Where corporate credit acquisition involves cross-border transactions, double counting issues may arise if such trades are not backed by parallel government-to-government Article 6 trades with corresponding adjustments. This is again not an issue specific to CCS or engineered carbon removals, but rather a wider issue that needs to be addressed in respect of the interactions and accounting between all voluntary and government-to-government carbon market trading.

Of the methodologies reviewed, Puro.earth is notable in requiring developers to provide evidence of no double counting or double claiming. Examples of evidence include attestations from the parties involved in the entire GCS chain.

Double counting is not a GCS-specific issue. The risk of double-counting is unlikely to pose issues unless transboundary projects are allowed, and this should be addressed through the Paris Agreement's requirement to apply corresponding adjustments for transfers of mitigation outcomes.

2.3.9 Transboundary projects

Existing methodologies and protocols do not address possible issues posed by the transboundary movement of CO_2 in a GCS project activity (which may occur either intentionally or unintentionally). Some work was undertaken within the CDM to address the issue,[21] although the matter was never fully concluded by Parties[22] (see also Annex B, Section B-3).

Issues relating to, inter alia, permitting of cross-border storage sites, unintentional cross-border migration of CO_2 in the subsurface, leaks from storage sites occurring across borders, and possibilities for double counting represent difficult subjects that are primarily legal in nature rather than methodological. The 2006 IPCC Guidelines provide guidance for how such movements of CO_2 should be recorded by national GHG inventory compilers (see Annex B-3).

03 SAFEGUARDS: PRINCIPLES, PRECEDENTS AND PRACTICE

3.1 GEOSTORAGE AND RISK

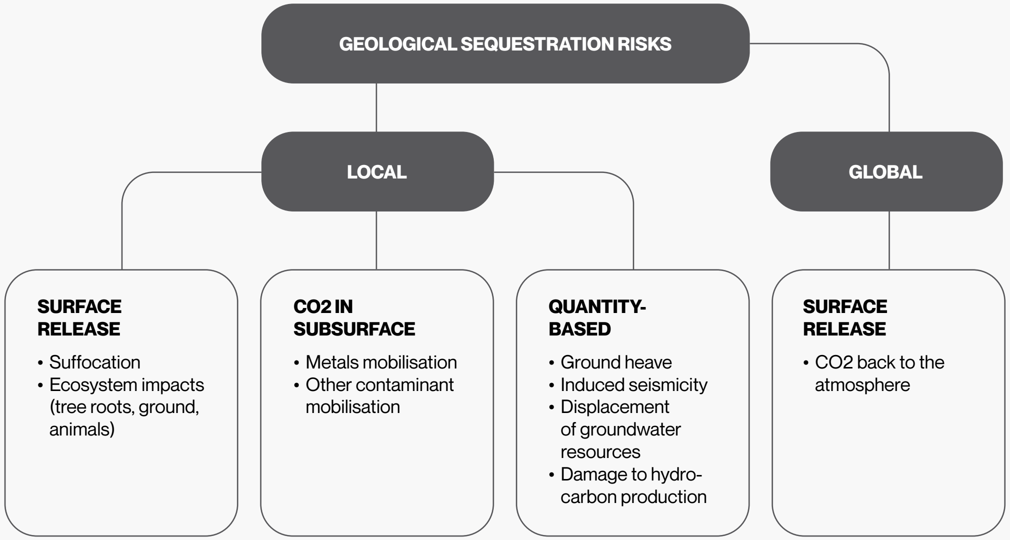
Unlike other GHG emission reduction activities that entirely eliminate CO2 generation and therefore achieve permanent emission reductions (e.g. renewable energy substituting fossil thermal power generation) GCS activities either avoid CO2 emissions to, or remove CO2 from, the atmosphere by enhancing geological carbon sinks and reservoirs.

Climate mitigation approaches involving GCS therefore present unique risks compared to other types of mitigation activities, including when they are credited under trading mechanisms. Risks include the environmental efficacy of such methods to deliver long-term, permanent, climate change mitigation effects should CO2 leak from a site in future (carbon reversal), the environmental integrity of the credits in the event of future carbon reversal, and the potential impacts of GCS activities on the local environment and human health. The nature of these parallel 'global' and 'local' risks is summarised graphically below (Figure 1).

Mitigation activities involving GCS therefore call for specific and additional safeguards in the design of incentives relative to other types of creditable climate mitigation project activities.

As shown below, the surface release of CO2 presents both 'global' non-permanence risks and 'local' environmental, health and safety issues. Taking steps to mitigate the risks of non-permanence can therefore also encompass and resolve local impacts in tandem, and vice versa (other localised ecotoxicological and physical risks may also be presented; Figure 1).

FIGURE 1: TAXONOMY OF POSSIBLE RISKS OF GEOLOGICAL STORAGE



Source: Wilson, E. J and Keith, D.W., 2002. 'Geological Carbon Storage: Understanding the Rules of the Underground.' In: Proc. of the 6th Intl. Conf. on GHG Control Tech.; Volume 1. J. Gale and Y. Kaya (eds). Kyoto, Japan, October 2002. Elsevier.

3.1.1 QA/QC to manage GCS risks

Building upon the risk concepts outlined, the past 15 years or so have seen the establishment of safeguards to manage and mitigate such risks, primarily built upon a three-part QA/QC approach noted above (Section 2.3.6):

1. **Development:** upfront QA/QC requirements relating to GCS site permitting or licensing conditions to ensure appropriate characterisation, selection and operation, including appropriate monitoring that can track storage site behaviour and provide assurances over storage integrity.
2. **Operation, closure and post-injection:** rules and regulatory oversight of geological CO2 storage site operations and closure to ensure effective management is applied that reduces the risk of leaks occurring.
3. **Liability:** allocation of short- and long-term responsibility for the stored CO2 to ensure appropriate redress is implemented if leaks/ carbon reversal occurs.

The EU, the U.S., Canada, Australia and the UK among others have established laws, regulations, technical standards and governance procedures to control these aspects. Project activities located in these jurisdictions can therefore rely on the local regulatory frameworks – primarily built upon permitting and licensing systems for geological CO2 storage sites – to manage the risk of non-permanence and to allocate liability in the event of carbon reversals.

Conversely, in jurisdictions where GCS laws and regulations are locally absent – and/or cannot be entirely filled by parallel laws and regulations – alternative means for implementing safeguards are needed if GCS activities are to proceed with high integrity in these countries.

CLIMATE MITIGATION APPROACHES INVOLVING GCS PRESENT UNIQUE RISKS COMPARED TO OTHER TYPES OF MITIGATION ACTIVITIES, INCLUDING WHEN THEY ARE CREDITED UNDER TRADING MECHANISMS.

Notably, overlaps exist in the scope of the methodological components described above and the safeguards discussed in this section, primarily relating to the following:

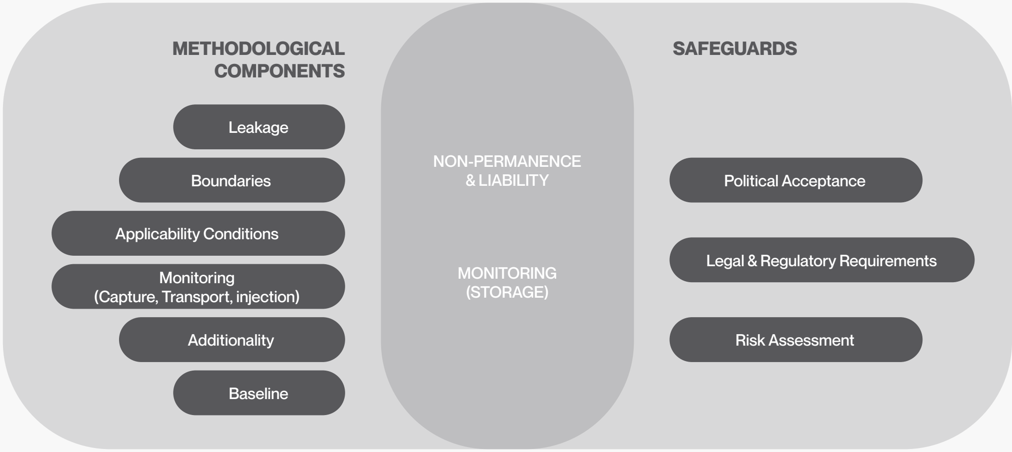
- **Non-permanence and liability.** To address the risk of carbon reversals in the future, methodologies must implement some form of QA/QC to ensure that appropriate site selection, operation, closure, liability etc has been carried out at the project level and that liability for reversals is allocated, an aspect also covered by safeguards.
- **Monitoring.** A site monitoring plan must be informed by risk features in and around a proposed GCS site. Safeguards implemented under risk-based environmental and health impact assessment are therefore critical to informing monitoring design at the methodological level (Figure 2).

The extent to which appropriate safeguards can be implemented through international project-based mechanisms remains a matter of debate.

The review in Section 2.3.6 provides indications as to the nature and form of these safeguards as developed in the VCM (e.g. Verra (CCS+), Gold Standard, GCC and Puro.earth hybrid approaches to non-permanence) and as expected by government Parties to the UNFCCC, per agreements under the CDM more than a decade ago.

In the following sections, the CDM precedents are further reviewed to develop insights into possible expectations of the safeguards Parties to the Paris Agreement ("the CMA") could seek for including GCS projects under Article 6, covering internationally transferred mitigation outcomes (ITMOs) under Article 6.2 and credits originated under the Article 6.4 mechanism.

FIGURE 2: RELATIONSHIP BETWEEN GCS METHODOLOGICAL COMPONENTS AND SAFEGUARDS



THE EXTENT TO WHICH APPROPRIATE SAFEGUARDS CAN BE IMPLEMENTED THROUGH INTERNATIONAL PROJECT-BASED MECHANISMS REMAINS A MATTER OF DEBATE.

3.2 SAFEGUARDS UNDER THE CDM

3.2.1 Background

In 2005, two CDM methodologies for CCS were submitted by project developers for consideration by the CDM Executive Board (EB). Following an initial review, the CDM EB requested guidance from Parties to the Kyoto Protocol ("the CMP") as to whether CCS projects could be considered as CDM project activities taking into account issues relating to project boundary, leakage and permanence.[23]

Thereafter, in 2006 the CMP agreed to request views from Parties and observers on the following concerns relating to CCS activities:[24]

(a) Long-term physical leakage (seepage) levels of risks and uncertainty;
(b) Project boundary issues (such as reservoirs in international waters or several projects using one reservoir) and projects involving more than one country (projects that cross national boundaries);
(c) Long-term responsibility for monitoring the reservoir and any remediation measures that may be necessary after the end of the crediting period;
(d) Long-term liability for storage sites;
(e) Accounting options for any long-term leakage (seepage) from reservoirs;
(f) Criteria and steps for the selection of suitable storage sites with respect to the potential for release of greenhouse gases (GHGs);
(g) Potential leakage paths and site characteristics and monitoring methodologies for physical leakage (seepage) from the storage site and related infrastructure, for example, transportation;
(h) Operation of reservoirs (for example, well-sealing and abandonment procedures), dynamics of carbon dioxide (CO2) distribution within the reservoir and remediation issues;
(i) Any other relevant matters, including environmental impacts.

Over the period 2007-2011, negotiations continued centred on the issues above, including further submissions by Parties and observers, and the production by the UNFCCC Secretariat of three synthesis reports on possible approaches to resolve concerns. [25] These documents and negotiations paved the way for agreement, in 2011, of the specific CDM CCS M&Ps.[26]

The focus of the then new CDM CCS M&Ps was the inclusion of specific safeguards for CCS activities that were not covered by the general modalities and procedures applicable to other types of CDM project activities,[27] and that Parties felt could not be readily agreed upon or implemented at the methodological level. The resulting CDM CCS M&Ps reflected a consensus reached after six years of detailed and protracted international discussions and remain the only significant attempt to codify UNFCCC Parties' concerns and the associated safeguards needed in respect of GCS activities.

These additional safeguards are considered below under items (a), (b) and (c).

3.2.2 Safeguards

a. Policy support for CCS

Because of the unique characteristics of GCS, the CMP wanted that countries wishing to host CCS project activities clearly acknowledge the risks and responsibilities involved in doing so. This also extended to the possibility of assuming the liability for any carbon reversals that could occur after crediting has ceased.[28]

To implement such a safeguard, the CDM CCS M&Ps Participation Requirements therefore oblige Parties hosting geological CO2 storage sites to have:

'... submitted an expression of its agreement to the UNFCCC secretariat to allow the implementation of CCS project activities in its territory...' [29]

In this way, explicit governmental agreement to host such activities must be provided in advance of deploying any such activity under the auspices of the CDM.

b. Legal and regulatory requirements

Furthermore, several Parties also wanted countries hosting CCS activities under the CDM to implement dedicated legal and regulatory standards to control the risks posed by GCS. The general view was that these standards would need to be similar to those applied to CCS projects in developed countries to avoid distortions in environmental standards and to support credit fungibility across carbon markets (i.e. high levels of regulatory alignment).

Several Parties wanted host countries to implement appropriate legal provisions to ensure that (i) clear property rights could be allocated for accessing and storing CO2 in subsurface geological pore space and (b) liability was clearly allocated in the event of any migration out of the intended storage zone (e.g. trespass onto adjacent property) and leakage of CO2 back to the atmosphere.

