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Certification of carbon removals

Part 2: A review of carbon removal certification mechanisms and methodologies

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CERTIFICATION OF CARBON REMOVALS

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GLOSSARY AND ABBREVIATIONS

Glossary

Additionality: Additionality refers to whether and to what extent the carbon removals project increases removals beyond what would have occurred in the baseline, i.e. in the absence of the project; additionality implies that the removals were caused by the carbon removals mechanism.

Baseline: A counterfactual against which the impact of a removals project is compared, i.e., the baseline describes the carbon removals (and potentially emissions) that would have occurred in absence of the carbon removal project. The baseline can be a quantitative number (e.g., in terms of t CO_2-e) or can refer to a scenario (i.e., a hypothetical reference case that best represents the conditions most likely to occur in the absence of a proposed removals project).

Carbon removal: The withdrawal of greenhouse gases from the atmosphere as a result of deliberate human activities.

Crediting period: The period of time for which participants/projects are rewarded for removals. In this time period, participants/projects are generally required to carry out MRV to quantify the removals that occur, as well as monitor other outcomes important to the mechanism. Participants/project may also have responsibilities after the crediting period (e.g., related to ensuring permanence).

Leakage: The net change of anthropogenic emissions/removals that occur outside the project boundary. If leakage occurs (i.e. removals within the project boundary decrease removals outside the project boundary), the overall mitigation impact of the project is reduced; if this is not considered in net quantification of removals, these removals will not all be additional.

Monitoring, Reporting, and Verification (MRV): Refers to the mechanism or methodology's processes, methods, and requirements for quantifying, reporting, and verifying removals.

Nature-based solutions (NBS): Within this report, NBS refers to any carbon removal activity that pre-dominantly relies on natural carbon sequestration processes (e.g., in soil or biomass).

Participants/projects: The actor who implements or manages the carbon removal action.

Permanence: Refers to the longevity of the storage of removals as a result of carbon removal activities.

System boundary: Refers to the removals and emissions that are captured by the methodology and included in the quantification of net removals.

Technology-based solutions (TBS): TBS rely on man-made technologies to capture and/or store carbon from the atmosphere.

Validation: A process for evaluating the reasonableness of the assumptions, limitations and methods that support a statement about the outcome of future activities (ISO, 2019). In the context of carbon removals, this refers to an initial assessment of a removals project plan and/or implementation.

Verification: A process for evaluating a statement of historical data and information to determine, if the statement is materially correct and conforms to criteria (ISO, 2019). In the context of carbon removals, this refers to an ex-post evaluation of a removals project or action to confirm the quantified climate impact and ensure alignment with other conditions.

Abbreviations

BECCS: Bioenergy with Carbon Capture and Storage

CCS: Carbon Capture and Storage

CCU: Carbon Capture and Utilisation

CCOP: California's Compliance Offset Program

CDM: Clean Development Mechanism

CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation

DACCS: Direct Air Capture and Carbon Storage

EOR: Enhanced Oil Recovery

ERF:Emissions Reduction Fund

ETS: Emissions Trading System

IPCC GL: Intergovernmental Panel on Climate Change Guidelines

JI: Joint Implementation

LBC: Label Bas Carbone

LULUCF: Land Use, Land Use Change and Forestry

MRV: Monitoring, Reporting, and Verification

MS: (EU) Member States

NBS: Nature-based Solution

NDC: Nationally Determined Contributions

PEFC: Programme for the Endorsement of Forest Certification

PFSI: Permanent Forest Sink Initiative

SFI: Sustainable Forestry Initiative

TBS: Technology-based Solution

TRL: Technology Readiness Level

VCS: Verified Carbon Standard

SUMMARY

Carbon removal certification mechanism for the EU

The European Commission is developing a certification mechanism for nature-based and technology-based carbon removals. To support its development, this report reviews existing carbon removal certification mechanisms and methodologies and identifies key lessons related to mechanism design.

Certification mechanisms for carbon removals or mitigation typically provide a set of rules, procedures and requirements for a range of eligible activities in order to verify that they have reduced emissions or removed carbon through sink enhancements and are eligible for certification/payment. These mechanisms have two main objectives: first, to ensure that carbon credits are real, measurable, additional, not resulting in leakage, not double-counted, and permanent; second, to achieve wide scale uptake and implementation, so as to maximise potential mitigation impact.

Existing carbon removal mechanisms

We assessed twelve mechanisms for carbon removals, along with an additional twelve underlying methodologies for nature-based and technology-based carbon removals. Each mechanism and methodology is summarised in a multi-page fiche; these are included in Annexes 1 and 2 of the report. The fiches provide descriptive information (including mechanism location, context, mitigation impact, and participants) and summarise key design decisions, describing the mechanism/methodology's approach to governance, monitoring, reporting, and verification (MRV), additionality, co-benefits/negative externalities, and other elements.

Main findings

Based on this review of existing mechanisms and methodologies, the report also provides cross-cutting analysis of existing mechanism approaches to key design challenges, identifying and evaluating different approaches to the following issues:

- **Mechanism governance:** Methodology development, approval, accounting approaches to manage double-counting, and administrative/transaction costs
- **Additionality:** Definitions of additionality, baseline setting methods, and additionality tests
- **Leakage:** Approaches to quantifying and managing leakage and differing definitions of system boundaries
- **Uncertainty:** Methodologies for quantifying and managing uncertainty of mitigation impact
- **Permanence:** Approaches for managing risk of impermanence
- **Sustainability:** Safeguards to protect against negative side-effects and approaches for increasing co-benefits
- **Verification and validation:** Evaluation of different verification and validation approaches

The report also summarises key conclusions related to evaluation of NBS and TBS methodologies. This methodology-level evaluation is important, as the specifics of individual methodologies are crucial for ensuring that removals are of high environmental integrity (i.e., real, permanent, additional, avoid leakage and double-counting). This includes discussion of different system boundaries, measurement approaches, and eligibility restrictions.

Overall, the report aims to provide a thorough overview of existing carbon removal certification mechanisms and methodologies. By documenting different approaches to key certification mechanism design issues, the report identifies and evaluates a range of options for the EU certification mechanism, supporting the development of a robust and effective system to incentivise uptake of carbon removals within Europe.

ZUSAMMENFASSUNG

Die Europäische Kommission entwickelt einen Rechtsrahmen für die Zertifizierung der Entfernung von Kohlendioxid aus der Atmosphäre. Um diese Entwicklung zu unterstützen, untersucht der vorliegende Bericht bestehende Zertifizierungssysteme und –methoden.

Bestehende Zertifizierungssysteme für Lösungen zur Entfernung von Kohlendioxid aus der Atmosphäre, sowie auch für die Reduktion von Treibhausgasen, beinhalten üblicherweise eine Reihe von Regeln, Verfahren und Anforderungen, um die Entfernung bzw. die Reduktion von Kohlendioxid zu bestätigen und ihre Zertifizierungswürdigkeit (meist verbunden mit Zahlungsflüssen) festzustellen.

Diese Zertifizierungssysteme weisen zwei wesentliche Zielsetzungen auf: 1) sicherzustellen, dass den generierten Zertifikaten eine tatsächliche, messbare, zusätzliche und dauerhafte Entfernung von Kohlendioxid gegenübersteht, die Entfernung nicht zu einer Verlagerung zu Treibhausgas-Emissionen geführt hat und nicht doppelt gezählt wurden; 2) eine breite Anwendung und Implementierung von Lösungen zur Entfernung von Kohlendioxid zu unterstützen, um deren Beitrag zum Klimaschutz zu maximieren.

Bestehende Zertifizierungssysteme zur Entfernung von Kohlendioxid aus der Atmosphäre

In diesem Bericht wurde zwölf Zertifizierungssysteme und zwölf darin enthaltene Methoden zur Zertifizierung von Lösungen zur Entfernung von Kohlendioxid aus der Atmosphäre untersucht. Dazu zählen natur-basierende Lösungen (nature-based solutions, NBS) und technologie-basierende Lösungen (technology-based solutions, TBS). Jedes System (Anhang 1) und jede Methode (Anhang 2) wurden in kurzen Informationsblättern zusammengefasst. Diese Zusammenfassungen umfassen eine deskriptive Beschreibung (geographischer Ort des Systems, Kontext, Klimaschutzbeitrag, Art der Teilnehmer), sowie einen Überblick über die Entscheidungsprozesse und das Design der Systeme, deren Methoden zur Überwachung und Berichterstattung, Nachweis der Zusätzlichkeit, der positiven und negativen Umwelt(neben)effekte, sowie andere relevante Design-Elemente.

Wesentliche Ergebnisse

Die wesentlichen Ergebnisse der Studie umfassen die folgenden Aspekte:

- **Steuerung des Zertifizierungssystems:** Methodenentwicklung, Genehmigung, Vermeidung von Doppelzählung, Administrations- und Transaktionskosten
- **Zusätzlichkeit:** Definitionen der Zusätzlichkeit, Methoden zur Bestimmung des Referenzpfades, Zusätzlichkeits-Tests
- **Emissionsverlagerung:** Ansätze, um etwaige Verlagerung zu quantifizieren, deren Handhabung und Umgang mit unterschiedlichen Definitionen von Systemgrenzen
- **(Mess)unsicherheit:** Methoden zur Bestimmung der Unsicherheiten und deren Handhabung
- **Dauerhaftigkeit:** Handhabung des Risikos geringer Dauerhaftigkeit und Umkehrbarkeit der Kohlendioxid-Entfernung

- **Nachhaltigkeit:** Schutzmaßnahmen gegen negative Umwelteffekte und zur Förderung positiver Effekte
- **Verifizierung und Validierung:** Unterschiedliche Ansätze der Zertifizierungssysteme zur Verifizierung und Validierung

Der vorliegende Bericht fasst die Kernergebnisse der Evaluierung bestehender Zertifizierungssysteme und –methoden für NBS und TBS zusammen. Diese Bewertung auf Methodologie-Ebene ist entscheidend zur Sicherstellung der Umweltintegrität (d.h. die Entfernung des Kohlendioxids aus der Atmosphäre ist messbar, zusätzlich und wäre ohne die Aktivität des Projektes nicht erfolgt, führt zu keiner Verlagerung von Treibhausgas-Emissionen, keine Doppelzählung). Diese Evaluierung umfasst weiters eine Bewertung der unterschiedlichen Systemgrenzen, der Methoden zur Messung und Quantifizierung, sowie die Beschränkung berechtigter Aktivitäten.

Die umfassenden Analysen der unterschiedlichen Zertifizierungssysteme und –methoden, sollen als Grundlage für die Entwicklung eines europäischen Zertifizierungssystems dienen und dessen Robustheit und Effektivität der zertifizierten Mengen an entfernten Kohlendioxid aus der Atmosphäre sicherstellen.

1 INTRODUCTION

Certification mechanisms for carbon removals

Certification mechanisms for carbon removals or mitigation typically provide a set of rules, procedures and requirements for a range of eligible activities in order to verify that they have reduced emissions or removed GHGs through sink enhancements and are eligible for certification/payment. These mechanisms have two main objectives: first, to ensure that carbon credits are real, measurable, additional, not resulting in leakage, not double-counted, and permanent; second, to achieve wide scale uptake and implementation, so as to maximise potential impact on the climate. To achieve these objectives, certification mechanisms operate at two levels:

- **Methodological –** The mechanisms provide methods for quantifying and certifying on-the-ground carbon mitigation/removals. These methods are specific to particular carbon removal solutions and contexts, including specific rules for eligibility. They are technical, including calculation methods, default data (e.g., emissions factors), and instructions to quantify removals, as well as rules and tests to demonstrate the quality of removals (e.g., related to additionality, leakage, etc.). A single certification mechanism can have single or multiple methodologies, each focussing on different solutions or contexts.
- **Mechanism architecture** – Every certification mechanism also has an overarching architecture that applies principles and approval frameworks to evaluate and certify methodologies and their associated removals to ensure that that they are of acceptable quality (i.e., real, additional, permanent, etc.). Mechanism architectures differ depending on factors such as scale or objectives but generally feature governance structures to validate projects/participants, verify and register removals, approve, develop or manage new methodologies, and facilitate uptake, among other roles.

Evaluation of 12 certification mechanisms and 12 methodologies

In this report, we evaluate twelve certification mechanisms (at the mechanism architecture level) and twelve additional methodologies from within these certification mechanisms, covering mechanisms related to nature-based solutions (NBS) and technology-based solutions (TBS). Each mechanism and methodology is described in an around 5-page fiche, which summarises key design aspects such as governance, monitoring, reporting, and verification (MRV), sustainability, performance, among other elements. Based on our analysis of the certification mechanisms, we draw overarching lessons for the design of a European carbon removals certification mechanism.

The report is structured as follows: section 2 describes the methodology; section 3 introduces the reviewed certification mechanisms and identifies key takeaways related to governance and to mechanism approaches to monitoring, reporting and verification; section 4 identifies key methodological-level conclusions, discussing TBS and NBS separately; Annexes 1 and 2 include all summary fiches; Annex 3 provides fiche templates.

This report is published alongside a second, related report, which evaluates technology-based and nature-based carbon removal solutions. It reports their potential mitigation impact and assesses their appropriateness for widespread implementation in Europe.

Bey, Niki et al. (2021): Certification of carbon removals - Part 1: Synoptic review of carbon removal solutions

2 METHODOLOGY

The review in this study proceeded in four steps:

1. Identification and prioritisation of mechanisms/methodologies: Having identified a long list of potential mechanisms/methods to evaluate, we selected a shortlist of 25 mechanisms and methods. Mechanisms/methodologies were prioritised to ensure that we assessed a broad range, covering all major NBS and TBS, as well as different governance scales and approaches (including voluntary and regulatory, project-based, jurisdictional and national scales). Where there were multiple mechanisms/methodologies focussed on the same solution, we prioritised based on an initial assessment of how sophisticated their Monitoring, Reporting, and Verification (MRV) approach was, market size, and how established the method/mechanism was.
2. Fiche template development[1]: We developed a template within which to capture information on each mechanisms/methodology in a consistent and comparable way to facilitate evaluation. The fiche template covers all aspects of the certification mechanisms that are relevant for understanding how the certification mechanism works, as well as background information to enable contextual understanding. In line with the two levels of certification mechanisms (i.e., high-level mechanism architecture and more specific methodological approaches), the following two separate fiche templates were prepared:
   - The mechanism architecture fiche template addresses the high-level characteristics of certification mechanisms
   - The methodology fiche template sets out a description of specific methods therein
3. Research and fiche completion: Fiches were completed based on desk research. To avoid duplication, we first drew on existing DG CLIMA studies related to carbon farming and CCU (COWI, Ecologic Institute, and the Institute for European Environmental Policy, Unpublished report; COWI, Ecologic Institute, and the Institute for European Environmental Policy, 2021; Ramboll, et al, 2019), then turned to documentation of the certification mechanisms and their methodologies, and to related academic and grey literature. All fiches are fully referenced to enable the reader to access additional knowledge related to specific areas of the synopsis provided in the fiche. Where necessary, interviews with external experts were carried out or mechanism administrators reviewed fiches and provided additional information to enrich the quality of information provided in the fiche, as well as using input and feedback gathered at an expert roundtable[2].

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[1] The fiche templates are included in Annex 3.

[2] Expert Roundtable on the development of a regulatory framework for the certification of carbon removals, 22nd of April, 2020.

4. Quality assurance: Completed fiches went through at least three rounds of quality assurance, including review by senior project team members and the European Commission. In addition, selected fiches have been externally reviewed by experts from the Expert Roundtable or from outside the consortium.

3 CERTIFICATION MECHANISMS: OVERVIEW AND CONCLUSIONS

3.1 Certification mechanism overview

Table 1 provides an overview of the twelve certification mechanisms that we evaluated. The top row identified the specific methodologies we evaluated, in addition to the overarching mechanism. As illustrated by the table, these evaluated mechanisms differ considerably across the following axes:

- **Governance and location:** We evaluated privately operated mechanisms (established by independent non-profit or for-profit organisations), which ranged in scale and location, with many globally active, and others geographically limited to a country or region. Mechanisms established by public bodies were all focussed at a national level.
- **Removal solutions:** Many mechanisms covered multiple solutions through many individual methodologies (including emissions mitigation methods as well as removals, e.g., VCS has more than 100 methodologies for carbon mitigation and removals). Other mechanisms focussed on just one solution (e.g., Woodland Carbon Code on afforestation/reforestation, MoorFutures on peatland rewetting).
- **Market:** All privately operated mechanisms developed offset certificates for the voluntary market. Publicly operated mechanisms used removals as part of a national Emissions Trading Scheme, had removals purchased through reverse auctions by the government, or were also linked to the voluntary market.
- **Number of participants/projects and amount of removals:** The size of the mechanisms varied hugely, with local mechanisms such as MoorFutures featuring five projects (with multiple participants) and a total climate impact of approx. 70,000 t CO_2-e (of avoided emissions); national regulatory schemes such as the forestry part of the New Zealand ETS, which feature more than 2000 participants and 18 million t CO_2-e removed; to global mechanisms such as VCS with 1500+ projects and 550 million t CO_2-e (including mitigation projects).

Table 1: Overview table of assessed mechanisms/methods and governance (note: green header: NBS only mechanism; grey header: NBS & TBS mechanism)

Mechanism	Verified Carbon Standard	Label Bas Carbone	Australian Emissions Reduction Fund	New Zealand ETS (Forestry)/ Permanent Forest Sink Initiative	MoorFutures	Woodland Carbon Code
Methods assessed	-Overall mechanism -VCS Jurisdictional and Nested REDD+ -VCS Improved agricultural land management -VCS GHG CCU in Plastic Materials -VCS CCU in Concrete Production	-Overall mechanism -Label bas Carbon: CarbonAgri	-Overall mechanism	-Overall mechanism (NZ ETS and NZ PFSI) -NZ ETS/NZ PFSI: Forestry method	-Overall mechanism -MoorFutures method	-Overall mechanism -Woodland Carbon Code method
Governance; location	Private (voluntary); global	Public (voluntary); France	Public (voluntary); Australia	Public (regulatory); New Zealand	Private (voluntary); Germany	Public (voluntary); UK
Removal solutions	NBS: Afforestation/reforestation, Peatland rewetting, forest management, soil carbon TBS: CCU (plastics, concrete production) Total: >100 methods (*incl. mitigation)	NBS: Afforestation/reforestation, Agroforestry, Soil carbon TBS: none Total: 6 methods (+ 23 being developed, which include mitigation)	NBS: Afforestation/reforestation, soil carbon TBS: none Total: 34 (*incl. mitigation)	NBS: Afforestation/reforestation, forest management TBS: none Total: 1 + many mitigation methods in NZ ETS	NBS: Peatland rewetting (avoided emissions) TBS: none Total: 1 method (avoided emissions)	NBS: Afforestation/reforestation TBS: none Total: 1 method
Market	Voluntary offset Link to regulatory schemes: CORSIA	Voluntary offset	95% purchased by government (reverse auction); otherwise, voluntary offset	Regulatory (ETS)	Voluntary offset	Voluntary offset
Projects/ participants	1677 registered projects	79 registered projects	940 registered projects	2276 forestry participants (in 2015)	5 projects	187 projects

Mechanism	Verified Carbon Standard	Label Bas Carbone	Australian Emissions Reduction Fund	New Zealand ETS (Forestry)/ Permanent Forest Sink Initiative	MoorFutures	Woodland Carbon Code
Total removals ***including mitigation**	Total removals: not available. Including mitigation: 550 million tonnes CO_2-e	Total removals: not available. Including mitigation: 280,000 t CO_2-e	90 million t CO_2-e (2014-2021)	18 million t CO_2-e (forest removals)	69,000 t CO_2-e (avoided emissions)	3.4 million t CO_2-e
Method development	Bottom up by developers	Bottom up by developers	Bottom up by developers	Top-down by operator	Top-down by operator	Top-down by operator
Method approval	Internal assessment; public consultation; external expert assessment OR n/a for Operator developed methods	Ad hoc expert group	Internal assessment; public consultation; external expert assessment	n/a	n/a	n/a

Mechanism	Nori Carbon Removal	Gold Standard	Clean Development Mechanism (CDM)	Joint Implementation (JI)	CORSIA	California Compliance Offset Programme
Methods assessed	- Overall mechanism	Overall mechanism	-Overall mechanism Annex 13: Recommendation on CCS as CDM project activities	-Overall mechanism	-Overall mechanism	-Overall mechanism
Public/ private; location	Private (voluntary); USA	Private (voluntary) with link to 2 regulatory markets; global	Public (voluntary); global (non-Annex 1 sell to Annex 1)	Public (voluntary); global (Annex 1)	Public (mandatory); global	Public (voluntary); USA, Mexico, Canada (primarily California)
Removals solutions	NBS: Soil carbon Total: 1 Method	NBS: Afforestation/reforestation, forest management, soil carbon TBS: none Total: 26 (*incl. mitigation)	NBS: Afforestation, reforestation TBS: CCS, mitigation Total: 20	NBS: agriculture, afforestation, methane avoidance, LULUCF projects TBS: mitigation Total: unknown JI-specific, could apply CDM methods	None. Evaluation and approval/rejection of existing methodologies via selection criteria	NBS: Afforestation/reforestation, forest management, agriculture TBS: Mine Methane Capturing Total: 6
Market	Voluntary offset	Voluntary offset. Link to regulatory schemes: Colombia carbon tax, South Africa carbon tax, CORSIA	Voluntary offset. Link to regulatory schemes like EU ETS (excluding LULUCF)	Voluntary offset. Link to regulatory schemes, e.g. NZ ETS and voluntary offsets, e.g. VCS.	Regulatory offsetting scheme	Complementary offsetting within California Cap-and-Trade-Program
Projects/ participants	unknown	1900 projects	7805 projects	604 final determinate projects	No own issuance of certificates (users: aircraft operators)	More than 500 projects
Total removals ***including mitigation**	40,000 t CO_2-e	Total removals: not available. Including mitigation: 151 million t CO_2-e	1.97 billion t CO_2-e (*includes mitigation)	863 million t CO_2-e (*includes mitigation)	Total removals: not available.	Total removals: not available. Including mitigation: 196 million t CO_2-e

Mechanism	Nori Carbon Removal	Gold Standard	Clean Development Mechanism (CDM)	Joint Implementation (JI)	CORSIA	California Compliance Offset Programme
					Forecast: annual market size 164 million tonnes CO_2-e (total, including mitigation and removals)	
Method origination	Top-down by operator so far)	Bottom up by developers	Bottom up by developers	Bottom up by developers	None: adoptions from eligible programs	Top-down by operator
Method approval	Internal assessment; public consultation; external expert assessment	Internal assessment; public consultation; external assessment	Internal assessment (CDM Executive Board)	Internal assessment (Joint Implementation Supervisory Committee), external expert assessment (Accredited Independent Entities)	None: adoptions from eligible programs	Internal assessment (California Air Resources Board) and external expert assessment (Offset Project Registries)

3.2 Certification mechanism governance

Table 1 also presents key, cross-cutting elements related to the governance of mechanisms. In this section, we summarise key conclusions related key governance issues such as methodology development and approval, accounting, and discuss administrative and transaction costs.

Method development: Mechanisms must decide whether to internally develop their own methodologies (i.e., top-down) or allow developers to propose their own methodology (subject to approval by the mechanism operator – see next). Developing methodologies internally can help to manage environmental integrity concerns, target specific areas, and support the strategic expansion of mechanisms into new solutions areas. However, top-down approaches can be costly and may result in limited interest and uptake if there is limited demand from developers. Devolving method development to project developers can reduce mechanism administrative costs[3] but leave the operator with less control over the quality, the coherence with national GHG inventories, and the harmonisation of methods in similar projects. Collaborating with sectors to develop new methodologies may represent a middle path.

Method approval process: Mechanisms that allow bottom-up development of methodologies or that accept methodologies from other mechanisms must establish processes for their assessment and approval. The methodology approval process differs across different mechanisms. Some mechanisms have established multi-stage processes that include initial internal evaluation, external expert evaluation (by scientific experts), rounds of public consultation and revision, and formal institutional approval structures. Other mechanisms operate with more informal, ad-hoc structures, especially in early stages, which become formalised over time. There are differing degrees of ongoing evaluation and revision of methodologies, although given the developing knowledge and practice related to removals and their certification this seems important.

Different mechanisms also feature different constellations of formal institutional bodies that are involved in evaluating and approving new methodologies. For example, some mechanisms have expert groups focussed on particular types of removals (e.g., agriculture, forest, and land-use), while others rely on external expertise and then more general bodies who evaluate expert 3rd party assessments of new methods.

The costs of methodology development and approval are often shared between the mechanism and the developer, for example, developers bear the costs of methodology development and pay some flat-rate fee for evaluation (both to the mechanism and 3rd party evaluators), which helps to cover the mechanism's administrative costs and costs of convening expert evaluators.

[3] Note, generally, there is only limited quantitative information on administrative costs available in all of the mechanisms assessed.

Accounting: To ensure that the certificates issued from a mechanism are of high environmental integrity, a registry system that records removals certificates as they are issued, and then any trades or retirement of the removals certificates. There is a risk that if not carefully accounted for, removals could be double-counted (i.e., the removal is "used" twice, e.g., counted both as a removal under the mechanism and also counted under a country's inventory or to avoid the need to purchase emissions reduction under a country/regional emissions trading scheme) or double-sold, e.g., the same removal certificate is sold to multiple parties. Mechanisms apply different rules to manage these risks, with many mechanisms using existing market registry software to monitor and record removals.

There are also different approaches to linking removals under the mechanisms to national targets and inventories. Generally, the link between mechanisms and inventories is indirect, i.e., the information gathered by the mechanisms can be used by national inventories but there is no direct link between mechanism removals and adjustments to national inventories (i.e., the mechanisms and methodologies generally do not apply exactly the same methods as national inventory accounting (e.g., applying different baselines, quantification methods, etc.) and therefore mechanism monitoring data on removals cannot be directly integrated into national accounts without processing).

Transaction and administrative costs: Any costs external to the costs of carrying out removals can be considered transaction costs. These costs can fall on participants or on administrators. For participants in certification mechanisms, these can include the ongoing transaction costs of monitoring, reporting and verification and one-off costs such as developing project plans, setting baselines or registering. For administrators, these costs can include ongoing costs of administering the system (e.g., verification, registry operation, auditing and enforcement) as well as one-off costs such as methodology development and approval. Sometimes these costs are shared between participants and administrators, for example through flat rate fees for registration and verification of projects or new methods, or per-unit fees (e.g., for selling certified units through a registry). Transaction costs faced by participants reduce the net benefit they receive from carrying out removals, thus reducing incentive to participate in voluntary certification mechanisms and acting as a barrier to high uptake. Administrative costs borne by administrators also reduce the net benefit of any certification mechanism.

The availability of quantitative evidence on administrative and transaction costs varied considerably across the different mechanisms and, when available, was reported using inconsistent metrics. We summarise here (more information and references can be found in the fiches in Annexes 1 and 2):

- Label bas Carbone: Currently, one full time employee, one part time, one intern. Methodology development costs estimated at €30,000-50,000
- Gold Standard: Gold Standard breaks down administrative/transaction costs as follows:

  - Preliminary review/validation: Certification: Projects must submit to a preliminary desk review (SustainCert), an independent audit (including site visit by 3rd party auditor) and review of audit. Cost: €5,000 for SustainCert reviews + €30,000-40,000 for audit
  - Verification: Projects must be verified by a 3rd party auditor within the first two years of the project, and then after every five years. The cost is €30,000-40,000 per verification, + €1,500 for SustainCert review.
  - Registry: To sell credits, project developers must pay a one-off fee to open a registry account (€1,000) and pay a fee of €0.30 per credit sold.
- New Zealand Emissions Trading Scheme: The New Zealand Ministry for the Environment states that since 2008 the NZ ETS has cost the government $38.9 million to implement and administer, and that the annual cost to the government of implementation and administration in the 2014–15 financial year was $6.4 million.
- Australian Emissions Reduction Fund (ERF):
  - Project development costs: For land-based abatement (the dominant mode of abatement under the ERF), indicative costs include initial registration ($10,000 per project), monitoring/sampling ($3,500 per project, per year) and reporting $5,000 per project per report
  - Audit costs: for cattle projects: $13,250 (initial audit) + $9,000 (subsequent audit) + $1,000 (site visit fee). For savannah & sequestration: $11,250 (initial audit) + $9,000 (subsequent audit) + $1,000 (site visit fee)
  - Total costs for a typical cattle project are estimated at around $100,000 (with a 7-year contract life), for a typical avoided land clearing/managed regrowth project (with obligations over 25 years) approximately $150,000
  - A review of an earlier version of the ERF (the 2011-2014 Australian Carbon Farming Initiative) was found that the costs of auditing were a small percentage (<2%) of returns from credits.

Trade-offs and potential conflicts of interest: From a mechanism developer's perspective, there is a trade-off between the aim of lowering administration/transaction costs and ensuring high environmental integrity of removals. This arises because ensuring the quality of removals often incurs greater costs for administrators and participants, e.g., more stringent verification and validation (such as more regular audits), more data-intensive monitoring, or more restrictive verification and vetting of project plans and lower transaction costs (and administrative costs). This creates potential incentives for mechanisms to lower their standards, so as to decrease their own and participants' costs, and therefore increase the number of projects or participants using their mechanism and methodologies.

Evaluating the existence of these potential conflicts of interest from outside can be challenging, as these trade-offs are often only apparent in the specific requirements set out in the mechanism methodologies (e.g., related to MRV, permanence, additionality) or in the verification and validation of specific projects/participants. In terms of best practice, to demonstrate this, mechanisms should maximise transparency. This should include publication of methodologies and any underlying models, as well as verification and validation processes. The development and approval of methodologies should also be independent, thorough, and transparent. Commonly, this involves external, independent experts as well as public consultation. For example, VCS publishes all public comments as well as the methodology developer's responses or revisions to those comments.

CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

CORSIA is a market-based mechanism that requires the aviation sector to offset emissions from international flights. Operated by the International Civil Aviation Organization, ICAO, it is unlike the other mechanisms we assessed in that it develops no removals methodologies and issues no certificates of its own. Instead, it acts as a "gatekeeper", setting criteria against which it evaluates existing mechanisms and methodologies, with only credits from approved mechanisms allowed to be used as offsets.

Mechanism/methodology evaluation process: Emissions unit programs are invited by ICAO to apply for assessment against the CORSIA Emissions Unit Criteria (EUC) (also referred to as eligibility criteria). These programs are then assessed by a Technical Advisory Board (TAB). The TAB has an outlined assessment procedure that includes screening of certain parameters e.g., whether a program has quantification methodologies, procedures and processes in place in relation to leakage, mitigation, verification, etc. A TAB Analysis Table is used to score each programme's consistency with each EUC. A scope of eligibility is defined for each program, meaning a program is eligible but certain activities under the program that are inconsistent with EUC will be excluded. The TAB presents its fin-dings and recommendations in a report. Eligible programs have to agree to maintain consistency with the EUC and inform of any changes.

Criteria applied: Emissions reductions or removals from approved mechanisms (and their specific methodologies) must:

1. Be additional
2. Be based on a realistic and credible baseline
3. Be quantified, monitored, reported, and verified
4. Have a clear and transparent chain of custody
5. Represent permanent emissions reductions
6. Assess and mitigate against potential increase in emissions elsewhere
7. Be only counted once towards a mitigation obligation
8. Do no net harm

See CORSIA fiche (section 6.9) for more detailed information

3.3 Certification mechanism approaches to monitoring, reporting, verification and related aspects

The quantification and verification of the amount of removals is the central challenge of all certification mechanisms. In this section, we provide cross-cutting evaluation of the different ways that mechanisms approach MRV, and how they manage related challenges of additionality, baselines, leakage, permanence, and sustainability. Table 2 provides an overview of how each mechanism regulates the issue[4]. The following section discusses key cross-cutting conclusions related to each MRV element. This cross-cutting section does not include specific examples; these can be identified in Table 2. For more information on the approaches applied in each mechanism and full references, see the fiches in Annex 1.

In the following section, we discuss different elements of MRV separately. However, mechanisms must develop MRV approaches as a combined set. That is, decisions taken in one MRV element (e.g., approach to additionality) will require specific approaches in other areas (e.g., verification). Accordingly, the cross-cutting conclusions and division into separate elements of MRV must be considered alongside the specific examples provided by the reviewed mechanisms, which present complete sets of how MRV is addressed as a whole in the different mechanisms; see Annex 1.

The MRV conclusions presented in this chapter focus on comparing different mechanism-level approaches. However, the specifics of MRV approaches for different removals solutions often occur at the individual methodology level. While our evaluation of methodologies informs our conclusions in this section, we also discuss methodology-level conclusions in more depth in the following section 4.

[4] In this table we summarise information on all mechanisms that we evaluated, with the exception of CORSIA. CORSIA is excluded from the table as it is not comparable to the other mechanisms because it does not have its own methodologies or offset certificates, and therefore does not make the same technical decisions as the other mechanisms. Methodologies are described in the next section.

Table 2 Overview of mechanism approaches to MRV (note: green header: NBS only mechanism; grey header: NBS & TBS mechanism)

Mechanism	Verified Carbon Standard	Label Bas Carbone	Australian Emissions Reduction Fund	New Zealand ETS/ NZ Permanent Forest Sink Initiative	MoorFutures	Woodland Carbon Code
Baselines	Method dependent e.g., Wetlands: historical (20 years data), project specific Jurisdictional method: historic data (10 years data); project specific /standardised	Method dependent e.g., Forestry methods: Scenario, specific CarbonAgri: Historic data, participant-specific, revised after 5 years	Differs per method	Historical baseline (based on Kyoto eligibility e.g., baseline = 1990 forest status) Standardised	Scenario, project-specific. Baseline reset minimum every ten years	Scenario, standardised (i.e., based on previous land-use, look-up tables) Small participants: assume baseline= 0
Additionality	Relative to baseline + additionality assessment tool: Financial additionality: cost-benefit/investment test Barrier test: qualitative explanation	Relative to baseline +financial additionality +regulatory (e.g., discounting if participant also receives other funding)	Regulatory additionality (guidelines exist) Uncommon practice test (e.g., <20% penetration rates)	No additionality test: Kyoto aligned: all forests planted post-1989 are considered additional. No other additionality tests apply (as ETS designed to cover all sectors).	Relative to baseline +financial additionality	Relative to baseline + Regulatory additionality +Financial additionality: carbon payments>15% of project establishment/planting costs AND investment test + Barrier test, if financial additionality failed
Leakage	Quantitative: Method-specific leakage assessment criteria and management (incl. leakage assessment tool)	Qualitative leakage identification/management	no information found	No leakage management (as ETS designed to cover all sectors)	Quantitative identification of leakage, which is deducted from net removals	Small projects: assume no leakage Standard: Qualitative/quantitative assessment (identify induced land use change assessment; if >5% of removals, deduct)

Mechanism	Verified Carbon Standard	Label Bas Carbone	Australian Emissions Reduction Fund	New Zealand ETS/ NZ Permanent Forest Sink Initiative	MoorFutures	Woodland Carbon Code
Uncertainty	Identify/quantify uncertainty Discounts apply if uncertainty high	Quantify uncertainty Discounting (depending on qualitative level of uncertainty)	Method dependent	No specific information found	Conservative assumptions and uncertainty discount buffer account (equal to 30% of removals) to cover later recalculations	20% buffer withheld, then retired
Permanence management	Pooled buffer account (retired at end of project), range 10-60% Project contribution determined by Non-Permanence Risk Tool, considering project risks (management, op. cost), external risks (natural disaster, politics, …)	Buffer Required to inform subsequent landowner	Long project duration (25/100 years) Participant liability (during project duration) if reversals >5%	ETS: Participant liable for reversals through ETS (for perpetuity) PFSI: Long project duration (99 years)	Discounting (30% buffer) Conservative estimates Long project duration (30-100 years) - credit max. 50 years of avoided emissions	20% buffer, retired at end of project. Participants liable during project Other forestry legislation limits post-project reversals
Sustainability	Identify/manage externalities Stakeholder consulting	Identify co-benefits, recorded on removal certificates Simple (co-benefit matrix) and complex (farm audit tool) tools	Negative lists (e.g., no tree planting in drought stressed locations)	No specific information found	Quantification of non-climate benefits (incl. Biodiversity, flooding, etc.). Recorded on MoorFutures certificates. Other ecosystem-services are not negatively impacted by rewetting	Ex ante validation assesses co-benefits, managed negative externalities

Mechanism	Verified Carbon Standard	Label Bas Carbone	Australian Emissions Reduction Fund	New Zealand ETS/ NZ Permanent Forest Sink Initiative	MoorFutures	Woodland Carbon Code
Crediting periods	Agriculture, forestry, land use: 20 to 100 years Agricultural Land (re. CH_4 and N_2O emissions reduction):10 year (fixed) or 7 years (2x renewable)	Method dependent e.g., Forestry: 30 years Agriculture: 5 years	25 years or 100 years	Annual payment	50 years max	Around 40 years (min: length of clear fell cycle - max 100 years)
Validation	Ex ante project evaluation (internal and 3rd party)	Ex ante project/participant evaluation (internal or 3rd party)	Basic ex ante assessment (internal)	No ex-ante validation	Ex ante project evaluation (by experts)	Ex ante validation (external)
Verification	Ex post verification (by 3rd party), incl. site visit; timing: see crediting period	Ex post verification (3rd party) incl. site visit; timing method dependent (Carbon-Agri 5 years)	External verification (3rd party, site visit); minimum 3 audits per project duration	Self-verification + random auditing	External verification; site visit (5 years, then every 10 years)	Ex post verification (3rd party; site visit); after 5 years then every 10 years
Payment timing	Ex post (on verification)	Forestry: ex ante award for 30 years Ag: ex post (after 5 years)	Ex post (annually)	Annual payment	Ex ante payment	Ex ante payment (Pending issuance units) Converted into ex post credits on verification

Mechanism	Nori Carbon Removal	Gold Standard	Clean Development Mechanism	Joint Implementation	California's Compliance Offset Programme
Baselines	Scenario, participant-specific, scenario, dynamic (adjusted each year due to weather)	Differ per methodology. Generally, project-specific scenario All land use/forestry must have baselines reset every five years	Scenario, project-specific and methodology-specific, conservative baseline	Scenario (BAU baseline), project-specific	Scenario (BAU baseline), project-specific and standardised (differ by methodology)
Additionality	Relative to baseline +Adoption of new management/production/technology test	Relative to baseline +Financial additionality (i.e., narrative evidence that offset credits necessary)	Relative to baseline + barrier test, investment and common practice analyses	Relative to baseline + CDM Additionality tool (depending on Track)	Sector-specific +Regulatory additionality
Leakage	Assume no leakage	Quantitative leakage calculation, deducted from gross removals	Quantitative leakage calculation necessary, methodology-specific, Project Design Document elaborates on procedure	Qualitative leakage identification	No specific method, i.e., no transparent and project-specific quantification of leakage effects
Uncertainty	20% buffer	Quantitative calculation (standard deviation at 90% level of confidence), based on monitoring, sampling, data. Discounts apply if uncertainty >20% Buffer: 20% for land-use/forestry projects, retired	Conservative assumptions, quantitative calculation (standard deviation at 90%/95% level of confidence), no overall data certainty requirements	Project developers must explain quality and undertake control procedures for data and variable monitoring and error sampling.	Conservative BAU assumptions
Permanence management	Participant liable for project duration plus ten years	Participant liability 20% buffer, retired	Temporary credits: periodically expire, re-issuance upon verification, expire after 5 years Long-term credits: expire after either 30 or 60 years	Project developers liable	Long project duration (storage for 100 years following credit issuance), compensation for reversals, Forest Buffer Account (10.5% to 21.2%)

Mechanism	Nori Carbon Removal	Gold Standard	Clean Development Mechanism	Joint Implementation	California's Compliance Offset Programme
Sustainability	Monitored at mechanism level but not managed	Must contribute to 2 additional SDGs. Qualitative identification/management of externalities Stakeholder involvement	Sustainable development criteria mandatory, managed negative externalities (impact assessment, mitigation action plan)	Sustainable development criteria not mandatory, anticipation of environmental impacts for LULUCF projects, management of externalities	Promote co-benefits: Revenues in Greenhouse Gas Reduction Fund: 60% towards sustainable communities, housing, public transport; 35% to disadvantaged communities
Crediting periods	10 years; renewable (with new baseline)	Method dependent: Either fixed 10 years or 3 x renewable 7 year (total 21 years).	Method-dependent: Standard period: 10 years or 7 years and extended 2x Sink projects: 30 years or 20 years + 2x review and extension	5 and 8 years in accordance with KP period (extension possible)	Sequestration: 10 to 30 years (forestry: 25-year average); Non-sequestration: 7 to 10 years
Validation	Ex ante validation (internal)	Ex ante validation (3rd party and internal)	Ex ante validation (approved 3rd party)	Ex ante validation (approved 3rd party)	Ex ante validation (approved 3rd party)
Verification	Ex post validation every 3 years: internal; at project end i.e., 10 years: 3rd party, site visit)	Ex post verification (external, site visit, after 2 years, then every 3 years (agriculture) or 5 years (forestry))	Ex post periodic, independent verification	Ex post verification (quality differs according to track)	Ex-post (internal, 3rd party), restriction per verifier up to 6 years
Payment timing	Ex post (upon internal verification)	Ex ante (max 20%) Ex post (upon verification)	Ex post	Ex post	Information not found. Offsetting via a private market exchange between emitters and offset project owners.

