CARBON DIOXIDE REMOVAL MISSION

CARBON DIOXIDE REMOVAL MISSION

Technical Track on Biomass Carbon Removal and Storage (BiCRS)

Scope of Work

Version 2.0

June 30, 2023

List of content

Version History

Version	Date	Comments/Changes from previous version
Version 1.0	7 December 2022	First version published
Version 2.0	….May 2023	Since the publication Version 1.0 of this BiCRS Scope of Work it has been realized that: • There is a need for a clearer distinction between CDR and CCU/CCUS. • Other Missions and Initiatives work on related topics. On this background, the following revisions have made in Version 2.0: 1. A section with acronyms and definitions has been added. 2. Chapter 1, Section 1.1: a. Text and a figure have been added to bring out the difference between CDR and CCU/CCUS. b. Text stating that focus is on engineered and hybrid, and text related to ocean and entirely nature solutions have been deleted. 3. Chapter 4: a. Text re-structured and some text regarding Phase 2 added. 4. Section 4.1: a. Phases 1a and 1b has been lumped together. b. Text has been added to illustrate possible limitations on use of biomass for bioCCS. c. Purpose, tasks and outcomes have re-phrased in an effort to make the message clearer. d. A note added to WP1. e. WP2: Simplified to see that each LCA case will only be evaluated on how different approaches and methods may impact results rather than doing complete analyses. f. Timeline has been adjusted. 5. Section 4.2. has been completely revised to separate what are specific to BiCRS and what can be accomplished in cooperation or by other missions and initiatives: a. WP3 has been changed to Topics specific to BiCRS specific (as opposed to Utilization in Version 1). This is extracts from former WP3 and WP4.

		b. WP3 has been expanded to include technical potential for CDR for technology approaches. c. WP4 has become Pilots and demonstration facilities (was WP5 in Version 1). d. WP5 has become Activities carried out by or in close cooperation with other missions and initiatives. This is extracts from former WP3 and WP4.

Some acronyms and definitions

Term	Explanation
BioCCS	Biomass with CCS. Includes but is not limited to: • BECCS • Combustion of municipal waste with biomass, fitted with CCS and deliverance of heat and power to nearby communities. • CCS fitted to pulp and paper mills where waste from pulp and paper production already is burnt for energy purposes. • Converting biomass to hydrogen via gasification, with CCS integrated after the hydrogen and CO_2 are separated. • Converting biomass to liquid fuel, with CCS for the fermentation process. • Integrating biogas (gas resulting from the decomposition of organic matter such as municipal waste under anaerobic conditions) collection systems with CCS.
BECCS	Combusting biomass with CCS for electricity or heat generation, including co-firing biomass with existing coal-fired power plants fitted with CCS.
BiCRS	Biomass with carbon removal and storage.
BioCCU	Biomass where the biogenic CO_2 is used to produce short-lived products.
BioCCS	Biomass where biogenic CO_2 is stored in a way intended to be permanent (in geologic formations or in long-lived products.)
CCS	Carbon capture and storage in geologic formations. Applies to both fossil and biogenic carbon.
CCU	Carbon capture where the CO_2 is used to produce short-lived products.
CCUS	Carbon capture where the CO_2 is used for products and/or stored in a way intended to be permanent. Applies to both fossil and biogenic carbon.
CDR	Carbon dioxide removal. To be CDR a pathway must document that[1] ▪ The gross removal from the atmosphere exceeds all emissions of greenhouse gases[2] from the process in the life cycle system. ▪ The removed CO_2 remains securely stored or locked away from the atmosphere in products in a manner intended to be permanent.

[1] The first two points based on Tanzer and Ramirez (2019) When are negative emissions negative emissions? Energy & Environmental Science, 12(4), 1210-1218. https://doi.org/10.1039/c8ee03338b. The third point is added here, modified from the Innovation Roadmap.

[2] Although CDR is about removal of CO_2, process emissions may include other greenhouse gases, thus it is CO_{2eq} that has to be negative.