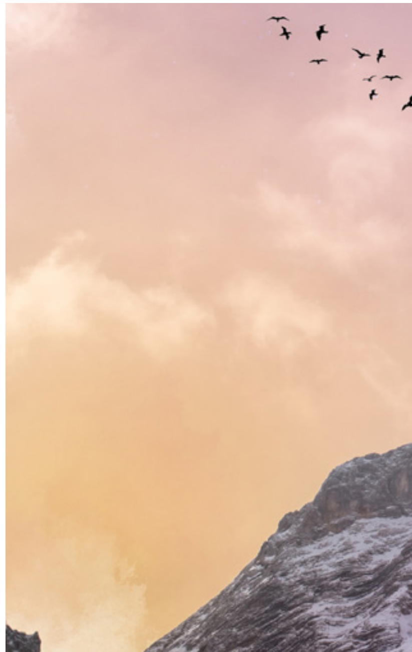
In the case of the latter, because CDM host countries (i.e. developing countries) did not face any strict emissions limitation targets, there were concerns that CO2 could leak from sites in the future, long after the end of the crediting period, without any recourse to the prior operator or host country to compensate for the resulting 'global' climate damages. Liability allocation was therefore a key part of the discussions, and ultimately the CDM CCS M&Ps allow host countries to choose whether or not they accept long-term liability. In practice, projects were unlikely to proceed in circumstances where the host country would not accept liability because the buyer of any credits would instead have to take on the liability in the event of a net reversal of storage.

Alignment of regulatory standards not only supports safe and sound deployment of geological CO2 storage. Strong alignment also allows for fungibility of credits originated from GCS in different jurisdictions insomuch as non-permanence would be governed by the same set of guiding requirements. The Participation Requirements in the CDM CCS M&Ps therefore set down de minimis legal and regulatory standards that are closely aligned to the permitting standards established for GCS site operations in Europe, the U.S. and Canada. Therein, Parties wishing to host CCS projects as CDM project activities need to have:

'...established laws or regulations which: [30]

- *(a) Set procedures that include provisions for the appropriate selection, characterization and development of geological storage sites, recognizing the project requirements for CCS project activities under the CDM set out in appendix B to this annex;*
- *(b) Define means by which rights to store carbon dioxide in, and gain access to, subsurface pore space can be conferred to project participants;*
- *(c) Provide for timely and effective redress for affected entities, individuals and communities for any significant damages, such as environmental damage, including damage to ecosystems, other material damages or personal injury, caused by the project activity, including in the post-injection phase;*
- *(d) Provide for timely and effective remedial measures to stop or control any unintended seepage of carbon dioxide, to restore the integrity of a geological storage site, and to restore long-term environmental quality significantly affected by a CCS project activity;*
- *(e) Establish means for addressing liability arrangements for carbon dioxide geological storage sites, taking into account the provisions set out in paragraphs 22 to 25 of appendix B to this annex;*
- *(f) For a host Party that accepts the obligation to address a net reversal of storage in the situation referred to in paragraph 26 below, establish measures to fulfil such an obligation.'*

ALIGNMENT OF STANDARDS SUPPORTS SAFE DEPLOYMENT OF GCS AND FUNGIBILITY OF CREDITS



THE SPECIFIC SAFEGUARDS SOUGHT FOR ENGINEERED CARBON REMOVALS INVOLVING GCS STORAGE WILL LIKELY IMPACT UPON HOW CCS WILL BE TREATED UNDER THE NEW ARTICLE 6.4 MECHANISM.

c. Requirements to undertake environmental and socio-economic impact and risk assessments

The unique risks posed by GCS activities also prompted Parties to request more stringent requirements for project approval compared to conventional CDM project activities. As a result, the Appendix to the Annex of the CDM CCS M&Ps also requires the additional risk-based impact assessments to be carried out:

"6. A comprehensive and thorough risk and safety assessment shall be carried out in order to assess the integrity of the geological storage site and potential impacts on human health and ecosystems in proximity to the proposed CCS project activity. The risk and safety assessment shall also be used to inform environmental and socio-economic impact assessments."

Thus, through these requirements, host country governments wishing to host CCS crediting activities under the CDM must put in place several safeguards that can support effective deployment. Problematically, however, these same rules and safeguards may not necessarily transfer easily into the Paris Agreement mechanisms.

3.3 SAFEGUARDING UNDER THE PARIS AGREEMENT

Drawing upon the safeguards established under the CDM, the following key criteria can be used to guide thinking for the design of safeguards for trading units and credits under the Paris Agreement:

a. Is GCS/geological storage politically supported in the host country?
b. Is the injection and storage of CO2 in geologic pore space legal and permissible, and will the activity be regulated (e.g. for site selection, development, operation and closure)?
c. Will the activity be suitably risk assessed?

In these respects, the Paris Agreement splits the landscape for emissions trading and project-based crediting into two separate pathways, namely, the Article 6.2 cooperative approaches and the Article 6.4 mechanism.[31] This division broadly aligns with the Kyoto Protocol's flexibility mechanisms of emissions trading and joint implementation (JI) between developed countries (Article 6.2) and the CDM for developing countries supplying credits to developed countries with targets (Article 6.4). On the other hand, the Paris Agreement significantly modifies the previous landscape, and Article 6.2 is expected to cover a variety of types of cooperation between various countries, whereas Article 6.4 crediting could be limited to only those developing countries with very low levels of implementation capacity.

The potential to establish similar safeguards in the Article 6 mechanisms as those established under the CDM, as set out in (a), (b), (c) and (d) above are considered in the following sections.

3.3.1 Article 6.4

In a similar way to the CDM, Article 6.4 cooperation has adopted a centrally governed project-based approach using standards approved by the Supervisory Body appointed by the CMA. In 2021, Parties agreed the broad rules, modalities and procedures ("the RMPs") for the mechanism, and therein requested the Article 6.4 Supervisory Body to review various methodological and procedural aspects of the CDM and other mechanisms to help inform its design.[32]

Safeguards (a), (b) and (c)

Notably, paragraph 6(c) of Decision 3/CMA.1 specifically requests the Supervisory Body to elaborate and further develop the following:

'Activities involving removals, including appropriate monitoring, reporting, accounting for removals and crediting periods, addressing reversals, avoidance of leakage, and avoidance of other negative environmental and social impacts, in addition to the activities referred to in chapter V of the annex (Article 6, paragraph 4, activity cycle)'

The specific safeguards sought for engineered carbon removals involving GCS storage will likely impact upon how CCS and engineered CDR will be treated under the new Article 6.4 mechanism. At time of writing, the Article 6.4 Supervisory Body agreed a draft recommendation on the treatment of carbon removals, but this was not approved by Parties (the CMA) at COP28 (Dubai, December 2023). The draft recommendation leaves latitude for future work to be carried out by the Supervisory Body, including on a non-permanence risk tool and on requirements for post-crediting period monitoring reporting and remediation of reversals.[33]

3.3.2 Article 6.2

Article 6.2 cooperative approaches differ from Article 6.4 in having decentralised governance, albeit subject to common guidance around the types of units, participation, accounting and reporting by participating Parties.[34] The decentralised arrangements are anticipated to bring various bilateral and multilateral crediting systems, including VCM mechanisms and standards, into the ambit of emissions trading under the Paris Agreement.

Third party mechanisms compliant with Article 6.2 guidance will have latitude to set their own methodological standards, although some degree of convergence with the centrally-agreed Article 6.4 rules and standards might be expected.

Under currently envisaged arrangements, countries hosting Article 6.2 compliant crediting activities may have little if any direct involvement in the approval of specific activities, other than to report and account for transactions of the resulting units (ITMOs).

Open questions therefore remain as to how governmental safeguards for GCS, like those established under the CDM CCS M&Ps, could be implemented under the looser, decentralised, arrangements of Article 6.2 crediting.

Important matters for consideration include:

1. Should crediting of CCS and engineered CDR activities under Article 6.2 be limited to jurisdictions with relevant safeguards in place? (e.g. through setting of geographical or other type of applicability conditions within Article 6.2 compliant methodologies) or
2. Could appropriate safeguards be established for GCS within third party methodologies that are compliant with Article 6.2 ? (e.g. through requiring host country authorisation and prescribing technical standards for site selection, development, operation, closure and post-injection). And if so:
   - Are the scheme operators willing and able to do so?
   - Would validation and verification bodies (VVBs) be willing to check and sign off on their implementation?
   - Would host countries be willing to trust and support such standards set by third parties?

In the case of government-operated Article 6.2 compliant schemes, such requirements may be more straightforward for (e.g. Japan's Joint Crediting Mechanism; JCM, or the Swiss Article 6 procurement programme). Typically, these programmes require the execution of bilateral agreements between the host and buyer countries, which can provide a workable basis for setting their own standards. Appropriate safeguards for geological CO2 storage activities could be integrated into these bilateral agreements (Box 1 next page).

In contrast, privately-run crediting schemes in the VCM are not yet subject to any government-to-government institutional arrangements. As such, implementing government backed safeguards for GCS within these schemes is potentially more challenging. As noted previously, approaches being taken by Verra, Gold Standard, GCC and Puro.earth seek to encourage good practice for project oversight by host country governments. But ultimately these standard setters have little control over such sovereign affairs. As such, it remains to be seen whether liquid markets for credits originated from GCS activities may emerge if uncertainty remains over the quality of safeguards in place in host countries.

Furthermore, exploration of the questions around safeguards in VCM mechanisms also needs to be further framed against the specific new features of the Paris Agreement that alter the landscape for crediting as compared to the Kyoto Protocol and CDM. These directly impact upon the safeguards in various ways, as described below.

a. Policy support for CCS

According to Article 6.2 guidance, each participating Party in a cooperative approach shall ensure that:

'4….(f) Its participation contributes to the implementation of its NDC and long-term low-emission development strategy, if it has submitted one…' [35]

Article 6.2 rules therefore imply that any Party wishing to host GCS-based cooperative approaches must include variants of the technology within its Paris Agreement climate mitigation plans (NDCs, long-term low emissions development strategies; LT-LEDS). Inclusion of CCS or engineered CDR within these plans could be used as a proxy check applied at the methodological level to give assurances that the host Party has established national policy support for geological CO2 storage technology and acknowledges the associated potential risks and responsibilities. This arrangement could be sufficient to fulfill safeguard (a): policy support for CCS, as was sought by the CMP for CDM CCS projects.

Notably, so far around 50 Parties mention CCS within their NDCs (Zakkour and Heidug, 2019) and according to the Global CCS Institute (2021) 80% of all LT-LEDS submitted up to 2021 also feature CCS.[36]

On the other hand, many developing countries have yet to consider CCS (and even fewer have assessed engineered CDR) within their near-term mitigation actions (i.e. NDCs) and may not have yet prepared a LT-LEDS. Therefore, if such safeguards are applied at the methodological level, the potential to establish creditable GCS project activities could be significantly constrained in some countries (at least until NDCs are updated or LT-LEDS are prepared).

PRIVATELY-RUN CREDITING SCHEMES IN THE VCM ARE NOT YET SUBJECT TO ANY GOVERNMENT-TO-GOVERNMENT INSTITUTIONAL ARRANGEMENTS.

BOX 1: POTENTIAL CCS SAFEGUARDS UNDER THE JAPANESE JOINT CREDITING MECHANISM (JCM)

Under the JCM, each partner country signs a bilateral agreement with the Government of Japan (see: https://www.jcm.go.jp/about). Various relevant safeguards are included in the project evaluation criteria. For example, Annex I of the FY2022 Guidelines for Submitting Proposals include the following eligibility requirements:

2) Is the model project expected to reduce emissions of GHG including energy-related CO2 through JCM?

- The model project should be consistent with the climate change policies in the country where the project is implemented (hereinafter referred to as 'partner and other countries').

6) Are the decarbonizing technologies internationally in practical use and can be introduced in the partner and other countries? This means:

- The technologies should be realized in other project(s) (a track record of commercial operation or demonstration project etc. will be reviewed), or the facilities/equipment using the technology should be commercially manufactured (Catalogues, specification etc. will be reviewed).
- Are equipment maintenance technologies and local support available in the partner and other countries?

11) Does the model project adhere to the environmental and social legal system requirement?

The installation and operation of the facilities/equipment shall comply with the environmental laws and regulations of the partner country and refer to international practices and guidelines regarding the environmental protection (air pollution, water contamination, waste treatment, noise/vibration, ecosystem etc.).

Further, the Japan Oil, Gas and Metals National Corporation (JOGMEC) has established guidelines for CCS projects, which draws heavily on ISO and US best practice standards. This standard could be integrated with the JCM bilateral agreements to ensure best practice is followed for CCS projects under the JCM.

Sources: GEC (2022) Call for Proposals for JCM Model Projects in FY2022, Guidelines for Submitting Proposals. 6 April 2022. Global Environment Centre Foundation (GEC). JOGMEC (2022). Recommended guideline for the implementation of Carbon dioxide Capture and Storage projects (JOGMEC CCS guideline). Executive Summary. Version 1. May 2022. Japan Oil, Gas and Metals National Corporation (JOGMEC).

b. Legal and regulatory requirements

According to the guidance for Article 6.2, internationally transferred mitigation outcomes (ITMOs) resulting from a cooperative approach must be:[37]

'1…(c) Measured in metric tonnes of carbon dioxide equivalent (t CO2 eq) in accordance with the methodologies and metrics assessed by the Intergovernmental Panel on Climate Change…'

Countries therefore wishing to host CCS activities and generate ITMOs from such activities should seek to fulfil the requirements of the 2006 IPCC Guidelines (as described in Annex B-2).

