PROPOSAL
SUBTASK

Subtask #2 “Circular Carbon”
in
Task XXI “Decarbonizing industrial processes in a circular economy framework”

Coordinated by

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1. Background

Task XXI aims to investigate the topic of circular carbon from an industry perspective, i.e., to describe industrial energy systems in the context of a sustainable, fossil-free economy, striving to meet the targets of both concepts, the circular economy and a sustainable energy system.

Circularity, efficiency and renewability will inevitably play an important role in a sustainable economy. Both future systems are rarely considered together in science and discourse, although they interact or often contradict each other.

Carbon is a key element in both systems. For industrial production, carbon in its various forms (hydrocarbons) plays an essential role as a raw material that can hardly be replaced. While the use of energy cannot enter a closed loop, fossil carbon must not be released at the balance sheet. Consequently, carbon shall be circulated both in the energy and in the product sector, striving for a Carbon Cycle or a Circular Carbon economy.

One goal of the work conducted within the first year of IETS Task XXI was to identify white spots to be included in subsequent new/updated subtasks. At the end of 2021, it became obvious that the activities carried out are, on the one hand, broad and attract many participants/groups, but are, on the other hand, too broad to allow for concrete joint elaboration and exchange from projects. In order to narrow down the activities with regard to contents and methods, also at the risk of losing groups involved in Task XXI in 2021, the Task management contacted all groups/participants asking for their interests and projects they can associate with potential activities. They were also free to propose own activities. In the following, only activities that received interest from at least 3 participants/groups are mentioned. The potential subsequent subtasks and activities are:

- Subtask: Circular Carbon[1]
    - Activity: LCA and Energy System modelling
    - Activity: Integration of carbon capture in industry
    - Activity: Networking with other IETS Tasks and other TCPs' Tasks (e.g., ETSAP)
- Subtask: Industrial Symbiosis
    - Activity: Definition and delimitation
    - Activity: Good practice examples
    - Activity: Business Models
    - Activity: Networking with other IETS Tasks and other TCPs' Tasks (e.g., IETS Task XI)

[1] Please note that during the preparation phase of this subtask proposal, due to further inputs and refining, the activity names have changed compared to the December 2021 headlines.

2. Objectives and Scope

As CO_2 has simply been released to the air so far, Circular Carbon implies new value chains and cooperation of yet independent actors, which explains the integration under the umbrella of a joint task with Industrial Symbiosis.

2.1 Objectives

In order to delimitate from the focus of the work done in other IEA TCPs, this subtask shall focus the integration of carbon capture technologies and systems in industry and potential technical and techno-economic pathways for the reuse of the carbon through CCU.

The following three Activities are proposed for this Subtask. Please note that during the preparation phase of this subtask proposal, due to further inputs and refining, the activity names have changed compared to the December 2021 headlines.

- Activity A: How to handle circular carbon in modelling: Based on the variety of perceptions of what is circular carbon and CCU actually is, and in which way CCU actually contributes to reduce carbon emissions, this activity shall discuss these issues from a modelling perspective. To do so, additionally, the technical/chemical pathways of further use of captured carbon shall be analyzed.
- Activity B: Integration of carbon capture in industry: Technological and techno-economic examination of the origin of the waste gas streams and their quality, CO2 separation technologies, options for intermediate storage and immediate making of hydrocarbon on site, integration of these systems into the industrial system (by branch), e.g., the impacts on energy use, waste heat usability, etc., resulting concentrations/purities.
- Activity C: Networking: This is a broad topic and its scope overlaps with part of the work done in many other IETS Tasks as well as other IEA TCPs. It is therefore important to develop channels of communication that allow for not only exchange of information but also to explore possibilities for carrying out joint actions (for instance workshops) that would be of mutual benefit. This activity aims to establish collaboration between the proposed Subtask and other Tasks in IETS as well as with the fitting TCPs. The first step will be to identify joint activities that can be conducted with minimal extra efforts from the parties. This could include participating in each other workshops. As a second step, it will be explored the possibility to carry out a joint activity, for instance, a joint workshop or a shared activity in subsequent subtasks.

In general, all activities and subtasks shall seek to identify new/updated subsequent activities/subtasks.

2.2 Scope

It was a clear result of the work of Task XXI performed in 2021 that Circular Carbon does not yet have an established definition. Although some participants require the carbon to have a full cycle, based on the idea of the concept of circularity. However, others also consider fossil carbon that is permanently stored again as sufficient to be in line with circular carbon. Others also emphasize the idea of the concept of a circular economy to get away from a linear use, thus also intermediate uses e.g., as synthetic fuels, are thought to be legitimate. In order to delimitate from the focus of the work done in other IEA TCPs, this subtask shall focus the integration of carbon capture in industry and potential pathways for the reuse of the carbon through CCU; CCS shall only be the residual that shall not be ignored but not be in the focus of this subtask work.