	▪ Pay due considerations to the United Nations Sustainable Development Goals (UN SDGs) in the relevant contexts (nationally, regionally).
CEM	Clean Energy Ministerial
MI	Mission Innovation
LCA	Life Cycle Analysis, a methodology to assess products, processes, and systems on their entire life-cycle environmental performance
TEA	Techno-economic Assesment, a decision-making tool used to evaluate technology options based on technical, economic, environmental, social, and regulatory criteria

1. Introduction

The Carbon Dioxide Removal (CDR) Mission, under Mission Innovation (MI), aims to enable CDR technologies to achieve a net reduction of 100 million tonnes of CO_2 per year by 2030. The CDR Mission is co-led by the US, Canada, and the Kingdom of Saudi Arabia. Members are Australia, the European Commission, India, Japan, Norway, and the United Kingdom.

The CDR Mission will work on three technical tracks:

- Direct Air Capture (DAC)
- Enhanced Mineralization
- Biomass with Carbon Removal and Storage (BiCRS)

and a cross-cutting track on Life Cycle Analysis (LCA) and Techno-Economic Analysis (TEA), which aims to develop consistent cradle-to-grave system boundaries, harmonize variables (e.g., land, process, temporal), enable access to high-quality data, and develop methods to measure, report, and verify carbon (MRV) removals.

1.1. The BiCRS Track – what is included

Japan and Norway are co-leads for the BiCRS technical track. By October 2022, participants are Australia, Canada, EU, India, UK and USA.

This scope of work will emphasize activities which contributes to fulfilment of the aims of the mission by 2030: To enable CDR technologies to achieve a net reduction of 100 million tonnes of CO_2 per year by 2030. The importance of this aim is based on climate models, such as those reported by the Intergovernmental Panel on Climate Change, suggesting that several gigatonnes of CO_2 removal annually will be needed by 2050.

For the purpose to structuring and limiting the work of the BiCRS track, the following precisions will be introduced:

- Biomass is defined as terrestrial and marine plants, woods, biogenic residues, including manure and the biological part of non-hazardous municipal waste.
- To be considered net negative a CDR pathway must document that it meets the three conditions set out in the definition.

Three approaches are included as BiCRS:

- BioCCS: Approaches that captures biogenic CO_2 that is a by-product from another value creation process using biomass and store the captured CO_2 in a geological formation.

- CCUS: Approaches that durably store carbon from biomass in long-lived products in a manner intended to be permanent.
- Other: Approaches with a primary purpose to sequester carbon from biomass without generating energy or physical marketable products.

This can be illustrated as follows (Figure 1):

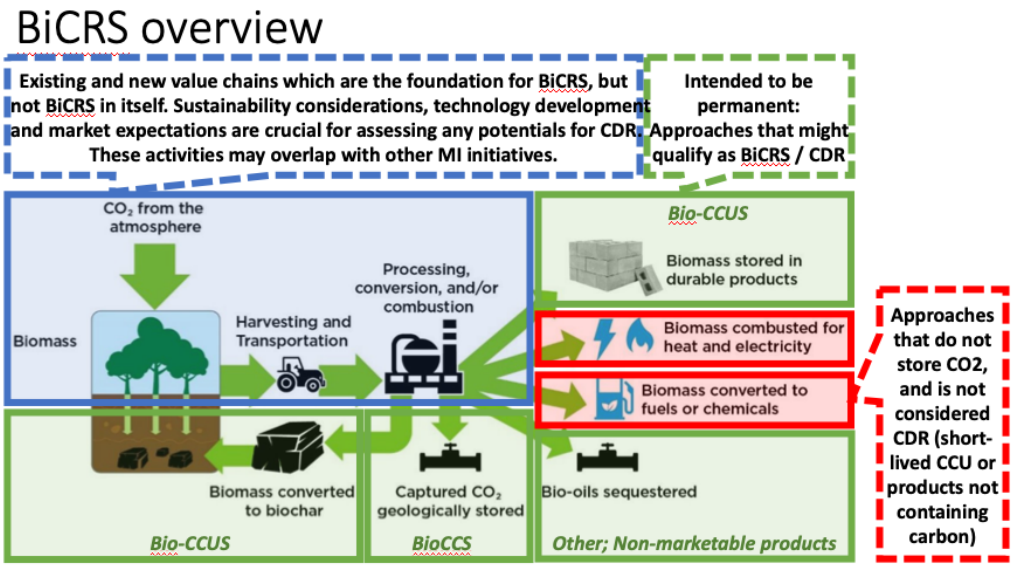

Figure 1. Overview of BiCRS steps; potential feedstock sources include biomass residues, energy crops, and algae; pathways with products shown in blue which involve combustion of biomass (e.g., heat and electricity) or conversion to short-lived end use products (e.g., fuels and chemicals) require capture and secure storage of CO2 emissions (Adapted from EFI 2022)

The green boxes in the illustration shows pathways of biogenic carbon or CO_2 having the potentials to be included as BiCRS. If fitted with CCS, the two red boxes may turn green, i.e. fall into the middle green box in the lower panel. Prioritization of these areas will be according to any national agendas of the member states involved.

