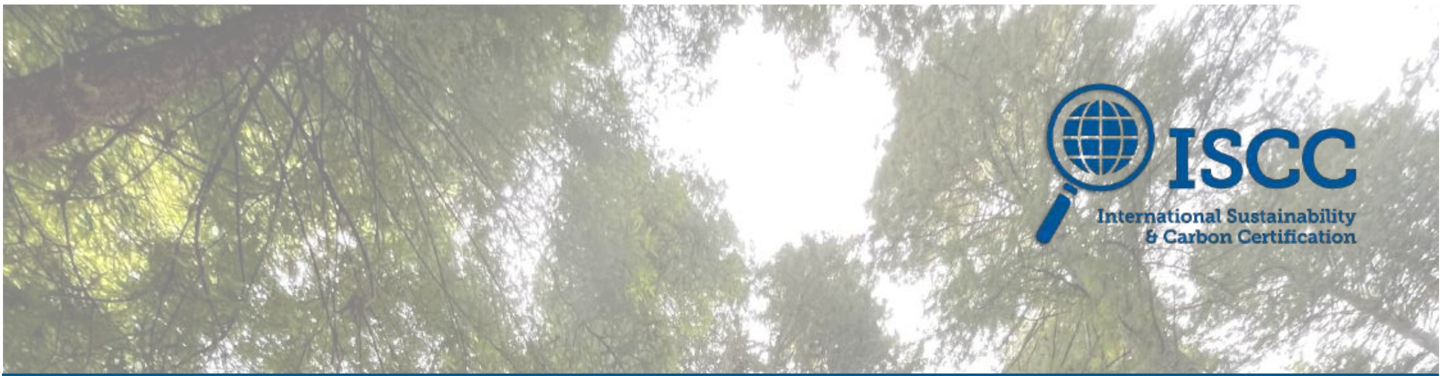

ISCC Carbon Footprint Certification

Version 1.2

Document Title: ISCC Carbon Footprint Certification

Version 1.2

Valid from: August 2024

Content

Summary of changes

Compared to version 1.1 the following changes were made:

- Generalisation of description of ISCC CFC certificate and ISCC CFC PCF declaration (adapted chapter 2)
- Inclusion of new developed certification approach for the PCF calculation of silicon metal production (new chapter 5)
- Description of certification approaches for downstream entities handling CFC certified material (new chapter 6)

The certification approaches for the usage of CCS (chapter 3) and CCU (chapter 4) remained unchanged.

1 Introduction, Scope, and Normative References

1.1 Introduction

Paris Agreement and long-term strategies

The Paris Agreement invites its signatory states to develop a long-term strategy for a decarbonization of their societies by 2050. Many countries already have published and implemented such strategies aiming to stepwise minimize greenhouse gas (GHG) emissions and to achieve zero net emissions by 2050. This may be achieved by combining different measures, such as reduction of fossil resource consumption, increase use of alternative and carbon-neutral feedstocks, permanent carbon storage, carbon utilisation or carbon offsetting measures.

Companies are implementing long-term decarbonization strategies

Based on the Paris Agreement, many companies have started to implement long-term strategies and measures to decarbonize their business, processes, and products as soon as possible, and at the same time to ensure long-term economic success. Part of this process for these companies is the determination and calculation of the relevant GHG emissions. Initiatives like the Science Based Targets Initiative (SBTi)[1], define and promote best practice in science-based target setting and are supporting companies on this. Thus, the reporting of carbon footprints for individual production steps, products, value chains and entire companies has become increasingly important in recent years. The reporting of such data for companies is requested by many stakeholders, e.g. regulators, financial institutions, customers, NGOs, to receive measurable and comparable information on relevant emissions. Carbon Footprints for products is a key indicator for environmentally friendly products and for many customers an important indicator for the comparability of products. In addition, brand owners are asking their suppliers for detailed information on carbon emissions for their products, aiming to minimize the overall carbon emission of final products and their supply chain.

ISCC – International Sustainability and Carbon Certification (ISCC) is a certification system that inter alia offers solutions for the implementation of decarbonization measures. This document describes the main guidelines for the "ISCC Carbon Footprint Certification" which can be used by system users to determine GHG emissions for different processes, feedstocks, and products. Innovative technological options to reduce GHG emissions like carbon capture and storage are described and it will be explained how to determine the relevant emissions and to make credible claims of the certified products.

The ISCC Carbon Footprint Certification can be used with ISCC PLUS certified materials and products based on non-conventional feedstocks, but also independent of ISCC PLUS certified material and sites. This could also include supply chains without non-conventional feedstock (e.g. fossil-based), for which GHG emission reductions e.g., against a comparator can be claimed. The ISCC Carbon Footprint Certification will be further developed by

[1] SBT: https://sciencebasedtargets.org

ISCC and its stakeholders. It is foreseen that the module will in future integrate additional processes and methodologies to determine GHG emission reductions supporting the decarbonization of industries. To add certification approaches under the ISCC Carbon Footprint Certification they must include processes, materials, and products aiming to reduce GHG emissions.

For the certification of processes with reduced GHG emissions or products with reduced product carbon footprints (PCFs) a comparable and reproducible calculation of GHG emissions or PCFs is important. Wherever possible, ISCC aims to harmonize the ISCC Carbon Footprint Certification with established norms and standards (e.g., ISO 14067, Together for sustainability PCF guideline). However, since these norms do not always exhibit detailed regulation for individual processes and leave room for interpretation, ISCC will introduce additional sets of minimum requirements for the developed certification and carbon footprint calculation approaches to improve comparability and reproducibility of the PCF results. Each certification approach will have a defined scope and system boundaries, for which specific additional requirements need to be fulfilled, as well as an individually defined baselining approach for the comparator. ISCC is developing the certification approaches for processes and products with reduced GHG emissions together with its stakeholders and will add their description in this document after development.

1.2 Scope and Normative References

This document comprises the requirements on the certification of products, whose production processes integrate decarbonization measures. A certification is only possible for products and their corresponding GHG and PCF information for the described certification approaches with defined scope and system boundaries in chapter 3. The specific criteria described complement the existing ISCC system documents and generally apply to all relevant elements in the value chain. The requirements defined for the PCF calculation in the certification approaches of individual setups that integrate carbon reduction measures aim to harmonize with the methodology defined in ISCC EU 205 – Greenhouse Gas Emissions. When non-conventional feedstock is used, the ISCC Carbon Footprint Certification can be combined with an ISCC PLUS certification and the respective ISCC PLUS system documents apply.

1.3 Certification approaches

Currently the following certification approaches for product PCFs are available under the ISCC Carbon Footprint Certification:

- PCFs of products including Carbon Capture and Storage (CCS) within the supply chain
- PCF of MeOH from Carbon Capture and Utilization (CCU)

- PCF of silicon metal production

Additional sets of requirements for specific scopes, carbon reduction measures and setups will be developed and supplemented within the ISCC Carbon Footprint Certification module in a stepwise approach and based on pilot projects where required.
For the time being, ISCC needs to be contacted for potential certifications under the defined certification approaches of the ISCC Carbon Footprint Certification module (Chapter 3) to accompany first certifications and further improve documentation and guidance, where appropriate.

2 Verification process and system documents

2.1 Verification process

The following verification approach is required for all individual calculations:

- Every Certification Body (hereinafter referred to as “CB”) that verifies individual GHG emission calculations needs to have at least one GHG expert auditor who is responsible for verifying the methodology and the input data prior to the audit. To become a GHG expert, the auditor must participate in an ISCC GHG training.
- The ISCC System User must make the GHG emission calculation available to the CB (e.g. in Excel)
- The GHG experts of the CB checks information (e.g. methodology, emission factors, lower heating values, other standard values etc.) prior to the on-site certification audit. If they have any questions and/or require any corrections, the CB can contact the client directly for clarification
- During the certification audit, the auditor verifies all relevant information concerning the calculation of actual GHG values, with a specific focus on the plausibility of the input data (e.g. type of heat, amount of input materials, plant capacity, mass of products produced, etc.)
- The auditor must document emissions occurring at the audited site (for all relevant elements) and, if relevant, the savings achieved in the audit report. If the emissions deviate significantly from typical values, then the report must also include information that explains the deviation
- If the Certification Body requests any corrections in the audit report, System Users must provide an updated GHG calculation to the CB so that a final confirmation can take place. Corrective measures shall be implemented within 40 days
- System Users are only allowed to use the ISCC PCF claim, after the CB has explicitly confirmed that it is correct

- Additionally, CBs need to provide GHG calculations to ISCC. This is in order to facilitate a prompt investigation by ISCC in case of alleged non-compliance of actual GHG emission values. These documents (preferably in Excel) must be complete, transparent and include the methodology, formulas, input values, emission factors and respective sources
- If a System User wishes to update an actual calculation which has already been verified, the System User must contact the CB. It is the responsibility of the CB to decide if an on-site audit is necessary to verify compliance with ISCC requirements
- In any case, the CB needs to provide ISCC with updated certification documents (annex, audit procedures, GHG calculations)

The economic operator / system user has to provide records and evidence of the following data which will be verified during the audit:

- Evidence of all data for all relevant in- and outputs of the production process (e.g. production reports, sustainability information, invoices)
- Sources of emission factors (e.g., scientifically peer-reviewed literature, LCA databases such as ecoinvent) including the year of publication and their applicability (with respect to time period and region)
- Sources (e.g. invoices) as a basis for the allocation to by-products (ratios of typical sales price between silicon metal and by-products)
- The methodology used for the individual calculation and the calculation itself must be transparent. The calculation itself must be done in a way that allows the auditor to verify the calculation

2.2 ISCC CFC documents

ISCC provides templates for the ISCC CFC certificate and the ISCC documents issued within the supply chain.