3. Organization of work

The work of the subtask will be subdivided into three activities. In the following, the activities' proposed leaders, objectives, preliminary methods (to be detailed in early activity work) and targeted deliverables are mentioned.

After approval of the subtask, the subtask leader should send out a template for inquiring about the projects of the subtask participants. The template collects the general project description, information on the priorities the project sets and a proposal for assignment to the activities, and clarifies to what extent the project goes beyond the current state of knowledge. In cooperation with the participants, the subtask leader may carry out additional literature research.

3.1 Activity A: How to handle circular carbon in modelling

Activity leader: Energieinstitut an der JKU Linz

Aim of the activity: In traditional process (LCA, TEA) and energy system modelling, CO_2 is treated as an emission, i.e., a gaseous waste that leaves the system boundaries via air. In the worst case, this causes some cost, due to technical treatment and/or the ETS. However, as the dependency on fossil fuels is still high, for some processes CO_2 generation cannot be avoided (e.g., cement) and as carbon actually is a crucial molecule for many industries (e.g., hydrocarbons), carbon capture and utilization (CCU) technologies have been developed. While these technologies clearly offer a climate change mitigation potential, the contribution of CCU remains unclear and there is a need to clarify how to calculate and allocate the induced/avoided environmental impact and economic value/costs among the players in the value chain, who produce, trade, store or utilize CO_2. In regard to environmental issues, especially the temporal (how long is the CO_2 bound?) and from a technoeconomic perspective, the geographic (where and how is the CO_2 released/bound?) system boundary is relevant. Also, treating the CO_2 as an emission, waste or product, decides on who has to (or should) pay for ETS

certificates and who possibly receives credits. This is strongly connected to various supply chains, e.g., the chemical market but also from an energy system (synthetic fuels) perspective. Furthermore, the use of fossil, renewable and recycled resources, raises the question, if CO_2 should be treated differently in modelling based on its original source. Current legal framework and modelling standards insufficiently answer these questions, especially as "fair" treatment of CO_2 is likely to differ a lot depending on the CCUS route. Also, the perspectives of different stakeholders add to the complexity of the topic. The scientific community aims on providing solution pathways for industry and policy makers in regard to the creation of a functioning circular (carbon) economy (in technical, environmental, economic and social manner). However, up to now, no scientific consensus was reached. Thus, this activity aims on gathering the status quo of modelling standards with the objective to identify trends in regard to allocation of CO_2.

- Is the CO_2 emitted again? If yes, where/how (e.g., concentrated in a furnace vs. decentrally as a fuel) and after which period of time (weeks to centuries)? What are the true GHG savings from applying CCU?
- The technical/chemical pathways of further use of captured carbon through CCU shall be analyzed.
- How to allocate the CO_2 in LCA, TEA and energy system modelling? Discussion of argumentative inputs from a legal, technical and economic perspective.

Preliminary methods: Identification and analysis of Subtask participants' research projects in regard to CCUS through workshops or surveys (e.g., one-page template); collection of current/developing modelling standards and recommendations, literature research.

Deliverable: See section 4.

3.2 Activity B: Integration of carbon capture in industry

Activity leader: Energieinstitut an der JKU Linz (preliminary, and continuously if no other activity leader is found)

Aim of the activity: The thematic area is to examine technologically and techno-economically the origin of the waste gas streams and their quality, CO2 separation technologies, options for intermediate storage and immediate making of hydrocarbon on site, integration of these systems into the industrial system (by branch), e.g., the impacts on energy use, waste heat usability, etc., resulting concentrations/purities.

- Discuss technologies potentially applicable and assumed to be added (e.g., amine scrubbing, electrolysis, etc.)? Discuss methods of integration?
- List/description of carbon capture technologies suitable for CO2 point sources, inclusive, e.g., TRL, achievable degrees of purity of the CO2 + energy consumption, typical locations (= branches of industry), yield potential, "low

hanging fruits" industrial carbon capture based on the before reults, R&D hotspots (i.e. where is there still a need for research/innovation?)

- Short/medium-term carbon storage & transport technologies, i.e. making CO2 available as a raw material for others
- Assignment of prices for carbon in the various forms it appears in the industrial processes (as fuels, process gas or off gas streams), including differentiation between diluted and concentrated CO2, or pressurized CO2, respectively. Discussion of technologies for different industries on a techno-economic basis and sensitivity testing towards fuel prices, (green) electricity prices and CO2 emission penalties.

Based on this thematic area, the following sub-activities are proposed:

- **Sub-activity B1**: Analyze the projects of the participants, aiming to find a pragmatic way of beneficial and concrete exchange by focusing a specific area within the activity.
- **Sub-activity B2**: Elaborate on these hotspots.

Preliminary methods: Identification and analysis of Subtask participants' research projects in regard to CCUS through workshops or surveys (one-page template); collection of current/developing modelling standards and recommendations, literature research.

Deliverable: See section 4.

