

#### Carbon Dioxide Removal Technologies and Carbon Capture, Utilization and Storage Background and objectives

IPCC Scoping Meeting Copenhagen, Denmark, 14-16 October 2024 IPCC TFI TSU





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# Background and objectives

- Why are we here?
- Meeting objectives
- The Task
- Some background
  - CDR technologies
  - Removals and capture
  - The IPCC classification system
  - IPCC guidance
  - Feasibility of estimation methods: illustrations based on existing IPCC guidance
- How will the Methodology report writing process operate?
- How will this meeting run?







![](_page_2_Picture_2.jpeg)

## Interest of Governments

- An unprecedented number of governments asked for this initiative for the Task Force on Inventories
  - CDR technologies are important in AR6 pathways to limit warming
  - TFI Methodology Reports underpin the Paris Agreement
  - Governments perceived a gap/need for update in the existing IPCC TFI guidance in relation to emerging Carbon Dioxide Removal (CDR) technologies and Carbon Capture Utilization and Storage (CCUS)

![](_page_3_Picture_5.jpeg)

# Removals are critical for AR6 pathways to limit warming to 1.5C

![](_page_4_Figure_1.jpeg)

![](_page_4_Picture_2.jpeg)

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## IPCC TFI Methodology Reports underpin Paris Agreement

#### • The IPCC Task Force on Inventories (TFI)

- 2006 IPCC Guidelines for national greenhouse gas inventories
- 2019 Refinement to the 2006 IPCC Guidelines
- 2013 Wetlands Supplement

![](_page_5_Picture_5.jpeg)

<u>IPCC - Task Force on National Greenhouse Gas Inventories (iges.or.jp)</u>

- Used by parties to the Paris Agreement (UNFCCC) in the estimation of emissions and sinks for national inventories
  - They also provide the basis for the rules agreed by Paris Agreement parties for national reporting
     by decision of the parties to those agreements

![](_page_5_Picture_9.jpeg)

# Decision of the IPCC Plenary to produce a new Methodology Report

The TFI will hold an Expert Meeting on *Carbon Dioxide Removal Technologies, Carbon Capture Utilization* and Storage and provide a Methodology Report on these by the end of 2027

IPCC 60, decision 9 para 7 January 2024

![](_page_6_Picture_3.jpeg)

IPCC Expert Meeting on CDR CCUS Vienna, 1-3 July 2024

- Meeting Report available
- Is there really a gap in the guidance?
- Agreed assessment criteria for new CDR processes
- For information only

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### **Objectives of this Scoping Meeting**

![](_page_8_Picture_1.jpeg)

# This IPCC TFI Scoping Meeting

Make recommendations to the IPCC Plenary on a draft Outline of the Methodology Report

 – (a preliminary draft 'thought-starter' will be introduced after lunch)

The Co-Chairs will also assemble a Meeting Report based on materials collected

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#### Your task

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# Your task

- Consider new CDR Technologies
  - Is **new** IPCC guidance required?
    - Do the Technologies involve sink or source processes not described by the existing IPCC classification system?
    - Are the assessment criteria addressed?
  - Does existing IPCC guidance need to be updated?
    - given development of the new technologies or
    - given, inter alia, publication of new empirical science in the case of Carbon Capture Utilization and Storage
  - You will also be asked to confirm
    - those parts of the IPCC Guidance that do not require update or elaboration

![](_page_11_Picture_10.jpeg)

#### Which CDR Technologies?

Technology is not defined by the IPCC Guidance

![](_page_12_Picture_2.jpeg)

# AR6 listing CDR technologies

Group	The IPCC WGIII AR6 Report examples of CDR methods
Engineered carbon capture with geological storage in the lithosphere	<ul> <li>Direct air carbon capture and storage</li> <li>Bioenergy with carbon capture and storage</li> </ul>
Carbon capture in products	Concrete carbonation*
Anthropogenic mineral processes with	Enhanced weathering
storage of inorganic carbon in minerals	Ocean alkalinity enhancement
or as bicarbonate ions	
Anthropogenic biological processes	Afforestation/Reforestation
(photosynthesis) – biomass	Agroforestry
	Improved Forest Management
	"Blue carbon management" in coastal wetlands
Anthropogenic biological processes (photosynthesis) – soils and waterways	<ul> <li>Soil carbon sequestration in croplands and grasslands</li> <li>Peatland and coastal wetland restoration</li> <li>Biochar</li> </ul>

#### Table 1: Grouping of CDR pathways by type of technology

Source: Derived from IPCC 2022 – IPCC WGIII Mitigation of Climate Change, Technical Summary. \*Additional.