ISCC CFC certificate: The ISCC CFC certificate is publicly available and gives the following information:

- ISCC CFC certified site and entity
- ISCC CFC certified products covered under certificate
- Used ISCC CFC certification approach with details on PCF methodology (Functional Unit and/or Reference Flow, system boundaries, data basis, and years of data)

The annex of a certificate can publicly show the PCF value of the certified products. This is a voluntary information under ISCC CFC, with the exception of the certification approach "PCF of silicon metal production", where the PCF value is a mandatory disclosure on the ISCC CFC certificate.

ISCC CFC PCF declarations: The PCF declaration needs to be shared within ISCC CFC certified supply chains from suppliers to customers together with the delivery note for a delivery of a ISCC CFC certified material. It gives information on the ISCC CFC certified material and allows traceability of CFC certified materials through supply chains. This document is not publicly available. Independent on the CFC certification approach applied, it contains the following mandatory information:

- Unique number of PCF declaration
- Information on supplier: Company name, address, address of dispatch, CFC certificate ID of supplier
- Information on recipient: Company name, address, address of receipt
- CFC certified material (naming according to annex of certificate)
- PCF value of ISCC CFC certified material calculated according to in this document outlined requirements
- Amount of CFC certified material

Depending on the CFC certification approach specific additional information on the CFC certificate or PCF declaration may be mandatory and / or additional documents may be mandatory to be used within the supply chain. This is described in the individual chapters describing the individual CFC certification approach.

3 PCFs of products including Carbon Capture and Storage (CCS) in the supply chain

3.1 Introduction

Carbon dioxide (CO_2) capture and storage (CCS) is the permanent storage of CO_2 in a geological site. This emission reduction process is designed to prevent large amounts of CO_2 from being released into the atmosphere. Permanent CO_2 storing can take place in natural underground reservoirs utilizing natural geological barriers to isolate the CO_2 from the atmosphere.[2]

Three process steps

The whole process can be divided into three major steps:

1) Capture: Separation of CO_2 from other gases and compression of the gas for transport purposes
2) Transport: Compressed CO_2 (“dense phase”, liquid-like state) can be transported to a suitable site for geological storage e.g., via pipelines, ship or truck

[2] IPCC Guidelines for National Greenhouse Gas Inventories (2006): Chapter 5 – Carbon Dioxide Transport, Injection and Geological Storage.

3) Injection and storage: Transported CO_2 is injected into deep, underground rock formation.

CCS is an option in the portfolio of actions that could be used to reduce greenhouse gas (GHG) emissions from the continued use of fossil fuels.[3] Under the ISCC Carbon Footprint Certification module, companies can get certified for the service of permanently storing CO_2. This service of storing CO_2 generates "CO_{2eq} savings" in the amount of the net quantity of CO_2 being stored. The net amount is the total amount of CO_2 being stored minus the emission (CO_{2eq}) occurring for the capturing, transport, injection, and the permanent storage of the CO_2 in the geological site (CCS unit). The CO_{2eq} savings being generated can be used for claims on reduced carbon emissions for fossil-based products and processes.

Under the ISCC Carbon Footprint Certification module, companies can consider using CCS to minimize carbon emissions of fossil-based products and to supply a more environmentally friendly product. The reduction of the CO_2 emissions for processing shall be applied to the CO_2 footprint of such a product.

Applicability

This chapter provides guidelines for the certification of CCS under the ISCC Carbon Footprint Certification module and the accounting of CO_{2eq} savings being generated for the permanent storage of CO_2. The approach can be applied combined with ISCC PLUS for all certified batches of material, intermediates, and products with non-conventional feedstock under ISCC PLUS. The requirements apply to all elements of the supply chain covering the three major steps for CCS: the processing unit from which the CO_2 is captured, the transport of the captured CO_2 to the storage facility and the storage facility (CCS unit) itself. Further, this document also applies for downstream elements in the supply chain (e.g., processing units, traders) as guidelines for claiming CO_{2eq} savings as well as for the avoidance of potential "double-claiming" of CO_{2eq} savings and carbon credits, e.g. under regulatory emission reduction schemes and ISCC simultaneously.

3.2 Certification approach for CCS supply chains

Certification concept for CCS supply chains

In the following the certification approach for CCS supply chains (including the respective certification requirements for the different elements of the supply chain) is described based on an exemplary supply chain including CCS (see figure 1).

---

[3] IPCC 2006.

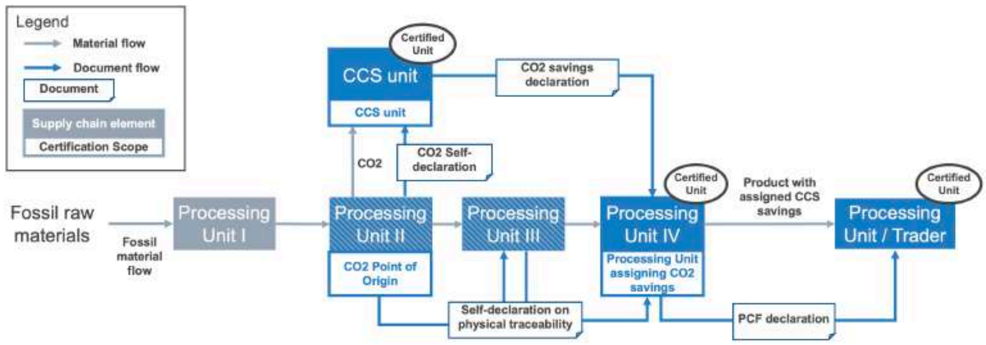

Figure 1: Example supply chain with a CCS unit in the chemical industry

CO_2 capturing and physical delivery to CCS unit

Point of origin is the processing unit capturing the CO_2

The CO_2 is captured at a processing unit (see figure 1: processing unit II) in the supply chain processing fossil-based raw materials and products. The CO_2 is a waste stream and without capturing the CO_2 would have been emitted to the atmosphere (direct emissions of processing unit II).[4] In this case, processing unit II is the point of origin (PoO) for CO_2. The upstream supply chain, including the extraction and the mining of the fossil resources (natural gas, oil) and previous processing steps cannot be covered under ISCC. The captured CO_2 must be quantified and transported (e.g., via pipelines, ship, or truck) to the CCS unit. A contract must be in place for the supply of the CO_2 from the processing unit to the CCS unit and a respective CO_2 self-declaration must be issued.

CO_2 storage at CCS unit

The CCS unit must be certified under ISCC for the service of storing CO_2 permanently (certification scope "CCS unit"). The processing unit capturing the CO_2 is a PoO covered by the certificate of this certified CCS unit. The storage of CO_2 generates a quantity of "CO_{2eq} savings" in the amount of the stored CO_2 minus the amount of CO_{2eq} emissions occurring for the capture, transport, and permanent storage of the CO_2.

Processing unit assigning the CO_2 savings

System boundaries for assignment of CO_{2eq} savings The CO_{2eq} savings can be issued to the processing unit from which the CO_2 has been captured or to downstream processing units, if these fulfil <u>all</u> following requirements:

- The downstream processing unit must be physically linked to the processing unit capturing the CO2. Physical link means that there must be a physical flow of intermediate materials between the PoO of CO_2 and the processing unit the CO_{2eq} savings are issued to (as depicted in figure 1) and that the products, to which the CO_{2eq} savings are assigned to, can be produced via this intermediate material flow (chemical / technical

[4] In this example the CO_2 is of fossil (post-industrial) origin captured from industrial processes, which use fossil sources to deliberately produce electricity, heat, or materials (e.g., cement, iron and steel, petrochemical industry). The CO_2 can also be of biogenic origin, when resulting from processing biomass at processing unit II.

feasibility). The physical link via this intermediate material flow is documented on “Self-declarations on physical traceability”.

- The downstream processing unit must be operated by the company also operating the unit capturing the CO_2 (within same corporate company structure).
- The downstream processing unit must be located on the same site as the unit capturing the CO_2 (same chemical park).

The processing unit, to which the CO_{2eq} savings are issued, need to be certified under ISCC (certification scope “processing unit assigning CO_{2eq} savings”, processing unit IV in figure 1), and can use the CO_{2eq} savings to make a claim for a respective amount of outgoing product. The CO_{2eq} savings can be assigned to one or several of the outputs of the processing unit. The respective processing unit must receive a documentation on the amount of CO_2 fixation in the CCS unit and issued to the respective processing unit (“CO_2 savings declaration”).

If for the handling of product batches with assigned CO_{2eq} savings the same infrastructure is used as for batches of the same type of product without assigned CO_{2eq} savings, system users must comply with ISCC PLUS requirements for mass balancing (Chain of Custody option Mass Balance). In comparison to the mass balancing requirements laid down in the ISCC PLUS system document, it is not allowed to conduct a multi-site-credit transfer for materials with assigned CO_{2eq} savings to ensure the required physical link between the CCS unit and the products with assigned CO_{2eq} savings (see description of physical link above, which is a crucial requirement for certification of CCS supply chains under ISCC).

Downstream handling of products with assigned CO_2 savings

The processing unit assigning the CO_{2eq} savings issues Product Carbon Footprint (PCF) declarations for the products with assigned CO_{2eq} savings under the ISCC Carbon Footprint Certification module. It is not allowed to issue ISCC PLUS sustainability declarations for fossil materials with assigned CO_{2eq} savings. Downstream entities not certified under the ISCC Carbon Footprint Certification module are not allowed to make claims related to PCFs reduced via CO_{2eq} savings under ISCC or issue ISCC Carbon Footprint Certification PCF declarations.[5] The PCF of products with assigned CO_{2eq} savings can be considered at downstream ISCC PLUS certified entities, if the ISCC PLUS GHG addon is applied. ISCC PLUS certified downstream entities must clearly separate fossil material with assigned CO_{2eq} savings as an input material from input materials with non-conventional feedstocks under ISCC PLUS.