Furthermore, host countries could use the 2006 IPCC Guidelines to shape the treatment of liability and liability transfer. Specifically, liability in essence only exists if monitoring is being carried out to detect and measure leaks. In these respects, the 2006 IPCC Guidelines provide indications as to the basis for discontinuing monitoring (see Annex B-2.4). Similar conditions are applied within, for example, EU law in the CCS Directive, and could be enacted at the methodological level in project-based approaches. The proposed methodology from the GCC, for example, seeks to implement such an approach (Section 2.3.6).

After a liability transfer from operator to host country is effected (essentially by ceasing monitoring), the host country must assume responsibility for any additional monitoring (e.g. if the storage site is affected by unexpected events, for example, seismic events) and to compensate for any carbon reversal. In respect of the latter, this obligation would be practically implemented through a combination of ongoing emission reduction pledges within NDCs, and the implementation of monitoring following the modalities, procedures and guidelines for the transparency framework for action and support ("the MPGs").[38] The MPGs, in Annex II.C (Methods) request all Parties to prepare national inventory reports 'using the 2006 IPCC Guidelines'. Thus, any leaks would be monitored using 2006 IPCC Guidelines methods and added to the country's national GHG inventory, which would impact upon its capacity to meet its NDC target.

Such an approach could therefore address safeguard (b) in respect of liability transfer.

The requirements of the 2006 IPCC Guidelines also establish, through the QA/QC and Reporting and Documentation requirements of Volume 2, Chapter 5, de facto obligations for host countries to ensure that proper site characterisation, selection, monitoring, and modeling is undertaken (and reports on site characterisation, monitoring, modeling etc. are all prepared and submitted) (see Annex B-2).

The Reporting and Docu¬mentation requirements in Section 5.10 could be supported by applying additional guidance and requirements in project standards at the methodological level, and could cover matters such as:

- Site characterisation and selection reporting
- The undertaking and reporting of modeling
- Monitoring plan design report
- Monitoring reports etc.

The combination of these activities could provide the basis to fulfill safeguard (b) in respect of regulation of site selection, development and operation. The draft methodology from the GCC, for example, seeks to implement such an approach.

c. Requirements to undertake environmental and socio-economic impact and risk assessments

The existing requirements applied in project-based mechanisms (Section 2.3.7) could be enhanced through GCS-specific requirements applied at a methodological level. For example, requirements to undertake risk and safety assessments (including scenario planning), and the use of the results of these assessments to inform environmental and socio-economic impacts and risks, could be incorporated into CCS-specific methodologies. The draft methodology from the GCC, for example, seeks to implement such an approach.

Drawing on the analysis above, Table 2 below summarises the range of safeguards that could be applied to GCS under Article 6.

TABLE 2: SUMMARY COMPARISON OF SAFEGUARDS ACROSS CDM AND ARTICLE 6 MECHANISMS

SAFEGUARD	KYOTO PROTOCOL CLEAN DEVELOPMENT MECHANISM	PARIS AGREEMENT	
		ARTICLE 6.2	**ARTICLE 6.4**
a. Policy support for CCS	**Decision 10/CMP.7 (CDM CCS M&Ps), Annex.F (Participation Requirements)** 'A Party not included in Annex I to the Convention may only host a CCS project activity under the CDM if it has submitted an expression of its agreement to the UNFCCC secretariat to allow the implementation of CCS project activities in its territory'	**Decision 2/CMP.3 Annex.II (Participation)** '4. Each participating Party shall ensure that: …(f) Its participation contributes to the implementation of its NDC and long-term low-emission development strategy, if it has submitted one'. Methodologies could require that the host Party has mentioned CCS and/or engineered CDR in NDC or LT-LEDS.	Rules under development by the Supervisory Body, taking account of the CDM approach and considering baseline and monitoring methodologies used in other market-based mechanisms (e.g. VCM standards).
b. Legal and regulatory requirements	**Decision 10/CMP.7 (CDM CCS M&Ps), Annex.F (Participation Requirements)** [and]…has established laws or regulations which: (a) Set procedures that include provisions for the appropriate selection, characterization and development of geological storage sites… (b) Define means by which rights to store CO_2 (c) Provide for timely and effective redress, (d) Provide for timely and effective remedial measures to stop or control any unintended seepage of carbon dioxide, to restore the integrity of a geological storage site, and to restore long-term environmental quality significantly affected by a CCS project activity; (e) Establish means for addressing liability arrangements for carbon dioxide geological storage sites, taking into account the provisions set out in paragraphs 22 to 25 of appendix B to this annex; (f) For a host Party that accepts the obligation to address a net reversal of storage in the situation referred to in paragraph 26 below, establish measures to fulfill such an obligation.	**Project Standard** All generally require that credited activities to be undertaken in accordance with national laws. Projects where storage rights are unclear should not pass the general requirement test. **Decision 2/CMP.3 Annex.I (Internationally transferred mitigation outcomes)** '1. (ITMOs) resulting from a cooperative approach must be:…(c) Measured in metric tonnes of carbon dioxide equivalent (t CO_2 eq) in accordance with the methodologies and metrics assessed by the Intergovernmental Panel on Climate Change…'. The requirement to follow IPCC guidelines when generating ITMOs triggers the various standards established in Vol. 2, Ch. 5, of the 2006 IPCC Guidelines including in respect of discontinuing monitoring (and potentially transferring liability to host country) **Decision 18/CMA.1 (Annex II.C Methods)** Ongoing liability for any carbon reversals would revert to the host country and be covered by NDCs and ongoing requirement to follow the 2006 IPCC Guidelines under the MPGs for the ETF. Post closure: all Parties to prepare NIRs using the 2006 IPCC Guidelines (para. 20) but …'flexibility' also possible (para. 6). Means hosts must implement obligations for operators & monitor stores and account for leaks after crediting period. **Decision 2/CMP.3 Annex.I (Internationally transferre mitigation outcomes)** The requirement to follow IPCC guidelines when generating ITMOs also triggers the standards established in Vol. 2, Ch. 5, of the 2006 IPCC Guidelines in respect of site selection, monitoring; and reporting. Requirements can also be reinforced at the methodology level through specific guidelines and standards	
c. Undertake ESIA impacts and risk assessments	**CDM CCS M&Ps Appendix B (6)** 'A comprehensive and thorough risk and safety assessment shall be carried out in order to assess the integrity of the geological storage site and potential impacts on human health and ecosystems in proximity to the proposed CCS project activity. The risk and safety assessment shall also be used to inform environmental and socio-economic impact assessments.'	Enhance the environment, health and safety standards set out in existing mechanisms through development of GCS-specific requirements at the methodological level.	

ANNEX A

– METHODOLOGICAL COMPONENTS WITHIN EXISTING CCS PROTOCOLS

Table A-1
Alberta, ACR, Puro.Earth

METHODOLOGICAL COMPONENT	ALBERTA CCS OFFSET PROTOCOL	ACR – CCS PROTOCOL V1.1	PURO.EARTH METHODOLOGY FOR GEOLOGICALLY STORED CARBON
Definitions	Glossary of Terms (e.g., Deep Saline Aquifer; Permanent Storage; Gas Source; Injected Gas; Carbon Sequestration Tenure Regulation)	List of definitions for standard terms (e.g., Atmospheric Leakage; Carbon Capture and Storage; Fugitive Emissions) Also contains a short list of acronyms.	Introduction contains a brief list of definitions for key terms used in the methodology.
Applicability Conditions	CCS projects applicable under this protocol consist of facilities that Capture CO_2 emissions from an industrial or non-industrial facility (other sections clarify the condition as 'any type of process that generates CO_2-rich gas, such as steam methane reforming'). By definition, dilute sources (i.e. combustion streams) are seemingly excluded. Store the CO_2 in deep saline formations, permitted in line with the Albertan Mines and Minerals Act and the Carbon Sequestration Tenure Regulation Not applicable to either EOR activities or to acid gas injection schemes.	Applicable projects/eligibility: • Only capture, transport, and inject CO_2 during EOR operations into an oil and gas reservoir located in the US or Canada. • Only if there is clear and uncontested ownership of the pore space. • The Project Proponent has filed a Risk Mitigation Covenant and secured the consent of surface owners. • Eligible CO_2 source types include: • Electric power plants (pre- or post-combustion or oxy-firing capture) • Industrial facilities (natural gas production, fertilizer manufacturing etc.) • Polygeneration facilities; and • DAC facilities. Eligible CO_2 transport options include barge, rail, or truck. Eligible geological storage of CO_2 must, at minimum, utilize UIC Class II wells (this is the lower of two well classes, the more stringent class being UIC Class VI, which applies to CO_2 storage in saline aquifers)	Applicability requirements include: 1. Project must increase geological carbon stock permanently by storing CO_2 or other GHG captured directly from the atmosphere or from biogenic sources 2. Applies to biogenic CO_2 or direct air capture only; CO_2 sources from purely fossil activities are not eligible. 3. Protocol applies to EOR Eligible Carbon capture types: A. Direct air capture (DAC) B. Biogenic CO_2 from combustion of biomass, bioliquids or biogas (BECCS; bio- CCS) C. Biogenic CO_2 fraction from incineration of biomass mixed with other substances (Waste + CCS) D. Biogenic CO_2 from biogas upgrading process (Biogas + CCS) E. Biogenic CO_2 Carbon capture from oxidization of biogenic materials in industrial processes F. Biogenic carbon- containing substance (carbonaceous liquids, bio-oil, carbon- containing slurry, ethanol, phenol)
Project Boundary	Wide range of sources and sinks: • Upstream • Site-level • Downstream of the project, both before and during the project. In one case even after the Project (P22 Decommissioning Carbon Capture and Storage facilities). It is challenging to discern what sources must be included because of the style of the methodology. However, notably, a number of 'Upstream' sources are included with the boundary. This includes the GHG emissions embodied in energy and chemicals used for CO_2 capture (e.g. item 'P4 - Production and Delivery of Material Inputs used in CO_2 Capture Process' and 'P21 - Loss, Disposal, or Recycling of Materials Used in CO_2 Capture Processes')	Project boundaries include a physical boundary, a temporal boundary and a greenhouse gas assessment boundary. The GHG assessment boundary includes: • CO_2 capture (vented CO_2 not subject to capture; other stationary combustion; electrical and thermal energy used) • CO_2 transport (stationary combustion; fugitives and vented CO_2; electricity usage; mobile sources) • CO_2 storage (stationary combustion; vented and fugitive CO_2; electricity usage; produced gas transferred outside the project boundary; atmospheric leakage from the geologic storage site) Does not include any up- or downstream or embodied emissions. The temporal boundary allows the crediting period to be renewed every 10 years for a seemingly unlimited duration according to the Project Term. The Project Term also includes: • A minimum of 5 years post-injection monitoring • Extension of a further 5 years post-injection monitoring if 'no leakage' cannot be assured after the first 5 years. • Extension by a further 2 years thereafter on a rotational basis until 'no leakage' assurance is achieved.	'The project boundary includes all activities existing solely for the purpose of CO_2 removal, include carbon capture, transportation geological storage. Emissions sources included within the boundary: A. Purpose-grown biomass (e.g. emissions from cultivation, harvesting and transportation of the biomass cradle-to-gate) if the biomass is solely grown for CO_2 removal purposes. B. Purpose-built equipment and facilities (e.g. emissions from materials and construction) if they are solely built for CO_2 removal purposes; if CO_2 removal supplier can show that these emissions are less than 1% of total project emissions they can be omitted. Emissions outside the boundary include other activities that do not exist solely for the purpose of CO_2 removal even if they are physically connected to carbon capture (e.g. bioenergy production, biogas production or waste treatment)

Table A-1
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METHODOLOGICAL COMPONENT	ALBERTA CCS OFFSET PROTOCOL	ACR – CCS PROTOCOL V1.1	PURO.EARTH METHODOLOGY FOR GEOLOGICALLY STORED CARBON
Storage Site Characterisation	Specific storage reservoir characteristics must be addressed during application for pore space tenure. CO2 must be stored by one or more trapping mechanisms listed on page 16 (namely: Each injection site included in the project must have: 1. An approved carbon sequestration lease(s) in accordance with the Mines and Minerals Act and the Carbon Sequestration Tenure Regulation as issued by the Government of Alberta 1. An approval for a CO2 Storage Scheme as per application and approval under the Alberta Energy Regulator's Directive 065, Unit 42 and the Oil and Gas Conservation Act.	The methodology does not set down detailed methodological standards and requirements for site characterisation and selection. In these respects: • The reservoir must be located in the US or Canada. • For EOR sites the geological storage site is generally well characterized and modelled. • Eligible geological storage of CO2 for an EOR project at minimum utilize UIC Class II wells. The monitoring, reporting and verification (MRV) plan must include details of inter alia: • The reservoir storage volume • Potential leakage pathways • Remediation of potential leakage paths, as needed • Development of monitoring strategy (see below)	No specific site characterisation requirements are set out. However, eligible geological storage sites include only those controlled by EU or US laws and authorised by following similar requirements as set out by those laws. These include: A. Direct injection of CO2 into deep geological formations (EPA CLASS VI or EU CCS directive) B. Injection of carbon containing substance into reservoir (EPA CLASS I, II) C. Oil and gas reservoirs as part of EOR+ (EPA CLASS II)
Baseline Emissions	Projection-based only. Baseline emissions are projected using the total quantity of CO2 that has been measured directly upstream of the injection wellheads in the project condition. The dynamic baseline ensures the baseline correctly accounts for the year-to-year variations. Sources and sinks of emissions for the baseline were assessed based on guidance from ISO 14064-2 and further categorized into either Controlled, Related or Affected. Baseline sources and sinks include injected CO2, CH4 and N2O. CH4 and N2O are both excluded from the baseline quantification.	The methodology presents two baseline options: • Projection-based, and • Standards-based (i.e. a benchmark) A project proponent must select the baseline that applies to its project, and then follow the matching calculation procedure. For most CCS projects the Projection-based baseline scenario will apply. If both baseline options are feasible for a given project, the more conservative shall be selected unless justification can be presented why the less conservative option represents a more credible and likely baseline scenario. CH4 and N2O are both excluded from the baseline quantification.	The methodology applies to removals only and does not apply baseline(s) for purposes of determining project emission reductions. The approach is instead based on calculation of net CO2 removal, which = captured CO2 - project emissions - CO2 losses.
Additionality	All Alberta Offset projects must follow the Technical Guidance for the Assessment of Additionality: https://open.alberta.ca/publications/technical-guidance-for-the-assessment-of-additionality 'Protocols will undergo a mandatory review every 5 years…to assess adoption rates and additionality of the activity.' (pp. 6)	Emission reduction from the project must be additional or deemed not to occur on the business-as-usual scenario. The assessment of additionality shall be made based on evaluating the project using the performance standard approach (Page 22). To qualify as additional the project must pass a regulatory additionality test and exceed a performance standard.	No requirements in the methodology. Demonstration of additionality is instead addressed under the General Puro Standard requirements, which require that the project must 'convincingly demonstrate that the CO2 removals are a result of carbon finance' and that suppliers 'must also show that the project is not required by existing laws, regulations, or other binding obligations'.