![](_page_13_Picture_4.jpeg)

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# Expert Meeting listing of CDR Technologies

#### Table 2 List of CDR technologies considered

Type of process	IPCC WGIII	Final list identified by BOGs
Engineered carbon	Direct air carbon capture and storage	Direct air carbon capture and storage
storage in the lithosphere	500080	
	Bioenergy with carbon capture and storage	Bioenergy with carbon capture and storage
Carbon capture in products		Concrete carbonation (incl. enhanced concrete carbonation)
		Carbonatable by-product materials (where not included elsewhere in national GHG inventory, e.g. slags, precipitated)
Anthropogenic mineral processes with storage of inorganic carbon in	Enhanced weathering	Enhanced weathering on managed land
minerals or as		Enhanced weathering in rivers
bicarbonate ions		
		Ex-situ mineralization (open and closed systems) including enhanced
		weathering using biogenic CO <sub>2</sub>
		(wastewater arkalinity dosing)
		injection and rapid mineralization)
	Ocean alkalinity enhancement	Ocean alkalinity enhancement
		(mineral based and electrochemical)
		Direct ocean CO <sub>2</sub> removal (stripping CO <sub>2</sub> from seawater)
Anthropogenic biological	Afforestation/Reforestation	Afforestation/Reforestation
processes (photosynthesis) –		
biomass		
	Agroforestry	Agroforestry
	Improved Forest Management	Improved Forest Management
	Blue carbon management" in coastal wetlands (seagrass	Blue carbon management" in coastal wetlands (seagrass meadow, macro
	meadow, macro algae)	algae)
Anthropogenic biological	Soil carbon sequestration in croplands and grasslands	Soil carbon sequestration in croplands and grasslands
(photosynthesis) – soils	cropianus and grassianus	cropianus and grassianus
and waterways		
	Peatlands and coastal wetlands restoration	Peatlands and coastal wetlands restoration
	Biochar	Biochar
	Ocean fertilization	Ocean fertilization
		Biomass burial, Slurry and Oil
	1	1

#### Assessing the CDR Technologies

![](_page_15_Picture_1.jpeg)

# Expert Meeting: Agreed assessment criteria for CDR Technologies

- 1. the **identification of gaps** in the existing IPCC Guidelines for specific anthropogenic sinks or sources; or the identification of relevant existing sources and sinks where an elaboration of the Guidelines is considered desirable;
- 2. the **delineation** of the anthropogenic sink or source to be estimated;
- 3. the current and **expected significance** of the anthropogenic activity;
- 4. the knowledge available to generalize an IPCC Tier 1 methodology applicable under any national circumstances:
  - a. availability of necessary **activity data** to implement the methods (readily available national or international statistics); and
  - b. the ability to specify tier 1 default values:
- 5. the feasibility of being able to specify **higher tier methods** for use by inventory compilers
- 6. guidance for inventory compilers as to how they may be able to devise appropriate **verification** activities.

![](_page_16_Picture_9.jpeg)

#### Assessment criteria (paraphrased)

#### CDR and CCUS processes

**Direct Air Capture** 

Carbonation:

cement

industry slags and wastes

alkalinization of water bodies

enhanced weathering

Direct removal of CO<sub>2</sub> from water bodies

Enhanced oil, gas or coalbed methane recovery

Production of CO<sub>2</sub> containing products

Consumption & use of CO<sub>2</sub> containing products

Biochar

Enhancing biomass in coastal waters/wetlands

Other durable biomass products

Wastewater based CDR/CCUS

Open Ocean fertilization and alkalinization

![](_page_17_Figure_17.jpeg)

Describe and classify the sink process or activity

![](_page_17_Picture_19.jpeg)

Consider whether **updated or new guidance** is necessary

Consider materiality

![](_page_17_Picture_22.jpeg)

Consider feasibility of estimation methods at Tier 1, 2 and 3 levels

![](_page_17_Picture_24.jpeg)

Consider whether verification actions may address issues around uncertainties

![](_page_17_Picture_26.jpeg)

#### Background

Determine if a new sink process (and related sources) should be identified for the IPCC Classification system

![](_page_18_Picture_2.jpeg)

#### What is a removal/sink/source?

![](_page_19_Picture_1.jpeg)

### Removals and sinks

![](_page_20_Picture_1.jpeg)

- Examples of sinks include processes like photosynthesis and Direct Air Capture technologies.

- <u>TSU Note</u>: **Removals** are the consequence of sink activities. One removal corresponds to 1 tonne of carbon dioxide removed from the atmosphere and, if by human activities, is counted as a negative contribution to the national total net carbon dioxide emissions in a national inventory
  - 'negative emissions' in the Guidelines (once only reflecting limitation/simplification of estimation processes)

7. "Reservoir" means a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.

8. "Sink" means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.

9. "Source" means any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.

