Recommendations

Carbon Removal Certification Methodologies

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zero emissions platform

Zero Emissions Platform
INDUSTRIAL CARBON MANAGEMENT

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EXECUTIVE SUMMARY

Recommendations on Carbon Removal Certification methodologies

The Zero Emissions Platform (ZEP) welcomes the adoption of the European Commission's Carbon Removal and Carbon Farming (CRCF) Regulation. As the first public certification scheme for carbon dioxide removals (CDR) globally, the CRCF will facilitate and encourage the deployment of high-quality permanent carbon removals, carbon farming and carbon storage in products. By adopting certification methodologies for each carbon removal activity, it will also help instil trust in the effectiveness of this solution.

The first methodologies are expected to be ready in 2026, while certification of the first units under the CRCF is expected in 2026/2027. As technical discussions unfold, this paper aims to provide eight key recommendations to the European Commission for the Delegated Acts on certification methodologies for DACCS and BioCCS, which are the subject of this report.

Capital Emissions

ZEP suggests including capital emissions in the CRCF for transparency and public trust. However, this should not be administratively and financially burdensome for project developers. Simplified reporting and analysis should focus on activities expected to have the most impact during construction such as raw material sourcing, equipment manufacturing, and onsite fuel and utilities used during the construction phase.

Energy Consumption Emissions	DACCS and BioCCS projects can incur significant Scope 2 emissions through energy consumed by projects. To ensure high-quality carbon accounting for energy emissions, strict rules, such as the '3 pillars' approached used in existing EU legislation are needed to address this issue in the long term. However, this comes with a potential trade-off of burdening early first-mover projects. In the near term, some flexibility is needed with regard to how the phase-in of the '3 pillars' should be done. There is also a need for a methodology for quantifying electricity GHG intensity for power purchase agreements from non-renewable power sources not covered by RFNBO. ZEP proposes that the CRCF should include a technology-neutral, full-lifecycle electricity GHG intensity methodology that allows for annual temporal correlation in the near-term, progressing to a stricter hourly temporal correlation in the 2030's.
Project Additionality	ZEP proposes that projects selling carbon removals that create co-products should undergo a cradle to grave life cycle assessment (LCA) to establish a zero-carbon intensity production process of removals, thus allowing only excess net negative emissions to be sold as CR. The assessment shall also account for additional emissions resulting from the installation of a capture process in case of an existing plant, transportation and potential losses.
Financial Additionality	Instead of investment analysis, ZEP suggests disclosing public funding and subsidies for transparency alongside guardrails to ensure no double issuance of a DACCs to sequestration removal credit. This would be aligned with the TAP's proposed approach to define projects with the only activity being removals as zero baseline, and hence inherently additional.
Permanent Storage Timeframes and Liability	Ensuring the storage of CO_2 is permanent is a key requisite for CDR, given the permanent effects of CO_2 in the atmosphere. ZEP considers the proposed minimum of 200 years to be low to qualify as permanent and calls for a consistent permanence definition to ensure equivalence in the climate impact of activities in the category of "permanent carbon removals" under CRCF and for a well-functioning market. ZEP also recommends the application of the existing liability framework set up for the geological storage of CO_2 as the benchmark for all removal methods eligible for certification as "permanent carbon removals" to ensure a high-quality carbon accounting and a level-playing field.

Biomass Usage	To ensure maximum climate benefits and limited environmental impact, ZEP recommends implementing stringent sustainable sourcing criteria for biomass feedstock and comprehensive traceability and oversight across the supply chain. As a rule, biomass for carbon removal should only be used when no other immediate, stronger use case exists from climate, ecosystem, or human impact perspectives. Biomass feedstocks for BioCCS must follow the cascading principle of biomass use as per Article 3 of the RED III Directive to prioritize the highest economic and environmental value. Certification methodologies should seek to develop certification schemes for potential carbon removals arising from the capture of biogenic CO_2 from the processing of biofuels, bioliquids, and biomass fuels, biochemicals and nutrition products which meet the Union sustainability and GHG emissions saving criteria established under RED.
Mixed Flue Gases	For carbon removals generated from industrial processes where diverse CO_2 sources are captured, ZEP recommends determining the respective shares of biogenic and fossil CO_2 in accordance with the Monitoring and Reporting Regulation.
Issuance of Certificates	ZEP suggests issuing carbon removal units only after a re-certification audit has verified that captured CO_2 from biomass or air has been injected into permanent storage.

CONCLUSION

In conclusion, while the CRCF is a significant step in the right direction, it requires further refinement to ensure robust, comprehensive, and clear system boundaries for future policies supporting CDR. By getting this right, we can ensure that as CDR gains prominence in EU policy discussions, we will have robust certification systems in place to help this technology fully deliver on its climate potential.

TABLE OF CONTENT


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Introduction

As outlined in the European Climate Law, carbon dioxide removal (CDR) is a key part of climate change mitigation and will play a key role in keeping the rise in global temperatures below 1.5°C, achieving climate neutrality by 2050, and achieving negative emissions thereafter.[1]

ZEP welcomes the Carbon Removal and Cabon Farming (CRCF) Regulation[2], which will facilitate and encourage the deployment of permanent carbon removals, as well as carbon farming and carbon storage in products, through the adoption of certification methodologies for specific carbon removal activities, in accordance with the QU.A.L.ITY (quantification, additionality, long-term storage, and sustainability) principles laid out in the CRCF.

While CDR will be an important part of the effort to reach carbon neutrality, prioritising emission reductions remains essential. ZEP supports the efforts by the European Union and industry partners in reducing emissions across industrial operations.

Despite differences in prices and energy needs, capturing CO_2 both from industrial point sources and from the ambient air will be needed on a large scale to contribute to the 2030 and 2040 net climate targets. Scaling up CCS deployment will not only reduce emissions but should also lower the cost of CDR, as infrastructure for transport and permanent storage can be shared. Moreover, CCS and CDR can further contribute to the decarbonization of other hard-to-abate sectors through the reutilization of the captured CO_2.

According to the Zero Emissions Platform, four principles must be met for any practice or technology to be commonly considered as achieving "Carbon Dioxide Removal"[3]:

1. Carbon dioxide is physically removed from the atmosphere.

2. The removed carbon dioxide is stored out of the atmosphere in a manner intended to be permanent – i.e. at least on the order of several centuries.

3. Upstream and downstream greenhouse gas emissions, associated with the removal and storage process, are comprehensively estimated and included in the emission balance.

4. The total quantity of atmospheric carbon dioxide removed and permanently stored is greater than the total quantity of carbon dioxide equivalent emitted to the atmosphere."

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1 Official Journal of the European Union, 'Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law")', L 243/1 § (2021).

2 European Union, 'Political Agreement on a Proposal for a Regulation of the European Parliament and of the Council Establishing a Union Certification Framework for Permanent Carbon Removals, Carbon Farming and Carbon Storage in Products', 2022/0394 (COD) § (2024), https://doi.org/10.5040/9781782258674.

3 Zero Emissions Platform, 'Europe Needs a Definition of Carbon Dioxide Removal', July 2020, https://zeroemissionsplatform.eu/europe-needs-a-definition-of-carbon-dioxide-removal/.

Certification methodologies

As the CRCF enters into force, EU carbon removal policy will now focus on the certification methodologies for carbon dioxide removals (CDR) at the EU level. As announced at the EU Carbon Removal Expert Group in April 2024, the European Commission plans to issue draft methodologies on the certification of CDR methods, starting in Q3 2024 with Direct Air Capture and Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BioCCS) and follow a set of initial recommendations outlined in the Technical Assessment Paper (TAP), provided by ICF at the Carbon Removal Expert Group in April 2024.). These will be finalised as Delegated Acts in 2025, with a potential start of certification of removals from 2026.

Given that these certification methodologies will form the regulatory basis for future policies to support CDR methods, including DACCS and Bio-CCS, there is a need to ensure these methodologies retain the highest possible standards. Removal credits with questionable additionality, durability or other weaknesses could lead to a lack of trust and lower the desire to advance ambitious policies to scale up CDR. Moreover, given Europe's role in advancing ambitious climate policy at the international level, it is critical that the CRCF methodologies are robust, and comprehensive with clear system boundaries.[4]

This paper aims to provide a set of recommendations for the certification methodologies for DACCS and Bio-CCS in the CRCF, building on the recommendations provided by the TAP, outlining the approach which should be taken to a number of key issues relevant to the Delegated Acts. CDR policy in the EU is relatively underdeveloped and currently does not provide economic incentives for DACCS, BioCCS or other novel removal methods at EU level, nor does it encourage EU Member States to develop national policy incentives.[5] While policies are needed to rapidly scale up CDR, a key precondition is robust certification at the EU level.

