Approach to setting the attribution of CO_2 reductions for CCU fuels

— Toward a system counting fuel selection as an emission reduction effort

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EXECUTIVE SUMMARY

As the global economy transitions towards carbon neutrality, innovative secondary energy sources are becoming increasingly pivotal. Hydrogen derived from zero-carbon power and synthetic fuels produced by bonding carbon dioxide (CO_2) with hydrogen—hereafter referred to as Carbon Capture and Utilisation (CCU) fuels in this article—are expected to complement electricity as critical components in this transition. However, to incentivise the use of these alternatives, mechanisms must be in place to ensure that their adoption effectively translates into reductions in CO_2 emissions for users.

With this in mind, this paper reviews the current issues related to the 'attribution' of GHG emissions or emission reductions for CCU fuels, reviews the current status and developments of the various relevant schemes, and identifies their challenges. It then categorises and proposes solutions:

☐ **CCU fuel characteristics and challenges arising from its counting methods**:

CCU fuels are attracting attention for their potential as a new energy source that does not require changes to existing fossil fuel infrastructure and utilisation equipment. Although CCU fuels emit CO_2 during combustion, their CO_2 is recovered from what would otherwise be in the atmosphere, so long as the carbon content (C) of the fuel is focused on, fuel use does not increase global CO_2 emissions. However, as long as the conventional counting rule—emissions are attributed to the physical emitting point—is applied, the fuel users are not incentivised to choose CCU fuels since they are identical to the fossil fuels under the rule. In order to design a system that promotes the use of CCU fuels, it is necessary to consider how to count the CO_2 emissions associated with the production and use of CCU fuels, not bound by conventional approaches. In particular, clear international rules need to be set on which countries get the value of the emission reductions when they are traded crossing national borders.

☐ **Approaches to international rule-making:**

Currently, the IPCC, ISO, EU, Japan and others are working on guidelines and rules directly or indirectly related to the handling of CCU fuels. Based on theoretical considerations and taking into account the content of these developments, this paper proposes the following approach:

- Basically, CCU fuels are counted by the user as fuels with zero emission factor during combustion. At the same time, at the origin of the CCU fuel, the counting method is adopted: 'CO_2 captured and used for CCU fuel synthesis is considered

as not captured for convenience';

- At the national level, possible approaches include (1) rule setting on the National GHG Inventory (IPCC Guidelines and relevant CMA decisions), which is used for accounting for the achievement of NDC targets; (2) adoption of national rules; and (3) transfer of ITMOs through bilateral agreements;
- It is best to set national rules for companies in each country that are also consistent with them; and
- Technically, the key point is how to guarantee "being CCU fuel" in the rules, such as certification of origin, and its emittability of captured CO_2 in the baseline.

The potential of CCU fuels can be maximised if the rules are set up in a way that is as easy to understand, common and workable as possible. To this end, instead of simply waiting for the completion of the IPCC methodology report and the subsequent discussions in the CMA of the Paris Agreement, it is desirable to continue to provide opportunities for all stakeholders, including governments and industry, to engage in dialogue and harmonise the rules, and to support discussions in the IPCC and UNFCCC.

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1. CCU Fuels as Next-Generation Energy Sources in a Carbon-Constrained Economy

The world is rapidly moving toward a society where the unabated combustion of fossil fuels is no longer viable. Alongside electricity, new fuels are emerging as secondary energy carriers. These include hydrogen produced through water electrolysis powered by renewable energy or fossil fuel-based power plants equipped with carbon capture and storage (CCS). Among these, synthetic fuels derived from captured CO_2—referred to here as CCU[1] fuels[1]—stand out due to their unique advantages.[2] Here, hydrogen (H) acts as an energy carrier.

These fuels can be broadly classified into two types, depending on whether they contain carbon (C) in their chemical composition:

- Hydrogen (H_2) and ammonia (NH_3):
  No CO_2 emissions when combusted due to the absence of a C component.
- Synthetic liquid fuels (e-fuels; e.g. e-kerosene), synthetic gaseous fuels (e.g. e-methane):
  CCU (carbon capture and utilisation) fuels that contain a C component and have the same chemical composition as conventionally used fossil fuels, but physically emit CO_2 during combustion (sometimes referred to as carbon capture and utilisation (CCU) fuels or carbon recycling fuels and will be referred to as CCU fuels in this paper).

The discussion in this paper will focus on the latter—CCU fuels, which have the following characteristics:

- C—that would be released into the atmosphere or present in the atmosphere if not converted into CCU fuel─is used as a base material and the hydrogen is electrolysed from water using a zero CO_2 power source, resulting in a fuel with zero stoichiometric emissions and considerably lower emissions in terms of LCA.
- Since the chemical composition is identical to that of conventional fossil fuels, it has the advantage of being easier to use (no additional investment required) than hydrogen or ammonia, in the sense that existing fossil fuel-related infrastructure, transport vehicles and utilisation equipment can be used without modification.
- On the other hand, the most important point is the availability of inexpensive, low-carbon hydrogen, as it is synthesised from hydrogen. As a synthetic fuel, it is more expensive per unit of energy than hydrogen, and the cost of capturing C as a base material also adds to the challenge for the blue one.

[1] CCU refers to all technologies that capture CO_2 from fuel consumption or process sources, or CO_2 present in the atmosphere, and utilise that Cs. Only cases where green or blue hydrogen (or nuclear-based pink hydrogen) is used to convert that C into synthetic fuels are covered here.

[2] Other liquid fuels derived from biomass (bioethanol and biodiesel) and gaseous fuels (biogas) are also considered promising, but here only fuels originated by renewable electricity-based *green hydrogen*, or *blue hydrogen* using fossil fuel (power generation (or natural gas steam reforming or coal gasification)) with CCS are considered.

There is also competition with electricity in the utilisation phase.

In other words, under conditions where the benefits can outweigh the high costs, it could play a role in fuel-form secondary energy in a carbon-constrained economy (especially in areas where other means are difficult to apply). As a base C source, fossil fuel combustion-derived and process-derived sources will be the mainstream for the time being, but if they are no longer allowed to be emitted (even in the baseline) due to tighter emission regulations, a transition to means of capturing CO_2 in the atmosphere (direct air capture (DAC)) is envisaged.

Thus, although CCU fuels have the potential as a secondary energy source towards a decarbonised economy, they physically emit CO_2 during use (combustion), so how they are treated (i.e., where they are counted) in emissions counting rules has a major bearing on whether they can be implemented in economy. This has a major significance in terms of whether or not it can be implemented in society. This paper analyses, discusses and proposes how it is appropriate to handle this rule barrier based on a theoretical understanding of where the problem lies, the approach channels for solving it, and recent developments in rule-making.

2. Theoretical Considerations and Issues in the Emission Calculations from CCU Fuels

For CCU fuels to be low-carbon and decarbonised alternatives to fossil fuels, three conditions are key:

(1) C constituting the CCU fuel must have been released into the atmosphere or present in the atmosphere if it was not used to synthesise the CCU fuel;

(2) The H comprising the CCU fuel shall be hydrogen electrolysed from water using a zero CO_2 source, or hydrogen with appropriate measures such as capture and storage of CO_2 emitted in the production process;

(3) Considerably lower GHG emissions in the overall LCA compared to the fossil fuel being replaced.

In this paper, the analysis focuses on condition (1) and assumes that conditions (2) and (3)[3] are satisfied.

The C that makes up the CCU fuel would have been released or present in the atmosphere had it not been used to synthesise the CCU fuel, so the calculation results in no CO_2 emissions on a stoichiometric basis compared to the baseline case, where an equivalent fossil fuel was burnt instead of the CCU fuel. The situation is illustrated in Figure 1, which represents the case where CO_2 is captured during fossil fuel combustion as source C. In the value chain from CCU fuel production to consumption, the project emissions are (a) and the baseline emissions are $(b) + (c) = 2 \times (a)$. In stoichiometric terms, $(a) = (b) = (c)$ (assuming that the baseline fossil fuel and the CCU fuel have the same chemical composition).

That is, if the counting approach is to offset CO_2 in fuel consumption in the project (CCU fuel consumption; (a)) and in the baseline (fossil fuel consumption; (c)) from the outset, then the project's consumption of CCU fuels as alternative fuels results in zero emissions (in stoichiometric terms) (see Table 1).[4]

Note that Figure 1 assumes that fossil fuel combustion exhaust CO_2 is captured as the C-source, but the same logic applies to CO_2 from cement or chemical plants. The key point here is that if this captured CO_2 had not been used for synthesising CCU fuel, it would have been released into the atmosphere, contributing to an

[3] How to express in the rules that these (b) and (c) are satisfied is also not simple. In particular, with regard to (b), it is not only necessary to use electricity from a carbon-free source, but theoretically it must be "additional". Otherwise, the electricity could be used for CO_2 emission reductions in the baseline separately from the CCU fuels, which could deteriorate the CO_2 reduction effect of the CCU fuels (and thus add to the LCA emissions). It is also important to consider how to express (or not to consider) in the rules that the electricity is carbon-free and procured exclusively for the production of CCU fuels, which has no such possibility.