3.3.1 Additionality and baselines

Most existing mechanisms issue credits/certificates at an individual project-level following a baseline and credit-based mechanism.[5] Baseline and credit-based mechanisms aim to incentivise and reward only additional new removals, i.e., those that would not have occurred in absence of the removal mechanisms. Implicitly, additionality aims to demonstrate causality, ensuring that payments are linked to the specific level of removals that they have affected. This is important for environmental integrity (especially if removals will be used to offset emissions or are expected to be fungible with removals in other sectors or locations). It is also important for cost-effectiveness reasons. However, identifying additionality can be challenging, especially in nature-based solutions. It can also be time-consuming and costly, meaning mechanisms must balance the benefit of more confident additionality against increased transaction costs and reduced uptake by participants. The evaluated mechanisms use multiple different approaches to evaluate additionality:

Baselines: Most common is the use of baselines, i.e., a counterfactual against which future removals are compared (with the difference considered additional). Different baseline setting approaches have strengths and weaknesses, with more simple approaches at risk of being gamed by participants (e.g., being inflated by selecting a 'worst-case' highly emissive activity as the counterfactual scenario, or through adverse selection of sites that could inherently exceed the baseline level because of their specific circumstances), while more complex methods result in high transaction costs for project developers and operators alike. Different mechanisms use different approaches to identify the relevant counterfactual:

- Historical, benchmark or scenario-based: Baselines can be set based on historical data (e.g., average carbon stocks over the last years, performance based (e.g., what is a typical removal/emission rate for this type of land use), forecast scenarios of business-as-usual under current policy frameworks (e.g., what would be the expected carbon stocks or removals over the next twenty years in absence of the mechanism) or forward looking scenarios (e.g., what might the type of land use be, taking into account medium- and longer-term climate policy ambitions). Scenarios can be more complex and costly to develop (and still be uncertain) but can include expected future changes that would affect the counterfactual, e.g., policy change, commodity price changes, etc.
- Specific or standardised: Baselines can be created specifically for individual projects/participants (i.e., specific baseline). These will be more accurate to their specific context, though also more costly.[6] Alternatively, some mechanisms and methods develop standardised approaches, where average fac-

[5] The only exception from the mechanisms we assessed was the New Zealand Emissions Trading Scheme.

[6] Note, even specific baselines feature some standardised elements (e.g.,, assume average emissions factors), and feature some specific elements (e.g.,, on-site sampling).

tors are assumed and applied as default values to all participants. Standardised baselines can be developed for and apply at different geographical scales:

- Mechanism-scale standardised baseline: Standardised baselines can apply to all participants/projects in the mechanism, wherever they are geographically located.
- Jurisdictional or national standardised baseline: Alternatively, standardised baselines can be set at the national of jurisdictional level, where jurisdictional usually means regional level. Under a jurisdictional/national standardised baseline, every project/participant located within that national or jurisdictional area applies the national or jurisdictional baseline. Jurisdictional baselines can offer a compromise between the costs of specific baselines and the inaccuracy of mechanism scale baselines, as the regional scale is more granular and can therefore better capture regional variation that is lost in mechanism-scale baselines, without requiring specific baselines to be developed for each project/participant.7
- Fixed baseline or revised: Baselines can also be fixed at project inception (potentially including forward-looking trends) or be revised over time to update to reflect changes in prevailing circumstances that mean the previously determined counterfactual scenario might no longer be relevant or applicable.

Additionality tests: In addition to evaluating additionality relative to baselines, mechanisms and methods commonly apply other tests to ensure that removals are additional to one or more counterfactual scenarios that could apply in absence of the support offered to the specific removal activity. These tests are generally applied at the level of the individual project. These include:

- Financial additionality: without removals payment, the removals would not be the best financial option (i.e., most profitable). This is generally assessed at the project/participant level, and demonstrated by narrative, simple cost-benefit calculations, or an investment test (showing that without carbon finance benefits, implementing the removal activity would not be the most attractive option).
- Regulatory additionality: removals activities go beyond requirements or obligations set by other laws. Can be assessed by incorporating regulation in baselines or using standardised tools or questionnaires. A common method for managing regulatory additionality is requiring regular updates to baselines. Note it can be challenging to manage regulatory additionality when laws and regulations set removals requirements in terms of outcomes (e.g., t C removals by a sector) rather than in terms of legally requiring specific actions, or through complex complementary policies (e.g., CAP), as this would imply having to assess the effects of complementary

[7] Note there is a difference between a jurisdictional standardized baseline (i.e.,, all projects/participants within that jurisdiction use the same baseline) and a jurisdictional baseline (i.e., a baseline for the jurisdiction as a whole, including all projects/participants as well as any other significant removals/emissions).

policy in the specific context of the participant/project, so as to disentangle these results from the additional removals.

- Barrier assessments: are there other significant barriers blocking implementation of removal activities that can be surmounted by the project, e.g., institutional or technological barriers, social or local knowledge barriers, among others.
- Uncommon practice test: Project/participant must demonstrate that the removal activity is uncommon in their sector/area, e.g., has less than a 20% penetration rate. This test is commonly applied in TBS.
- New activity test (e.g., first-of-its-kind test): Project/participant must demonstrate that they have undertaken new activities. This test is commonly applied in TBS, where it is relatively easy to demonstrate that new activities (e.g., investment in new technologies) has occurred.

3.3.2 Leakage and system boundaries

Leakage occurs when mechanism-incentivised removals result in increases of emissions/reduced removals elsewhere, reducing the overall climate impact. Leakage can occur due to activity shifting (i.e., where emissions-producing activities moves elsewhere), market leakage (where decreases in production lead to market impacts that increase production and associated emissions elsewhere), or ecological leakage (where removal activities impact emissions/removals in neighbouring areas, e.g., peatland rewetting within a project decreases water levels in neighbouring fields). Leakage can also be positive, (also called a positive spill-over), where removals by a project/participant induce additional removals that are not counted, for example by inducing neighbouring farmers or other producers to implement removals activities. Identifying leakage is highly uncertain due to difficulty identifying unmonitored impacts outside of the direct control of the project/participant.

System boundary refers to the removals and emissions are captured by the methodology and included in the quantification of net removals. System boundaries can be limited to, or exclude, particular carbon pools (e.g., soil carbon, above-ground biomass, etc.), gases (e.g., CO_2, methane), geographic areas (e.g., parts of a farm unit, intra/extra-EU), sections of the production process or lifecycle (e.g., carbon capture, transport, emissions occurring upstream or downstream, such as bought-in heat, electricity or mechanical power), or time. The system boundary is generally determined at the methodological level, rather than mechanism level. Boundaries are intimately connected to leakage, because if significant sources of emissions/removals are left outside of the boundaries, there is a risk of incentivising actions that will have less net climate impact than calculated due to impacts outside the system boundary. For example, excluding soil carbon from methodologies can result in activities that increase removals in other carbon pools (e.g., above-ground biomass) but reduce soil carbon stocks (a form of leakage not captured by the mechanism or methodology).

Mechanisms took different approaches to assess and manage leakage, which often differ across different methodologies. Common approaches:

- **Assume no leakage:** This assumption lowers complexity and MRV costs but will increase uncertainty. Some mechanisms only assumed no leakage for small projects, requiring larger participants to calculate leakage using more stringent approaches.
- **Qualitative leakage assessment:** A number of mechanisms require only a qualitative analysis of leakage e.g., identify potential sources of leakage (such as land use), and in some cases how these will be minimised or managed.
- **Quantitative leakage assessment:** Some mechanisms require the quantitative analysis of leakage, using leakage assessment tools (a questionnaire or spreadsheet) to identify expected leakage, which are then deducted from gross removals before payment. In some cases, the methodology guides for TBS already contain explicit instructions for leakage estimation, either by providing a fixed rate or by providing a formula for project-based calculation.
- **Other approaches:** expanding system boundaries (e.g., including whole lifecycle in methodology, or whole farm), limiting eligibility to removal actions that do not have significant leakage effects (e.g., excluding removals actions that induce land-use change). Mechanisms can also rely on other, related regulations or standards to manage leakage risk (e.g., European certificate of sustainably produced biochar standards are required as part of the PuroEarth biochar methodology to manage leakage due to biomass production).

3.3.3 Uncertainty (of quantification)

The methodologies for quantifying the amount of removals differ significantly within the mechanisms we assessed (i.e., is specific to the removal solution and methodology), and were therefore excluded from Table 2 and are instead discussed in the next section. However, mechanisms often apply consistent approaches to dealing with the quantification of uncertainty across all methodologies. Uncertainty refers to the inherent dispersion in removal quantification (i.e., the gap between quantified removals and actual removals). This can arise from a number of sources, including measurement uncertainty, quantification (e.g., assuming average values for calculation inputs such as emissions factors), or due to uncertain additionality, permanence, or leakage. Quantification uncertainty is an order of magnitude higher for NBS than for TBS, so this section is most relevant to mechanisms managing NBS. Different mechanisms take different approaches to identifying and managing uncertainty:

- **No acknowledgement:** A number of mechanisms provided no information about identifying or quantifying uncertainty.
- **Identify and quantify uncertainty:** Many mechanisms require their methodologies to identify sources of uncertainty and estimate the size of uncertainty. Uncertainty is commonly quantified in terms of a standard de-

viation around the mean at the 95 or 90 percentile level of confidence. Uncertainty is quantified based on sampling techniques, expert opinion, data distribution, Monte-Carlo simulations, or literature sources.

- **Discounting of removals/buffer account:** To account for uncertainty, a number of mechanisms discount the estimated removals when these are uncertain (e.g., if uncertainty is more than 20%, removals are discounted by 30%). Alternatively, mechanisms store some percentage of the total estimated removals in a buffer account, which can be drawn down at later date; the credits in the buffer account are sometimes released to the participant at the end of the project duration, or are retired (equivalent to discounting).
- **Conservative assumptions:** Many mechanisms require that methodologies and projects/participants use conservative assumptions when quantifying removals.

3.3.4 Permanence

Different solutions pose different risks of removals being reversed and stored carbon being re-released to the atmosphere, with NBS posing particular challenges. The reviewed mechanisms apply different approaches to managing permanence and to reducing the risk of intentional or unintentional reversal of carbon removals. Mechanisms take different approaches to managing permanence, which offer differing degrees of security and differing barriers to participants:

- **Long project duration:** Some mechanisms require participants to sign-up to long monitoring plans (e.g., up to 100 years) or long crediting periods (i.e., where participants/projects continue to receive payment for removals up to 50 years into the future. Monitoring obligations can extend beyond crediting periods. Others use shorter project durations (e.g., 5, 7 or 10 years), or issue temporary credits that can be renewed, with the belief that this approach can nevertheless incentivise continuation and permanence.
- **Discounting of removals/buffer accounts:** Many NBS mechanisms require methods with a risk of reversal to be discounted or stored in a buffer account, which can then be drawn down if reversals occur. Buffers often account for between 10 to 25 per cent of the expected emission reductions or removals. Various management, financial, social, and natural disturbance risks may be considered in the calculation of the level of discount applied.
- **Participant liability:** Some mechanisms make projects/participants liable for any removals, within the duration of the project and beyond. Projects/participants would then be required to offset any removals e.g., through replanting of forests, purchase of offset certificates, or payment of penalties.
- **Contractual or legal approaches:** Mechanisms also rely on contracts, legal restrictions on land use, and on other existing legislation that will minimize reversals (e.g., UK forestry legislation restricts deforestation).

3.3.5 Sustainability – co-benefits and negative externalities

Carbon removal actions have the potential to affect societal objectives beyond climate targets. For example, NBS can support or decrease biodiversity outcomes, TBS can affect energy use and localised air pollution. This poses both a risk and opportunity for the EU CRC-Mechanism, which must be designed to maximize the co-benefits of removals actions whilst minimizing the risk of negative externalities so the EU can meet multiple objectives simultaneously, effectively and efficiently. Co-benefits can also be important selling points for participants, and for buyers of carbon removals. Existing mechanisms have different methods for quantifying and managing these broader sustainability impacts:

- **Qualitative/quantitative identification of co-benefits:** Mechanisms can require methodologies and projects/participants to identify likely sustainability impacts, for example using simple "co-benefit matrices" or questionnaires, and to identify how they will manage these. Some mechanisms offer methodologies for quantifying impact on multiple outcomes, and reporting and methodology-level monitoring of these impacts. These co-benefits are sometimes listed on carbon removal certificates/offsets, so that buyers can reward those projects/participants generating co-benefits.
- **Requirement that methods deliver multiple benefits:** Some mechanisms explicitly require methodologies to target multiple outcomes, beyond climate mitigation.
- **Negative/positive lists:** Mechanisms can require methodologies to establish negative lists that exclude removals actions or participants when they are likely to generate negative externalities (e.g., exclude afforestation in water-scarce regions). Alternatively, they can limit eligibility to participants/projects that generate significant co-benefits. This is sometimes referred to as applicability conditions.
- **Stakeholder consultation:** Many mechanisms require that methodology and project developers involve stakeholders and that new methods/projects are subject to public consultation and feedback.

3.3.6 Verification, validation, and payment timing

Validation refers to when mechanisms require projects/participants to be evaluated and approved ex ante, to ensure that they are aligned with the methodology and mechanism's rules and principles. This validation step often coincides with baseline setting. This validation stage can include requirement for internal (i.e., mechanism administrator) or third-party evaluation of the proposed project or its initial implementation. This can be limited to a simple administrative, desk-based assessment of project documents (e.g., proposed monitoring plan) or can involve site-visits by third party experts, as well as public consultation on proposed projects and feedback and revision rounds. While validation can increase certainty regarding the removals that follow, if it is thorough (e.g., involves site visits), this can pose significant transaction costs for participants and administrators.

Verification is the ex-post assessment and endorsement of the stated removals resulting from monitoring. Larger projects are commonly required to undertake more regular verification to ensure that they are operating in accordance with the established project and monitoring plans, which can include 3rd party evaluation (including site visit and on-site measurements). Other mechanisms apply a system based on the tax system, where participants are required to self-verify and report, with penalties for submitting false returns accompanied by random and targeted audits.

Mechanisms commonly set requirements for the third parties who carry out validation and verification. They often require third parties to be accredited e.g., in accordance with ISO 14065 for Greenhouse Gas activities accreditation, UNFCCC-CDM Accreditation, or ASI – FSC Certification Body status.

Payment timing: Mechanisms assessed have different forms and timing of payments. Most mechanisms provide offset certificates (i.e., non-fungible voluntary offsets that can only be sold once) or credits (fungible offsets) in return for verified removals, which can then be traded for payment. Some mechanisms pay participants directly e.g., where the central buyer (e.g., government) uses reverse auctions to identify cost-effective removals. The timing of payments also differed: most mechanisms paid ex post upon verification of removals. Some mechanisms pay participants/projects ex ante, in some cases the full expected removals for the project duration, in others only a limited amount (e.g., 20% of the expected project removals); this occurs by allowing projects to sell ex post non-verified credits, which are converted into verified credits upon verification; this enables projects/participants to receive early payment (e.g., to cover establishment costs), which buyers are willing to purchase at a slight discount. Only NBS-related methodologies offered ex ante payments, which they justified based on the relatively long timespan over which removals occur.

4 CERTIFICATION MECHANISM METHODOLOGIES: CONCLUSIONS

In addition to evaluating mechanisms, we also evaluated specific methodologies within the mechanisms. This methodology-level evaluation is important, as the specifics of individual methodologies are decisive in whether the removals that result can be considered of high environmental integrity (i.e., real, permanent, additional, avoid leakage and double-counting). In this section, we discuss key conclusions of TBS and NBS methodologies separately.

4.1 Nature-based solution (NBS) methodologies

In this section we present key, cross-cutting conclusions based on our review of nature-based solutions and their key elements.

Certification boundaries[8], scope, gases: The evaluated NBS methodologies illustrate the different certification boundary scopes covered by different methodologies, even those focussing on the same solution. As discussed in the leakage section (section 3.3.2), excluding particular carbon pools or gases from the calculation can result in greater uncertainty and potentially bias in the form of untracked increases in emissions/decreases in removals outside the certification boundary. For example, the New Zealand ETS and PFSI methodologies focus exclusively on above-ground biomass, excluding potential soil carbon impacts. If these soil carbon impacts are significant, this could affect the real climate impact of the mechanism, hence the environmental integrity of the certificates.[9]

Broader scopes (i.e., methodologies capturing more carbon pools, gases, and geographical areas), will leave less gaps for leakage. Alternatively, focussing methodologies at logical whole units (e.g., the whole farm, rather than partial farm) can ensure that the most significant changes are considered by the methodology (and avoid leakage within farm units). The VCS Jurisdictional Nested REDD+ (JNR) methodology offers the broadest version of this, with its requirement of a jurisdiction-wide baseline (that considers all significant gases, carbon pools, and sources) to minimise the risk of leakage and increase certainty. The trade-off is that these broader system boundaries can be more complicated and costly. Many methodologies apply a *de minimis* exception to exclude gases or pools that are not expected to change significantly (e.g., <5%).

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8 Certification boundary refers to the scope of the system boundary that is included in the quantification of removals, i.e.,, what gases, carbon pools, and stages of the removal lifecycle are included.

9 This is a particular risk if the soil carbon impacts go in the opposite direction to biomass impacts, as measuring increases in above-ground biomass would be overstating the real climate impact (which would be smaller due to soil carbon decreases).

Methodologies' monitoring and measurement: The review of methodologies illustrated that there are significant differences in the way that removals are quantified in different methodologies (i.e., their monitoring and measurement approach), even for similar solutions or within the same mechanisms. This means that to understand the environmental integrity of the removals, it is necessary to go to the methodology-level. The monitoring and measurement methods fall into three main categories:

- Modelling: Removals are calculated using complex models that factor in numerous inputs, covering multiple gases and carbon pools. Sometimes removals (and emissions) are calculated directly, other times these are calculated as changes in carbon stock. Examples include the whole farm audit tool applied in the CarbonAgri methodology at the farm scale, or the jurisdiction-wide modelling required by the VCS Jurisdictional and Nested REDD+ (JNR) methodology.
- Sampling, site-visits: A number of mechanisms rely on site visits and sampling (for example for soil carbon).
- Simplified approaches: A number of NBS methodologies simplify the input and calculations that the participant has to complete by using methodologies developed to relatively accurately estimate removals based on easily observable proxy data. For example, the MoorFutures methodology relies on water table depth, land use, and vegetation data to estimate avoided emissions from peatland rewetting. This approach is common in afforestation methods, which use "look-up tables" that link tree type and region to expected removals. These simpler approaches require previous scientific knowledge, may have higher uncertainty at project-level, but come at significantly lower transaction costs, which is important given the relatively small size (and net benefits) of average NBS projects.

Baseline setting: Baseline setting methodologies are generally set at the mechanism level (see discussion in section 3.3.1), however, the specifics also differ across different methodologies with the same mechanism, in large part determined by the monitoring and measurement methodology. Due to the large differences between the methodologies that we evaluated (e.g., different types of solutions), generalisations are difficult to identify. However, in general, methodologies provide more detailed information on how to set baselines, which allows for a clearer understanding of its robustness. For example, different methodologies specify different amounts of historical data (e.g., from 10+ years' worth data for the VCS Jurisdictional Nested REDD+ to just three years for the VCS Improved Agricultural Land Management methodology). The methods also detail the acceptable data sources for setting baselines, ranging from GIS data to photos, logbooks, or where this information is not available, assumed regional averages. Generally, methodological-level baseline determination illustrates numerous individual design decisions to balance the desire for low uncertainty versus the desire to reduce administration and participant transaction costs, which need to be evaluated against the objectives (and necessary certainty) of a certification mechanism.

Eligibility (also known as applicability conditions): The methodologies illustrate that eligibility is often used to manage additionality, leakage, or uncertainty. Methods commonly exclude particular land uses, gases or actions that will affect these objectives. For example, CarbonAgri sets eligibility criteria that require participants who receive other public support to reduce emissions (e.g., subsidies for installing energy efficient production) to deduct the emissions reductions that arise from this other public support from their estimated net removals (to ensure additionality). The MoorFutures method excludes N_2O from its calculations because of the relatively small expected effect and the relatively high level of uncertainty around N_2O estimation using the project methodology. Generally, limiting methodology applicability/eligibility to specific contexts and conditions (i.e., location, climate actions, and participants) can help to reduce uncertainty of baseline calculations, monitoring and measurement, as well as externalities.

4.2 Technology-based solution (TBS) methodologies

In this section, we evaluate some of the significant, cross-cutting conclusions from our review of technology-based methodologies.

Certification boundaries, scope, gases: Similar to NBS methodologies, the certification boundaries are specific to the methodology applied. Some of them are cradle-to-gate, others cradle-to-grave (e.g., United States (U.S.) federal 45Q tax credit system). Generally, boundaries are frequently gate-to-gate which include the facility level and manufacturing process as well as the facilities where the substituted material is manufactured (e.g., plastic). This can include, for example, the use of raw materials, transport to facility, production process (e.g., Puro Earth) or the full CCS chain from capture through compression, transport, injection and storage, as for the Alberta Methodology and the American Carbon Registry. Similarly, all CO_2 sources, sinks, and reservoirs from the CCS project are considered within the certification boundary for the methodology recommended by the California Air Resource Board. Problems setting those boundaries can occur, however, in the case of cross-border maritime activities, in ocean storage, and when the mitigation of gases occurs in multiple countries (e.g., CCS under CDM); when any part of the removal lifecycle occurs outside or across country borders, it can lead to quantification problems. Therefore, a clearer definition of the exact spatial extent of the storage area is necessary. For carbon storage projects, for example, methodologies should include particular information measures to detect leakage of the stored carbon, such as the installation of secondary sedimentary basins above the injection reservoirs. In the case of the CCS Directive, the key measure to detect and minimise the risk of leakage is appropriate selection and management of sites as well as monitoring activities and corrective measures. In addition to differing geographic and lifecycle boundaries, other elements of methodology scope also differed across the analysed TBS methodologies. One example is the key GHG considered. In JI, American Carbon Registry, the Alberta Methodology those are CO_2, N_2O, and CH_4; whereas mechanisms focusing on the removal via capture, disposal, injection and utilisation only covered CO_2 (e.g., CCS under CDM, VCS 2019, Puro Earth), or variations of Carbon oxides, such as CO (US 45Q).

Monitoring and measurement methodologies (and baselines): Across the TBS methodologies, measurement and monitoring (as well as baselines) approaches are similar, although there are slight differences. The net GHG emission removals are frequently calculated as project emissions subtracted from the baseline. For VCS baselines, traditional manufacturing processes are used as a baseline scenario, that builds on historical data. These consider two components: emissions from traditional production processes and the emissions that remain in the atmosphere or are released in the absence of the project. Both the CDM and Alberta CCS methodologies require project–specific baselines based on the project type. These can be calculated by estimating emissions in the absence of the project or emissions from traditional production processes. Within the American Carbon Registry, baselines can either be project-specific or standardized: project-specific baselines are calculated using actual measured CO_2 (which is mostly applied for CCS); standards-based is an intensity metric or performance standard. To demonstrate that the proposed process results in a net reduction of CO_2-e, Life Cycle Assessment in line with ISO 14040:2006 and ISO 14044:2006 or Environmental Product Declaration (EPD) may be mandatory, e.g., in US 45Q and PuroEarth.

Most carbon removal through TBS (CO_2 inputs and product outputs) can be measured with a high level of accuracy, as it is possible to measure net removals as flows per unit time (i.e., metered flows). Monitoring and sampling is often started ahead of the activities to collect the baseline data, particularly for CCS in geological storage sites, where the data is also used for risk assessment (e.g., CDM, CCS Directive). Methodologies describe precise requirements that may include conducting several samples per year and requiring results to fall in a certain range (e.g., VCS CCU in concrete production).

Similar to NBS, the methodology-level describes individual design decisions suitable for the specific context to balance the desire for environmental certainty versus the desire to lower administration and participant transaction costs, to achieve and maintain acceptance of the programme.

Eligibility: The methodologies illustrate that eligibility is often used to manage additionality, leakage, or uncertainty. Considering geographic eligibility, significant discrepancies between the CDM mechanism and the second KP scheme, JI, are apparent: Whereas CDM projects can only be implemented in non-Annex-1 States and then sold to Annex-1-parties, the latter ones are the only possible participant in JI to generate credits. In combination with national additionality criteria and generous baselines, this can lead to an imbalance in the geographical distribution of carbon removal projects, as was the case of JI, where concentrations of projects emerged in Russia and Ukraine. Other programmes narrow their project's territorial scope more strictly: projects within the California Compliance Offset Program (CCOP) may only be implemented in Canada and the USA. Within the CCS Directive, the geographic eligibility is within the EU and two types of geological formation (depleted oil and gas fields, and saline aquifers). Furthermore, a site analysis must be performed in order for criteria to bet met, including modelling, risk assessment and potential hazards. If the criteria are met, a storage permit will be issued, which is required for CO_2 storage.

Eligibility requirements are also used to manage risk. For example, ownership of sites and other criteria for the sites and processes are also significant concerning eligibility. Starting with the American Carbon Registry, projects are only eligible if there is a clear and uncontested ownership of the core space and the project proponent has filed a Risk Mitigation Covenant. Eligibility is also used to manage sustainability and permanence. For instance, raw materials sourcing, certification or use of material in certain sectors is restricted for the biochar methodology within Puro Earth's biochar methodology. Approaches to address permanence are also found in the examined programmes: In the case of the California Air Resources Board's Carbon Capture and Sequestration (CCS) Protocol Under the Low Carbon Fuel Standard (LCFS), project developers can apply for a Permanence Certification, provided they implement specific criteria and standards in the geologic carbon sequestration projects.

5 REFERENCES

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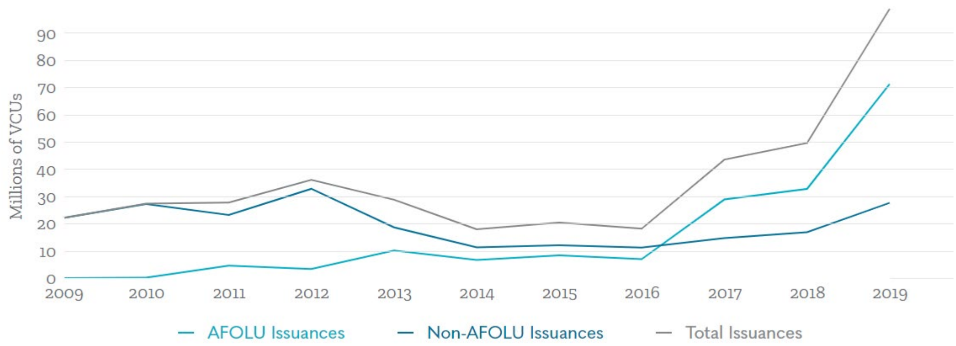
- Ramboll et al (2019). Identification and analysis of promising carbon capture and utilisation technologies, including their regulatory aspects, https://op.europa.eu/en/publication-detail/-/publication/7656142c-7083-11e9-9f05-01aa75ed71a1 Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007 https://op.europa.eu/s/pcDV

6 ANNEX 1 – EXISTING CERTIFICATION MECHANISM FICHES

6.1 Fiche: Verified Carbon Standard (VCS)

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**Verified Carbon Standard (VCS)**
Introduc-tion	• International, project-based voluntary mechanism for carbon mitigation and removals (multiple NBS and TBS). • Founded in 2005 by consortium including IETA, World Economic Forum, World Business Council and others to establish adequate quality assurance in voluntary markets. Now the largest voluntary mechanism worldwide.

Governance	• **Operator/administrator**: Verra, a non-profit corporation located in USA.
	• **Voluntary mechanism:** VCS projects are for voluntary offsetting, although methodologies are also accepted for ICAO CORSIA and for use in relation to Colombia and South Africa carbon tax regulations.
	• **Key governance bodies:**
	  ◦ Verra Board of Directors and Verra staff: have overarching responsibility for VCS programme (and other programmes e.g., CCB). Includes directors with NGO background, private sector; all with climate expertise.
	  ◦ VCS Program Advisory Group: Multi-stakeholder body that supports the development of the VCS Program.
	  ◦ AFOLU Expert Assessment Panel: Evaluate experts that then review and advise on methods and projects.
	  ◦ Nature-Based Solutions (NBS) Working Groups: Established in 2020 to focus on new nature-based solution sector opportunities (blue carbon and regenerative agriculture). Include a mix of NGO representatives and mitigation/removal project developer companies.
	  ◦ VVB Working Group: Features representatives from Validation and Verification bodies and carries out the methodology assessments and projects' validation/ verification process financed by the project developers.
	• **Methodology approval process** is bottom-up (created by developers). Steps:
	1. Developer submits a methodology concept, which Verra reviews and accepts into the full approval process, if it meets evaluation criteria
	2. Methodology developer develops full method and submits
	3. Verra review: initial review to ensure "sufficient quality" – professionally written, aligned with rules etc. Verra charges USD2000 at this point (an additional USD13000 is charged if method is accepted).
	4. Public stakeholder: Method is published online for 30 days for public comment
	5. Validation/verification body (VVB) assessment and final approval: Verra contracts eligible experts to review. Project developer pays them directly (in addition to Verra fees). They review; project developer responds to any comments and can amend. The VVB produce a final assessment report, which Verra will review and accept/reject accordingly.

Mechanism architecture fiche	
Section	Aspects covered
	Note: Verra revised VCS in 2019 and excluded some methods going forward (e.g., new grid-connected renewable energy projects), as Verra concluded they were no longer needing carbon financing/no longer additional (World Bank, 2020).
Participants	• Project developers are responsible for applying approved methodologies. Generally, project developers (individual or groups of private companies, NGOs, or public institutions) then work with multiple individual landowners or emissions sources. Project developers can apply existing methods or develop their own (for certification).
Scope, objective, and eligibility	• **Carbon removal solutions:** Wide range of carbon mitigation and carbon removal methodologies included, in following sectors: Energy, Industrial processing, Construction, Transport, Waste, Mining, Agriculture, Forestry, Grasslands, Wetlands, Livestock and Manure. VCS also allows methodologies developed for CDM or Climate Action Reserve. Overall, more than 100 methodologies, the full list can be seen here. • **Geographic eligibility:** Global. • **Geographic scale:** Differs per project and methodology
Performance	• **Number of registered carbon removal projects:** 1677 projects, of which 1284 have issued credits (i.e., all projects - mitigation and removals) • **Number of participants:** unclear how many participants • **Carbon dioxide removals under the mechanism (tCO_2-e):** Credits produced: 550,880,530 VCUs Issued (each equivalent to a reduction or removal of 1 tonne carbon dioxide equivalent (CO_2e)) Note: all information from Verra registry, unless otherwise noted  *Chart: VCS credits issued over time (Verra, 2019)* *Data and Insights: VCS Quarterly Updates ISSUE #2 - Q1/2020.*
Core design decisions	

Cross-cutting MRV aspects - high-level	• **Additionality – baselines**: "The baseline scenario represents the activities and GHG emissions that would occur in the absence of the project activity" (Verra Methodology Requirements), i.e., a business-as-usual scenario and not a set number of emissions. There is no cross-cutting approach to baseline setting; all methodologies propose specific criteria and procedures for identifying an alternative baseline and selecting the most credible scenario. However, there are some common elements:
	  ◦ Baselines have to consider the following elements: Identified sources, sinks and reservoirs of GHG; Existing and alternative project types, activities and technologies that yield similar results; Data availability, its accuracy and potential drawbacks; and other relevant information concerning present or future conditions, such as legislative, technical, economic, socio-cultural, environmental, geographic, site-specific and temporal assumptions or projections.
	  ◦ AFOLU methods must apply IPCC 2006 Guidelines

Mechanism architecture fiche	
Section	Aspects covered
	◦ There are specific cross-cutting requirements for different types of AFOLU methods (i.e., Wetland Restoration, REDD, improved forest management), e.g., regarding the time period of evidence required (e.g., 20 years climate data for wetland methods); 10 years for avoided deforestation), scale, etc. • **Additionality**: "A project activity is additional if it can be demonstrated that the activity results in emission reductions or removals that are in excess of what would be achieved under a "business-as-usual" scenario and the activity would not have occurred in the absence of the incentive provided by the carbon markets." (Verra Methodology Requirements. This has three elements: 1) must go beyond local regulations; 2) implementation barrier: it must face at least one of the following: an investment barrier (I.e., financial additionality) or technological barrier or institutional barrier, that cannot be overcome without the VCS project; 3) must not be common practice. Each method must set its own additionality test. • **Uncertainty:** Methods are required to identify sources of uncertainty and calculate level of uncertainty, with different methods applied in different methods. Where uncertainties exceed a certain threshold (where uncertainty is measured as half the width of the 95% confidence interval), removals are discounted (e.g., in method for improved agricultural land management, if uncertainty exceeds 15%, an increasing discount applies). • **Permanence, carbon reversals, and liability**: All VCS credits should be permanent. Non-permanence risk is managed using a pooled buffer account (for agriculture, forestry, and other land use projects). Each AFOLU project applies the AFOLU Non-Permanence Risk Tool to calculate the number of credits to deposit into the AFOLU pooled buffer account (this tool calculates a % of total credits for the buffer account based on internal risk factors (e.g., management, opportunity costs), external risks (e.g., political, land tenure, community engagement), and external risks (e.g., natural), with a range of 10-60%). These pooled buffer credits are cancelled. Accordingly, even when projects fail, their credits do not have to be paid, as they are covered by the pooled buffer account. The non-permanence risk tool is reconciled periodically based on review of existing projects and risk analyses; these are not retroactive. Projects that demonstrate their sustainability and ability to mitigate risks, or in other words: permanence related risks did not materialise, are eligible for discharging of buffer VCUs from the AFOLU pooled project buffer account. • **Reporting requirements:** Different for each methodology. Projects are obliged to keep all data that is necessary to validate and verify the project results. • **Verification/validation:** Carried out in accordance with ISO 14064-3:2006. Validation assesses whether the project complies with VCS rules. Verification is periodic ex-post assessment of the GHG removals/mitigation (for AFOLU projects this also assesses non-permanence risk and leakage). Verification/validation must be carried out by a Verra-approved validation and verification body (VVB), who has to be accredited either as a UND CDM Designated Operational Entity or under ISO 14065. The VVB can only validate the same project for up to 6 years, then must change. Group validation/verification can be carried out using statistical sampling.
Accounting	• Verra manages a **central registry**, which transparently lists information on certified projects, issued and retired units, and enables the trading of units. This ensures that credits are unique (avoids double counting of VCS credits). Any entity wishing to register projects or issue, retire or transfer credits must have a registry account. Verra launched its combined registry in 2020; prior to that it did not manage its own registry (which was instead managed by external providers IHS Markit/APX). More info: Verra registry system.

Mechanism architecture fiche	
Section	Aspects covered
	• **GHG inventory:** Verra has developed a proposal to manage international trade of voluntary credits in light of Paris Agreement Article 6 discussions, including the option to add an "article 6 compliant" label to VCUs that are matched by Corresponding Adjustments in the host country when traded internationally. More info: VCS Proposal
Sustainabil-ity	• **Carbon leakage settings:** VCS requires each methodology to have criteria and procedures for quantifying leakage (i.e., each methodology will have its own approach). These should control for market leakage (where supply increases elsewhere due to VCS-related reductions), activity shifting (where the agent of deforestation etc. shifts elsewhere and continues), ecological leakage (where VCS project results in hydrological changes that affect GHG fluxes). International leakage is not considered. Credits are then discounted based on degree of leakage. More info: VCS Methodology requirements. • **Sustainability safeguards:** VCS projects should achieve "no net harm" by identifying potential negative externalities and how they will be mitigated. All projects must have local stakeholder consultation. There is also a 30-day public comment review period on website for all projects. VCUs can be advertised with additional certifications/standards to demonstrate this (e.g., CCB Climate, Community, and Biodiversity standard).
Incentives, market elements	
Costs	• **Transaction costs:** Similar to the other carbon schemes, transaction cost has been identified as one of the main barriers for the majority of projects' implementation. Pearson et al. (2013) carried out a comparative study of carbon sequestration costs in tropical forest sector for VCS, Clean Development Mechanism, Climate Action Reserve and American Carbon Registry schemes. The study results suggest that the estimated transaction costs for all four schemes were ranging from 0.3% to 270% of the anticipated revenue, depending on the price of credits and project size. For VCS , the insurance costs (mainly non-permanence buffer) took the highest share of the total transaction costs structure, 86,6%, comparing to the monitoring costs share of 4,7% (Pearson et al., 2013). • Transaction costs of methodology development: to incentivise new and broadly applicable methodologies, VCS pays a rebate to methodology developers based on how many VCUs are issued using that methodology (decreasing from USD0.02 per VCU for first million credits per year; see VCS Fee Schedule (v 4.1))
Type and timing of reward	• **Form of reward for participant:** Verified Carbon Units, tradeable voluntary credits equivalent to 1 tonne of CO_2-e in reductions/removals. • **Crediting period and timing of reward:** Project receives VCUs ex-post once reduction/removal relative to baseline has been verified. For non-AFOLU projects, the project crediting period shall be either seven years, twice renewable for a total of 21 years, or ten years fixed. AFOLU Projects differ, depending on the specific type of project. Agricultural Land Management (ALM) projects focusing exclusively on reducing N_2O, CH_4 and/or fossil-derived CO_2 emissions have the project crediting period shall be either seven years, twice renewable for a total of 21 years, or ten years fixed. For all other AFOLU projects other than such ALM projects described above, the project crediting period shall be a minimum of 20 years up to a maximum of 100 years, which may be renewed at most four times with a total project crediting period not to exceed 100 years. Note: For avoided emissions, the maximum crediting period is ten years, even if such GHG emissions are likely to have continued over a longer period of time under the baseline scenario.
Offset mar-kets/use of removals	• What is the removals market demand structure: Voluntary offsetting. Some methods can now also be applied as part of ICAO CORSIA, as well as in South Africa and in Colombian carbon tax regulatory systems.

Mechanism architecture fiche	
Section	Aspects covered
	• VCU price (2018): Average price US$3/$tCO_2$ (World Bank, 2020)
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007Pearson, T., S. Brown, B. Sohngen, J. Henman, and S. Ohrel (2013). "Transaction Costs for Carbon Sequestration Projects in the Tropical Forest Section". Mitigation and Adaptation Strategies for Global Change, 1-14. • VCS homepage: https://verra.org/project/vcs-program/ • VCS Registry: https://registry.verra.org/ • Verra (2019) VCS Standard 4.0 • Verra (2019) VCS Methodology requirements v4.0 • Verra (2019) VCS Methodology Approval Process. • Verra (2019) AFOLU Non-permanence risk tool v 4.0 • Verra (2020) VCS Fee Schedule (v 4.1) • VCS (2020) VCS Proposal for scaling voluntary carbon markets and avoiding double-counting post 2020 • World Bank. (2015). Overview of Carbon Offset Programs: Similarities and Differences. Washington, DC: Partnership for Market Readiness, World Bank. License: Creative Commons Attribution CC BY 3.0 IGO

6.2 Fiche: Label Bas Carbone

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**Label Bas Carbone** (LBC)[10] *A portion of the information from this fiche comes from the DG CLIMA Carbon Farming Appendix: COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007 https://op.europa.eu/s/pcDV*
Introduction	• The French Label Bas Carbone (French Carbon Standard) is a framework for voluntary carbon reduction and removal projects that was adopted by the French Government in November 2018. • Current methods are focused on carbon removals and GHG emission reductions in the forestry and agriculture sector, but methods for additional sectors are currently under development.
Governance	• **Key governance body:** The French Ministry for Ecologic and Solidary Transition (MTES) manages the LBC, which it jointly developed with the Ministry of Agriculture and Food, as well as many other partners (I4CE, Ademe, Institut de l'élevage, CNIEL, CNPF, ONF, NGOs, etc.).[111] • The specific methodologies differ, but the general steps for implementing remain the same: project developers register their project that applies an approved methodology and meets its quality requirements; they then request the Label Bas Carbone approval by submitting project description and required documents/evidence. The regulator reviews and asks any clarifying questions/requests additional evidence and denies the project or approves it for recording in the Ministry-run register, which records projects, credits, and buyers. Only projects that are additional will be approved. The registry is free to use for both buyers and sellers; no fees are required along the registration and certification process. Considering the LBC is still in the development phase, it was deemed a priority to avoid adding such barriers to participation. In the future, however, such fees could be introduced to cover for the cost of the administration and monitoring of projects.