3.3 Methodology for the calculation of net CO_{2eq} savings

IPCC guidelines

[5] This also holds for downstream entities not being able to get certified under the ISCC Carbon Footprint Certification module, since they fall not under the defined scope and system boundaries of the certification approach.

The methodology for the calculation of net CO_{2eq} savings must take the IPCC guidelines into account[6]. All process steps for CCS (capturing, transport, injection, and storage) must be considered for calculating the net CO_{2eq} savings. For all three steps, leakages and uncontrolled CO_2 fluxes must be monitored, measured, and considered to determine the net CO_{2eq} storage. The following equation describes how to determine the amount of CO_{2eq} savings:

$$\Sigma\, CO2eq\ savings = \Sigma\, CO2\ stored\ (C1) - \Sigma CO2eq\ emissions\ for\ capturing\ (C2) - \Sigma CO2eq\ emissions\ for\ CO2\ transport\ (C3) - \Sigma CO2eq\ emissions\ for\ injection\ and\ storage\ (C4)$$

The processing unit from which the CO_2 is captured must calculate and provide data for CO_{2eq} emissions for capturing. The CCS unit must calculate and provide data for CO_{2eq} emissions for transport, injection, and storage as well as the amount of CO_2 stored. The operator of the CCS unit must provide data on annual CO_2 storage, leakages and any CO_2 fluxes through the seabed or ground surface.

3.4 Generation and utilization of net CO_{2eq} emission savings

The net CO_{2eq} savings can be transferred from the CCS unit to the processing unit from which the CO_2 was captured, or to other downstream processing units physically linked to the supply chain (see description of system boundaries for assignment of CO_{2eq} savings in chapter 3.1.3.). Only CO_2, which is captured within the supply chain of the product the savings are assigned to and transported to the CCS unit can generate CO_{2eq} savings for the assignment to the respective product. The CO_{2eq} savings cannot be transferred, sold, or assigned to other supply chains under ISCC.

Site-specific PCF baseline calculation required

To evaluate the impact of the CO_{2eq} savings, a cradle-to-gate product carbon footprint (PCF) baseline calculation for the product(s) the CO_{2eq} savings are assigned to must be provided. The PCF baseline calculation shows the PCF without consideration of any CO_{2eq} savings and must be site-specific from the PoO of the CO_2 until the downstream processing unit producing the respective product (usage of primary data within this system boundaries). Therefore, site-specific PCF calculation of the intermediate products between the CO_2 PoO and the processing unit assigning the CO_{2eq} savings (see mandatory information in document "Self-declaration on physical traceability") must be available at the processing unit assigning the CO_{2eq} savings.[7] This is needed be able to verify the site-specific baseline PCF calculation of the products the

[6] IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5: Carbon Dioxide Transport, Injection and Geological Storage.
[7] Alternatively at the processing unit assigning the CO_{2eq} savings the operational data of the processing units between the CO_2 PoO and the processing unit assigning the CO_{2eq} savings needs to be available.

CO_{2eq} savings are assigned to. The PCF baseline calculation is verified during the ISCC certification process and can be used during the validity period of the certificate (one year). An update of the baseline PCF calculation is needed after one year for the recertification process.

The site-specific PCF baseline calculation between the CO_2 PoO and the processing unit assigning the CO_{2eq} savings together with the net CO_{2eq} savings stored via the physically connected CCS unit represent the emission inventory of the considered CCS supply chain within the system boundaries. Under the certification approach for CCS supply chains of ISCC the CO_{2eq} savings can be assigned to specific products of the considered CCS supply chain within this system boundaries. The total sum of the calculated PCFs needs to be equal to the emission inventory of the supply chain within the system boundaries and products without assigned CO_{2eq} savings need to show the baseline PCF result.

If the CO_{2eq} savings are only used to reduce the processing emissions of the processing unit capturing the CO_2, the CO_{2eq} savings are assigned to the products of the processing unit capturing the CO_2 following common allocation principles for emission or emission savings of PCF norms (e.g. ISO 14067). This assignment of the CO_{2eq} savings gives the CCS reduced PCFs of the products of the processing unit capturing the CO_2.

"Carbon neutral" claims

If, for example, "carbon neutral" claims of downstream products of the supply chain should be made, the PCF baseline calculation is used to calculate the amount of CO_{2eq} savings needed for the carbon neutral claim of the product.[8] In such a case the assignment is used to compensate feedstock emissions and processing emissions of other processing units of the supply chain including emissions for the extraction and mining of fossil resources, transport, and processing (upstream supply chain of processing unit assigning the CO_{2eq} savings). It is not allowed to compensate emissions originating downstream the processing unit assigning the CO_{2eq} savings, which means that no negative cradle-to-gate PCFs are possible for products of the processing unit assigning the CO_{2eq} savings (e.g. no compensation of processing emissions downstream of the processing unit assigning the CO_{2eq} savings and no compensation of emissions originating from use phase or end-of-life).
The assignment to products of processing units downstream the CO_2 PoO does not necessarily need to follow common allocation principles for emission or emission savings of PCF norms (e.g. ISO 14067). Information on the assignment mechanism used must be transparently available for the downstream supply chain, e.g., by giving information on the compensated upstream emissions and the disclosure of the baseline PCF together with the "carbon neutral" claim on the PCF declaration. The products, for which carbon neutral claims should be made, must be listed on the Annex of the certificate

[8] The baseline PCF verified during the certification process can be used during the validity period of the certificate to calculate the CO_{2eq} savings for carbon neutral claims if no major changes with a significant influence on the baseline PCF occurred.

of the respective processing unit and a respective site-specific PCF baseline calculation must be in place.

Requirements on Carbon Balance

In all cases the balance of net CO_{2eq} savings stored, and CO_{2eq} savings assigned must be closed, meaning that the sum of assigned CO_{2eq} savings cannot exceed the amount of net CO_{2eq} savings stored (see calculation of net CO_{2eq} savings stored in chapter 4) within a balancing period[9]. Therefore, all certified entities need to conduct an individual balance of CO_{2eq} savings (e.g., the CCS unit needs to conduct a balance of net CO_{2eq} savings stored and issued to the processing unit(s) assigning the CO_{2eq} savings and a processing unit assigning CO_{2eq} savings need to conduct a balance of CO_{2eq} savings received from the CCS unit and assigned to its product(s)). The CCS unit needs to hold a valid ISCC certificate to generate CO_{2eq} savings under ISCC (CO_2 stored prior to ISCC certification cannot generate CO_{2eq} savings under ISCC) and the maximum time frame for a balancing period is three months. Generated CO_{2eq} savings not assigned to a product within a respective period can be transferred to the next balancing period as long as the participating entities are ISCC certified. The product quantities with assigned CO_{2eq} savings under ISCC must be separately documented from products without assigned CO_{2eq} savings.

3.5 Mandatory information to be transferred within the supply chain

In the following, mandatory information is described, which needs to be transferred between different entities of the CCS supply chain (see figure 1):

CO_2 self-declaration

- PoO of CO_2
- CCS unit receiving the CO_2
- Amount of CO_2 captured
- GHG emissions related to capturing

CO_2 savings declaration

- CCS unit storing the CO_2 and issuing the CO_{2eq} savings (incl. address and certificate number)
- Processing unit receiving the CO_{2eq} savings (incl. address and certificate number)
- PoO of CO_2
- Quantity of issued CO_{2eq} savings
- Confirmation that CO_2 is physically received from CO_2 PoO at CCS unit

[9] In case the calculation of net CO_{2eq} savings is done on a yearly basis, a conservative estimate of the emissions from capturing, transport and injection based on the previous years can be used to determine the net CO_{2eq} savings for a respective balancing period (e.g. 3 months). The balance of CO_{2eq} savings need to be reconciled, when the emissions from capturing, transport and injection are available for the respective year.

Self-declaration on physical traceability

- Confirmation of fossil intermediate product flow from CO_2 PoO to processing unit assigning the CO_{2eq} savings (incl. chemical / technical feasibility that intermediate products can be produced from products of processing unit capturing the CO_2)
- Supplier and recipients of fossil intermediate products
- Type of fossil intermediate products
- CO_2 PoO
- Site-specific baseline PCF of fossil intermediate products (PCF calculation without consideration of CO2eq savings)

PCF declaration

- Supplier (incl. certificate number) and recipient of product with assigned CO_{2eq} savings
- Type of product with assigned CO_{2eq} savings
- Total quantity of product with assigned CO_{2eq} savings
- Baseline PCF of given product (PCF calculation without consideration of CO_{2eq} savings)
- PCF with assigned CO_{2eq} savings
- Quantity of used CO_{2eq} savings
- Information on used assignment mechanism:
    - Were the CO_{2eq} savings only used to reduce processing emissions of the processing unit capturing the CO_2?
    - Were the CO_{2eq} savings used to compensate other emission within the supply chain of the product? (processing emissions of upstream elements of the supply chain, upstream transport emissions and feedstock emissions including extraction and mining of fossil resources)
- Confirmation chemical / technical feasibility: product with assigned CO_{2eq} savings can be produced from fossil intermediate product flow

3.6 Requirements for CCS units

CCS unit needs a valid storage permit

CCS units can be certified for the "service" of permanent CO_2 storage. A prerequisite for this is that the CCS unit has a valid storage permit issued by the respective national/ international competent authority. The CCS unit shall have implemented a quality management system or shall be monitored by the respective competent authority documenting and ensuring that[10]:

- the geological formation for CO_2 storing is defined
- the CO_2 is permanently stored
- the amount of CO_2 being stored is verified by an independent third party
- the energy consumption for CO_2 injection and storing is monitored and reported

[10] Requirements in line with DIR 2009/31/EC on the geological storage of carbon dioxide

- the injection and storage facility is monitored. The monitoring programme should include:
  - measurement of background fluxes of CO_2
  - continuous measurement of the mass of CO_2 injected
  - determination of CO_2 emission from injection system
  - determination of any CO_2 fluxes through the seabed or ground surface
  - post-injection monitoring
  - incorporation of improvements in monitoring techniques over time
- regular reports by the operator to the competent authority are issued and regular inspections from third party verifiers that controlling the entire technical process of CO_2 storing are conducted.