[4] CO_2 (and GHGs) emissions from fuel consumption, when assessed in terms of LCA, include direct emissions from the oxidation of C in the molecules of the fuel (*i.e.* fuel combustion) as well as CO_2 (and GHGs) emitted during the production, refining, synthesis, transport and storage of the fuel. The term stoichiometric means that only CO_2 from the C-derived component of the fuel is covered (assuming no losses), which in the case of C-containing fuels usually forms the main part of the overall CO_2 emissions of the LCA. However, this value depends on the way the system boundary of the LCA is taken and the calculation methodology (here, the methodology of considering the comparison with the baseline is used). The LCA assessment does not essentially deal with the question of to whom the emissions of individual processes should belong. It should also be noted that the stoichiometric discussion of C does not depend on the H-source.

increase in atmospheric CO_2 concentration.

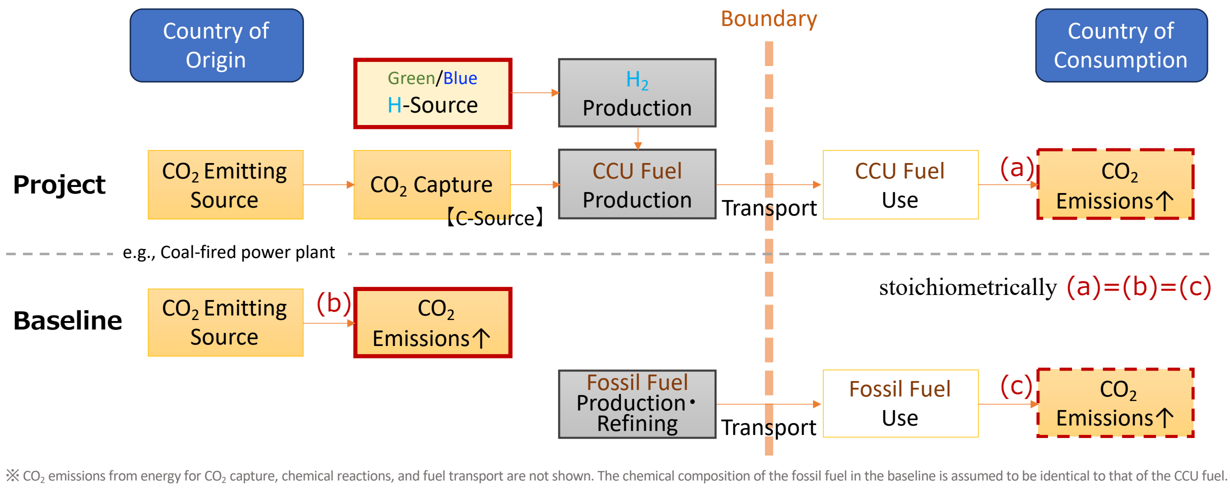

Figure 1: Green/Blue hydrogen-derived CCU fuel production project emissions vs. baseline emissions stoichiometry
(CCU fuel synthesis by capturing CO_2 that would otherwise have been emitted))

Furthermore, in cases that are slightly different from the case of CO_2 capture from emissions, there are also cases where CO_2 is captured directly from the atmosphere, such as DAC (see Figure 2, where Project emissions: (a) − (b) = 0, Baseline emissions: (c)), or from biogas and BECC (Bio-Energy with Carbon Capture) exhaust gas, the balance with the atmospheric CO_2 pool is the same, and CCU fuels can be considered to be fuels with zero CO_2 emissions in terms of stoichiometry.

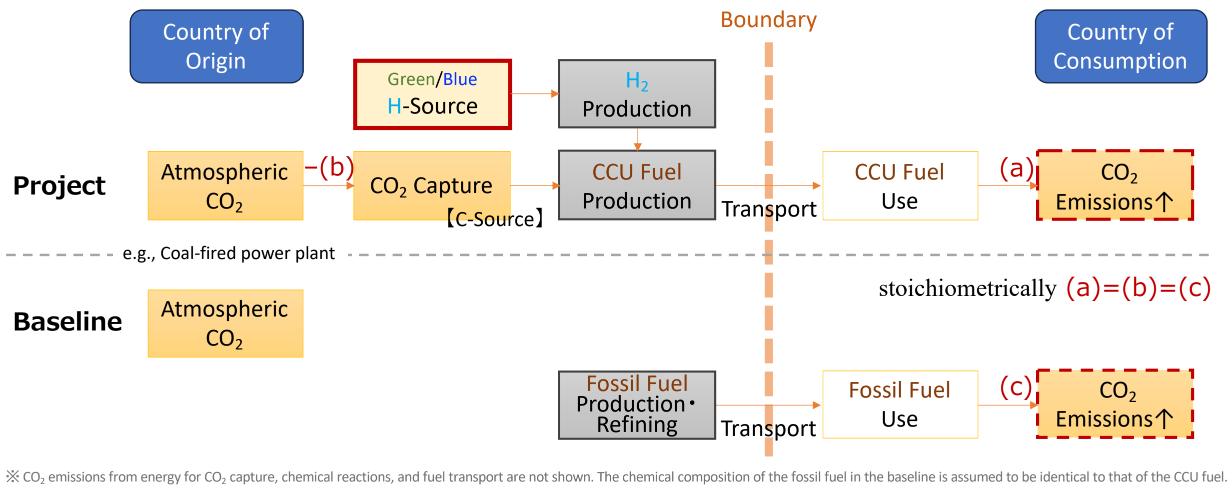

Figure 2: Green/Blue hydrogen-derived CCU fuel production project emissions vs. baseline emissions stoichiometry
(CCU fuel synthesis by capturing CO_2 from the atmosphere)

	Calculation method in the Figures		Calculation method offsetting fuel CO_2 emissions from the outset		Emission reductions $BE - PE = (BE' - PE')$
	PE	BE	PE'	BE'	
Figure 1 (Emitted CO_2 capture case)	(a)	(b)+(c)	0	(b)	(b)
Figure 2 (Atmospheric CO_2 capture case)	(a)–(b)=0	(c)	–(b)	0	(b)

Table 1: Stoichiometric emissions and emission reductions due to differences in CO_2 capture sources and baseline level settings

In summary, the emissions assessment should include the following:

(1) CCU fuels can be considered carbon-neutral fuels when focusing only on the C in the fuel (in terms of stoichiometry);

(2) A condition for this includes that the captured CO_2, to make the body of the CCU fuel, must have been otherwise released into the atmosphere or captured CO_2 from the atmosphere; and

(3) On the other hand, other energy-derived CO_2 is added in terms of LCA, such as for CO_2 capture, various chemical reactions/synthesis/liquefaction, transport/storage and H_2 production.

(If emission reductions from CCU fuels are to be quantified, an LCA assessment of the contrasting fossil fuels is also required, but this is not discussed here).

The next challenge is how to express these emissions considered across the system boundary as individual process emissions in a quantification method. Specifically, if the life cycle is considered from CCU fuel production to consumption, then with regard to the C-derived CO_2 emissions count location (emissions attribution) in the CCU fuel, it can be pointed out that:[5]

(a) If counting where CO_2 is originated, counting where CCU fuel is consumed is not necessary; OR

(b) If not counting where CO_2 is originated, counting is required where CCU fuel is consumed.

On the other hand, from an LCA perspective, several action-based emissions within the system boundary, such as H-source operation, H_2 production, H_2 liquefaction, H_2 transport, H_2 storage, CCU fuel production (synthesis), CO_2 capture, CO_2 transport, CO_2 storage, CCU fuel liquefaction, CCU fuel transport, CCU fuel storage and CCU fuel delivery, should also be counted. Usually, the emissions of each process that do not

[5] The term 'origin' is used here without distinguishing between the entities that *emit CO_2 otherwise* to the atmosphere and the entities that *capture* it as the base material of the CCU fuel, C. In practice, those entities can be different. In the case of (a), which of these entities the emissions should be attributed to depends on the rule-setting of the national system.

originate from C in stoichiometrically expressed CCU fuel are often assigned to the emissions at the physical location or entity where the process was carried out, and will be considered as such here as well.

The challenge arises where CCU fuels are imported/exported, i.e., the country of production (country of origin) and the country of consumption are different. As described below, the current accounting rules of the National GHG Inventory (with a few exceptions) stipulate the principle of "accounting for emissions in the country (or sector) where they are physically emitted", and if this principle is applied, the CO_2 from the import and consumption of CCU fuel is counted as emissions in the consuming country. This means that for the CCU fuel consuming country, the treatment is identical to the case of import/consumption of fossil fuel. For the CCU fuel producer (country of origin), on the other hand, in the case of Figure 1 (capturing the CO_2 emitted in the baseline), the associated CO_2 emissions are stoichiometrically zero, as there are no physical emissions of C which turns to the base material for the CCU fuel. In the case of Figure 2, the stoichiometric emissions in the CCU combustion producer country are calculated as negative.