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METHODOLOGICAL COMPONENT	ALBERTA CCS OFFSET PROTOCOL	ACR – CCS PROTOCOL V1.1	PURO.EARTH METHODOLOGY FOR GEOLOGICALLY STORED CARBON
Project emissions (including seepage)	All emissions associated with the capture process the transport and the storage in deep saline aquifers must be accounted for in the project condition. Can later be excluded from quantification if they are not expected to change between baseline and project condition. This also includes the CH4 injected and the N2O injected into the deep saline aquifers. The geological formation must be monitored and tested regularly for signs of CO2 leakage and or migration consistent with the approved Monitoring, Measurement and Verification Plan.	CCS project emissions equal the sum of CO2 emissions from CO2 capture transport and storage. The GHG included in the project emissions are CO2, CH4 and N2O (CH4 and N2O are excluded from any calculation). The emissions associated with the combustion of hydrocarbons produced by EOR products are also excluded. Atmospheric leakage shall be monitored during the entire Project Term. No leakage is assured when it can be verified that no migration of injected CO2 is detected across the boundaries of the storage volume and the modelled failure scenarios all indicate the CO2 will remain contained within the storage volume.	Project emissions include: • Scope 1 and 2 emissions from capture, transport and injection activities • Emissions from chemicals, membranes and purpose-built equipment including the construction and materials for the equipment (to be quantified according to LCA calculation principles of ISO, WRI or PAS2050) • CO2 losses (calculated as the difference in mass between CO2 captured and CO2 injected)
Leakage	Not addressed.	The Protocol determines that GHG emissions from the combustion of incrementally produced oil from EOR activities do not need to be included within the project boundary or as leakage. It indicates that the approach is consistent with other methodologies that also exclude product emissions. It also suggests that produced oil would displace other sources of oil and helps to encourage domestic oil production.	Not addressed specifically, although project boundary and project emissions [see above] include requirements for inclusion of LCA emissions relating to equipment and biomass source(s)
Monitoring	Monitoring requirements are based on the characteristics of the project specific deep saline aquifer. The monitoring plan must be submitted as part of the tenure application under the Mines and Minerals Act. A number of directives specify the requirements for measurement and monitoring (Directives 007, 017, 020…). Monitoring requirements apply to the following four project phases: 1. Pre-Injection, 2. Injection, 3. Closure, 4. Post-injection Monitoring includes both baseline monitoring tasks as well as complementary operational monitoring tasks.	The Protocol requires projects to include a site-specific MRV plan, which is subject to independent third-party validation by a CCS expert on the VVB team. The MRV plan needs to be tailored to site-specific geologic conditions and operational considerations. The Protocol lists a number of components that must be included in a MRV framework, including: 1. Remediation of potential leakage pathways; 2. Identification of potential leakage pathways within this storage volume. 3. A strategy for quantifying any atmospheric leakage of CO2 The MRV plan is where most of the site characterisation and selection standards arise. The protocol goes on to list several components that must be included in MRV reporting requirements (e.g., Description of the reservoir; Site characterisation of storage volume).	Few specific monitoring requirements are set out in the methodology, including monitoring parameters and frequencies. Instead, the methodology lists the evidence/data to be provided by the project proponent to the verifier [5. Verification and evidence from the CO2 Removal Supplier] in order to meet the methodology requirements. These cover: 1. Evidence of source of CO2 (including technologies and standards) 2. Evidence of net-negative carbon balance 3. Evidence of permanent storage (including documentation that the storage site is classified and permitted under EU CCS or EPA criteria, or similar regulation) 4. Evidence of no double-counting/claiming In addition, the methodology makes reference to a number of standards and techniques to be used throughout (e.g. ISO, LCA analysis).

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METHODOLOGICAL COMPONENT	ALBERTA CCS OFFSET PROTOCOL	ACR – CCS PROTOCOL V1.1	PURO.EARTH METHODOLOGY FOR GEOLOGICALLY STORED CARBON
Permanence **Liability for CO2 reversal**	**General QA/QC Requirements** See Applicability Conditions **Short- and long-term liability** The project developer retains liability until a closure certificate is issued. Once a certificate has been issued the liability transfers from the developer to the Government of Alberta. There is no fixed amount of time for liability of the project developer. CO2 reversals after the project crediting period must be trued up prior to approval of closure certificate.	**General QA/QC Requirements** See Applicability Conditions **Short- and long-term liability** Short: Project Proponents must quantify atmospheric leakage of CO2 emissions from the storage volume, if they arise. Atmospheric leakage shall be monitored during the entire Project Term, which includes the injection period and a time-period following the end of injection. Project Term Long: Long-term liabilities arise from migration of CO2 plume either vertically or horizontally. If a CO2-EOR project has leakage which causes damage, the operating Company may be liable in criminal or civil court. GHG removals may not be permanent if a project has exposure to risk factors, including unintentional reversals and intentional reversals. See Project Boundary for the temporal terms and requirements for post closure monitoring for a minimum of 5 years.	**General QA/QC Requirements & Short- and long-term liability** Management of permanence, and liability arrangements in the event of a CO2 reversal, are not directly addressed in the methodology. Instead, the methodology lists “evidence for permanent storage” as follows: 1. Shipping documentation of the delivery of the captured CO2 to an injection and storage site, indicating that it is going to be used in permanent storage of carbon. 2. Documentation that the storage site is classified and permitted under EU CCS or EPA criteria, or similar regulation.
Environment-al and Social Impacts	Not mentioned	If an Environmental Assessment (EA) or an Environmental Impact Assessment (EIS) is required that document or summary thereof shall be provided to ACR and provided to the VVB on request. In the U.S, there are different state and federal laws, regulations and guidance that require an EA or EIS for certain government actions. Project Proponents shall document in the GHG Project Plan a mitigation plan for any foreseen negative community or environmental impacts and shall disclose in their annual Attestations any negative environmental or community impacts made during the reporting year.	Requires that CCS activities should do no net harm to the environment (e.g. cause deforestation, loss of biodiversity or to society through loss of arable land and decreased food security, chemical emissions or health risks).
Sustainability	Not mentioned	Not mentioned	For all activities undertaking biogenic CO2 capture, the biomass must be ‘sustainable’ in accordance with the sustainable biomass criteria as defined in the EU RED II (Renewable Energy Directive II) or similar criteria, even if the biomass is not purpose-grown but residues or side streams are used.

Table A-2
CDM, Gold Standard, Verra (CCS+)

METHODOLOGICAL COMPONENT	MODALITIES AND PROCEDURES FOR CCS UNDER CDM	GOLD STANDARD – BIOMASS FERMENTATION WITH CCS	VERIFIED CARBON STANDARD (VERRA) CCS+ INITIATIVE
Definitions	Annex A contains several key definitions: 'Carbon dioxide capture and storage'; 'Geological storage site'; 'operational phase; … etc.	Long list of terms, including: **Geological** (e.g. primary seal, secondary seal, pore space, secure underground formation, CO2 plume, injectivity, geologic reservoir) **Technical** (e.g. blowout, casing, string, packer, mechanical integrity, kick etc) **Legal/regulatory** (e.g. area of review, abandonment, closure period, injection period, pore space tenure holder, post-injection site care, renewable biomass etc)	A comprehensive list of definitions in included in the (1) Methodology for carbon capture and storage.
Applicability Conditions	At the rules level, requirements are that: 1. Under the proposed conditions of use, there is no significant risk of seepage, no significant environmental or health risks exist, and the geological storage site will comply with all laws and regulations of the host Party 2. Not located in international waters 3. All available evidence, such as data, analysis, and history matching, indicates that the injected carbon dioxide will be completely and permanently stored such that, under the proposed or actual conditions of use, no significant risk of seepage or risk to human health or the environment exists. 4. Not in reservoirs suitable for potable water supply	• No operational or depleted oil & gas reservoirs • No double counting if the project is regulated under host climate policy • Only CO2 from fermentation of renewable biomass (renewable can be determined according to RFS definitions in U.S./Canada/EU legislation) • Only CO2 transport by pipeline • Only CO2 strogage in liquid or supercritical state • Must demonstrate regulatory oversight of the storage site by govt/agency. Must apply requirements detailed in APPENDIX 1 • Must maintain a valid permit in line with the local regs • Must be divided where projects are transboundary • Must prepare a "Non-Permanence Risk Rating Assessment" per APPENDIX 3 • Must have and make available, at validation and each verification, a legal opinion from an appropriately qualified, independent third-party lawyer, licensed to practice within the jurisdiction or host country where the project is located • Must have uncontested pore space teunure rights per APPENDIX 2 (same as Verra GCS Requirements) Contains provisions for non-project CO2/fluids, which includes: non-project source sites; sources of CO2 other than ren biomass fermentation; CO2 capture that is counted towards national mitigation goals or other voluntary programs.	From (1) Methodology for carbon capture and storage: 1. Eligible CO2 sources include: a. DAC b. Post combustion capture from power plants, heat generation, CHP based on fossil fuel or geothermal power c. Flue gas capture from industrial processes (chemicals, steel, cement etc) d. Flue gas capture from oil & gas production and processing (including "native" CO2) e. Biogenic sources (biomass combustion or fermentation) 2. Transport by road, rail, ship/barge or pipeline. 3. Storage in saline aquifers or depleted oil and gas reservoirs 4. Must have 95% CO2 stream 5. Must adhere to all applicable regulations of national/regional/local project jurisdiction related to capture, transport and storage of CO2 6. Certain restrictions apply on refrigerants Not currently applicable to: CO2 utilisation; ERW, mineralisation, biochar or OAE; must not divert CO2 streams; produce or extract CO2 from geological reservoirs for the purpose of capturing it, etc.

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Project Boundary	The project boundary of a CCS project activity shall include all above-ground components, including, where applicable, the following: 1. The installation where the CO2 is captured 2. Any treatment facilities 3. Transportation equipment 4. Any reception facilities or holding tanks at the injection site 5. The injection facility 6. Subsurface components, including the geological storage site and all potential sources of seepage The project boundary shall also encompass the vertical and lateral limits of the CO2 storage site. Does not require any up- or downstream or embodied emissions to be included in methodologies.	(1) the physical, geographical site(s) where CO2 generated by biomass fermentation is captured (2) the site(s) where the captured CO2 is processed (3) the site(s) where the processed CO2 is compressed and dehydrated (4) the site(s) of the CO2 transport system (5) the site(s) where CO2 is injected for storage, and (6) the secure underground formation(s) where the injected CO2 is stored	The spatial extent of the project boundary consists of the sites, leases, rights-of-way, areas of review, and other land areas needed to operate and monitor the project. May include multiple capture facilities, modes of transport, and storage sites. For project activities that capture CO2 from a source facility, the project boundary includes the elements of the source facility that are directly affected, modified, or added to capture CO2 (e.g., equipment for flue gas capture). The source facility is otherwise not included in the project boundary. GHG sources, sinks and reservoirs within the project boundary and controlled by the project include the primary effects: • CO2 capture, transport, and storage; • Fuel combustion; • Electricity and heat inputs (including grid electricity, onsite generation and directly connected offsite generation); and • Process emissions (e.g., venting and fugitives). GHG sources and sinks related to, or affected by the project are secondary effects and are considered leakage and include: • Upstream fuel production and transport emissions including such effects in fuel consumption for electricity generation; • Material inputs and consumables (e.g., chemicals) for operation; and • Decommission and disposal activities for equipment and materials.
Storage Site Characterisation	Several steps are required to characterize the proposed geological storage site: 1. Data and information collection, compilation, and evaluation 2. Characterization of the geological storage site architecture and surrounding domains 3. Characterization of dynamic behaviour, sensitivity characterization and risk assessment 4. Establishment of a site development and management plan A wide range of information shall be used: 1. Geological Information 2. Geophysical Information 3. Geomechanical Information 4. Geochemical Information 5. Hydrogeological Information	**APPENDIX 1 - Regulatory Oversight Requirements:** Secure Underground Formation Selection and Reservoir Characterization - For projects using a secure underground formation(s) to permanently store CO2, regulators shall evaluate all the following: (a) Reservoir capacity, including the geometry and extent of storage, and the spatial distribution of relevant geologic properties (e.g., porosity, permeability, pressure, temperature and/or fluid saturation). (b) Injectivity of the storage reservoir, including a geological and hydrogeological characterization of the storage reservoir. (c) Trapping mechanism(s), including characterization of the primary seal, secondary seals, any other confining strata, faults, and fractures. (d) The integrity of both pre-existing and new wells, including their design and future ability to confine fluids. (e) Proximity to and potential impacts to/from other subsurface activities and/or resources including hydrocarbons, mineral resources, geothermal energy sources, dissolved minerals, waste disposal and other CCS projects. (f) Geochemical properties of the caprock/storage reservoir rock and/or fluid interaction. (g) Geo-mechanical properties including natural seismicity, tectonic activity, faults, in-situ stress properties, and rock mechanical properties of both the storage reservoir and seals. (h) Characterization and protection of aquifers used for potable water or other water resources.	**Geological Carbon Storage (GCS) Requirements:** Regulators providing regulatory oversight within the project jurisdiction must have evaluated, and found adequate for the project activity, at least all the following: (a) Reservoir capacity, including the geometry and extent of storage, and the spatial distribution of relevant geologic properties (e.g., porosity, permeability, pressure, temperature and/or fluid saturation). (b) Injectivity of the storage reservoir, including a geological and hydrogeological characterization of the storage reservoir. (c) Trapping mechanism(s), including characterization of the primary seal, secondary seals, any other confining strata, faults, and fractures. (d) The integrity of both pre-existing and new wells, including their design and future ability to confine fluids. (e) Proximity to and potential impacts to/from other subsurface activities and/or resources including hydrocarbons, mineral resources, geothermal energy sources, dissolved minerals, waste disposal and other CCS projects. (f) Geochemical properties of the caprock/storage reservoir rock and/or fluid interaction. (g) Geo-mechanical properties including natural seismicity, tectonic activity, faults, in-situ stress properties, and rock mechanical properties of both the storage reservoir and seals. (h Characterization and protection of aquifers used for potable water or other water resources.