However, scaling up CDR in the immediate future (i.e. pre-2030) will entail the construction of various first-of-a-kind (FOAK) DACCS and BioCCS projects of a comparatively small-scale (i.e. less than 1 million metric tonnes per year). These projects will include a plethora of uncertainties and variables, while the learnings from these projects will prove invaluable to scaling up CDR in the long term. Providing sufficient flexibility in the regulatory frameworks which will govern these projects is necessary to ensure these projects see the light of day. Failure to do so could result in the development of a CRCF which ultimately leads to the under-development of CDR in the EU.

There is therefore a need to ensure that the CRCF methodologies adequately balance the interests of robust certification, while also ensuring that sufficient flexibility is afforded to project development for CDR technologies to be deployed in the EU.

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4 Felix Schenuit et al., 'Secure Robust Carbon Dioxide Removal Policy through Credible Certification', Communications Earth & Environment 4, no. 1 (3 October 2023): 349, https://doi.org/10.1038/s43247-023-01014-x.

5 Mathias Fridahl et al., 'Novel Carbon Dioxide Removals Techniques Must Be Integrated into the European Union's Climate Policies', Communications Earth & Environment 4, no. 1 (7 December 2023): 459, https://doi.org/10.1038/s43247-023-01121-9.

1. Emissions associated with construction of the carbon removal project

Before a carbon removal project commences operation, emissions will be incurred through the construction of DACCS and BioCCS facilities, i.e. capital emissions. The CRCF is unclear on whether capital emissions are included in the definition of $_{GHGassociated}$ emissions from the "entire lifecycle".

However, Recital 8 of the CRCF states that the term $_{GHGassociated}$ should include "any associated GHG emissions occurring during the lifecycle of the activity and related to the implementation of the activity" but does not include capital emissions in the list of examples of emissions that should be included.[6]

1.1 An overview of capital emissions from DACCS and BioCCS projects

For DACCS and BioCCS, emissions could be incurred through activities such as:

- Preparation of the site
- Construction of buildings including materials, potentially roads needed to operate the facility
- Equipment used for the construction phase and the transport of this equipment to the site.
- Use of transportation methods during construction
- Chemicals and Utilities used during construction

Given that the deployment of DACCS and BioCCS facilities has hitherto been only done on a small scale, there is little data on the expected emissions to be incurred through their construction.

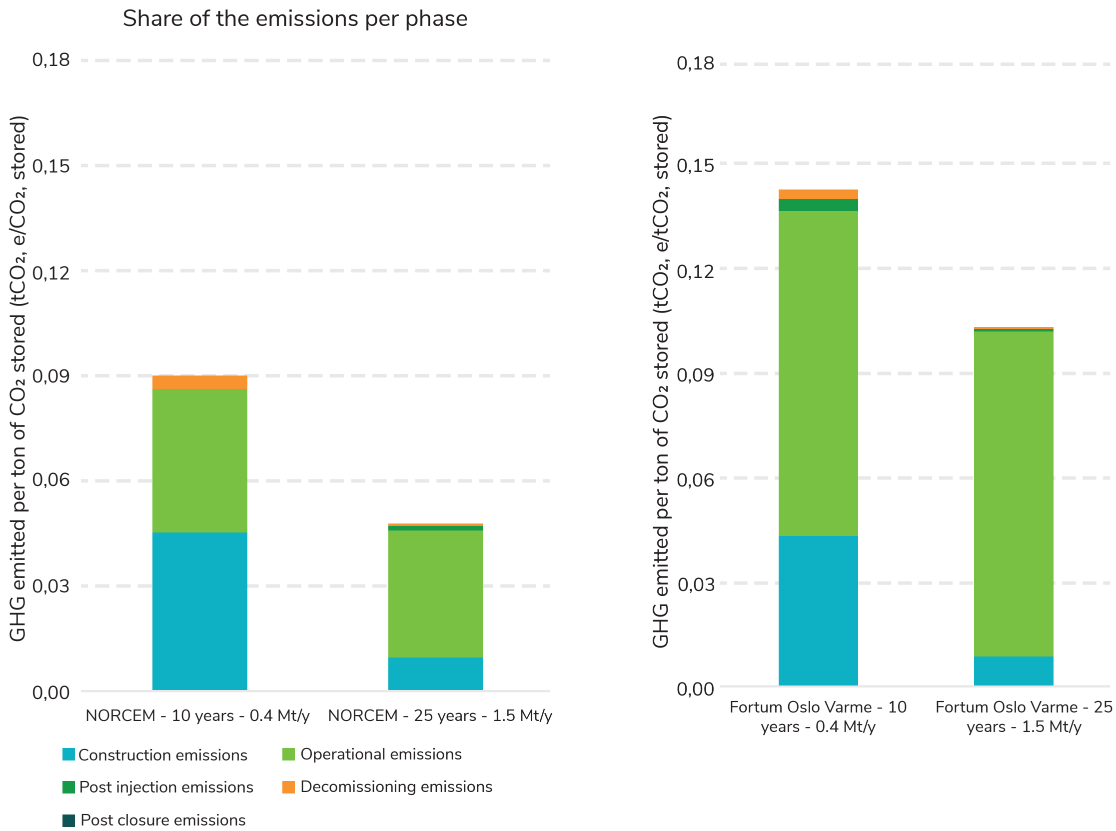
Emissions associated with the construction of a BioCCS facility will be of a similar nature to other point source capture projects, see Figure 1. Evidence from the Longship project[7] shows, the construction phase is generally less important compared to the operation phase, and that the impact of construction phase is dependent on operational life of the project.[8]

6 "Relevant GHG emissions that should be taken into consideration include direct emissions, such as those resulting from the use of fertilisers, chemicals, fuel or energy, other material inputs and transportation, or indirect emissions, such as those resulting from land use change with consequent risks for food security due to displacement of agricultural production, or displacement effects due to competing demand for energy or waste heat".

7 Gassnova, 'Full Chain CO_2 Footprint: Northern Lights', 25 November 2019.

8 Note: The overall emissions impact of NORCEM project is low due to usage of waste heat in the capture process. So, while the construction emissions look significant as a percentage of the total project emissions, their impact is not significant in comparison to the amount of CO_2 that is stored.

Figure 1: Overview of lifecycle emissions in the Longship CCS project[9]



For example, in both cases shown in the figure, the impact of construction emissions decreases substantially more than operational emissions as a share as the project lifetime extends and injection rates are increased. It is worth noting that the NORCEM project uses waste heat in the capture process. Therefore, while the construction emissions look significant as a percentage of the total project emissions, their impact is not significant in comparison to the amount of CO_2 that is stored. In this regard, the expected project operating life must be accounted for to establish materiality. The materiality threshold is based on the expected lifetime climate benefit of the project, not the relative share of the project emissions.

An illustrative example of emissions associated with the construction of a DAC facility has been provided by the construction of the Orca plant by Climeworks, which has a capacity of 4 kt CO_2/yr, has a carbon footprint of 15 g CO_2e per kg CO_2 capture,[10] equating to approximately 6 kg CO_2e per ton of gross CO_2 removal.

From this illustrative evidence, similar outcomes could be expected for DACCS and BECCS facilities in future, although it should be noted, given the expected increases in efficiency through project deployment and the decarbonisation of supply chains across industries, it is likely that the emissions incurred through the construction of both DACCS and BioCCS facilities will reduce on a levelised per tonne basis.

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9 Gassnova, 'Full Chain CO_2 Footprint: Northern Lights', 8.

10 Rocio Gonzalez Sanchez et al., 'The Role of Direct Air Capture in EU's Decarbonisation and Associated Carbon Intensity for Synthetic Fuels Production', Energies 16, no. 9 (3 May 2023): 11, https://doi.org/10.3390/en16093881.

1.2 Recommendations for accounting for capital emissions in the CRCF

As also noted in the TAP, construction emissions are expected to be less significant in comparison to CO_2 captured and stored over the lifetime of industrial-scale CCS projects and are typically excluded in existing compliance markets and certification methodologies.[11] Therefore, while arguments could be made that these initial emissions could be excluded for simplicity without significantly impacting the environmental benefit delivered by the CDR projects, including all capital emissions in the CRCF emissions balance, insofar as it is applicable to and consistent among all CDR approaches, would more accurately represent the project impact and could ensure greater public trust and full transparency is provided by certified CDR projects.

Furthermore, the approach must not make it administratively and financially burdensome for project developers by being required to report and analyse each construction site activity. The analysis should rather focus on activities expected to have the most impact during construction, e.g., raw material sourcing, equipment manufacturing, and onsite fuel and utilities used during construction, which would likely already be analysed for other sustainability reporting requirements. Moreover, project developers should be permitted to use existing data from other projects of their kind.

11 ICF, Cerulogy, and Fraunhofer ISI, 'Support to the Development of Methodologies for the Certification of Industrial Carbon Removals with Permanent Storage - Technical Assessment Paper on Certification Methodologies of Permanent Carbon Removals', 27 March 2024.