In other words, if the counting method in the case of Figure 1 is used to count CCU fuels as zero-CO_2 fuels, then that amount needs to be counted in the country of origin (even though no CO_2 is physically emitted). If CCU is counted as zero-CO_2 fuel in the case of Figure 2, then the emissions in the country of origin are zero (although they are physically removed from the atmosphere).

The main attraction of CCU fuels, in terms of comparison with fossil fuels of the same chemical composition, is that they have considerably lower LCA (i.e. global) CO_2 emissions (this paper assumes the case: (emissions associated with C combustion in the fuel) > (LCA emissions difference between fossil fuel and CCU fuel).

The awareness of the issue of this paper is that global emission reductions through the social implementation of CCU fuels will not, in principle, be feasible unless social rules are in place to ensure that the entities paying the additional costs (compared to fossil fuels) receive this climate change mitigation benefit in return. Of course, it is a prerequisite that the production costs of CCU fuels are reduced so that they become competitive[6] with fossil fuel prices with an add-on carbon price, but at the very least, barriers associated with the rules need to be removed.

The question of where to count CO_2 emissions or where to attribute CO_2 reduction values is a rule-setting issue. This paper aims to examine the possibility of simple, easy-to-understand rules based on the current system, with appropriate incentives for proper reduction.

[6] In the early years of introduction, policy subsidies were sometimes given to CCU fuels, and indeed in Japan there is such a policy to compensate for the price difference[2] (similar to the feed-in tariff (FIT) for renewable energy). In reality, at the dawn of the market, it is difficult to invest in CCU fuel facilities when no off-taker has been decided. In terms of economy and convenience, it is also necessary to compete in the market with electricity, which is a different form of secondary energy (consumption itself does not directly emit CO_2).

3. Channels for Approaching the Problems

3.1. Necessity and rules for avoiding double counting

In principle, the methodology for calculating CO_2 emissions from fuel combustion should be such that double counting is avoided, whether the emissions are counted at the place where the fuel was produced, at the place where it was combusted, at the place where the electricity was consumed when it was used for power generation, or in a mixed form. This is to avoid the total of the emissions counted being greater than the physical emissions.[7]

Both the National GHG Inventory and the current EU ETS adopt the principle of counting at the point of physical combustion as a rule to avoid double counting and to make monitoring as simple as possible (in the case of the EU ETS, the intention is to cover all emissions from electricity generation The intention is also to take as wide a coverage of the system as possible[8]). However, in the case of these rule settings, there is also the problem that the incentives to save power in electricity-consuming areas do not manifest themselves in ways other than cost reduction. In Japan, the Energy Conservation Law and the Law Concerning the Promotion of the Measures to Cope with Global Warming have traditionally counted the emissions associated with electricity consumption (on the power plant side) as the emissions of the electricity-consuming establishments using the emission factor of the electricity used, while the emissions from the generation of electricity by power plants are calculated separately (they are not simply summed up to form the overall emissions).

The *de facto* standard guideline for calculating corporate emissions worldwide, the GHG Protocol[3] by WBCSD/WRI classifies three categories of emission coverage, including Scope 1 for direct emissions by the targeted emitter, Scope 2 emissions for indirect emissions from power plants, *etc*., while Scope 3 emissions count part of the emissions of other entities, so that simply adding them together results in double counting. However, the main purpose of this scope classification is to clarify the 'scope of emission responsibility' of a company under a concept similar to corporate accounting and not to make an overall assessment by adding up the emissions of many companies, so double counting is not a problem as it is.

In the area of carbon credits, which express emission reductions, the Paris Agreement Article 6 rules also apply the concept of a corresponding adjustment to avoid double counting of emission reductions (how this 'adjustment' is made is described below).

In any case, double-counting should be avoided 'where it is necessary to consider the scheme as a whole'. If double-counting is allowed for the purpose of setting incentives or clarifying responsibilities, the system

[7] In addition, in order to avoid the total of the counted emissions being less than the physical emissions, it is also necessary to be careful to avoid 'omissions in accounting' for emissions.

[8] On the other hand, under the new EU ETS2, emissions from the transport and commercial sectors will also be covered, and in this case, they will be counted on the fuel supply side.

becomes more complicated, as it requires a fairly careful and consistent rule design and its application.

In addition, when LCA assessments of the GHG emissions of a certain product, as described below, it is necessary to avoid double counting within this life cycle.

3.2. Classification of GHG Accounting

There are two main types of accounting approaches to GHG quantification: quantification of emissions (and removal) and quantification of emission reductions (and removal increases). The former is a simple calculation of emissions (and removal), while the latter involves setting a hypothetical baseline (usually on a case-by-case basis) and calculating reductions (and removal expansion) from that baseline, which generally makes the application of rules more complicated.

There is also a distinction between *ex-ante* estimates and *ex-post* fixed values. The latter often requires some kind of (third-party) verification.

Both emissions accounting and emission reductions accounting require methodological guidelines and rules for calculation. They can be set up in similar but different ways for different GHG regulation and management schemes that exist at different levels. This section will henceforth focus on the accounting used to determine whether or not an NDC under the Paris Agreement can be achieved, and will detail the rules and calculation methods used.

3.3. Current Status and Issues in the Approach to Calculating and Reporting Emissions in National GHG Inventories

Under the United Nations Framework Convention on Climate Change (UNFCCC), each Party is required to compile and report a National GHG Inventory in accordance with the guidelines prepared by the Intergovernmental Panel on Climate Change (IPCC). In the framework of the Paris Agreement adopted under the UNFCCC, the preparation and reporting of the National GHG Inventory from 2024 onwards is required to comply with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.[4] It should be noted, however, that the rules for calculating and reporting GHG emissions under the UNFCCC, the Kyoto Protocol and the Paris Agreement are not exclusively determined by the IPCC Guidelines, but are Partly-defined (and overridden) by decisions of the Conference of the Parties, as described below.

3.3.1. Basic principles of the IPCC National GHG Inventory Guidelines

The IPCC is an intergovernmental panel established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP). Its role is to conduct scientific, technical and socio-economic assessments of climate change issues in a comprehensive, objective and transparent manner and to provide information and advice to policymakers. One of the IPCC's main activities is to develop and disseminate a set of calculation methods for different emission sources and sinks so that governments have as accurate a picture as possible of GHG emissions and removals, which are important data on which to base policy considerations. The calculation methods developed by the IPCC have been published as the IPCC Guidelines.

According to the IPCC Guidelines, in principle, emissions and removals should be calculated and reported where they physically occur.[9] The National GHG Inventory should include anthropogenic emissions and removals that occur in a country's territory. When products (including electricity) are imported or exported between countries, all GHG emissions resulting from the production of these products are included in the inventory of the producing country and not in the inventory of the consuming country. Even within a country, for example, GHG emissions generated by thermal power generation are reported as emissions in the power generation sector and not on the side of the final consumer of the electricity. Thus, it is a basic principle of the IPCC Guidelines that the National GHG Inventory should focus on where and when the emissions/removals physically occurred rather than who is responsible for the emissions/removals. Given the subjectivity that is inevitably involved in discussions about responsibility for emissions and removals, it is natural that the IPCC, which is tasked with objective scientific assessment, would adopt this basic principle. In addition, this basic principle of the IPCC Guidelines facilitates avoidance of double-counting and omissions of emissions/removals.

However, in GHG emissions calculations methodology, the (activity level) in $(\text{GHG emissions}) = (\text{activity level}) \times (\text{emission factor})$ is not necessarily the information of the emitter to which the emissions are 'attributed', and in some cases, the emissions are calculated using the activity level of the 'upstream side of the activity chain'.

In addition, in spite of the basic principles, in some cases, calculations and reporting that deviate from these basic principles are allowed in the IPCC Guidelines, for the sake of simplicity in calculation methods and ease of obtaining related data. The following are deviated examples:

- GHG emissions from vehicle travel:
  According to one of the suggested methods, GHG emissions are calculated and reported on the basis of fuel sold for vehicles, not fuel consumed by vehicles. In this case, if there are cross-border vehicle journeys, there will be a deviation from the above basic principle because emissions are reported by the country where the fuel was sold, not by the country where the fuel was consumed.

- GHG emissions related to Harvested Wood Products (HWP):
  Some of the suggested calculation and reporting methods deviate from the basic principle above, as they calculate and report the emissions that occur in the country where the harvested wood products are consumed in the country where the wood is harvested, except for one. This deviates from the above

[9] There is a difference between where the emissions are assigned ('attributional' aspect) and how they are determined 'methodological' aspect; (what is measured and how it is calculated). The latter is often calculated from the amount of energy, fertilisers, etc. input to the sector, rather than a direct measurement of emissions.

basic principle.