3.7 Double claiming of CO_{2eq} savings

Double claiming of CO_{2eq} savings is not allowed

The double claiming of environmental attributes such as CO_{2eq} emission savings is not allowed under ISCC. The amount of CO_{2eq} emission savings being generated via the storage of CO_2 in the CCS unit can only be assigned to one defined volume of material under ISCC. The same CO_{2eq} saving can hence not be assigned twice or multiple times to different products of the supply chain. The CO_{2eq} savings can also not be separated, transferred, or sold individually without the product they were assigned to. Thus, in case the CO_{2eq} emission savings are used under ISCC, those cannot be used to generate e.g., carbon credits on the voluntary market.

4 PCF of MeOH from Carbon Capture and Utilization (CCU)

4.1 Introduction

Methanol (MeOH) is a high-volume commodity chemical. It is a precursor to several important industrial chemicals such as formaldehyde, acetic acid, methyl tertiary-butyl ether (MTBE) and dimethyl ether (DME). Global installed MeOH production capacity has been growing since 2009 with an average annual rate of about 10%, while the production has been also growing at a slightly smaller rate, around 7%, reaching 58 Mt in 2012, according to the International Energy Agency (IEA) or 60.6 Mt according to the Methanol Market Services Asia (MMSA).

Methanol is typically produced from pressurized synthesis gas (or syngas, a mixture of mainly H_2, CO and CO_2), which reacts in the presence of a catalyst, according to Eq. (1):

$$CO + 2H_2 \rightarrow CH_3OH \qquad \text{Eq. (1)}$$

The reaction is highly exothermic and a major challenge is the removal of excess heat, in order to shift the equilibrium towards the products and avoid side reactions and catalyst sintering. Syngas can be produced either by steam reforming in the case of light hydrocarbons, such as natural gas or light naphtha, or by partial oxidation, in the case of heavy oils or solid carbonaceous materials.

Carbon capture and utilization (CCU) represents a new economy for CO_2, since captured CO_2 can be used as raw material for other processes. This includes the synthesis of chemicals and materials (such as methanol, formic acid, polyols for polyurethanes, carbonates), fuels (like methane or kerosene) and direct use in applications based on CO_2 physico-chemical properties (for example in supercritical state). To produce hydrocarbons from CO_2 the carbon atom of CO_2 needs to be reduced, which requires energy – again leading to another output of CO_2 and by this to CO_2 equivalents (CO_2-Eq. = CO_2e =GHG emissions). The consumption of energy in CCU processes is hence important and must be considered to compare the CCU process with the conventional production of the respective product, regarding emitted CO_2e and needed energy. Therefore, in this certification approach requirements will be described to calculate a cradle-to-gate (resource extraction until company gate) product carbon footprint (PCF) for low-carbon CCU MeOH.

4.2 Scope and Normative Reference

The scope of this chapter is the PCF calculation for CCU MeOH within a cradle-to-gate approach. The general approaches for GHG emission calculations of various products will be, to the extent possible, widely harmonized under the ISCC carbon footprint certification module (ISCC CFC). The methodology defined in this document follows the general approach defined in ISO 14067:2018, with further specifications to produce CCU methanol from CO_2 and with the aim of standardizing CCU and the subsequent CO_2e calculation.

4.3 CCU MeOH supply chain elements

In this chapter the supply chain elements to be covered under the certification approach for CCU MeOH will be described. As depicted in figure 2, the MeOH production unit needs to be certified under the scopes “Collecting Point” and “Processing Unit”. The processing unit capturing the CO_2 will be the CO_2 Point of Origin (PoO) and can be covered under the collecting point certificate of the MeOH converter.

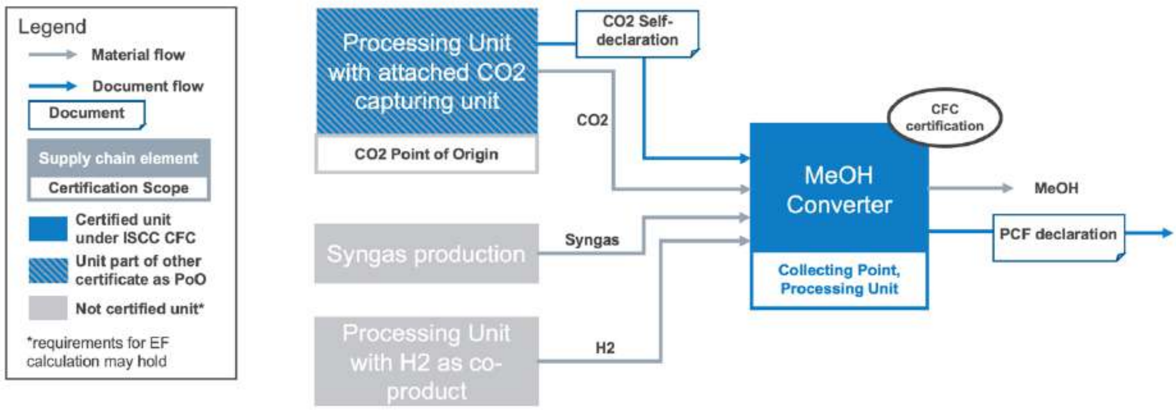

Figure 2: Covered elements of CCU MeOH supply chain, material and document-flow in supply chain

The PoO issues a self-declaration for the collecting point. This CO_2 self-declaration includes information on the captured CO_2 and a confirmation that the CO_2 savings of the CO_2 captured and transported to the MeOH converter has not been considered already in the PCF calculation for the products at the processing unit which emits the CO_2 (this approach is denoted 0:100, because 100% of the benefit is allocated to the plant utilizing the CO_2.). This means that the processing unit with attached CO_2 capturing needs to include the CO_2 captured and transported to the MeOH converter as emitted emissions in the PCF calculation of their products. All CO_2 PoOs will be audited during the collecting point audit of the MeOH converter.

An alternative certification concept for the CO_2 supply to the MeOH converter may be via a separately ISCC PLUS certified “Collecting Point” (collecting the CO_2 from associated PoOs with respective CO_2 self-declarations) or ISCC PLUS certified “Trader”. In this case the MeOH converter would only be certified as “Processing Unit” under CFC and receive the CO_2 from the ISCC PLUS certified “Collecting Point” or “Trader” with an ISCC PLUS sustainability declaration.

The documents shared within the supply chain need to provide the following information.

CO_2 self-declaration:

- Information on supplier and recipient
- Information on CO_2 source
- Emissions related to CO_2 capturing
- Declaration, that the benefit has not been considered at capturer (0:100 approach)

PCF declaration:

- Information on supplier and recipient
- PCF of CCU MeOH according to here outlined methodology

4.3.1 Eligible CO_2 sources

The CO_2 used in the certified MeOH converter needs to come from one of the following eligible sources:

- Biogenic CO_2 which originates from biomass
- Atmospheric CO_2 from direct air capture
- Post-industrial (fossil) CO_2 captured from industrial processes, which use fossil sources to deliberately produce electricity, heat, or materials (e.g., cement, iron and steel, petrochemical industry) and would have otherwise been emitted to the atmosphere.

CO_2 produced deliberately for the usage in the CCU process as well as CO_2 whose benefit has already been considered (e.g. in the PCF calculation of the products at the processing unit with attached CO_2 capturing unit (100:0 approach)) is not eligible under this certification approach for CCU MeOH.

During the conventional MeOH production, CO_2 is formed in the syngas production process. This CO_2 being part of the syngas during a conventional production process of MeOH cannot be considered as an eligible CO_2 source under this certification approach. Hence the respective part of a conventional MeOH production originating from this CO_2 being part of the conventional syngas cannot be considered as CCU MeOH under this approach.

4.3.2 Eligible H_2 sources

The used H_2 in this certification approach can originate from fossil sources (e.g., natural gas), but needs to be a by-product produced together with other products from the used fossil source (e.g., excess H_2 as part of a flue gas stream from the production of conventional MeOH, H_2 from syngas production with co-product CO, …). Dedicated production processes, which produce H_2 from fossil sources as the only product with all the carbon of the fossil feedstock being released as CO_2 to the atmosphere are not eligible under this approach (e.g., hydrogen from natural gas or coal with all carbon of the fossil feedstock being vented as CO_2). So called “blue hydrogen” with all carbon emissions originating from the fossil feedstock during the H_2 production being stored permanently via CCS is an eligible H_2 source under this certification approach (e.g., H_2 with certified net-zero PCF under the CCS certification approach of the ISCC Carbon Footprint Module[11]).

[11] ISO 14067 compliant assignment of CO_{2eq} savings required, see documentation of CCS certification approach.

4.4 Methodology for the PCF calculation of low Carbon CCU MeOH

This chapter defines specifications in the calculation of the PCF of low carbon CCU MeOH as well as the necessary verification of PCF calculations for low carbon CCU MeOH under the ISCC CFC.

The calculation of GHG emissions for low carbon MeOH production with a CCU unit shall consider the direct emissions of the methanol production process, the upstream emissions associated with the production and the supply of process inputs such as electric energy, feedstock input to the process (e.g., syngas with its specific composition), process heat, captured CO_2, used as a process input, other process chemicals as well as potential co-products of the process. The GHG calculation needs to be performed on a yearly basis (preferred twelve months prior to certification) and needs to be updated prior to recertification. The PCF calculated is valid for the validity period of the certificate (one year), if no major changes for the PCF are expected e.g. by significant process changes.