[10] We appreciate the feedback and review provided by Daphné Lecellier, Julian Viau and Maguelonne Joubin from the French Ministry of the Environment (Ministère de la transition écologique)

[11] The LBC is the result of a three-year multi-stakeholder program (2015-2018) VOCAL (Voluntary Carbon Land Certification), which was financed with national and European funds.[11]

<table>
<tr><th colspan="2">Mechanism architecture fiche</th></tr>
<tr><td>Section</td><td>Aspects covered</td></tr>
<tr><td></td><td>Methodology approval process: Individuals or sectors can propose methodologies, which the regulator must approve. These methodologies set guidelines for how to do the following: establish eligibility criteria, calculate baseline scenario and demonstrate additionality of the project, demonstrate environmental integrity (i.e., co-benefits), requirements on identifying and managing non-permanence risks, calculate emissions reductions relative to baseline, and MRV requirements and methods. Approval of the methodologies is an ad-hoc and collaborative process. The Ministry works with the developer to prepare the method, consulting with experts and stakeholders. The Ministry then convenes an ad-hoc, informal expert group to help the Ministry review and approve the methodology. The expert group participates on a voluntary basis (without contracts or tendering procedure) and consist of relevant research centres, public institutes and NGOs, who provide feedback and comment on the methodology. The Ministry is considering making the process more formal in the near future by establishing an independent scientific committee. The credits that are produced using the scheme are not fungible i.e., they are project-specific and cannot be resold. Three methods (related to afforestation, hedgerows and livestock) were the result of existing research projects.</td></tr>
<tr><td>Participants</td><td>Supply: According to MTES (2019), any natural or legal person can develop a project under the scheme. The mechanism also allows for several actors to jointly develop a project.[2] As shown by the CarbonAgri project, in practice, intermediaries (such as farmers associations, agricultural companies, or regions) coordinate multiple farmers to implement the project (See Fiche 16 LBC Carbon Agri Methodology).
Demand: French companies, public organisations or individuals that wish to compensate their emissions can voluntarily acquire emission reductions.</td></tr>
<tr><td>Scope, objec-tive, and eligi-bility</td><td>LBC is a voluntary standard that covers all sectors excluded from EU ETS. The scheme addresses emissions and removals in the French agricultural and forestry sector. Additional methods for reductions in the marine, construction and transport sectors are currently under development.[3]</td></tr>
<tr><td>Performance</td><td>Carbon removal solutions: Currently, a total of 6 methods are approved:
Forestry (3) – Afforestation of agricultural land, rehabilitation of degraded lands, conversion of a coppice forest into an uneven-aged high stand.
Agriculture (3) - Emissions reductions on beef and dairy farms (CARBON AGRI, which also includes removals in the form of soil sequestration), sustainable management of hedgerows and orchard planting.
The LBC is currently in the process of expanding the amount of available methods, also developing methods that go beyond the forestry and agriculture sector. As of 10 February 2021, a total of 23 methods were being drafted for the following topics (non-exhaustive list)[4]: forestry (4), agriculture (11), natural spaces (e.g., peatlands restoration) or (4) and other areas (e.g., buildings as carbon sinks using bio-based materials) (4).
Geographic eligibility: France
As of 26 February 2021, 79 projects were registered for the Label Bas Carbone. The smallest project registered accounted for 80 tonnes of CO_2, the biggest one for 6139 tonnes of CO_2. There is no restriction on who can buy credits, international purchases are allowed. However, credits are not tradable and are sold only once. Moreover, they cannot be used to comply with a regulatory obligation (e.g., EU ETS).[5] An overview of all registered projects can be found here
Quantitative information on carbon dioxide removals under the mechanism (tCO_2-e):</td></tr>
</table>

Mechanism architecture fiche	
Section	Aspects covered
	• Forestry projects: 94 projects accounting for 142 700 TCO_2 on 640 Ha (mainly carbon removals) • Livestock projects (CARBON AGRI): 1 project accounting for 137 900 TCO_2 with 302 farmers (mainly avoided emissions)
Core design decisions	
Cross-cutting MRV aspects - high-level	• **Additionality:** Each methodology sets out methodologies and requirements for baseline setting and additionality. These will differ for each solution. In the methodology on conversion of a coppice forest into an uneven-aged high stand, additionality is defined as a project going beyond legal requirements (i.e., regulatory additionality) and current practices, and in financial terms, i.e., through the absence of funding through certified emission reductions, the removal would not have occurred (i.e., financial additionality). In the CARBON AGRI methodology, the baseline is set using a farm carbon audit tool, CAP2'ER®. Participants are supported by consultants. Their baseline can be set either using a conservative generic reference (using default inputs values coming from CAP'2ER® national database) or a more accurate specific reference per farm calculated with CAP'2ER® level 2 which requires approx. 150 activity data. Additionality is then proven by rerunning CAP2'ER® (an accurate level 2 run) after five years, to calculate new carbon intensities and determine the net emissions gains relative to the baseline. This baseline is reset after the five-year project period. The baseline for afforestation projects is related to the BAU scenario, i.e., removals are compared against those from fallow land.[6] • **Environmental integrity** is ensured through the utilisation of standardised methodologies in line with the overarching rules set in the regulation and approved by MTES.[7] An interesting and innovative feature is the discount principle to address uncertainty. Methodologies can include several alternatives for monitoring and verifying removals, aimed at letting project developers set a cost/accuracy ratio which is optimal for them. The more accurate – and likely costlier – alternatives are rewarded by issuing exactly as many credits as estimated removals, while less accurate alternatives can only be applied at the expense of receiving fewer credits than the total estimated removal. This principle is based on accuracy, i.e., risk of biased estimate, rather than precision (i.e., the confidence interval around the estimate). An example is given by the CARBON AGRI methodology, which allows farms to calculate their baseline either using a conservative generic reference (using default inputs values coming from CAP'2ER® national database) or a more accurate specific reference per farm calculated with CAP'2ER® level 2 which requires approx. 150 activity data. To account for higher uncertainty of using generic reference, reductions are discounted by 10%. • **Uncertainty:** In part to manage uncertainties, the LBC uses buffers/discounts (also to manage permanence risk). The uncertainties are determined by the writer of the methodology, based on the available scientific references and on similar methodologies used in other voluntary standards (and are updated over time). The evaluation of the expert group plays an important role in this regard. Statistical analysis to determine the size of the buffer/discount is difficult due to a lack of data and the heterogeneity of contexts each methodology (and the uncertainty evaluation) must consider. • **Permanence:** There are restrictions to ensure that permanence is achieved within the duration of project lifetimes, however, there are no permanence restrictions that go beyond the life of the project.

Mechanism architecture fiche	
Section	Aspects covered
	◦ Within project lifetimes: Forestry project have a lifetime of 30 years. Within this, permanence is addressed by legal force of strict forest management framework and by applying a buffer mechanism (which is filled by putting aside 10%-25% of estimated removals/emissions reductions); depending on the fire risk of the department where the project is set as determined in the forest code.[8] Project developers should inform, if applicable, the next landowners. In the CarbonAgri methodology (duration five years) permanence is managed through discounting. For example, most GHG reductions associated with CARBON AGRI are avoided emissions but for farms that sequester carbon in biomass or soil (where non-permanence risk exists), a 20% discount is applied to those removals. ◦ Beyond project lifetimes: There are no mechanisms in place to ensure the permanence beyond the project's lifetime. The CarbonAgri method duration is for five years - and farmers are rewarded for soil carbon storage over this time period – but there are no permanence requirements after the period ends (unless the farmer signs up to continue for another five years). [9] • **Reporting:** Methodology-dependent. The regulation defines the overarching rules for reporting and transparency. Among others, the former mandates that the MTES maintains and posts online a database with exhaustive and up-to-date information on all registered projects. This includes the project leader as well as the financer(s) of the project.[10] • **Verification:** Third-party verification by certification bodies or professional consultants is generally required. For example, for all forestry projects, a desk review to verify is compulsory (at the expense of the project developers), to be carried out by a competent and independent auditor at the end of the project. The qualification of the auditor differs per methodology, e.g., for forestry methods recognised certification bodies include Programme for the Recognition of Forest Certification (PEFC), Forest Stewardship Council (FSC) or Verified Carbon Standard (VCS). The project developers should provide the auditor with at least a certificate of acceptance of the work, relevant invoices and photo(s) of the site. For the methods that address the afforestation of agricultural land and rehabilitation of degraded lands, and additional mandatory field visit by the auditor is foreseen five years after project start, to assess whether the emission reductions calculated a priori appear to be consistent. After these verifications are completed, the project developers can formally request the MTES to recognize the emissions reductions by providing its monitoring report and the report by the auditor. A template for the monitoring report is issued by the developer of the methodology. Guidelines for the auditor report are provided in the methodology (as opposed to a template).
Accounting	• The LBC technical specifications restrict the purchase of voluntary credits to non-state actors. The underlying idea is that France is the only country to be able to claim the reductions for compliance (which is viewed as sufficient to tackle double-claiming between countries and firms). Emissions reductions or sequestration are part of the national GHG inventory and included in the national climate target.[11]
Sustainability	• **Carbon leakage settings:** Methodology specific. An example is given by the CarbonAgri methodology manages leakage by calculating emissions reductions and removals per unit of output measure, which reduces incentives to decrease production (and therefore reduces risk of leakage in the form of increased production elsewhere). • **Sustainability safeguards:** Environmental integrity is ensured through the utilisation of standardised methodologies in line with the overarching rules set in the regulation. The LBC guarantees that projects do not exert negative impacts on socio-economic and environmental issues.[12]

Mechanism architecture fiche	
Section	Aspects covered
	• The scheme favours projects that create socio-economic and environmental co-benefits (particularly in relation to biodiversity). These co-benefits are monitored and recorded so that they can be rewarded by investors.[13] The forestry methodologies include a "co-benefit matrix", which shows how many points a project can score by implementing measures that generate co-benefits related to socio-economic, soil conservation, biodiversity and water (maximum of 2 co-benefits per category, available categories differ per methodology). There are no general rules on the difference in economic value of project credits based on co-benefits and insufficient evidence at this point to evaluate whether projects with co-benefits receive higher market prices. Generally, projects that favour biodiversity are valued higher, but this is not necessarily the case. All project receive the same certification irrespective of the co-benefits, but the reporting of co-benefits can help buyers to choose a project that best fits their interest and which they can highlight in their communication. In the CarbonAgri tool, as the project is applying a whole-farm approach using the CAP2'ER® tool, environmental externalities/co-benefits can also be monitored, which represent a value for valorising carbon credits and communication.[14]
Incentives, market elements	
Costs	• **Transaction costs:** Given the relatively high MRV requirements (including on-site visits from consultants and verifiers), transaction costs will be relatively high. Limited information was available. • **Administrative costs:** Currently, one person works full-time on LBC, assisted by one person that works part-time and one intern. The cost of developing a new methodology is estimated to be between €30 000 and €50 000 (or more), depending on the complexity of the methodology and whether in-house or external expertise is required.
Type and timing of reward	• The Label bas Carbone is reward-based, that is project developers receive 1 "credit" (recognised reduction that can be sold to voluntary financers) per t CO_2 sequestered/avoided. Generated offsets can be voluntarily acquired by companies, public organisations or individuals that wish to compensate their emissions.[15] • The CARBON AGRI project pays rewards at the end of the 5-year project period, upon verification (i.e., ex post). Rewards are calculated based on changes in emissions intensity i.e., decrease in emissions per unit of output over project duration x level of output at end of 5-year project. While this does not provide a direct incentive for decreasing total emissions (unlike an absolute indicator), the scheme relies on other environmental policies to stop production expanding (e.g., Nitrates Directive). • Ex-ante credits are issued for forestry projects, rewarding up to 30 years of carbon storage, once proof is provided that most of the investment and initial forestry work has been carried out.
Offset markets/use of removals	• **Market structure:** Voluntary offsetting i.e., purchasers buy a claim on the carbon content of the removals. The purchaser is recorded on the Ministry-run registry, so that they cannot be sold again. However, LBC credits are not transferable nor tradable, i.e., once they are purchased by the external party voluntarily offsetting their emissions, they cannot be traded on.[16] • **Market:** Prices in CarbonAgri are €30-40 per tonne of Carbon.[17] For forestry projects, prices mainly range from €15-40 per tonne of carbon (in some cases €60)
Key references	• Ministère de la Transition écologique et solidaire (2021). Label bas-carbone : récompenser les acteurs de la lutte contre le changement climatique. Hyperlink: https://www.ecologie.gouv.fr/label-bas-carbone

Mechanism architecture fiche	
Section	Aspects covered
	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007 • COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007 https://op.europa.eu/s/pcDV

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[4] Ministère de la Transition écologique et solidaire (2021). Liste des projets de méthodes ayant été notifiés pour le Label Bas-CarboneVersion du10février 2021. Hyperlink: https://www.ecologie.gouv.fr/sites/default/files/20210209%20Projets%20de%20m%C3%A9thode.pdf

[5] Ministère de la Transition écologique et solidaire (n.d.). Questions fréquentes sur le Label bas-carbone.

[6] Ministère de la Transition écologique et solidaire (2019). Label bas-carbone : ré-compenser les acteurs de la lutte contre le changement climatique.

[7] I4CE (n.d.). Project VOluntary Carbon Land Certification (VOCAL). Hyperlink: https://www.i4ce.org/go_project/project-voluntary-carbon-land-certification-vocal/

[8] Ministère de la Transition écologique et solidaire (2019). Label bas-carbone : ré-compenser les acteurs de la lutte contre le changement climatique.

[9] Cevallos, Gabriella, Grimault, Julia & Bellassen, Valentin. Domestic carbon stand-ards in Europe - Overview and perspectives.

[10] Ministère de la Transition écologique et solidaire (2021). Le fonctionnement du Label bas-carbone. Hyperlink: https://www.ecologie.gouv.fr/label-bas-carbone#scroll-nav__1

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[13] Ministère de la Transition écologique et solidaire (2019). Label bas-carbone : ré-compenser les acteurs de la lutte contre le changement climatique.

[14] Dolle, J. (2019). "CARBON AGRI Certification of GHG reductions in cattle and crops farms presentation." Presented at Carbon Farming Schemes in Europe – Roundtable, 9.10.2019.

[15] Ministère de la Transition écologique et solidaire (2019). Label bas-carbone : récompenser les acteurs de la lutte contre le changement climatique

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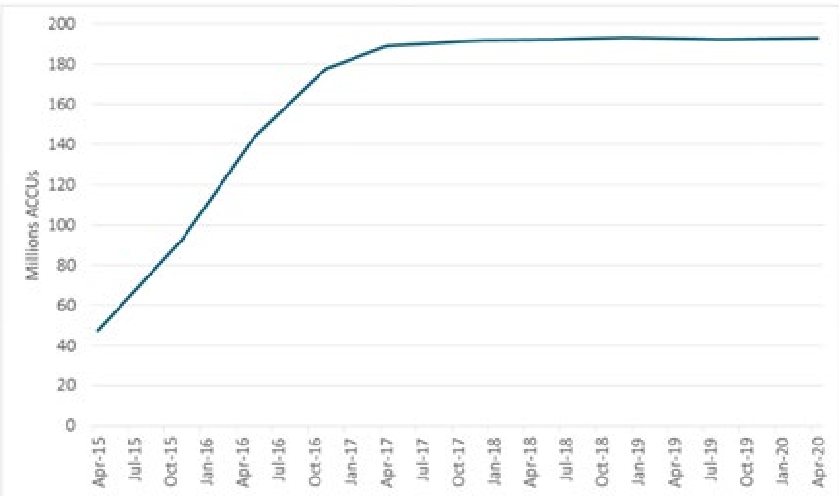
[17] Interview with Jean-Baptiste Dollé, 12.03.2020

6.3 Fiche: Australian Emissions Reduction Fund

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**Australian Emissions Reduction Fund (ERF)** *A portion of the information from this fiche comes from the DG CLIMA Carbon Farming Appendix: COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007 https://op.europa.eu/s/pcDV*
Introduction	• The Carbon Credits (Carbon Farming Initiative) Act 2011 created the ERF in 2015.[1] • The Australian ERF is a voluntary scheme "that aims to provide incentives for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions"[2], with the overarching objective to achieve the lowest cost abatement possible, achieved using reverse auctions.
Governance	• **Key governance bodies**: The **Clean Energy Regulator** (CER, Australian independent statutory authority) is responsible for developing the technical rules, administering the ERF and making emissions reduction purchases on behalf of the Government. The Australian Department of Industry, Science, Energy and Resources is responsible for ERF policy development, legislation and oversight of the ERF. This includes advising the Minister on establishing the technical rules (or methods).3 The Emissions Reduction Assurance Committee is an independent expert committee that assesses whether methods developed by the Department meet the ERF's offsets integrity standards.4 • **Methodology development process:** The ERF involves the Minister for Energy and Emissions Reduction, the CER, the Emissions Reduction Assurance Committee, Australian Department of Industry, Science, Energy and Resources, and consultation with industry, potential end-users and experts.5 The CER develops methods, which are prioritised by the Minister based on a pre-defined set of criteria, through a co-design process with stakeholders and develop new methods within 12 months of work (after the start), unless intractable scientific or technical issues emerge. The Emissions Reduction Assurance Committee advises the Minister for Energy and Emissions Reduction as to whether a method should be made or adjusted, based on whether it complies with the integrity standards found in the Carbon Credits (Carbon Farming Initiative) Act 2011. 6 Each method contains specific and detailed instructions on how abatements should be calculated.7 • The Australian Climate Change Authority is obligated to review the ERF every three years, which is laid down in the Carbon Credits (Carbon Farming Initiative) Act 2011 (Cth) (CFI).8
Participants	• **Supply:** Different participants can supply emissions reductions (i.e., receive credits), including businesses, households and landowners. • **Demand**: The Government is by far the biggest purchaser of abatement; in 2019, 95% of all ACCUs sold were purchased by the Government (i.e., by CER).[9]
Scope, objective, and eligibility	• **Carbon removal solutions**: covers a wide variety of carbon mitigation and carbon removal methodologies, including for the following sectors: agriculture, energy efficiency, facilities, mining, oil and gas, transport, vegetation management, and waste and wastewater. Carbon removal solutions include soil carbon and afforestation/reforestation. • Current method development priorities are soil carbon, carbon capture and storage, biomethane, plantation forestry and blue carbon.[10] Key GHGs covered are CO_2, N_2O, and CH_4. • **Geographical eligibility:** all project activities need to be carried out in Australia.

Mechanism architecture fiche	
Section	Aspects covered
Performance	• As of 31 January 2021[11]: ◦ **Number of registered carbon mitigation and removal methodologies:** total of 34 methods, including for agriculture (7), energy efficiency (7), facilities (1), mining, oil and gas (2), transport (2), vegetation management (11), waste and wastewater (4). Overview with all methods can be found here. ◦ **Number of registered carbon removal projects:** 940 (180 revoked projects). ◦ **Quantitative information on climate impact (including mitigation and carbon removals) under the mechanism (tCO_2-e):** 89,705,950 ACCUs issued (210,713 relinquished) between 31 December 2012 and 14 February 2021. The relinquishment requirement states that in case of a significant reversal, the project proponent needs to waive a certain amount of ACCUs. Significant reversal relates to at least 5% of the total project area or 50ha of the area, whichever amount is smaller. However, farmers do not have to give back ACCUs, in case the reversal was due to bushfire, drought, pest attack unless farmers did not have reasonable risk mitigation measures in place and would not re-establish lost carbon stocks.[12] • As of April 2020, 97 percent of all ACCUs were issued related to vegetation, waste, and savannah fire management projects. In addition, the ERF had awarded contracts for a total of 193 million tonnes of abatement (total commitment of $2.3 billion).[13] Since 2017, the ERF has not contracted significant new amounts of abatement because uncertainty about Government funding for the ERF has both influenced confidence in future demand and impeded decisions to develop new abatement projects.[14]  *Chart: Cumulative contracted abatement under the ERF (millions of tonnes CO_2-e) from April 2015 to April 2020*[15]
Core design decisions	
Cross-cutting MRV aspects - high-level	• **MRV and treatment of uncertainty** differs by methodology. Quantification of sequestration and emissions reductions/avoided emissions are generally calculated based on a mix of limited sampling (e.g., of soil carbon stocks) and proscribed equations (e.g., to calculate emissions based on livestock type and number and grasslands management). There does not appear to be a cross cutting treatment of uncertainty. • **Additionality:** For a project to be eligible under the ERF, it must NOT: ◦ Have commenced before it has been registered with the CER (the newness requirement);

Mechanism architecture fiche	
Section	Aspects covered
	- Be required to be carried out by or under a Commonwealth, State or Territory law (the regulatory additionality requirement); The CER has developed guidelines on how it will assess and implement regulatory additionality for the ERF.[16] These guidelines can be found here. - Likely to be carried out under another Commonwealth, state or territory government program in the absence of registration under the Emissions Reduction Fund (the government program requirement, i.e., regulatory additionality).[17] - Otherwise, additionality and baseline rules differ by methodology. For example, in some methodologies if an activity had less than 20% uptake with adoption not rapidly accelerating, the activity was considered uncommon and therefore any implementation would be seen as additional. • **Permanence, carbon reversals, and liability:** ACCUs may be required to be relinquished if: the issue of the ACCUs is attributable to the giving of false or misleading information, the ACCUs were issued in relation to a sequestration offsets project and the declaration of the project as an eligible offsets project has been revoked; or the ACCUs were issued in relation to a sequestration offsets project and there has been a complete or partial reversal of sequestration (mandatory relinquishment). In addition, former may be voluntarily relinquished: in order to voluntarily terminate a sequestration offsets project, or in order to terminate a carbon maintenance obligation imposed in relation to a project area (voluntary relinquishment).[18] A project application must include a request for the project be subject to either a 100-year or 25-year permanence period. Once declared, this period is fixed, and it will not be possible for projects to alter.[19] • **Reporting requirements:** ERF participants are required to report on their project at regular intervals. In some cases, these reports need to be accompanied by an audit report (if required in the project's audit schedule), to verify the accuracy of the abatement achieved. Auditors need to be registered as category 2 greenhouse and energy auditors. The majority of projects require a minimum of three scheduled audits, across the seven plus year crediting. Such audits need to establish "reasonable assurance" that the abatement achieved and reported on a by a project is accurate.[20] • Participants are free to choose when to report, as long as they adhere to the minimum and maximum reporting periods (periods between reports). Generally, prescribed reporting periods widely differ, depending on the type project, as well on the size of the net abatement (more information available here). A reporting period should not exceed two years for emissions avoidance projects, or five years for sequestration projects, and should start from a project's crediting period start date, or immediately follow the previous reporting period.[21] Participants need to submit a project report to the CER within six months of each reporting method (unless specified differently in the method).[22] • A failure to report may result in civil penalties, a review to check participant's fitness to participate in the ERF, project revocation, or loss of entitlement to ACCUs. In some cases, an extension can be granted (up to 18 months). Participants anticipating a reporting delay should contact the CER early on.[23] The CER holds enforcement powers, including the ability to: inspect the premises to determine whether a project complies with legislations and regulations; require documents and information; and require scheme participants to appoint a registered greenhouse and energy auditor to carry out compliance audits. The former also closely collaborates with other agencies that have regulatory responsibilities under climate change and other legislation, which includes the sharing of relevant information, intelligence gathering, and referring matters for the attention of other agencies where appropriate.[24]

Mechanism architecture fiche	
Section	Aspects covered
Accounting	• The ERF distinguishes between Kyoto ACCUs and non-Kyoto ACCUs, based on whether a project is an eligible Kyoto project and whether the reporting period ends on or before the Kyoto abatement deadline.[25] • The CER manages an ERF register, which contains an overview of all registered projects (including project name, scheme participant, method, project location, total amount of ACCUs issued). Potential buyers on the secondary market, which is not regulated by the Government, can use the register to identify possible sources of ACCUs. An interactive online map, which shows the volume, location and type of projects across Australia, is available as well.
Sustainability	• **Carbon leakage settings**: No information found • **Sustainability safeguards:** Negative lists apply, i.e., projects that could potentially have adverse environmental or social impacts in specific contexts are excluded, e.g., permanent tree planting is not allowed in drought areas to avoid compounding water availability issues.[26]
• Incentives, market elements	
Costs	• **Project development costs**: For land-based abatement (the dominant mode of abatement under the ERF), indicative costs include initial registration ($10,000 per project), monitoring/sampling ($3.500 per project, per year) and reporting $5,000 per project per report • **Audit costs:** for cattle projects: $13,250 (initial audit) + $9,000 (subsequent audit) + $1,000(site visit fee). For savannah & sequestration: $11,250 (initial audit) + $9,000 (subsequent audit) + $1,000 (site visit fee) • Total costs for a typical cattle project are estimated at around $100,000 (with a 7-year contract life), for a typical avoided land clearing/managed regrowth project (with obligations over 25 years) approximately $150,000[27] • A review of the Carbon Farming Initiative (which ran from 2011-2014 and was integrated with the ERF) noted that some costs associated with MRV and reporting have been unnecessarily high and has not matched the risks being managed. These costs may include direct project costs such as tree planting and maintenance, project transaction costs including time and expense of starting a project and reporting emission reductions and costs carried by the government associated with administration and verification. In addition, auditing costs varied between AUD 15.000 and 30.000, where in some cases these types of prices could be prohibitive. On the other hand, one consulting company providing auditing services reported that from their project experience, the costs associated with auditing are a small percentage (<2%) of returns from credits.[28] • More information on the relative costs and performance of the ERF can be found here
Type and timing of reward	• **Reverse auction**: the CER uses reverse auctions to achieve reductions at lowest cost. The process for participants is as follows: reward structure is shown by the steps ERF projects go through: ◦ Apply. Joining the Emissions Reduction Fund scheme by registering the participant and project with the CER;

Mechanism architecture fiche	
Section	Aspects covered
	◦ Contracts and auctions. Participants securing a contract to provide removals to the CER by bidding at an auction. This is a reverse auction i.e., the CER selects the lowest price bids. Two types of contracts with the CER are available: fixed delivery and optional delivery contracts. The latter was piloted in March 2020 (auction 10) and will be available at future auctions. As opposed to fixed delivery contracts, optional delivery contracts allow project proponents to deliver abatement on the secondary market if the price is higher than what was contractually agreed with the CER. Another difference is that project proponents need to deliver Australian Carbon Credit Unites (ACCUs) from a single ERF project (as opposed to sourcing from any ERF project on the secondary market). Finally, the optional delivery contract allows for the lowering of outstanding quantities when a scheduled delivery is not made.[29] More information on carbon abatement contracts and the available types of contracts can be found here; ◦ Reporting and auditing and then delivery and payment of (ACCUs) for the project's emissions reductions and receiving financial compensation for the ACCUs sold.[30] • **Form of reward for participant:** one ACCU is earned for each of carbon dioxide equivalent (tCO_2-e) stored or avoided by a project.[31] ACCUs can be sold to generate income, either to the Australian government (through a carbon abatement contract), or in the secondary market.[32] ACCUs earned by projects in the reporting period issued into the participant's Australian National Registry of Emissions (ANREU) account.[33] • **Crediting period and timing of reward:** participants that have a contract with the CER should deliver ACCUs according to the schedule in the contract. Once ACCUs have been transferred from the former's ANREU account, payment is made in accordance with the price agreed to at the auction (which is laid down in the contract as well) within 20 business days of the delivery date.[34] • Project proponents of soil carbon projects may be eligible for an advance payment of up to $5000 for a certain number of ACCUs from a carbon abatement contract (to help with upfront costs of soil sampling).[35] • The trading of ACCUs is considered a financial service and is regulated the same way as trade in financial products, however with some exceptions. This means trading may require a license and verification of identities of the involved parties or persons.
Offset markets/use of removals	• Market form: voluntary offsetting/central government buyer • With regard to the auction in September 2020 (eleventh one, most recent at time of writing)[36]: ◦ The CER committed to purchase 7 million tonnes of abatement on behalf of the Commonwealth ◦ The average price per tonne of abatement purchases was $15.74 ($15.77 for optional delivery, $15.53 for fixed delivery). ◦ 35 contracts were awarded for 33 projects with two projects securing both an optional and fixed delivery contract ◦ The value of all contracts awarded was $110.3 million
Key references	• Australian Government Clean Energy Regulator (2016). About the Emissions Reduction Fund. Hyperlink: http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund • Interactive Emissions Reduction Fund Questionnaire (to determine eligibility for ERF). Hyperlink: http://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund/eligibility-to-participate-in-the-emissions-reduction-fund

Mechanism architecture fiche	
Section	Aspects covered
	• Australian Government Climate Change Authority (2020). Review of the Emissions Reduction Fund. Hyperlink: https://www.climatechangeauthority.gov.au/sites/default/files/2020-11/ERF%20Review%20Final%20Report%2020201009_2.pdf • COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

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6.4 Fiche: New Zealand Emissions Trading Scheme (NZ ETS) and Permanent Forest Sink Initiative (PFSI)

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**New Zealand Emissions Trading Scheme (NZ ETS)** **New Zealand Permanent Forest Sink Initiative (PFSI)** *Throughout, we focus on the forestry sector and identify where the schemes differ, otherwise the reader should assume that the same applies to both NZ ETS and PFSI.*
Introduction	• New Zealand Emissions Trading Scheme (NZ ETS) has operated since 2008. It was intended to be an all sector, all gas system, including the forestry sector as both a source and sink and the agricultural sector, though agriculture does not ultimately have surrender obligations[1]. Removals by forestry, alongside free government allocation, are the key source of credits within the NZ ETS (in 2017, forestry removals were equivalent to 30% of New Zealand's gross emissions)[2] (Ministry for the Environment 2019a). The NZ ETS forestry approach allows for harvesting. • The New Zealand Permanent Forestry Sink Initiative (PFSI) was operational from 2006-2018, when it was discontinued to be integrated into the ETS following a review[3]. The PFSI focused on permanent forestry regeneration, allowing for only very limited harvesting as part of permanent management. It was targeted at afforesting marginal land, with the aim of encouraging in particular native regeneration and co-benefits such as reduced erosion and biodiversity. To ensure permanence, PFSI land has a covenant registered on the land title, valid for 99 years.

Governance	• **Operator/administrator:** New Zealand Government
	• **Regulatory mechanism:** All pre-1990 forests were obliged to participate in either NZ ETS or PFSI; post 1989 forests could opt in.
	• **Methodology development process:** Methodology developed by New Zealand Government
	• **Key governance bodies:**
	  ◦ NZ Ministry for the Environment: The general administration and operations' assessment of the NZ ETS and legislative amendments related to the Climate Change Response Act.
	  ◦ NZ Environmental Protection Agency: In charge of NZ ETS Unit Register, which includes the registration of non-forestry participants, management of the NZU issuance, and emission reporting, allocation, surrenders, and NZU transfer under the NZ ETS.
	  ◦ NZ Ministry for Primary Industries: Administration of the forestry participants and provides the policy advise along with the MfE within agricultural and forestry sectors. MPI was also responsible for the PFSI.

Participants	• **Supply side:** Owners of forest land (individual landowners, farmers, Maori landowners, large forestry companies). As of June 2015, there were 2276 forestry participants[4]. • **Demand side:** There were approximately 300 additional NZ ETS participants from other sectors (e.g., fossil fuels, waste, stationary energy), who purchase NZUs to cover obligations (along with any foresters who deforest).
Scope, objective, and eligibility	• **Carbon removal solutions:** Afforestation, improved forest management (i.e., related to IPCC GL Vol. 4 Ch. 4)[5]. • **Land category:** Forest land (or land converted to forestry land, i.e., also applies to cropland, grassland, wetlands). Land is considered a forest if trees are over 5m, land area is greater than 1 ha (and at least 30m wide), land canopy cover is >30%.

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<tr><td>Section</td><td>Aspects covered</td></tr>
<tr><td></td><td>

- **Gases:** CO_2 (note: NZ ETS is all gases but for forestry, only CO_2 is considered).
- **Geographic eligibility:** land must be within New Zealand.
- **Coverage:** The NZ ETS was designed to cover all sectors and all gases, though agriculture has never been fully integrated or faced costs. NZ ETS: All pre-1990 forestry land is automatically covered by the NZ ETS; land that has been afforested post-1989 can opt in. In the NZ PFSI, land has to have been afforested post-1989 and be the result of active steps such as planting, seeding, or facilitating natural regeneration.

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<tr><td>Perfor-mance</td><td>

- **Number of registered carbon removal methodologies:** Two: "Lookup tables" approach (which applies to forestry participants registering <100ha); Field Measurement Approach (which applies to forestry participants registering >100ha).
- **Number of participants:** NZ ETS: 2276 forestry participants (as of June 2015)[6]; NZ PFSI: In 2015, there were 61 participants in the PFSI[7].
- **Quantitative information on carbon dioxide removals under the mechanism (tCO_2-e):**
  - NZ ETS: 18.3 Mt CO_2-e removals by forestry[8] (covering 325,000ha of post-1989 forests, and 1,227,000 ha of pre-1990 forest[9].
  - PFSI: relatively small (only 15,900ha under PFSI in 2015) [10]
- **Performance:** A 2017 study assessed lessons from including forestry in New Zealand's ETS, identifying that When New Zealand Unit prices have been high (for example, 2009-2011), there is evidence that the NZ ETS reduced deforestation and incentivised additional planting. However, both in the lead up to the NZ ETS forestry obligations coming into effect (i.e., landowners having to purchase credits to cover deforestation) and in times of low prices, there is evidence of deforestation. The NZ ETS failed to achieve the forecasted additional afforestation due to low carbon prices, a lack of future markets, high returns in alternative land uses, and policy uncertainty.[11]

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<tr><td colspan="2">Core design decisions</td></tr>
<tr><td>Cross-cutting MRV aspects - high-level</td><td>

For more information on MRV, see Fiche 14/15 NZ ETS/PFSI Forestry Methodology.

- **Monitoring:** Both the PFSI and the NZ ETS apply the same monitoring/measurement methods. These match those set by the UNFCCC Guidelines[12] and aligned with Kyoto Protocol accounting approaches, with equations and emissions factors adapted to New Zealand. There are two different methods: for small forests (area <100ha) a simple, low-cost method Default Table Approach applies; forests larger than 100ha must apply the Field Measurement Approach (FMA), which includes site measurement. More information on the methods can be found in Fiche 14/15 NZ ETS/PFSI Forestry Methodology.
- **Treatment of uncertainty:** Not explicitly discussed but there appears to be some acceptance of uncertainty of emissions reductions by individual participants, as this is seen as variation around a mean rather than a bias. See extended discussion in Fiche 14/15 NZ ETS/PFSI Forestry Methodology.

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Mechanism architecture fiche	
Section	Aspects covered

	• **Cross-cutting additionality approach:** The New Zealand ETS conducts no additionality tests. Instead, all forests planted post-1989 are considered additional (in line with Kyoto Protocol accounting rules) and can voluntarily join the ETS, which entitles them to receive credits (but also to face obligation to purchase credits if the land is subsequently deforested). The symmetrical price incentives (i.e., to avoid deforestation/incentivise afforestation) avoids the need to manage baselines/leakage/non-permanence.[13] All pre-1989 forests were mandatorily included in the NZ ETS and are awarded a baseline of being forested (they are therefore not eligible for NZUs but would be liable for any deforestation). Pre-1989 forest landowners were compensated using free allocation of allowances equivalent to approximately 8% of their potential liabilities. [14] To participate in the PFSI, land must be post-1989 forest. To identify whether land was pre or post 1989, photos or planting records were used. This simple assumption of additionality lowers transaction costs for all and benefits all post-1989 forestry owners, who have the option to be paid for afforestation they carried out in absence of emissions payments; this is effectively a transfer from the New Zealand Government (which would have otherwise "benefited" from the afforestation's contribution to NZ Kyoto and other targets.
	• **Permanence:** In the NZ ETS, permanence is managed by making forestry participants liable to cover any declines in sequestration by purchasing an equal number of equivalent credits (i.e., that are generated by other ETS participants, whether that is other afforestation or through emissions reductions/free allocation). Therefore, if a forester decides to cut down forests, they have to purchase sufficient credits to offset this with other emissions reductions within the ETS. In the PFSI, permanence was ensured by requiring landowners to place a 99-year covenant on the land that bans clear felling, and by requiring participants who do cut down forests to surrender credits equivalent to the reduction in carbon storage. [15] Participants are also liable for natural events (though payment could be avoided by replanting forests).
	• **Reporting:** Both PFSI and NZ ETS apply a self-assessment model for MRV. ETS/PFSI participants record the activities that occurred on the forestry plots registered for ETS/PFSI over the previous calendar year in annual emission return report, which they then submit by March 31 to the New Zealand Environmental Protection Agency, who then use the report to calculate the estimated surrender or allocation of units. The NZ EPA has one month to accept the report. If the landowner's activities resulted in net removals, they would at this point be credited an equivalent amount of emissions units; if there were net emissions from their land in the last year (e.g., due to forest clearing), they would have one month to surrender an equivalent number of credits. These movements are recorded in the NZ EPA Registry. In both the NZ PFSI and the NZ ETS, there is differentiated reporting requirements for the two categories of participants, i.e., landowners with more or less than 100ha of registered forestry land under the NZ ETS/PFSI:
	  ◦ Landowners <100ha: Report annually via annual emission return report, using default look-up tables (i.e., default emissions factors, default regional growth rates, etc.).
	  ◦ Landowners > 100ha: In addition to the annual return report, larger landowners have to make a mandatory report on the removals and emissions at the end of each five-year mandatory emission reporting period, which is based five-yearly on-site measurements. Participants can take these measurements and report this information themselves, or can contract a consultant. The mandatory report requires EPS and PFSI participants to use across the most up-to-date participant-specific or default carbon tables and takes into account any previous voluntary annual reports to avoid double-counting the calendar year or years within each five-year periods[16].

Mechanism architecture fiche	
Section	Aspects covered
	• **Verification procedure and bodies:** Independent third-party validation and verification is not required (to reduce compliance and transaction costs[17]). To enforce compliance, participants face automatic penalties for failing to surrender required credits, with increasing fines for failing to meet record keeping, reporting, and notification obligations, and criminal charges for providing false information. Instead, the government enforces compliance through a threat of random and targeted audits and penalties, similar to the tax system. The use of default look-up tables limits opportunities for non-compliance for small participants (i.e., landowners >100ha).
Accounting	• The New Zealand EPA operates the New Zealand Emissions Trading Register[18]. All participants in the NZ ETS or PFSI must have an account. It logs all New Zealand emissions units earned, allocated, or surrendered. It is connected to international registries via the International Transaction Log (ITL) run by the United Nations Framework Convention on Climate Change (UNFCCC), although since 2015, the New Zealand ETS has not accepted international units and is for now a domestic-only system.
Sustainabil-ity	• **Carbon leakage settings:** Leakage is managed in the NZ ETS by providing intensity-based allocation of allowances to industries at risk (i.e., in "highly exposed" sectors, a % of last year emissions are freely allocated).[19] This does not apply to the forestry sector. • **Sustainability safeguards:** Very limited. Fiche 14/15 NZ ETS/PFSI Forestry Methodology.
Incentives, market elements	
Costs	• **Transaction costs:** The DG CLIMA Carbon farming project found that all interviewed project owners did neither perceive the PFSI nor the ETS registration and MRV procedures burdensome. However, the complication and technical nature could be an issue especially for small scale farm foresters. • **Administrative costs:** Leining and Kerr (2016)[20] report that the Ministry for the Environment state that since 2008 the NZ ETS has cost the government $38.9 million to implement and administer, and that the annual cost to the government of implementation and administration in the 2014–15 financial year was $6.4 million.
Type and timing of re-ward	• **Form of reward for participant**: New Zealand Units (i.e., credits, which can then be sold) • **Crediting period and timing**: Ex-post. Crediting occurs annually, following the submission and acceptance of an annual emission return report.
Offset mar-kets/use of removals	• **Market demand structure:** ETS linkage i.e., the afforestation credits are purchased by other emitters within New Zealand's ETS (e.g., stationary energy, fossil fuel importers, ...)