3.3.2. Current status of the treatment of CCU in the IPCC GHG Inventory Guidelines

In the 2006 IPCC Guidelines, there are various references to the treatment of CO_2 emissions and removals related to CCU, and for example, the following is given as basic guidance:

> Should CO_2 capture technology be installed and used at a plant, it is *good practice* to deduct the CO_2 captured in a higher tier emissions calculation. **Quantities of CO_2 for later use and short-term storage should not be deducted from CO_2 emissions except when the CO_2 emissions are accounted for elsewhere in the inventory**.
> (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 1)

This guidance means that the amount of CO_2 that is recovered, utilised and stored in the short term (retained in the product) should not be deducted from the source emissions, unless the amount of CO_2 that is ultimately released into the atmosphere after recovery and utilisation is accounted for elsewhere in the inventory (i.e. the amount of CO_2 that is recovered, utilised and stored in the short term is subtracted from the emissions from which it is recovered. This guidance decisively makes it clear that double-counting or omission of CO_2 emissions should be avoided. However, it avoids deciding whether the amount of CO_2 that is recovered, utilised and ultimately released into the atmosphere should be accounted for downstream of the CCU (where the final release into the atmosphere physically occurs) or upstream (where CO_2 is recovered). Although no general criteria for the choice between these two approaches are given in the IPCC Guidelines, the following considerations could be made:

(1) If the uses of collected CO_2 are diverse and it is difficult to track the actual CO_2 emissions for all these uses, an approach of accounting for CO_2 emissions upstream rather than downstream of the CCU (i.e. not deducting the amount of CO_2 collected upstream) makes sense from the perspective of avoiding the omission of CO_2 emissions as a whole. However, this would lead to a deviation from the basic inventory principle (i.e. recording emissions where they are physically emitted or absorbed) described above.

(2) On the other hand, if it is easy to comprehensively track the actual CO_2 emissions after recovery and utilisation, there is little risk of omission in the approach where CO_2 emissions are accounted for downstream of the CCU and the CO_2 recovery is deducted for the upstream side. In this case, deviations from the aforementioned basic principles of the Inventory Guidelines can be avoided.

Although no general criteria are given for the choice between these two approaches, clear guidance is given in the 2006 IPCC Guidelines for the next two cases of CCU:

- CO_2 generated in ammonia production is used in the production of urea:
  The amount of CO_2 recovered and utilised is subtracted from the CO_2 emissions from ammonia production and the amount of CO_2 ultimately released into the atmosphere due to the use of urea

products (e.g. urea-based catalysts to control vehicle emissions, urea-based fertilisers used in agriculture) is accounted for in the reporting category related to the use. (Approach (2) above)

- If recovered CO_2 is used for refrigeration, dry ice, etc:
  CO_2 emissions are not accounted for downstream, but upstream. (approach (1) above)

However, for CCU fuels, which were not yet the focus of attention in 2006, the 2006 IPCC Guidelines do not provide clear guidance as in these two cases; the IPCC released a partially improved version of the 2006 Guidelines[5] in 2019, it does not include clear guidance on CCU fuels yet.

3.3.3. Special rules beyond the IPCC GHG Inventory Guidelines—Examples and CCU

In 'real' National GHG Inventory reporting, especially when it is used to determine the achievement of international emission reduction commitments/targets, issues can arise that cannot be resolved by the scientific assessment by the IPCC alone, but require political negotiation and agreement. For this reason, under the Kyoto Protocol and the Paris Agreement, while the use of the IPCC Guidelines has been the basis, special rules that are not in the IPCC Guidelines or that differ from the IPCC Guidelines have been established as decisions of the Conference of the Parties.

For example, under the Kyoto Protocol, Parties with quantified emission commitments shall calculate and report not only GHG emissions and removals for forests and other land uses as a whole following the IPCC Guidelines, but also GHG emissions and removals for certain activities (afforestation, reforestation, deforestation, etc.) shall be reported as supplementary information as a special rule. Also, under the Kyoto Protocol, if certain conditions are met, a portion of the emissions calculated under the IPCC Guidelines may not be included in a country's total emissions. These special rules were established and applied for the first commitment period (2008–2012).[6][7] These rules were not in the IPCC Guidelines and were decided at the Kyoto Protocol's Meeting of the Parties after political negotiations.

Emission calculation and reporting rules for CCU, including its fuel category, can have a significant impact on the emission calculations of the countries concerned, especially if their products are exported or imported, such that political negotiation and agreement are considered essential for their establishment. Therefore, it would be desirable to consider and agree on special rules at the Conference of the Parties to the UNFCCC or the Paris Agreement, if necessary, regardless of how they are handled in the IPCC Guidelines, but this has not been achieved so far. There is a possibility that some decision will be made on the basis of the CDR/CCUS Methodology Report, pending its completion, which will be discussed later.

3.3.4. Future of the treatment of CCU in the IPCC GHG Inventory Guidelines

As explained above, at present, the IPCC Guidelines, which serves as the basis of international rules for national GHG inventories, includes elements that could form the basis for future discussions, but no clear guidance has yet been provided regarding the calculation and reporting approach for emissions related to CCU fuels in the

National GHG Inventory. In addition, no special rules have been established for the calculation and reporting approach for emissions related to CCU fuels, even as a special rule under the decisions of the Conference of the Parties to the UNFCCC and the Paris Agreement.

In January 2024, the IPCC decided to start work on a methodological report on ‘Carbon Dioxide Removal (CDR) Technologies and CCUS’, which will also consider CCU fuels and is likely to supplement the 2006 IPCC Guidelines. It will be interesting to see how it develops in the future. The methodology report is discussed in more detail in Section 4.1.

3.4. Accounting elements contributing to determining the achievement of NDCs under the Paris Agreement

As the philosophy behind NDCs is *nationally determined*, the criteria for determining whether or not they can be achieved generally differ from country to country. As discussed in Section 3.2, different rules and calculation methods for emissions, removals and emission reductions are used to determine whether or not NDCs can be achieved under the Paris Agreement:[10]

(a) Calculations using the National GHG Inventory:
IPCC Guidelines and relevant decisions of the Paris Agreement Conference of the Parties (CMA decisions) are used. These Guidelines and relevant decisions apply as common rules to all countries.

(b) Modified calculation of parts of the National GHG Inventory based on methods determined independently by each country:
Modified rules specific to the Party—which may include the exclusion of some emission source categories—to the IPCC Guidelines are used. Modified calculation methods may be specified, or a certain degree of freedom may be given to Parties.

(c) Methodology for the calculation of ITMOs and their inter-Party transfers under Article 6:
Common rules are applied for all Parties, such as methodologies by project type and corresponding adjustments, counting method in case of single-year targets, etc.

It should be noted that the National GHG Inventory’s emissions and removals calculation rules are not the only rules (although they are the basis), but all the above are applied in the determination of whether or not to meet the NDC target.

Specifically, in (a) + (b), the emissions and removals for the target year/period are to be calculated, and the

[10] Strictly speaking, the calculation of the effects on CCU fuel emissions could also be carried out by the indexing method on the ‘reference’ side, which is compared to the target year emissions in the NDC, but for the sake of conceptual complexity avoidance and feasibility, this is regarded as a subclass of (b) and is not considered here.

In addition to cases where these emissions are used as NDC targets as they are, there is also a wide choice of indicators for which targets are set, such as deviation from the BaU scenario, intensity vs. GDP, etc. Note that targets may also be set for indicators other than GHG (e.g. renewable electricity capacity ratio), but the cases of such indicators are not dealt with here.

ITMOs in (c) are added or subtracted (converted to one year in the case of a single-year target) to determine whether the target can be achieved.

Progress or achievement of NDC targets are self-assessed in the Biennial Transparency Reports (BTRs) submitted by Parties, which are subsequently subject to technical review.

3.5. Approaches using carbon credits, allowances and certificates and related challenges

Let us consider the possibility of making the CO_2 reductions in CCU fuels an added value, e.g. carbon credits. Since a voluntary crediting approach, which is not related to the Paris Agreement, would be independent of the achievement of the NDC targets under the Paris Agreement in each country, we only consider the case of carbon credits—Internationally Transferred Mitigation Outcomes (ITMOs)—that are transferred under Article 6.2 or 6.4 of the Paris Agreement and can contribute to achieving the NDC targets of the transferred Party (corresponding to case (c) in the previous Section 3.4).

With regard to the transfer of ITMOs, there are three possible cases:

- Transfer of part of the certified emission reductions as ITMOs from the project implementing country to another country through the procedure referred to in Article 6.4, subject to the corresponding adjustment procedure;
- Under an existing programme under Article 6.2, a portion of the emission reductions certified under that programme scheme may be transferred from the project implementing country to another country as ITMOs, subject to the corresponding adjustment procedure; and
- Bilateral transfers of agreed quantities of ITMOs through some kind of new intergovernmental arrangement, with the corresponding adjustment procedure.