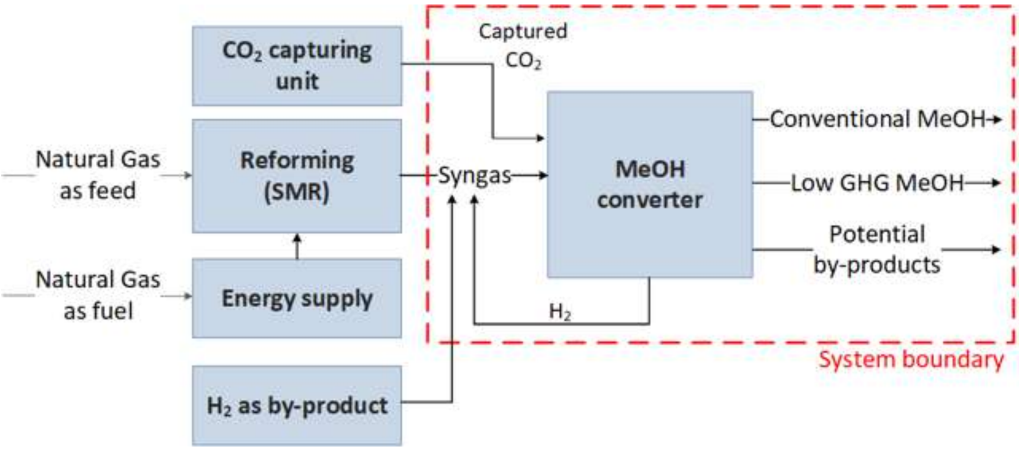

Figure 3: Main parameters for the PCF calculation of MeOH Production

4.4.1 PCF calculation for low carbon CCU MeOH (simplified)

$$E_{low\ carbon\ CCU\ MeOH} = -E_{CCU\ CO2\ intake} + E_{CCU\ CO2\ upstream\ emissions} + Ep_{low\ carbon\ CCU\ MeOH} + E_{unconverted\ CCU\ CO2}$$

Where,

$E_{low\ carbon\ CCU\ MeOH}$	Emissions from the production of low carbon methanol in kg CO_2-Eq. per t of methanol (PCF)
$E_{CCU\ CO2\ intake}$	Emission savings from capturing of CO_2, directly related to the production of low carbon CCU MeOH. A credit for the avoided emissions from capturing the CO_2 is granted in the PCF calculation (pls. see section on eligible sources). The credit is limited to the emissions

	avoided through the amount of captured CO_2, introduced to the MeOH process. The credit is considered as a negative value in the equation (see negative sign of this term in equation above).
$E_{CCU\ CO2\ upstream\ emissions}$	Emissions from the capturing and supply of the CCU CO_2 for the low carbon CCU MeOH production, including emissions from the use of energy for CO_2 capturing, compressing, the production and use of process chemicals for purification / concentration of the CO_2 as well as the transport of CCU CO_2 to the low carbon CCU MeOH process.
$Ep_{low\ carbon\ CCU\ MeOH}$	Emissions from processing of low carbon CCU MeOH.
$E_{unconverted\ CCU\ CO2}$ =	This term shall consider emissions of excess CCU CO_2, not converted into MeOH. These emissions shall be accounted for if a respective credit for the intake of CCU CO_2 was considered in the calculation.

Emissions from processing of low carbon CCU MeOH are to be calculated as follows:

$$Ep_{low\ carbon\ CCU\ MeOH} = m_{n,i} x\ EF_{n,i}\ +\ W_{el}\ x\ EF_{el} + W_{th}\ X\ E_{th} + m_{H2}\ X\ EF_{H2} + E_{de}$$

Where,

$EP_{low\ carbon}$	emissions from processing of low carbon
$m_{n,\ i}$	quantity of process input in kg
$EF_{n,i}$	emission factor for the production and transport of the process input to the processing unit in kg CO_2-Eq. per kg
W_{el}=	quantity of electricity (electrical work) input in kWh
EFel=	emission factor for the production and supply of electricity (electrical work) to the processing unit in kg CO_2-Eq. per kWh
W_{th}=	quantity of process heat (thermal work) input in kWh
EF_{th}=	emission factor for the production and supply of process heat (thermal work) to the processing unit in kg CO_2-Eq. per kWh
m_{H2}	net quantity of hydrogen used as feedstock for CCU MeOH production. Excess hydrogen, leaving the process unconverted shall be subtracted from this term. It is preferred to determine the net quantity of H_2 input to produce the CCU MeOH via measurement of H_2 introduction and measurement of H_2 purge leaving the process unconverted. If this is not possible, the net quantity can also be determined via the chemical reactions of the process.
EF_{H2}	emission factor for the production and supply of hydrogen to the MeOH process, in kg CO_2-Eq. per kg H_2
E_{de} =	direct process emissions in kg CO_2-Eq., This term shall consider direct GHG emissions of the MeOH process,

excluding emissions of excess CCU CO_2, not converted into MeOH.

4.4.2 Emission factor of H_2 and by-product allocation

Besides CCU CO_2, hydrogen is an essential input to produce low carbon CCU MeOH. Thus, the PCF calculation shall include the respective environmental burdens associated with the production of the H_2 used for MeOH production.

The emission factor for the production and supply of the H_2 used to produce low carbon CCU MeOH must be calculated based on actual process data. For potential production processes to produce eligible H_2 under this certification approach, see chapter 4.3.2. The EF of H_2 must consider the input of energy sources (e.g., electricity or a gaseous energy carrier) and direct GHG emissions of the H_2 production process as well as emissions from the distribution of the H_2. Since the H_2 for the low carbon CCU MeOH production results from a multi-output process, the EF of the H_2 shall be determined based on an energy-based allocation, following the formula below.

$$AF_{H2\ upstream\ \mathrm{emissions}} = \frac{m_{H2}\ [kg]\ x\ LHV_{H2}[MJ/kg]}{(m_{H2}\ [kg]\ x\ LHV_{H2}[MJ/kg]) + (m_{co-product}\ [kg]\ x\ LHV_{co-product}\ [MJ]}$$

Where:

m_{H2}	net quantity of hydrogen
LHV_{H2}	Lower Heating Value (LHV) of hydrogen

Allocation of by-products from low carbon CCU MeOH production

In case the low carbon CCU MeOH is produced from a multi-output process, the GHG emissions calculated with the approach described under section 4.1 shall be allocated between the main product, the low carbon CCU MeOH and co-products such as heat or conventional MeOH. A prerequisite for the consideration of heat as a by-product is that the heat is utilized in other processes. Emissions from downstream processing or transport and distribution emissions of low carbon CCU MeOH cannot be added prior to allocation, as those emissions are not related to the co-products. The allocation of GHG emissions to any products that are considered waste or residue is not permitted[12]. Additionally, the allocation of the CCU CO_2 credit to conventional MeOH as a potential by-product is not permitted.

The allocation of emissions shall be based on the energy content of the products. Consequently, the allocation factor AF for low carbon CCU methanol production, shall be calculated as:

[12] For the classification of waste and residues, please refer to ISCC 202-5.

$AF_{low\ carbon\ CCU\ MeOH}$ =

$$\frac{m_{low\ carbon\ CCU\ MeOH}\ [kg]\ x\ LHV_{low\ carbon\ CCU\ MeOH}[MJ/kg]}{(m_{low\ carbon\ CCU\ MeOH}\ [kg]\ x\ LHV_{low\ carbon\ CCU\ MeOH}[\frac{MJ}{kg}])+(m_{co-product}\ [kg]\ x\ LHV_{co-product}\ [\frac{MJ}{kg}])}$$

4.4.3 Consideration of CO_2 benefit in PCF calculations

The benefit split for PCF calculations of the captured and to the MeOH converter transported CO_2 follows a 0:100 approach. This means that the MeOH converter ("user") receives the full benefit of the CO2 captured and transported to the MeOH converter. The CO_2 capturer is not allowed to use the CO_2 savings associated with the capture and use by the MeOH converter in the PCF calculations of their products (to avoid double counting/benefiting). The benefit of the CO_2 in the CCU MeOH PCF calculation accounts for 1kg CO_{2eq} per kg captured CO_2 (term $E_{CCU\ CO2\ intake}$) minus the emissions related to capturing the CO_2 (term $E_{CCU\ CO2\ upstream\ emissions}$) and minus the unconverted CO_2 during the MeOH production (included in E_{de} in $Ep_{low\ carbon\ CCU\ MeOH}$).

4.4.4. Calculating a PCF for conventional MeOH production

When assessing integrated production systems, in which low carbon CCU MeOH is produced together with conventional MeOH, the methodology defined under section 4.4.1 can also be used to calculate a PCF of the conventional MeOH. Unlike the low carbon CCU MeOH, no CCU CO_2 and related CO_2 credits can be applied during the PCF calculation for conventional MeOH. Furthermore, the sources of CO_2 and H_2 might differ from the eligible sources for low carbon CCU MeOH defined in this document.

4.4.5 Data basis

The PCF calculation is based on actual data gathered from the ISCC System User and data sourced from databases and literature.
Data gathering is relevant for the process inputs defined in the PCF calculation equation under chapter 4 including e.g. energy consumption, other process inputs and output data like process emissions, wastes, products and by-products. Relevant parameters, which cannot be measured directly, shall be calculated based on the input and output flows of the process.
Actual data measured and gathered at the system user's site must be documented and provided to the auditor for verification. This can include production controlling sheets, production reports, production information systems, delivery notes, weighbridge protocols, contracts, invoices and others. The calculation period should cover a full twelve-month period. It must be as up to date as possible. As an alternative, it must cover the previous calendar or financial year. In cases of exceptional maintenance measures and unstable production conditions a shorter period (for inputs and respective outputs) may be considered if it better reflects the relevant timeframe. The

respective period for data gathering and thus for the calculation of GHG emissions must be transparently displayed in the calculation.