Mechanism architecture fiche	
Section	Aspects covered
	• **Market summary:** In general, the afforestation incentives of the NZ ETS has been limited due to relatively low prices faced (see figure below). The particularly low prices 2011-2016 occurred due to unlimited links to internationally generated CDM and JI credits, which were very low due to oversupply and questions of environmental integrity[21]. After the NZ ETS was decoupled from international markets, prices remained artificially low due to the government's provision of a $25 NZD (14.70 EUR) price cap and a one-for-two surrender rule[22,23].  *Price of New Zealand Units, 2009-2017 (MfE, 2019)*[24]
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007 • Leining, Catherine, and Suzi Kerr. 2016. 'Lessons Learned from the New Zealand Emissions Trading Scheme'. Motu Working Paper 16–06. Motu Economics and Public Policy. http://motu-www.motu.org.nz/wpapers/16_06.pdf. • New Zealand Ministry of Primary Industries. 2016. The Permanent Forest Sink Initiative MPI Discussion Paper https://www.mpi.govt.nz/dmsdocument/8614/direct

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6.5 Fiche: Nori Carbon Removal Marketplace

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**The Nori Carbon Removal Marketplace**
Introduction	• The Nori Carbon Removal Marketplace was established in 2017 in the USA and is currently in a pilot phase. It exclusively focuses on removing CO_2 from the atmosphere. For now, only agricultural projects that focus on storing carbon dioxide in soils can apply. • Nori uses blockchain technology to replace an offset market registry.
Governance	• **Operator/administrator:** The Nori Carbon Removal Marketplace is a voluntary mechanism, which is managed by Nori Inc., a private for-profit entity.[1] • Voluntary market • **Key governance bodies:** The Nori Peer Review Committee consists of independent scientific experts and plays a central role in the development, approval, and potential revision of Nori methodologies and ensuring the scientific integrity of the outcomes.[2] • **Methodology development process:** At present, there is only one methodology. In the future, Nori will enable anyone to propose a methodology through the use of an open peer review system but it is not yet clear how this mechanism will work.[3] Nori reports that they develops methodologies in accordance with ISO 14080:2018, with a particular focus on the following ISO principles; gathering input from stakeholders and scientific experts, drafting the methodology (including identification of what independent, third-party controlled, publically accessible, analytical tools to use), implementing a pilot program to test the draft methodology (including environmental integrity), reviewing feedback from market participants, the wider community and Nori's peer review committee members; and publically publishing the input of the wider community and the peer review committee members, including reasons and schedules for the adoption of new and/or modification of existing methodologies.[4]
Participants	• **Suppliers:** At the moment, Nori prioritizes US farmers with 1000 acres and up, but exceptions can be made when smaller projects make up a representative example greater than 1000 acres. [5] For each farmer that participates in the pilot, a unique profile page is created (example can be found here). • **Buyers**: Buyers include companies and individuals who wish to voluntarily offset their emissions.
Scope, objective, and eligibility	• **Carbon removal solution:** Soil carbon sequestration • **Geographic eligibility:** US • **Geographic scale:** In the pilot phase, Nori targets US farmers with more than 1000 acres. Partial farm units are permitted (i.e., farmers can define subsets of their farm as part of the project area, exclude some fields)[6]. • **Gases/carbon pools:** CO_2, CO, N_20, CH_4; above ground biomass, soil carbon[7]
Performance	• **Number of registered carbon removal methodologies:** At present, only the Croplands Methodology is available, which can be found here. Nori intends to add grazing projects and grazing forestry; industrial technologies are a little farther off but might become options (especially CCU). [8] • **Quantitative information on carbon dioxide removals under the mechanism (tCO_2-e):** as of 22-03-2021, 22,212 tonnes of CO_2 were purchased and 17,568 were available.[9]
Core design decisions	

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<tr><td>Section</td><td>Aspects covered</td></tr>
<tr><td>Cross-cutting MRV aspects - high-level</td><td>

The lifecycle of a Nori project consists of the following steps;

Suppliers create an account and pick a methodology;
Suppliers apply to register their projects, which including setting of a (dynamic) baseline with verifiable data; this must be approved by an independent verifier;
Suppliers submit annual data;
Suppliers choose to verify their carbon removal claims, which must occur every three years (but can also be done on an annual basis);
Nori Carbon Removal Tonnes (NRTs – a non-fungible Nori offset certificate) are issued based on a positive verification, i.e., ex-post (note: farmers can then exchange this for a fungible NORI token, which works like a tradeable offset certificate);
The supplier commissions a final project audit to establish a new baseline and determine whether Nori over-issued or under-issued NRTs over the project duration of 10 years. The respective auditor should not have previously verified the project registration or carbon removal claims for the project;
NRT contract retention and review. Nori considers a project invalid if suppliers fail to meet an annual reporting deadline/report incompletely, and/or if there is an intentional reversal/release of the C stock.[10]

Croplands Methodology: To date, these is only one Nori methodology, for Croplands. Nori collaborates with COMET-Farm to model carbon removals based on comparing sustainable farming practices with a (dynamic) baseline. The COMET-Farm greenhouse gas accounting tool allows farmers to evaluate different options for reducing GHG emissions and sequestering more carbon over a 10-year period. The tool takes into account local climate and soil conditions and allows farmers to enter detailed information for their field and livestock operations.[11] Soil sampling is not a requirement for enrolling in the Nori program. However, at the end of the 10-years period, an audit is conducted that includes on-site sampling to establish a final level of soil carbon.[12]
Treatment of uncertainty: In the Nori market, every NRT (i.e., non-fungible offset certificate) must be traded in exchange for a NORI token (fungible) to retire the NRT. Nori keeps 100 million tokens (20% of the total supply) as a buffer in case NRTs are over issued. When a supplier sells its NRTs for NORI tokens, Nori splits the supplier’s token holdings into separate “unrestricted” and “restricted” accounts based on the NRT score. The NRT score reflects, among others, the risk that incremental CO_2 drawdown was overestimated in the earlier years of the project registration term and uncertainty associated with NRT retention. A lower score means that more NORI tokens are allocated to the restricted account (typically no more than 30%). Suppliers are not allowed to liquidate or convert these NORI tokens to cash, but their market value still can be used as “restricted assets”. Suppliers need to continue reporting operating data for any of the outstanding NRTs to release all of the NORI tokens of their restricted account. The NRT score can improve over time, and as a result, NORI tokens are shifted from the restricted to the unrestricted account.[13]

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Mechanism architecture fiche	
Section	Aspects covered
	• **Cross-cutting additionality approach:** As opposed to applying a financial or regulatory additionality test, Nori calculates individual baselines to determine additionality, as well as requiring that a potential supplier "adopts new land management or production practices, or installs new technologies which are reasonably expected to remove CO_2 from the atmosphere and retain the recovered C in a terrestrial reservoir for at least 10 years". In other words, any improvements over the project baseline scenario due to the introduction of new practices is considered additional.[14] This applies retrospectively: Nori counts as additional those farmers who adopted new practices in the last 10 years, as long as farmers can demonstrate at least 3 years of pre-switch operating data to support their claim.[15] The baseline is specific to the participant, and is a scenario based on historical data (at least 3 years), revised each year to account for elements outside suppliers control (e.g., weather). • **Permanence, carbon reversals, and liability:** Nori guarantees that one Nori Carbon Removal Tonne (NRT) is equivalent to one tonne of incremental CO_2 removed from the atmosphere and retention of recovered C in the earth's natural storage system for a minimum of 10 years. This ten year period applies from the date that they credit is sold (i.e., ex post after it has been verified), meaning that this extends up to ten years past the ten year project duration (i.e., a removal is sold after final project verification then must continue to be monitored for ten years). Suppliers can re-enrol and re-register projects after this period. Nori believes that long-term permanence for nature-based solutions can only be achieved through recurring carbon retention payments, as opposed to large up-front payments and land-use restrictions imposed by covenants.[16] If a farmer engages in fraud with regard to the creation or issuance of NRTs, or deliberately releases the carbon underlying the NRT within the project or ten year monitoring period (with the exception of a release to due to Force Majeure, such as flooding earthquakes or national public health emergencies), Nori has the right to recover the equivalent value of the released carbon from the supplier's restricted NORI tokens.[17] • **Reporting requirements:** To set baselines, farmers have to provide data sufficient to calculate baseline using the COMET farm tool. Nori's data requirements for the Croplands Methodology can be found here. Nori allows some "smart" default averages to be used (e.g., tillage methods, irrigation rates, rate and timing of fertiliser application) but will not back pay (grandfather) credits based on these defaults (farmers must have three years of data). Farmers must update the Nori data template annually and every three years farmers are required to work with third-party verifiers to review their carbon removal data and provide additional evidence required.[18] • **Verification procedure and bodies (and timing):** Farmers have to submit verification reports once every three years. To do so, they select a Nori-approved verifier listed on the website, who verifies the automatically generated draft verification report by COMET-Farm and assigns levels of assurance and verification quality in line with Nori guidance. The verifier submits a report to Nori on their analysis; every certificate of carbon removal sold includes a copy of this report. The final end of ten-year evaluation procedure is still being developed (as Nori expect significant technological progress over the coming years).[19] Nori relies on independent verifiers; they must be accredited under ISO 14065 and in good standing with verification office; Nori automatically accepts approved verifiers for Climate Action Reserve, American Carbon Registry, and Verra.[20]

Mechanism architecture fiche	
Section	Aspects covered
Accounting	• **Avoiding double-counting:** Nori uses blockchain technology (Ethereum) to avoid double-counting. They permanently registers NRTs in a publically accessible blockchain database and assigns them a unique serial number, including information such as the amount of carbon removals, the farmer and fields where the carbon was stored, as well as any additional information provided by the farm.[21] NRTs are retired as soon as they are sold, which makes it clear who owned the NRT and what point in time.[22] Only indirect link to national GHG reporting, with regulations for international trade yet to be developed.[23]
Sustainability	• **Carbon leakage settings:** Nori assumes that, in the case of Nori suppliers who include only a subset of fields, soil carbon gains within project boundaries result in SOC losses outside of boundaries; suppliers will have to provide some evidence of this in verification stage, although the specific evidence is not clear[24]. Nori tracks the direct and some of the indirect positive and negative GHG emission impacts of the carbon removal projects registered on the marketplace, including nitrous oxide, carbon monoxide, and nitrogen retention in soils. If it turns out "over time" that certain carbon removal activities likely result in higher associated GHG emissions, Nori may refuse to register these projects in the marketplace. • **Co-benefits/externalities:** COMET farm also tracks other environmental indicators (e.g., excess nitrogen). However, Nori does not manage these.
Incentives, market elements	
Costs	• **Transaction costs:** Nori collects a 15% transaction fee to maintain the marketplace. Buyers can purchase removal offsets from the available inventory in the Nori Carbon Removal Marketplace, and as a result, transactions costs are very low (according to Nori, transaction costs "become effectively zero"). [25] • Nori estimates potential verification costs for the Croplands Methodology to be approximately 5000 US dollars, which is paid for by the farmer.[26]
Type and timing of reward	• **Form of reward for participant:** NRTs are awarded to suppliers that provide verified evidence of removing incremental CO_2/committing to retaining C in a terrestrial reservoir for at least 10 years.[27] The supplier can then convert these NRTs into a NORI token (minus deductions for uncertainty – see additionality section), which can be traded in the Nori marketplace for money at the market price. In the pilot stage, Nori is additionally paying suppliers USD 15 per NRT. • **Timing:** Payments are ex post, after verification. Projects run for 10 years and can then renewed (with revised baseline).
Offset markets/use of removals	• Market structure: Voluntary offset market ◦ Potential buyers that aim to purchase an NRT in the Nori marketplace first need to buy a NORI token, which corresponds to one NRT (i.e., one Nori tonne of carbon removals, guaranteed for ten years).[28] When sold through Nori, farmers can set a floor price for their Nori token. During the pilot phase, farmers are paid 15 US dollars plus one NORI token for one NRT. The NORI token is a cryptocurrency that will fluctuate in value; once the pilot program ends the price of NRTs will correspond with the price of the NORI token (which in turn is based on supply versus demand).[29] There will be a fixed supply of NORI tokens; Nori needs to ensure that the total amount of NORI tokens grows proportionally with the numbers of NRTs in the market (the plan is to mint 500 million tokens in total).[30] Moreover, NORI tokens might also be traded in secondary markets for other currencies.[31]

Mechanism architecture fiche	
Section	Aspects covered
	• Nori will also hold Forward Contract Auctions, following a single or uniform price Dutch auction; potential buyers indicate their maximum price and suppliers set their minimum price. Based on this, both parties are matched up to sign bilateral, non-assignable Forward Contracts.[32] On the Forward Contract settlement dates, every NRT will be exchanged for NORI tokens on Nori platform (possibly complemented by US dollars over the counter, depending on the market price of the NORI tokens relative to the contract price on the settlement date).[33]
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6.6 Fiche: Gold Standard

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**Gold Standard**[12]
Introduction	• Gold Standard was established in 2003 by WWF and other international NGOs to certify and provide a mechanism for voluntary offsetting. Gold Standard is active globally and is the second largest independent offset mechanism by emissions reductions/removals.[1] Gold Standard credits are predominantly used voluntarily but some are also accepted in regulatory regimes (Colombia carbon tax, South Africa carbon tax, CORSIA). Gold Standard offers methodologies for many sectors, though the majority of credits produced come from avoided emissions through renewable energy (42%), with only small amounts from forestry (2%) or agriculture (0.2%).[2]

Governance	• **Operator/administrator:** Gold Standard Foundation (not-for-profit foundation, based in Switzerland)
	• **Methodology development process:** Developers can have new methodologies approved and can then apply that method to generate offset credits. Steps involved[3]:
	  ◦ Concept: Mechanism developers develop a concept method that outlines and justifies the method, and submit it to Gold Standard technical advisory committee to assess initial eligibility.
	  ◦ Full draft: If concept is approved, methodology developers create a full draft, setting out methods, management, and uncertainty, and re-submit it.
	  ◦ Review: Gold Standard reviewers (two internal reviewers and one external reviewer e.g., scientist) identify issues that the developers must address (up to 3 rounds of review).
	  ◦ Final approval: Gold Standard technical advisory committee give final approval of the methodology.
	  ◦ Note: For a new methodology the cost is €50,000, and the approval takes approximately 5 months. For a methodology already recognised elsewhere (e.g., CDM) the cost is €7,500 and the approval takes approximately 2 months.
	• **Key governance bodies:**
	  ◦ Foundation board: provides financial oversight and strategic governance. Board members come from NGOs (e.g., WWF), public (e.g., Asian Development Bank), and private (e.g., Danone) sectors.
	  ◦ Gold Standard Secretariat: develops and manages standards and mechanism, contributes to climate policy/SDG discussions.
	  ◦ Technical governance committee: provides strategic input/oversight of standards
	  ◦ Technical advisory sub-committees: thematic expert groups (e.g., on land-use).
	  ◦ NGO supporter network: NGOs such as WWF, IUCN, Fairtrade provide advocacy and support

Participants	• **Supply side:** Project developers are responsible for applying approved methodologies. Generally, project developers (individual or groups of private companies, NGOs, or public institutions) then work with multiple individual landowners or emissions sources. Project developers can apply existing methods or develop their own (for certification).

[12] We appreciate the answers to specific questions provided by Owen Hewlett from Gold Standard.

Mechanism architecture fiche	
Section	Aspects covered
	• **Demand side:** credits purchased by companies and individuals, either voluntarily or in some cases to meet regulatory requirements (e.g., in Colombia, South Africa).
Scope, objective, and eligibility	• **Carbon removal solutions:** Covers carbon removals (only NBS) and avoided emissions (many sectors). NBS removal methods include afforestation and agricultural soil carbon. In terms of total emissions reductions/removals since inception, 2% have come from removals, the rest from avoided emissions (42% of removals/reductions come from renewable energy, 26% for fuel switching, 13% energy efficiency, 11% waste, 6% fugitive emissions, 2% forestry, and 0.2% agriculture[4]. This is in part an artefact of the late development of forestry methods (2013) and agriculture (2017). 26 methods in total, listed here. • **Geographic eligibility:** Global. Projects must demonstrate that the area is not used to meet other voluntary or compliance standards (or demonstrate how double-counting will be avoided)[5]. • **Geographic scale:** Differs per project and methodology.
Performance	• Number of registered carbon removal projects: 1,900 projects • Carbon dioxide reductions / removals under the mechanism (tCO_2-e): the Gold Standard has issued 159 million tonnes[6] worth of carbon credits from projects since inception (2003)
Core design decisions	

Cross-cutting MRV aspects - high-level	• **MRV cycle**[7]:
	  ◦ Preliminary review: All projects must deliver Gold Standard a draft project design document, completed stakeholder consultation report for a preliminary review
	  ◦ Validation: Projects must then be validated to become certified. This includes a site-visit by an independent verification and validation body, as well as fully completed project design and monitoring/reporting plans.
	  ◦ Verification: Every five years, projects must complete verification and performance review. This involves a site visit by an independent verification and validation body, as well as completion of monitoring reports. Projects are also required to submit annual reports, which summaries recent relevant activities/incidents.
	  ◦ Re-certification: To extend past five years, the project must be recertified. This follows same process as validation, but is mainly limited to redefining baseline and updating methods to match any Gold Standard updates.
	• **Additionality:** Project additionality is measured against baselines.
	  ◦ Baseline: All projects must develop a baseline scenario, using conservative assumptions. Gold Standard baselines differ per methodology. However, generally they are project specific (i.e., specific to the individual participant/project, developed ex ante and then fixed until the end of the project crediting period, and in scenario form based on historical data) The specific instructions differ per methodology, which set out what carbon sources and sinks are to be included. For example, for the Afforestation/reforestation methodology, baseline must include above and below-ground tree and non-tree biomass (but not soil, harvested wood, or litter).[8]
	  ◦ Financial additionality: In addition, projects must demonstrate financial additionality (at validation and at re-certification stage). They must demonstrate using qualitative narrative that the income from sale of offset credits is “material to the ongoing sustainability of the project” e.g., by explaining relative size of income and project costs.[9]

Mechanism architecture fiche	
Section	Aspects covered

	• **Uncertainty:** Gold Standard manages by quantifying uncertainty and then discounting the amounts of credit. Gold Standard quantifies uncertainty as the standard deviation around the mean at the 90% level of confidence, where uncertainty is known based on direct monitoring (if possible), statistical sampling, published data or defaults from IPCC. Where these measures of uncertainty cannot be directly quantified, Gold Standard aims that inputs (emissions factors, data, and other inputs/coefficients) have an uncertainty level of less than 20% at the 90% confidence level. At higher rates of uncertainty, Gold Standard requires projects to apply steep credit discounts, i.e., 50% for 20-30% uncertainty (i.e., for each tonne of estimated reduction, participants only receive 0.5 credits), and up to 100% for more than 40% uncertainty[10].
	  ◦ Buffer: In addition, 20% of all credits generated in land-use/forestry projects are retired into a Gold Standard Buffer[11].
	• **Permanence, carbon reversals, liability:** To ensure permanence, projects are contractually required to ensure that the carbon stocks in their project are sufficient to cover all credits associated with the project[12]. If any incident or event occurs that affects this (e.g., unintentional such as a fire, or intentional/mismanagement e.g., harvest), they must report to Gold Standard and cover these losses in one of these ways:
	  ◦ retiring/locking credits from the project which are not yet transferred or retired/locked
	  ◦ purchasing of credits from any other Gold Standard projects (these can also be from non-LUF project types such as renewable energy)
	  ◦ replanting of an appropriate planting area and recovery of the project carbon stocks over time
	  ◦ planting of new areas to generate further credits.
	  ◦ These permanence requirements only apply during the crediting period. Gold Standard has a five year renewable certification period. Soil projects can be renewed up to three times (i.e., have a crediting period of 5-20 years), afforestation/reforestation projects have crediting periods of 30-50 years. There are currently no permanence requirements beyond the crediting period. Gold Standard is currently exploring options for managing permanence beyond the crediting period. This might include a requirement to demonstrate how activities will be sustainable post-crediting, potentially in combination with a focus on the additional benefits related to climate actions (including farmer livelihoods, resilience, and soil health).
	• **Reporting requirements:** Projects are required to complete annual reports that cover significant activities/events, as well as any monitoring data. Full verification occurs every five years for afforestation/reforestation, three years for agriculture projects.
	  ◦ Project verification/validation[13]: To generate credits, projects implement the approved methodologies and get certified/verified/registered by an independent, approved Validation Verification Body, as well as SustainCert (Gold Standard's independent certification body. To become an approved Validation and Verification Body, they must be accredited under ISO 14065 for Greenhouse Gas activities accreditation offered under the ANSI-GS Accreditation Program or UNFCCC-CDM Accreditation (AIE or DOE status) or ASI – FSC Certification Body status)[14]. :
	  ◦ Preliminary review/validation: Certification: Projects must submit to a preliminary desk review (SustainCert), an independent audit (including site visit by 3rd party auditor) and review of audit. Cost: €5,000 for SustainCert reviews + €30-40,000 for audit

Mechanism architecture fiche	
Section	Aspects covered
	• Verification: Projects must be verified by a 3rd party auditor within the first two years of project, and after then every five years. The cost is €30-40,000 per verification, + €1,500 for SustainCert review. • Registry: To sell credits, project developers must pay a one-off fee to open a registry account (€1,000) and pay fee of €0.30 per credit sold).
Accounting	• **Registry:** Gold Standard has a registry for all projects and the credits they produce. • **Double-counting:** Gold Standard are currently revising their rules on double-counting to ensure that they are robust to manage situations where Gold Standard projects occur in countries that have national targets (e.g., NDCs). They already have requirements to manage double-counting of units: Double counting evaluation is carried out at project inception as part of validation. Any project occurring in Annex B country, or with international commitments that are likely to be met through trade, or that have a domestic carbon tax or ETS have to demonstrate that the removals under Gold Standard are additional or they will be cancelled. See Annex A here.[15]
Sustainability	• **Leakage:** Projects are required to calculate leakage arising due to their project and deduct this when quantifying emissions. The activities considered depend on the methodology. For example, the Afforestation/reforestation methodology requires that projects calculate the impact on forestry biomass as a results of any of the following activity shifting: (a) collection of wood (for firewood, charcoal, etc.) (b) timber harvesting (c) agriculture (crop cultivation, shrimp cultivation, etc.) (d) livestock.[16] • **Sustainability safeguards:** Gold Standard methodologies are required to deliver on climate security and in addition contribute to at least two other Sustainable Development Goals (e.g., biodiversity protection, water security, employment, health, among others). These impacts must be primary impacts, and not one-offs (i.e., not just occurring at time of implementation or decommissioning). These must be demonstrated to go beyond baseline (i.e., face the same additionality requirements as climate impacts), as demonstrated by using a Gold Standard methodology or tool or using approved national SDG indicators.[17] Gold Standard excludes projects that associated with fossil fuels, geo-engineering, or anything that prolongs energy generation. To manage sustainability impacts (including social impacts as well as economic and environmental – see full list of principles), all projects must assess potential risks and identify mitigation strategies, as well as monitor and report on their alignment with sustainability requirements as part of project development, verification, reporting, and validation[18]. Stakeholders must also be engaged in design and implementation, as well as through the life of the project. [19]
Incentives, market elements	
Costs	• **Transaction costs, administrative costs:** See Project verification/validation bullet in Cross-cutting MRV section (above).
Type and timing of reward	• **Form of reward:** Tradeable voluntary credits (Gold Standard Verified Emissions Reductions, GSVERS). These can also be used in CORSIA and to offset obligations in Colombia carbon tax, South Africa carbon tax. • **Crediting period:** For soil projects: five year certification period that can be renewed up to three times (i.e., 5-20 years). For afforestation/reforestation: 30-50 years. See discussion in Permanence section. • **Timing of reward:** Ex-post, upon verification of removals/mitigation.

Mechanism architecture fiche	
Section	Aspects covered
	• Ex ante exception[20]: Projects can receive Planned Emissions Reductions credits before verification (which must happen every five years). This is limited to 20% of the expected removals over the five year period, per year. These are then converted into GSVERs once the removals are verified. The project developer must cover any discrepancies between expected (i.e., PERs) and actual (i.e., GSVERs) (e.g., by purchasing additional credits, planting, etc.)
Offset markets/use of removals	• Generally, voluntary offset. • Regulatory. More than 200,000 Colombian VERs have been used to comply with the Colombia carbon tax.[21]
Key references	• Gold Standard (2018) Gold Standard for the Global Goals. Land Use & Forests Activity Requirements. Version 1.2. Accessed at: https://globalgoals.goldstandard.org/501-pr-ghg-emissions-reductions-sequestration/ • Gold Standard (2019) PRINCIPLES & REQUIREMENTS Version 1.2. Accessed 25.03.2021. https://globalgoals.goldstandard.org/101-par-principles-requirements/ • Gold Standard (2017) AFFORESTATION/REFORESTATION GHG EMISSIONS REDUCTION & SEQUESTRATION METHODOLOGY Version 1. Accessed 25.03.2021. https://globalgoals.goldstandard.org/403-luf-ar-methodology-ghgs-emission-reduction-and-sequestration-methodology/

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6.7 Fiche: Clean Development Mechanism (CDM)

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**Clean Development Mechanism** *(CDM)* *A portion of the information from this fiche comes from the DG CLIMA Carbon Farming Appendix: COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007* https://op.europa.eu/s/pcDV
Introduction	• CDM is one of the three flexibility mechanisms that were established under the Kyoto Protocol (KP). Joint Implementation (JI) and Emissions Trading (ET) being the two others. CDM started in 2001; the first project was approved in 2004.[1] • CDM is project-based. It promotes carbon removal projects that assist developing countries in realising social, environmental, economic, and sustainable development while generating certified emission reductions (CERs) for investments from industrialised countries[1].

Governance	**Operator/Administrator:**
	• The CDM Executive Board (CDM EB) supervises the CDM. The CDM EB is fully accountable to the CMP, under its authority and guidance. To CDM project participants it is the contact for the registration of projects and the issuance of CER. The CDM EB is assisted by the UNFCCC Secretariat.[2]
	Key Governance Bodies:
	• *Owner/authority:* The CMP (the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol): 1) has authority over the CDM, 2) decides on the recommendations made by the CDM Executive Board, and 3) designates operational entities that are provisionally accredited by the Executive Board.[2]
	• *Validator/verifier:* A designated operational entity (DOE) is an independent auditor, a domestic legal entity or an international organisation, accredited by the CDM EB and designated by the CMP to validate projects or verify greenhouse gas emission reductions.[2]
	• *National Authority:* A designated national authority (DNA) is the organisation granted responsibility by a Party to authorise and approve participation in CDM projects. It assesses whether potential CDM projects will assist the host country in achieving its sustainable development goals. Eligible projects will receive a letter of approval from the DNA, which is required for the project registration.[2]
	• *Process:* The main steps of the CDM project cycle and their actors are:[3]
	  ◦ Project design (Project Participants);
	  ◦ National approval (Designated National Authority);
	  ◦ Validation (Designated Operational Entity);
	  ◦ Registration (CDM Executive Board);
	  ◦ Monitoring (Project Participant);
	  ◦ Verification (Designated Operational Entity);
	  ◦ Issuance (CDM Executive Board)
	• **Regulatory or voluntary mechanism**: Project-based and voluntary but CERs can be used in some regulatory schemes. For example, the EU-ETS allowed some types of CERs (although not from LULUCF).[1]

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
	• **Methodology development process:** The methodologies and baselines are mostly developed in a bottom-up approach. When CDM was launched, only a few baseline methodologies were available. Additional top-down development acted to close loopholes in existing methodologies, consolidate methods of similar nature, and create "tools" useful for several or all methodologies (15). If there is no approved methodology applicable, then a project developer can propose a new methodology or request a revision or consider a deviation of an approved methodology or methodological tool.[3]
Participants	• Most CDM projects consist of project owner, project developer and various external advisors. Project participants such as farmers can be involved within the implementation phase[3].
Objective, Scope and Eligibility	• **Objective:** Assisting Non-Annex-1-parties' sustainable development simultaneous to supporting Annex-1 parties to reach emission reduction targets.[1] • **Type of mitigation activities/technologies:** Afforestation, reforestation, carbon capture and geological storage, energy efficiency improvement, industrial process/fugitive emissions abatement, renewable energy generation etc.[1] • **Geographic eligibility:** Projects can only be implemented in non-Annex-1-parties. Credits generated are sold to Annex-1-parties (and now to private entities wishing to offset their emissions using CERs).[1]
Performance	• **Number of registered methodologies:** The CDM counts a total of five methodologies on GHG removal by sinks and more than 15 on GHG destruction in the non-energy-sectors, as of 2020[3]. Altogether, the CDM has developed over 216 baseline and monitoring methodologies covering most sectors[4] [5]. • **Number of registered projects:** In 2019, a total of 7,805 projects generating 1.97 billion CERs were registered since 2001[3]. Overall, climate and sustainable development projects were supported by investments of 303.8 billion USD and almost 2 billion tonnes of CO_2e reductions and removals were achieved in the Global South (equivalent to the 1.97 CERs). 72% of the projects are in the renewable energy sector, and the remaining projects deal with e.g., tree planting and clean drinking water[5]. • **Trends & developments:** Increased fragmentation and regional divergence particularly due to regulation. Within the EU ETS, CERs have become non-compliant and cannot be used in EU ETS after 2020 but can be exchanged for general EU ETS emission allowances (i.e., transitioned into Article 6[.4] of the Paris Agreement).[6]
Core design decisions	
Cross-cutting MRV Aspects - high-level	**Treatment of uncertainty:** • Requirement to "reduce bias and uncertainties as far as is practical/cost effective".[7] Thereby, conservative assumptions reduce the risk of overestimation and over-issuance of credits. No overall data certainty requirements exist in the monitoring guidelines. However, requirements for sampling error activity data and for specific CDM methodologies are in place[3]. • Required reliability level using 90% or 95% confidence levels and a precision of ± 10% of variables and sampling data, depending on the project scale. The required precision and confidence determine the sample size. The calculation depends on the type of parameter, i.e., mean value or proportion value, and the target value, i.e., the expected value of the parameter. This serves to guarantee conservativeness and that emission reductions/removals are based on reliable calculations and hence reduce the risk of inflation of mitigation outcomes.[1]

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	

	Additionality approach:
	• All CDM project activities require the application of a baseline and monitoring methodology to determine the amount of CERs and the additionality of a mitigation project. The methodology, including the conservative baseline scenario, entails the procedure to calculate emission reductions and test additionality criteria.[3]
	  ◦ *Large-scale projects:* two tests for assessing additionality: (1) tool for the demonstration and assessment of additionality[8], (2) combined tool to identify the baseline scenario and demonstrate additionality[9]. The tests cover barrier, investment and common practice analyses.[10]
	  ◦ *Small-scale projects:* tested at methodology stage which specifies type of test[11]. A list of approved technologies gives orientation.[4]
	Permanence, carbon reversals, and liability:
	• *Temporary credits:* Established to combat non-permanence and hence mitigate risks stemming from activities involving removals by sink enhancement. Temporary CERs periodically expire and re-issuance is done upon verification. Two types of credits were established, i.e., temporary credits (tCERs) and long-term CERs (lCERs). tCERs are based on sequestration levels at a given verification date and expire after 5 years. In contrast, lCERs expire after either 30 or 60 years[1 3]. tCERs are typically chosen due to the upfront financial benefits. Yet, potential investors were reluctant to engage due to the higher administrative burden of reapplications. In addition, tCERs and lCERs were not allowed to be traded under EU ETS due to the risk that a replacement with permanent credits would not be feasible. As a result, there have only been a few sink projects under CDM.
	Reporting requirements:
	• A Project Design Document (PDD) must include a description of the project activity, its duration, the baseline methodology, a monitoring plan, the estimation of GHG emissions by sources and related calculation methods, environmental impacts and stakeholder comments.[12]
	• There are different crediting periods for sink and emission reduction projects. The standard period is set for 10 years. Alternatively, a project can be reviewed after 7 years and extended twice if the baseline is still applicable[4]. Sink projects can either last 30 years or be performed in a 20-year period that can be renewed twice. Public access to the CDM scheme and project-level documentation are given.[3]
	• A monitoring plan with aggregation, communication of data and methodology according to the Project Standard needs to be developed. It is submitted to a DOE for verification. Yet, the frequency of submission and the duration of report validity is not fixed and is influenced by project size.[3]
	Verification/validation:
	• Periodic, independent review and ex-post determination of monitored reductions in emissions by the DOE[13]. Thereby, an independent auditor shall avoid potential conflict of interest. Yet, in small-scale projects the DOE may perform both validation and verification of project emission reductions at the same time.
	• The DOE auditor provides a verification report, including verification of compliance with CDM guidelines, monitoring plan, methodology, frequency as well as an assessment of data and calculation of reductions. Certificates confirm the verified amount of emission reductions.[3]

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Accounting	• GHG registries and integration in GHG inventories & transparency: • Requirement to establish the assigned amount calculated in accordance with their quantified limits and reduction commitments inscribed in Annex B under Article 3 of the Protocol. the parties need to set up a national system for the estimation of GHG, a project registry, an annual inventory, and an accounting system for selling and purchasing emission reductions.[3] The registry is publicly accessible; each project is registered with a unique code and the trading is centralised through the CDM portal.

Sustainability	• **Carbon leakage settings:** Methodologies have to contain estimation of leakage and planned mitigation. Depended on the methodology, the PDD needs to further elaborate on the procedure for periodic review of measures[3].
	• **Sustainability safeguards:**
	  ◦ Sustainable development criteria mandatory to cover and justify in PDD[3]: Social criteria (e.g., improving the quality of life, alleviating policy, enhancing equity), Economic criteria (e.g., financial returns to local entities, technologies transfer), Environmental criteria (e.g., reducing GHG emissions, nature conservation), Co-benefits (e.g., socioeconomic standing of the community, employment).[1]
	  ◦ If any negative impacts are identified, the sink projects are required to provide a socio-economic and environmental impact assessment of the proposed activity as well as a mitigation action plan[3].

Incentives, market elements	
Costs	• **Transaction costs** are significant especially in the early project phase[3] and underestimated in up to 30% of the cases, ranging between a third and 100 % of offset income. Significant cost drivers are insurance, monitoring and regulatory approval[14]. Monitoring costs include the monitoring of GHG emission reductions, accounting and verification. More accurate monitoring often comes with increasing costs. External verification represents around half of total MRV costs.[3] In fact, trade-offs between the stringency and the cost of monitoring have been proven to exist.[15]
Type and timing of reward	• **Rewards for participants:** One credit equals one estimated tCO_2e reduced or removed.[1] • **Crediting period and timing of reward & renewals:** Market-based mechanism, rewards ex-post i.e., based on measurable results of the implemented project compared to the baseline, called baseline & credit.[3].

Offset markets/use of removals	• **Market demand structure:**
	  ◦ Voluntary offsetting: The commitment to reduce emissions is stated in Emissions Reduction Purchase Agreement (ERPA) covering ownership rights, rewards for participants, e.g., project owners obtain the revenues[16]. Local communities can be excluded from the reward mechanism due to high initial costs because ownership rights belong to the investing entities and project participants[1] [3].
	  ◦ Regulations create a substantial demand for credits. Particularly the bulk demand by EU firms regulated under the ETS in the early years led to strong demand and a market with 11,000 industrial sites and more than 3 million CERs traded each day. Hence, the CER price peaked at US EUR 20/tCO_2 in 2008[17]. Yet, in mid-2012, when it became clear that the supply of CERs would soon exceed the regulatory limit of 1,650 $GtCO_2e$[18], the market collapsed, and prices dropped to nearly EUR 0/tCO_2.[19] Both traded volumes and price became almost non-existent. Currently, CDM carbon offsets are a niche demand.

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
	• The price of the CERs differs depending on time horizon and market conditions. In the past, demand was driven by Annex I countries that have pledged to reduce emissions under KP and/or under the EU-ETS. The regulation allowed firms to use up to 11-20% CERs for compliance between 2008-2012.[3]
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

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6.8 Fiche: Joint Implementation (JI)

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<tr><td>Section</td><td>Aspects covered</td></tr>
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<tr><td>Scheme name</td><td>Joint Implementation (JI)

A portion of the information from this fiche comes from the DG CLIMA Carbon Farming Appendix: COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007 https://op.europa.eu/s/pcDV</td></tr>
<tr><td>Introduction</td><td>• The JI was one of three international flexible project-based market-mechanisms established under the Kyoto Protocol (KP), that were in place between 2000 and 2012. Clean Development Mechanism (CDM) and Emissions Trading (ET) being the two others.
• Industrialized countries (Annex I Parties) could earn emission reduction units (ERU) from emission reduction or removal units (RMU) from removal projects in another industrialized country and use them to meet part of their emission reduction targets and KP commitments.[1]
• The JI operated two verification procedures for projects: host countries that met all eligibility criteria outlined in the guidelines could verify the additionality of JI projects themselves (Track 1) or choose to use the governance structure of Track 2. A Track 2 procedure had to be implemented under supervision of the Joint Implementation Supervisory Committee (JISC) for projects in host countries that met only limited eligibility criteria.[1]</td></tr>
<tr><td>Governance</td><td>• Operator/Administrator:
  ◦ The Joint Implementation Supervisory Committee (JISC) was responsible for the validation procedure of methodologies, including baseline setting and monitoring approach of a JI project.[1]
• Key Governance Bodies:
  ◦ Accredited Independent Entities (AIEs) acted voluntarily as accredited, independent third-party entities and verified whether the requirements had been met before issuance or transfer of ERUs/RMUs. AIEs were accredited by the JISC, ensuring compliance of the projects with JI guidelines, including issues related to monitoring, transparency, and environmental integrity.[1]
  ◦ Designated Focal Points (DFP) were appointed agencies that were officially responsible for approving JI projects within their jurisdictions. Moreover, for Track 1, a government agency could serve as a DFP; for Track 2 countries, the JISC could serve as DFP.[1]
• Regulatory or voluntary mechanism: Voluntary flexible project-based mechanism under the KP. ERUs/RMUs can be used in carbon trading schemes, where accepted e.g., EU ETS.
• Methodology development process: Bottom-up approach; JI Track 1 allowed flexible selection of appropriate methodologies for setting baseline and monitoring procedures. Participants were allowed to propose methodologies and a JI project developer could select one of the following three approaches:[1]
  ◦ 1) Developing a project specific approach according to Appendix B (JI guidelines). It could build on elements of CDM methodologies combined with already approved JI methodologies. The baseline, assumptions and scenarios should be explained.
  ◦ 2) An approved CDM methodology following strict guidelines.</td></tr>
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Mechanism architecture fiche	
Section	Aspects covered
	• 3) Using an approach from a comparable registered Track 2 project, i.e., the same emission reduction technology in the same host country. Additionally, taking this approach required a time span between the two projects of less than five years; a similar/identical regulatory framework; and the difference in activity scale should not exceed 30%.
Participants	• **Verification procedure:** project developer, host country, national or international administration, independent entity (AIE), JISC.[1] • **Projects:** project developers; public and private agents from the developed countries and/or economies in transition could engage in reduction projects when approved by the host country.[1]

Scope, objective, and eligibility	• **Objective:** Allowing industrialized countries an alternative to domestic emission reductions to meet KP commitments.[1]
	• **Type of mitigation activities/technologies:** A JI project was required to provide additional emission reductions or removal. Projects had to have approval of the host Party and participants had to be authorized to participate by a Party involved in the project.[2]
	  ◦ Key GHGs covered: CO_2, N_2O, and CH_4
	  ◦ Wide range of sectors that included agriculture, afforestation or methane avoidance. In contrast to CDM, JI recognised a number of LULUCF projects as eligible to generate credits that would not comply with the CDM eligibility criteria.[1]
	  ◦ ERUs/RMUs can only be issued for a crediting period beginning no earlier than 2008.[1]
	• **Geographic eligibility:** Only Annex I Parties to the KP with capped emission reduction targets were eligible to participate in JI to generate ERUs/RMUs from GHGs reduction projects and transfer these ERUs/RMUs to other Annex I Parties. The distribution of ERUs/RMUs under the JI was uneven with Russia and Ukraine representing approximately 90% of global ERU issuances. This geographical concentration was influenced by the low-carbon policies, for example, by Western European countries and the EU.[1]

Performance	• **Number of registered methodologies:** There were three general approaches for setting a baseline and monitoring according to the JI guidelines on baseline and monitoring (see section Governance). Methodologies approved by the Executive Board of the Clean Development Mechanism could be applied as appropriate. The number of specific carbon removal methodologies is unclear.[1] • **Number of registered projects:** As per November 2018, a total of 788 projects had been published under the JI mechanism (including rejected and withdrawn), with 604 final determinate projects. Among those 604 projects, 555 are registered for Track 1 with 838 million ERUs/RMUs issued, and 49 are Track 2 projects with 25 million ERUs/RMUs issued.[1] According to the website, projects increased to 597 in Track 1 and 51 in Track 2 as of 2021.[3] • **Number of participants:** 37 host parties[4] (i.e., EU and several member states, New Zealand, Russian Federation, Australia, Canada, Japan, Switzerland).[5] • **Quantitative information on carbon dioxide removals under the mechanism:** ERUs/RMUs are equal to one tCO_2e calculated using global warming potentials as per decision 2/CP.3. • **Trends & developments**: A technical paper from the UNFCCC in 2015 expected, based on experiences from CDM implementation, "a convergence towards similar regulatory cycles across both [track procedures]. This is possibly due to the essentially similar nature of the activities that both [procedures] attract." [6]
Core design decisions	

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<tr><td>Section</td><td>Aspects covered</td></tr>
<tr><td>Cross-cutting MRV aspects - high-level</td><td>

Methodology assessment and environmental integrity assessment approach: According to the KP, ERUs/RMUs from JI project activities were determined following a baseline and monitoring methodology approach. JI projects had to meet the additionality criteria, which was calculated by determining actual emissions after the projects and the emissions baseline.[1]
Treatment of uncertainty: Since CDM methodologies could be applied, MRV challenges are the same with monitoring uncertainty and high cost. Project developers had to explain quality and control procedures undertaken for data and variables monitoring and error sampling.
Additionality approach: Under Track 1, requirements for verifying additionality were set by the host country and determined on a project-by-project basis. In practice, standards varied significantly from host Party to host Party and for Track 2 the CDM Additionality tool was often applied.[1] Also, in JI Track 1, a project developer could select one of three approaches for setting a baseline and monitoring (see section Methodology development process). To prove additionality, JI project developers had to provide information on how leakage would be assessed and how to avoid indirect negative effects, such as increased GHG emissions, outside the project scope.[1]
Permanence, carbon reversals, and liability: In contrast to CDM, JI was implemented in Annex I Parties only. Therefore, reversals connected to JI afforestation and reforestation projects, as well as forest management for the second commitment period, would be captured in the host country's accounting, which means that the country purchasing the units gets to keep the generated credits.[1]
Reporting requirements:

Projects had to undergo an MRV process to ensure additional emission reduction. This required a Project Design Document (PDD) that included a monitoring plan generated by the project participants with justification of the choice of methodology and its applicability. Moreover, detailed information on i) the estimation of GHG emissions, AAUs, ERUs/RMUs; ii) the baseline GHG emissions; and iii) leakage in a transparent, reliable and relevant way needed to be provided. Monitored reductions were verified ex-post.[1]
Data transparency level in Track 1 projects was dependent on the approving host country. Track 2 projects were supervised by the JISC providing higher transparency.[1]

Verification/validation:

Reported data and information on emission reductions were verified by auditors from AIE and the host country in Track 1 without any requirement concerning international oversight of verification. Here, the quality of verification differs according to the choice of project track, third-party entity and host country. In Track 2, on the other hand, the final verification was performed by the JISC, following the audit by AIEs[7].
The appointed designated focal point (DFP) was responsible for administering JI project activities. In Track 1, a government agency could take this role. Whereas for Track 2 countries, the JISC could serve as DFP.[7]

</td></tr>
<tr><td>Accounting</td><td>

GHG registries and integration in GHG inventories & transparency:

Each ERU/RMU generated by a JI activity had to be converted from the KP emission budget of the host country, as the emissions cap from Annex I countries remained at the same level.[1]

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Mechanism architecture fiche	
Section	Aspects covered
	◦ The Track 1 procedure was only applicable in countries with a national system for the estimation of emissions, a national registry, and provided they had submitted annual inventories of GHG emissions and supplementary information on its assigned amount.[1]
Sustainability	• **Carbon leakage settings:** In demonstrating additionality, JI project developers had to provide information on how leakage would be assessed and how to avoid indirect negative effects, such as increased GHG emissions, beyond the project scope.[1] • **Sustainability safeguards:** JI projects did not have to comply with sustainable development criteria. Nevertheless, socio-economic or/environmental benefits such as improved soil fertility and/or prevention of erosion were observed in some of the projects. LULUCF projects under JI included an analysis of anticipated environmental impacts. In case negative impacts were identified with proposed activities, an environmental impact assessment and a mitigation plan were required.[1] • **Co-benefits:** Transfer of technologies and know-how between the Parties potentially contributed to capacity building, local development, and long-term climate mitigation opportunities or other ecological improvements in the host country.
Incentives, market elements	
Costs	• **Transaction costs:** Project-based mechanisms within the KP could entail considerable transaction costs for baseline development, verification, certification and was the single most serious threat to the JI market. Projects with annual emission reductions less than 50,000t CO_2e were not necessarily viable at costs of up to several hundred euros per t CO_2e.[8] • **Administrative costs:** Similar to CDM, high costs related to MRV procedures were found in JI project implementation and contingency. This is due to monitoring project activities, and the need for entities to operate in multiple jurisdictions resulting in the non-standardized JI project methodologies applied by each host Party under Track 1.
Type and timing of reward	• **Rewards for participants:** The reward mechanism under the JI was market-based. The approved project participants could earn ERUs/RMUs, which could be sold or used to comply with national GHG obligations and traded between industrialised countries.[1] • **Crediting period and timing of reward & renewals:** The crediting period for the JI Track 1 projects followed the KP 1st and 2nd commitment periods and was set for 5 and 8 years, respectively. It was possible to extend upon the agreement with the host country.[1]
Offset markets/use of removals	• **Market demand structure:** ◦ Rewards for participants were generated from trading the ERUs/RMUs in national or international carbon markets, broadly the same as for the Clean Development Mechanism.[1] ◦ To comply with, e.g., Kyoto Protocol, market demand was created in countries, where emission reduction costs were higher than in others. At first JI was not chosen by industrial states predominantly. However, in 2013 its offsets accounted for a third of all Kyoto offsets (i.e., approx. 658 million JI credits)[9]. After 2020, ERUs/RMUs were no longer compliance units within the EU ETS and therefore needed to be exchanged to EU ETS emission allowances to be valid within the EU ETS.[10] However, the ERUs/RMUs are accepted within some national or international programmes, such as VCS or NZ ETS.
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

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[10] European Union (2021), Emission Trading System: Use of International Credits (link)

6.9 Fiche: Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)**
Introduction	• To limit and reduce aviation's CO_2 emissions, the 'Carbon Offsetting and Reduction Scheme for International Aviation' (CORSIA) was agreed at the 39th International Civil Aviation Organization (ICAO) Assembly in 2016.[2] It is the first global scheme for the limitation of air transport's CO_2. It covers only "international" flights, i.e., flights which depart and arrive in different countries. The European Union Emissions Trading System (EU ETS) is the only other trading system addressing air transport's international CO_2 emissions. However, the latter has temporarily limited the geographical scope to cover only flights within the European Economic Area.[1] The EU ETS also covers domestic flights. • Three phases of implementation: pilot phase (2021 to 2023), first phase (2024 to 2026), and second phase (starting from 2027).[2] • CORSIA is a market-based mechanism that requires the aviation sector to offset emissions occurring beyond the baseline level of all international flights under the scheme in 2019. *Note: CORSIA does not issue any certificates itself. However, it sets out eligibility criteria under which certificates from existing mechanisms are eligible for offsetting emissions. Therefore, CORSIA's structure and objectives are different from the other mechanisms evaluated in the project. Accordingly, the structure of this fiche differs from other fiches. Throughout, the focus lies on the most relevant information for informing CRC-M development (i.e., processes for evaluating existing methodologies and associated credits). We include only limited discussion on the demand side (e.g., airline) and CORSIA mitigation methodologies (lower carbon aviation fuels, sustainable aviation fuels).*
Governance	• **Operator/administrator:** International Civil Aviation Organization (ICAO)[2], with implementation at the level of the ICAO member states. • **Voluntary mechanism will eventually become mandatory:** Voluntary offsetting is planned to start from 2021. Voluntary in this context means that the ICAO member state can decide to apply CORSIA or not during the pilot phase. However, if a state decides so, the scheme is mandatory for the aeroplane operator. The scheme will eventually become mandatory by 2027. During the first phase, states can decide to join or withdraw from the scheme at the beginning of every year.[3] • **Methodology development process:** CORSIA does not create its own removals methods, instead evaluating and approving/rejecting existing methodologies in diverse types of project activities. The ICAO invites Emission Unit Programmes to apply and the Technical Advisory Board (TAB) assesses the applicability of programmes meeting the EUC and makes recommendations to the Council annually. Following Assembly Resolution A39-3, emission units generated within mechanisms that belong to UNFCC and the Paris Agreement are eligible if they align with decisions taken by the Council and CAEP. Emission units originating from climate protection projects that started after 01 January 2016 (with exceptions) can be purchased through project developers, brokers, aggregators or wholesale[4]. A certificate states the record from the seller with details on the project and the amount of CO_2 reduced.