The scope of BiCRS spans over several established scientific and technological disciplines, operational industries and existing regulatory regimes which all are affected by the ongoing global energy transformation. Current industries utilising biomass will experience changes in their business environment triggered by new regulations regarding climate and sustainability requirements, changes in market demand and new technologies. Increased competition for biomass will also be affected by land conflict related to food production, nature conservation and land used for growing other biobased materials. Introducing BiCRS to sell carbon credits will add a new value stream to businesses, which in turn may change valuation of biomass, alter the business model of companies and will thereby affect the competitiveness of specific resources and products in the market. In total, involved industries and its value chains will over time be challenged and potentially be disrupted. Companies that can use any type of low-priced biogenic resources to

create the largest values, at the lowest costs, and create added value through BiCRS, will have the best chance to survive over time. **The contribution of the BiCRS technical track are overviews and insights of when and how industrial use of biomass combined with CDR-solutions can be in position to deliver sustainable and competitive CO_2 removals in line with the aims of the Mission.**

As BiCRS entails a high degree of complexity and have significant overlap with concurrent climate initiatives, it will be important to cooperate with other missions and international initiatives where appropriate.

In line with the MI CDR Mission's Innovation Roadmap and Action Plan[3], the three top priorities of the BiCRS technical track are:

1. Biomass feedstocks.
2. System (logistics) – including biomass resource evaluation and value-chains relevant for BiCRS.
3. Utilization – including the development of innovative products of higher value, long-lived products, as well as understanding the "cascading principles" for use of biomass

These priorities are included in the scope, albeit with different words and under different headlines.

The focus of the work will be challenges of engineered and hybrid (combination of engineered and natural) CO_2 removal approaches. This is in line with MI CDR Innovation Roadmap. However, non-technical issues such as public acceptance, financial and policy incentives, MRV guidelines and certification of removals, and governance challenges are important for the technical tracks to understand challenges. These issues will be included to the extent necessary and in cooperation with the cross-cutting technical track LCA/TEA track and other missions, like Integrated Biorefinery and Net Zero Industries.

1.2. Purpose of this document

This document is the first version of a work scope for the MI CDR BiCRS technical Track. The scope is based on the MI CDR Innovation Roadmap and discussion amongst the BiCRS track countries in a virtual workshop June 21, 2022.

The purpose of this document is to outline the proposed work of the BiCRS technical track, with the objective to

- Obtain an agreed scope of work by getting feedback from all participants.

[3] The Roadmap and Action Plan can be found at http://mission-innovation.net/wp-content/uploads/2022/09/Attachment-1-CDR-Mission-Roadmap-Sept-22.pdf/

- Lay the basis for a shared workload and responsibilities by inviting participants to select and take responsibility for work tasks that fit their competence and capacity, including suggesting new tasks.
- Make it easier to attract potential new members to the track and inform where their competence will be useful.

NOTE: This is a living document, with potential activities and intended to initiate discussion and, hopefully, encourage volunteers among members of the track to raise their hand and perform these tasks or suggest and perform other supporting tasks. For example, the co-leads are open to discuss how approaches leaning more towards natural processes and the non-technical issues can be included.

The co-leads encourage input, changes, and comments of any kind. In particular they encourage track members to volunteer for specific work tasks.

2. BiCRS Technical Track – commitments, roles, and responsibilities

Each member of the BiCRS track commits to be an active part of a knowledge sharing forum across all countries to identify key challenges and to supply documents and other information needed to perform the agreed work. Countries could also commit to supporting the implementation and demonstration of promising technologies.

If the members of the track agree to common calls, the main rule is that each members fund their own participating research organizations. If funds shall cross borders, it shall be after unanimous agreement and according to agreed rules for what to fund, for contributions and for distribution of the funds.