Table A-2
CDM, Gold Standard, Verra (CCS+)

METHODOLOGICAL COMPONENT	MODALITIES AND PROCEDURES FOR CCS UNDER CDM	GOLD STANDARD – BIOMASS FERMENTATION WITH CCS	VERIFIED CARBON STANDARD (VERRA) CCS+ INITIATIVE
Baseline Emissions	No specific requirements. To be defined at the methodology level following standard CDM methodological features. These could be either • Projection based (e.g. historical emissions, in the case of a retrofit at an existing facility or actual CO2 injected in the case of CO2-rich industrial off-gases streams that are unaffected by the CO2 capture process) or Standards based (e.g. combined margin approach under ACM002)	Captured CO2 that would have been emitted to the atmosphere in the absence of the project **Baseline scenario =** apply the latest approved version of CDM TOOL02 (Combined tool to identify the baseline and demonstrate additionality) to identify the most plausible baseline scenario among all realistic and credible alternatives. If more than one credible and plausible alternative scenario remains, select the scenario corresponding with the lowest baseline emissions as the baseline scenario. **Baseline emissions =** direct measurement of the injected fluid streams that are measured upstream of the injection wellhead in the project	Eligible baseline scenarios: • For CO2 captured from point sources: the CO2 captured under the project activity would be emitted to the atmosphere in the absence of the project activity. • For CO2 captured from the atmosphere: the CO2 captured under the project activity would not be captured in the absence of the project activity. The separate capture modules provide further procedures and requirements for identifying the baseline scenario. The baseline scenario applies to: • Greenfield capture facilities; • The addition or expansion of capture facilities at locations where capture facilities existed; and • The refurbishment of capture facilities that would have been decommissioned in the absence of the project.
Additionality	No specific requirements. Would likely would draw from CDM tools.	Demonstrated in accordance with the Principles & Requirements, by using the latest version of one of the following: • CDM TOOL01 – Tool for the demonstration and assessment of additionality; or • CDM TOOL02 – Combined tool to identify the baseline and demonstrate additionality; or • An approved Gold Standard VER additionality tool In addition, shall consider revenue which is enabled by project activity within the project boundary, of which the project developer and/or project participants are beneficiaries, such as from: (i) Services rendered to project and non-project participants for the capture and/or transport and/or storage of CO2 in secure underground formation(s) (ii) Provisions in jurisdiction or host country regulations which incentivise the construction and/or operation of infrastructure for the capture and/or transportation and/or permanent storage of CO2	3-step process required to demonstrate additionality: **Step 1: Regulatory Surplus** (in accordance with the latest version of the VCS Methodology Requirements) **Step 2: Implementation Barrier** (investment barrier that prevents the project from being implemented in the absence of carbon credit revenues). CDM Tool 01 (Additionality) and CDM Tool 27 (Investment Analysis) to be used. • Wide range of conditions prescribed for the investment analysis. • Specific guidance also outlined on: (1) choice of investment benchmarks, taking account of technology risk etc. (2) O&M contingencies for new technology. **Step 3: Common Practice** (analysis of various activities in the jurisdiction) Projects that demonstrate regulatory surplus, the presence of an implementation barrier, and are considered not common practice are deemed additional
Project Emissions (including seepage)	Any seepage [defined as 'transfer of carbon dioxide from beneath the ground surface or seabed ultimately to the atmosphere or ocean'] that occurs during the crediting period(s) of a CCS project activity shall be accounted for as project or leakage emissions in the calculation of the monitored reductions in anthropogenic emissions by sources of greenhouse gases that have occurred as a result of the registered CDM project activity. Any seepage that occurs after the end of the last crediting period shall be quantified and reported in monitoring reports.	(a) Emissions due to cultivation of biomass in dedicated plantations, and processing and transportation of biomass and biomass residues (b) Direct land use change emissions resulting from the installation of project infrastructure (c) Emissions from the construction of project infrastructure, including well drilling and servicing (ONLY kick or blowout from drilling) (d) Emissions from the production, transportation, and delivery of material inputs consumed by project infrastructure, such as amine-based sorbents, glycols, or lubricants (e) Direct and upstream well-to-tank (liquid fuels) or well-to-meter (gaseous fuels) emissions from fuels consumed by project equipment (f) Emissions from the generation of electricity on- and off-site which is consumed by the project (g) Emissions from fugitive GHG, and routine and non-routine venting throughout the CCS value-chain (h) Emissions from the subsurface to the atmosphere due to loss of containment or loss of conformance of CO2 plume	Project emissions [in each year y (tCO2e)] include the sum of: (1) project emissions from CO2 capture (2) project emissions from CO2 transport (3) project emissions from CO2 storage [Details are provided in each capture/transport/storage module] [Only (2) DAC capture module published so far] [Only (3) Saline Aquifer storage module published so far] • DAC includes (a) electricity consumption (b) energy consumption (c) CO2 stream processing (CO2 losses) • Saline aquifer includes same sources (a) + (b) + (c)

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Leakage	[See Project emissions]	(a) Leakage emissions from biomass due to shift of pre-project activities, diversion of biomass from other applications, processing and transportation of biomass and biomass residues outside of the project	Leakage emissions [in each year y (tCO2e)] include the sum of: (1) leakage emissions from CO2 capture (2) leakage emissions from CO2 transport (3) leakage emissions from CO2 storage [Details are provided within in each capture/transport/storage module] [Only (2) DAC capture module published so far] [Only (3) Saline Aquifer storage module published so far] • DAC includes (a) upstream sources related to fuel consumed in on-site equipment (b) consumption of electricity (c) capture materials. • Saline aquifer includes same sources (a) + (b) + (c) + (d) intentional/ unintentional discharges of CO2 from subsurface storage.
Monitoring	The monitoring of the geological storage site shall be conducted by the entity or Party that is liable for the geological storage site, or by an entity that is under contractual arrangement with the liable entity or Party. The monitoring of the geological storage site shall: 1. Begin before injection activities commence 2. Be conducted at an appropriate frequency during and beyond the crediting period(s) of the proposed project activity 3. Not be terminated earlier than 20 years after the end of the last crediting period of the CDM project activity or after the issuance of CERs has ceased, whichever occurs first. Only be terminated if no seepage has been observed at any time in the past 10 years and if all available evidence from observations and modelling indicates that the stored carbon dioxide will be completely isolated from the atmosphere in the long term.	Requirements set forth in APPENDIX 5 (Monitoring Requirements) (1) Reservoir Modelling (static and dynamic + history matching) (2) Resevoir Management (pressure management) (3) Monitoring Program (plan, plum observation, 10 years PISC etc) (4) Closure Plan • There is no significant risk that injected CO2 will have a significant adverse impact on the environment or human health; • There is no evidence for CO2 leaking from the storage site(s) at the time of closure; • The behaviour of the CO2 has trended towards increased conformance with modelled predictions; • The future CO2 plume migration is understood.	Usual surface monitoring requirements for capture, transport, and equipment at injection sites The **Module for CO2 Storage in Saline Aquifers** requires that a monitoring program support the permanent storage of CO2 injected by ensuring the containment of the plume over time. The monitoring program shall include: (a) surface and subsurface equipment for continuous monitoring (e.g., pressure and temperature gauges), and (b) a defined monitoring program (e.g., set seismic data acquisition frequencies). A **loss of conformance occurs** if the injected CO2 does not adhere to the predicted behaviour based on the reservoir model but remains within the target geological storage complex (no migration outside of a seal(s). A loss of conformance may lead to a loss of containment. A **loss of containment occurs** if injected CO2 migrates out of the geological storage complex and its respective seal(s). A loss of containment may occur in another zone or directly in the atmosphere. Project proponents are requires to describe • techniques used to detect, localize, and quantify subsurface CO2 movement outside the geological storage complex • a specific detection threshold to detect a loss of containment (e.g., tCO2/year or tCO2) for each monitoring technique • the expected mean time to detect a loss of containment • how the reservoir model and monitoring approaches are used to localize and quantify the loss of containment • the maximum undetected leak

Table A-2
CDM, Gold Standard, Verra (CCS+)

METHODOLOGICAL COMPONENT	MODALITIES AND PROCEDURES FOR CCS UNDER CDM	GOLD STANDARD – BIOMASS FERMENTATION WITH CCS	VERIFIED CARBON STANDARD (VERRA) CCS+ INITIATIVE
Permanence **Liability for CO2 Reversal**	**General QA/QC Requirements** The management of permanence is treated on a risk and regulatory basis. Thus, the risk of carbon reversal becomes a function of 1. Proper site selection (covered in Appendix B section 1.) 2. Monitoring (covered in Appendix B section 3.) 3. Allocation of liability in the event of CO2 reversal (covered through the participation requirements the buffer account and other long term liability arrangements-see below) Furthermore, Annex B.5 details various requirements to manage liabilities: 1. The project participants shall clearly document in the project design document how the liability obligations arising from the proposed CCS project activity, or its geological storage site are allocated during the operational phase, closure phase and post-closure phase in accordance with this decision. **Short- and long-term liability** Short: During the operational phase and any time thereafter until a transfer of liability to the host Party has been affected in accordance with paragraph 3 below, liability shall reside with the project participants. A buffer account is also established to withhold 5% of issued CERs to project operators. **Long:** A transfer of liability from the project participants to the host Party shall be affected after: (a) The monitoring of the geological storage site has been terminated (b) The host Party has established that the conditions set out by the designated national authority in its letter of approval, have been complied with. Furthermore, a financial provision shall be established in accordance with Annex B.4. This shall cover a wide variety of potential costs including 20 years post-closure monitoring and the cost of replacing CERs if seepage occurs.	**General QA/QC Requirements** See Site Characterisation and Selection above **Short- and long-term liability** (see also Monitoring above) **Short:** • Buffer: Shall assess the project's "Non-Permanence Risk Rating" and contribute GSVERs proportionally to the project buffer account to ensure that all issued GSVERs remain valid despite the potential for reversals. • Reversal: (exceeding removals in period OR after cessation of injection), GSVERs shall be cancelled from (a) project's registry acc (b) the project buffer acc (c) acquired from other GS projects. • Only thereafter shall projects obtain "Performance Certification" (defined in the rules and standards, basically a positive verification/VVB review) **Buffer Acc Contributions:** calculated from non permanence risk rating (NPRR) in APPENDIX 3, based on: • Regulatory Risk (%) • Political Risk (%) • Resource Tenure Risk (%) • Land Tenure Risk (%) • Closure Risk (%) • Design Risk (%) Mainly follows same/identical framework as Verra NPRT, with same criteria, scoring and weighting Buffer Contributions(y) = ER(y) × NPRR(y) Where: Buffer Contributions(y) = Project buffer account contribution in year y (t CO2e); NPRR(y) = Overall non-permanence risk rating in year y (%) **Long:** see Closure Plan requirements under.	**General QA/QC Requirements** See Site Characterisation and Selection above **Short- and long-term liability** Short-term: Upon loss of CO2 conformance, and prior to the next verification, the proponent must: • Evaluate the potential for current or future release to the atmosphere; • Identify the root cause(s) for the loss of conformance, and • Revise the monitoring program to reflect the changed CO2 migration. • Upon loss of containment, project must halt injection at the affected storage site. **The Geologic Carbon Storage Non-Permanence Risk Tool** (NPRT) requires a quantitative risk assessment for buffer determination: (1) Regulatory Framework Risk [max. 0.3125]; (2) Political Risk [max. 6.75]; (3) Land and Resource Tenure Risk [max. 0.375](4) Closure Financial Risk [max. ~] (5) Design Risk [max. 4.5]. Sum of score on each risk category = risk rating. Max allowable at validation/ verification = 7. Buffer contribution (%) = risk rating (as a %) Projects are deemed no longer eligible if quantity of CO2 lost >10% of the total CO2 injected quantity to date. **Long-term:** • Verra Standard/GCS Requirements: (1) Minimum criteria for project eligibility and (2) Operational and Closure requirements Consists of: (a) host of legal requirements/evidence (b) reg oversight by gov agency (c) checklist to have been evaluated by regulatory agency: (i) Storage site selection and reservoir characterisation (ii) Well-design, construction, operating limits (iii) Monitoring requirements (iv) Storage site closure requirements Also includes: • Monitoring Requirements • Site closure (Site closure plan; Storage site closure conditions)