2. Emissions factors related to energy consumption from CDR projects

The agreed CRCF text states that the term $_{GHGassociated}$ should include “direct emissions, such as those resulting from the use of … energy, … or indirect emissions, such as those resulting from … displacement effects due to competing demand for energy or waste heat.” This section provides an overview of how to approach the issue of accounting for indirect emissions resulting from CDR projects.

2.1 CDR Energy Consumption Emissions

Energy consumption for CO_2 capture is inversely correlated to the CO_2 concentration in the gas from which CO_2 is captured. DACCS projects will therefore require more energy consumption than CO_2 capture from industry and power per tonne captured. A significant proportion of DACCS energy requirement is expected to be from electricity. As such, the treatment of the GHG intensity of that electricity could significantly impact the net carbon removals calculated for a project.

There is a clear need to account for the emissions from the electricity consumed by DACCS and BioCCS. Doing so will require clear, rigorous accounting to ensure that emissions are accurately accounted for when certifying when a removal produced through DACCS or BioCCS, is indeed a removal.

However, there are also large uncertainties in the future deployment potential and costs of DACCS and BioCCS, particularly given the scope for considerable improvements in efficiency through continued research and innovation (R&I) and learning-by-doing, which can only be achieved through deployment.

Strict rules on temporal and geographical matching can ensure the integrity of certified removals from DACCS projects but will likely introduce large cost burdens and potential execution risks on project developers at a time when there is little demand-side pull for CDR. Such strict rules could make investment in DACCS prohibitively risky, lowering the overall deployment. Therefore, given the current uncertainty regarding the stringency needed to ensure adequate accuracy and the imperative for near-term development and deployment of this critical climate technology, it is important to ensure some flexibility is afforded to developers in the short term (i.e. until stable market demand has developed) in order to ensure this learning-by-doing can actually occur.

2.2 Factors Influencing Electricity Consumption Emissions

When assessing the consumption of electricity, there are three key issues, commonly referred to as the three pillars which are equally relevant to the production of carbon removals:

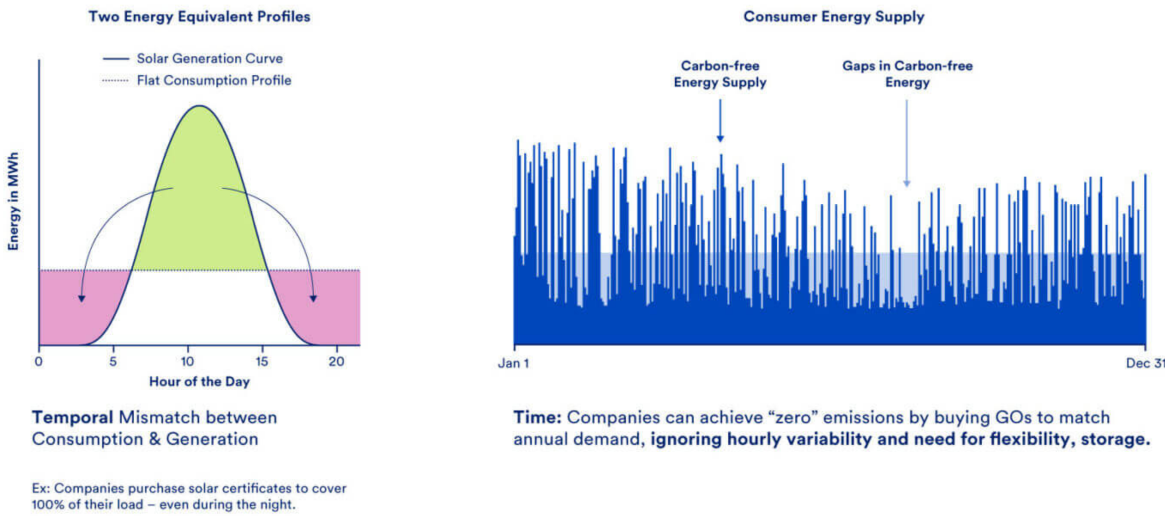
1. **Additionality** –The assessment of whether new low-emissions energy sources are used to power the facility producing carbon removals.

2. **Geographical Correlation** – Electricity demand must be located within a reasonably connected region to the clean electricity source.

3. **Temporal Correlation** – The electricity consumed during the production of carbon removals and the electricity generated by the new clean energy source is matched over a certain timeframe. Together with geographical correlation, this pillar is to ensure physical flow of additional electricity from the source to the carbon removal facility.

With the increased production of electricity through variable renewable sources, the carbon intensity of the grid in each region or bidding zone is extremely variable. Figure 2 shows the profile of solar energy production during a given day, as consumption of a given unit remains constant (left) which is then shown over the course of a given year (right).

Figure 2: The correlation between the production of variable, renewable electricity and consumption.[12]



In this case, Figure 2 (right) shows that for a constant grid demand, the proportion of carbon-free energy supply varies over time, which often leads to use of firm supply sources like gas, coal or nuclear. In the case of demand sources like DACCS or BioCCS plants, which typically have relatively constant demand on a daily basis, their ability to vary demand in response to changes in the supply of renewable electricity is likely to be hindered. This presents a challenge both in certifying removals and grid decarbonisation efforts, more broadly. The application of the "three pillar approach" in assessment of the renewable electricity used by DACCS projects is expected to address the certification challenge.

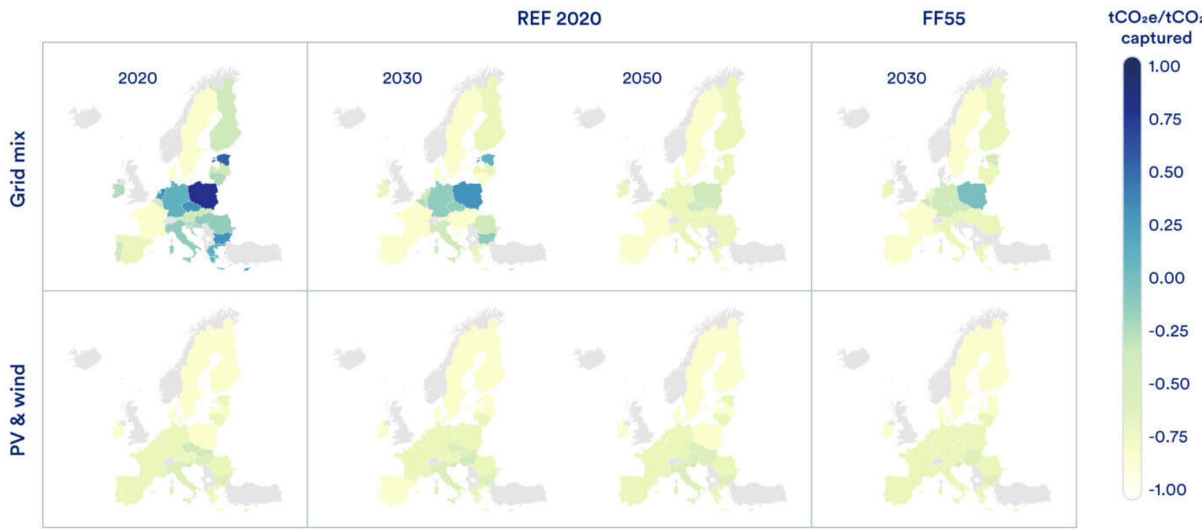
Evidence shows that carbon capture, particularly DAC, processes currently demand significant quantities of energy, heat, and water.[13] Depending on how the energy is sourced, as well as material inputs, DACCS may not always lead to net negative emissions as shown in Figure 3 below.[14]

12 Clean Air Task Force, '24/7 Carbon-Free Energy: How Europe Can and Must Secure Clean Electricity around the Clock', 21 November 2023, https://www.catf.us/2023/11/24-7-carbon-free-energy-europe-secure-clean-electricity-around-clock/.

13 For an overview of the process requirements for DAC technologies currently constructing demonstration scale projects, see: David W. Keith et al., 'A Process for Capturing CO_2 from the Atmosphere', Joule 2, no. 8 (August 2018): 1573–94, https://doi.org/10.1016/j.joule.2018.05.006; Mahdi Fasihi, Olga Efimova, and Christian Breyer, 'Techno-Economic Assessment of CO_2 Direct Air Capture Plants', Journal of Cleaner Production 224 (July 2019): 957–80, https://doi.org/10.1016/j.jclepro.2019.03.086.