Mechanism architecture fiche	
Section	Aspects covered
	• **Key governance bodies:** The ICAO Council approves certification systems, reports to the Assembly and administers the finances. It is composed of 36 Member States elected by the Assembly for a three-year period. As the second governing body, the Advisory Group on CORSIA (AGC) is composed of 12 Council representatives.[2] Further, the Committee on Aviation Environmental Protection (CAEP), which is a technical committee of the ICAO Council, assists the Council with new policies, SARPs[13], reports on technical and environmental issues and undertakes specific studies, including aspects related to CORSIA.[5] The Technical Advisory Board (TAB) assesses the applicability of programmes meeting the EUC and makes recommendations to the Council annually. The scheme is governed by a multinational body, yet, currently governments voluntarily decide to participate and once this is defined for a given year, requirements are then applied to the state's aircraft operators.
Participants	• **Supply side:** ◦ Independently audited (Quality Assurance Standard) and approved offset credits from existing carbon mitigation and carbon removal mechanisms, arising from projects in the field of forestry, clean energy solutions, protection of eco-systems or remote community-based projects. To be able to provide offset credits to ICAO, they need to fulfil specific programme design elements (e.g., clear methodologies and protocols, statement of scope - see cross-cutting MRV section below). • **Demand side:** ◦ Aeroplane operators: Credits purchased by aeroplane operators (performing international flights between participating member states are subject to emission offsetting requirements, if emissions are above 10,000t CO_2 p.a., as of 2019).[4] [6] ◦ States: Currently, states can voluntarily decide to participate. From 2027 onwards, participation will be determined based on 2018 data. Flights to and from Least Developed Countries (LDCs), Small Island Developing States (SIDS), Landlocked Developing Countries (LLDCs) and states with very low proportions of global flights will be exempt from the requirements, if their government does not participate on a voluntary basis (p. 208). Opt-out is still possible under certain conditions.
Scope, objective, and eligibility	• **Sectors:** Includes Agriculture, Forestry and Other Land Use (AFOLU) covering removals through afforestation, reforestation and revegetation, agricultural land management, improved forest management, reduced emissions from deforestation and degradation, avoided conversion of grasslands and shrublands, and wetland restoration and conservation. Projects that started after 01 January 2016 (with individual exceptions) are eligible[4]. • **Geographic eligibility:** ◦ Supply: depends on method (global)[4] ◦ Demand: ICAO member states
Performance	• **Number of registered carbon removal methodologies:** None. • **Number of participants:** ◦ 88 states/countries (= approx. 77% of international air traffic) will participate in CORSIA 1 January 2021.[7] ◦ In 2020: Information on 608 aeroplane operators from 141 States. 80 States updated the information previously submitted.[15]

[13] SARPs = Standards and recommended practices

Mechanism architecture fiche	
Section	Aspects covered
	• **Greenhouse gases covered:** CO_2 • **Quantitative information on demand for carbon dioxide mitigation/removals under the mechanism (tCO_2):** Projection (before COVID-19): demand for of around 164 million tonnes annually (2.5 billion tonnes of CO_2 between 2021 and 2035) (= approx. annual CO_2 emissions from the Netherlands)[8]. • **Trends, developments:** Air traffic has been one of the fastest growing markets before the COVID-19 pandemic, whose long-term effects are yet unclear. Sustainable aviation fuels and CORSIA are ICAO's primary measures to contribute to reducing international aviation net CO_2 emissions, nevertheless, demand for offset credits through is expected to remain high.
Core design decisions	

Cross-cutting MRV aspects - high-level	• Regarding the supply side, there is a process for deciding on CORSIA eligible emissions units (note: CORSIA refers to all offset credits as emissions units, these include removals as well as emissions reductions; we use the "Emissions units" terminology throughout this fiche to stay consistent with CORSIA language). ICAO have approved CORSIA emissions unit eligibility criteria, consisting of Program Design Elements (i.e., an evaluation of the mechanism) and Carbon Offset Credit Integrity Assessment (i.e., an evaluation of the specific methodology).
	• **Methodology assessment and environmental integrity assessment approach:** Emissions unit programmes (i.e., existing carbon removal/mitigation mechanism such as VCS, Gold Standard, etc.) have been invited by ICAO to apply for assessment against the CORSIA Emissions Unit Criteria (EUC) (also referred to as eligibility criteria). These programmes are then assessed by a Technical Advisory Board (TAB). Eligible emissions programmes to be included in CORSIA are recommended by TAB and approved by the Council.[9] TAB has an outlined assessment procedure that includes screening of certain parameters e.g., if a programme has quantification methodologies, procedures and processes in place in relation to leakage, mitigation, verification, etc. A TAB Analysis Table is used to score each programme's consistency with each EUC. A scope of eligibility is defined for each programme, meaning a programme is eligible but certain activities under the programme that are inconsistent with EUC will be excluded. TAB presents its findings and recommendations in a report. Eligible programmes have to agree to maintain consistency with the EUC and inform of any changes.[10]
	• **Program Design Elements eligible emission unit programmes must adhere to the following criteria**[11]:
	  ◦ Clear methodologies and protocols, and their development process
	  ◦ Scope considerations
	  ◦ Offset credit issuance and retirement procedures
	  ◦ Identification and tracking of units
	  ◦ Legal nature and transfer of units
	  ◦ Validation and verification procedures
	  ◦ Programme governance
	  ◦ Transparency and public participation provisions
	  ◦ Safeguards system
	  ◦ Sustainable development criteria
	  ◦ Avoidance of double counting, issuance and claiming

Mechanism architecture fiche	
Section	Aspects covered

	• **Carbon Offset Credit Integrity Assessment Criteria:**
	CORSIA does not issue any certificates for offsetting themselves but sets out eligibility criteria under which emission unit programmes and their methodologies are assessed regarding the eligibility for offsetting emissions. The TAB makes recommendations on eligible emission units. The criteria are based on a number of generally agreed principles that have been broadly applied across both regulatory and voluntary offset credit programmes to address environmental and social integrity. The eligibility criteria apply at the programme level (i.e., VCS, Gold Standard, American Carbon Registry, China GHG voluntary emission Reduction Program, CDM, Climate Action Reserve):[11] [4]
	1. Are regulatory additional: Carbon offset credits must represent emissions reductions, avoidance, or removals that exceed requirements by law, regulation, or legally binding mandate as well as a conservative, business-as-usual scenario. Procedures must be in place to assess, test and provide assurance for additionality.
	2. Are based on a realistic and credible baseline: that represents the level of emissions that would have occurred assuming a conservative “business as usual” emissions trajectory, without the offset project in place.
	3. Are quantified, monitored, reported and verified: calculations must be done in a conservative and transparent manner. Offset credits should be based on accurate measurements and quantification methods/protocols. Independent, ex-post verification of the project’s emissions should be required, whereas ex-ante issuance should not be eligible.
	4. Have a clear and transparent chain of custody: tracking with an assigned identification number from when the unit is issued through to its transfer or use via a registry system.
	5. Represent permanent emissions reductions: if there is a risk of reversal, then either a) credits are not eligible, or b) mitigation measures need to be in place to monitor, mitigate, and compensate.
	6. Assess and mitigate against potential increase in emissions elsewhere: there must be an established process for assessing and mitigating leakage.
	7. Are only counted once towards a mitigation obligation: measures must be in place to avoid double issuance, double use, and double claiming.
	8. Do no net harm: projects should not violate any regulations or obligations and show how compliance with social and environmental safeguards are achieved as well as publicly disclose which institutions, processes, and procedures are used to implement, monitor, and enforce safeguards.
	• **Eligible Emissions Unit Programmes:**
	  • As of March 2021, eight programmes are approved by the ICAO Council to supply CORSIA Eligible Emissions Units: 1) American Carbon Registry (ACR), 2) Architecture for REDD+ Transactions (ART), 3) China GHG Voluntary Emission Reduction Program, 4) Clean Development Mechanism (CDM), 5) Climate Action Reserve (CAR), 6) Global Carbon Council (GCC), 7) The Gold Standard (GS), and 8) Verified Carbon Standard (VCS).[4]
	  • These programmes are eligible for cancellation for use toward CORSIA offsetting requirements in the 2021 – 2023 compliance cycle. Eligible unit dates include activities that started from January 1st 2016 and emissions reductions occurring through December 31st 2020. For each programme a scope of eligibility applies, i.e., removals/mitigation from certain activities, methodologies or programme elements are excluded.[4]

Mechanism architecture fiche	
Section	Aspects covered
	• Specifications and guidelines are available for the demand side, too. There are two aspects with special procedures: ◦ **CORSIA baseline setting:** In regards to the demand side, CORSIA has a baseline period, where all aircraft operators are required to monitor CO_2 emissions from international flights.[2] It was initially set for 2019 and 2020, but was adjusted to 2019 due to the COVID-19 pandemic. For the period 2021-2023 aircraft operators must report data on the increase in CO_2 compared to this baseline. The data must be verified and sent to ICAO for processing.[12] Aeroplane operators have to offset reported emissions above 2019 levels. Whereas the baseline-setting for the supply side varies depending on the approved programme, with the requirement that baseline methodologies are developed in a context of third-party assessment and full transparency. ◦ **Verification:** CORSIA foresees a three-step verification pathway: 1) An aeroplane operator conducts an internal pre-verification of its data before submitting the report to the verification body; 2) A third-party verification of the report is performed by an independent verification body, before the operator reports to the State Authority; 3) State Authority conducts an order of magnitude check to verify the data against different sources of information that the State has access to.[14]
Accounting	• **CORSIA Central Registry (CCR):** Information management system where states can submit CORSIA-relevant information to ICAO, and ICAO can store information, perform calculations, report data back to states, and make aggregate information publicly available.[13] [15] • **Cancelation of eligible emission units**: Operators may cancel emissions units within a registry designated by a CORSIA Eligible Emissions Unit Program.[15] “Cancel” refers to the permanent removal and single use of an emissions unit so that the same emissions unit may not be used more than once.[15] Operators request each CORSIA Eligible Emissions Unit Program Registry to make information on cancelation publicly available on the registry’s website.[15]
Sustainability	• **Credit supply:** Some of the programmes entail “no harm” principles and require an ex-ante risk assessment. Yet, continuous monitoring or reporting of risks during the crediting period is often lacking. Thus, final approval of a standard should not be given before the necessary procedures are in place.[14] See eligibility criteria or other mechanism/methodology fiches for more information.
Incentives, market elements	
Costs	• **Transaction costs:** Limited information available. The costs are likely to be reflected in flight ticket prices. • **Administrative costs:** Search costs for choosing appropriate programme/project for airline/state participating, cost of reporting, monitoring, external third-party certification on frequent basis.
Type and timing of reward	• **Form of reward for participant:** Tradeable credits. See mechanism/methodology for more information. • **Eligibility timeframe and unit dates for Emissions unit programmes:** ◦ Eligibility timeframe: The credits from Emissions unit programmes are currently eligible for use toward CORSIA offsetting requirements in the 2021 – 2023 compliance cycle. ◦ Eligible unit dates: include activities that started from January 1st 2016 and emissions reductions occurring through December 31st 2020.[4]

Mechanism architecture fiche	
Section	Aspects covered
Offset markets/use of removals	• **Demand side:** The operator purchases and cancels eligible emissions units equivalent to its final CO_2 offsetting requirements for the compliance period.[15] Emissions Units (offsets) are calculated as the difference between emissions at business-as-usual scenario and actual emissions. Emissions units are purchased in carbon markets on a per-tonne basis, where 1 Emissions Unit = 1 Tonne of CO_2.[15] A carbon credit is a tradable certificate or permit representing the right to emit one tonne of carbon dioxide or its equivalent (CO_2e). Carbon credits can be derived by GHG reduction projects that deliver measurable reductions in emissions or removals. • **Offsetting requirement steps**: 1) The state calculates the offsetting requirements attributed to an aeroplane operator (operator's annual emissions x Growth Factor = CO_2 offsetting requirements); 2) The operator reports the use of CORSIA Eligible Fuels (CEF) for a 3-year - compliance period; 3) The state accounts for the benefits from the use of CEF and informs the operator of its final CO_2 offsetting requirements for a 3-year compliance period.[15]
Key references	• ICAO website - CORSIA homepage (link) • ICAO Secretariat (2019), Introduction to CORSIA (link) • ICAO (2021), CORSIA Eligible Emissions Units (link) • Schneider, L.; Michaelowa, A.; Broekhoff, D.; Espelage, A. & A. Siemons (2019), Lessons learned from the first round of applications by carbon-offsetting programs for eligibility under CORSIA. Öko-Institut e.V., Perspectives, Stockholm Environment institute. Berlin/Zürich/Seattle (link) • Dardenne, J. (2021). Corsia: worst option for the climate. Transport & Environment (link) • Schneider, L.; Cames, M.; Healy, S.; Keimeyer, F. & S. Schütte. (2019). Analysis and Assessment of the Design of an Offsetting System for International Aviation. Climate Change (link)

[1] Article 28a of the EU ETS Directive. See also DG CLIMA's website (link)

[2] ICAO website - CORSIA homepage (link)

[3] ICAO (2020), Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) – FAQs (link)

[4] ICAO (2021), CORSIA Eligible Emissions Units (link)

[5] ICAO website - Committee on Aviation Environmental Protection (CAEP) (link)

[6] ICAO Secretariat (2019), Introduction to CORSIA (link)

[7] CORSIA States for Chapter 3 State Pairs. ICAO document (link).

[8] IATA (2019). Fact Sheet: CORSIA (link)

[9] ICAO website – CORSIA 2020 TAB Assessment (link)

[10] ICAO (2021), Technical Advisory Body (TAB) Procedures (link)

[11] ICAO (2019), CORSIA Emissions Unit Eligibility Criteria (link)

[12] Strouhal, M. (2020), CORSIA – Carbon Offsetting and Reduction Scheme for International Aviation (link)

[13] ICAO, CORSIA Central Registry Brochure (link)

[14] Schneider, L.; Michaelowa, A.; Broekhoff, D.; Espelage, A. & A. Siemons. (2019). Lessons learned from the first round of applications by carbon-offsetting programs

for eligibility under CORSIA. Öko-Institut e.V., Perspectives, Stockholm Environment institute. Berlin/Zürich/Seattle (link)

[15] ICAO, CORSIA Offsetting Requirement Steps (link)

6.10 Fiche: California's Compliance Offset Program (CCOP)

Mechanism architecture fiche	
Section	Aspects covered
Descriptive/context	
Scheme name	**California's Compliance Offset Program (CCOP)** *A portion of the information from this fiche comes from the DG CLIMA Carbon Farming Appendix: COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007* https://op.europa.eu/s/pcDV
Introduction	• The California Compliance Offset Scheme (CCOP) is a crediting mechanism which began in 2013 and is complementary to the California Cap-and-Trade program that aims to reduce emissions by 40% and 80% below 1990 levels by 2030 and 2050, respectively.[1] • Entities that are covered under the California Cap-and-Trade program can use compliance offsets from CCOP for up to 8% of their total compliance obligation, i.e., up to 8% in 2020, 4% (2021-2025) and 6% (2026-2030).[1] At least 50% of those must provide direct environmental benefits in the state[2]. Compliance offset credits are issued based on approved Compliance Offset Protocols. They are tradable and cover verified GHG emissions reductions or removal enhancements only from sources that are without compliance obligation in the Cap-and-Trade Program.[2]

Governance	• **Operator/administrator:** The California Air Resources Board (CARB) adopts the California Cap-and-Trade Regulation, amends it and is in charge of the Compliance Offset Protocols.[2] CARB has full control of the program, although the 12 members of the board are appointed by policy makers in state legislature, and an independent Market Advisory Committee oversees auction procedures through audits.[1]
	• **Regulatory mechanism:** The CCOP is structured around compliance offset credits. But voluntary projects that were outset before the start of the program are also included.[1]
	• **Methodology development process:** CARB follows a top-down approach and periodically reviews and considers offset protocols, in cooperation with the non-profit organisation Western Climate Initiative. Protocols are prioritised based on, e.g., the potential for projects in province, generable offset supply, cost-effectiveness, and co-benefits. Approval is subject to the Administrative Procedure Act, which entails public announcements, informal development and drafting activities, rulemaking action, 45-Day commenting period, public hearing, response to comments and submission of a rulemaking for review.[1]
	• **Key governance bodies:**
	  ◦ *Ownership:* CCOP is a compliance scheme, with a sub-national governance body and therefore publicly owned by the State of California.[2]
	  ◦ *Project developers:* Offset Project Operators (OPOs) may develop offset projects to achieve GHG reductions and removal enhancements in uncapped sources. Offset Project Operators may also designate an Authorized Project Designee (APD) to develop the project and interact with ARB and Offset Project Registries.[1]
	  ◦ *Registries:* Offset Project Registries may be approved to help facilitate the listing, reporting, and verification of offset projects developed using the Compliance Offset Protocols, and to issue registry offset credits. Currently approved are the American Carbon Registry (ACR), Climate Action Reserve (CAR) and Verra (formerly Verified Carbon Standard).[1]
	  ◦ *Task Force:* The Offsets Protocol Task Force provide guidance to CARB in establishing new offset protocols with direct environmental benefits in the state.

Mechanism architecture fiche	
Section	Aspects covered
Participants	• **Supply side**: Offset Project Operators (OPOs) or designated Authorized Project Designee (APD), register in the Compliance Instrument Tracking System Service (CITSS). • **Demand side:** Entities with compliance obligations of the Cap-and-Trade program with local direct emissions, indirect emissions generated from electricity imported from outside the state, and fuel emissions from gasoline and natural gas combustion.[1]
Scope, objective, and eligibility	• **Sectors:** Projects must adhere to Compliance Offset Protocols and follow one of six developed sectoral methodologies: U.S. Forest, Urban Forest, Livestock, Ozone Depleting Substances, Mine Methane Capture, and Rice Cultivation. The specific project focus for evaluation of CCOP is under Livestock, U.S. Forestry, and Rice Cultivation[1] • **Geographic eligibility:** The territorial scope of the CCOP is limited to the US, Mexico and Canada (linked with the Quebec ETS)[1]. Projects occur in California, Canada and the USA. From 2021, the Cap-and-Trade requires 50% of credits with direct environmental benefits in the state.[2]

Performance	• **Number of registered carbon removal methodologies:** 6 Compliance Offset Protocols (2021)[2]
	On removal: Mine Methane Capture (MMC) Projects (capture and destruction of CH_4 that would otherwise be vented into the atmosphere, also accounts for changes in CO_2), U.S. Forest (sequestration of carbon on forestland through forest management and reforestation), Urban Forest Projects (removal enhancements associated with tree planting and maintenance activities), Livestock (manure biogas capture and destruction technologies), Ozone Depleting Substances (destruction of ODS, avoided emissions)[2]
	• **Number of total registered projects:** more than 500 projects (2021)[2]
	• **Number of participants:** 225 participating entities in 2021[3]
	• **Quantitative information on carbon dioxide removals under the mechanism:** The average number of credits issued per registered project is 67,000 (2014)[4]. Majority of credits results from U.S. Forest projects (122,176,953 credits, 80.04% of total credits in 2019).[1] Total issued compliance credits in 2021: 195,890,312.[2]
	• **Trends & developments:**
	  ◦ Recent changes include the formation of the Compliance Offsets Protocol Task Force, and the potential of developing additional offset protocols[1].
	  ◦ Potential for the program to expand coverage regionally (e.g., Oregon) and to more international programs (e.g., REDD+)[1].
	  ◦ International sector-based offset credits may be incorporated through, e.g., the California Tropical Forest Standard (TFS), which has yet to be implemented[1].

Core design decisions	
Cross-cutting MRV aspects - high-level	• **Treatment of uncertainty:** ◦ Use of a conservative BAU baseline[1] and emissions factors and methodologies with higher probability of understating net GHG reductions/removal enhancements. Immense need for strong guidance and regulation within each protocol, as a concern of misreporting or overreporting of mitigated GHGs appeared in a project.[1] • **Cross-cutting additionality:**

Mechanism architecture fiche	
Section	Aspects covered
	- Regulatory additionality: An offset project is considered additional, if its GHG emissions reductions and removals go beyond what is required by law, regulation, or legally binding mandate, and exceed the BAU scenario. Offset credits can only be generated in sectors not covered by the scheme, i.e., emission sources that are not capped to avoid double-counting. Moreover, every protocol defines sector-specific additionality requirements.[1] - Proofing additionality is simplifying procedures due to narrow scopes, i.e., the careful and time-consuming development of protocols leads to few, specific projects that entail strong additionality criteria and therefore make project-level determination redundant.[1] • **Permanence, carbon reversals, and liability:** - U.S. forests protocol entails three mechanisms to mitigate carbon risks by ensuring the permanence of credits: 1) A prerequisite that the carbon represented by the offset credit remains stored for 100 years following credit issuance (ensured through reporting and monitoring); 2) An obligation for compensation for reversals of GHG reductions due to wilful intent or negligence, and 3) A risk management clause introducing a Forest Buffer Account (a pool of set-aside credits) as insurance against unintentional reversals.[1] - Intended removals entail compensation and penalties. Unintended removals are made-up for by withdrawing from the Forest Buffer Account. Default nationwide risk factors determine the share a project allocates into the buffer, considering management, financial, social, and natural disturbance risks (range: 10.5% to 21.2%).[1] • **Reporting requirements:** • *Reporting:* GHG emissions reporting under the California Cap-and-Trade is conducted through the Mandatory Reporting Regulation (MRR) that was established under AB 32 and requires reporting from entities emitting at minimum 10,000 CO_2e (this is below the 25,000 CO_2e compliance level)[1](p. 114). An incentive for accurate reporting is the risk that project owners/designers face of being accounted for misreporting and non-compliance[1]. • *Documentation:* Submission of data to meet reporting requirements, e.g., through the California Electronic Greenhouse Gas Reporting Tool or Cal e-GGRT. Project data and documents are compiled through one of three registry websites, ACR, CAR or Verra. OPO chooses the website based on preferences, e.g., fee, timeliness, and ease of use.[1] • *Monitoring:* Distinction between types of projects with different requirements. In the case of forest projects, a detailed plan for reporting annual carbon stocks must be outlined at the project outset. After the initial application and project plan, reports must be submitted with carbon stock information following calculation methods, conforming to CARB, ACR, CAR or Verra. The reports are available publicly through any of the four sites.[1] • *Verification body:* Verification is conducted by a CARB-accredited offset verification body. To ensure credibility, the CCOP uses the ISO 14065 Accreditation Standard. If a facility/ electric power entity exceeds 25,000 $MTCO_2e$ per year, the report needs to be verified by a CARB-accredited, third-party verification body[5]. After six years, a verifier can no longer continue to audit a project.[1] • *Conflict of interest*: is a key aspect of verification which could arise, for instance, when there has been a relationship with a reporting entity within the last five years. This prior relationship is to be disclosed.[6]

<table>
<tr><th colspan="2">Mechanism architecture fiche</th></tr>
<tr><td>Section</td><td>Aspects covered</td></tr>
<tr><td></td><td>Verification process: After a 30-day review process by CARB, the verification can be undergone. This entails a data audit, verification plan, and risk analysis. After an initial compliance report, project operators are also given the opportunity to participate in corrective action. This provides flexibility to project owners that are willing to improve their management and operations[1]. A materiality threshold is used to assess errors, omission or misstatement that may impact the GHG assertion[6].</td></tr>
<tr><td>Accounting</td><td>GHG registries and integration in GHG inventories; transparency
Offset credits and emission allowances are listed in the Compliance Instrument Tracking System Service (CITSS), which acts as a tracking system for compliance instruments in Western Climate Initiative's (WCI) programmes.[1]</td></tr>
<tr><td>Sustainability</td><td>Carbon leakage settings
Risk of leakage can be minimised with a closed system with clearly defined boundaries. However, CCOP allows for flexibility with changing and incomplete boundaries due to the exclusion of some industries in its accounting framework and because projects are not limited to California. Such flexibility emphasises the necessity of an inclusion of transparent and project-specific quantification of leakage effects.[1]
Sustainability safeguards
The revenues generated through auctions are utilised through the Greenhouse Gas Reduction Fund (GGRF). 60% are permanently diverted towards sustainable communities, affordable housing and public transportation. In addition, 35% of the GGRF must be invested in projects that can be proven to assist disadvantaged communities.[1]
To ensure that U.S. project activities do not interfere with ecosystem functions, the protocol requires the recruitment and retentions of structural and important elements, such as dead wood. Furthermore, projects concerning native forest species of different ages, a maximum of 40% of forest stands can be in age classes younger than 20 years.[1]
Perform environmental impact assessments, if required locally, regionally or nationally[1](p. 120). Social risks are deemed irrelevant to the U.S. domestic context, thus the protocols for U.S. forest and rice cultivation do not contain any social safeguards[1].</td></tr>
<tr><td colspan="2">Incentives, market elements</td></tr>
<tr><td>Costs</td><td>Transaction costs
Cost containment in the Cap-and-Trade Program: Cost-effectiveness guaranteed through multi-year compliance periods, allowance banking with strict holding limits, a limited use of offsets, which offer additional low-cost emissions reduction opportunities; the Allowance Price Containment Reserve which provides access to allowances at set prices as a hedge against higher costs, and a price ceiling for robust cost containment.[5]
An annual Reserve sale for allowance if quarterly auction results in a settlement price greater than or equal to 60% of the lowest reserve tier price. For 2021-2030, allowances in the Reserve will be offered at two tier prices: USD 41.40 and USD 53.20 in 2021, which will increase by 5% plus inflation every year. A price ceiling mechanism of USD 65.00 per allowance or unit in 2021 that similarly increases by 5% plus inflation annually.[5]
Administrative costs:
High upfront costs for set up is an entry barrier for small scale operators/farms. Also, long-term monitoring costs for forest projects (e.g., can be high costs with a 100-year monitoring period).</td></tr>
<tr><td>Type and timing of reward</td><td>Form of reward for participant:</td></tr>
</table>

Mechanism architecture fiche	
Section	Aspects covered
	• ARB offset credits. Market-based system, with rewards based on the standard emission trading principle. Following established cap, the obliged sectors and facilities must surrender the emissions specified by the program or regulation. Then ERUs are issued by the government allowance or obtained through emission reduction activities. Later on, they can be traded in the domestic market or internationally resulting in direct financial rewards.[1] • Crediting period and timing of reward: • Crediting period for sequestration activities is 10 to 30 years, with a 25-year average for forestry. Crediting period of non-sequestration projects is 7 to 10 years.[1]
Offset markets/use of removals	• **Market demand structure:** • Allowances are distributed either by free distribution or quarterly auctions with a price floor baseline. The purchase is complementary to the cap-and-trade scheme and results in a private market exchange between emitters and offset project owners.[1] • Price floor is the key factor of the California Cap-and-Trade compared to other carbon markets. It serves as a safeguard for participants and ensures a sufficiently high price to incentivise further emission reductions and provides adequate rewards.[1] The Market Advisory Committee oversees all market actions and acts as an advisor to CARB to reduce market risks and market efficiencies.[1] • Compared to voluntary markets in North America, projects achieve higher prices in the compliance market. Under California Cap-and-Trade, buyers are obliged to either reduce or compensate their emissions so there is demand certainties. But buyers do not distinguish credits according to other environmental or social benefits.[1] • As market participants have raised concerns regarding the increased supply of allowances, which could lead to a decreasing number of regulated entities to address the emission reduction actions, 50% of offsets have to be generated within California from 2021 onwards.[1]
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007 • California Air Resource Board. (2021). Compliance Offset Program: About (link)

[1] COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

[2] California Air Resource Board. (2021). Compliance Offset Program: About (link)

[3] California Air Resource Board. (2021). Cap-and-Trade Program Vintage 2021 Allowance Allocation Summary (link)

[4] World Bank (2015), Overview of Carbon Offset Programs - Similarities and Differences (link)

[5] California Air Resource Board. (n.d.). California's Cap-and-Trade Program (link)

[6] Climate Action Reserve. (2021). Verification Program Manual (link)

7 ANNEX 2 – EXISTING CERTIFICATION METHODOLOGY FICHES

7.1 Fiche: Methodology - VCS Jurisdictional and Nested REDD+ (JNR)

Methodology fiche	
Fiche section	Aspects covered
Methodology document	**VCS (2017) Jurisdictional and Nested REDD+ (JNR)** Requirements v 3.4. Available: https://verra.org/wp-content/uploads/2018/03/JNR_Requirements_v3.4.pdf - all page numbers refer to this document
Methodology scope	• **Specific removal solution covered: Afforestation** and improved forest management as part of REDD+ (i.e., Deforestation and Degradation, Improved Forest Management and Afforestation, Reforestation and Revegetation) • **Land-use category:** Forestland, cropland, grassland, wetlands • **Carbon pools:** aboveground tree biomass (or aboveground woody biomass, including shrubs), aboveground non-tree biomass (aboveground non-woody biomass), belowground biomass, litter, dead wood, soil (including peat) and wood products (p. 19). Projects must include all pools that are expected to potentially decline above a de minimis exception level of 10% (e.g., must include wetlands if present in the area). • **GHGs affected:** all GHGs that are likely to be significantly affected (i.e., more than 10% de minimis change): CO_2, methane, nitrous oxide • **System boundaries**: Jurisdictional approaches are applied at national or sub-national levels (i.e., cover whole of the selected jurisdiction). The smallest allowed scale is two levels below national level (e.g., in Brazil, the smallest jurisdiction would be municipality, which is one level below state) (p. 13). System boundaries can be defined using political boundaries, or ecoregions: this must be defined up front and not result in gaps or overlapping areas; they can cover multiple sub-regions (e.g., multiple adjoining municipalities).
Solution	• Jurisdictional projects must always cover Reduced Emissions from Deforestation and Degradation (REDD), and may also include Improved Forest Management and Afforestation, Reforestation and Revegetation (ARR).
MRV aspects	• **Jurisdictional approaches** can be conceptualised in three ways (p.5): ◦ *Jurisdictional baseline* with standalone project crediting (p.6): a baseline is set at the jurisdictional level, along with emissions factors etc. This jurisdictional baseline is then applied in individual standalone projects within the jurisdictional areas, which are then monitored and receive credits independently relative to the jurisdictional baseline. There is no monitoring (or crediting) at the jurisdictional scale. This approach is similar to standard, individual project approaches, with the only difference being the use of baselines set at the jurisdictional level (i.e., rather than less precise default baselines or project-specific baselines, potentially increasing accuracy and/or decreasing transaction costs).

  - *Jurisdictional program with crediting to the jurisdiction and direct crediting of nested projects (p.7):* Baselines are set at the jurisdictional scale. This baseline is applied in nested projects within the jurisdiction. Monitoring occurs at both the project scale and the jurisdictional scale. Credits can then be paid to either the jurisdiction or the nested projects (depending on agreements/rules established by the jurisdiction with the individual project). The maximum amount of credits would be limited to net GHG impact at the jurisdictional level. The monitoring at jurisdictional scale decreases the possibility of leakage or adverse selection, increasing environmental integrity. This enables jurisdictions to receive credit payments for actions/policies taken at the jurisdictional scale, as well as incentivise individual projects within the jurisdiction. The nested approach can also avoid double counting, as the total credits available will be limited to jurisdictional net GHG impact.
  - *Jurisdictional program with crediting only to jurisdiction and no direct crediting of nested projects[14] (p.9):* Baseline, monitoring, and crediting all occur at the jurisdictional level. The jurisdictional proponent can then establish other programmes to incentivise afforestation etc. within their jurisdiction. This enables jurisdictions to receive credits for actions/policies taken at the jurisdictional scale, and by doing so to access private funding for public actions.
- **Quantifying removals/emissions (p.38):** JNR projects include removals as well as emissions reductions. Projects receive credits equivalent to net GHG impact (i.e., net removals + net emissions reductions) minus leakage and credits set aside for a permanence/certainty buffer. Net GHG impact is the difference between the baseline scenario and the ex post jurisdictional project scenario. The credits equivalent to the net GHG impact are distributed differently, depending on which of the three jurisdictional approaches is applied (i.e., either to the individual projects, to both individual projects and the jurisdiction, or to the jurisdiction only). This is calculated using monitoring results. Monitoring plans should be established in project proposal documents, and must be carried out at least every five years. Monitoring should be carried out using IPCC tier 2 approaches, though IPCC defaults can be used for carbon pools representing less than 15 percent of carbon stocks. Land-use change monitoring must follow IPCC methods. Afforestation and degradation can be monitored directly (using remote sensing or forest inventory approaches) or indirectly through surveys, statistical data. The same emissions factors must be used in baseline and subsequent monitoring. Monitoring and reporting should occur at least every five years.
- **Specific additionality elements:**

[14] In effect, this matches the current EU LULUCF framework, where Member States have national (i.e., jurisdictional) baselines, which they then attempt to meet through national (and EU) policies. If they do better than their baseline (i.e., have greater net removals) they can effectively use these as credits, trading off less GHG reductions in other Effort Sharing Regulation-sectors or trade them with other Member States.