Table A-2
CDM, Gold Standard, Verra (CCS+)

METHODOLOGICAL COMPONENT	MODALITIES AND PROCEDURES FOR CCS UNDER CDM	GOLD STANDARD – BIOMASS FERMENTATION WITH CCS	VERIFIED CARBON STANDARD (VERRA) CCS+ INITIATIVE
Environmental and Social Impacts	A comprehensive and thorough risk and safety assessment shall be carried out in order to assess the integrity of the geological storage site and potential impacts on human health and ecosystems in proximity to the proposed CCS project activity the risk and safety assessment shall consider the following: 1. The contamination of underground sources of drinking water 2. The chemical properties of seawater 3. Cover the full chain of carbon CCS, including surrounding environments For CCS project activities, as a minimum, the comprehensive environmental and socio-economic impact assessments shall analyse thoroughly and exhaustively air emissions, solid waste generation, and water use associated with current CCS technologies. In all cases, in conducting the environmental and socio-economic impact assessments, best available techniques will be applied in order to facilitate a high level of protection for the environment as a whole and for communities.	**GS Principles and Requirements** Projects shall conduct a Safeguarding Principles Assessment and conform to Gold Standard Safeguarding Principles and Requirements. Assessment covers 9 principles: P.1 HUMAN RIGHTS P.2 GENDER EQUALITY AND WOMEN'S EMPOWERMENT P.3 COMMUNITY HEALTH AND SAFETY P.4 CULTURAL HERITAGE, INDIGENOUS PEOPLE, DISPLACEMENT AND RESETTLEMENT P.5 CORRUPTION P.6 ECONOMIC IMPACTS P.7 CLIMATE AND ENERGY P.8 WATER P.9 ENVIRONMENT, ECOLOGY AND LAND USE **Bio-CCS Methodology** Shall not undermine or conflict with any national, sub-national or local regulations or guidance relevant to project activity. Closure plan must show no significant risk that injected CO2 will have a significant adverse impact on the environment or human health.	The latest **VCS Standard** (V4.6, March 2024) requires that all projects shall "not negatively impact local communities or environments"" (Safeguards). Project proponents must identify and address any negative environmental and socio-economic impacts of project activities. The CCS+ Guidance and Principles document states that "it is critical for any CCS or CCU project to prevent any adverse impact from an environment and social (community) standpoint during its design, development, implementation, and monitoring" and further that "if any potential environment and socio-economic negative impact is identified, the risk should be addressed, and the project must ensure its mitigation"". Also sets requirements for sustainable biomass, covering sustainability principles and traceability requirements.
Sustainability	Not mentioned	See above	The latest VCS Standard (V4.6, March 2024) mandates the contribution of all project activities towards at least 3 SDGs. The CCS+ Guidance and Principles document further suggests that project proponents will be encouraged to demonstrate the contribution of CCS and CCU activities towards meeting SDGs.

Table A-3
British Columbia [draft], Global Carbon Council, Isometric

METHODOLOGICAL COMPONENT	BRITISH COLUMBIA PROTOCOL [DRAFT]	GLOBAL CARBON COUNCIL	ISOMETRIC (DAC AND SALINE AQUIFER STORAGE)
Definitions	Wide range of definitions. Particular focus on alignment with existing regulations and standards.	A comprehensive list of definitions in including: • Geological storage site • History-matching • Net reversal of storage • Significant deviation • Storage complex (similar to Area of Review applied in U.S. legislation)	Wide range of definitions. Terminology applied in the Saline Aquifer Storage based on U.S. regs. For example, the term Area of Review (AOR) is applied throughout, defined by U.S. SDWA. Other jurisdictions (EU, UNFCCC) refer to "stroage complex" to mean a similar delination. "AOR means Area of Review (AOR) is the area surrounding an injection well described according to the criteria set forth in the U.S. Code of Federal Regulations § 40 CFR.146.06, which, in some cases, such as Class II wells, the project area plus a circumscribing area the width of which is either 1⁄4 of a mile or a number calculated according to the criteria set forth in § 146.06."
Applicability Conditions	A CCS Project is eligible under this Protocol if (a) the Project involves the Sequestration of Captured Carbon in British Columbia, and (b) the Project is not excluded under section 5. **5. Excluded Projects** A Project is not eligible under this Protocol if (a) the Project Start Date was before January 1, 2022, or (b) the Project is not likely to result in Project Removals, as determined in the Project Plan in accordance with this Protocol. **Additional Requirements** (1) A Project Plan for a Subsurface CCS Project must include the following assertions: (a) the Project Proponent (i) holds a storage reservoir license in accordance with Part 14 of the PNGA, or holds a PNG lease for the spacing area where the CO2 originates from oil and gas activity, and (ii) has complied with financial security requirements under Section 30 of OGAA, and provided security to the BCER sufficient to cover the costs of A. operation, monitoring, and reporting during the Project Crediting Period, B. Storage Complex monitoring, corrective actions, and reporting during the Stabilization Period, C. Storage Complex monitoring, maintenance, and reporting after the Stabilization Period for the period set out in section 29 (1) (a) or (b) of this Protocol, as applicable; (b) the development or use of the storage reservoir has been designated as a special project under s. 75 (1) (c.1) of OGAA, (2) A Project Plan for a Chemical Transformation CCS Project must include an assertion that the Project Proponent has provided sufficient evidence to demonstrate a reasonable likelihood for CO2 Sequestration.	Covers the following. **CO2 capture from:** • industrial process sources (dilute or high-purity) • fossil point point sources (boilers, turbines etc) • biogenic point sources ("BECCS") • mixed bio and fossil sources (e.g. waste incineration with CCS) • direct from air (DAC) **CO2 transportation:** • Pipelines, rail, or road tanker **CO2 storage:** • Saline aquifers • Depleted hydrocarbon reservoirs • Enhanced oil recovery is excluded **Site permitting:** • In jurisdictions where the requirements for storage are entirely fulfilled by local regulations, the local regulations shall prevail. • In jurisdictions where any of the requirements for storage are not specified in local regulations, project owners must follow the GGCS. A permit to store CO2 from a national authority must also be provided.	**DAC Protocol:** • Projects anywhere that capture CO2 from ambient air and store captured CO2 for >1000 years via physical or chemical trapping mechanisms. • Projects within 1km of major industrial CO2 source must do isotope tracing enable to enable accounting of only non-fossil CO2 in such locations. • CO2 characteristics and the conditions within the storage reservoir must be well defined, modeled and planned to be monitored in line with jurisdictional post-closure requirements. • Evidence that CO2 will be trapped via the intended method and within the intended reservoir with no free phase migration after closure (as per regulating permitting requirements) is needed to support that carbon dioxide can be durably stored. **Saline Aquifer Storage Module:** • Injection site must have a current well permit issued by the responsible authority for the location of the injection facility and reservoir. • Where there is a lack of distinct relevant local regulations to meet the minimum requirements of this module, Project Proponents are required to follow either the U.S. EPA Underground Injection Control (UIC) or EU directives. • The permit shall define the Area of Review (AOR) for the site in accordance with the requirements for the specific well class, formation, and local characteristics. • Wells used for enhanced hydrocarbon recovery activities are excluded from the module.

Table A-3
British Columbia [draft], Global Carbon Council, Isometric

METHODOLOGICAL COMPONENT	BRITISH COLUMBIA PROTOCOL [DRAFT]	GLOBAL CARBON COUNCIL	ISOMETRIC (DAC AND SALINE AQUIFER STORAGE)
Project Boundary	Not covered	Above-ground components, including, where applicable: (a) The facility (Part of the Source plant) where the CO2 is captured; (b) The CO2 capture equipment; (c) Any CO2 treatment facilities; (d) Transportation equipment, including pipelines and booster stations along a pipeline, or offloading facilities in the case of transportation by rail, road, or ship tanker; (e) Any reception facilities or holding tanks at the injection site; (f) The CO2 injection facility. NOTE: embodied CO2 and upstream emissions are excluded from the boundary/scope. Subsurface components within the storage complex, including the geological storage site, connected infrastructure (e.g., wells injection, observation, production, abandoned wells, etc.), any pressure front associated with displaced brines, and all potential sources of seepage	**DAC Protocol:** • Cradle-to-grave GHG Assessment covering: + DAC Process (energy, embodied CO2, transport, misc) + CO2 Transport + CO2 Storage + CO2 Monitoring Emissions for processes within the system boundary should include all GHG sources, sinks and reservoirs (SSRs) from the construction or manufacturing of each project and associated equipment, closure of each project and disposal of associated equipment, and operation of each process **Saline Aquifer Storage Module:** • Area of Review
Storage Site Characterisation	Covered by reference to OGAA in Applicability Conditions (see above)	Subject to the national laws and regulations, following steps shall be applied: • Step 1: Data and information collection, compilation, and evaluation • Step 2: Characterization of the geological storage site architecture and surrounding domains • Step 3: Characterization of dynamic behaviour, sensitivity characterization, and risk assessment • Step 4: Establishment of a site development and management plan Extensive technical guidance and reporting templates are provided in the GCC Guidance for Geological CO2 Storage (GGCS). The GGCS consists of the following: 1. GEOLOGICAL STORAGE SITE SELECTION AND CHARACTERIZATION 2. RISK AND SAFETY ASSESSMENT 3. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT ASSESSMENT 4. MONITORING REQUIREMENTS 5. SITE DEVELOPMENT AND MANAGEMENT PLANS	• Should be well characterized in accordance with the permit application and approval requirements under the national/international regulations • Lack of distinct relevant local regulations to meet the minimum requirements of this module, Project Proponents are required to follow either the U.S. EPA Underground Injection Control (UIC) or EU directives. **Project Proponent must demonstrate the geologic system:** • Includes a sequestration zone of sufficient volume, porosity, permeability, and injectivity to receive the total anticipated volume of the CO2; • Includes a confining system free of transmissive faults and fractures and of sufficient extent and thickness to contain the injected CO2, displaced formation fluids and any gas generated), and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zone(s); • Will not be impacted by, or induce as a result of the injection process, seismicity at levels that may inhibit the durability of CO2 storage due to changes in the formation structure. In addition, characterization of site geology and geochemistry, potential interaction of the injected CO2 and in-situ fluids and injectant mobility and reservoir simulations will be required. Must also include a baseline (pre-injection) characterisation of the AOR. Site characterizations and analytical modeling shall be reviewed every 5 years as part of the regulators permit renewal application minimum.

Table A-3
British Columbia [draft], Global Carbon Council, Isometric

METHODOLOGICAL COMPONENT	BRITISH COLUMBIA PROTOCOL [DRAFT]	GLOBAL CARBON COUNCIL	ISOMETRIC (DAC AND SALINE AQUIFER STORAGE)
Baseline Emissions	A.1 Subsurface CCS: The Baseline Emissions (BE) are equal to the total amount of injected CO2 as measured directly at the point of injection A.2 Chemical transformation: The Baseline Emissions (BE) and Baseline Removals (BR) are zero.	**Baseline scenario:** a similar type of "Source Plant", with similar levels of output, that would occur in the absence of the financial incentive to capture (or remove) and store CO2 offered by project crediting under GCC. **Baseline emissions:** distinguishes between (i) retrofit or (ii) new-build. (i) retrofits tend towards using historical emissions (performance-based) (ii) new-builds towards using a benchmark (sstandards-based) There cases presented with decision support matrix. • Case 1: Actual emissions measured in each project year • Case 2: Historical emissions (average of three years) • Case 3: Average emissions of similar "Source plants" undertaken in the previous five years, in similar circumstances, and whose performance is among the top 20 percent of their category [Various sub-types covered for different types of source plants] DACCS and BECCS have zero removal/emissions baseline.	DAC Protocol: Zero. No allowance for baselines with removals greater than zero.
Additionality	**20 A Project Plan** (a) is not required to include the assertion in section 14 (3) (n) (xi) of GGECR, but (b) must include an assertion that the revenue from the sale of Offset Units was or will be required to implement the Project and a justification for that assertion. **24** (1) A Project Plan must include either (a) an assertion that the Primary Project Activities are not required, directly or indirectly, by a Regulatory Requirement, or (b) an assertion that the Primary Project Activities are required, directly or indirectly, by a Regulatory Requirement, but the Primary Project Activities exceed the standards required by the Regulatory Requirement. (2) For the purposes of validation of a Project Plan, if a Project Plan includes an assertion referred to in subsection (1) (b), the Project Proponent must demonstrate in the Project Plan that the Primary Project Activities exceed the standards required by the Regulatory Requirement.	Applies CDM "TOOL01: Tool for the demonstration and assessment of additionality". • CCS and BECCS: supplemental guidance provided to guide assessment. • DACCS considered to all be additional unless mandatory.	**DAC Protocol** [in reference to the Isometric Protocol]: • Financial: removals are the main purpose and only source of revenue, or that economic barriers would prevent implementation absent of Carbon Finance. • Environmental: climate impact is net negative when compared to the Counterfactual scenario, using a Cradle-to-Grave GHG Assessment. • Regulatory: if not required by any regulatory, policy or other legal requirement. • Otherwise, the Project must be able to demonstrate that it exceeds the minimum regulatory requirements, as outlined in the Regulatory Additionality Considerations section below.