3.3 Activity C: Networking

Activity leader: Energieinstitut an der JKU Linz

Aim of the activity: leverage synergies with other IETS Tasks and other TCPs' Tasks. Based on the work and networking done in 2021, a close communication with IETS Task XV (excess heat), ETSAP TCP, IEAGHG TCP, IEA Bioenergy TCP are appropriate.

Preliminary methods: Identify and define IETS Tasks and other TCPs' Tasks that are thematically interlinked. Contact these and perform at least one joint activity (e.g., workshop). Workshop idea (to be discussed with other Tasks and TCPs and to be refined): Definitions of Circular Carbon, CCU, CCS.

Deliverable: Protocols and implications of networking activities [non-public], which is communicated to the IETS ExCo and an overview is integrated in the [public] Final subtask report.

4. Deliverables

The main deliverables in the Subtask will be the

- Final subtask report.

The Subtask leader is responsible for report creation and the framework text. The activity leaders contribute with subchapters on aims, methods, results and conclusions (or other, if appropriate) of their respective activity.

More specifically, the deliverables mentioned in section 3 are derived for the activities.

- How to handle circular carbon in modelling: Either a chapter within the final subtask report, or one or more scientific paper(s), with a summary of methods, conclusions and implications presented in the final subtask report.
- Integration of carbon capture in industry: Either a chapter within the final subtask report, or one or more scientific paper(s), with a summary of methods, conclusions and implications presented in the final subtask report.
- Networking: Summary of interactions and recommendations, to be included in the final report.

5. Program Subtask Plan

The time schedule and the amount of work performed in the Subtask will be the following:

	22/Q3	22/Q4	23/Q1	23/Q2	23/Q3	23/Q4	24/Q1	24/Q2	24/Q3	24/Q4
Act. A	x	x	x	x	x	x	x	x	x	x
Act. B	x	x	x	x	x	x	x	x	x	x
Act. C	x	x	x	x	x	x	x	x	x	x

6. Dissemination

6.1 Dissemination

The results from the Subtask will be disseminated through the following activities:

- Final subtask report, presented to IETS executive committee and prepared for publication on the IETS homepage. The activity leaders contribute with subchapters on aims, methods, results and conclusions of the activity.
- Presentation at scientific conferences and, in parallel, as conference articles.
- Presentation at not-yet-specified workshops of other IETS Tasks, other TCPs, other TCPs' Tasks, related research projects, or similar, when available or requested.
- If applicable, dissemination of innovative results through scientific papers

6.2 Intellectual property rights

All main results from the Subtask, including outcomes from workshops, shall be open. Parties participating in the Subtask, however, may decide if a small part of a report shall be confidential. Any uploaded / shared material shall mention the original author. Unless otherwise stated and agreed, the author agrees that the material may be used and copied without restriction.

7. Duration of Subtask

This Subtask shall enter into force on July 1st, 2022, and shall remain in force for a period of 2.5 years until December 31th, 2024.

8. Resources

The Subtask manager and, if applicable, the activity leaders will be the following:

- Subtask manager: Energieinstitut an der JKU Linz
- Activity A leader: Energieinstitut an der JKU Linz
- Activity B leader: Energieinstitut an der JKU Linz (preliminary)
- Activity C leader: Energieinstitut an der JKU Linz

9. Obligations and Responsibilities of the Participants

Participants to the Subtask commit themselves:

- to contribute actively to the Task with the results from at least one project, already ongoing or recently finished in their group or country. The project(s) will count in the person-month contribution.
- to provide their activities on their own costs but may actively strive for the corresponding funding of personnel and travel costs.
- to actively contribute to the work with the synthesis report.

Each participating country shall contribute with an amount of work corresponding to at least one person-month per year plus one international travel during the Subtask duration. This includes responsibilities for contributing to the synthesis report. In accordance to the practice in the TCP IETS, projects/results that are already financed by the groups/countries and are brought into the Subtask will count towards the person-month contribution.

Participants shall contribute to the networking activity, when requested and possible. Moreover, they must contribute to at least one activity and can decide to contribute to more or all activities.

10. Participants

Participants confirmed to commit immediately after subtask approval:

- Austria
- Italy
- Sweden
- Netherlands

Other participants (IETS members) are not confirmed but can also join immediately after the approval of the subtask proposal.

11. Subtask management

11.1 Subtask management effort

The workload for managing the Subtask, in addition to the Subtask manager's own contribution as a participant, will be at least one person-months per year.

11.2 Subtask host country and funding

The costs for Subtask Management will be borne by the countries hosting the Subtask managers. The Subtask Manager will be proposed and funded by Austria.

11.3 Subtask management obligations

The Subtask Manager shall:

- organize meetings (telephone meetings, webinars or face-to-face meetings) and workshops in accordance with the description in the Subtask proposal,
- coordinate the work within the Subtask (including dissemination actions),
- be responsible for a synthesis report of the work in the Subtask,
- with help of the other participants and the IETS executive committee and secretariat, identify new participants for the Subtask.

Contact details

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