Alternatively, data can also be obtained directly from the supplier/external vendors when its readily available. If needed technological specific data derived from detailed data at plant/site, market reports, industry average data, or literature studies.

On-site data gathering

The following data for the calculation of GHG emissions from the MeOH production process must be gathered on-site. They will form the basis for the calculation of GHG emissions. All input values must be gathered for the same reference time period (identical start and end date). In the example below the period of 1 year (yr) is used.

- Amounts of CO, CO_2 and H_2 introduced into the process (e.g., per t of MeOH per yr) as well as their specific source (e.g., syngas process, “recycled” excess H_2)
- The input and output data of the syngas process, including the use of feed, electricity, as well as the process output (e.g., syngas, heat) and process emissions
- Source and amount of electricity used for the operations (e.g., MWh per yr)
- Source and amount of process heat used for the operations (e.g., MWh per yr)
- Source and amount of CO_2, captured from external processes
- Type and amount of additional process inputs (e.g., t per yr)
- Amount of MeOH produced (e.g., t per yr)
- Amount of by-products produced (e.g., t excess H_2 per yr)
- Amount of process wastes (e.g., t per yr). Waste streams might be clustered in case the emission factor for their treatment processes is the same.
- Amount and composition of flue gas and other direct process emissions, especially in relation to climate relevant emissions (e.g., CO_2, CH_4, N_2O, etc. in t per yr). If these emissions cannot be measured directly, they shall be calculated based on the process inputs and outputs.

Published data

The following types of data for the calculation of GHG emissions can be gathered from reviewed databases and literature as well as from official statistics:

- Emission factors (EF) for the production and supply of the process chemicals
- Emission factors for the supply of the feedstock to the syngas process

- Emission factors for the production and supply of additional process inputs
- Emission factors for electricity and other energy sources in kg CO_2-Eq. per unit of energy used
- Emission factors for the treatment of wastes and residues

Emission factors can be sourced from, e.g.,:

- Life Cycle Inventory databases such as e.g., EcoInvent, GaBi (Sphera), SimaPro etc.
- "Official" sources, such as Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA) or governments,
- Other reviewed sources of data, such as E3 database, GEMIS database,
- Peer-reviewed publications

Requirements for the emission factor of used electricity
If electricity is sourced from the grid, the EF for electricity from the regional electricity mix shall be used.
If electricity from renewable energies or other sources is directly consumed, an adapted EF for the type of renewable electricity may be used. This is possible under two conditions: a) if that plant is not connected to the electricity grid; or b) there is a direct connection between the processing unit and the individual electricity production plant, being possible to validate the amount of electricity used with a suitable meter.[13]

4.5 Mass balancing requirements

Since the CCU MeOH will be most often produced together with conventional MeOH in one reactor in a co-processing setup, mass balance rules shall to be applied for the attribution of the CCU MeOH characteristics to specific MeOH product batches. This mass balancing needs to be conducted according the ISCC PLUS mass balance regulations.

The amount of CCU MeOH needs to be calculated according to the CO_2 and H_2 input streams for the CCU MeOH under consideration of respective conversion rates (unconverted CO_2 and H_2). Actual measurement data for the CO_2 input needs be used. Also, for the H_2 input, unconverted CO_2 and unconverted H_2 actual measurement data is preferred, but also data based on the chemical reaction of the underlying process can be used.

4.6 Benchmarking

Under the ISCC Carbon Footprint certification approach for low carbon CCU MeOH, the absolute value of the PCF calculated via the here described

[13] Potential usage of adapted emission factors for the use of power purchase agreements are currently being evaluated by ISCC. This section may be updated accordingly in the next revision of this document.

methodology ($E_{low\ carbon\ CCU\ MeOH}$, see formula above) needs to be published together with the certification. In addition to the absolute PCF value to be given, potential emission reductions are claimed in comparison to a respective benchmark:

$$Emissions\ reduction\ (\%) = \left(\frac{Benchmark\ value - E_{low\ carbon\ CCU\ MeOH}}{Benchmark\ value}\right) \times 100$$

The benchmark value is a reference value for emissions related to conventional MeOH production (cradle-to-gate PCF) on a global level. ISCC has selected a cradle-to-gate PCF value for MeOH production from of 28.2 gCO_2eq/MJ MeOH (= 0.561 kg CO_{2eq}/kg MeOH[14]), sourced from the Commission Delegated Regulation 2023/1185. The value will be updated by ISCC once more recent data are available.

When the calculation of the CCU MeOH PCF according to the here outlined methodological requirements results in lower emissions than a defined threshold of the reference global value, a claim on “low-carbon CCU MeOH” is possible. For the certified CCU MeOH PCFs under ISCC CFC this threshold is set to 70% reduction compared to the global reference value to qualify for a low carbon CCU MeOH claim (PCF lower than 0.561*(1-0.7) = 0.168 $kgCO_{2eq}$/kg MeOH).

4.7 Terminological definitions

CCU MeOH: Under this certification approach, MeOH, which is produced via the reaction of captured CO_2 and H_2 can be referred to as “CCU MeOH”, if the requirements on the eligible CO_2 and H_2 sources are met. As outlined in the chapter on eligible CO_2 sources, MeOH molecules which originates from CO_2 being part of the syngas processed in a conventional MeOH production, is not seen as CCU MeOH. This also holds for MeOH produced via the conventional MeOH production process with a hypothetically changed syngas ratio to only CO_2 and H_2.

Low Carbon CCU MeOH: If the requirements on the eligible CO_2 and H_2 sources are met and the defined PCF threshold is met by calculating the CCU MeOH PCF according to the here defined calculation methodology, the respectively produced CCU MeOH could be referred to as “low carbon CCU MeOH”.

[14] Units converted via Lower Heating Value of Methanol LHV_{MeOH} = 19,9 MJ/kg, Source: IRENA AND METHANOL INSTITUTE (2021), Innovation Outlook : Renewable Methanol, International Renewable Energy Agency, Abu Dhabi.

4.8 Interface of low carbon CCU MeOH approach under ISCC CFC to certified MeOH under ISCC PLUS

Under ISCC CFC carbon footprints of products are certified whereas under ISCC PLUS the origin of feedstocks is traced and certified. MeOH from CO_2 and H_2 can also be certified under ISCC PLUS, if CO_2 and H_2 come from the respective ISCC PLUS eligible sources (see ISCC PLUS system document).[15] Under ISCC PLUS the H_2 reacting with post-fossil and atmospheric CO_2 needs to come from ISCC PLUS compliant sources, since CO_2 does not contain usable energy and the energy needed to drive the MeOH production processes comes from H_2. Therefore, the CCU MeOH produced with a certified PCF under ISCC CFC does not exhibit a certified share under ISCC PLUS.

[15] Terminological differentiation: Under ISCC PLUS MeOH from renewable / bio / bio-circular hydrogen and CO_2 is referred to renewable / bio / bio-circular MeOH.

5 PCF of silicon metal production

5.1 Introduction

Silicon is an important pre-product for many applications in different industrial sectors. Besides its use in the electrical, semi-conductor, photovoltaic and chemical industry, silicon is also used as an alloying element for the steel and aluminum production.
The various fields of application require different qualities, which results in different process treatments of the silicon. However, the first step always is the production of raw silicon in forms of ferrosilicon or silicon metal.

On an industrial level, the production of silicon is usually done with an electric arc furnace (EAF) which reduces quartzes and quartzites (hereinafter referred to as "Quartz/ite"), which are both mainly composed of silica (silicon dioxide - SiO2) with carbon as a reducing agent in an energy intense process. Besides silicon metal and silica fume, this process results in different off-gas components.
Depending on the specific process set-up as well as the type of reducing agents (e.g., the use of fossil or biogenic carbon) or electricity sources used, the PCF of the silicon product can vary significantly. Thus, the approach described in this chapter shall provide a basis to calculate, verify and communicate greenhouse gas (GHG) emissions and emission reductions in the production of silicon metal compared to business as usual scenarios or a benchmark for the industry average.

This section describes the general approach for the calculation of GHG emissions for silicon metal production under the ISCC CFC module and provides guidelines for the certification of the corresponding PCFs. Specific requirements related to the collection of input data and the verification of the calculation are subject to the subsequent chapters.

5.2 Scope and Normative References

The scope of this chapter is the PCF calculation for Silicon metal within a cradle-to-gate approach. The general approaches for GHG emission calculations of various products will be, to the extent possible, widely harmonized under the ISCC carbon footprint certification module (ISCC CFC). The methodology defined in this document follows the general approach defined in ISO 14067:2018, with further specifications to produce silicon metal.

5.3 Methodology for the calculation of PCFs for silicon metal products

The ISCC EU System Document 205 “Greenhouse Gas Emissions” explains the options of stating GHG emissions along the supply chain and provides the methodology, rules and guidelines for calculating and verifying GHG emissions and emission reduction.

This chapter defines specifications in the calculation of the PCF for silicon metal as well as the necessary verification of PCF calculations for silicon metal under the ISCC CFC.

The calculation of GHG emissions from the production of silicon metal shall consider the direct emissions of the silicon metal production process, the upstream emissions associated with the production and the supply of process inputs such as electric energy, other process inputs and reducing agents, as well as potential co-products of the process (e.g., silica fume). The certification approach for silicon metal under the ISCC CFC hence aims for the calculation of a cradle-to-gate PCF for silicon metal considering all emissions happening prior to the gate of the silicon metal selling company, which can be forwarded to the downstream customer.

Figure 4 shows a simplified process flow with the relevant parameters for the calculation.