Table A-3
British Columbia [draft], Global Carbon Council, Isometric

METHODOLOGICAL COMPONENT	BRITISH COLUMBIA PROTOCOL [DRAFT]	GLOBAL CARBON COUNCIL	ISOMETRIC (DAC AND SALINE AQUIFER STORAGE)
Project Emissions (including seepage)	Based on CARB CCS Protocol.	Project emissions include the following: (a) CO_2 emissions due to fossil fuel combustion from stationary sources (i.e., used to power CO_2 capture, treatment, transportation by pipeline, reception, and injection of the CO_2) and from mobile sources (e.g., in the transportation of CO_2 by rail, road and/or ship tanker) within the project boundary; (b) CO_2 emissions from electricity consumption relating to the capture, treatment, transportation by pipeline or rail (if applicable), reception and injection of the CO_2; (c) CO_2 emissions from bought-in heat consumption used for the capture of the CO_2; (d) CO_2 removals arising from the injection and geological storage of biogenic CO_2 or direct air capture (accounted for as negative project emissions); (e) Fugitive (non-seepage) CO_2 emissions occurring across the project activity due to losses (leaks) from pipelines, loading and unloading etc; (f) Potential CO_2 emissions from seepage of CO_2 from the geological storage site, which can potentially occur at any time after injection commences. Three key parameters included for the Geological Storage Complex: 1. Conditions of use - operational safety margins and appropriate conditions of use to avoid activating pressure-driven processes in the injection formation. 2. CO_2 migration analysis - history matching to confirm that there is an agreement between the numerical modelling of the CO_2 plume distribution in the geological storage site and the monitored behaviour of the CO_2 plume. 3. Geological storage site architecture - monitoring of the geological storage site architecture (i.e., features), based on comparison with base-level survey data collected during site characterisation. CO_2 flux rate measurements must be applied where seepage is detected.	Five categories of emissions counted as project emissions: 1. Energy = Total GHG emissions associated with energy consumption [under Energy Use Accounting v1.1] 2. Transportation = the total GHG emissions associated with transportation [under Transportation Emissions Accounting v1.0] 3. Embodied = the total embodied GHG emissions [under Embodied Emissions Accounting v1.0.2] 4. Monitoring = the total GHG emissions associated with storage monitoring [under the storage modules] 5. Misc. = the total miscellaneous GHG emissions [non-CO_2 other; staff travle, waste etc]
Leakage	Not covered	Two variants covered: 1. Electricity generating plant de-rating 2. Biomass use	Not covered by the DAC Protocol Wide boundary of project emissions suggest leakage is excldued. Reference is made to 'counterfactual energy use' being covered in the Energy Use Accouting module.

Table A-3
British Columbia [draft], Global Carbon Council, Isometric

METHODOLOGICAL COMPONENT	BRITISH COLUMBIA PROTOCOL [DRAFT]	GLOBAL CARBON COUNCIL	ISOMETRIC (DAC AND SALINE AQUIFER STORAGE)
Monitoring	Monitoring Period 29 (1) For the purposes of monitoring and maintenance requirements under section 25 of GGECR, (a) a Project Proponent of a Subsurface CCS Project that injects Captured Carbon into an oil and gas reservoir or saline formation must comply with the obligations under that section for 100 years after the Crediting Period of the Project ends, and (b) a Project Proponent of a Subsurface CCS Project that injects Captured Carbon into a mafic rock formation must comply with the obligations under that section for 20 years after the Crediting Period of the Project ends instead of 100 years. (2) A Project Proponent of a Chemical Transformation CCS Project is not required to comply	**Methodology:** Monitoring plan covers two types of parameters: (a) Those that are determined ex-ante, and therefore not monitored during the crediting period, and (b) Those that are to be monitored during the crediting period. **CCGS:** Sets out detailed requirements for preparing a CO2 Storage Complex Monitoring Plan. Focus is on establishing techniques to fulfil the three project emission elements described above (i.e. Conditions of Use; CO2 Migration; Storage Site Architecture)	**DAC Protocol:** Appendix 1 sets out Monitoring Plan requirements across the DAC project **Saline Aquifer Module:** Injection and Injectant Operation & Monitoring 1. Injection and Injectant Operation & Monitoring • Maximum allowable surface injection pressure (MASIP) • Maximum CO2 injection rate • CO2 analysis 2. System Integrity Monitoring 3. Migration and Storage Reversal Monitoring • Onshore (surface; near-surface; sub-surface) • Offshore (surface; subsurface) 4. Leakage **Post-Injection Monitoring** • Recommend to apply to same monitoring strategy as in the operational phase • Plume stabilization to be assessed around 15-2o years in compliance with permit • Align duration to regulatory guidance. In absence of regulatory guidance = 50 years Appendix B: Risk Reversal Questionnaire
Permanence **Liability for CO2 Reversal**	**General QA/QC Requirements** See applicability **Short- and long-term liability** Short: Applies a buffer account based on the following Annex: Project Reductions = ∑ER and REM x (1 - Risk Rating) (4) The Risk Rating factor in Equation 3 must be calculated using CARB Equation G.1 in the CARB CCS Protocol. (5) After determining the Risk Rating factor, the Project Proponent must calculate the total emissions reductions to be credited to the government's Contingency Account by using Equation 4. Long: Generally relies on the Project Plan including the relevant provisions of the B.C. Oil and Gas Activities Act (OOGA), including the financial provision mechanism therein. In addition, monitoring is required until the end of the "Stabilization Period", which starts after injection ceases and ends when BC Energy Regulator (BCER) verifies that stored CO2 stabilization has occurred to an extent ensuring Sequestration. (NOTABLY: S.33 implies that monitoring by a project owner is still mandatory after the end of the Stabilization Period, so it remains unclear whether long-term liability has any cut off).	**Operational phase:** Seepage from the CO2 Geological Storage Site should be treated as project emissions. Where reductions/removals exceeded in a monitoring period, net removal of storage applies. **Net reversal of storage (i.e. seepage exceeds reductions/removals):** Buffer pool. Where net reversal occurs, an equivalent number of ACCs shall be cancelled from the GCC pooled buffer account for geological carbon storage. **Post-injection monitoring, cessation of monitoring and transfer of stewardship:** • Project owner continues MRV to the GCC for a minimum of five years after the cessation of injection. • If evidence from MRV indicates that the risk of seepage is sufficiently low and that permanent storage is highly likely to be achieved, site closure can occur and monitoring can be discontinued • If evidence does not show permanent storage after five years post-injection monitoring, MRV shall continue in two-year increments until such conditions are met. • After monitoring ceases, host country liable for undertaking any future monitoring as per paragraph 4(v) of Volume 2, Chapter, 5, Section 5.7.1, of the IPCC 2006 Guidelines	**Isometric Standard:** • Includes a Buffer Pool approach for reversals risk • Buffer contributons based on assessed risk - Very low (2%) - Low (5%) - Medium (10%) - High (20%) Level of assessed risk informed by specific Risk Assessment Questionnaires. For example, Appendix B of Aquifer Storage Module. **Long-term Liability: notes the following:** • U.S. : Site decommissioning does not eliminate any potential liability under law. Project proponent may still hold some responsibility for any remedial action deemed necessary for USDW endangerment • EU: site is transferred from the project proponent to a competent authority (i.e., national or local authorities) once plume stability has been established.

Table A-3
British Columbia [draft], Global Carbon Council, Isometric

METHODOLOGICAL COMPONENT	BRITISH COLUMBIA PROTOCOL [DRAFT]	GLOBAL CARBON COUNCIL	ISOMETRIC (DAC AND SALINE AQUIFER STORAGE)
Environmental and Social Impacts		**Methodology:** • Project owners must apply the GCC "Environment and Social Safeguards Standard – V3.0" **CCGS:** • Sets out detailed requirements for Environmental and Social Risk and Impact Assessment (for CO2 geological storage sites)	Must comply with national and local laws and regulations and, where relevant, international conventions and standards. **Environmental Impacts:** A Project must demonstrate that it creates no net environmental harm (covering Resource efficiency and pollution prevention; Biodiversity conservation and sustainable management of living natural resources) **Social Impacts:** Labor rights and working conditions; Land acquisition and involuntary resettlement; Impacts on Indigenous People (IP), Local Communities (LC) and cultural heritage; Respect for human rights and stakeholder engagement)
Sustainability		**Methodology:** • Project owners required to follow the GCC Project Sustainability Standard – V3.1.	Projects must demonstrate, where relevant and feasible, how their carbon removal activities are consistent with relevant Sustainable Development Goals (SDG). To be included in the Project Design Document.

ANNEX B

– 2006 IPCC GUIDELINES

B-1 COVERAGE OF CCS AND BECCS IN 2006 IPCC GUIDELINES

The following sections of the 2006 GLs apply to CCS and BECCS activities:

- **Volume 1, Chapter 1 (Introduction).** The general concepts for reporting indicates that
  - CO2 emissions from biomass combustion for energy are reported in the AFOLU Sector as part of net changes in carbon stocks;
  - Captured CO2 should be allocated (i.e. reported as emitted) in the sector generating the CO2 unless it can be shown that the CO2 is stored in properly monitored geological storage sites as set out in Chapter 5, Volume 2. As such, countries wishing to count CCS or BECCS towards their NDCs must fulfill the MRV requirements for CO2 transport and storage described below.

- **Volume 2, Chapter 2 (Stationary Combustion).** Subsection 2.3.4 describes how emissions reductions achieved by CO2 capture at combustion sources may be deducted from the relevant sector emissions total in the national GHG inventory. This includes capture of CO2 from fossil thermal, biomass or waste-to-energy fired plants. The guidance confirms capture of biogenic CO2 can be treated as negative emissions in national GHG inventories. In all cases, Tier 3 methods must be applied to CO2 capture sources.[39]

- **Volume 2, Chapter 4 (Fugitive Emissions).** This section describes how both fugitive emissions from GCS projects and the transport and disposal of acid gas from oil and gas facilities must be treated. Subsection 4.2.1 describes methods for natural gas processing and hydrogen production. Guidance on accounting and reporting of emissions from EOR systems is also included.

- **Volume 3, various chapters (Industrial Processes and Product Use).** Chapter 1 describes the general methods for the capture of process CO2 emissions from industrial activities, while the specific chapters for each subsector provide further details on each (cement (2.2), methanol (3.9), ammonia (3.2), iron and steel (4.2)).[40]

- **Volume 2, Chapter 5 (Carbon Dioxide Transport, Injection and Geological Storage).** This chapter sets down specific requirements for the MRV of CO2 after the capture stage, covering emissions from the transport of CO2 in pipelines, surface injection facilities and underground geological CO2 storage sites.

In combination, the guidance in Volumes 2 and 3 provide the basis for monitoring and reporting captured and geologically stored CO2 as ‘not emitted’ in national GHG inventories (i.e. recognising CCS as an emission reduction activity). Importantly, this combination provides the basis for the MRV of GCS activities as measures in pursuit of nationally determined contributions (NDCs) under the Paris Agreement.

Notably, CO2 captured in the relevant source sectors may only be deducted from the sector totals in a national GHG inventory if it is stored in “properly monitored storage sites” following the guidance in Volume 2, Chapter 5.[41] Therein, Volume 2, Chapter 5, sets down detailed requirements for inventory compilers to follow in respect of the oversight to GCS in order to build confidence in the durability of storage.

Presently DAC is not covered by IPCC GHG inventory compilation guidance, although the elements applicable to geological CO2 storage sites should be see as common, regardless of CO2 source.

These requirements are described in detail below.

B-2 REQUIREMENTS FOR CO2 STORAGE SITES UNDER IPCC 2006 (VOL. 2, CH. 5)

B-2.1 Monitoring

National GHG inventory compilers must apply Tier 3 monitoring to estimate emissions from the capture, transport, and storage of CO2. All data collected by operators at the site level must therefore be reported to the host country national inventory compiler and directly used to compile the national GHG inventory report.

Estimates of emissions from these activities based on Tier 1 or Tier 2 emissions factors may not be used for inventory compilation.

B-2.2 Site characterisation and selection

Volume 2, Chapter 5, sets down specific Tier 3 requirements for geological CO2 storage sites to ‘help build confidence that there will be minimum leakage’ (p. 5.14). In these respects, the 2006 IPCC Guidelines state that:

> *‘In order to understand the fate of CO2 injected into geological reservoirs over long timescales, assess its potential to be emitted back to the atmosphere or seabed via the leakage pathways identified in Table 5.3, and measure any fugitive emissions, it is necessary to:*

(a) Properly and thoroughly characterise the geology of the storage site and surrounding strata;
(b) Model the injection of CO2 into the storage reservoir and the future behaviour of the storage system;
(c) Monitor the storage system;
(d) Use the results of the monitoring to validate and/or update the models of the storage system.’ (pp. 5.13-5.14)’

As such, in order to meet Tier 3 reporting requirements, these same requirements must be passed onto site operators. Thus, a common GCS standard must seek to fulfill these requirements so that emission reductions from GCS project activities can be effectively recorded in national inventory reports.

B-2.3 Regulatory requirements

In respect of regulatory interactions, the 2006 Guidelines suggest that:

> *'...if one or more appropriate governing bodies that regulate carbon dioxide capture and storage exist, then the inventory compiler may obtain emissions information from those bodies... [and that]... If no such agency exists, then it would be good practice for the inventory compiler to follow the methodology presented below.'*

The step-wise methodology covers the following:

1. Identify and document all geological storage operations in the jurisdiction...
2. Determine whether an adequate geological site characterization report has been produced for each storage site....
3. Determine whether the operator has assessed the potential for leakage at the storage site...
4. Determine whether each site has a suitable monitoring plan...
5. Collect and verify annual emissions from each site...