14 For example, "in 2020 using the grid mix, there are five countries in which the carbon footprint of DAC is above zero (Bulgaria, Cyprus, Czech Republic, Estonia, and Poland) with values ranging from 0.007 to 0.747 tCO_2e/tCO_2 captured." See: Gonzalez Sanchez et al., 'The Role of Direct Air Capture in EU's Decarbonisation and Associated Carbon Intensity for Synthetic Fuels Production', 14; See also: Tom Terlouw et al., 'Life Cycle

Figure 3: The Carbon footprint of DAC (tCO_2e/tCO_2 captured) in the EU member states for the grid mix and PV and Wind cases for the years 2020 and 2030[15]



Using clean energy to supply DACCS energy needs is critical to maximizing the removal benefit delivered by DACCS projects. However, given clean electricity supply may be limited in the near- and medium-term future, the use of clean electricity for DACCS will need to be carefully balanced with more direct (and likely more emission reducing) uses for power demand. It should be noted however, that given the limited number of operational and planned DAC facilities, the risks of DAC jeopardising other sectors' access to clean electricity is limited in the near term (i.e. before 2035).[16]

Furthermore, there are also large uncertainties in the technology's future deployment potential and costs, particularly given the scope for considerable improvements in efficiency through continued research and innovation (R&I) and learning-by-doing, which can only be achieved through deployment. Ensuring learning-by-doing for early projects is enabled particularly in the near term is critical to also improving the design, construction and operational efficiency improvements are maximised in the long run.[17]

2.3 Approaching the application of the three pillars to certifying carbon removals

To ensure that the deployment technologies which use significant amounts of power do not compromise broader efforts to decarbonise electricity production, rules regarding the three pillars can be proposed, each with advantages and drawbacks:

Assessment of Direct Air Carbon Capture and Storage with Low-Carbon Energy Sources', Environmental Science & Technology 55, no. 16 (17 August 2021): 11397–411, https://doi.org/10.1021/acs.est.1c03263.

15 Gonzalez Sanchez et al., 'The Role of Direct Air Capture in EU's Decarbonisation and Associated Carbon Intensity for Synthetic Fuels Production'.

16 Currently there are just four DAC projects in planning, construction or operation in Europe (Iceland and the UK) and none in the EU. See: Clean Air Task Force, Global Carbon Capture Activity and Project Map (Clean Air Task Force), accessed 7 August 2023, https://www.catf.us/ccsmapglobal/.

17 Climeworks, 'The Reality of Deploying Carbon Removal via Direct Air Capture in the Field', 15 May 2024, https://climeworks.com/news/the-reality-of-deploying-direct-air-capture-in-the-field.

1. **Additionality** – In order to ensure the deployment of carbon removal facilities do not divert current renewable electricity production from other uses, deployment is linked to additional sources of clean electricity generation through a power purchase agreement or similar agreement with a new power project which comes online within 36 months of the project.

    - **Advantages:** Ensures existing clean electricity supply is able to meet existing demand, while providing new supply is incentivised.

    - **Disadvantages:** Small carbon removal companies may have difficulty making the contractual guarantees necessary to secure a PPA for a new power project

2. **Geographical Correlation** – The power plant output and the electricity consumed by the carbon removal facility need to be in the same region or bidding zone.

    - **Advantages:** Ensures electricity demand in one region is met with clean electricity supply in that same region, which gives greater certainty in emissions accounting.

    - **Disadvantages:** Can lead to a saturation of deployment in specific regions which may have negative socio-economic impacts, while creating challenges for carbon removal deployment in regions where new clean power cannot be built.

3. **Temporal Correlation** – The power plant output and the electricity consumed by the carbon removal facility need to match in a certain timeframe. This requirement could be fulfilled by measuring the correlation within a certain timeframe from 15 minutes to annual basis.

    - **Advantages:** Ensures the time which electricity is consumed is met with clean electricity that is produced.

    - **Disadvantages:** Can be technically and economically challenging to meet, which can significantly limit or even de facto prohibit project deployment if implemented.

Implementing rules governing energy consumption requires careful balancing and the marginal benefit of stringency applied for each pillar should be evaluated in the context of the requirements of the other two pillars. Therefore, ZEP supports TAP's recommendation of using the "three pillar" approach in assessment of power consumption for certification of carbon removals but recommend some modifications below in order to appropriate balance the stringency of each pillar in the near-term.

2.3.1 Risks of an overly weak rules on consumption emissions

For example, the use of renewable energy certificates (REC's) or Guarantees of Origin (GO's) has enabled electricity consumers to claim their consumption as "100% renewable" on the basis of purchasing certificates for hours where electricity from other sources has been consumed. This approach does not require new power (additionality), or geographic correlation. This has been standard practice in voluntary corporate greenhouse gas accounting schemes, notably the "GHG Protocol's Corporate Standard and Scope 2 Guidance"[18], while several certification methodologies on the voluntary carbon market enable the use of GO's with annual matching to meet the requirements of certification.

When the three pillars are not applied in unison, as in the case of GO's, there is a greater chance that the

18 Cynthia Cummis et al., 'GHG Protocol Scope 2 Guidance - An Amendment to the GHG Protocol Corporate Standard', n.d., https://ghgprotocol.org/scope-2-guidance.

true induced electricity sector emissions are higher due to temporal misalignment between the renewable supply and electricity demand. The result could therefore be carbon removals being certified which are not, in fact, driving the implied impact on carbon flows. This poses significant risks to public trust in carbon removals, a critical factor in providing enduring policy support which is necessary to support the scale up of removals.

2.3.2 Risks of an overly restrictive rules on consumption emissions

Implementing strict rules, particularly in the short term, comes at the cost of inhibiting technology deployment. Stringency in criteria needs to be balanced between the incremental environmental benefit delivered by that measure vs the commercial risk posed by it to the DACCS project.

As described in the section below, there is mixed evidence on the question of whether hourly or annual matching is needed to ensure emissions accounting accuracy at this stage of DAC deployment and depending on a number of variables, including important policies to decarbonise the power sector. However, there is high confidence that hourly matching would cause significant project technical and financial risks that would impede project deployment.

Today we are in beginning phases of DAC project deployment. Commercial scale facilities are only beginning to run and there is patchy, uncertain demand from the voluntary carbon market while compliance markets to enable deployment do not exist. As a result, project developers are taking on sizable risk to push the technology forward.

If restrictive temporal matching is added to the risk profile of the project, it is highly unlikely that commercial scale projects would be financeable. Because of the geographic correlation and additionality requirements also proposed, the market for local additional hourly renewable energy attributes that eligible energy could be procured on would be shallow and illiquid with significant price and volume risk that will be hard to quantify or mitigate. Therefore, if a DACCS project developer sees in retrospect that an hour of the facility running was not deemed to be eligible based on temporal correlation, the CDR credits could be discounted. This creates an unbounded degree of uncertainty on the production side which, when combined with the uncertainty on the demand side, is unlikely to be palatable for finance providers.

As a result, we would be unlikely to see deployment of CRCF eligible DACCS projects until suitable locations would meet a sufficient grid average renewable capacity (90%) for grid power to be considered renewable. This delay also poses a significant risk to the EU's goal of reaching climate neutrality in 2050.

2.4 An optimal approach to energy consumption emissions

Several academic studies have investigated the impact of schemes which aimed to implement versions of the 'three pillars', most of which outline the need for flexibility in designing rules on energy consumption emissions in the short term, while advancing towards stricter rules in the long term.[19] An assessment of

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19 Michael A. Giovanniello et al., 'The Influence of Additionality and Time-Matching Requirements on the Emissions from Grid-Connected Hydrogen Production', Nature Energy 9, no. 2 (8 January 2024): 197–207, https://doi.org/10.1038/s41560-023-01435-0; Oliver Ruhnau and Johanna Schiele, 'Flexible Green Hydrogen: The Effect of Relaxing Simultaneity Requirements on Project Design, Economics, and Power Sector Emissions', Energy Policy 182 (November 2023): 113763, https://doi.org/10.1016/j.enpol.2023.113763; Wilson Ricks, Pieter Gagnon, and Jesse D. Jenkins, 'Short-Run Marginal Emission Factors Neglect Impactful

these studies shows that outlining exactly what that approach should essentially rest on the assumption that either:

(1) There will be enough additional clean supply for all, in which case carbon removal does not take clean supply from other decarbonisation efforts, or other policies covering the electricity sector such as emissions trading schemes or clean/renewable energy standards are driving the overall grid emissions such that emissions will be the same regardless of DAC deployment;

(2) The additional clean electricity supply will be tight and the deployment of carbon removals, especially DACCS, could result in additional fossil power generation and risk undermining decarbonisation efforts.

If one assumes (1), implementing strict rules to implement the 'three pillars' are less impactful. However, if one assumes (2), then implementing strict rules could prove critical to mitigate decarbonisation risks.

2.4.1 Examples of regulatory measures governing emissions from energy consumption: The RFNBO Framework

While the CRCF provides a 'first of a kind' regulatory framework to certify carbon removals globally, compliance frameworks which govern energy consumption emissions already exist. In particular, rules regarding the production of hydrogen through electrolysis, where the key input is electricity, are already in place in the EU and in the United States and have faced similar challenges to finding a pragmatic approach to governing consumption emissions.