The last case is classified as Article 6.2 activity under the Paris Agreement. It is possible to establish bilateral procedures specific to the CCU fuel projects. Furthermore, in theory, ITMOs transfer is possible even if associated projects or related verification processes linked to ITMOs are not specified. It is an international emissions trading (IET) or green investment scheme (GIS) type under Article 17 of the Kyoto Protocol, and as in other cases, the corresponding adjustment procedure is required. This is a bilateral arrangement, and in theory, it should be possible, but because it has not been clearly envisioned in the negotiations so far, there is a possibility that it may cause some confusion when it is actually implemented. In addition, both countries shall be Parties to the Paris Agreement.

Even if international transfers such as domestic carbon credits of some kind, domestic/regional ETS allowances or certificates are possible, it is a prerequisite in relation to achieving NDCs under the Paris Agreement that they are converted into ITMOs under some rule and that they are adjusted correspondingly.

Note that, as mentioned above, if the national target using ITMOs is a single-year target, the ITMOs acquired in a certain period are converted into one year's worth (e.g. by averaging method) and contribute to achieving the NDC target.

4. Recent Developments in Rulemaking

4.1. IPCC CDR/CCUS Methodology Report

At its 60th session in January 2024, the IPCC decided to produce a Methodology Report on Carbon Dioxide Removal (CDR) Technologies and Carbon Capture, Utilisation and Storage (CCUS) by the end of 2027 (Decision IPCC-LX-9).[8] The methodology report is a guideline for the National GHG Inventory. The details of the content and format have not yet been finalised, but it is likely to be positioned as a supplement to the 2006 IPCC Guidelines, which are currently used by governments around the world.

In the run-up to the 60th session, the IPCC Member Governments were invited to express their views on what topics the IPCC should cover in its reports in the coming years (the Seventh Assessment Period). As a result, there were significantly more requests for a methodological report on this topic (CDR and CCUS) than on other topics, leading to a formal decision by the IPCC. Many countries are concerned that the current IPCC Guidelines do not yet contain clear guidance for quantitatively calculating the contributions of the various new types of GHG emission reduction and removal measures that are expected to be implemented more than ever before in order to achieve the long-term goals of the Paris Agreement.

Based on the abovementioned decision of the IPCC, an IPCC Expert Meeting on the same topic was held in July 2024.[11] Based on the discussions there, a 'scoping meeting' was held in October 2024 to prepare a draft outline of the methodology report.[12] The draft outline will be considered and approved by Member Governments at the 62nd session of the IPCC, which will be held around February 2025. The approval and finalisation of the outline will determine which specific technologies will be the subject of guidance development in the methodological report. The methodology report prepared by the IPCC is then normally forwarded to the UNFCCC for a decision by the Conference of the Parties on whether it should be mandatory or available for use by Parties under the UNFCCC and the Paris Agreement. The decision then finalises the guidance on CDR/CCUS to be developed by the IPCC as an international rule.

As mentioned in Section 3.3, the 2006 IPCC Guidelines currently in use do not provide clear guidance on the approach for calculating and reporting CO_2 emissions associated with CCU fuels. At a stage when the outline has not yet been finalised, it is difficult to predict whether CCU fuels will be covered by the development of new guidance in the methodological report to be produced by the end of 2027. Based on the results of the aforementioned expert meeting (July 2024), it seems likely that the outline will specify that CCU fuels will be

[11] According to the minutes of the expert meeting,[9] for CCUS, the need for clear guidance on the treatment of transboundary transport and storage of captured CO_2 and synthetic fuels using it was recognised for inclusion in the new methodology report for consideration. The need to ensure consistency between pre- and post-transboundary CO_2 emission counts for transboundary transport of captured CO_2 and the need to address double counting issues associated with CCU fuel use were also raised.

[12] At the time of writing, the results of the scoping meeting have not been published.

covered, but even in that case, it is difficult to foresee what guidance the authors will develop. For example, they may avoid specifying a particular approach and instead present multiple options, leaving the choice to national governments. Also, as mentioned above, whatever guidance the IPCC develops, special rules could subsequently be considered and decided by the Conference of the Parties to the UNFCCC or the Paris Agreement.

In any case, it is expected that in the coming years, through the IPCC methodology report and subsequent discussions at the UNFCCC or the Conference of the Parties to the Paris Agreement, significant progress will be made in reaching a consensus on international rules for a National GHG Inventory of approaches to calculating and reporting the CO_2 emissions associated with CCU fuels. The process of preparing the methodology report will provide an opportunity to gather and consider the views of governments, experts and various stakeholders from around the world, so that a wide range of perspectives will be reflected in the consensus-building discussions.

4.2. Standardisation of carbon footprint calculation methods in ISO 6338-1:2024

The International Organization for Standardization (ISO) is an international non-governmental organization that was established in 1947 with the aim of developing international cooperation in scientific and technical activities. As of 20 August 2024, it has 172 member countries member countries and has published 25,499 international standards. Although the use of ISO standards is not mandatory but voluntary, it has contributed to improving quality and facilitating international trade by providing internationally common standards and guidelines.

In January 2024, the ISO published a new standardised method for calculating the life-cycle GHG emissions (carbon footprint (CFP)) of e-methane (synthetic methane), a CCU fuel, in the Annex of ISO 6338-1:2024.[10]

Due to the nature of the physical CO_2 emissions during the life cycle of e-methane, in which CO_2 that would have been emitted into the atmosphere is recovered and synthesised as raw material, particular consideration should be given to avoiding double counting of CO_2. The ISO working group ISO/TC67/SC9/WG10 therefore proposed the following calculation formula, taking these points into account, and reached an agreement with the support of all countries. The formula is based on the CFP calculation standard ISO 14067, summarising:

$$\text{CFP for e-methane} = \sum(\mathrm{CO_2}\text{ emissions associated with product processing, storage, transport, etc.}) - (\mathrm{CO_2}\text{ captured and used for synthesis}) + (\mathrm{CO_2}\text{ emissions at combustion})$$

Where, "CO_2 captured and used for synthesis" is deductible if the CO_2 fulfils the following conditions:

(a) CO_2 recovered by DAC, or CO_2 from biomass, or

(b) CO_2 emissions reported by a third party (original emitters of raw CO_2).

In other words, in the case of (b), which is particularly realistic in the near future, if the CO_2 emissions already reported by the original emitters are used as feedstock of e-methane, physical CO_2 emitted during final consumption of e-methane is counted as zero (offset by the amount of CO_2 recovered (used as feedstock)) if the feedstock CO_2 is directly used as base material for CCU fuel. Therefore, if the CO_2 emissions associated with hydrogen supply and electricity consumption during e-methane production are appropriately controlled, the net CFP[13] is considerably smaller than for the fossil fuel natural gas. This means that the international standard clarifies that properly produced e-methane contributes reliably to reducing environmental impact over its entire life cycle.

In this rule, the point (b) "emissions reported by the original emitter" is a point of reference. The condition regarding the underlying CO_2 that 'would otherwise have been emitted' is ensured here. In other words, it means that it is possible to emit (in a way that does not conflict with national regulations) as an original emitter (see the EU case in the next section).

On the other hand, this ISO assessment methodology clarifies the factors to be considered in the LCA emissions assessment of e-methane, but does not specify to whom the emissions should be attributed.

4.3. EU Renewable Energy Directive and treatment of CCU fuels in the EU ETS

In the EU, in order to add new categories of non-biogenic renewable fuels (RFNBO and RCF)[14] (CCU fuels synthesised using green hydrogen are classified as RFNBO) to the Renewable Energy Directive RED II (2018/2001),[12] the RED Delegated Regulation (2023/1184)[13] specified conditions for these RED-eligible fuels and the methodology for calculating their LCA emissions (2023/1185).[14]

In this case, the methodology for calculating the GHG emissions of the LCA assessment involves subtracting from the sum of the emissions of each step of the LCA assessment the baseline GHG emissions of the fuels that result in captured and recovered CO_2 emissions ($\boldsymbol{e_{ex\ use}}$ = emissions from inputs' existing use or fate) is to be subtracted. In other words, in the case of CCU fuels synthesised by capturing and recovering CO_2 from fossil fuel combustion (derived from green hydrogen), the captured CO_2 is not included in the LCA emissions. This is based on a similar concept to the aforementioned ISO 6338-1 standard for calculating LCA emissions.

However, the main CO_2 to be captured and recovered is the CO_2 that would have been emitted (if not captured and recovered) from facilities regulated by the EU ETS (corresponding to (b) on the previous page), and it is stipulated that this deduction will not apply in the future (after 2036 for power plants, after 2041 for others) when the EU ETS Cap becomes more stringent. This reflects the fact that the situation where CO_2 emissions are no longer effectively allowed in the baseline is expressed in this way[15] as an intra-regional rule, so that

[13] Incidentally, in the case of LNG used in Japan, its life cycle assessment[11] shows that CO_2 emissions at the stage of fuel use correspond to approximately 84% of the total lifecycle.