Furthermore, fulfilling the QA/QC requirements in the 2006 IPCC Guidelines also implies several de facto regulatory approval and verification elements. Specifically:

> *'On-site QA/QC will be achieved by regular inspection of monitoring equipment and site infrastructure by the operator. Monitoring equipment and programmes will be subject to independent scrutiny by the inventory compiler and/or regulatory agency. (pp. 5.19)*
>
> *All data including the site characterization reports, geological models, simulations of CO2 injection, predictive modeling of the site, risk assessments, injection plans, licence applications, monitoring strategies and results and verification should be retained by the operator and forwarded to the inventory compiler for QA/QC.*
>
> *Where applicable, the relevant regulatory body can provide verification of emissions estimates and/or the monitoring plan described above. If no such body exists, the site operator should at the outset provide the inventory compiler with the results of peer review by a competent third party confirming that the geological and numerical models are representative, the reservoir simulator is suitable, the modeling realistic and the monitoring plan suitable. As they become available, the site operator should compare the results of the monitoring programme with the predictive models and adjust models, monitoring programme and/or injection strategy appropriately. The site operator should inform the inventory compiler of changes made.' (5.20)'*

Furthermore, Section 5.10 specifies the Reporting and Documentation to be obtained by the national inventory compiler prior to the start of geological storage operations:

> *'5.10 REPORTING AND DOCUMENTATION Guidelines for reporting emissions from geological storage:*
>
> *Prior to the start of the geological storage operation, the national inventory compiler where storage takes place should obtain and archive the following:*

- *Report on the methods and results of the site characterization*
- *Report on the methods and results of modeling*
- *A description of the proposed monitoring programme including appropriate background measurements*
- *The year in which CO2 storage began or will begin*
- *The proposed sources of the CO2 and the infrastructure involved in the whole CCGS chain between source and storage reservoir.*
- *The same national inventory compiler should receive annually from each site:*
- *The mass of CO2 injected during the reporting year*
- *The mass of CO2 stored during the reporting year*
- *The cumulative mass of CO2 stored at the site*
- *The source (s) of the CO2 and the infrastructure involved in the whole CCGS chain between source and storage reservoir*
- *A report detailing the rationale, methodology, monitoring frequency and results of the monitoring programme - to include the mass of any fugitive emissions of CO2 and any other greenhouse gases to the atmosphere or seabed from the storage site during the reporting year.*
- *A report on any adjustment of the modeling and forward modeling of the site that was necessary in the light of the monitoring results.*
- *The mass of any fugitive emissions of CO2 and any other greenhouse gases to the atmosphere or seabed from the storage site during the reporting year.*
- *Descriptions of the monitoring programmes and monitoring methods used, the monitoring frequency and their results.*
- *Results of third-party verification of the monitoring programme and methods.'*

There may be additional reporting requirements at the project level where the site is part of an emissions trading scheme' (p. 5.20)

Consequently, it must be considered good practice in any GCS protocol to be cognizant of these reporting obligations and include them accordingly. Problematically however, in many jurisdictions the inventory compiler may not be competent or suitably prepared for the collection and review of these sorts of technical reports, information and data.

B-2.4 Linkages to permanence, liability, and carbon reversals

In respect of liability for carbon reversals, countries reporting CO2 as not emitted consistent with 2006 IPCC Guidelines will have to backstop liability for any emissions of stored CO2 in line with MRV requirements under the Paris Agreement.[42]

A project-based methodology can devolve liability to the project operator during the crediting period, and potentially beyond the crediting period and into the post-injection phase through some form of ongoing monitoring and remediation obligations. The extent to which ongoing monitoring can be enforced through a voluntary standard are open to debate, however, as discussed in the main body of the report (Section 3).

The CDM CCS M&Ps provide some additional guidance on how these aspects may be managed, in particular the requirements associated with the establishment of a financial provision (see Annex A).

For long-term monitoring, the 2006 IPCC Guidelines support reduction and cessation of monitoring on a performance basis. Specifically, host countries are required to ensure that:

> *'The [monitoring] plan should provide for monitoring of the site after the injection phase. The post-injection phase of monitoring should take account of the results of the forward modeling of CO2 distribution to ensure that monitoring equipment is deployed at appropriate places and appropriate times. Once the CO2 approaches its predicted long-term distribution within the reservoir and there is agreement between the models of CO2 distribution and measurements made in accordance with the monitoring plan, it may be appropriate to decrease the frequency of (or discontinue) monitoring. Monitoring may need to be resumed if the storage site is affected by unexpected events, for example seismic events.' (pp. 5.15-5.16).*

The provisions for continued monitoring of the site post-injection, and the termination of monitoring, can help inform methodological choices regarding the period of time during which project operators must undertake storage monitoring.

B-3 TRANSBOUNDARY ACCOUNTING

The 2006 IPCC Guidelines include provisions for the MRV and accounting of cross-border transfers of CO2 across a chain of operations. Specifically, in respect to the Reporting and Documentation requirements, inventory compilers are obliged to meet the following requirements:

'Reporting of cross-border CCS operations
CO2 may be captured in one country, Country A, and exported for storage in a different country, Country B. Under this scenario, Country A should report the amount of CO2 captured, any emissions from transport and/or temporary storage that takes place in Country A, and the amount of CO2 exported to Country B. Country B should report the amount of CO2 imported, any emissions from transport and/or temporary storage (that takes place in Country B), and any emissions from injection and geological storage sites.

If CO2 is injected in one country, Country A, and travels from the storage site and leaks in a different country, Country B, Country A is responsible for reporting the emissions from the geological storage site. If such leakage is anticipated based on site characterization and modeling, Country A should make an arrangement with Country B to ensure that appropriate standards for long-term storage and monitoring and/or estimation of emissions are applied (relevant regulatory bodies may have existing arrangements to address cross-border issues with regard to groundwater protection and/or oil and gas recovery).

If more than one country utilizes a common storage site, the country where the geological storage takes place is responsible for reporting emissions from that site. If the emissions occur outside of that country, they are still responsible for reporting those emissions as described above. In the case where a storage site occurs in more than one country, the countries concerned should make an arrangement whereby each reports an agreed fraction of the total emissions.' (pp. 5.20-5.21)

These requirements imply that a project activity that potentially risks cross-border movement of CO2 – either deliberately, accidentally, or because of shared infrastructure – will need to ensure agreement is reached between the relevant countries regarding how monitoring and reporting will be undertaken, and how liability will be allocated in the event of carbon reversals.

These types of requirements typically far exceed the types of obligations that can be placed on a project developer within voluntary carbon crediting methodologies.

Notably, the cover decision to the CDM CCS M&Ps agreed that the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP) would consider 'The eligibility of carbon dioxide capture and storage project activities which involve the transport of carbon dioxide from one country to another or which involve geological storage sites that are located in more than one country'.[43]

A UNFCCC Technical Report on transboundary projects was prepared in 2012 (UNFCCC 2012) to support decisions in these regards.[44] The paper covered a range of technical scenarios and some of the potential legal aspects and implications. However, since then, no further decisions were taken by the CMP to determine eligibility of cross-border CCS projects and so guidance is lacking in these respects.

ENDNOTES

1. The European Union Directive 2009/31/EC on geological CO2 storage ("the EU CCS Directive"); U.S. EPA Safe Drinking Water Act, Underground Injection Control Class VI Well Rule ("the UIC Class VI Well Rule")
2. Notably, standards and methodologies are frequently being updated with a tendency towards reducing the differences in methodological aspects. Six of the larger VCM standards issued a joint statement in November 2023 indicating an intention to work together to enhance standardization (through accreditation and alignment with carbon principles). Alignment with common criteria that provide a strong baseline of QA/QC requirements for site selection, operation, closure and long-term liability would be advantageous of GCS activities.
3. With leadership from Mitsui & Co.
4. https://www.ieta.org/initiatives/high-level-criteria-for-carbon-geostorage-activities/
5. 'Conditions of use' is term in the CCS CDM M&Ps (see Annex A), drawing from the EU CCS Directive (Article 4)
6. Tool to calculate the emission factor for an electricity system v7.0; https://cdm.unfccc.int/Reference/tools/index.html
7. Here we use the term seepage to refer to fugitive emissions (leaks) from the CCS system to avoid confusion with the emissions leakage concept introduced under the CDM.
8. Insurance products are also being increasingly considered as a means to underwrite and compensate against such risks.
9. The capture of co-mingled fossil CO2, as might be found in waste incinerator emissions, is allowed but not credited.
10. The Province also has an EOR Protocol that was not covered by this review.
11. Both set requirements for the regulatory program to cover: (1) Storage site selection and reservoir characterisation; (2) Well-design, construction, operating limits; (3) Monitoring requirements; (4) Storage site closure requirements.
12. Although the methodology does require proponents to distinguish between retrofit or new-build bioenergy facilities in respect of up- and downstream GHG effects associated with the project.
13. The terms 'purpose-grown' and 'purpose-built' reflect use of biomass and equipment respectively where these are used solely for purposes of CO2 capture.
14. Isometric modules include Energy Use Accounting v1.1, Transportation Emissions Accounting v1.0, Embodied Emissions Accounting v1.0.2, Biomass Feedstock Accounting v1.0 etc.
15. Environmental additionality equates to an assessment of whether an activity leads to emission reductions or removals that exceeds a pre-agreed crediting baseline, such as a standardised performance benchmark.
16. Tool for the demonstration and assessment of additionality
17. Combined tool to identify the baseline scenario and demonstrate additionality
18. See Annex, B-2.4.
19. Decision 2/CMA.3. Guidance on cooperative approaches referred to in Article 6, paragraph 2, of the Paris Agreement
20. Decision 18/CMA.1. Modalities, procedures and guidelines for the transparency framework for action and support
21. FCCC/TP/2012/9: Technical paper on trans-boundary carbon capture and storage project activities
22. FCCC/SBSTA/2012/L.21: Draft conclusions proposed by the Chair
23. 22nd Meeting of the CDM Executive Board, November 2005.
24. Decision 1/CMP.2
25. FCCC/SBSTA/2008/INF.1, FCCC/SBSTA/2008/INF.3, FCCC/SBSTA/2011/INF.7
26. Decision 10/CMP.7. 'Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities'
27. Decision 3/CMP.1. Afforestation and reforestation (A/R) project activities were also subject to specific CDM modalities and procedures (Decision 5/CMP.1) with additional safeguards relating to permanence (i.e. the limitation of issuance of temporary and long-term certified emission reduction (tCERs and ICERs) and ecological protection (i.e. additional environmental and socio-economic impact assessment requirements).
28. In accordance with the Decision 10/CMP.7, Annex, para. 26 and 27.
29. Decision 10/CMP.7 Annex, Section F (Participation Requirements), paragraph 8.
30. ibid
31. Non-market cooperative approaches under Article 6.8 are not considered here, although similar safeguarding questions would apply were CCS to be included thereunder.
32. Decision 3/CMA.3.
33. Document A6.4-SB009-A02. Recommendation: Activities involving removals under the Article 6.4 mechanism.
34. Decision 2/CMA.3
35. Decision 2/CMA.3. Annex II, paragraph 4(f)
36. Zakkour, P.D. and W. Heidug, 2019. A Mechanism for CCS in the Post-Paris Era: Piloting Results-Based Finance and Supply Side Policy Under Article 6. King Abdullah Petroleum Studies and Research Center discussion paper. April 2019. https://doi.org/10.30573/KS--2019-DP52
37. Decision 2/CMA.3; Annex I.
38. Decision 18/CMA.1
39. The IPCC Guidelines allow for different tiers to be used to estimate emission and removals by sinks. Tiers 1 and 2 involve the use of international or regional emission factors, respectively. Tier 3 methods usually involve using data and information specific to a particular project or activity, thereby resulting in a better quality of inventory.
40. Process and fugitive streams are similar to 'CO2-rich' streams covered by the Alberta CCS Protocol.
41. 2006 IPCC, Volume 1, section 1.1
42. Biennial Transparency Reports; BTRs – as guided by the Modalities and Procedures for the Transparency Framework; the MPGs; Decision 18/CMA.1
43. Decision 10/CMP.7
44. UNFCCC, 2012. Transboundary carbon capture and storage project activities. Technical paper. FCCC/TP/2012/9.

ACRONYMS AND ABBREVIATIONS

BECCS	Bioenergy with carbon capture and storage
COP	Conference of Parties to the UNFCCC
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
CMA	Conference of the Parties serving as the meeting of the Parties to the Paris Agreement
CCGS	CO2 capture and geological storage (from 2006 IPCC Guidelines)
CCS	Carbon dioxide (CO2) capture and storage
DAC	Direct air capture
DACCS	Direct air carbon capture and storage
EOR	Enhanced Oil Recovery
ETF	Enhanced transparency framework
GCC	Global Carbon Council
GCS	Geological CO2 storage
IPCC	Intergovernmental Panel on Climate Change
M&P	Modalities and procedures
MPG	Modalities, procedures and guidelines for the Paris Agreement's enhanced transparency framework (ETF)
MRV	Monitoring, reporting and verification
NDC	Nationally determined contribution
LT-LEDS	Long-term low emissions development strategies
UNFCCC	United Nations Framework Convention on Climate Change
VVB	Validation and verification body
VCM	Voluntary carbon market

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