![](_page_20_Picture_8.jpeg)

INITED NATIONS FRAMEWORK CONVENTIO ON CLIMATE CHANGE

### **Emissions and sources**

![](_page_21_Picture_1.jpeg)

• **Source** - means any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere (UNFCCC).

4. "Emissions" means the release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time.

![](_page_21_Picture_4.jpeg)

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 $(\mathfrak{A})$ 

Distinguishing between real flows and artefacts of the estimation method: The case of capture at a power plant

- An emission is the gas released into the atmosphere
- How might emissions be estimated in the IPCC GLs?
  - Tier 3 direct measurement method
    - End of pipe (in the smokestack or, increasingly, by satellites) but after the point of capture

#### OR

- Tier 1 or 2 estimation method
  - (I) assess carbon in the fuel input and estimate potential emissions
  - (II) deduct amount captured from the amount at (I).
    - The 'deduction' for capture is required only because of the estimation method chosen
    - Capture is NOT a sink.

![](_page_22_Picture_11.jpeg)

![](_page_22_Picture_12.jpeg)

![](_page_22_Picture_13.jpeg)

![](_page_22_Picture_14.jpeg)

![](_page_23_Picture_0.jpeg)

## The IPCC Classification system of sources and sinks

IPCC classification system does not organise by technologies but by categories of sources and sinks

![](_page_23_Picture_3.jpeg)

# **IPCC** classification system

Sinks and sources are classified systematically

- Sinks and sources are classified by purpose of activity

- [In AFOLU, sinks and sources are classified by the purpose of the management on the land on which it occurs]
- Inventories are already designed to be complete

![](_page_24_Picture_5.jpeg)

## **IPCC Classifications of sources and sinks**

#### **Current IPCC Sectors**

![](_page_25_Figure_2.jpeg)

#### IPCC classification system (1)

![](_page_26_Figure_1.jpeg)

(reported under 1B) and CINTERGOVERNMENTAL PANEL ON Climate change

#### IPCC classification system (2) Industrial Processes and Product Use

C 1 c Other (please speci

gitive emissions from other systems used to transport CO<sub>2</sub>

SOURCES	1 C 2 Injection and Storage	Fugitive emissions from activities and equipminipection site and those from the end containment	ent at the the the	CO <sub>2</sub>
Mineral Industrie	es - Use of carbonates in specif	CO <sub>2</sub> is placed in storage. ied production processes and equipment injection site	at the	GO2
Chemical Indust	1 C 2 b Storage ries for specified production pro	Fugitive emissions from the end equipment once CESSES in storage.	the CO <sub>2</sub> is	CO2
Metal Industries	s - Use of fossil fuels for non-e	Any other emissions from CCS not reported else	vhere. duct use,	CO <sub>2</sub>
production pro	Cesses	<ul> <li>excluding those related to energy combustion under 1A), extraction, processing and transpe- (reported under 1B) and CO<sub>2</sub> transport, injection a</li> </ul>	(reported rt of fuels nd storage	N₂O, HFCs, PFCs,
Product Use [fu	gitive emissions]	(renorted under 1C)	~	SF <sub>6</sub> ,

- \* Example of steel and aluminium: The purpose of the use of fossil fuels is to apply the carbon as a reductant for a chemical reaction.
  - [For each industrial process, different **technologies** are identified if they lead to differences in the estimation method for net emissions]

![](_page_27_Picture_6.jpeg)

#### IPCC classification system (3) Agriculture, Forestry and Other Land Use

 SOURCES and SINKS
Forest Land
Cropland, Grassland
Wetlands
 Settlement land, Other land
CO <sub>2</sub> emissions from urea, liming application
Agriculture emissions
<ul> <li>On land, conceptually, the Managed Land Proxy concept is applied. Once land is declared to be managed, then all sinks and sources are considered to be anthropogenic (except for natural disturbances).</li> </ul>
 inco

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#### IPCC classification system (4) Waste

![](_page_29_Figure_1.jpeg)

![](_page_29_Picture_2.jpeg)

![](_page_30_Figure_0.jpeg)

![](_page_31_Picture_0.jpeg)

## What does 'IPCC guidance' look like?

IPCC Guidelines for estimating national greenhouse gas inventories of GHG emissions and removals

![](_page_31_Picture_3.jpeg)

# National methods

- For use by national inventory compilers in estimation of <u>national</u> greenhouse gas emissions
  - Not project-based methods
- **Territorial -** National inventories should include anthropogenic greenhouse gas emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction

- (2019 Refinement to the 2006 IPCC Guidelines, Vol 1.1.1 page 1.6).