Much like the production of CDR through BioCCS and DACCS, the production of efuels can provide a useful analogue since they consume significant amounts of energy to produce. As outlined in the TAP, precedent exists at the EU level for assigning GHG intensity to consumed electricity in the case of renewable electricity for efuels. Thus, the TAP recommends the rules from the renewable fuels of non-biological origin (RFNBO) framework[20] for treating consumed electricity as zero emissions be applied to the certification methodologies for carbon removals.[21] The RFNBO rules have clear requirements to achieve each of the 'three pillars'. [22]

Phenomena and Are Unsuitable for Assessing the Power Sector Emissions Impacts of Hydrogen Electrolysis', Energy Policy 189 (June 2024): 114119, https://doi.org/10.1016/j.enpol.2024.114119.{\\i{}Energy Policy} 189 (June 2024

20 Empowered by Article 27(3) of Renewable Energy Directive, the European Commission has defined the criteria for what constitutes renewable hydrogen for the EU. See: European Commission, 'Commission Delegated Regulation (EU) 2023/1184 of 10 February 2023 Supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by Establishing a Union Methodology Setting out Detailed Rules for the Production of Renewable Liquid and Gaseous Transport Fuels of Non-Biological Origin', L 157/11 § (2023) (RFNBO Framework).

21 ICF, Cerulogy, and Fraunhofer ISI, 'Technical Assessment Paper on Certification Methodologies for Permanent CDR', 10–13.

22 Under the RFNBO Framework, power nominally purchased from a renewable supplier, but which does not meet the set conditions, is not treated as renewable, and is therefore assessed at the average GHG intensity and renewability of the grid. Grid power can be identified as zero carbon under the following conditions:

1) Over 90% renewable energy consumption in the local bidding zone in the previous calendar year;

2) Greenhouse gas intensity of electricity below 18 gCO_2e/MJ in the bidding zone, with fuel producers having PPAs with renewable power generators;

1. **Additionality and Geographical Correlation** – The additionality criteria contain a series of conditions, including:

    a. The renewable energy installation's operation needs to come into operation not earlier than 36 months before the electrolyser (where coming into operation is understood as commissioning date)

    b. The renewable energy installation has not received any public financial support in the form of operating aid or investment aid.

    A transitional phase is envisaged for the additionality requirement criteria and for all RFNBO installations which came into operation before the end of 2027, with the additionality requirement applying only from 1 January 2038. For all other RFNBO installations coming into operation after 1st January 2028, additionality requirements will apply from the first day.

    There are two key exemptions to additionality requirements, namely:

    - The electrolyser is located in a bidding zone with more than 90% RES-E share or,
    - where the emission intensity of electricity is lower than 18 gCO_2eq/MJ

2. **Temporal Correlation** - The RFNBO DA implements the temporal correlation principle for hydrogen produced via electricity sourced from the grid in the following way:

    a. Until 31st December 2029 the electricity consumed for the production of RFNBO must be matched with electricity generated within the same month.

    b. Starting from 1st January 2030, the electricity consumed for the production of RFNBO must be matched with electricity generated within the same hour.

    c. There is no grandfathering rule – i.e. the above implementation phases apply equally to all RFNBO installations irrespective of the date of entry into operation.

    d. There is one exemption where the temporal correlation rule does not need to be followed: i.e. when the electrolyser operates during hour when day ahead electricity price in the bidding zone was ≤ 20 €/MWh or ≤ 0.36 of the ETS carbon price (€/t CO_2).

    e. At the latest by 1 July 2028, the Commission should deliver a report to the European Parliament and the Council assessing the impact of the gradual strengthening of the requirements on temporal correlation – with the possibility of further relaxation of the rules depending on the outcome of that report.

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3) Consumption during periods of renewable power surplus;

4) PPAs with renewable power generators established within 36 months before the installation of the Renewable Fuels of Non-Biological Origin (RFNBO) facility. No state support;

5) The number of operating hours of the facility in a year should not exceed the number of hours in the preceding calendar year when the marginal price of electricity was set by installations producing renewable electricity or by nuclear power plants;

6) If available, the marginal unit generating electricity at the time of operation should be zero carbon, as provided by the national Transmission System Operator (TSO).

2.4.2 Issues with direct application of the RFNBO framework

There are several key issues with the RFNBO requirements and how directly implementing these rules could negatively impact the deployment of carbon removals. Carbon removal technologies like DACCS are capital intensive and need a high utilisation rate to minimise the levelized cost of carbon removals. By implementing strict rules, particularly hourly matching requirements, this can severely negatively impact the deployment of projects as outlined in the Section 1.3.2. Moreover, the rules applied under the RFNBO framework in the case of hydrogen rest on considerable uncertainty and it remains to be seen how these rules will impact on the scale-up of hydrogen production.

More broadly, there are three key significant differences between the production of RFNBOs and DACCS.

1) First, the use of renewable and low-carbon hydrogen is intended to replace fossil fuels and grey hydrogen, thereby achieving significant emissions reductions today. However, the use of DACCS is only to achieve carbon removals, which will be increasingly important in the longer term. As outlined above, ZEP has already outlined that the deployment of carbon removal technologies should come secondary to emissions reductions in the near-term.

2) Second, the technology readiness level (TRL) and commercial readiness level (CRL) for DAC and electrolysers are comparatively different while[23] the first commercial DACCS facility came into operation in 2021.[24] Due to the primary production cost being power, electrolysers have evolved to be flexibility turned on and off based on power costs (or emission intensity). DAC facilities are also less able to vary load rapidly in response to renewable output compared with hydrogen electrolysers, at least at this nascent stage of technology development.

3) Third, the deployment of electrolysers to produce renewable and low-carbon hydrogen is expected to increase at significantly higher rates in the coming years, compared with DAC. This is largely due to the large amounts of subsidies and policies dedicated to achieving the scale-up in the production of hydrogen. In Europe, DACCS has thus far not received any significant funding or dedicated policies to accelerate its deployment and is therefore dependent entirely on voluntary purchases of the pure environmental good for carbon removal.

While lessons from the regulation of electrolytic hydrogen can be learned, a simple analogous application of rules regarding emissions from the production of electrolytic hydrogen is not recommended. Nevertheless, insights can be gained from approaching the production of RFNBOs and carbon removals produced via DACCS with a pragmatic approach to ensure flexibility in the near term, with a view to implementing stricter rules in the longer term.

23 For example, the International Energy Agency (IEA)'s ETP Clean Energy Technology Guide regards polymer electrolyte membrane and alkaline electrolysers at TRL 9-10, while several DAC technologies exist ranging from Solid DAC at TRL 7-8 to Liquid DAC at TRL 5-6. See: International Energy Agency, 'ETP Clean Energy Technology Guide', 14 September 2023, https://www.iea.org/data-and-statistics/data-tools/etp-clean-energy-technology-guide.

24 Climeworks, 'Climeworks Begins Operations of Orca, the World's Largest Direct Air Capture and CO_2 Storage Plant', 8 September 2021, https://climeworks.com/press-release/climeworks-launches-orca.

2.5 Recommendations for accounting for emissions factors in certification of DACCS and BioCCS

Ensuring coherence across EU policy and regulations is necessary to ensure sufficient trust and investor confidence. In order to achieve the necessary scale-up of DACCS, it is also essential that sensible policy and regulatory measures be implemented to support the scale up of DACCS and BioCCS. There is also a need for a methodology for quantifying electricity GHG intensity for power purchase agreements from non-renewable power sources not covered by the RFNBO framework.

As outlined, the case of annual matching has between discouraged both at the EU level through the RFNBO framework, which follow a 'phased approach' and were recommended to policymakers on the basis of several academic studies, including two which modelled the impact of deploying projected electrolyser deployment on the grid in the US[25] and Germany,[26] which has been subject to a recent significant rebuttal.[27]

ZEP proposes that the CRCF could include the RFNBO methodology for electricity supply to be classified as fully renewable with zero emissions, but could also include a second technology-neutral methodology pathway that could be used to quantify full-lifecycle electricity GHG intensity for power purchase agreements from any type of electricity source. The primary reason for this is the CRCF is a carbon accounting framework which should accurately reflect the full lifecycle emissions factors from non-renewable sources of energy. ZEP's key recommendations for a technology-neutral methodology are detailed in the following subsections.

A technology-neutral methodology should include the full lifecycle cradle-to-grave emissions for electricity supply, including emissions factors for embedded emissions in manufacturing and construction of electricity projects and upstream fuel production emissions. This pathway therefore would never have zero emissions for electricity supply, even from renewable sources, but would reflect greater accuracy in emissions produced from electricity used by carbon removal projects.

2.5.1 Additionality and Geographical Correlation

Given the need to ensure additional clean supply of electricity sources is promoted in the EU, the application of the rules as they pertain to additionality and geographical correlation in the RFNBO framework is to be recommended.

2.5.2 Temporal Correlation

ZEP recommends that the suggested technology-neutral methodology could initially allow for annual matching in the near-term, with higher-frequency temporal matching phased in over time and the application of hourly matching at some point in the 2030s. As requirements become more stringent, particularly for hourly temporal correlation requirements, the Commission should include a similar approach to tightening temporal correlation as in the RFNBO Delegated Regulation.