	- Baseline: JNR relies on stringent baseline setting to ascertain additionality, requiring jurisdiction-specific scenarios based on historical data that are regularly revised. For activity based accounting approaches (p.23): Baselines are set for each activity that is included in the project (e.g., avoided deforestation, afforestation, and improved forest management). These are set based on historical data (at least two years before start date of project). Deforestation rates should be determined using remote sensing imagery (with minimum coarseness of 100m x100m; and minimum of three data points over minimum two years). For land based accounting methods (still under development), baseline will be established using sample plots, remote sensing, and modelling (p. 25). To develop baseline scenarios, projects should identify trends over a period of 8-12 years up to two years before project begin; these must be conservative and justified and can include factors that affect deforestation rates (e.g., GDP, access to forests, commodity prices) (p. 26); these should exclude large one-off events or projects in the past, but include any planned future one.-off events. Alternatively, UNFCCC baselines can be used (p. 29). Baselines must be revised every 5-10 years. - Participation in other GHG programs: jurisdictions have to demonstrate that they will not double-count removals that occur due to other GHG programs (e.g., ETS, or other related CDM, VCS or other projects. • **Leakage:** Projects are required to quantify any leakage due to activity shifting, market leakage, and ecological leakage using a VCS tool.[1] This aims to identify drivers of leakage, mitigation strategies, and to calculate an overall leakage reduction, which will be deducted when calculating net sequestration (p. 33). They do not have to consider international leakage but do have to calculate within jurisdiction and domestic leakage. • **Uncertainty:** Projects must assess accuracy using IPCC guidelines (p. 42), e.g., using Monte Carlo experiments and by identifying sources of uncertainty and how this is addressed. The accuracy of forestry vs non-forest classification must be at least 75%. Where uncertainty in quantification of baseline and project results (measured by the width of the 95% confidence interval) exceeds 30% of the mean, then uncertainty deductions apply (p.43). • **Reporting requirements (p. 43):** Reporting must occur at least every five years. JNR proponents must complete a jurisdictional monitoring report that describes all the data and information related to the monitoring of GHG emission reductions and removals. The jurisdictional proponent shall use the JNR Monitoring Report Template and adhere to all instructional text within the template. • **Verification and validation:** The verification and validation method is set out here[2]. - Validation: Jurisdictional projects first develop project documentation, including all monitoring and non-permanence and leakage calculations. This must then be made publically available; stakeholders have 60 days to comment. The project must then propose an independent verification body, who must be approved by VCS, and who then prepare a draft verification report (which must also address stakeholder comments). This is then subject to a peer-review by one local and two international experts; their comments must be addressed by the verifier, who the produces a final report. Finally, VCS evaluates and approves or rejects the project. - Verification: Before being issued credits, jurisdictional projects must be assessed by external verification. They assess all reported documents that are required to assess net removals. These are then assessed by the VCS registry administrator, which also checks to make sure removals have not been also credited under other GHG programs. • **Co-benefits/externalities:**

	• Stakeholder involvement: Projects must be developed in consultation with stakeholders, and be transparent. The details of this must be included in the project description (p.17). • Co-benefits: The standard allows the use of additional frameworks (such as the Climate, Community & Biodiversity Standards or FSC, although these are not mandatory (p. 18).
Permanence	• **Specific management of impermanence risks:** Jurisdictional projects have a maximum crediting period of ten years, which can be extended twice (i.e., maximum of 30 years) (p. 12). Projects must also identify how permanence will be managed beyond the project duration: these actions affect the buffer. • **Buffer (p.10):** To manage non-permanence risk, jurisdictional projects must contribute a pooled jurisdictional buffer account. The level of contribution is based on risk analysis using the JNR Non-Permanence Risk Tool for jurisdictions. This determines the number of credits to be deposited in the jurisdictional pooled buffer account. The tool takes into account five categories of risk: political and governance risk, program design and strategy risk, carbon rights and use of carbon revenues, funding risk, and natural risks (not all would be apply in the EU). The tool must be rerun each time verification occurs. The jurisdictional pooled buffer account holds non-tradable buffer credits to cover the non-permanence risk associated with jurisdictional programs and nested REDD+ projects. The jurisdictional participant is required to make up any draw down on the buffer account by replenishing the account before they can claim credits (p. 47).
Key references	• Verra (2021) Jurisdictional and Nested REDD+ (JNR) webpage. https://verra.org/project/jurisdictional-and-nested-redd-framework/

[1] VCS (2014) VT0004 JNR LEAKAGE TOOL v1.0. Available: https://verra.org/wp-content/uploads/2016/05/JNR-Leakage-Tool-v1.0-04-FEB-2014.pdf

[2] VCS (2013) Jurisdictional and Nested REDD+ (JNR) Validation and Verification Process. VCS v. 3. Available: https://verra.org/wp-content/uploads/2018/03/JNR_Validation_and_Verification_Process_v3.0.pdf

7.2 Fiche: Methodology - VCS Indigo AG - Methodology for improved agricultural land management

Methodology fiche	
Fiche section	Aspects covered
Methodology document	**VCS (2020) VM0042 Methodology for Improved Agricultural Land Management, v1.0**. https://verra.org/wp-content/uploads/2020/10/VM0042_Methodology-for-Improved-Agricultural-Land-Management_v1.0.pdf[1] *Note: All information comes from this methodology document, unless otherwise noted. We provide page references in brackets where applicable.*
Methodology scope	• **Specific removal solution covered:** Agricultural land management on cropland/grasslands for soil carbon storage and/or to reduce emissions of CO_2, CH_4, and N_2O (i.e., soil carbon and avoided emissions) (VCS, 2020)[15]. This includes any management changes that result in reduced fertiliser application, improved water management/irrigation, reduced tillage/improved residue management, improved crop planting/harvesting, and improved grazing practices (p. 110). • **Eligibility:** Area must be cropland or grassland (at start and end of project); excludes any area that has been cleared of native ecosystems in last ten years and wetlands. Also, productivity must not decrease by more than 5% (p.8). • **Land-use category:** Croplands, grasslands (p.8) • **Carbon pools:** Aboveground woody biomass, soil organic carbon, belowground woody biomass (potential) (p.10) • **Emissions sources:** CO_2, CH_4, and N_2O emissions from: soil organic carbon, enteric fermentation, manure, nitrogen fertiliser, and nitrogen fixing species. Optional: fossil fuels, soil methanogenesis, biomass burning, woody biomass. Note: all can be excluded if expected difference between project and baseline scenarios are *de minimis* (i.e., expected change is <5%) (p.11). • **System boundary:** Partial farm: The spatial extent of the project boundary encompasses all lands subject to implementation of the proposed improved agricultural land management practice(s) (p.9). Projects can include multiple "sample units", which are modelled separately (p. 20). There is also some consideration re. actions that go beyond project boundaries e.g., biochar application only accepted if it would otherwise have naturally decayed and comes from a set of eligible feedstocks (p. 8), other examples in leakage section below.
Solution	• Soil carbon sequestration – covered by IPCC GL Volume 4 Chapter 2.[2]
MRV aspects - specific	**Quantification of emissions reductions** (p.18): Two (three) quantification approach options, which farmer can choose between: • **Quantification Approach 1:** Measure and model: Use an "acceptable model" to estimate GHG flux based on soil characteristics, agricultural practices, climate, and measured (continuously monitored), measured initial soil organic carbon (SOC) stocks. *Note: Method does not define specific models but provides guidance on inputs necessary for baseline and project scenarios.*

[15] All information comes from the methodology document (VCS, 2020), unless otherwise noted. We provide page references in brackets where applicable.

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Baseline: Soil organic carbon stock and density determined through sampling (p.85); other soil properties identified from soil maps with known uncertainties; climatic variables from local monitoring stations. 2019 refinement of IPCC 2006 Guidelines used for calculations. Baselines are set as average of last three years (or last full crop rotation, whichever is longest) (p. 13). Calculation considers factors including crop types, manure type/compost type/nitrogen application rate, tillage depth/frequency, %soil area disturbed/% crop residue removed, irrigation/flooding rate, animal type stocking rate/time grazing. Baseline should be revaluated every ten years: project must use regional agricultural production data to assess if baseline commercial crops continue to be produced using same management methods.
Project emissions/carbon sink flux (p. 36): Stock changes/emissions are modelled/calculated based on monitored inputs: Soil organic carbon and bulk density is re-measured every five years or less (directly or via emerging technology such as remote sensing, with known uncertainty); climate variables continuously monitored; agricultural management activities (e.g., whatever inputs are necessary to capture these in the model).

Quantification Approach 2: Measure and re-measure - this is proposed but not yet implementable. Idea is to measure and re-measure soil carbon (i.e., sampling) and compare relative to a “performance benchmark” but this benchmark has not yet been developed.
Quantification Approach 3 Calculation: i.e., all GHG fluxes (SOC stocks as well as CO_2, N_2O and CH_4 fluxes) are calculated using a series of equations consistent with IPCC 2019 refinement to 2006 guidelines.

Baseline: Calculated using 2019 IPCC GL and default emissions factors (p. 21). Otherwise same as approach 1.
Project emissions carbon sink flux: Calculated using 2019 IPCC GL and default emissions factors (p. 37).

Uncertainties: Two key sources of uncertainty identified:

Sample error (for soil carbon sampling): The method assumes that project applies an unbiased sample design (e.g., proposes simple random sampling with replacement with two-stage sample design, though others can be used – recommends using standard measures from FAO Soils Portal, or IPCC Guidelines). The error is a function of the level of change and the number of samples taken (p. 50)
Model prediction error (quantification approach 1): Quantified based on experiments which compare modelled and direct-re-measured sites. This could come from data external to project areas (e.g., same data that validated the model). If there is large error variance for different crops, soil, climate zones, then model prediction error can be predicted and applied to different sites (p. 50).
Uncertainty reductions: Based on the sample and model prediction error, the level of uncertainty is then calculated as the half width of the 95% confidence interval. Uncertainty is allowed to be up to 15% of the mean, after which a deduction applies equal to every percentage point beyond 15%. e.g., if half width of 95% confidence interval is equal to 32% of mean, then the emissions reduction estimates would be deducted by 17% (p. 48).

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	• **Reporting requirements:** Projects must propose a monitoring plan that details how to collect and report all data required to calculate removals/emissions reductions (p.107). All model inputs must be monitored and recorded annually. Qualitative information must be accompanied by signed attestation from landowner. Quantitative must be supported by documentation (e.g., management logs, receipts or invoices) (p. 37); if this is unavailable, farmer must sign an attestation, or use regional data (p. 53). The method lists all data that must be collected, method, frequency, etc. (e.g., Livestock grazing days (p. 97): average days per livestock type per year per sample unit, must be monitored every five years, reported through direct consultation + documented evidence such as management log).
	• **Verification and validation:** No methodology specific verification/validation (see Fiche_003_VCS).
	• **Additionality** (p. 14): Reductions/removals must:
	  ◦ Be surplus to regulatory requirements.
	  ◦ Identify barriers that block management change (e.g., social/cultural barriers, risk or uncertainty) – proved by reference to existing studies.
	  ◦ Not be common practice: the suite of management method changes must not be common practice in the region (common practice: weighted average of management changes has greater than 20% adoption rate – this follows CDM definition of common practice) (p. 111).
	• **Leakage: Rules for managing three types of leakage:**
	  ◦ Activity shifting: i.e., applying manure not previously applied. The associated emissions must be deducted unless: the manure comes from within project boundaries; it comes from anaerobic lagoon (i.e., avoiding high methane emissions); or the manure would have otherwise been applied and stored outside the project area (p. 38).
	  ◦ Livestock displacement: To avoid crediting for livestock displacement, the number of livestock in project scenario is assumed to be at a minimum at the level of the baseline scenario (p.39), i.e., cannot reduce emissions by reducing animal numbers.
	  ◦ Productivity decline: Project must demonstrate every ten years that average productivity has not fallen by more than 5% in the project scenario versus baseline (excluding extreme weather events) OR the ratio of project productivity to regional productivity does not fall by more than 5%. If productivity declines are identified, and are not due to initial implementation (i.e., excluding first three years from calculation), then project will be ineligible for all credits unless they can identify a specific cause (e.g., fertilisation rates), in which case, all credits associated with the specific cause would be ineligible (p. 39).
	• **Baseline:** See quantification of emissions reductions section.
	• **Co-benefits/externalities: The** methodology does not include specific reference to co-benefits or externalities. See Fiche_03_VCS.

Permanence	• **Permanence management**: Buffer credits must be stored in AFOLU pooled buffer account; i.e., project receives credits for estimated emissions reductions minus buffer contribution. In terms of project duration, VCS agricultural land projects have 10 year (fixed) or 7 years (renewable twice) durations. See Fiche 003_VCS for description.
Key references (in addition to method)	• VCS (2020) Public Comments for the Methodology for Improved Agricultural Land Management. Available: https://verra.org/wp-content/uploads/2020/10/PCP-Comments.pdf

[1] VCS (2020) VM0042 Methodology for Improved Agricultural Land Management, v1.0. https://verra.org/wp-content/uploads/2020/10/VM0042_Methodology-for-Improved-Agricultural-Land-Management_v1.0.pdf

[2] IPCC (2019) Chapter 2: Generic methodologies applicable to multiple landuse categories in: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf

7.3 Fiche: Methodology - VCS GHG CCU in Plastic Materials

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**VCS (2019), VM0040 Methodology for Greenhouse Gas Capture and Utilisation in Plastic Materials (v1.0)** (link). *The information from this fiche comes primarily from the methodology document.*
Mechanism architecture overview	• See Fiche 03 Voluntary Carbon Standard (VCS) for more information on the overarching mechanism
Methodology scope	• **Specific removal solution covered:** Project activities that convert carbon dioxide (CO_2) and/or methane (CH_4), which would have otherwise been emitted into the atmosphere or is sourced through direct air capture technology, into a useful plastic material for sale on the plastics market. • **There are seven applicability conditions:** 1) Conversion of CO_2 and/or CH_4 into a useful plastic material through a carbon capture and utilisation technology, the plastic must either have a lifetime >100 years or be biodegradable (in such case only emission reductions related to the displacement of virgin plastic and not capture and sequestration); 2) Production of plastic material for useful products that are sold in the commercial market; 3) Must produce PHA CO_2 or CH_4 to displace one of eight plastic materials including PP, PE, PC etc.; 4) CO_2 and CH_4 cannot be combined as feedstock to form a single plastic material (due to determining the source of the carbon atom in the molecular formula of the plastic, and whether it came from CO_2 or CH_4 would be difficult); 5) CO_2 must be derived from a source that would otherwise be emitted to the atmosphere or it must be derived from direct air capture technology; 6) Demonstrate that CH_4 as feedstock is qualifying or non-qualifying; and 7) CH_4 as feedstock cannot be displaced by a more carbon-intensive fuel. (p. 5-6). • **Land-use category:** n/a • **Carbon pools:** n/a • **GHGs affected:** CO_2, optional CO_2 and CH_4 from capture • **System boundary**: Emissions related to a) the project facility where plastic materials are produced; b) the facilities from which the GHG feedstock is sourced (if not direct air capture); c) the facilities where displaced conventional plastic material is manufactured (p. 6).

MRV aspects	• **Quantifying removals/emissions**
	  ◦ **Net GHG emission reductions and removals:** are calculated as 'Baseline emissions in year y (tCO_2e)' minus 'Project emissions in year y (tCO_2e)' (p. 16).
	  ◦ **Baseline setting:** Baseline scenario is based on the continuation of manufacturing plastic material through traditional processes based on the use of virgin plastic, which is typically made from petroleum-based materials. The crediting baseline is determined using a project methodology. Baseline scenario emissions are calculated as tCO_2e and are comprised of two components: 1) emissions associated with traditional plastic materials production processes, and 2) emissions from the GHG feedstock which would remain in the atmosphere or be released to the atmosphere in the absence of the project. (p. 9).

	- **Project emissions**: are calculated as tCO_2e and include emissions from electricity use and fossil fuel combustion at the project production facility, and emissions from the amount of plastic made by the project activity that is eventually destroyed by incineration (p. 13). - **Testing:** Determining GHG input by direct measurement is intended to be used as a cross-check of the molecular formula ratio because a verifier cannot directly measure or test the exact molecular formula of the plastic resin. (p. 23) - **Uncertainties**: GHGs may be captured but some may escape throughout each stage of the process. The meter for captured GHGs should be at the point where as much of the GHGs will be captured as possible (p. 13). - **Additionality:** Activity Penetration option is used to determine additionality. Under this option, a methodology must demonstrate that the project activity has achieved a low level of penetration relative to its maximum adoption potential. Activity Penetration must not be higher than 5 % (pp. 9 and 30). Projects must demonstrate a) regulatory surplus in accordance with VCS Standard and b) to comply with all applicability conditions ("positive list"). **• Monitoring and reporting requirements:** - **Monitoring data collection:** includes quantity of CO_2 and CH_4 if captured from the atmosphere at project facility as a GHG feedstock for the plastic material; quantity of methane that is collected must be piped or shipped into the production facility; production of plastic material; if methane is used, an analysis of whether that methane would be qualifying or non-qualifying; quantities of electricity and any fossil fuel used at the facility (for project emissions). - **Monitoring plan and GHG information system:** is required and must include criteria and procedures for obtaining, recording, compiling and analyzing data, parameters and other information important for quantifying and reporting GHG emissions relevant for the project and baseline scenarios. - **Monitoring procedures:** must address Types of data and information to be reported; Units of measurement; Origin of the data; Monitoring methodologies (e.g., estimation, modeling, measurement and calculation); Type of equipment used; Monitoring times and frequencies; QA/QC procedures; Monitoring roles and responsibilities, including experience and training requirements; GHG information management systems, including the location, back up, and retention of stored data (p. 27). - **Documentation**: All data collected as part of monitoring must be archived electronically and kept at least for 2 years (p. 28). - **Quality assurance:** must include but are not limited to Data gathering, input and handling measures; Input data checked for typical errors, including inconsistent physical units, unit conversion errors; Typographical errors caused by data transcription from one document to another, and missing data for specific time periods or physical units; Input time series data checked for large unexpected variations (e.g., orders of magnitude) that could indicate input errors; All electronic files to use version control to ensure consistency; Physical protection of monitoring equipment; Physical protection of records of monitored data (e.g., hard copy and electronic records); Input data units checked and documented; All sources of data, assumptions and emission factors documented (p. 28). **• Verification and validation:** by Validation and Verification Body (VVB) – see VCS mechanism architecture fiche. **• Co-benefits/externalities:** Products created through CCU processes can act as long-term storage of the captured GHGs used in their production and displace products created through conventional processes (p. 30).

Permanence	• **Specific management of impermanence risks:** ◦ One potential source of leakage is when the project activity use methane as a feedstock. Thereby, the facility previously using the methane turns to more carbon-intensive fuels. Consequently, certain conditions must be met to use CH_4 as a feedstock to avoid leakage. If those conditions are not met, the CH_4 cannot count towards baseline emissions (p. 15). ◦ A discount factor (DFEL) is applied to the calculation of project emissions to account for the fact that a certain amount of GHGs captured as part of the project may be re-released when plastic is incinerated, and therefore would not represent a permanent sequestration. DFEL can be determined as 1) a default value for U.S.-based projects; 2) criteria for projects to determine DFEL where appropriate data is available, and; 3) a conservative global default value (p. 35).
Key references	• Heek, J.V; Arning, K.; Ziefle, M. (2017), Reduce, reuse, recycle: Acceptance of CO_2-utilisation for plastic products. Energy Policy, Volume 105, Pages 53-66 (link). • Arning, K.; Heek, J. O.; Linzenich, A.; Kaetelhoen, A.; Sternberg, A.; Bardow, A.; Ziefle, M. (2019), Same or different? Insights on public perception and acceptance of carbon capture and storage or utilisation in Germany. Energy Policy, Volume 125, Pages 235-249 (link).

7.4 Fiche: Methodology - VCS CCU in Concrete Production

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**VCS (2021), VM0043 Methodology for CO_2 Utilisation in Concrete Production** (link) *The information from this fiche comes primarily from the methodology document.*
Mechanism architecture overview	• See Fiche: Voluntary Carbon Standard (VCS) more information on the overarching mechanism
Methodology scope	• **Specific removal solution covered:** Project activities that capture waste CO_2, which would have otherwise been emitted into the atmosphere, and utilize that gas as a feedstock in the production of concrete. This includes sequestering of CO_2 into the material itself or manufacturing a product with reduced Portland cement. CO_2 from direct air capture is permitted under this methodology. • **Land-use category:** n/a • **Carbon pools:** n/a • **GHGs affected:** Only CO_2 is considered (as it is the main gas that can be captured by carbon capture and utilisation technology) • **System boundary:** The project facility where concrete materials are produced; The facilities from which the CO_2 feedstock is sourced (if not direct air capture); The facilities where displaced Portland cement is manufactured. • **Constraints:** The use of recycled, non-commercial, and less-than-traditional compressive strength products is not eligible. A prerequisite for a climate benefit from CCU over its life cycle is that it relies on low-carbon energy and displaces a product with higher life cycle emissions.[1] • The CO_2 feedstock is ubiquitous, and there are no particular barriers (e.g., market access or customer acceptance) that would limit the adoption of this technology. (p.31) CH_4 and N_2O has been excluded for simplicity.
Solution	• CCU: Mineral Industry – Covered by IPCC GL 2006 Volume 3 Chapter 2 (link)

MRV aspects	• **Quantifying removals/emissions:**
	  ◦ **Net GHG emission reductions and removals**: are calculated as 'Baseline emissions in year y (tCO_2e)' minus 'Project emissions in year y (tCO_2e)'
	  ◦ **Baseline setting:** Baseline scenario is the traditional manufacturing of concrete, determined using project method with two components. The first component of the baseline calculation is the displacement of conventional cement production, the second component is the emissions from the CO_2 that are captured in the concrete by the project activity.
	  ◦ **Project emissions:** any additional electricity or fossil fuels required for project activity at the concrete manufacturing facility.
	  ◦ **Testing:** Minimum three decomposition tests per year for each mix design required to measure sequestered CO_2. Three tests in a row must reveal a carbon content that is within 10% each other. All test procedures and results are to be made available to the Validation and Verification Body (VVB).
	  ◦ **Uncertainties:** Technically none. CO_2 inputs and product outputs can be measured with high level of accuracy.[1]

	- **Additionality:** Activity Penetration option is used to determine additionality. Under this option, a methodology must demonstrate that the project activity has achieved a low level of penetration relative to its maximum adoption potential. Activity Penetration must not be higher than 5 %. Projects must demonstrate a) regulatory surplus in accordance with VCS Standard and b) to comply with all applicability conditions ("positive list").
	- **Monitoring and reporting requirements**:
	  - **Monitoring data collection:** includes Quantities of cement produced for the concrete supplied both in the baseline and project scenarios; Quantity of CO_2 supplied and injected into the concrete (determined by meter, and meter data, along with calibration measurements can be provided to the VVB); Quantity of CO_2 embedded into the concrete; Quantity of electricity and fuel used as part of the concrete production process at the project facility; Production and sale of concrete produced by the project activity (this will be monitored through industry-standard weighing techniques).
	  - **Monitoring plan and GHG information system:** is required and must include criteria and procedures for obtaining, recording, compiling and analyzing data, parameters and other information important for quantifying and reporting GHG emissions relevant for the project and baseline scenarios.
	  - **Monitoring procedures:** must address Types of data and information to be reported; Units of measurement; Origin of the data; Monitoring methodologies (e.g., estimation, modeling, measurement and calculation); Type of equipment used; Monitoring times and frequencies; QA/QC procedures; Monitoring roles and responsibilities, including experience and training requirements; GHG information management systems, including the location, back up, and retention of stored data. All data collected as part of monitoring must be archived electronically and kept at least for two years after the end of the last project crediting period.
	  - **Documentation:** All data collected as part of monitoring must be archived electronically and kept at least for two years after the end of the last project crediting period.
	  - **Quality assurance procedures:** must include but are not limited to Data gathering, input and handling measures; Input data checked for typical errors, including inconsistent physical units, unit conversion errors; Typographical errors caused by data transcription from one document to another, and missing data for specific time periods or physical units; Input time series data checked for large unexpected variations (e.g., orders of magnitude) that could indicate input errors; All electronic files to use version control to ensure consistency; Physical protection of monitoring equipment; Physical protection of records of monitored data (e.g., hard copy and electronic records); Input data units checked and documented; All sources of data, assumptions and emission factors documented.
	  - **Verification and validation:** by Validation and Verification Body (VVB) – see VCS mechanism architecture fiche.
	  - **Co-benefits/externalities:** emissions reduction because cement production is highly energy and carbon intensive.

Permanence	• **Specific management of impermanence risks**: No sources of leakage have been identified for this project activity. Duration of removals can be permanent for building materials. The retention of CO_2 in CCU products depends highly on the application. It is temporary for fuels and chemicals building blocks (less than 1 year for fuels, up to 10 years for most chemical intermediates, up to hundreds of years for polymers), while it can be permanent for building materials. Experts advocate LCA to address impermanence issues in accounting, but no consensus on the methodology.[1] CCU is not fully recognised or rewarded by carbon credit mechanisms, thus it is necessary to enable economic incentives and provide a supportive regulatory framework for further deployment of CCU.[2]
Key references	• IOGP (2019), The potential for CCS and CCU in Europe - Report to the thirty second meeting of the European Gas Regulatory (link).

[1] See Task 2 Carbon Capture and Utilisation (CCU) fiche

[2] IOGP (2019), The potential for CCS and CCU in Europe - Report to the thirty second meeting of the European Gas Regulatory (link)

7.5 Fiche: Methodology - Label Bas Carbon: CarbonAgri

Methodology fiche	
Fiche section	Aspects covered
Methodology document	**CARBON AGRI - Méthode de suivi des réductions d'émissions en élevages bovins et de grandes cultures conforme au Label Bas Carbone** (2019). Link: https://www.ecologie.gouv.fr/sites/default/files/M%C3%A9thode%20%C3%A9levages%20bovins%20et%20grandes%20cultures%20%28Carbon%20Agri%29.pdf *Explanatory note: while the CARBON AGRI method mainly focuses on avoided emissions, we included it for evaluation for three reasons: it uses a relatively novel carbon audit tool (i.e., computer program that estimates removals/emissions based on input data) to calculate baseline and future emissions/scenarios, it also includes soil sequestration (a removal), and it is a widely implemented Label bas Carbone method, so a clear example of the mechanisms methodological approach.* *A portion of the information from this fiche comes from the DG CLIMA Carbon Farming Appendix: COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007* https://op.europa.eu/s/pcDV.[16]
Methodology scope	• **Specific removal solution covered:** Soil carbon (and avoided emissions) • **Land-use category:** Cropland, grassland • **Carbon pools**: Soil carbon • **GHGs affected:** Carbon dioxide, methane, nitrous oxide • **System boundary:** CARBON AGRI focuses on cattle farms located in France (whole farm). • CARBON AGRI provides a method for project developers (i.e., person/organisation/company) to account for emissions reductions on cattle farms in France thanks to actions that mitigate GHG emissions or increase carbon storage. These validated emissions reductions can then be traded for payment from an external party voluntarily offsetting their emissions. The method includes six types of actions: herd management and feeding, animal manure management, crop & grassland management, consumption of fertilisers, and energy, and carbon storage (in total 40 low carbon practices). It quantifies both reductions on farm as well as associated upstream emissions, applying life cycle assessment. Emissions change is calculated using the whole farm carbon audit tool CAP2'ER®, which calculates emissions and soil sequestration based on input data that describes farm characteristics and management (from 20-150 data sources, depending on selected accuracy). Change in emissions is calculated based on change in emissions intensity (i.e., kg GHG per kg of output). Each project runs for 5 years and can be renewed. • Project proponents can be individual farmers, but also collectives (several farms) (p. 4). The maximum project lifetime is 5 years, but they can be renewed (p. 28).
Solution	• Soil carbon – predominantly covered by IPCC GL Volume 4 Chapter 2.[1] The mechanism also covers livestock emissions e.g., IPCC GL Volume 4 chapter 10.

[16] We also appreciate the feedback and review provided by Daphné Lecellier, Julian Viau and Maguelonne Joubin from the French Ministry of the Environment (Ministère de la transition écologique)

MRV aspects	• **Quantifying removals/emissions:** Avoided emissions and soil sequestration are quantified at individual farm level. All quantification of emissions and soil sequestration occurs using the CAP2ER whole farm carbon audit tool, a computer programme that calculate a farm's GHG emissions and removals (and other indicators such as for example nitrogen balance, economic profit), based on input data that summarise the farm's management elements (e.g., animal number and type, feed type, etc.). The CAP2er tool can be run at two levels of detail: the simpler level 1 requires 30 parameters, and the more detailed level 2 has 150 parameters. The CARBON AGRI methodology only requires level 1 to be applied to set the baseline, and on the basis of this the consultant makes climate action recommendations, though requires the farm to move to level 2 for the end-of-period evaluation. The simpler level 1 method doesn't fully capture whole farm effects (in particular, this simpler method is less accurate for estimating soil sequestration). The level of rewarded avoided emissions/removals is calculated as baseline level of net emissions x change in emissions intensity (i.e., it is an intensity reduction, and may not be an absolute reduction).[2]
	• **The CAP2ER tool** was built specifically for the French context of the mechanism. It can be relatively simply extended to other areas or other farm types by changing the default data and some of the operating equations in the tool. The tool consists of a series of equations (based on IPCC guideline methodologies, generally aligned with IPCC Tier 2; though with some aspects e.g., methane at tier 3 level) run by consultants (with the help of farmers) who visit the farm to set a baseline based on historical data, and then return to the farm five years later to calculate the increase in soil sequestration and decrease in emissions since baseline.
	• **Uncertainties:** The methodology explicitly assesses the uncertainty of the data/methods (p. 25) and concludes that the level of uncertainty is low enough that the emissions reductions/removals do not need to be discounted due to uncertainty. Sources of uncertainty
	  ◦ Activity data: data provided by farmers with accompanying documentation – this is considered to be low uncertainty
	  ◦ Default data: where a farmer doesn't have farm-specific data or gathering it would be prohibitively expensive, defaults are used. Some equations also use defaults to reduce the amount of data required (e.g., average animal weights, average temperatures). This is considered to be moderate level of uncertainty.
	  ◦ Emissions factors: Emissions factors used in the quantification are based on IPCC 2006 GL and best available French data but nevertheless have intrinsic uncertainty.
	• **Reporting requirements**: Landowners need to record information to run the whole farm carbon audit tool to set baseline and then again at the end of the five year period. They also need to keep documentation to support this (e.g., animal numbers, farm management measures etc.).
	• **Verification and validation:** The implementation of a verification process is a requirement for the MTES to recognize the achieved emission reductions. The project proponent can request this verification; for collective projects it can be done individually for each farmer's project independently or by pooling individual requests. External audits are carried out on a sample of farms using the rule 0.5 x √number of farms (as listed in Table 8 of the methodology) with a minimum of 5 farms. Any reduction differences identified on the verification sample by the auditor will be applied in proportion to the total emissions reductions in the follow-up report (p. 30).

	• **Specific additionality elements:** Baseline: Additionality is measured against a farm-specific historical baseline that is fixed for the duration of the project (5 years). It is set using the CAP2ER tool. Any avoided emissions or sequestration that occurs after this point is considered additional. Farmers do not have to prove regulatory or financial additionality, except related to two specific French schemes (energy saving certificates or French support for agricultural methanisation units on farms); if farmers implement these during the project period, the associated emissions reductions will not be fully credited (i.e., discounted by 20%) (p.21). LBC is assumed to be additional to CAP (p.19). • **Co-benefits/externalities:** The CAP2ER carbon audit tool also calculates multiple other sustainability impacts, including nitrogen leaching, area set aside for biodiversity protection, etc. Project proponents can report on co-benefits and impacts indicators at the beginning and at the end of the project (e.g., increased contribution to biodiversity or reductions in ammonia emissions), but are not obligated to do so. The former can also suggest additional co-benefits, as long as they can be monitored and verified (p. 15).
Permanence	• **Specific management of impermanence risks:** Due to uncertainty and potential for impermanence, soil sequestration removals are discounted by 20% (p.25) and hedges (i.e., agroforestry component) by 10%. There is no further management of impermanence in the CarbonAgri method.
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007 • COWI, Ecologic Institute, and the Institute for European Environmental Policy (2021) Annexes to Technical Guidance Handbook – setting up and implementing result-based carbon farming mechanisms in the EU. Report to the European Commission, DG Climate Action on contract no. CLIMA/C.3/ETU/2018/007 https://op.europa.eu/s/pcDV

[1] IPCC (2019) Chapter 2: Generic methodologies applicable to multiple landuse categories in: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch02_Generic%20Methods.pdf

[2] COWI A/S, Ecologic Institute, and the Institute for European Environmental Policy (2021) Guidance document: Annex 5 – Livestock Whole Farm Audit. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

7.6 Fiche: Methodology - New Zealand ETS/PFSI Forestry Methodology

Methodology fiche	
Fiche section	Aspects covered
Methodology document	• **New Zealand Ministry for Primary Industries (2017) A guide to Carbon Look-up Tables for Forestry in the Emissions Trading Scheme**. https://www.mpi.govt.nz/dmsdocument/4762-A-guide-to-Look-up-Tables-for-Forestry-in-the-Emissions-Trading-Scheme - (referred to as "LTA") • **New Zealand Ministry for Primary Industries (2018) A guide to the Field Measurement Approach for Forestry in the NZ ETS** https://www.mpi.govt.nz/dmsdocument/3666-A-Guide-to-the-Field-Measurement-Approach-for-Forestry-in-the-Emissions-Trading-Scheme - (referred to as "FMA")
Methodology scope	• **Summary:** The New Zealand Emissions Trading Scheme and Permanent Forest Sink Initiative apply two methodologies for afforestation. Small (<100ha) participants use default emissions factors (per tree-type, region); large (>100ha) must carry out field measurement in combination with allometric modelling. • **Specific removal solution covered:** Afforestation • **Land-use category:** Forest land, cropland, grassland, wetlands, other land • **Carbon pools:** Aboveground woody biomass (other carbon pools are not explicitly included) • **GHGs affected:** CO_2 • **System boundary:** Part of farm: Forestry owners define the system boundary when the land is registered for the PFSI or NZ ETS. These forestry areas are recorded as GIS polygons that then set the borders of the forestry land; all other land is excluded (e.g., the rest of the landowners land is not considered). To be considered forestry land, the minimum size is 1ha (and minimum 30m wide) and tree crown cover must be at least 30%.
Solution	• Afforestation - Covered by IPCC GL Volume 4 Chapter 4.[1]
MRV aspects	**Two methodologies:** used in both NZ Emissions Trading Scheme (NZ ETS) and Permanent Forestry Sink Initiative (PFSI) • **Default Look-up Table (LTA):** Applies to participants with forest areas <100ha • **Field Measurement Approach (FMA):** Applies to participants with forest areas >100ha of post-1989 forest (i.e., considered additional forest) **Quantifying removals/emissions** • **LTA**: Foresters use "look-up tables" to quantify the carbon sequestered by their area of forest. These look-up tables are a set of pre-calculated average values of change in carbon stocks (in t CO_2 per ha) over time, based on forest type (five categories – radiata pine, douglas fir, indigenous, exotic softwood, exotic hardwood,), age (by year), and region (regionally specific estimates are only available for radiata pine; the rest are New Zealand averages) (LTA; p. 4). In this way, they align with IPCC Guidelines for above-ground biomass calculation (Tier 3). Landowners should break down their forest areas into sub-areas (minimum 1 ha) that have the same forest type and age. These are then multiplied by the carbon stock value (provided by the look-up table according to the sub-area forest category, age, and region). These sub-are values are totalled to give the total forestry area carbon stock, which can be compare to the previous year carbon stock to identify removals/emissions.

	• **FMA:** Larger landowners (>100ha of post-1989 forests) are required every five years to complete a Field Measurement MRV return. This return requires on-site measurement. These measurements are then used to generate a participant-specific look-up table, which the participant then uses for emissions returns in the intervening four years before their next FMA quantification. FMA can be carried out by the landowner or by a consultant. They are required to measure at least 20 trees on random sample plots. The minimum number of sample plots is prescribed by law, increasing with forest size at a decreasing rate (e.g., 30 samples for 100ha, 37 for 200ha, 200 for 10 000ha or more) (FMA, p. 20). The regulator uses a computer program to randomly allocate sample plots across the forest land and have to be established in accordance with regulation (FMA, p.25). The forest plots, where the measurements are taken, are permanent and of standard size. Measurements comprise the following variables and calculations (FMA, 3): • ›Slope of the terrain for growth calculations; • ›Radius that is required to cover 20 trees to estimate stem density; • ›Diameter at breast height; • ›For 8 trees per plot: tree height; • ›Tree species. • ›Forest management and silvicultural information • This is then submitted to MPI who then apply allometric equations/modelling techniques to calculate an individual look-up table for the participants' forest that includes ground-truthed calculations of carbon stock storage (FMA, p. 45), which landowners must then use in future. The same sample locations are then the basis for all future monitoring/measurement. **Baseline:** The NZ ETS/PFSI uses a simple baseline definition based on whether the land was forested or not in 1990. All land that was forested pre-1990 is mandated to join ETS and receives a baseline of being already forested. In effect, this means that they are not eligible for credits for increases in carbon stock and if they deforest, they would drop below their baseline and be liable for purchasing NZUs. Apart from the restriction on deforesting, there are no limits on forest management (e.g., change in harvest rates does not result in liability or credit). All land that was not forested in 1990 is assumed to have a baseline of zero sequestration when they enter the NZ ETS/PFSI. This applies even if they then planted trees on the land in e.g., 1992; when they enter ETS/PFSI, they would receive a baseline of zero sequestration (and be able to claim credits for all sequestration post-1990 (see additionality elements below). **Uncertainty:** Not explicitly discussed but there appears to be some acceptance of uncertainty of emissions reductions in individual participants, as this is seen as variation around a mean rather than a bias.[17]

[17] The following excerpt from the FMA description document provides an example of the approach to uncertainty: "Use of a smaller minimum number of sample plots for regenerating indigenous forest will result in less accurate estimates of forest carbon stocks than for exotic forest, not just because of smaller plot numbers but also because regenerating forest is more variable. However, the expected error limits (in tonnes of carbon dioxide per hectare) are not expected to differ greatly. Consider the following example. Carbon stocks in radiata pine and indigenous forests at age 30 are about 750 and 250 t CO_2/ha respectively. It is expected that carbon stocks in a relatively uniform exotic forest will be estimated to within 5–10 percent of the mean, but in indigenous forests (once fully stocked) to within only about 25 percent of the mean, using the minimum number of sample plots. The likely error limits in carbon terms are similar in both cases – about 60 t CO_2/ha." (FMA, p. 20)

	Reporting requirements: • **LTA:** Can voluntarily report every year, minimum every five years. Must report: forest age, type, and area size (by sub-area); region; age at harvest (if has been previously harvested); whether the forestry land is pre/post 1989 (different accounting rules, due to alignment with Kyoto Protocol) (LTA; p 8). This is reported as part of an emissions return document to the New Zealand Environmental Protection Agency. • **FMA:** Landowners have to do full FMA report once every five years. They must report three types of information (FMA, p. 33): FMA-participant information (administrative information); information about the sample plots; actual sampling information (e.g., tree type, crown cover, living/dead trees, heights, silviculture information. This information should be communicated to New Zealand Ministry of Primary Industries in a standard format digitally (using an online template or by uploading a digital file) digitally or in hard copy. **Verification and validation:** No independent third-party validation and verification required. Random and targeted audits and penalties to enforce compliance. Both methods are carried out by the landowner, though to carry out the FMA approach landowners can employ consultants. Participants are required to declare that all information provided is complete and correct; if this later proves to be untrue they can face fines or even jail time. **Specific additionality elements:** • All forestry planted post-1989 is considered additional. There is no specific management of leakage, though as all of New Zealand's emissions are covered by a cap the regulator does not consider this an issue; however, there is still the potential for leakage due to impacts on international markets. **Co-benefits/externalities:** • **LTA:** Little consideration of co-benefits or externalities. Policy documents note the co-benefits of afforestation (e.g., avoided erosion, biodiversity provision (PFSI)) but there are no rules or payments to address these. Some types of trees are excluded as of 2020 ("tree weeds"), which are invasive alien species. • **FMA:** Indigenous forestry is encouraged by allowing foresters who have predominantly indigenous forest on their land to have half as many sampling plots, reducing costs for such participants (FMA, p. 11).

Permanence	• **Specific management of impermanence risks**
	  ◦ Intentional reversal: Generally, if foresters deforest and therefore reverse removals, they must purchase an equivalent amount of emissions credits from the NZ ETS, i.e., offset any reversal by purchasing an equal amount of removals/reductions elsewhere within New Zealand. Owners of pre-1990 forestry land are exempt from this if, when they clear land, they offset this by planting an equivalent amount of forest in another location[2].
	  ◦ Unintentional reversal (e.g., fire, wind etc.): Previously, foresters were required to surrender emissions credits in the case of adverse events such as fire. However, in 2020, this has been revised and the government now does not require foresters to surrender emissions units in the case of an adverse event, as long as they replant.

Key references (in addition to methods)	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007 • New Zealand Ministry of Primary Industries (2021) Forestry Resources (webpage). https://www.mpi.govt.nz/forestry/forestry-resources/

[1] IPCC (2019) Chapter 4: Forestry Land in: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch04_Forest%20Land.pdf

[2] New Zealand Ministry for Primary Industries (2021) Emissions Trading Scheme improvements for forestry (webpage). Accessed 11.03.2021. Available: https://www.mpi.govt.nz/forestry/forestry-in-the-emissions-trading-scheme/emissions-trading-scheme-improvements/

7.7 Fiche: Methodology - MoorFutures

Methodology fiche	
Fiche section	Aspects covered
Methodology document	**MoorFutures (2017). Methodologie für MoorFutures-Projekte**. Hyperlink: https://www.moorfutures.de/app/download/31771519/Moorfutures_Methodologie.pdf in German *The information from this fiche comes primarily from the DG CLIMA Carbon Farming Appendix.*
Mechanism architecture overview	*We summarise mechanism architecture elements here, as there is no accompanying mechanism architecture fiche. The methodology fiche follows.* • **Overview and performance:** MoorFutures is a result-based voluntary scheme to incentivise the rewetting of peatlands to reduce GHG emissions. Projects are rewarded in the form of voluntary carbon credits for the reduction in GHG fluxes that arises from rewetting. Currently, the MoorFutures scheme operates in three states in Germany and has been selling voluntary carbon credits from peat rewetting since 2010 (the five existing or completed projects have expected lifetime GHG flux reductions of 68,889t/CO_2-e). Climate impacts are quantified by developing forward-looking baseline and project scenarios, which estimate changes in GHG fluxes based on indicators including water table depth, soil type, and plant community ("GEST approach"). Permanence is enforced through 50+ year contracts and permanence through the use of conservative emissions factors. The MoorFutures 2.0 standard includes a method to quantify non-climate benefits. The website https://www.moorfutures.de/ contains thorough information on the scheme, its functioning and the projects. For each project, the project design documents (PDD), monitoring and verification reports can be accessed. • **Governance**: The Mecklenburg-Vorpommern (MV) State Ministry of Agriculture and Environment and the Academy for Sustainable Development in MV is the scheme owner, but there is also a project work group (PAG) and a scientific advisory board (WB). The key GHGs covered are CO_2, CH_4 (with N_2O fluxes assumed zero for conservativeness). The MoorFutures certificates follow the internationally recognised environmental standards ISO 14064 and ISO 14065.[1] The MoorFutures certificates are inspired by VCS and the KP.[2] Following the demand for regional and flexible mechanisms for financing rewetting of peatlands, the MV State Ministry of Agriculture and Environment and the Academy for Sustainable Development in MV set up MoorFutures. Neighbouring states reacted with interest and Brandenburg (BB) and Schleswig Holstein (SH) implemented projects themselves.[3] • **Eligible participants**: rewetting projects of non-forested peatlands in their states in Germany (i.e., landowners). • **Market:** MoorFutures certificates were developed for the voluntary carbon market and can be purchased by private households or companies who want to improve their climate footprint. Prices are project-dependent and range between currently range between EUR 40 and 80 per tonne reduced. Certificate prices are based on the costs of their production, i.e., calculated by dividing the costs of implementation, divided by the total amount of emission reductions over the project crediting period (EUR per t CO_2e).[4] The main buyers are companies (70% of credits sold), including Engbers, McDonald's, Commerzbank, with the remainder sold to individuals.[5]
Methodology scope	• **Specific removal solution covered:** Peatland rewetting • **Land-use category:** Cropland, grassland, wetlands. • **Carbon pools:** Aboveground biomass (trees or other); belowground biomass, and soil organic carbon.