- Reporting emissions and removals...when and where they occur
  - HWP/biomass emissions is an exception

![](_page_32_Picture_7.jpeg)

## For each source and sink

- Delineation of source or sink
- Specification of estimation method
  - Tier 1 estimation method
    - Most often are independent of technology
  - Higher tier 2 or tier 3 estimation methods
    - These methods might take account of different technologies
- Quality Assurance/Quality Control [verification]
- Uncertainty
- Reporting for transparency

![](_page_33_Picture_10.jpeg)

#### The feasibility of estimation methods: Illustrations from existing IPCC Guidance

The cases of forest biomass and cropland soil carbon pool sinks

![](_page_34_Picture_2.jpeg)

# Estimation methods (Forest land sinks)

![](_page_35_Picture_1.jpeg)

<u>Assessment criteria: 5</u>. .... the feasibility of being able to specify **higher tier methods** for use by inventory compilers

![](_page_35_Picture_3.jpeg)

Concept: Managed Land Proxy (Introduced into the IPCC Guidance in 2003) Captures all removals [and CO<sub>2</sub> emissions] on the managed land - regardless of cause Carbon stock change over time on managed land Net emissions on unmanaged land is out of scope

![](_page_35_Picture_6.jpeg)

Tier 3: measured using forest inventories (or using complex models)

Implemented systematically in a handful of countries

![](_page_35_Picture_9.jpeg)

# Estimation methods (Forest land sinks)

![](_page_36_Picture_1.jpeg)

<u>Assessment criteria 4</u>: the knowledge available to generalize an IPCC Tier 1 methodology applicable under any national circumstances: availability of necessary **activity data** to implement the methods (readily available national or international statistics); and

the ability to specify tier 1 default values

![](_page_36_Picture_5.jpeg)

Tiers 1 and 2

Simple linear functions (more or less) of forest area

![](_page_36_Picture_8.jpeg)

Long term sinks flow from AD on forest area

![](_page_36_Picture_10.jpeg)

# Estimation methods (Grassland sinks)

![](_page_37_Picture_1.jpeg)

<u>Assessment criteria 5.</u> the feasibility of being able to specify **higher tier methods** for use by inventory compilers

![](_page_37_Picture_3.jpeg)

Concept: Managed Land Proxy (introduced into the Guidance in 2003) Captures all removals and [CO<sub>2</sub> emissions] on the land - regardless of cause Carbon stock change over time

Net emissions on unmanaged land is out of scope

![](_page_37_Picture_7.jpeg)

Tier 3: measured using soil inventories (or using complex models)

Not often implemented

![](_page_37_Picture_10.jpeg)

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# Estimation methods (Grassland sinks)

![](_page_38_Picture_1.jpeg)

<u>Assessment criteria 4</u>: the knowledge available to generalize an IPCC Tier 1 methodology applicable under any national circumstances: availability of necessary **activity data** to implement the methods (readily available national or international statistics); and

the ability to specify tier 1 default values

Tier 1 and Tier 2:

simple linear functions (more or less) of land management activity data

![](_page_38_Picture_7.jpeg)

Sinks flow from AD on areas of land stratified by management classes

![](_page_38_Picture_9.jpeg)

# Feasibility of estimation methods

Existing methods for removals provide a reference point for the appraisal of the feasibility of new estimation methods (Tier 1, 2 and 3)

![](_page_39_Picture_2.jpeg)

# How will the Report writing process operate?

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# Roles and responsibilities of you, the authors and the IPCC Plenary

Scoping Meeting: Make recommendations on table of contents (List) based on your **technical advice** 

![](_page_41_Picture_3.jpeg)

In February 2025, the IPCC Plenary will decide on the scope

During report writing, if authors determine that there is insufficient evidence to support methods:

Work can be relegated into an appendix during the writing process

¥Ξ.	

In mid 2027, if the IPCC Plenary determines that insufficient evidence to support methods

Work can be relegated into an appendix during the acceptance process

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#### How will this Meeting operate?

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# Meeting format

#### Break Out Group discussions

- BOG1 (Direct air capture, carbon capture, utilisation and storage, carbonation processes (cement, metal industry wastes and slag), removal of CO<sub>2</sub> from oceans, cross-boundary issues)
- BOG2 (AFOLU Chapters: Soils (biochar, enhanced weathering and inorganic carbon, other), biomass products other than HWP; coastal wetlands (seagrass, tidal marshes, macro algae, enhanced alkalinization); wastewater-

based CDR/CCUS; cross-boundary issues and open water bodies (ocean fertilization, enhanced alkalinization)

- Plenary Discussions
  - Reporting back to Plenary by rapporteurs; discussion and wrap up

![](_page_43_Picture_7.jpeg)

![](_page_44_Picture_0.jpeg)

# Thank you

<u>https://www.ipcc-nggip.iges.or.jp/index.html</u> <u>https://www.ipcc-nggip.iges.or.jp/meeting/meeting.html</u>

![](_page_44_Picture_3.jpeg)