[14] Renewable Fuels of Non-Biological Origin (RFNBO) and Recycled Carbon Fuel (RCF), where the CCU fuel is synthesised using H_2 from non-bio renewable energy sources that meet requirements such as additionality, and the LCA assessment emissions are 28.2 gCO_2 eq/MJ-fuel or less (>70% reduction compared to the baseline), it is allowed as this RFNBO.

[15] In the EU ETS, there is no rule that CO_2 from power plants must be zero after 2036. Nevertheless, the fact that such strict rules have been set can be

after 2041 only CCS fuels using direct and indirect capture of atmospheric CO_2 are eligible (for green hydrogen-based CCS fuel).

There is also a set of conditions that the electricity at the time of H_2 production is renewable energy that can be considered CO_2 free, is not subsidised, and has been in operation for less than three years, and has a geographical correlation, which expresses the requirement of "additionality" of the renewable electricity used.[15]

RFNBOs can be used as renewable energy to achieve the renewable energy targets for each sector in the RED, and are also used as a precondition for companies to receive public support from the EU, but it is not a precondition for the import of these fuels or their introduction into the EU market. It is important to note that the above rules apply to cases where the fuel is 'consumed within the EU', and the fact that they are also expected to apply to cases where the fuel is 'manufactured outside the EU' shows the EU's approach of using the same rules even when crossing national borders.

The EU ETS is more specific about the attribution of CO_2 emissions from the combustion of the carbon content of CCU fuels, in that it specifies the emission factors for cases where CCU fuels are used at individual installations regulated within the EU, rather than cases where fuels are imported from outside the territory into the EU.

In Fit-for-55, the Amendment to the rules of the EU ETS (2021/0211(COD))[16] in relation to RFNBOs and RCFs, shows that "... to the adoption by the Commission of implementing acts laying down the necessary adjustments for how to account for the eventual release of CO_2, in a way that ensures that all emissions are accounted for, including where such fuels are produced from captured CO_2 outside the Union, while avoiding double counting and ensuring appropriate incentives are in place for capturing emissions,… (para 68)[16]". It is also important to note that the need to set incentives for the private sector is also clearly stated. Furthermore, the same requirements for imports of hydrogen derived from renewable energies are required for production outside the EU as within the EU,[17] and a method to confirm these requirements through voluntary certification by a third party has been adopted. However, for CCU fuels, as mentioned above, the eligibility of the C source is affected by the EU ETS regulation, and no rules have been established to require the same requirements for imported CCU fuels as those in the EU.

Furthermore, the EU ETS amendment on emissions from aircraft in (2021/0207(COD))[18] more explicitly treats green hydrogen-origin CCU fuels as zero emission fuels (under the EU ETS, which is basically an on-site

seen as an expression of the EU's position.

[16] Renewable liquid and gaseous fuels of non-biological origin and recycled carbon fuels can be important for reducing greenhouse gas emissions in sectors Where recycled carbon fuels and renewable liquid and gaseous fuels of non-biological origin are produced from captured CO $_2$To ensure that renewable fuels of non-biological origin and recycled carbon fuels contribute to the reduction of greenhouse gas emissions in sectors that are hard to decarbonise. To ensure that renewable fuels of non-biological origin and recycled carbon fuels contribute to greenhouse gas emission reductions and to avoid double counting for fuels that do so, it is appropriate to To ensure that renewable fuels of non-biological origin and recycled carbon fuels contribute greenhouse gas emission reductions and to avoid double counting for fuels that do so, it is appropriate to explicitly extend the empowerment in Article 14(1) of Directive 2003/87/EC to the adoption by the Commission of implementing acts laying down the necessary adjustments for how to account for the eventual release of CO_2 , in a way that ensures that all emissions are accounted for, *including where such fuels are produced from captured CO_2 outside the Union*, while avoiding double counting and *ensuring appropriate incentives* are in place for capturing emissions, taking also into account the treatment of those fuels under Directive (EU) 2018/2001.

emissions regulation), as "Emissions from renewable fuels of non-biological origin using hydrogen from renewable sources Using hydrogen from renewable sources compliant with Article 25 of Directive (EU) 2018/2001 *shall be rated with zero emissions* for aircraft. operators using them until the implementing act referred to in Article 14(1) of this Directive is adopted." (Annex (2) (b)), as an amendment to Annex IV Part B "Monitoring of carbon dioxide emissions" of Directive 2003/87/EC. Again, this applies even if the CCU fuel is produced outside the EU.

The EU has assumed that CCU fuel is for use in fields where decarbonisation is difficult, such as the aviation sector, and so it is specified as such in the aviation sector, but the thinking behind this may be that CCU fuel (at least that derived from renewable energy hydrogen) should be considered to have zero emissions when it is combusted.

4.4. Developments in the design of CCU fuel emission accounting rules in Japan

In Japan, issues relating to CO_2 counts for CCU fuels have been recognised relatively early on, and discussions have been led by the Government. The Ministry of Economy, Trade and Industry (METI) launched the Public-Private Council for Methanation Promotion in 2021 and formed a Task Force on CO_2 counting under it in February 2022 to deepen discussions specifically on this issue. The Task Force has been working on an interim report[19] in March 2022 and presented four proposed approaches in the table below on where the emissions of e-methane—one of the CCU fuels—should be attributed:

Ap-proach	Where CO_2 emissions are counted	Double counting of reductions[17]	Features
1	Counted at origin (CO_2-recovery side). Zero emissions on the fuel user side.	Not allowed	Maximising incentives for fuel use while ensuring incentives for CO_2 recovery.
2	Zero emissions at origin. Counted on the fuel user side.	Not allowed	Maximising CO_2 recovery incentives.
3	Proportionate emissions at origin and fuel user side.	Not allowed	A compromise between Approaches 1 and 2.
4	Zero emissions both at origin and user side.	Allowed	Maximising incentives for both CO_2 recovery and fuel use.

Table 2: Proposed approaches to CO_2 emission attribution in the Task Force on CO_2 Counting in Japan

In this interim report, these four proposed approaches are further examined in the following interim outputs:

[17] The original argument should have been double-counting of 'emissions' (not 'emission reductions'), but the task force discussions did not make a clear distinction between the two uses.

- Assuming that double counting of emission reductions is not allowed, it is desirable that the national system should be based on Approach 1 from the perspective of promoting the use of CCU fuels.

- The institutional design of complementary mechanisms is important, as there is a risk of sub-optimal results if incentives do not work for the original emitters in such cases.

- Approach 4 is preferable, provided that double counting of emission reductions can be allowed. However, this may not lead to real emission reductions, which should be taken into account when designing the scheme, and consistency with international rules should also be considered.

Although the Task Force is a forum for discussion with e-methane (synthetic methane) in mind, discussions are being held with an awareness of CCU fuels in general due to the commonality of issues, and the conclusions reached here form the basis for the formation of rules in Japan, including those for other CCU fuels. In particular, the rules for domestic GHG Emissions Accounting, Reporting and Disclosure Program[20] (MRV system for corporate facilities, etc.) based on the Act on Promotion of Global Warming Countermeasures, which also reflects the results of the study of the Task Force on CO_2 counting, as described below.

The system, which started to operate on 1 April 2006, requires large emitters of GHGs to calculate their own greenhouse gas emissions and report them to the government. Discussions have recently started on how to handle CCUs.

The "Study Group on Calculation Methodologies for the GHG Emissions Accounting, Reporting and Disclosure Program" discusses the handling of CCUs, especially CCU fuel. The document[21] of the above-mentioned Study Group on 26 December 2023 and 18 June 2024 present, consistent with the conclusions of the above-mentioned Task Force, the concept of recovery incentives and emission reductions for the original emitters, based on the assumption that the environmental value[18] of the users should be enjoyed in order to promote carbon recycling, which can be interpreted as follows. Currently, the system is being considered to be put into concrete legislation with the aim of operationalising the system from FY2025, when the results for FY2024 will be reported:

- It is pre-conditioned that the transfer of environmental values resulting from the production and use of CCU fuels is agreed upon between the original emitter (collector) and the user.

- In order to avoid double counting of emissions in the base emissions (= emissions treated as actual emissions not including ex-post operations such as credits) and to ensure that the initiatives of operators are properly assessed, the results of environmental value transfers are reflected in the base emissions.

- The environmental value generated by recovery once belongs to the collector and is transferred from

[18] The Study Group on Calculation Methodologies for the GHG Emissions Accounting, Reporting and Disclosure Program distinguishes between the concept of "recovery value", meaning the attribute of CO_2 recovered, and the concept of "emission reduction value", each of which requires a certificate and evidence, and is somewhat complicated in that the former is transferred from the collector to the fuel user and then set. In this paper, the term "environmental value" is used to simplify the discussion. Here, the environmental value is not supposed to require a process like carbon credits.

there to the original emitter or user. The transfer of environmental value to the user is actually carried out by the CCU fuel producer, who procures the environmental value from the collector and provides it to the user by linking the value to the product.