	• **GHGs affected:** Carbon dioxide, methane. Nitrous oxide is excluded due to conservativeness concerns. • **System boundary:** Project based, i.e., covering a section of one or more farm units.
Solution	• Peatland rewetting - covered by 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands[6]

MRV aspects	**Quantifying removals/emissions:** Primarily, an observational method (GEST) is applied, where the calculation of expected GHG fluxes is based on different observable land characteristics (e.g., peat type, climatic conditions, site characteristics, vegetation, land use/land cover), which are then associated with locally-specific emissions factors. This is supported by an initial site visit to support calculations.
	• **Quantification approach:** With the support of consultants, projects develop a forward-looking project baseline and project plan. The baseline identifies the expected land use that would occur without the project and quantifies the expected associated GHG fluxes (i.e., sequestration – emissions) that would occur over the lifetime of the project (minimum 30-100 years). A project plan is then developed, which sets out how the project area will be managed for the life of the project (i.e., under rewetting, retirement of land), as well as MRV requirements, and quantifies the expected GHG fluxes under rewetting. The impact of the rewetting is calculated as the difference in GHG fluxes (i.e., t CO_2-e) between the baseline and project plans, making conservative assumptions. The MoorFutures methodology proposes the use of maps, photos, aerial photographs, publications and stakeholder statements for identifying the most probable baseline scenario. Field visits and expert opinions should be integral part of this process.[7] The MoorFutures methodology allows for any proven method that is suitable for quantifying climate impacts and refers to international schemes such as VCS (see section 2.4).[8]
	• **GEST Method**: While multiple methods can be applied, the standard method for estimating emissions within MoorFutures is the GEST method, developed by the local University of Greifswald.[9] Instead of measuring the site-specific factors, a process that is technologically challenging and resource consuming, the GEST method estimates the sequestration based on observable or easily identifiable characteristics, including:
	  ◦ water table height
	  ◦ peat type;
	  ◦ climatic conditions;
	  ◦ site characteristics;
	  ◦ spatial heterogeneity of many locations, incl. changing widths of peat;
	  ◦ current type of management;
	  ◦ current type of vegetation (e.g., open peat or timber forest);
	  ◦ climate-relevant gases released during rewetting. [10]
	• The GEST method then calculates expected sequestration based on this observed data, based on relationships established in the literature.[11] Note this methodology has been developed specifically for the local region, and the emissions factors associated would have to be adjust to apply the same method in other locations.
	• GHG fluxes are calculated ex ante, and project owners can sell credits ex ante to cover set up costs. To ensure validity, the chosen scenario is re-assessed every ten years and in case of deviations, emissions have to be recalculated.[12]

	Specific additionality elements: MoorFutures determines additionality using a baseline (project-specific, scenario, fixed at project beginning). In addition, MoorFutures assesses financial additionality, i.e., the project only economically viable due to the sale of carbon credits (p. 10). The MoorFutures credits do not have to be the sole source of additional funding considered in this calculation. Regarding leakage, MoorFutures requires projects to identify if any changes in land use will result in GHG leakage outside system boundaries; these would then be deducted from estimated emissions reductions. **Uncertainties:** MoorFutures uses buffer accounts to manage uncertainty. To mitigate estimation errors, the actual impacts of the projects are re-evaluated ex-post, and if necessary, inconsistencies are corrected through a buffer account/crediting.[13] MoorFutures includes a "buffer" to ensure that rewards are at minimum matched by GHG impact, even considering uncertainty: Projects are rewarded for the difference between project scenario (which is conservatively estimated, i.e., highest likely emissions) and the baseline scenario (which is also conservatively estimate, i.e., lowest likely emissions). This creates a buffer equivalent to the difference between the conservative and (less conservative but more likely) expected emissions. In addition, MoorFutures retains 30% of generated credits in a buffer reserve to cover risks. According to the MoorFutures Standard, the conservative approach to baseline consists of considering only 50 years of emission reduction, despite the additional emission reduction potential of the project beyond this (and the minimum 100 year permanence requirements).[14] **Reporting requirements:** Participants face external monitoring within the first five years (to assess establishment of peatlands project) and then every 10 years to ensure project plan is being followed (p13)[15]. This includes at least one recalculation of the estimated sequestration (i.e., an ex post evaluation of change in sequestration, which is then compare to the ex-ante estimation). Monitoring is directed to the condition of equipment and entails at least one recalculation of estimated emissions, considering the actual development of the project. Reporting requirements are detailed in a monitoring plan, which each project is required to develop when they develop their project. **Verification and validation:** Monitoring and verification are performed by a designated publicly funded regional scientific research institute. The methodologies and results of MoorFutures projects are available for validation and verification by third parties. **Co-benefits/externalities:** The MoorFutures methodology requires that other ecosystem-services are not negatively impacted by rewetting. The proposed version 2.0 methodology also proposes methodologies for monitoring and reporting impact on other ecosystem services (e.g., water quality, flood prevention, groundwater enrichment, evaporative cooling, biodiversity), either through observatory methods equivalent to GEST or modelling[16].
Permanence	• **Specific management of impermanence risks:** to decrease risk of projects reversing (and releasing all carbon sequestered through rewetting), MoorFutures requires that all projects stipulate in their plans how permanence will be guaranteed (e.g., through legal contracts, change of title etc.). In addition, project lengths must be a minimum of 30 years (up to 100 years) (p.12).
Key references	• MoorFutures. (2017). Der MoorFutures Standard. Hyperlink: https://www.moorfutures.de/downloads/ • Joosten, H., Burst, K., Couwenberg, J., Gerner, A., Holsten, B., Permien, T., Schäfer, A., Tanneberger, F., Trepel, M., Wahren, A. (2015). MoorFutures®Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions. BfN Skript 407. https://www.moorfutures.de/app/download/31771524/BfN-407_MoorFutures-ecosystem-services_2015.pdf This document provides an English language overview of MoorFutures Methodology v1, as well as proposing an advanced version 2.0, that also incorporates other sustainability indicators. See especially pp. 34-35.

	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

[1] MoorFutures. (2017). Der MoorFutures Standard. Hyperlink: https://www.moorfutures.de/downloads/

[2] MoorFutures. (2017). Der MoorFutures Standard.

[3] MoorFutures. (2017). Der MoorFutures Standard.

[4] Joosten, H., Burst, K., Couwenberg, J., Gerner, A., Holsten, B., Permien, T., Schäfer, A., Tanneberger, F., Trepel, M., Wahren, A. (2015). MoorFutures® Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions.

[5] Permien, Thorsten 2019. "MoorFutures Presentation". Presented at Carbon Farming Schemes in Europe – Roundtable, 9.10.2019. Available at: https://nx5846.your-storageshare.de/s/tye6wTXwSe7fjMG.

[6] IPCC 2014, 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Hiraishi, T., Krug, T., Tanabe, K., Srivastava, N., Baasansuren, J., Fukuda, M. and Troxler, T.G. (eds). Published: IPCC, Switzerland. Available: https://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html

[7] MoorFutures. (2017). Methodologie für MoorFutures-Projekte. Hyperlink: Hyperlink: https://www.moorfutures.de/downloads/

[8] MoorFutures. (2017). Methodologie für MoorFutures-Projekte.

[9] Joosten, H., Burst, K., Couwenberg, J., Gerner, A., Holsten, B., Permien, T., Schäfer, A., Tanneberger, F., Trepel, M., Wahren, A. (2015). MoorFutures® Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions

[10] Joosten, H., Burst, K., Couwenberg, J., Gerner, A., Holsten, B., Permien, T., Schäfer, A., Tanneberger, F., Trepel, M., Wahren, A. (2015). MoorFutures® Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions

[11] Zeitz, J., Ruess, L., & Ellmer, F. (2012). Methoden zur Kohlenstoffbilanzierung Treibhaus-Gas-Emissions-Standort-Typen-Verfahren (GEST-Verfahren). In J. Zeitz, L. Ruess, & F. Ellmer, CARLOS - CARbon Learning Online System. Berlin, DE: Humoldt-Univeristät zu Berlin.

[12] MoorFutures. (2017). Methodologie für MoorFutures-Projekte.

[13] Joosten, H., Burst, K., Couwenberg, J., Gerner, A., Holsten, B., Permien, T., Schäfer, A., Tanneberger, F., Trepel, M., Wahren, A. (2015). MoorFutures® Integration of additional ecosystem services (including biodiversity) into carbon credits – standard, methodology and transferability to other regions. Bonn: Federal Agency for Nature Conservation. https://www.moorfutures.de/app/download/31771524/BfN-407_MoorFutures-ecosystem-services_2015.pdf

[14] MoorFutures. (2017). Der MoorFutures Standard.

[15] MoorFutures. (2017). Methodologie für MoorFutures-Projekte.

[16] Joosten, H., Burst, K., Couwenberg, J., Gerner, A., Holsten, B., Permien, T., Schäfer, A., Tanneberger, F., Trepel, M., Wahren, A. (2015). MoorFutures® Integration of additional ecosystem services (including biodiversity) into carbon credits – standard,

methodology and transferability to other regions. Bonn: Federal Agency for Nature Conservation. https://www.moorfutures.de/app/download/31771524/BfN-407_MoorFutures-ecosystem-services_2015.pdf

7.8 Fiche: Methodology - Woodland Carbon Code

Methodology fiche	
Fiche section	Aspects covered
Methodology document	**Woodland Carbon Code – Requirements for voluntary carbon sequestration projects (2018).** Hyperlink: https://woodlandcarboncode.org.uk/images/PDFs/WWC_V2.0_08March2018.pdf Page numbers below refer to this document See also the Woodland Carbon Code website, which gives a clearly structured overview: Woodland Carbon Code (2021) UK Woodland Carbon Code website. https://woodlandcarboncode.org.uk/ *The information from this fiche comes primarily from the DG CLIMA Carbon Farming Appendix.*[18]
Mechanism architecture overview	*We summarise mechanism architecture elements here, as there is no accompanying mechanism architecture fiche. The methodology fiche follows.* • **Overview and performance:** The UK Woodland Carbon Code incentivises UK landowners for woodland planting (i.e., afforestation and reforestation – for simplicity referred to as afforestation throughout this fiche) for carbon removal through a voluntary standard. The Code sets out how to plant and manage woodlands, and how to robustly measure, report, verify and govern the resulting sequestration. As a reward, landowners receive voluntary emissions credits that are recorded in the Woodland Carbon Code Registry and which can be sold to companies/private individuals to offset their emissions. Since its launch in 2011, 187 projects covering 8,261ha have been validated, with expected carbon sequestration of 3.4million tCO_2[1]. • **Governance:** Scottish Forestry, a government agency, governs the project (on behalf of the Forestry Commission in England, the Welsh Government, and the Northern Ireland Forest Service), with support from an expert Advisory Board, made up of external public and private experts who meet four times per year. Woodland Carbon Code units contribute to meeting the UK's national emissions reduction targets. Woodland Carbon Code is managed by an executive board, who are responsible for its day to day management (i.e., promoting the Code, developing it, etc.). This is made up of representatives from public sector forestry agencies from the UK. The executive board is supported in its work by the Advisory Board, who provide expert and strategic advice. The Code also has a separate disputes panel, consisting of two members of each of the executive and advisory boards. They adjudicate in any issues related to Code interpretation. • **Scope:** UK land previously not forested (i.e., for the last 25 years) and not deep peatland is potentially eligible (p. 6). Projects are required to prove that the land has not been wooded in the last 25 years, e.g., through land use records, photos, government databases. The Code covers the human-induced creation of woodland, either through planting, seeding, or natural regeneration. Any UK land is eligible, except organic soils i.e., soils with an organic (peat) layer of more than 50 cm. Any project size is eligible. • **Market:** ◦ Participants in Woodland Carbon Code are rewarded in the form of credits, which can then be sold to companies within the UK. Woodland Carbon Code has two forms of credits, Pending Issuance Units (PIUs), which are ex ante credits based on removal estimates (i.e., promises to deliver verified credits in the future); these convert into verified Woodland Carbon Units (WCUs) once removal is verified ex post (p. 12).

[18] We appreciate the feedback and review provided by Pat Snowdon, Head of Economics and Woodland Carbon Code at Scottish Forestry.

	• Projects can sell either type of unit; PIUs cannot be used by buyers to meet regulatory requirements, however, they will automatically into WCUs once the project is verified, which can then be used to meet regulatory requirements. All credits and trades are recorded in a central registry. Buyers include UK corporates and smaller businesses. Prices range from €6 to over 20t/CO_2 and in 2019 accounted for 90% of volume sold in EU voluntary credit markets[2]; more info on buying credits. • Buyers are UK-based bodies seeking to offset their own emissions. 60% of credits have been sold upfront as pending issuance units. Buyers include retail stores, paper companies, transport and travel companies, among others. Since 2019, in England, the government has become a major buyer of English Woodland carbon credits through a Woodland Carbon Guarantee, which effectively takes the form of a reverse auction and subsequent minimum price guarantee for credits as they become verified ex post. • Landowners can then either accept the minimum price or sell on the open market. The Guarantee is additional funding from government to encourage woodland creation in England, which was implemented as a response to the low planting rates previously in England. • The Government's GHG inventory accounts for all woodland creation in assessing levels of CO_2 removals using a national carbon model.
Methodology scope	• **Specific removal solution covered:** Afforestation • **Land-use category:** Forestland, cropland, grassland • **Carbon pools:** Aboveground biomass (trees or other), belowground biomass, litter and deadwood, soil, GHG emissions from woodland management • **GHGs affected:** Carbon dioxide • **System boundary:** Project based, i.e., covering a section of one (or less commonly multiple) land units.
Solution	• Afforestation/reforestation - Covered by IPCC GL Volume 4 Chapter 4.[3]
MRV aspects	**Quantifying removals/emissions:** The Woodland Carbon Code sets out a step-by-step process with guidelines for planning and planting woodlands, registering and validating projects, verifying expected removals, receiving and selling carbon credits, and ongoing monitoring, verification, and verification (MRV) (p. 14 or see here). Expected carbon sequestration (and baseline storage) are calculated using a WCC Carbon Look-up Tables and a Calculation Spreadsheet (i.e., an excel sheet with underlying calculations). This calculates expected sequestration based on factors including timing of planting, species, woodland management, soil type and other factors, minus the baseline sequestration levels (see Additionality below). The look up tables were constructed using UK Forestry Commission models (the former are also used for forest carbon modelling for the national GHG inventory), which estimate growth and yield of different tree types in different contexts;[4] this would appear to align with IPCC Tier 3 methods. The monitoring and calculation can be completed by the landowner, project manager, or an independent third party. There are two slightly different quantification methods: 1) Standard approach (for projects >5ha) and 2) Small projects approach (for projects <5ha). The small projects approach is generally simpler, making more assumptions to lower transaction costs (e.g., assumes no leakage, assumes baseline of zero). • Specific additionality elements

- **Baselines** (p. 14): The Woodland Carbon Code requires projects to complete a baseline assessment of the project area when registering. They must submit a project design document in accordance with the guidance (and necessary evidence). This sets out a baseline (i.e., carbon stock without woodland planting) and the planned woodland planting and management (and quantifies expected project carbon sequestration), as well as carbon leakage. All of this is used to calculate the expected net removal (in terms of tCO_2 sequestered). The Project Design Document also sets out all administrative information, MRV plans, etc. Standard project baseline must include above and below-ground biomass (survey existing trees on site), soil carbon (look-up table based on previous land use), non-tree biomass (e.g., shrubs), litter and deadwood (assume zero). Small projects assume baseline of zero.
- **Leakage** (p. 15): As part of the baselining process, projects >5ha are required to consider whether activity shifting could occur due to Woodland creation (e.g., increase in intensity of land use in another area of land owned by the participant as a result of Woodland creation; no specific methodology is proposed). If this is expected to lead to emissions equivalent to more than 5% of the project, then this must be deducted as part of net sequestration calculation.
- **Additionality:** Must be additional to existing regulatory requirements. Financial additionality: carbon payments must be minimum 15% of project establishment/planting costs in first ten years; also, must pass investment test (without carbon finance, woodlands is either net negative or not most attractive land use) – if this is not passed, a barrier test can be applied e.g., investment, cultural, other barriers).

* **Uncertainties:** To manage any uncertainties in calculations, the Woodland Carbon Code removes 20% of estimated sequestration to guard against any modelling uncertainty. A further 20% is removed and placed in a buffer to protect against any future losses of verified credits, i.e., the projects only receive about 60% of estimated sequestration as credits (p. 10). This buffer is used to cover any losses of verified credits over the project duration (which if drawn down must be replenished e.g., through replanting) and are then retired at the end of project life. Previously, the Woodland Carbon Code had calculated different buffer contributions depending on project risk characteristics, but the flat 20% approach has applied since 2018 based on risk-analysis work by Edinburgh University.
* **Reporting requirements:** Projects must first register on the UK Woodland Carbon Code Registry, either individually or as a combined group of projects. Landowners' project plans must be validated ex ante and then verified ex post at least at year 5 and then every ten years. Monitoring at year five includes a visit by an external verifier (i.e., a field visit) and verifies that the woodland has been successfully established in line with the project plan (including density, species mix, tree health/protection). Monitoring at subsequent 10-year intervals will assess actual carbon sequestration and tree growth rates (included sampling measurements of tree density etc.). Small projects (<5ha) can apply optional streamlined validation and verification processes (i.e., with lower MRV requirements). Initial validation costs approx. £750 / project plus 6 pence per carbon unit listed in the registry. Additional costs borne by participants are for verification, this costs approximately £1,500- £2,000 / project with a site visit, or £750 / project with no site visit. In addition, the participant has to pay 3 pence per unit to convert units in the registry from pending to verified units. Costs per project can be reduced by joining with other projects in a group scheme.

	• **Verification and validation:** Projects must develop a monitoring plan as part of the project design documents, which an accredited independent body assesses and validates before projects can be implemented. Upon validation, projects receive Pending Issuance Units, which they can sell to buyers or retain to sell at a later date. Regulators convert these into Woodland Carbon Units upon verification. Credits are tracked in the UK Woodland Carbon Registry operated by HIS Markit. The Registry tracks issuance, ownership, transfer and use. Credits come in two types: Pending Issuance Credits, which are a "promise to deliver" but not guaranteed. Companies who purchase these can use them to make corporate social responsibility statements regarding future offset plans. These are converted upon verification into Woodland Carbon Units, which are ex post, guaranteed (with a buffer), and be used to offset emissions. • **Co-benefits/externalities:** To minimise the risk of negative externalities, projects are validated before they are approved (i.e., ex ante), this validation includes ensuring that projects are required to meet the Woodland Carbon Code standard, including managing for positive environmental outcomes as set by the UK Forestry Standard. To promote native woodlands, 75% of the Woodland Carbon Guarantee reverse auction funding is prioritised for predominantly native woodlands[5]. The co-benefits of the Woodland Carbon Code as a whole have been evaluated to include recreational use, non-use value of biodiversity and air quality regulation (which generates an average of £18 – 25 million per year), impacts on job creation and GDP (70 – 160 FTE, £4.8 million per year contribution, respectively), as well that parts of the Woodland Carbon Code project's area are in priority areas to manage river catchments (12.5%) and address social deprivation (2.2%).[6]
Permanence	• **Project duration:** Max 100 years. Minimum duration period is equal to the length of the clearfell management time-period (i.e., how long between planting and clearfelling of all trees, at which point all trees would be replanted). Many projects are for 40 years. • **Specific management of impermanence risks** (p. 10): to minimise risks of impermanence, landowners are required to identify and mitigate risks. They are required to restock if wood is harvested and replant if woodland is lost (e.g., through fire, pest, wind etc.). The project plan must set out plans for permanence (i.e., beyond the duration of the project). They are also contractually obliged to manage in accordance with their project plan, as are subsequent landowners. In addition, the standard relies on other UK regulations, e.g., the Code relies on UK contractual law and forestry legislation), which limits landowners ability to cut down woodlands without approval by the government, to help enforce permanence and reduce negative externalities; due to these additional legal restrictions, all projects are expected to be permanent. • Permanence is also supported through forestry legislation in the UK which makes woodland creation a permanent change in land-use, and through safeguards provided by Environmental Impact Assessments. • **Buffer:** If a reversal occurs, landowners must report the loss to Woodland Carbon Code, and can then draw on the buffer account. They must then replenish the buffer account by replanting or alternatively planting elsewhere. The buffer account is retired at the end of the project duration (i.e., not sold).
Key references	• COWI, Ecologic Institute, and the Institute for European Environmental Policy (Unpublished report) Analytical support for the operationalisation of an EU Carbon Farming initiative Task 1 and 2 Report: Appendix A: File cards of the schemes and projects. Prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007 • Woodland Carbon Code. UK Woodland Carbon Code. Hyperlink: https://woodlandcarboncode.org.uk/

	• Dickie, Ian, Tinch, Rob, Anderson, Shannon, Connaghan, Darren (2016). Assessing the wider benefits of the Woodland Carbon Code. Hyperlink: https://forestry.gov.scot/publications/sustainable-forestry/economic-research/588-assessing-the-wider-benefits-of-the-woodland-carbon-code

[1] Cevallos, Gabriella, Grimault, Julia, & Bellassen, Valentin (2019). Domestic carbon standards in Europe Overview and perspectives. I4CE and ClimateKIC. https://www.i4ce.org/wp-core/wp-content/uploads/2020/02/0218-i4ce3153-DomecticCarbonStandards.pdf

[2] Cevallos, Gabriella, Grimault, Julia, & Bellassen, Valentin (2019). Domestic carbon standards in Europe Overview and perspectives. I4CE and ClimateKIC. https://www.i4ce.org/wp-core/wp-content/uploads/2020/02/0218-i4ce3153-DomecticCarbonStandards.pdf

[3] IPCC (2019) Chapter 4: Forestry Land in: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use. https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch04_Forest%20Land.pdf

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[5] Woodland Carbon Code (2021) Woodland Carbon Guarantee (webpage). https://woodlandcarboncode.org.uk/woodland-carbon-guarantee

[6] Dickie, Ian, Tinch, Rob, Anderson, Shannon, Connaghan, Darren (2016). Assessing the wider benefits of the Woodland Carbon Code. Hyperlink: https://forestry.gov.scot/publications/sustainable-forestry/economic-research/588-assessing-the-wider-benefits-of-the-woodland-carbon-code

7.9 Fiche: Methodology - Carbon Dioxide Capture and Storage under CDM

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**Carbon Dioxide Capture and Storage under CDM** • Recommendation on CO_2 capture and storage as CDM project activities based on the review of cases NM0167, NM0168 and SSC_038 (link) • UNFCCC Decision 10/CMP.7 Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities (link)
Mechanism architecture overview	• **Overview and performance:** Carbon Dioxide Capture and Storage can be applied under the CDM since 2011, but no CCS methodologies or projects have been approved under the CDM yet[1] [2]. Please refer to the CDM mechanism fiche.

Methodology scope	• **Specific removal solution covered:** For CCS under the CDM there are currently modalities and procedures, which are project level guidance as there are no approved methodologies in place.[3] Three methodologies have been proposed, but they do not address the methodological and accounting issues appropriately or in adequate fashion. Consequently, the methodologies could not be approved in their current form but present key learnings[4]:
	  ◦ NM0167: capture CO_2 from industrial GHG emission sources and injection into geological reservoirs.[4]
	  ◦ NM0168: capture of a mixture of waste acid gases from natural gas processing plants and liquefied natural gas (LNG) plants and storage in underground aquifers or abandoned oil/gas reservoirs.[4]
	  ◦ SSC_038: CO_2 from power station flue gases is pumped through flowing seawater with limestone in porous baskets. Thereby, CO_2 is converted to bicarbonate leaving only a fraction (approx. 50%) of the flue gases.[4]
	• **Land-use category:** n/a
	• **Carbon pools:** n/a
	• **GHGs affected:** CO_2
	• **System boundary:** above-ground a) the installation where CO_2 is captured; b) treatment facilities; c) transportation equipment; d) reception facilities or holding tanks at the injection site; e) injection facility; f) subsurface components (i.e., geological storage site, potential sources of seepage). It encompasses vertical and lateral limits of the geological storage site expected when the CO_2 plume stabilizes during closure and post-closure phases.[3] For NM0167 activities capture, transport, injection, EOR installations, and the storage reservoir are included.[4] Considering NM0168, boundaries are compression, transport, and the storage reservoir. For SSC_038 those are the physical boundary of the power station and cooling water channel.[4] [5]

Solution	• CCS: 2006 IPCC Guidelines – Volumes 2 (Chapter 5) on carbon transport, injection and geological storage, Volumes 2 & 3 on carbon capture from fuel combustion (under "Energy") or process-related (under "Industrial Processes and Product Use") (link)
MRV aspects	• **Quantifying removals/emissions** ◦ Baseline setting: for NM0167: continued Enhance Oil Recovery with seawater; site section based on criteria in IEA GHG R&D Programme publication. For NM0168 the baseline is the incineration of the acid gas rather than the storage underground.[5]

	• **Uncertainties:** There is a trade-off between monitoring stringency and the cost of monitoring. Therefore, an uncertainty standard can be useful to reduce the risk. Suggestions cover discounting emission reductions based on the level of monitoring uncertainty, the use of conservative default or the choice to conduct own measurements or use good practice instruments by the project developer[6].
	• **Specific additionality elements**
	  ◦ Monitoring of the geological storage site shall begin before injection activities to ensure adequate time for the collection of baseline data[3]. Those sites shall only be used to store carbon dioxide as activities under CDM when there is no risk of seepage, environmental or health risks and when in compliance with host party laws and regulations[3]. Monitoring lasts for at least 20 years after the last crediting period.[6]
	  ◦ NM0167: emissions leakage is assumed to be negligible. If physical leakage is below 0.1% p.a., emission reductions are deemed permanent. If higher, permanence is insufficient and all CERs are cancelled[4].
	  ◦ NM0168: physical leakage estimated based on monitoring procedures (i.e., monitoring of CO_2 stream into reservoir, potential seepage paths through seismic measurements)[4].
	  ◦ SSC_038: leakage may occur using additional electricity to achieve a constant flow rate past the limestone cages[4].
	• **Monitoring and reporting requirements:** On collection, timing, risk and safety assessment, monitoring plan[3]. It is necessary to collect sufficient data and information to characterize the geological storage site and determine potential seepage pathways, e.g., geomechanically[3]. Monitoring shall be conducted in a two-stage process.
	  ◦ NM0167: direct measurement at injection point and underground via 4D seismic analysis. Methane in soil gas, impurities in injected CO_2 and potential seepage routes are not considered[4].
	  ◦ NM0168: CO_2 stream into the reservoir and potential seepage paths identified through seismic 3D measurements[4].
	  ◦ SSC_038: pH and temperature measurements and estimation of amount of Dissolved Inorganic Carbon (DIC). No monitoring of potential leakage.[4]
	• **Verification and validation:** Designated operational entities (DOEs) with appropriate experience are responsible for validation and verification. It determines whether a) monitoring is in accordance with monitoring plan, b) site development and management plan is being adhered to, c) significant deviations were observed, d) seepage occurred during the verification period[3]. For instance, site characterisation, risk and safety assessment, environmental and socio-economic assessment are covered.[7] In case of non-submission, CERs resulting from the project need to be compensated by cancelling other CO_2 allowances.
	• **Co-benefits/externalities:** Creation of environmental and social value associated with reducing carbon emissions to the atmosphere. Particularly when social costs are rising, increasingly beneficial for society.[8] Yet, CCS is an expensive and technically challenging carbon emissions abatement option and needs to be considered in the context of overall an efficient, sustainable and economic mitigation plan as, for instance, marginal costs for the gas sector in CCS are lower than for others.[8]

Permanence	• **Specific management of impermanence risks:** comprehensive risk and safety assessment necessary to assess integrity of site and potential impacts on human health and ecosystems in proximity to project. It shall prove a basis for remedial measures, including action plans to stop or control unintended emissions from surface installations and seepage[3]. If leakage occurs during the crediting period, it is deducted from the number of CERs. After the end of the last crediting period, seepage will be quantified, reported and addressed by the reserve account.[7] For NM0168, permanence is accounted for by discounting CERs for seepage beyond the crediting period based on an ex-ante estimated rate[4].
Key references	• Earth Ocean and Space Pty Ltd. (2005). Proposed Additional Project Category for Small-Scale CDM Simplified Baseline and Monitoring Methodologies: Anthropogenic Ocean Sequestration by Changing the Alkalinity of Ocean Surface Water (Alkalinity Shift). Version 2.2 (link) • Dixon, T.; Leamon, G., Zakkour, P. & L. Warren. (2013) CCS projects as Kyoto Protocol CDM activities. Energy Procedia. 37. 7599 (link) • Hardisty, P.E.; Sivapaplan, M. & P. Brooks. (2011). The Environmental and Economic Sustainability of Carbon Capture and Storage. Int J Environ Res Public Health. 8(5). 1460-1477 (link)

1 UNFCCC CDM website – CDM Methodologies (link)

2 Climate Analytics (2021), Governing large-scale carbon dioxide removal: are we ready? - an update (link)

3 UNFCC Decision 10/CMP.7 Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities (link)

4 UNFCCC CDM Executive Board (2006). Meeting Report Annex 13: Recommendation CO2 Capture and storage as CDM project Activities Based on the Review of Cases NM0167, NM0168, SSC_038 (link)

5 Earth Ocean and Space Pty Ltd. (2005). Proposed Additional Project Category for Small-Scale CDM Simplified Baseline and Monitoring Methodologies: Anthropogenic Ocean Sequestration by Changing the Alkalinity of Ocean Surface Water (Alkalinity Shift). Version 2.2 (link)

6 UNFCC. (n.d.) Guidance on Addressing Uncertainty. CDM-Meth Panel. 32nd meeting report, Annex 14 (link)

7 Dixon, T.; Leamon, G., Zakkour, P. & L. Warren. (2013) CCS projects as Kyoto Protocol CDM activities. Energy Procedia. 37. 7599 (link)

8 Hardisty, P.E.; Sivapaplan, M. & P. Brooks. (2011). The Environmental and Economic Sustainability of Carbon Capture and Storage. Int J Environ Res Public Health. 8(5). 1460-1477 (link)

7.10 Fiche: Methodology - Puro.Earth

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**Puro.earth's Rules and Methodologies: Puro.earth CO_2 Removal Marketplace – General Rules version 2.0** (link)
Mechanism architecture overview	• **Overview and performance:** Puro.earth is a global voluntary mechanism, that started in 2018/2019. The mechanism currently has three methodologies: biochar, carbonated building elements and wooden building elements. A methodology for geologically stored carbon is also underway.[1] • **Governance:** Puro.earth is a start-up under Fortum (a Nordic energy company with a purpose to drive change for a cleaner world), but was acquired by Nasdaq, a global technology company, as of June 2021. The CO_2 Removal Certificates (CORCs) compliance to the rules is audited by an independent assessor – DNV GL as of beginning of 2021. • **Operator/administrator:** Puro.earth • **Issuing Body:** Fortum Power and Heat Oy, which is responsible for issuing CORCs, for operating the system and for overseeing the reliability of the system, and for the Certificate Listing Service (an online service, that lists CORCs made available for Direct Purchase or Cancellation Purchase). • **Credit registry:** CO_2 Removal Marketplace where CORCs are issued, traded and cancelled. CORCs are issued to facilities capable of removing CO_2. Cancellation realized the value and removes it from circulation. The Registry and Auction System is operated by Grexel Systems Oyj, which is a subcontractor of Fortum Power and Heat Oy. • **Committee:** A market-independent Committee who gives statements on Removal Method Methodologies. The Committee is elected for a 1-year period at a time. • **Market:** Voluntary, CORCs are available in any country and are traded on a B2B basis. Buyers are primarily companies, municipalities, states and governments to get sufficient trading volume and liquidity right from the beginning.[2] • CORCs can be purchased through an online or Pre-Purchase agreement with suppliers. The price of the CORC is determined entirely by the supplier.[3] Costs of CORCs ranging from 20 € / CORC to 150 € / CORC.[4]
Methodology scope	• **Specific removal solution covered:** biochar, carbonated building elements, and wooden building elements. • **Land-use category:** n/a • **Carbon pools:** n/a • **GHGs affected:** CO_2 • **System boundary:** cradle-to-gate[1] • **Biochar:** Requirements for eligibility include a) use of biochar in applications other than energy, b) raw materials e.g., sustainably sourced or waste material, c) certified production process, d) in production process pyrolysis gases must be recovered, e) specific H/Corg and O/Corg ratios, which indicate the biochar stability. Activity boundary includes raw materials used, transport of raw material to production facility, production process and use of biochar, and excludes transport of the biochar to the end use site and emissions from end use. • **Carbonated building elements:** Eligible activity capable of producing as Output carbonated building element that is net CO_2 removing. Activity boundary includes raw materials used, transport of raw material to production facility and production process, and excludes transport of elements to construction site, construction, and end of life.

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- **Wooden building elements:** Including raw materials used; transport of raw materials to production facility; production process; long-term storage (proof of use in construction). Excluding transport of elements to construction site; construction; end-of-life.

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<tr><td>Solution</td><td>

- **CO_2 Removals**
  - **Biochar:** pyrolytic conversion of organic biomass to biochar (p. 16) – covered by IPCC GL 2006 Volume 4 Chapter 5
  - **Carbonated Building Elements:** chemical binding of CO_2 into the building element during the hardening phase – covered by IPCC GL 2006 Volume 3 Chapter 2
  - **Wooden Building Elements:** wooden building elements when used in construction of buildings – covered by IPCC GL 2006 Volume 4 Chapter 12

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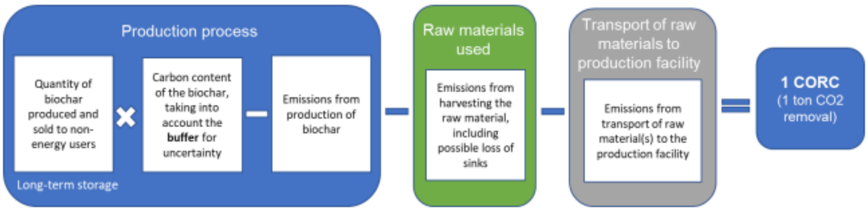
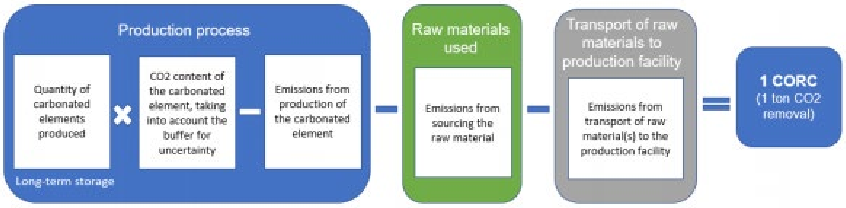
<tr><td>MRV aspects:</td><td>

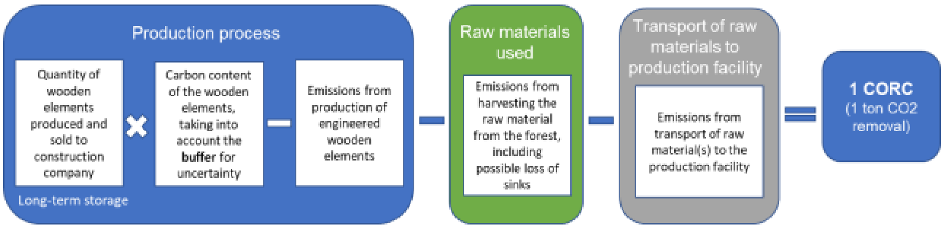
- **Quantifying removals/emissions:**
  - **Biochar:** Calculation and calculation parameters are shown in the figure below. Certified sampling process for carbon content and the solar O/Corg ratio required. Valid certificate of sustainable biochar production is required e.g., from the European Biochar Foundation (EBC). Alternatively, LCA or carbon footprint results are accepted for calculation. Calculation formula of CO_2 removal:



  - **Carbonated building elements:** Calculation parameters include and calculation parameters are shown in the figure below. Existing LCA or EPD with verification from a third party may be used as reference for calculation where applicable. Calculation formula of CO_2 content:



  - **Wooden building elements:** Calculation parameters include, and calculation parameters are shown in the figure below. Existing LCA or EPD with verification from a third party may be used as reference for calculation where applicable. Calculation formula of CO_2 removal:



- **Uncertainties:**

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	- Possible uncertainties include metering inaccuracies, losses of the CO_2 storage after production, or other losses that may occur. A buffer is used to reflect the uncertainty i.e., uncertainty-corrected CO_2 Removal Output. Any uncertainties or losses that may occur needs to be estimated and corresponding buffer-percentage defined. - Biochar: uncertainties during production include metering inaccuracies in production volumes and in CO_2 storage volumes due to sampling or testing techniques. During use include amount of decomposing or re-emitting of CO_2 in the normal use of the product. - Carbonated building elements: uncertainties during production include metering inaccuracies in production volumes and in CO_2 content in the element due to sampling or testing techniques. During use include amount of decomposing or re-emitting of CO_2 in normal use of the product. Proof of no re-emitting or decomposition needs to be presented. - Wooden building elements: uncertainties during production include metering inaccuracies in production volumes and in CO_2 content in the element due to sampling or testing techniques. During use include possible decomposing or re-emitting during the lifetime of the product. Small risk that CO_2 is re-emitted before end of life due to unlikely incidents such as fire and flooding. • **Reporting requirements:** - **Reporting entity:** CO_2 Removal Supplier e.g., production facility. - **Proofs and evidence needed from the CO_2 Removal Supplier include:** Principle of eligibility; Raw materials used; Production process of the CO_2 positive carbonated product and quality of the product; end use of CO_2 removing product; and no double counting, which can be documented in the form of certificates, lab results, chemical formulas, LCA or EPD, measured data, book-keeping, documentation of sale, statements, and use of standards. - Biochar: FSC certification as proof of sustainability of the raw material used; EBC certificate and lab results as proof that production technology of the CO_2 removing end product (biochar) is net CO_2-negative; data and documentation from book-keeping as proof of production volume; documentation of sale as proof that end-use of the product does not cause CO_2 returning to the atmosphere (it is not burned or sold for energy use); evidence of no double counting in the form of a statement from the Removal Supplier. - Carbonated building elements: documentation of sustainably sourced or third party verified LCA or EPD and also CO_2 emissions from extraction and manufacturing as proof of the used raw materials and their composition; description of technology as proof of CO_2 positive production; lab test as proof of amount of CO_2 absorbed in an element and CO_2 emissions created in production process; chemical formula or other verifiable method as proof of leakage or no leakage of CO_2 after production; lab tests and assessments as proof of quality; use of standards e.g., ISO 14067 or similar; evidence of no double counting in the form of a statement from the Removal Supplier. - Wooden building elements: Eligible activity types include Production of engineered wooden building elements, sourced from sustainably managed forests and used for construction of buildings, also elements need to be installed-to-measure, pre-cut and ready for construction when shipped from the production facility. Standards or certificates as proof of sustainability of the raw material used; Lab tests, EDP or LCA as proof that production technology of the product is net CO_2-removing; output report and book-keeping as proof of production volume; shipping and delivery documentation as proof of end use of CO_2 removing product; evidence of no double counting in the form of a statement from the Removal Supplier.

	• **Verification and validation:** Verification is done in a Production Facility Audit to ensure facility is eligible and that corresponding CO_2 removal has taken place and is considered permanent. DNV GL is the Output Auditor and Production Facility Auditor. • **Leakage:** ◦ Biochar: Possible CO_2e emissions from the waste heat/gas from the biochar production process (not captured and used). ◦ Carbonated building elements: Leakage of CO_2 from the finished product in normal use conditions does not occur. The product is used in construction and will in normal use not be heated to temperatures where CO_2 leaks (temperature where there could be a CO_2 leak is at temperatures above 800 C). The CO_2 stored in the product will not be re-emitted in case the house or construction where the product is used is demolished. The crushed elements can be reused e.g., for road construction or in new carbonated products, without the captured CO_2 leaking. ◦ Wooden building elements: no leakage aspects described in methodology. • **Co-benefits/externalities:** Co-benefits are not in the scope of Puro.Earth. However, suppliers mention reduced waste, displacement of conventional more energy-intensive products, certified sustainably sourced materials, green jobs and local employment.[4]
Permanence	• **Specific management of impermanence risks:** ◦ A correction in the form of a buffer in percentage (%) is used to reflect the uncertainty and to reduce the volume of CO_2 removal Output to be certified i.e., uncertainty-corrected CO_2 Removal Output=Output*(100%-Buffer). ◦ The CORC issuing process is based on CO_2 removal actions that have already been completed prior to issuing the CORC, which can eliminate the possibility of issuing more than one CORC for the same production output and limits vintage, as CORCs that have not been activated expire after 18 months from the issuing date.[5] ◦ The Issuing process eliminates the possibility of Issuing more than one CORC for the same Output. CORCs are Issued based on an Output Report from the CO_2 Removal Supplier for a specified time period and produced in a Production Facility registered in the System. CORCs are always Issued for net CO_2 Removal in the production process, taking into account CO_2 emissions directly or indirectly generated by the removal process or materials used
Key refer-ences	• Puro.earth website • Puro.earth (2019), White paper – Reversing climate change with Puro CO_2 removal marketplace (link)

[1] Puro.earth website – Carbon Removal Methods (link)

[2] Puro.earth (2019), White paper – Reversing climate change with Puro CO_2 removal marketplace (link)

[3] Puro.earth website – FAQ (link)

[4] Puro.earth website – Suppliers (link)

[5] Puro.earth website – Why Puro.Earth (link)

7.11 Fiche: Methodology - Alberta Carbon Offset Program CCS

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**Alberta Carbon Offset Program (2015), Quantification Protocol for CO_2 Capture and Permanent Storage in Deep Saline Aquifers** (link)
Mechanism architecture overview	• **Overview and performance:** Purchasing Alberta-based emission performance credits (EPC) is one of the compliance options for regulated entities under the Technology Innovation and Emissions Reduction Regulation in Alberta. Since 2007 the mechanism can be applied to large industrial emitters to report emissions and carry out mandatory reductions. Thereby, one EPC credit is equal to a reduction of one tonne of CO_2e. Within the Alberta Carbon Registries there are 80 mil Active AEOR Offsets, 100's of Registered Projects, 100's of Total Facilities, and 100,000's of Active EPC Credits. The offset period is set at 20 years with the possibility of a 5-year extension. There are 16 approved protocols.[1] • **Governance:** Project approval through carbon sequestration lease(s) issued in accordance with the Mines and Minerals Act (2011) and Carbon Sequestration Tenure Regulation. Offsets are quantified using approved methodologies, registered and publicly accessible on the Alberta Emission Offset Registry (AEOR) and the Alberta Emission Performance Credit (EPC) Registry. The latter is operated by the CSA Group in coordination with the Government. Offsets are verified by a third party.[1] • **Market:** EPC credits are revocable licenses which can be banked or sold, and ultimately retired by facilities subject to the regulation to meet their reduction targets.[1]
Methodology scope	• **Specific removal solution covered:** Carbon capture and storage (CCS) in deep saline aquifers. • **Land-use category:** n/a • **Carbon pools:** n/a • **GHGs affected:** Carbon dioxide, methane and nitrous oxide (quantification of emissions affecting materiality as result of project necessary). • **System boundary:** The full CCS chain from capture through compression, transport, injection into deep saline aquifers and storage.