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25 Giovanniello et al., 'The Influence of Additionality and Time-Matching Requirements on the Emissions from Grid-Connected Hydrogen Production'.

26 Ruhnau and Schiele, 'Flexible Green Hydrogen'.

27 Ricks, Gagnon, and Jenkins, 'Short-Run Marginal Emission Factors Neglect Impactful Phenomena and Are Unsuitable for Assessing the Power Sector Emissions Impacts of Hydrogen Electrolysis'.

Specifically, the Commission should monitor closely and assess the impact of the requirements set out in this Regulation, notably the gradual strengthening of the requirements on temporal correlation, regarding production costs, greenhouse gas emission savings and the energy system and submit at the latest by 1 July 2030, and 2035 a report to the European Parliament and the Council. This would ensure that as conditions regarding matching requirements are incrementally tightened, there is sufficient supporting evidence to justify these additional regulatory requirements.

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3. Establishing standardised baselines to ensure project additionality

Ensuring that carbon removal projects are additional is a key cornerstone to developing robust EU CDR policy. As outlined in Articles 5 (1) and 5 (2) of the CRCF, the setting of the standardised baseline represents a critical measure of when carbon removal projects are deemed to be additional, and when they are not. The TAP has proposed that a standardised baseline of zero for projects where carbon removal units represent the only revenue stream or are clearly the primary revenue stream.[28] Moreover, the TAP recommends that standardised baselines for other activities should be assessed on a case-by-case basis with reference to potential revenues.

3.1 Assessing CDR projects which provide co-products

When assessing how this setting of the standardised baseline would impact carbon removal projects, it is important to assess both:

1) Projects which are solely producing carbon removals, and;

2) Projects which are producing carbon removals and co-products.

For projects which are solely producing carbon removals, this approach could allow for a zero baseline and therefore any removals produced would be deemed additional. This would be a sensible approach. However, for projects which are producing carbon removals as a co-product, the proposed baselining approach for removals may not be sufficiently dynamic enough to respond to the changing economic conditions in the production, and ultimately, sale of carbon removals. Given the lack of robust economic incentives, lack of a clear business model, or regulatory measures to accelerate the deployment of CDR, there are risks in taking this approach since defining the "primary revenue stream" for projects where no clear business case yet exists, may not be possible.

By allowing a CDR credit to be associated with an activity, there is an additional revenue stream created thereby changing the decision-maker's boundary condition for continuing to operate or not. An allocative approach to life cycle accounting with co-products may be appropriate when a minor product is created as a byproduct of a CDR activity. However, it may not be sensible to use this approach when a CDR process is appended to an existing industrial process as this may indirectly promote an expansion of industrial emissions.

3.2 Recommendations for approaching project additionality

ZEP therefore recommends that projects selling carbon removals that creates co-products should be subject to a cradle to grave Life Cycle Assessment (LCA) that accounts for emissions resulting from all activities associated with the production of those carbon removals (e.g. including additional emissions resulting from the installation of a capture facility at an existing plant, transportation, potential loses) to first establish a zero-carbon intensity production process of removals, allowing only excess net negative emissions to be sold as carbon removals. The capital emissions from these projects should be depreciated over the lifetime of the project, as provided with further details in Section 6.

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28 ICF, Cerulogy, and Fraunhofer ISI, 'Technical Assessment Paper on Certification Methodologies for Permanent CDR', 21.

4. Requirements on financial additionality

For a project to be additional, Article 5 (b) of the provisionally agreed CRCF outlines that it must be established that 'the incentive effect of the certification is needed for the activity to become financially viable.' If a project is assessed against a standardised baseline, Article 5 (2) outlines that this condition will be automatically considered to be complied with. If the project proposes an activity-specific baseline, then the agreed text requires that this should be demonstrated by an additionality test specified in the relevant certification methodology.

4.1 Evidence on the use of financial additionality tests in the voluntary market

Determining whether the incentive effect is indeed required for the project to be viable requires an assessment of whether the project would be viable in the absence of an incentive effect. This could be done through a financial additionality test.

The legacy approach of most Voluntary Carbon Market (VCM) frameworks, including CDM, leans heavily on financial additionality, which is not appropriate for assessing technological removals such as DAC. Facilities that use DAC to capture CO_2 from the air and subsequently inject it for geological sequestration have no other purpose than the removal of carbon dioxide. The proposed CDM investment analysis tool requires project proponents to disclose detailed financial information that is commercially sensitive in nature, yields results based on first-of-a-kind (FOAK) facility or front-end engineering-design (FEED) data that have inherent uncertainty, or requires project information that simply does not yet exist. In addition to not having this information, the nascent DAC industry is also in an early deployment phase with substantial risk for first movers and no precedent for expected returns on investment.

4.2 Recommendations on requirements for financial additionality

ZEP recommends the creation of a positive list or performance-based test against a zero baseline as the preferred option for assessing additionality of DAC projects. Instead of an investment analysis, we propose disclosure of public funding and subsidies for transparency along with guardrails to ensure no double issuance of a CO_2 capture to sequestration removal credit. This would be aligned with the TAP's proposed approach to define projects with the only activity being removals as zero baseline, and hence inherently additional.[29]

29 ICF, Cerulogy, and Fraunhofer ISI, 21.

5. Permanent Storage Timeframes and Liability

Ensuring the storage of CO_2 is permanent is a key requisite for any removal methods to be defined as "permanent carbon removals". This is particularly important because the effects of CO_2 in the atmosphere are permanent, thereby ensuring that any activity which is defined as a "permanent carbon removal" under the CRCF must reverse the climate impact of CO_2 emissions in their totality.

5.1 Defining "permanence" under the CRCF

Article 2(g) of the provisionally agreed CRCF defines permanent carbon removal as 'any practice or process that, under normal circumstances and using appropriate management practices, captures and stores atmospheric or biogenic carbon for several centuries, including permanently chemically bound carbon in products, and which is not combined with Enhanced Hydrocarbon Recovery.'

The TAP understands the meaning of "several centuries" to be at least 200 years.[30] By defining the meaning of "several centuries" to be at least 200 years, the TAP risks undermining the general interpretation of permanent storage to be permanent. This is because the storage of CO_2 in geological formations is currently regulated in the EU and EEA under the CCS Directive[31], which provides for comprehensive rules on issues relating to the licensing, operating, closure and post-closure obligations of storage operators.[32] Given that the Commission are considering to certify other removal methods which are not currently regulated under the CCS Directive, such as biochar, there are risks to undermining the CRCF in its entirety by setting the definition of 200 years as a minimum.

5.2 Defining liabilities under the CRCF

Art 6 (2.b) of the CRCF provides that "an operator or group of operators shall comply with both of the following criteria and be liable to address any reversal of the carbon captured and stored by an activity, occurring during the monitoring period, through appropriate liability mechanisms as set out in the delegated acts adopted pursuant to Article 8." As outlined earlier, removal methods which involve the storage of CO_2 in geological formations are currently regulated under the CCS Directive, Article 17 and 18 of which provides for a set of rules regarding the liability of storage site operators at all stages of a project.

Currently, there is no framework for other removal methods, which may be considered as "permanent carbon removals" under the CRCF, such as biochar. There is therefore a clear need for consistency across the CRCF, particularly for different removal methods considered in the same category of "permanent carbon removals" in order to ensure a well-functioning market emerges.

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30 ICF, Cerulogy, and Fraunhofer ISI, 'Technical Assessment Paper on Certification Methodologies for Permanent CDR', 23.

31 European Union, 'Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the Geological Storage of Carbon Dioxide and Amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006', L 140/114 § (2009).

32 Chapters 2, 3 and 4 of the CCS Directive provide comprehensive rules for the regulation of geologic storage sites. See: European Union.

5.3 Recommendations on storage and liabilities

In outlining the minimum criteria for eligible carbon removal projects to certify their removals as "permanent" there is a clear need for strong minimum requirements on the storage timeline for all "permanent carbon removals". The proposed interpretation of permanence used in the TAP of the length of storage to be at least 200 years is likely too short to be considered as "permanent". Several centuries is an acceptable time limit and has already been recommended by ZEP since 2020 as CO_2 should be stored in a manner intended to be permanent.[33]

A consistent criterion for permanence is important to ensuring equivalence in climate impact of activities in the category of "permanent carbon removals" under CRCF and for a well-functioning market. The monitoring and reversal risk management for ensuring permanence should then be set on an activity specific basis. Where an activity is associated with an expected storage period in another piece of legislation (e.g. the specifications for geological storage under the CCS Directive) then that period should be reflected in the certification methodology.