- By purchasing and using carbon recycled products with a linked environmental value, the user reflects the environmental value in their own base emissions, i.e. the CCU fuel is effectively a fuel with zero emission factor (with proof of origin of the recovered CO_2) for the calculation of the base emissions.
- As an incentive for recovery on the part of the original emitters, the amount recovered can be reported and published separately from the amount emitted.

The document by "Study Group on Calculation Methodologies for the GHG Emissions Accounting, Reporting and Disclosure Program" does not explicitly state that the entire environmental value should be transferred to the user, and does not exclude the possibility of the environmental value being split 50-50 between the original emitter and the user. However, based on the conclusions of the aforementioned Public-Private Council for the Promotion of Methanation and the Task Force on CO_2 Counting interim report, it is expected that further discussions will proceed in the direction of 'emissions being accounted for by the original emitter and not by the user', i.e. the user receiving the entire amount of environmental value. This direction means that it will be clear to users that the environmental value of CCU fuels is equivalent to that of renewable fuels.

Since CCU fuels physically emit CO_2 during combustion, it is difficult to understand their environmental load reduction effect, and there are some negative opinions on their social implementation. However, as CO_2 is recovered as a raw material, the equivalent amount of CO_2 does not actually contribute to an increase in CO_2 in the atmosphere. From the viewpoint that this fact should be recognised and assessed appropriately, the direction of the above-mentioned system for calculating, reporting and publishing GHG emissions is reasonable in that it not only functions as an incentive for social implementation, but also accurately assesses the actual environmental load reduction effect.

On the other hand, the above is based on the assumption that the original emitter (CO_2 collector) is in Japan, and it is not possible to read from the documents of the Council whether (or how) the same treatment is possible if the original emitter is abroad (i.e. when CCU fuel is imported). However, it seems highly likely that the same treatment would be possible by making the basic concept of 'proof of origin' conditional.

4.5. Other developments

Various initiatives have also been undertaken by Japan with regard to international cooperation with the issue of CO_2 counting for CCU fuels in mind, and such initiatives are becoming increasingly evident in the public and private sectors.

4.5.1. Revision of the GHG Protocol

The GHG Protocol is currently the *de facto* standard guidelines for calculating emissions in business activities. In response to technological progress and the diversification of business forms, the guidelines are planned to be substantially revised by the second half of 2026. In response to these developments, various proposals have been made, mainly by industry-related parties, regarding the rules that should be revised.

As an example on the corporate side, the Japan Gas Association, the industry association for city gas in Japan, has declared the decarbonisation of city gas by 2050, and in particular considers the replacement of natural gas by e-methane as a key enabler. Against this background, the association, together with 17 co-signatories from 17 national and international cross-industrial and cross-regional companies/associations to the Secretariat of the GHG Protocol in January 2024, has submitted a proposal,[22] requesting the development of rules for the use of certificates and credits for Scope 1 emissions and the development of rules for calculating emissions related to CCU technology. The GHG Protocol is currently being prepared for practical work on its revision, which is expected to involve a wide range of stakeholders. The GHG Protocol is currently being prepared for actual revision and is expected to involve a wide range of stakeholders.

4.5.2. Confirmation of common understanding at the US-Japan Summit meeting

On the other hand, there is a growing recognition on the government side that not only the industry but also governments need to promote CCU fuels as a national policy in cooperation with other countries in order to make the most of the GHG emission reduction potential of CCU fuels. For example, at the US-Japan Summit in April 2024, a common understanding of the importance of CCUS was confirmed between the leaders of the two countries as shown in the Factsheet:[23]

> The United States and Japan reaffirm our commitment to the Carbon Management Challenge, Clean Energy Ministerial (CEM) Carbon Capture Utilization and Storage (CCUS) Initiative, and to the Mission Innovation CDR Launchpad in the pursuit of developing carbon management technologies to support achieving the Paris Agreement goals. Additionally, the United States commits to supporting collaboration with Japanese counterparts to evaluate the potential for cross-border carbon dioxide transport and storage hubs between Alaska and Japan. For example, the United States is pursuing carbon dioxide shipping feasibility studies and tools such as life cycle assessment and technoeconomic analysis that can aid in this goal. We welcome the progress of ongoing projects in carbon capture, utilization, and storage, as well as carbon recycling, between U.S. and Japanese companies. On e-methane, Japanese companies have signed Letters of Intent (LOIs) with U.S. companies to avoid CO_2 double counting.

Although the contents of the LOIs are not made public, the fact that the leaders of both countries have referred to avoiding double counting of CO_2 in CCU fuels shows that both governments recognise the importance of the method of CO_2 counting.

4.5.3. Positioning in Japan's next NDC

In addition, in order to promote the spread of CCU fuels as a national policy and to clearly position them within the NDC under the Paris Agreement, in May 2024, the Japanese Ministry of the Environment presented the following concept[24] that positions the issue of (international) attribution of emissions from CCU fuels as an important point for their spread, with a view to formulating the next NDC to be submitted in February 2025:

- Carbon-recycled fuels, including synthetic methane, are new fuels that are expected to be utilised in the future, and although there are currently no clear rules on how to calculate CO_2 emissions when using them, the use of carbon-recycled fuels themselves is an effective means of reducing CO_2 emissions on a global scale.
- Therefore, if carbon-recycled fuels are imported from abroad and used, the emissions in each country associated with the implementation of such carbon recycling need to be organised and claimed in a manner that can be reasonably explained.
- With regard to national emissions counting, each country is to calculate its own emissions and submit its NDC progress to the UN, ensuring that double counting is avoided, in accordance with the Paris Agreement.
- When submitting the progress of the NDC, the counts will be based on this principle of avoiding double counting and will be claimed as emission reductions for our country, based on the arrangement between private operators.

Here, no specific explanation is given for an ‘arrangement between private operators’. However, based on, for example, the aforementioned discussion of the interim arrangement in the Public-Private Council for Methanation Promotion and Task Force on CO_2 Counting, it is highly likely that the arrangement will be made in the direction of maximising the incentives for the use of CCU fuels. If this happens, a counting method that assumes zero CO_2 emissions on the part of users of carbon-recycled fuels will be adopted in future NDC progress submissions by Japan. As a result, international recognition of the CO_2 emission reduction benefits of replacing fossil fuels with CCU fuels will be further enhanced, and discussions on their evaluation will be further advanced.

4.5.4. Revision of international standards for product classification in energy statistics

Although it does not directly correspond to the perspective of GHG emissions, it is worth noting that the revision of the Standard International Energy Products Classification (SIEC) is being promoted under the United Nations Statistical Commission. According to the latest information[25] available as of October 2024 from the United Nations Committee of Experts on International Statistical Classifications, which is currently working on the revision proposal, it appears that discussions are progressing in the direction of establishing a new classification called ‘synthetic fuels and other fuels’ that includes hydrogen, ammonia, and CO_2-derived fuels (CCU fuels).

The revision process has been underway with the aim of reaching an agreement and completing it at the 56th session of the UN Statistical Commission in 2025, but there is a possibility that it will be extended by one more year. In that case, the new international standard for energy product classification will be approved at the 57th session of the UN Statistical Commission in 2026. It is expected that countries with a high sense of urgency will establish their own rules and improve their own statistics.

5. Looking to the Future

5.1. Summary of discussions

CCU fuels have excellent properties as a measure against climate change, as they have far lower CO_2 emissions (in terms of fuel comparison, they are stoichiometrically zero) than alternative fossil fuels, if CO_2 emissions associated with CO_2 capture as a raw material and fuel production are low, and they can also use existing liquid and gaseous fossil fuel infrastructure as it is.

However, it does emit CO_2 during the fuel consumption (combustion) stage physically. If this is counted as emissions from the fuel consumption stage, there will be no incentive to use this fuel from an environmental perspective, and the intention to implement it in society and build a climate change mitigation energy system will not be realised.

Therefore, it is important to consider how to set the 'CO_2 emission counting rules for CCU fuel' under the condition that there is no double counting at each stage of 'CO_2 capture', 'fuel production' and 'fuel consumption'. If the process is closed within a country, the country can set the rules freely as domestic rules, and such rules are being (or are about to be) set in the EU and Japan.

On the other hand, if there is an import and export of CCU fuels, international rules are necessary. However, the current international rules for National GHG Inventories do not clearly cover the issue of counting CO_2 emissions for CCU fuels import/export. The need for clear international rules on this point is recognised, and progress in future discussions is expected. Furthermore, if domestic rules adopt methods that are inconsistent with international rules, some means of resolving the discrepancy will be necessary.