MRV aspects	• **Quantifying removals/emissions:**
	  ◦ **Net GHG emission reductions and removals:** Project emissions throughout capture, compression, transport and injection are subtracted from baseline emissions. Sources and sinks that are not expected to change between baseline and project are excluded from quantification. Appropriate quality data shall support the quantification requirements.
	  ◦ **Baseline setting:** Project-based baseline to quantify emissions that would have been emitted in the absence of the project based on ISO 14064-2 and recommendations by Alberta Environment and Parks and Environment Canada. Baseline is established as project emissions subtracted from of injected CO_2.

	- **Project emissions:** include quantification of 1) Production and Delivery of Material Inputs used in CO_2 Capture Process, 2) Extraction/Processing and Transportation of Fuels Used On Site for Heat and Electricity Generation, 3) Extraction/Processing and Transportation of Fuels Used Off Site for Heat Generation, 4) Extraction/Processing and Transportation of Fuels Used for Generation of Off-Site Electricity, 5) Off-Site Electricity Generation, 6) Off-Site Heat Generation, 7) On-Site Heat and Electricity Generation, 8) Carbon Capture and Storage Facility Operation, 9) Venting of CO_2 at Injection Well Sites, 10) Emissions from Subsurface to Atmosphere, and 11) Loss, Disposal, or Recycling of Materials Used in CO_2 Capture Processes. Quantification through direct metering, samples, calculations, and measurements. Equations and methods are provided in protocol. - **Uncertainties:** If leak event occurs, the mass of CO_2e leaked from the subsurface to the atmosphere shall be estimated with a maximum overall uncertainty over a reporting period of ±7.5%. In case the overall uncertainty of the applied quantification approach exceeds ±7.5%, an adjustment shall be made. • **Additionality:** Additionality can be assessed according to four main components: emissions, technological, legal/regulatory, and financial indicators. To determine additionality, activities are subject to regulatory surplus review, an analysis of the penetration rate, and various barriers analyses, depending on the status of the activities.[2] • **Monitoring and reporting requirements:** - **Monitoring data collection:** Measurements of relevant parameters to account for all supplemental energy inputs required for the operation of the CCS project. Monitoring techniques should use off the shelf metering equipment. Data collection must be sufficient to support quantification and verification of emission reductions. - **Monitoring plan:** is required and must specify how data for all relevant parameters will be collected and recorded. The plan must include: frequency of data acquisition; record keeping plan; frequency of instrument calibration activities; QA/QC provisions on data acquisition, management and record keeping that ensures consistency and precision; roles of individuals performing specific monitoring activities; methods to measure and quantify incremental energy inputs required to capture, transport, inject and store CO_2, quantity of CO_2 emitted from the capture site, quantity of CO_2 input into the CO_2 transport pipeline, quantity of CO_2 sold to third parties, and quantity of CO_2 injected into each well in the deep saline aquifer metered at the wellhead. - In addition, a Measurement, Monitoring and Verification Plan (MMV), specific to the storage complex that CO_2 is being injected into, must be submitted and approved that identifies all activities needed to demonstrate containment of the injected CO_2. MMV Requirements apply to four project phases, i.e., 1) Pre-injection, 2) Injection, 3) Closure, and 4) Post-closure. - **Monitoring procedures:** include continuous measurements and metering. Meters must be maintained for consistency and calibrated regularly. - **Documentation:** include project eligibility, baseline documentation and project documentation. Record keeping after end of crediting period is required for seven years. - **Quality assurance:** include, but are not limited to, protecting monitoring equipment, protecting records of monitored data (hard copy and electronic storage), checking data integrity on a regular and periodic basis, providing sufficient training to operators, and performing recalculations.

	• **Verification and validation:** Validation, verification and audit is performed by a third party. Reasonable assurance shall confirm the accuracy of the GHG assertion. Mandatory review every 5 years assesses the state of science, general assumptions on emission factors, adoption rates and additionality of the activity. Independence to be documented in "conflict of interest form" as part of the validation or verification report.
	• **Co-benefits/externalities**
	  ◦ Beyond Canada, deep saline aquifers are distributed across the world and have the largest storage capacity, with sufficient capacity to store emissions from large stationary CO_2 sources for at least a century.[3]
	  ◦ Deep saline aquifers have largest identified storage potential and could therefore be a bridging technology in the transition to carbon-free energy sources.[3]

Solution	• CCS: IPCC Guidelines – Volumes 2 (Chapter 5) on carbon transport, injection and geological storage, Volumes 2 & 3 on carbon capture from fuel combustion (under "Energy") or process-related (under "Industrial Processes and Product Use") (link)

Permanence	• **Specific management of impermanence risks:**
	  ◦ Quantification methods to quantify reversals are provided in protocol (p. 64). Emissions from leakage events must be quantified and included consistent with the approved measurement, monitoring and verification plan.
	  ◦ MMV plan that identifies all activities needed to demonstrate containment of the injected CO_2 must be submitted and receive approval. MMV includes minimum requirements for well abandonment, testing to detect leakage and mitigation measures in the event of detecting leakage (ibid).
	  ◦ Accidental/intentional release or removals from the deep saline aquifer after the project crediting period must be corrected before the certificate of completion is approved (measurement, monitoring and verification for different project phases, see MMV plan).

Key references	• Alberta Carbon Registries website (link) • Government of Alberta (2018), Technical Guidance for the Assessment of Additionality (link) • Celia, M.A.; Bachu, S., Nordbotten, J.M. & K.W. Bandilla. (2015). Status of CO_2 storage in deep saline aquifers with emphasis on modeling approaches and practical simulations. Water Resource Research (link) • Duan, Y. & Wu, T. (2020). An Analysis on the Effects of Carbon Pricing in Alberta (Unpublished master's project). University of Calgary, Calgary, AB (link)

1 Alberta Carbon Registries website - About (link)

2 Government of Alberta (2018), Technical Guidance for the Assessment of Additionality (link)

3 Celia, M.A.; Bachu, S., Nordbotten, J.M. & K.W. Bandilla. (2015). Status of CO2 storage in deep saline aquifers with emphasis on modeling approaches and practical simulations. Water Resource Research. (link)

7.12 Fiche: Methodology - American Carbon Registry CCS

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	The American Carbon Registry (2015), Methodology for Greenhouse Gas Emissions Reduction from Carbon Capture and Storage Projects (link) • • The information from this fiche comes primarily from the methodology document.
Mechanism architecture overview	• Overview and performance: The American Carbon Registry (ACR) was founded in 1996 as the GHG Registry by the environmental non-profit organisation Environmental Resources Trust (ERT) and was the first private voluntary GHG registry in the USA. It is now part of Winrock International, a non-profit based in the USA. As of June 2017, 80+ million tons of CO_2-e emissions reduction credits issued.[1] • Governance: ACR is governed by the Board of the Environmental Resources Trust (ERT) • Market: In the voluntary market, ACR oversees the registration and independent verification of projects that meet ACR Standards and follow ACR approved carbon accounting methodologies.[1] The “ERT” is the ACR unit of exchange for tradable, project-based verified carbon offsets. ERTs refer to both emission reductions and enhancements in sequestration. ACR issues one ERT for each metric tonne of CO_2e emission reductions or removals verified against an ACR standard and methodology.
Methodology scope	• Specific removal solution covered: CCS projects that capture, transport and inject anthropogenic CO_2 during enhanced oil recovery (EOR) operations into an oil and gas reservoir located in the US or Canada where it is sequestered. • Land-use category: n/a • Carbon pools: n/a • GHGs affected: carbon dioxide (CO_2) • System boundary: The project boundary includes a physical boundary, a temporal boundary, and a greenhouse gas (GHG) assessment boundary. The physical boundary includes the full CCS process, covering emissions from CO_2 capture, transport, and storage in oil and gas reservoirs, as well as CO_2 recovery and re-injection operations at EOR sites. The temporal boundary consists of the crediting period (10 years and can be renewed) and the project term (length of time with commitment to project continuance, monitoring and verification, +5 years). The GHG assessment boundary entails the greenhouse gases included in calculations of baseline emissions and project emission, i.e., carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).
Solution	CCS: 2006 IPCC Guidelines – Volumes 2 (Chapter 5) on carbon transport, injection and geological storage, Volumes 2 & 3 on carbon capture from fuel combustion (under “Energy“) or process-related (under “Industrial Processes and Product Use“) (link)

MRV aspects	• Quantifying removals/emissions: • Net GHG emission reductions and removals: GHG emission reductions (ERs) equal Baseline Emissions minus Project Emissions. • Baseline setting: Two baseline options, Projection-based and Standards-based. Projection-based option corresponds with the project's actual CO_2 capture site, without the capture and compression system located at the CO_2 source. Baseline emissions are determined according to actual measured quantities of CO_2 captured from the project and prevented from entering the atmosphere. The Projection-based baseline option is mostly used for CCS projects. A standards-based option can be based on a technology or specified as an intensity metric or performance standard. It is sector-specific to ensure reasonable accuracy, but it could mean that different emissions profile is used than that at the CO_2 capture site. • Project emissions: CCS project emissions equal the sum of CO_2e emissions from CO_2 capture, transport, and storage. • Uncertainties: Detection and identification of leakage and potential leakage pathways. Uncertainties are primarily associated with fluid flow and composition analysis of gas and liquid streams, plant operating parameters, and accurate logs of emission leakage events maintained by site operators. The sources and relative magnitude of uncertainties (and changes thereof) shall be explicitly addressed, discussed and described in the GHG Project Plan. • Additionality: To qualify as additional, the project must 1) Pass a regulatory additionality test; and 2) Exceed a performance standard. To pass the regulatory surplus test, a project must not be mandated by existing laws, regulations, statutes, legal rulings, or other regulatory frameworks. It can be considered surplus if the CO_2 captured and stored exceeds the requirements imposed by regulation. To exceed a performance standard, a project is required to achieve a level of performance that is significantly better than average compared with similar practices or activities that are recent and in a relevant geographic area. The performance threshold may be: 1) Practice-based, 2) Technology standard, or 3) Emissions rate or benchmark. • Leakage: If atmospheric leakage is detected during injection operations, it must be quantified and deducted as project emissions in the year the leakage was detected. Operators must identify leakage pathways from the subsurface through a detailed site characterisation and monitor atmospheric leakage during the entire Project Term, including injection period and a time-period following the end of injection. Examples of leakage pathways include CO_2 injection wells, oil or gas production wells, monitoring wells, abandoned wells, and faults and fractures. Leakage is estimated based on monitoring and measurements completed as part of the MRV plan. • Monitoring and reporting requirements: • Monitoring data collection: Data collection related to the measurement, quantification and verification of facility processes, CO_2 capture, transport, storage, leakage which include continuous, daily or monthly measurement or metering of monitoring parameters. Monitoring parameters include but are not limited

	to: total volume of gas produced, % CO_2 in gas stream, volume of gas captured, volume or mass of fuel, electricity usage, quantity of thermal energy and electricity purchased, quantity of process energy generated.
	• Project Monitoring plan: A detailed monitoring, reporting, and verification (MRV) plan must be developed for each geologic storage site used in the CCS project (p. 49), which shall include: Determination of the storage volume; Identification of potential leakage pathways within this storage volume; Remediation of potential leakage pathways (as needed); Development of a monitoring strategy to demonstrate effective retention of anthropogenic CO_2 and for detection of potential leakage; A strategy for quantifying any atmospheric leakage of CO_2; A plan for monitoring the parameters outlined in the protocol.
	• Monitoring plan reporting: The MRV reporting shall include: Description of the reservoir where CO_2 is injected; Description of model and key model parameters; Site characterisation of the storage volume; Monitoring strategy, including procedures, tools, and frequency; remedial actions taken to rectify the source of leakage, if leakage is detected.
	• Quality assurance: QA/QC procedures need to assure data quality and completeness. QA/QC procedures include e.g., calibration, data collection procedures to ensure site-specific data, periodic reviews of data accuracy, completeness and consistency.
	• Verification and validation:
	• Requirements: The ACR Standard requires a field visit by the verifier at minimum every 5 years. In between field visits, verification may be via a desktop assessment, which may be annual or at any other interval at the Project Proponent's discretion, but verification is required prior to any issuance of offset credits. For CCs projects an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) may be required.
	• Verification and validation responsibilities: Validation of the MRV plan shall be conducted by a competent third party Validation and Verification Body (VVB) with in-house or subcontracted CCS expertise. The VVB also reviews the EOR operator's injection permit and verify that site compliance remained during the reporting year. The project specific MRV Plan requires independent validation by a professional with demonstrated experience and a high degree of knowledge of design and implementation of CCS monitoring systems, along with earth science expertise relevant to monitoring. Validation of initial MRV Plan and subsequent validations and verifications must also be signed off by a registered Professional Engineer (PE) or geologist.
	• Co-benefits/externalities:
	  ◦ Mitigation plan for any foreseen negative community or environmental impacts or claims of negative community or environmental impacts made during the reporting year, including legal actions and/or other written complaints.
	  ◦ There can be issues of pore space ownership, but they are beginning to be addressed.
	  ◦ No Sustainable Development requirements. Impact assessment to ensure compliance with environmental and community safeguards best practices.[2]

Permanence	• **Specific management of impermanence risks:** ◦ Project Proponents must demonstrate through monitoring and modelled scenarios that the CO_2 captured and stored is permanently sequestered underground. ◦ If leakage occurs, the Atmospheric Leakage Mitigation Procedures must be followed. If atmospheric leakage occurs during the post-injection period, then the Project Proponent shall mitigate the leaked quantity by liability insurance or by the retirement of an equivalent quantity of offset credits from the project's Reserve Account. Project Proponents shall indicate their mitigation strategy (i.e., insurance or Reserve Account) in their GHG Project Plan. Monitoring period is based on the site-specific monitoring plan. The minimum post-injection monitoring period is five years and may be extended further depending on the results of the first five years. ◦ The emission reduction calculations in this methodology are designed to minimize the possibility of overestimation and over-crediting of GHG emission reductions, due to various uncertainties. These uncertainties are addressed in the GHG Project Plan and the QA/QC program elements. ◦ Corrective plan for wells of high risk of leakage, which may involve remediation or monitoring for leakage at the well.
Key references	• The American Carbon Registry website (link) • Perspectives Climate Group (2019), Overview and comparison of existing carbon crediting schemes (link) • California Air Ressource Board (2016), Carbon Capture and Sequestration Protocols Comparative Study (link)

[1] The American Carbon Registry website (link)

[2] Perspectives Climate Group (2019), Overview and comparison of existing carbon crediting schemes (link)

7.13 Fiche: Methodology - Carbon Capture and Sequestration (CCS) Protocol under the Low Carbon Fuel Standard (LCFS)

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**California Air Resources Board (2018), Carbon Capture and Sequestration (CCS) Protocol Under the Low Carbon Fuel Standard (LCFS)** (link) *The information from this fiche comes primarily from the methodology document.*
Mechanism architecture overview	• **Overview and performance:** The California Air Resources Board (CARB) adopted the Carbon Capture and Sequestration Protocol (CCS Protocol) under the Low Carbon Fuel Standard for use in its Low Carbon Fuel Standard (LCFS). The LCFS is designed to reduce greenhouse gas emissions associated with the life cycle of transportation fuels used in California and diversify the state's fuel mix.[1] Examples of how the CCS Protocol can be used in the LCFS include low carbon fuel pathway, refinery investment, innovative crude, or direct air capture. To generate credits for CCS projects, capture facilities can earn credits and need to be co-applicants but do not need to be co-located. All CCS projects must receive a Permanence Certification before credit generation is possible. Recognized reservoirs under the LCFS include saline formations, CO_2 enhanced oil recovery, and depleted oil and gas reservoirs.[2] • **Governance:** The California Air Resources Board (CARB). • **Market:** The program has an established market for credit transactions. The total value of credit transactions exceeded $2 billion in 2018. There are three ways to generate credits in the LCFS: fuel pathways, projects, and capacity-based crediting. Applications for carbon capture and sequestration may be approved through: 1) AFP (fuel pathway-based crediting) if the capture occurs within the process of an alternative fuel pathway, e.g., CO_2 from ethanol fermentation, 2) LRT (project-based crediting) if the capture is associated with crude oil production (Innovative Crude provisions) or a petroleum refinery (Refinery Investment Credit provisions), or by direct air capture (not associated with any fuel; may be credited as a stand-alone project).
Methodology scope	• **Specific removal solution covered:** CCS projects, including direct air capture, CCS at oil and gas production facilities, CCS at refineries and all other CCS projects, e.g., CCS with ethanol (projects can be anywhere, provided the transportation fuel is sold in California).[3] • **Land-use category:** n/a • **Carbon pools:** n/a • **GHGs affected:** Primarily CO_2, but N_2O, CH_4, CO and VOC are also covered. • **System boundary:** All CO_2 sources, sinks, and reservoirs (SSRs) from the CCS project. The system boundary begins with carbon capture and ends with injection operations including CO_2 leakage. Downstream emissions of the sequestration site are excluded.
Solution	• CCS: IPCC Guidelines – Volumes 2 (Chapter 5) on carbon transport, injection and geological storage, Volumes 2 & 3 on carbon capture from fuel combustion (under "Energy") or process-related (under "Industrial Processes and Product Use") (link)
MRV aspects	• **Quantifying removals/emissions:** ◦ Net GHG emissions reductions are equal to 'Amount of injected CO_2 (MT CO_2/year)' minus 'CCS project GHG emissions (MT CO_2e/year)'.

	- **Baseline setting:** Project Operators must design a baseline testing strategy that supports and informs a testing and monitoring program that is capable of detecting leaks of CO_2 outside of the sequestration zone and storage complex. Project Operator must submit a descriptive report of baseline monitoring data and interpretations that must include geophysical, pressure, and chemical data from the subsurface, near surface, and surface analyses. - **Project emissions:** Emissions are calculated as 'GHG emissions associated with carbon capture, dehydration, and compression' plus 'GHG from CO_2 transport' plus 'GHG emissions from injection operations' plus 'GHG emissions from direct land use change'. Equations are provided for each of the parameters. - **Uncertainties:** Examples of possible material uncertainties include, but are not limited to: 1) High permeability zones that may lead to horizontal CO_2 leakage; 2) Natural or well-related flaws in the confining system that may allow vertical CO_2 leakage; 3) Compartmentalisation of the sequestration zone that may lead to elevated pressure; and 4) Geomechanically sensitive features that may be activated by pressure changes and increase risk of unacceptable seismicity. • **Monitoring and reporting requirements:** - **Reporting frequency:** For crediting purposes, CCS Project Operators are required to submit quarterly or annual reports of GHG emissions reductions and ongoing monitoring results (depending on how often the project elects to undergo verification). - **Reporting requirements:** Reports must include the quantification and documentation of CO_2 sequestered, including all metered measurements of inputs to GHG emissions reductions, analysis of the CO_2 stream, and injection rate and volume. For crediting purposes, CCS Project Operators are also required to submit annual reports of GHG emissions reductions, project operations, and ongoing monitoring results. This includes, e.g., operational parameters, summary of any incidents or changes in operational parameters, summary of any incidents that required implementation of emergency and remedial response etc. - **CCS project emissions monitoring:** Quantification and measurement activities required to quantify the net GHG reductions from the CCS project. Encompasses the analysis of the CO_2 stream, injection rate and volume, injection pressure, fluid volume, corrosion monitoring, mechanical integrity, pressure fall-off test, surface monitoring. - **Monitoring, measurement and verification plan (MMV):** MMV activities to ensure safe and permanent storage of CO_2. The plan must be specific to the CCS project's storage complex and include those methods the CCS Project Operator will use to monitor the extent of the CO_2 plume and elevated pressure, any atmospheric CO_2 leakage, and natural and induced seismic activity as well as methods and plans for the quantification of CO_2 leakage if it occurs. The plan must be able to; 1) Validate that the computational modelling shows the CO_2 plume will remain within the storage complex at least until the end of the post-injection site care and monitoring period; and 2) Ensure that if any CO_2 leakage occurs, it is detected with a detection threshold equal to, or better than, 5% of the total volume of leaked CO_2. - **Documentation:** Reporting must be in an electronic format. Recordkeeping of all monitoring information, including all calibration and maintenance records and all original chart recordings, is required for a period of 10 years after site closure. • **Verification and validation:**

	- **Verification responsibilities:** Third-party verification. Each verification team must include a CARB-accredited oil and gas systems specialist, and a professional geologist with the required level of experience and expertise. Third-party verification is international best practice for credible greenhouse gas monitoring and reporting and considered a requirement for carbon pricing systems. The verification program is based on ISO 14064-3 and 14065. From 2019 onwards, verifiers will apply for CARB accreditation and take required training and exam(s). CARB will publish the list of verification bodies and verifiers accredited to perform LCFS verification services on the LCFS website.[2] - **Verification must include:** a review of documentation and maps to verify the boundaries of the project; procedures for data quality assurance and quality control; the operator's CCS project risk rating for determining its contribution to the LCFS Buffer Account; all plans, assessments, and reports for conformance with the LCFS Regulation and the requirements of this protocol. CCS projects must be verified pursuant to sections 95500 through 95503 of the LCFS Regulation, regarding requirements for verification and validation, including accreditation requirements for verification bodies and conflict of interest assessment of verifiers[4]. - **Verification of CO_2 leakage:** Within six months of an event that triggers CO_2 leakage, the operator must submit the verified mass of CO_2 leakage. The verification team must review the quantification and methods for determining CO_2 leakage reported by the project operator. - **Specific additionality elements:** The term "additionality" is not mentioned in the methodology. • **Co-benefits/externalities:** - Diversifying fuel mix, reducing petroleum dependency, and reducing GHG emissions as well as other air pollutants.[3] - Potential opportunity to combine or "stack" LCFS credits with 45Q tax credits.[3]
Permanence	• **Specific management of impermanence risks:** - To receive credits issuance under this protocol, the following applies: 1) All CCS projects must contribute a percentage of LCFS credits to the Buffer Account at the time of LCFS credit issuance by CARB; 2) Sequestered CO_2 must remain within the storage complex for at least 100 years in order to be considered permanently sequestered and subsequently credited; and 3) Buffer Account contributions: the CCS project's contribution to the Buffer Account is determined by a project-specific risk rating method. - Issued credits will be invalidated if the sequestered CO_2 migrates outside the storage complex or is released to the atmosphere. The amount of credits that will be invalidated for CCS projects is equal to the CO_2 leakage originating from the storage complex. - Site-Based Risk Assessment shall quantify the risk of CO_2 leakage over a period of 100 years post-injection. It describes the potential pathways for leaks or migration of CO_2 out of the storage complex and the potential resulting scenarios. The results of the risk assessment must be used to inform and design the Testing and Monitoring Plan as well as building the foundation to submit a Risk Management Plan. High risk scenarios must be mitigated to be able to re-classify those as medium or low risk. - CCS Project Operators must monitor the surface, near-surface, and deep subsurface for CO_2 leakage that 1) may endanger public health or the environment, or 2) require reversals of the storage credits due to a failure to achieve and maintain permanence.

	• Inspection and Leak Detection Plan that includes: 1) Quarterly inspection of all wellheads, valves, and piping, employing effective gas leak detection technology; 2) Bi-annual testing of all surface and subsurface safety valve systems to ensure ability to hold anticipated pressure; and 3) Annual testing of the master valve and wellhead pipeline isolation valve for proper function and verification of the valve's ability to isolate the well. • To be eligible to claim credits, a CCS operator must receive a Permanence Certification by demonstrating the suitability of the sequestration site to permanently store CO_2, e.g., through minimum site selection criteria, and needs to have established plans and financial resources to manage any residual risk of CO_2 leakage over the project's lifetime.[3]
Key references	• California Air Resource Board (2020). Low Carbon Fuel Standard. Basic Notes (link) • Elkind, E.N.; Lamm, T. & K. Segal (2020). Capturing Opportunity: Law and Policy Solutions to Accelerate Engineered Carbon Removal in California (link) • Townsend, A. & I. Havercroft (2019). 2019 Policy Report: The LCFS and CCS Protocol: An Overview for Policymakers and Project Developers. Global CCS Institute. Version 2 (link)

1 California Air Resource Board (2019), Low Carbon Fuel Standard FAQ - Carbon Capture and Sequestration Project Eligibility (link)

2 California Air Resource Board (2020), Low Carbon Fuel Standard. Basic Notes (link)

3 Townsend, A. & I. Havercroft. (2019), 2019 Policy Report: The LCFS and CCS Protocol: An Overview for Policymakers and Project Developers. Global CCS Institute. Version 2 (link)

4 California Air Resource Board (2020), Unofficial Electronic Version of the Low Carbon Fuel Standard Regulation. (link)

7.14 Fiche: Methodology - US45Q Tax credit system

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	**US 45Q tax credit system – MRV guidance on the tax credit requirements** (link) *The information from this fiche comes primarily from the methodology document.*
Mechanism architecture overview	• **Overview and performance:** 45Q - named after the relevant section in the US tax code - first enacted in 2008. In 2018, the United States expanded and enhanced its federal carbon capture "45Q" tax credits. In January 2021, the Treasury Department and Internal Revenue Service (IRS) issued final regulations regarding the section 45Q credit[1]. • **Governance:** Treasury Department and Internal Revenue Service (IRS) (USA) • **Market:** The 45Q tax credits provides incentives for CCS applications in a variety of energy-intensive sectors. The tax credit applies to those investing in and using equipment for carbon capture. The 2018 45Q provisions increased credits per tonne of qualified carbon captured by the taxpayer from \$10/tonne for enhanced oil recovery (EOR) projects and \$20/tonne for geological storage to \$35/tonne and \$50/tonne, respectively (plus inflation)[2]. The value of 45Q tax credits is fixed and rises linearly from \$31/tCO_2 and \$19/tCO_2 in 2019 to \$50/tCO_2 and \$35/tCO_2 in 2026, respectively, for CO_2 stored in dedicated geological storage and injected for utilisation purposes. Thereafter, the value of the tax credit will rise with inflation.[3]
Methodology scope	• **Specific removal solution covered:** Capture and disposal, injection (Enhanced Oil Recovery), or utilisation of CO_2, captured from the atmosphere or from industrial installation and which would have otherwise been released to the atmosphere. • **Land-use category:** n/a • **Carbon pools:** n/a • **GHGs affected:** Carbon dioxide, carbon monoxide, and carbon suboxide.[4] • **System boundary:** Cradle-to-grave boundary, which considers the entire product life cycle, including all phases from raw material extraction until end-of-life. ISO 14040:2006 and ISO 14044:2006 identify the rules regarding the system boundary. Due to the fact that final regulations require LCAs to be performed in conformity with those standards, the final regulations provide that generally an LCA must take into account emissions from cradle to grave, unless the deletion of lifecycle stages is permitted by ISO 14040:2006 and ISO 14044:2006. Any decisions to omit lifecycle stages must be clearly stated in the LCA report, and reasons and implications for the omission must be explained in the LCA report.
Solution	• CCS: IPCC Guidelines – Volumes 2 (Chapter 5) on carbon transport, injection and geological storage, Volumes 2 & 3 on carbon capture from fuel combustion (under “Energy“) or process-related (under “Industrial Processes and Product Use“) (link)

MRV aspects	• **Quantifying removals/emissions:**
	  ◦ **Net GHG emissions reductions**: An LCA must demonstrate that the proposed process results in a net reduction of CO_2-e, when compared to another system.
	  ◦ **LCA requirements:** The LCA must be prepared in conformity with ISO 14040:2006 and ISO 14044:2006. In addition, taxpayers must use the NETL’s CO_2 Utilisation Guidance Toolkit, including the guidance and data available on DOE’s website.

	- **Qualified carbon oxide:** The amount of qualified carbon oxide utilized by the taxpayer is equal to the metric tons of qualified carbon oxide which the taxpayer demonstrates, based upon an analysis of lifecycle greenhouse gas emissions and subject to the requirements 1) captured and permanently isolated from the atmosphere, or 2) displaced from being emitted into the atmosphere, through use of a process. The qualified carbon oxide eligible for the section 45Q credit cannot exceed the amount of qualified carbon oxide that is captured. - **Uncertainties:** In case of incomplete data to perform an LCA. - **Additionality:** It is not named additionality but based on an LCA, it must be demonstrated that an utilisation process leads to a reduction in CO_2-e. The reduction may be achieved by capturing and permanently isolating qualified carbon oxide from the atmosphere through a) use of a process, or b) by displacing the qualified carbon oxide from being emitted into the atmosphere using a process. Displacement is a process which assumes that an existing product in the market will be substituted with the product from the carbon oxide utilisation process. It should be noted that the term "additionality" itself is not explicitly mentioned in the document. • **Monitoring and reporting requirements:** - **LCA data and reporting:** The LCA may consist of direct and indirect data in conformity with ISO 14040:2006 and 14044:2006. The results of the LCA must be documented in a written LCA report. - **Measurement and quantification**: Measurement of qualified carbon oxide at the point of capture is required. In case of leakage, the metric tons of qualified carbon oxide that has leaked to the atmosphere must be quantified. - **Monitoring and reporting guidelines:** Subpart UU, Subpart RR and CSA/ANSI ISO 27916:2019 each provide methodologies for monitoring and reporting the secure storage of qualified carbon oxide and is not addressed further in the final 45Q regulations. - **MRV plan (according to subpart RR):** The MRV must contain 1) Delineation of the maximum monitoring area and the active monitoring areas, 2) Identification of potential surface leakage pathways, and the likelihood, magnitude, and timing, 3) A strategy for detecting and quantifying any surface leakage of CO_2, 4) A strategy for establishing the expected baselines for monitoring CO_2 surface leakage, 5) A summary of the considerations intended to use to calculate site-specific variables for the mass balance equation, 6) Well identification number used for the Underground Injection Control permit and the Underground Injection Control permit class, and 7) Proposed date to begin collecting data for calculating total amount sequestered.[5] - **Monitoring and reporting parameters (according to subpart RR):** CO_2 received, injected and produced, CO_2 emissions from equipment leaks and vented emissions of CO_2. Report the amount of carbon dioxide geologically sequestered using a mass balance approach.[5] • **Verification and validation:** - **Third-party verification:** The LCA report must be performed or verified by an independent professionally licensed third-party that uses generally accepted standard practices of quantifying the greenhouse gas emissions of a product or process and comparing that impact to a baseline. The LCA report must provide a statement documenting the qualifications of the independent third-party, including proof of appropriate U.S. or foreign professional license, an affidavit from the third-party stating that it is independent from the taxpayer.

	- **LCA verification:** The LCA report will be subject to a technical review by the DOE. The IRS will determine whether to approve the LCA and will notify the taxpayer. The taxpayer must receive approval of its LCA prior to claiming the section 45Q credits for such taxable year on any federal income tax return. - **Leakage verification:** The amount of leakage must be certified by a qualified independent engineer or geologist. The IRS will consider all available facts and circumstances and may consult with the relevant regulatory agency with jurisdiction over such site, in verifying the amount of qualified carbon oxide that has leaked to the atmosphere. • **Co-benefits/externalities:** - Displacement: An existing product in the market will be substituted with the product from the carbon oxide utilisation process. - High degree of progress: 45Q is perceived the most progressive CCS-specific incentive. It provides a stable and predictable value on carbon reflecting externalities created by pollution. By introducing a defined time frame with clear guidelines once the full Internal Revenue Service (IRS) guidance is published, 45Q is not subject to the same potential volatility of carbon markets or carbon trading mechanisms. At the same time, the value is high enough to be able to incentivize CCS applications in a variety of energy-intensive industry sectors. Furthermore, 45Q provides a federal tax credit that supplements, and can be combined with, state and local clean energy incentives including but not limited to the California Low Carbon Fuel Standard CCS protocol. [4]
Permanence	• **Specific management of impermanence risks:** - Three-year recapture period. - Use of last-in-first-out method, which promotes administrative ease, and further reflects the fact that carbon oxide is at the greatest risk of leakage shortly after it is initially disposed of or used as a tertiary injectant. - The leaked amount is subject to recapture and shall be subtracted from the amount of qualified carbon oxide that is securely stored in the taxable year.
Key references	• Beck, L. (2020), The US Section 45Q Tax Credit for Carbon Oxide Sequestration: An Update. Global CCS Institute (link) • Kennedy, K. & K. Hausker (2019), Insider: Guiding Implementation of Carbon Capture Tax Credits: responses to the IRS Request for Comments. World Resources Institute (link) • Townsend, A. & I. Havercroft (2019), 2019 Policy Report: The LCFS and CCS Protocol: An Overview for Policymakers and Project Developers. Global CCS Institute (link) • U.S. Department of Treasury (2021), Treasury Department and Internal Revenue Service Release Final Rule on Section 45Q Credit Regulations (link)

[1] U.S. Department of Treasury (2021), Treasury Department and Internal Revenue Service Release Final Rule on Section 45Q Credit Regulations (link)

[2] Kennedy, K. & K. Hausker (2019), Insider: Guiding Implementation of Carbon Capture Tax Credits: responses to the IRS Request for Comments. World Resources Institute (link)

[3] Townsend, A. & I. Havercroft (2019), 2019 Policy Report: The LCFS and CCS Protocol: An Overview for Policymakers and Project Developers. Global CCS Institute (link)

[4] Beck, L. (2020), The US Section 45Q Tax Credit for Carbon Oxide Sequestration: An Update. Global CCS Institute. (link)

[5] Electronic Code of Federal Regulations (2021), §98.448 Geologic Sequestration Monitoring, Reporting, and Verification (MRV) Plan (link)

8 ANNEX 3 – FICHE TEMPLATES

Table 3. Mechanism architecture fiche template

Mechanism architecture fiche template	
Section	Aspects covered
Descriptive/context	
Scheme name	• Name
Introduction	• Context: context of the mechanism (including maturity) • Brief description of the mechanism
Governance	• **Operator/administrator:** • **Regulatory or voluntary mechanism:** • **Methodology development process** summary (including summary of bottom-up procedures) • **Key governance bodies:** (list/describe key governance bodies)
Participants	• **Supply side:** (i.e., who generates removals, what types and size of participants are involved) • **Demand side:** (i.e., who pays for the removals e.g., buys credits, or funds removal actions)
Scope, objective, and eligibility	• **Carbon removal solutions:** /projects (incl. development of new methodologies) (i.e., what types of removal solutions are covered – what source of CO_2 and what type of sink/end-**use?)** • **Geographic eligibility:** (i.e., where can projects occur, scale of projects)
Performance	• **Number of registered carbon removal methodologies** • **Number of registered carbon removal projects** • **Number of participants** (if possible) • **Quantitative information on carbon dioxide removals under the mechanism (tCO_2-e)** • Trends, developments
Core design decisions	
Cross-cutting MRV aspects - high-level	• **MRV cycle or Quantification:** an overview of how quantification of removals is done (what are the steps). • **Additionality approach** (i.e., how do we know that these actions (and the removals) are additional to what would have happened anyway? e.g., what is the baseline, how is it set, how does it interact with existing regulatory compliance, financial additionality) ◦ Baseline: (Historical or Scenario (i.e., historical baseline based on historical data OR a future scenario). Identify historical data included (i.e., how many years of data). Or what is included in the scenario; Specific or standardized – i.e., is the project specific to the participant or standardized across multiple participants. - Fixed baseline or dynamic or revised) • **Treatment of uncertainty** (here you might have to check one or two methodologies to get an idea) • **Permanence, carbon reversals, and liability** • **Reporting requirements** (frequency/duration, differentiation, transparency) • **Verification** procedure and bodies (and timing)
Accounting	• GHG registries and integration in GHG inventories; transparency (i.e., is there a public registry to record removals and transactions to avoid double counting; are international trades allowed and if so how are these recorded)

Mechanism architecture fiche template	
Section	Aspects covered
Sustainability	• **Carbon leakage settings**: • **Sustainability safeguards:** (e.g., "do-no-harm" requirement, use of negative lists, or other management of negative externalities/positive co-benefits)
Incentives, market elements	
Costs	• **Transaction costs** (for participants e.g., project/credit developers, farmers, and for credit buyers) - if available • **Administrative costs**: for administrator (set up, ongoing costs) – if available
Type and timing of reward	• **Form of reward:** for participant (e.g., tradeable credits, tax credits) • **Crediting period/timing:** and timing of reward, renewals
Offset markets/use of removals	• **Removals market demand structure:** i.e., how are removals used? Support-based certificates (Financial incentives, voluntary claims, result-based climate finance) or transaction based certificates (voluntary offsetting, ESR/LULUCF-R linkage, ETS linkage, supply side obligations)[19] • (If applicable) Market summary (prices and volumes, description of buyers)
References	• key references, in addition to the end notes that are recorded at the end of the template. • e.g., COWI A/S, Ecologic Institute, and the Institute for European Environmental Policy (2020) Analytical support for the operationalisation of an EU Carbon Farming initiative, prepared for DG CLIMA/European Commission under project: CLIMA/C.3/ETU/2018/007

[19] See definitions on page 70 of proposal

Table 4. Methodology fiche template

Methodology Fiche	
Fiche section	Aspects covered
Methodology document	• For the methodology fiche, we will often principally be referring to the methodology document itself. Accordingly, provide a full reference to the methodology up front (including link) – as well as a full reference in the endnotes. In the rest of this methodology fiche, include specific page references to help later reader navigate quickly to the correct section of the methodology. e.g., ... (p. 26).
Mechanism architecture overview	• Summarise mechanism architecture elements here, as there is no accompanying mechanism architecture fiche. The methodology fiche follows. *(Note: This only needs to be included for methodologies that do not have a mechanism architecture fiche. e.g., MoorFutures. If a mechanism architecture fiche has been completed, please reference it here. e.g., See Fiche 01 CDM for more information on the overarching mechanism. Here, briefly summarise the mechanism architecture information (max ¾ page)* • **Overview and performance:** • **Governance:.** • **Market:**
Methodology scope	• **Specific removal solution covered:** • **Land-use category:** (include if appropriate. use land use categories from IPCC (i.e., from here: https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html) • **Carbon pools:** (Use IPCC guideline categories: https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html) • **GHGs affected:** • **System boundary:** (Whole of unit/part of unit (i.e.,whole farm or part of farm, whole of TBS site/part of TBS site) - Are lifecycle elements included?- Are any relevant gases and carbon pools excluded?)
Solution	• Name the solution that the method applies to. And provide a link to the relevant IPCC guidelines for national GHG inventories. ◦ e.g., Peatland rewetting - covered by 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
MRV aspects	• **Description of specific MRV procedures and methods related to the methodology:** • **Quantifying removals/emissions** (including comparison to IPCC guidelines (tiers), • **Uncertainties** • **Reporting requirements** e.g., what data to collect, timing, how to report • **Verification and validation** (who, impartiality assessment, etc.) • **Specific additionality elements** (how baseline is set; leakage) • **Co-benefits/externalities** *Note- if this information is covered in the mechanism architecture fiche, can be skipped.* *Include links to more information and full references*
Permanence	• **Specific management of impermanence risks** (intentional reversal risks and non-intentional reversal risks)
Key references	• Key references (other than the methodology itself)

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The European Commission is developing a certification mechanism for nature-based (NBS) and technology-based carbon removal solutions (TBS). To support its development, this report reviews existing carbon removal certification mechanisms and methodologies. By documenting different approaches to key mechanism design issues, the report identifies and evaluates a range of options for the EU certification mechanism, supporting the development of a robust and effective system to incentivise uptake of carbon removals within Europe.

The report also summarises key conclusions related to evaluation of NBS and TBS methodologies as a crucial base for the environmental integrity.

This report is published alongside a second, related report, “Certification of carbon removals - Part 1: Synoptic review of carbon removal solutions”.

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