The co-leads (Norway and Japan) will:

- Coordinate the work by:
  - Suggesting work programme and modify as needed after input from members.
  - Initiate workshops on relevant topics within the track.
  - Being a consistent driver to keep timelines, for production of reports and organizing workshops.
- Initiate and contribute to common calls and commit to funding as agreed.
- Compile/synthesize/summarizing input from members, workshops, and stakeholders to final reports and/or other products.

All Member countries of the track will:

- Be active parts of a knowledge sharing forum.
- Perform tasks and studies, and supply information/data as agreed.
- Provide input and comments as requested to plans, reports etc.
- Volunteer to perform tasks and studies.

- Supply information/data as agreed.
- Take active part in the organization and executing of workshops.
- Suggest and contribute to common calls and commit to funding as agreed.
- Involve research community, private industry, academia, and other relevant stakeholders in agreed countries to participate in Mission activities within BiCRS.

3. Timeline

Execution of the scope depends heavily on available resources amongst the track member countries. Japan and Norway propose the following tentative timeline:

- *Work scope with volunteers for tasks as agreed: End October 2022.*
- *Phase 1 starts: Mid-November, 2022.*
- *Phase 1 completed: Tentatively December 1, 2023 but some sub-tasks will have to work in progress.*
- *Phase 2 starts: May 1, 2023*

4. Work plan

The CDR Action Plan has three: Short-term Outcomes[4]:

#1: "Enhanced understanding of local and global CDR potential".
#2: "Advancement of Research and Development (R&D) for CDR" .
#3: "Global demonstrations and Pilot-Scale Tests".

The work plan for BiCRS will be carried out in phases and Work packages (WPs).

Phase 1 of BiCRS will address Short-term Outcome #1. It consists of work packages (WPs) WP1 and WP2, which will map biomass resources, opportunities for capture, transport and storage of biogenic CO_2, as well as potential industrial users and conducted LCAs. It will also perform LCA on a few selected cases in cooperation with the LCA/TEA Technical Track.

WPs 1 and 2 will give important background information for further work. They will mainly use existing information and expected to be moderately resource demanding. Phase 1 will have to carried in cooperation with other missions and/or initiatives.

Phase 1 of the work plan could include 'lighthouse' countries/regions, specifically the Nordic countries, which form an innovative region with different types of biomass, bio-related industries and CO_2 storage options available. Other regions/countries may be added if there are volunteers. Further work will be based on the learnings from this phase.

[4] For Short-term Outcomes, see Carbon Dioxide Removal Mission – Action Plan 2022-26 (http://mission-innovation.net/wp-content/uploads/2022/09/Attachment-2-Public-Facing-CDR-Mission-Action-Plan-Sept-2022.pdf)

Phase 2 of BiCRS, consisting of WPs 3-5, will contribute to the CDR Mission's Short-term Outcome #2: "Advancement of Research and Development (R&D) for CDR" and the Short-Term Outcome #3: "Global demonstrations and Pilot-Scale Tests".

WPs 3-5 are formulated to meet most of the challenges in the Innovation Roadmap. They may require new and partly ground-breaking work. The work in Phase 2 will be focussed on, but not necessarily, limited to approaches that capture and permanently remove from the atmosphere CO_2 generated from combustion or conversion[5] of biomass to useful products (e.g. to heat, electricity hydrogen, liquid fuels, other potential industrial feedstocks, biochar, or building materials in way that results in net negative emissions. These processes are included in the term BioCCS, as described in the Innovation Roadmap.

Phase 2 will have be divided in two parts: one that addresses topics that are specific to BiCRS, and one consisting of activities that will be carried out by or in close collaboration other missions.

4.1. Phase 1

WP1 - Mapping and characterizing biomass feedstock resource, transport and storage of CO_2, and user

WP1 includes the left side of the blue box in Figure 1 i.e. excluding the part "Processing, conversion, and/or combustion" It is part of the Mapping Project of the CDR Mission. However, BiCRS will be in dialogue with the MI Mission on Integrated Biorefineries and the CEM Biofuture Platform for exchange of approach, data and work-load sharing.