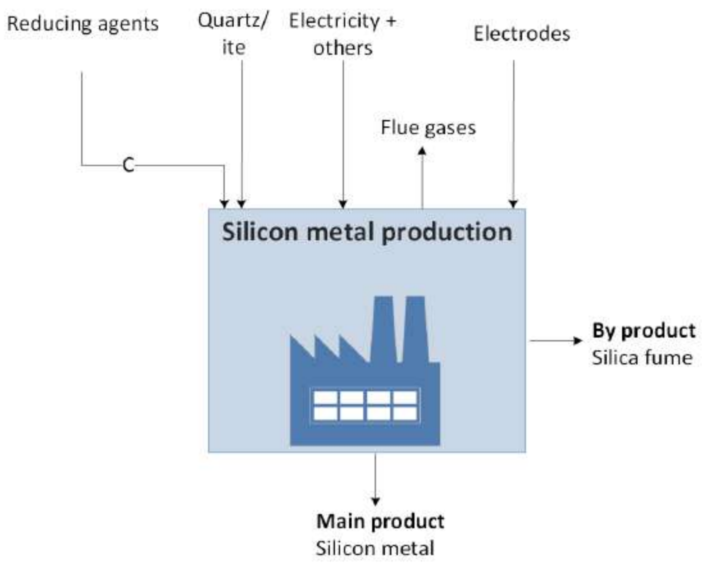

Figure 4 Main parameters for the PCF calculation of silicon metal

Typical[16] set ups for the production of silicon metal consider the use of SiO_2-based raw materials (Quartz/ite) as the material feedstock, different kinds of carbon sources as reducing agents (RA, e.g. coal, wood, charcoal), the input of electric energy for the operation of the EAF, the use of consumable electrodes and potential other process inputs (e.g. limestone, oxygen,

[16] As for example defined by SCHEI, A.; TUSET, J. K.; TVEIT, H. ET AL.: Production of high silicon alloys.
Trondheim: TAPIR, (1998). ISBN: 8251913179.

nitrogen, fuels). Thus, the GHG emissions of the silicon metal production shall be calculated as:

$$E_{sm} = \left(m_{ra,i}\ x\ EF_{ra,i} + m_{Quartz/ite}\ x\ EF_{Quartz/ite} + W_{el}\ x\ EF_{el} + m_{n,i} x\ EF_{n,i} + E_{flue\ gas}\right) x\ AF_{sm}$$

Where

E_{sm} =	emissions from the production of silicon metal in kg CO_2-Eq. per t of silicon metal
$m_{ra,\ i}$ =	quantitiy of reducing agent i in kg
$EF_{ra,\ i}$ =	emission factor for the production and transport of the reducing agent i to the processing unit in kg CO_2-Eq. per kg. The EF shall consider all process steps until the provision of the process input to the silicon metal production unit, including production, storage and transport steps.
$m_{Quartz/ite}$=	quantitity of Quartz/ite inputs in kg
$EF_{Quartz/ite}$=	emission factor for the production and transport of Quartz/ite to the processing unit in kg CO_2-Eq. per kg, the EF shall consider all process steps until the provision of the Quartz/ite to the silicon metal production unit, including production, storage and transport steps.
W_{el}=	quantity of electricity (electrical work) input in kWh
EF_{el}=	emission factor for the production and supply of electricity (electrical work) to the processing unit in kg CO_2-Eq. per kWh, the EF shall consider all process steps until the provision of the process input to the silicon metal production unit
$m_{n,\ i}$=	quantitiy of additional process input i in kg
$EF_{n,\ i}$=	emission factor for the production and transport of the additional process input i to the processing unit in kg CO_2-Eq. per kg, the EF shall consider all process steps until the provision of the process input to the silicon metal production unit, including production, storage and transport steps.
$E_{flue\ gas=}$	direct process emissions in kg CO_2-Eq., the climate impact of the flue gas emissions shall be considered according to the characterisation factors of the different GHG components. CO_2 emissions from the combustion of biogenic carbon sources (e.g., when sustainably sourced charcoal is being used as a reducing agent) shall be taken to be zero.
AF_{sm}=	allocation factor for silicon metal

5.4 Allocation factors for silicon metal and by-products

Emissions calculated according to the above defined approach shall be allocated between the main product silicon metal and any by-products

occurring from the silicon metal production process. The allocation of GHG emissions to any products that are considered a waste is not permitted.[17]
The allocation of emissions shall be based on the mass flows of the products. Consequently, the allocation factor AF of the silicon metal, shall be calculated as:

$$AF_{sm\ based\ on\ mass\ flows} = \frac{m_{sm}\ [kg]}{(m_{sm}\ [kg] + m_{co-product}\ [kg])}$$

5.5 Benchmarking and claiming

Under the ISCC Carbon Footprint certifiation approach for silicon metal, the absolute value of the PCF calculated via the here described methodology (E_{sm}, see formula above) needs to be published together with the certification. In addition to the absolute PCF value to be given, potential emission reductions can be claimed in comparison to respective benchmarks. Once the benchmark value is selected, the emissions reductions can be calculated as:

$$Emissions\ reduction\ (\%) = \frac{Benchmark\ value - E_{sm}}{Benchmark\ value}$$

For claiming emission reductions, the selected benchmark needs to be clearly referenced. Two possibilities apply for the benchmark value:

1) **Reference global value:** In this case, the benchmark value will be a reference value for emissions related to silicon metal production on a global level. ISCC has selected a value from the Ecoinvent data base of 10.9 kgCO_{2eq}/kg-silicon metal. This value is based on the "market for silicon, metallurgical grade, GLO" activity from Ecoinvent, version 3.9.1, impact category GWP100 IPCC 2021. The value will be updated by ISCC once more recent data are available.
   When the calculation of silicon metal emissions according to the here outlined methodological requirements (including identical system boundaries, identical functional unit/reference flow) results in lower emissions than a defined threshold of the reference global value, an additional claim on "low-carbon silicon metal production" is possible. For the certified silicon metal PCFs under ISCC CFC this threshold is set to 40% reduction compared to the global reference value to qualify for a low carbon product claim (PCF lower than 10.9 *(1-0.4) = 6.5 kgCO_{2eq}/kg-silicon metal).

2) **Reference to System User's silicon metal production prior to emission reduction measures:** In this case, the benchmark value for the silicon metal production emissions is the emission value calculated

[17] For the classification of waste and residues, please refer to ISCC 202-5.

for the System User, before a new emission reduction measure was in place. This means the System User shall identify what were the original emissions for silicon metal production on its own production plant. The emissions from prior to the added emission reduction measure shall be calculated following the same methodology as laid out in this document. The systems user's reference production PCF value cannot be older than three years prior to the certification year and the year of comparison need to be stated in the claim.
Independent of the achieved emission reduction compared to the System User's reference production this comparison does not qualifiy for the additional "low carbon silicon metal production" claim. The low carbon product claim is only possible when achieving the threshold of 40% reduction compared to the reference global value (see previous paragraph).

It shall be highlighted that, while the calculation and claiming of emission reductions is optional, the communication of the calculated absolute PCF value is mandatory under the ISCC Carbon Footprint Certification.

5.6 Data basis

The PCF calculation is based on actual data gathered from the individual (to be) certified company and, if needed, data sourced from databases and literature.
Data gathering during the audit is relevant for the process inputs defined in the PCF calculation equation under chapter 3.2.3, including e.g. energy consumption, other process inputs and for output data like process emissions, wastes, products and by-products. Relevant parameters, which cannot be measured (e.g., process flue gas emissions) shall be calculated based on the input and output flows of the process and the corresponding chemical conversion. Actual data measured and gathered at the System User's site must be documented and provided to the auditor for the verification. This can include production reports, production information systems, delivery notes, weighbridge protocols, contracts, invoices and others. The calculation period should cover a full twelve-month period. It must be as up to date as possible. As an alternative, it must cover the previous calendar or financial year. In cases of exceptional maintenance measures and unstable production conditions a shorter period (for inputs and respective outputs) may be considered if it better reflects the relevant timeframe. The respective period for data gathering and thus for the calculation of GHG emissions must be transparently displayed in the calculation.

On-site data gathering

The following data for the calculation of GHG emissions from the silicon metal production process must be gathered on-site. They will form the basis for the calculation of GHG emissions. All input values must be gathered for the same reference time period. In the example below the time period of 1 year (yr) is used.

- Type and amount of reducing agent (e.g., t coal or charcoal per yr)
- Amount of Quartz/ite (e.g., t Quartz/ite per yr)
- Source and amount of electricity used for the operations (e.g., MWh per yr)
- Type and amount of additional process inputs (e.g., t per yr)
- Amount of silicon metal produced (e.g., t per yr)
- Amount of by-products produced (e.g., t silica fume per yr)
- Amount of process waste (e.g., t per yr). Waste streams might be clustered in case the emission factor for their treatment processes is the same.
- Amount and composition of flue gas and other direct process emissions, especially in relation to climate relevant emissions (e.g., CO_2, CH_4, N_2O, etc. in t per yr). If these emissions are not measured directly, they shall be calculated based on the process inputs, outputs and corresponding chemical conversion (e.g., the amount of CO_2 based on the amounts of used carbon reducing agent inputs and the assumptions of a chemical conversion to CO_2). If the amount of a climate active flue gas cannot be measured, the company must show during the audit that these flue gases are only produced in neglectable amounts (e.g. by literature process description of the applied process).

Published data

The following types of data for the calculation of GHG emissions can be gathered from reviewed databases and literature as well as from official statistics:

- Emission factors (EF) for the production and transport of the used reducing agents
- Emission factors for the production and transport of the Quartz/ite used in the process
- Emission factors for the production and supply of additional process inputs
- Emission factors for electricity and other energy sources in kg CO_2-Eq. per unit of energy used
- Emission factors for the treatment of wastes and residues

Emission factors can be sourced from, e.g.,:

- Life Cycle Inventory databases with critically reviewed datasets, such as EcoInvent, Sphera

- Data published by the Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA), governments or governmental institutions,
- Peer-reviewed publications from scientific journals,
- Critically reviewed LCA or PCF studies.