Development of the certification methodologies beyond the first versions of the Carbon Removal Certification methodologies for permanent carbon removal must be based on existing European legislation such as the CCS Directive and methodologies such as the CDM analysis tool, as well as current knowledge, understanding and best practices. In order to ensure consistency and a robust certification framework for all permanent removals, it is essential that the existing liability framework set out for the geological storage of CO_2, which would apply to DACCS and BioCCS, be set as the benchmark for all removal methods eligible for certification as "permanent carbon removals".

33 Mathilde Fajardy and Niall Mac Dowell, 'Can BECCS Deliver Sustainable and Resource Efficient Negative Emissions?', Energy & Environmental Science 10, no. 6 (2017): 1389–1426

6. Ensuring high-integrity, sustainable biomass feedstocks are used in the production of removals

BioCCS integrates the combustion of biomass with CCS, enabling the potential for negative emissions as biomass sequesters CO_2 during its growth. This approach offers the prospect of immediate, relatively cost-effective, and permanent carbon removal. However, to accurately assess whether negative emissions are actually achieved, a thorough lifecycle analysis of the entire value chain is necessary.[34] Moreover, the cultivation of biomass necessitates a significant land area, potentially leading to conflicts with food production and the preservation of biodiversity.[35]

The CRCF preamble states that 'certification methodologies should, as much as possible, incentivise the generation of co-benefits for biodiversity going beyond the minimum sustainability requirements, with a view to generate a premium for the certified units, by including for instance positive lists of activities that are deemed to generate co-benefits.'[36] The Renewable Energy Directive provides a framework for biomass use and sets sustainability requirements on biomass used for energy.[37]

6.1 Using BioCCS to contribute maximum climate benefits with lower environmental risks

Utilising feedstocks that are genuine wastes or do not contribute to land use change, along with BioCCS facilities that capture current biogenic point sources, are likely to yield climate benefits with limited environmental risks.[38] To ensure that biomass use does not result in adverse environmental impacts, stringent sustainable sourcing criteria for biomass feedstock and comprehensive traceability and oversight across the supply chain are essential.[39]

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34 Samantha Eleanor Tanzer and Andrea Ramírez, 'When Are Negative Emissions Negative Emissions?', Energy & Environmental Science 12, no. 4 (2019): 1210–18, https://doi.org/10.1039/C8EE03338B.

35 Fajardy and Mac Dowell, 'Can BECCS Deliver Sustainable and Resource Efficient Negative Emissions?'; Augustin Prado et al., 'Assessing the Impact of Carbon Dioxide Removal on the Power System', iScience 26, no. 4 (April 2023): 106303, https://doi.org/10.1016/j.isci.2023.106303; Caleb M Woodall and McCormick, 'Assessing the Optimal Uses of Biomass: Carbon and Energy Price Conditions for the Aines Principle to Apply', Frontiers in Climate 4, no. 993230 (18 October 2022).

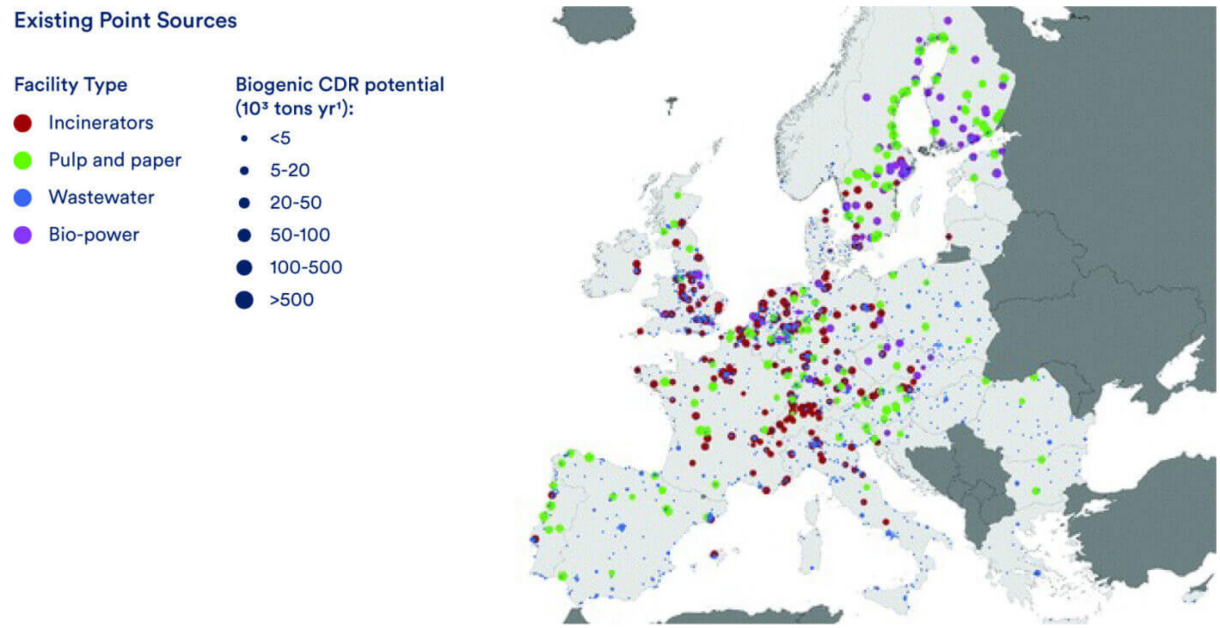
36 European Union, Political Agreement on a Proposal for a Regulation of the European Parliament and of the Council establishing a Union certification framework for permanent carbon removals, carbon farming and carbon storage in products, Recital 17.

37 European Union, 'Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources (Recast)', L 328/82 § (n.d.), Article 29.

38 Muir Freer et al., 'Putting Bioenergy with Carbon Capture and Storage in a Spatial Context: What Should Go Where?', Frontiers in Climate 4 (7 March 2022): 826982, https://doi.org/10.3389/fclim.2022.826982.

39 Freer et al.

Figure 4: Geospatial distribution of biogenic carbon dioxide removal potential from existing point sources in Europe in 2018[40]



Short-term opportunities for BioCCS can be capitalized on by leveraging existing biogenic point sources, which have the potential to achieve negative emissions from ongoing processes. These opportunities include the implementation of CCS in sectors such as cement, pulp and paper, bioenergy, and waste-to-energy, which collectively emit over 100 Mt of biogenic emissions in Europe.[41] Certain biogenic point sources offer high-purity CO_2 streams, significantly reducing capture costs, as seen in ethanol production. These cost-effective CCS applications, if implemented sustainably and effectively, could potentially yield negative emissions and reduce the emissions intensity of products. It must however be recognized that cost-efficient access to transport and geological storage could be a challenge for these sources, if minor, and if not clustered with other CO_2 capture facilities with access to transport to permanent storage.[42]

6.2 Recommendations for accounting for biomass usage in certification

In order to ensure the deployment of BioCCS yields maximum climate benefits and limited impact on the natural environment, safeguards should be applied to the use of biomass feedstocks in the certification of removals through BioCCS.

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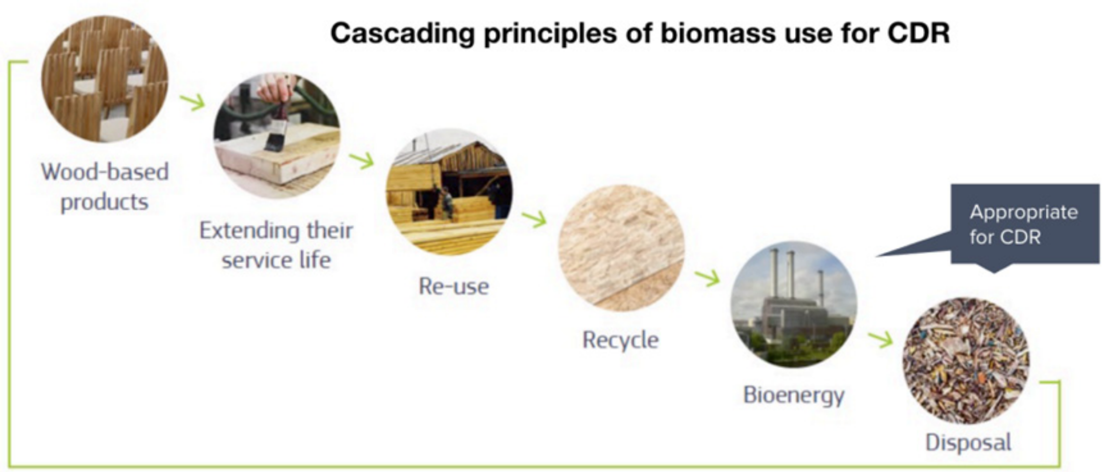
40 Lorenzo Rosa, Daniel L. Sanchez, and Marco Mazzotti, 'Assessment of Carbon Dioxide Removal Potential via BECCS in a Carbon-Neutral Europe', Energy & Environmental Science 14, no. 5 (13 April 2021): 3089, https://doi.org/10.1039/D1EE00642H.