According to IPCC, the net technical CDR potential of BECCS is estimated to be 0.5-11.3 Gt CO2/yr globally[6] thus BECCS appears to have the potential to play an important part in reaching the CDR target if sufficient biomass is available. However, doubts have been cast the ability for BECCS to deliver on the scale of negative emissions required in emission projections[7,8] when using grown biomass (i.e. not including organic waste). The value chain is complex and involves energy, water and carbon inputs, as well as land use and land use change, amongst other factors. This implies that the CDR potential will be case specific[8]. BioCCS, of which BECCS is part, will interact with the United Nations Sustainable

[6] IPCC 2020 (SR15, Ch.5)
[7] https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/BECCS-deployment---a-reality-check.pdf
[8]https://www.researchgate.net/publication/315969584_Can_BECCS_deliver_sustainable_and_resource_efficient_negative_emissions

Development Goals[9] (UN SDGs). The challenges connected to bioCCS with forest, agriculture and energy crops indicate that efforts should also be directed at organic waste streams, as shown in the IEA report Net Zero by 2050.

The substantial amount of biomass and land required by bioCCS towards 2050[9] will come in addition to existing use, which has many forms, amounts and availability[10]. There will be competition for the biomass resources.

Assessment of what is a technical and sustainable viable value chain for BiCRS in the present and the future will be essential to obtain a balanced view of supply, demand, co-benefits and trade-offs. In addition to biomass type, amount and location, the assessment of the supply chain logistics must include locations of biomass user industries, means of transport, suitable geologic storage for CO_2, and sustainability issues. As the CDR potential of bioCCS is case specific, results should be presented on a country scale and finer, particularly where a country spans two or more climatic zones.

On this background, the overall purpose of WP1 is

Providing a tool for (rough) assessment of available bioresources and CO_2 storage sites to:

- Support industry and governments to identify possibilities for bio-based CDR as a contribution to reach net-zero targets.
- Assist authorities to ensure use of bioresources stay within sustainability limits.

Activities to achieve objectives will include:

- Identifying sources for present and future (time span to be decided) biomass resources and possible value chains.
- Establishing a wholistic, balanced, and realistic potential for CDR using biomass as feedstock, present as well future (e.g. 2040). The mapping must include organic waste streams.
- Getting an overview of transport possibilities and storage sites at national/regional levels.

Mapping tasks include but are not limited to (tasks can also be removed if members do not have capacity and /or competence):

- Through desktop or metadata studies, identify, compile and synthetize existing information on present and future (e.g. 2050) availability and location of various biomass feedstocks, including agricultural, organic waste, forest and, possibly, aquatic resources. Existing information can be data reported as international obligations such

[9] https://sdgs.un.org/goals
[10] Examples of existing uses, see the MI CDR Innovation Roadmap (http://mission-innovation.net/wp-content/uploads/2022/09/Attachment-1-CDR-Mission-Roadmap-Sept-22.pdf).

as the Land Use, Land-Use Change and Forestry (LULUCF) reporting to UN FCCC and EU. Unity of reporting may be in tonnes of biogenic CO_2 removed.

- Present the data in simple charts, preferably pie, on country maps, one or more charts per member country as fit according to administrative or climate regions, using the categories forestry, agricultural, waste and aquatic biomass resources.
- Include links to more detailed/granular information.
- Using existing information to locate infrastructures for transport of CO_2, with indications of capacities and availability.
- Using existing information to locate storage sites. Atlases of CO_2 storage sites with the necessary information are available from most of the MI CDR members and many other countries/regions. This task will be common to the DAC technical track.
- If data and resources allow: Establishing potential demand for biomass feedstock in e.g. 2050.

More detailed suggestions will be issued in separate document.

NOTE: The mapping of bioresources will produce an upper limit of how much biogenic carbon is available for CDR. The actual CDR potential will depend on the processes in which the biomass is used. For example, some biogenic carbon may be released with products and only part will be available for permanent storage.

Other tasks in WP1 include:

- Reviewing literature on sustainability definitions related to use of bioresources.
- Identifying and contacting industries/companies with existing or planned use of biomass feedstock to obtain information on use, technology, potential demand of biomass, and potential for CDR. Examples of users include:
    - Industry that has energy as marketable product (biogas, heat and electricity).
    - Industries/companies that plan to use biomass in their process, e.g. for internal heat production.
    - The metallurgic industry that may use biomass as reducing agent.
- Other industries and potential stakeholders.
- Identifying national and international networks and associations of industries relevant for implementation of bioCCS.

All the above should be presented on aggregated country scale and finer if more than one climatic zone is involved within a country.
WP1 **may** also include, if agreed by members and resources allow:

- Mapping national and international regulations for uptake and development of BiCRS (will be useful also for other technical tracks, maybe this could be common to all CDR technical tracks)
    - Enhancing understanding of regional and international regulations that would help the private sector.
    - Within member countries, understand the regional and international regulations impacting BiCRS technologies to encourage and scope the update and support.