5.2. Approaches for dealing with the counting of CCU fuel emissions between countries with imports and exports

In terms of international systems, the most important thing to consider is 'how to count in determining whether a country achieves its NDC'. As mentioned in Section 3.4, there are three accounting approaches involved, and it is theoretically possible to deal with the counting of CCU fuel emissions in each of these approaches. From the perspective of promoting the use of CCU fuel, in order to make it possible to count the CO_2 emission factor[19] on the user side (importing country) as zero, as in the case of the EU ETS, the following measures can be considered under the conditions in Section 5.2.1, as described in Sections 5.2.2 to 5.2.4.

[19] This is an emission factor for the fuel itself and does not take into account LCA-type evaluation.

5.2.1. Requirements for the country of origin to be accepted as CCU fuel

The key point is how to introduce the 'checking function for certificates of origin' as a condition[20] for being accepted as CCU fuel, as a condition for applying zero-counting, in any of the cases in Sections 5.2.2–5.2.4 below.

In order to count the CO_2 emission factor for CCU fuel as zero when it is combusted at the point of consumption, the method of counting is to 'consider that the CO_2 captured and used for CCU fuel synthesis was not captured for convenience' on the production side. In that case, there may be difficulties in how to express in the rules that 'it was emitted into the atmosphere or remained in the atmosphere as a baseline (if it was not used for CCU fuel production) at the production site'. Incidentally, when synthesising CCU fuel using CO_2 from the aforementioned EU ETS-regulated facilities, a deadline for the eligibility period is set as a condition for allowing baseline emissions. In the case of DAC, this condition setting is not necessary, but the relationship between the importing country and the producing country is the same.

There are two possible approaches to certification of origin: one is to handle it through the energy statistics or National GHG Inventory of the exporting country, and the other is to request a micro-level certification process (e.g. third-party verification at the CO_2 capture location).

In addition, when CCU fuel is produced using hydrogen derived from renewable electricity, other conditions such as the additionality of the renewable electricity used will be required (outside the scope of this paper).

5.2.2. An approach using the IPCC Inventory Guidelines and relevant decisions of the Conference of the Parties to the Paris Agreement

This issue will be addressed if the rule of counting CO_2 emissions from the consumption of CCU fuel as zero and counting them in the country of origin is introduced in the IPCC methodology report on CDR/CCUS to be produced by the end of 2027. The term 'country of origin' here refers to the country that captured the CO_2. In the case of capturing CO_2 from the atmosphere (DAC), CO_2 emissions are counted as zero in the country of origin because the CO_2 removals by DAC are cancelled out by the eventual CO_2 emissions that physically occur but are not counted by the country of consumption of CCU fuel. As mentioned above, how to confirm that the conditions for use as a CCU fuel are met is also part of the methodology.

Even if this is not made into a rule in the IPCC methodology report, if the Conference of the Parties to the Paris Agreement agrees and decides (CMA decision) on rules associated with the use of the methodology report, the same result will be achieved. In the country of origin, CO_2 is captured and recovered, so there is physically no net CO_2 emissions (excluding those derived from energy used in the recovery process, etc.), but if the CO_2 recovery amount is not included in the calculation according to the rules, and the CO_2 emitted in the baseline is captured to synthesise CCU fuel, it will be counted as if there were net CO_2 emissions. If CO_2 is captured

[20] One somewhat complicated treatment that arises is how to handle cases that do not fulfil all the conditions for CCU fuel.

and recovered from the atmosphere, such as in DAC, it is not necessary to count it.

Furthermore, as discussed in Sections 3.3.1 to 3.3.2, given that counting CO_2 emissions associated with the consumption of CCU fuel in the country of origin is a deviation from the basic principles of the 2006 IPCC Guidelines, careful discussion is needed to make it a rule in the IPCC methodology report to be produced by the end of 2027. The most probable approach, given the historical background of the rules set for the National GHG Inventory to date, would be for the IPCC methodology report to suggest various options for addressing this issue, and for the final rules to be agreed by CMA decision. On the other hand, as mentioned in Section 4.1, given that many countries are concerned about the lack of clear guidance in the IPCC Guidelines for quantitatively calculating the effects of CDR and CCUS to be a problem, it is possible that rules will be set in the IPCC methodology report that are not bound by conventional approaches. In any case, the discussions/negotiations at future IPCC and UNFCCC/Paris Agreement Conferences of the Parties should be closely watched.

5.2.3. An approach using each country's own NDC accounting method

CCU fuel-consuming countries can make their own decision to exclude or treat as zero emissions for CO_2 emissions from CCU fuel when judging whether or not they have achieved their NDC targets (even if it is included in the National GHG Inventory). This means that they will adopt a calculation method that deviates from the conventional National GHG Inventory rules or reduces the coverage of emission sources, and they should state this in their NDCs.

It is desirable to make bilateral arrangements that are consistent between the country of origin and the country of consumption for avoiding double counting.

5.2.4. An approach using ITMOs transfer under Article 6 of the Paris Agreement

There is an approach: Counting the emissions associated with the consumption of CCU fuel in the importing country (which is the physical point of emission), while this amount is offset by transferring ITMOs from the country of origin, effectively and reducing the associated emissions to zero (from the perspective of achieving the NDC). In this case, the action of capturing CO_2 to obtain C, which makes up the CCU fuel, is a CO_2 reduction action, and the project that generates ITMOs is a project that captures CO_2. The ITMOs exporting country must make a corresponding adjustment in conjunction with the transfer.

This could be done through the channels set out in Article 6, Paragraph 4 of the Paris Agreement, or through the channels set out in Article 6, Paragraph 2. In the latter case, it is also theoretically possible to do this under a common scheme that is also used for other types of reduction projects, such as the JCM, or under a bilateral agreement that is specific to the import and export of CCU fuels. This is a kind of expedient, and in the case of a bilateral agreement in particular, the rules for generating and transferring ITMOs can be decided by the two countries, but corresponding adjustments will be necessary.

However, this approach requires that both countries are Parties to the Paris Agreement.

5.3. The Way Forward

It is not predictable at this stage whether CCU fuels will be an economically feasible secondary energy source. However, any of the approaches described in section 5.2 above could be used to incentivise the climate change mitigation aspects of choosing CCU fuels under the rules.

One possible concern about these approaches is that even though activities to capture CO_2 take place in the country of origin, the transfer of the CO_2 reduction effect to the CCU fuel-consuming country does not contribute to its NDC achievement of the country of origin. However, this is not an essential problem, as CCU fuel exports incorporate this effect and can only be realised if the economic benefits of exporting are more important than doing so at home (leading to reductions at home). The same point in principle as the corresponding adjustment associated with the transfer of carbon credits ITMOs due to the implementation of GHG reduction projects.

In the approach outlined in Section 5.2 as a way of dealing with the promotion of CCU fuels, a straightforward and simple one would be:

(1) In setting common global rules for the National GHG Inventory (the IPCC Guidelines and relevant decisions of the Conference of the Parties to the Paris Agreement), the most straightforward and simple approach for CCU fuels would be to set the "CO_2 emission factor for combustion to zero" like hydrogen and ammonia. This would give them the same treatment as bio-liquid fuels and biogas, as well as hydrogen and ammonia. At the same time, in the origin, the counting method would be "the CO_2 captured and used for CCU fuel synthesis will be considered as not having been captured for convenience";

(2) The next simplest method is for each country to voluntarily apply its own rules to the possibility of achieving its own NDC, even if it is difficult to establish common rules. It is desirable to have a substantial coordination agreement between the importing and exporting countries.

(3) For an approach that deals in the form of ITMOs transfers, a bilateral agreement specific to CCU fuels under Article 6.2 of the Paris Agreement is relatively simple.

In these cases, the key point is how to formulate the rule that 'the fuel must be CCU fuel' (e.g. certification of origin, certification of use of CO_2-free power sources, etc.).

On the other hand, in addition to accounting between countries (regarding NDCs), it is generally necessary to set domestic rules for companies, etc. within each country, and it is also desirable to set rules that are consistent with international rules between countries as much as possible.

The potential of the CCU fuel approach can be exploited broadly if the rules are made as simple and workable as possible in the above-mentioned manner. For this reason, it is desirable to form rules that have many common elements internationally, paying attention to the mutual relevance between the local rules of the EU and other regions, where discussions are already underway, and the development of IPCC methodology report, which is about to begin. On the other hand, it is not desirable to take too much time in order to make timely investment decisions by companies.

At present, there are no actual projects, and even in the case of the EU, which is ahead of the curve, there are still some outstanding aspects in the rules for CCU fuel imports, blue hydrogen, and DAC. The IPCC's methodology report will take some time to be produced, with a deadline of the end of 2027. Under the circumstances, rather than simply waiting for the completion of the IPCC methodology report and subsequent discussions at the CMA of the Paris Agreement, it would be preferable to continue to create opportunities for dialogue and harmonisation of rules among all stakeholders, including national governments and industry, and to support discussions at the IPCC and UNFCCC. It would also be effective to make efforts to prevent the rules from becoming unnecessarily complicated and diverse.

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