41 Rosa, Sanchez, and Mazzotti, 'Assessment of Carbon Dioxide Removal Potential via BECCS in a Carbon-Neutral Europe'.

42 Emma Jagu Schippers and Olivier Massol, 'Unlocking CO_2 Infrastructure Deployment: The Impact of Carbon Removal Accounting', Energy Policy 171 (December 2022): 113265, https://doi.org/10.1016/j.enpol.2022.113265.

As a rule, biomass for carbon removal should only be used when no other immediate, stronger use case exists from climate, ecosystem, or human impact perspectives. Biomass feedstocks for BioCCS must follow the cascading principle of biomass use. This is currently regulated at EU level under Article 3 of the RED III Directive prioritising the highest economic and environmental value,[43] while Article 29 of the RED II Directive provides for sustainability requirements for biomass used in the production of energy.[44] The underlying idea of the cascading principle is that biomass should only be used for energy when it cannot be used for other purposes. Because the cascading principle is not yet implemented on an EU level, it is not fully clear how it will work in practice. The ZEP therefore welcomes research on the implementation of the cascading principle for BioCCS as well as production of biochar, in particular when biochar is applied for industrial use, combined with CCS. Research should put the cascading principle of high-value wood and the use of lower-value biomass such as treetops and branches, agricultural waste and similar in a CDR context. Until a broader knowledge base has been established, a conservative approach for the use of biomass for CDR should be applied.

Figure 5: The cascading principles of biomass use for carbon removal.



In sum, ZEP recommends the prioritisation of waste and residues over purpose-grown biomass. It is however important to ensure sufficient residues are left to maintain ecosystem health, as they provide essential nutrients and soil organic carbon.

43 European Union, 'Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 Amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as Regards the Promotion of Energy from Renewable Sources, and Repealing Council Directive (EU) 2015/652', OJ L, 2023/2413 § (2023), Article 3.

44 European Union, Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast).

7. Accounting for mixed flue gases

A key issue for permanent carbon removals generated through BioCCS methods is the accounting for mixed flue gases at point source capture facilities. Installations that utilise variety of fuel sources and/or feedstock must distinguish between the portion of the biogenic vs fossil CO_2 generated during the thermal process such as in waste-to-energy plants, and depending on the installation, any other CO_2 stream (i.e. process emissions in the production of cement).

7.1 Recommendations for accounting for mixed flue gases

For carbon removals generated from industrial processes where diverse CO_2 sources are captured the determination of the respective shares of biogenic and fossil CO_2 can be determined and measured in accordance with the Monitoring and Reporting Regulation (MRR). [45]

The MRR is used already for CO_2 reporting compliance for installations under the EU ETS. For example, t defines the calculation of combustion emissions according to the source stream (fuels source) by multiplying the activity data related to the amount of fuel combusted, by the corresponding emission factor, and the corresponding oxidation factor.

Calculation factors could be either as default values or values based on analysis, depending on the applicable tier. The operator shall be required to determine the biomass fraction only for mixed fuels or materials. For other fuels or materials, the default value of 0 % for the biomass portion of fossil fuels or materials shall be used, and a default value of 100 % biomass fraction for biomass fuels or materials consisting exclusively of biomass.

For mixed fuels or materials, the operator may either assume the absence of biomass and apply a default fossil fraction of 100% or determine a biomass by carrying out analyses to determine the biomass fraction. It shall do so on the basis of a relevant standard and the analytical methods therein, provided that the use of that standard and analytical method is approved by the competent authority.

Estimation methods are allowed for fuels or materials originating from a production process with defined and traceable input streams, the operator may base the estimation on a mass balance of fossil and biomass carbon entering and leaving the process. In such a case, the operator shall provide evidence that the installation's total emissions are not systematically underestimated by the applied monitoring methodology and that the total mass of carbon corresponding to the biomass fractions of the carbon contained in all relevant output materials does not exceed the total mass of biomass fractions of the carbon contained in input materials and fuels. The emission factor of biomass shall be zero.

The application of the MRR to the CO_2 flue gases assessment should ensure a consistent approach towards fuels and biogenic content. To ensure consistency across the EU, same approach should be used for plants not yet covered by the EU ETS, in which the CO_2 streams come from fossil and biogenic sources.

Ultimately, regarding the mass balance rules for captured CO_2, EU rules developed under the EU ETS MRR should apply.

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45 European Commission, 'Commission Implementing Regulation (EU) 2018/ 2066 - of 19 December 2018 - on the Monitoring and Reporting of Greenhouse Gas Emissions Pursuant to Directive 2003/ 87/ EC of the European Parliament and of the Council and Amending Commission Regulation (EU) No 601 / 2012', L 334/1 § (2018).

8. Issuance of certificates

The time of issuance for carbon removal certificates can be critical in ensuring credibility for high-quality removals. Article 12(1a) of the CRCF states that "certified units shall be issued … only after the generation of a net carbon removal benefit or net soil emission reduction benefit, based on a valid certificate of compliance resulting from a re-certification audit."

The TAP suggests that the principle of issuing carbon removal units only *after* the net carbon removal has been physically achieved should be adopted, with the exception of biomass-based removals for which carbon removal credits would be issued following demonstration that carbon has entered permanent storage.

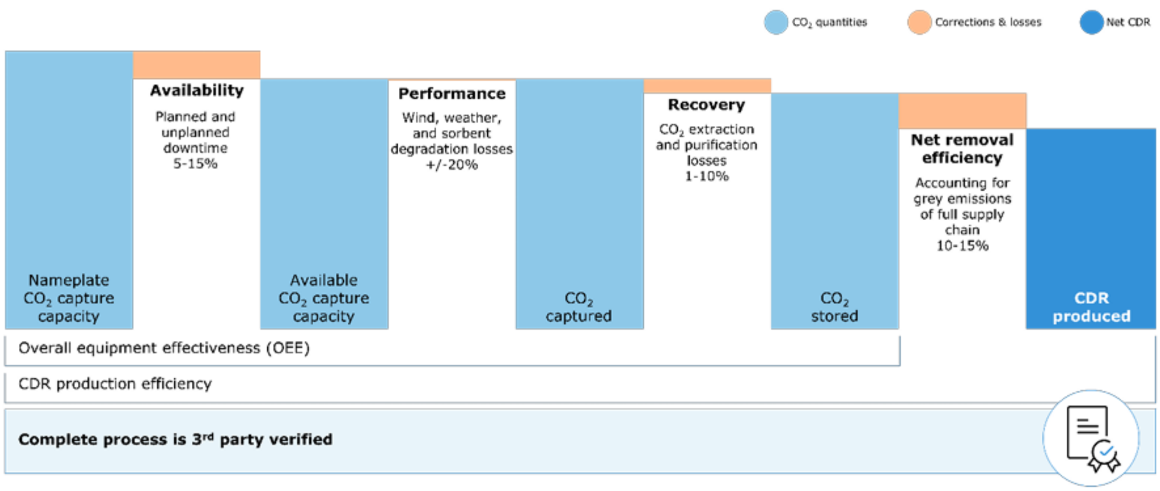
8.1 The importance of certification upon injection for DACCS and BioCCS

In determining whether a permanent carbon removal unit has been generated, it is critical to ensure this is done so only at the time of entry of the CO_2 into the storage media. For DACCS and BioCCS, this is done so only at the point of injection into geological formations.

Amagger Bakke waste-to-energy plant

There are several reasons why this point is critical to ensure high-integrity permanent carbon removals. As Climeworks' carbon removal production waterfall outlines in detail, although their Orca plant is designed for a nameplate capture capacity of up to 4,000 tons of CO_2 per year, this translates into a design net carbon removal capacity of approximately 3,000 tons per year.[46] Moreover, evidence from the field indicates that this number is variable, reaching as low as approximately 1000 tons per year based on their 2023 operating data, as shown in Figure 6.[47]

Figure 6: Climeworks' CDR production waterfall model - from capture to net removal



This evidence is not limited to the experience of DACCS projects and is reflective of the nature of first-of-a-kind projects which deploy any technology. As more projects deploy, improvements in the performance and predictability of project performance of DACCS and BioCCS will also be seen.

8.2 Recommendations for issuance of certificates

Based on the reality of deployment of permanent carbon removal methods in the field, carbon removal units for permanent carbon removal should be issued only after a re-certification audit has verified that captured CO_2 from biomass or air has been injected into permanent storage.

Nevertheless, given the challenges involved in determining exactly how much CO_2 has been removed permanently from the atmosphere, it is necessary to ensure that the point of certification occurs only when the CO_2 has been injected into geological formations, after which the likelihood of re-emitting is negligible, as outlined in Section 5.

46 Climeworks, 'Climeworks Publicly Releases Its Carbon Removal Production Model', 29 November 2023, https://climeworks.com/uploads/documents/20231129_publication_climeworks-releases-carbon-removal-production-waterfall-1701074164.pdf.

47 Climeworks, 'The Reality of Deploying Carbon Removal via Direct Air Capture in the Field'.

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