Outcomes of WP1:

- Library or collection of links to available information on biomass (metadata).
- Country-wise "atlases" with extracts of information in form charts (for example pie, bar or otherwise) on overview maps, with links to relevant parts of the library.
- **NOTE: Full digitalization of results and harmonization, will, if agreed to be necessary, be part of a later phase of the mapping process.**
- Recommendations on further work on sustainability
- List of identified industrial networks and associations, in particular Waste-to-energy, that may be contacted.

Timeline:
Start: Fall 2022.
End: Draft version tentatively December 2023 but some tasks will still be work in progress.

WP2 - Harmonize LCA/TEA methodology for BiCRS

LCA for engineered CDR approaches is challenging due to factors that include insufficient or diverging data, use of different system boundaries, and confusion between removed and replaced CO_2 (MI CDR Innovation Roadmap). Some considerations are:

- There is a need for
    - Examples.
    - A common approach/method.
    - Case studies that allow cross-country comparisons.
- Accounting for dynamic nature of CO_2 absorption and release for biomass.
- The permanency of storage (beyond 100 years).

The purpose of WP2 is:

- Improve understanding of differences and shortcomings in LCA for BiCRS.

MI CDR has a separate and dedicated technical track for LCA and TEA. The BiCRS track will have to work with the cross-cutting technical track (LCA/TEA). However, the BiCRS technical track will undertake some dedicated tasks:

- Identifying LCAs performed within the relevant BiCRS topics (partly done by the LCA/TEA track and the list will be non-exhaustive).
- Performing LCA for at least two cases.
- Evaluating how different approaches and methods may impact the results.
- The LCAs must document how they address factors like climate impacts of direct and indirect land use, land use change and forestry, competition with other uses of land, water consumption, and impacts on biodiversity, the carbon, nutrient, and hydrological cycles, as well as trade-offs with the UN Sustainability Goals. The LCAs must also address non-climate impacts, such as ecotoxicity and eutrophication.

- Evaluating the results in form of differences in results and methods and convey to the LCA/TEA technical track for improvement (in cooperation).

Outcome of WP2:

- Recommendations to the LCA/TEA Technical Track on how LCA for BiCRS can be improved.

Timeline:
Start Spring 2023.
End: Tentatively Summer 2024 but this will be an evolving process.

In the longer run, WP2 may be expanded to include broader system analysis and a sustainable transition pathway.

4.2. Phase 2

Phase 2 has a strong element of CO_2 utilization technologies. Therefore, the scope is divided in two parts – one, with WP3 and WP4, that addresses topics that are specific to BiCRS, and one, WP5, consisting of activities that will be carried out by or in close collaboration other missions, in particular the MI missions Integrated Biorefineries and Net-Zero Industries Missions as well as other Initiatives.

WP3 – Topics specific to BiCRS (preliminary scope)

WP3 will address the three green boxes at the bottom of Figure 1 – capturing and storing biogenic CO_2, biochar and other products that lead to storage intended to be permanent. Generating products based on biogenic CO_2 that create revenue stream for facilities without achieving CDR status (net negative CO_{2e} on a life cycle basis) are excluded from this WP. However, some activities will incorporate collaboration and dialogue with the Integrated Biorefineries and Net-Zero Industries Missions.

The purpose of WP3 is:

- Driving down costs of integration of conversion of biomass feedstocks and the capture of biogenic CO_2.
- Developing and understanding the benefits and trade-offs of other BiCRS products with storage intended to be permanent.
- Establishing a realistic potential for CDR, considering the impacts of various conversion processes on the amount of biogenic carbon available for permanent storage.

WP3 tasks could include:

- Identifying capture technologies relevant for CDR for the identified industries, identifying knowledge gaps and prepare a state-of-the art report.
- Evaluate the potential for capture and permanent storage of biogenic carbon for a range of processes (processes to be selected, task to be performed with other Missions and Initiatives).
- RD&D on energy- and cost-efficient integration of biomass conversion with CO_2 capture.
- Identifying issues related to geological storage of CO_2.
- Quantifying biochar carbon sequestration potential and permanence.
    - Understanding how biochar soil amendments affect agricultural productivity, water use, and albedo.
- Identifying and understanding environmental, technical and economic aspects of non-marketable products with storage intended to be permanent, like sequestered bio-oil or wood vaults.
- RD&D on ocean CDR (to be aligned with/transferred to an Ocean Track/Pillar if established)
    - Cultivation of algae (macroalgae as well as microalgae) at large scales while minimizing ecological risks.
    - Direct ocean capture (not directly BiCRS).

Outcomes of WP3:

- Status report of capture technologies suited for adaptation to biomass conversion processes.
- Recommendations on future work on biochar and non-marketable products.
- Review of issues related to geological storage of CO_2.
- Recommendation of issues related to use of aquatic biomass.

Timeline: To be decided, depending on resources.

WP4 – Pilots and demonstration facilities (preliminary scope)

It is imperative to gain experience from operating facilities for further implementation and upscaling of BiCRS including data for LCA/TEA.

The purpose of WP4:

- Pave the ground for build-out of pilot and demonstration bioCCS facilities.

The task of WP4 could include:

- Facilitate knowledge transfer between stakeholders with operating facilities and those that are in the planning phase, including engineering, permitting, and operating phases and other relevant information. The knowledge transfer will include:
    - Relevant documentation, with due consideration to IPR and proprietary information.

    - Workshops, with participation by and dialogue between experienced and future owners/operating organizations, engineering companies, permitting entities and funding organizations.
- Facilitate funding opportunities, private as well as public at the national/regional levels.

Outcome of WP4:
- 1000 tonnes CO_2 year pilot/demonstration facilitates in construction by 2025.

Timeline: To be decided, depending on resources.

WP5 – Activities carried out by or in close cooperation with other missions and initiatives (preliminary scope)

WP5 will cover activities that appears to be the main focus of the Integrated Biorefineries and Net-Zero Industries Missions, as well as the CEM Biofuture Platform. However, several of such activities will be necessary input to BiCRS activities. Therefore, WP5 will involve collaboration and dialogue with these Missions and contributions to activities of main importance to BiCRS.

Many technology elements required for the other Missions are already mature and commercially available at scale today in global supply chains. High cost, non-technical issues, and potential conflicts with the UNSDGs (e.g. food security and biodiversity) remain challenges. Improvements are possible through R&D investments in existing and emerging technologies and by learning by doing.

From a BiCRS perspective, the purpose of WP5 is:
- Understanding higher value products, using biogenic CO_2 as feedstock.
- Understanding the permanency of CO_2 stored in the products.
- Understanding the long-term environmental impact of the products, as well as benefits and trade-offs .
- Driving down costs of conversion of biomass feedstocks and the capture of biogenic CO_2.

From a BiCRS perspective, WP5 tasks could include:
- RD&D on optimizing for fuel switching (from fossils to biobased fuels; where, when and how).
- RD&D on technologies for the production of high value and long-lived products:
    - Developing of long-lived bio-based chemical products and bio-fiber concrete.
    - Developing of advanced construction techniques and new application areas for long-lived engineered wood products.
    - Identifying permanence (life-time) of CO_2 storage in products other than biochar and bio-oil.
- Performing LCAs for the products.
- RD&D on use biomass in the energy intensive industries, such as metallurgic.
- Understanding the “cascading principles” for the use of biomass.

- RD&D on optimal biomass densification, pre-treatment, and formation techniques.
- RD&D on challenges related to transport of biomass to conversion facilities and markets.
- RD&D on biomass feedstock that is optimized for life-cycle carbon removal, including genetically modified biomass to increase uptake of carbon without increasing environmental impacts in a life cycle's perspective (understanding the sustainability such biomass feedstock).

From a BiCRS perspective, outcomes of WP5 could include:

- Improved technical solutions for biomass conversion, combustion and use as feedstock in industry with respect to energy, water, land use, and cost as they relate to carbon capture technologies for CDR.
- Potential for CDR in energy intensive industries.
- Guidelines for the sustainable use of biomass feedstocks for the various carbon capture technologies and approaches, e.g., pre-combustion vs. post-combustion and so forth.
- Checklist for developing innovative biomass to enhance carbon uptake and capture.

Alternatives for funding and execution of RD&D under WP5 include:

- Funded and carried out purely at the national/regional level.
- Joint calls where participating organizations work on the same topic/problem but where the main rule is that each member country fund their own participating research organizations.

Timeline: To be decided, depending on resources.

.