Requirements for the emisson factor of used electricity

If electricity is sourced from the grid, the EF for electricity from the regional electricity mix shall be used.
If electricity from renewable energies or other sources is directly consumed, an adapted EF for the type of renewable electricity may be used. This is possible under two conditions: a) if that plant is not connected to the electricity grid; or b) there is a direct connection between the processing unit and the individual electricity production plant, being possible to validate the amount of electricity used with a suitable meter.[18]

5.7 Specific verification guidance for Silicon metal PCF calculation and used EFs

Existing publications on the GHG emission of silicon production indicate important drivers and influencing factors for the overall PCF of silicon. These can include:

- the source and GHG intensity of the electricity used in the silicon production process,
- the amount and specific composition of the flue gas emissions from the silicon production process,
- the source of the reducing agent (carbon) and the emissions associated with its production.

Verification of PCF calculations for silicon under the ISCC CFC should recognize the importance of these parameters and verify individual calculations or emission factors for these elements.

In case biogenic carbon (e.g., from charcoal or wood chips) is used as a reducing agent, the following aspects need to be verified for the choice of an appropriate emission factor:

- The emission factor for the reducing agent shall include the complete supply chain from the cultivation and sourcing of the biogenic feedstock, the transport of the feedstock, to the processing and final transport to the silicon production. Respective PCF calculations and emission factors of the used charcoal shall be checked regarding the completeness of system boundaries, covering the complete value

[18] Adapted emission factors by the use of power purchase agreements are currently being evaluated by ISCC and may be added in revisions of this document.

chain from the production and supply of the biogenic feedstock, the conversion to a reducing agend as well as the distribution process to the silicon metal production.

- Direct emissions from the processing of the biogenic feedstock (e.g., in a pyrolysis process to produce charcoal as reducing agent) have to be considered, following the methodology defined in the ISCC 205 GHG emission document:
  - Evidence of appropriate measures for the recording of emissions from the processing of the biogenic feedstock shall be provided when requested.
  - Records of emissions from the processing of the biogenic feedstock shall be provided when requested.
  - Records for energy consumption of the processing of the biogenic feedstock shall be provided when requested.
  - The verification of those primary data from the suppliers of the reducing agent processing biogenic feedstock may need a direct communication between the auditor and the supplier. The System User is to facilitate that direct communication. If requested, the auditor may also decide to verifiy specific parts of the EF calculation of the reducing agent on-site at the supplier (e.g. the handling of pyrolysis gases from pyrolysis process).
  - The calculation of emissions of co-products produced during the production of reducing agents from biogenic feedstock need to follow the methodology defined in the ISCC 205 GHG emission document (see defined allocation procedures, e.g., no system expansion).
- It shall be verified that the biogenic feedstock is sourced from sustainably managed areas and forests. Biomass and biofuels used as a process input (e.g., as a reducing agent) produced from forest biomass shall meet the following land-use, land-use change and forestry (LULUCF) criteria:
  - the country or region of origin of the forest biomass:
    - is a Party to the Paris Agreement;
    - has submitted a nationally determined contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC), covering emissions and removals from agriculture, forestry and land use which ensures that changes in carbon stock associated with biomass harvest are accounted towards the country's commitment to reduce or limit greenhouse gas emissions as specified in the NDC; or
    - has national or sub-national laws in place, in accordance with Article 5 of the Paris Agreement, applicable in the area of harvest, to conserve and enhance carbon stocks and sinks, and providing

evidence that reported LULUCF-sector emissions do not exceed removals;

- where evidence in regard to these points is not available, verification of the sustainable sourcing of biomass can be done in two alternative approaches:
  - sourcing biomass from an ISCC certified forest/ forest management unit
  - certification against the requirements of a certification scheme recognized by ISCC, or of compliance with appropriate ISCC recognised local regulation (EU forestry strategy[19])

- Records of the shipment of materials from forest to processing units, and from processing units to secondary processing units (etc) shall be provided when requested.

[19] https://environment.ec.europa.eu/topics/forests_en

6 Certification of downstream entities handling CFC certified material

Downstream entities handling CFC certified material need to be ISCC CFC certified, if they want to forward PCF information of the certified products under ISCC CFC. A downstream entity is every unit following a CFC certified entity, which is certified according to the above-described certification approaches for different decarbonization measures (e.g. CCS, CCU or low carbon silicon metal production). Depending on the purpose of the downstream unit, two different CFC certification scopes are applicable, which differ in certification and audit requirements: Traders and Processing units processing CFC certified material (see figure 5).

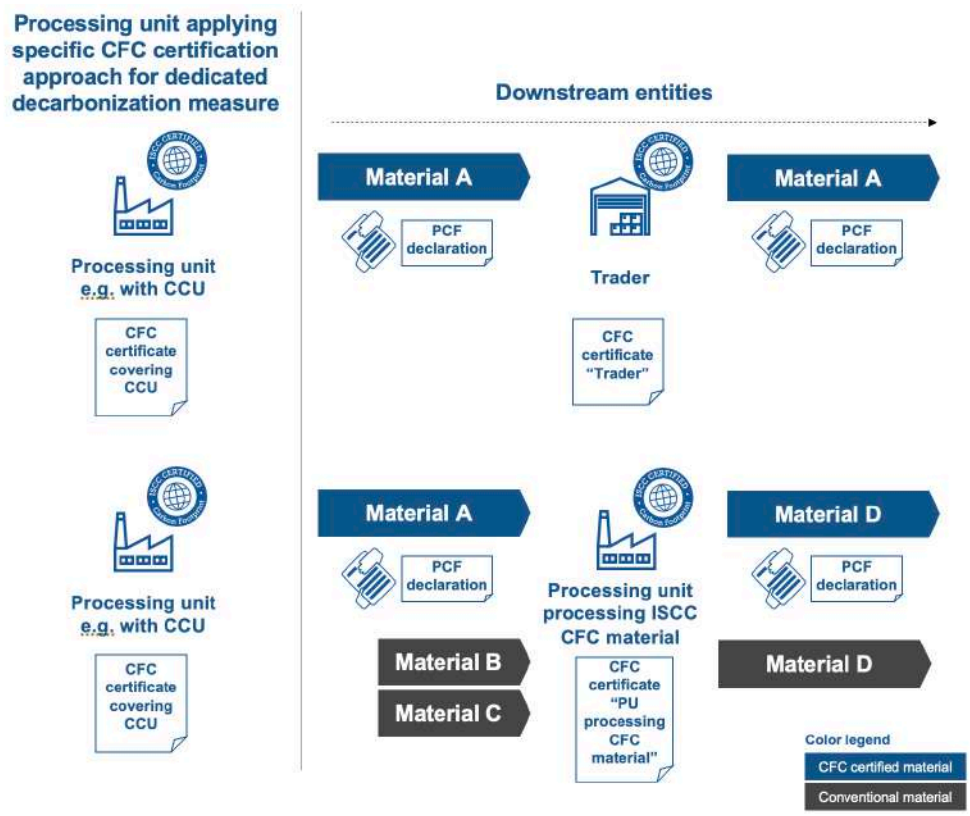

Figure 5: ISCC CFC certificate for downstream entities handling CFC certified material: Trader & Processing Unit processing CFC material.

6.1 Trader

6.2.1 Certification requirements and handling of CFC certified material

Trading entities trading CFC certified material need to have an own CFC trader certificate. CFC traders need to implement a mass balance for ISCC CFC certified material, including the documentation for incoming and outgoing ISCC CFC certified material, e.g. "Low carbon CCU MeOH". Same mass balance principles apply as for ISCC PLUS certified traders. ISCC CFC certified traders receive and issue ISCC CFC PCF declarations with the respective amounts of certified CFC material. If an ISCC CFC certified trader also trades ISCC PLUS or EU certified material (via own EU / PLUS certificate), they need to implement separate mass balances for CFC, EU and PLUS certified material (also in case of the same chemical material, e.g. MeOH)

6.2.2 Emission calculation

Trading entities will not do an individual (product) carbon footprint calculation. They issue PCF declarations with the same PCF value as received from the previous processing unit, which is the “cradle-to-gate” PCF of the upstream processing unit, which produces the CFC material (see Figure 6). The following processing unit downstream the trading entity needs to consider all transport and storage emissions between upstream processing unit producing CFC material and the gate of the downstream processing unit.

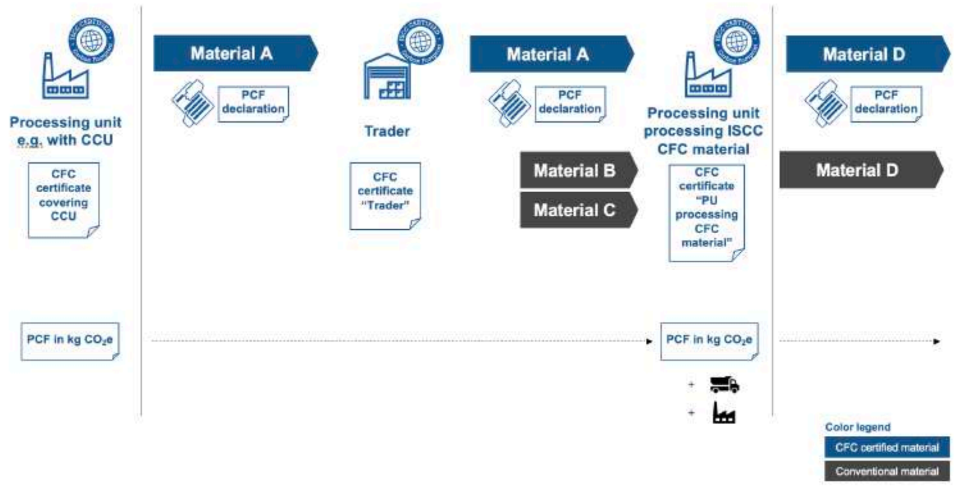

Figure 6: ISCC CFC Trader: Emission of storage and transport needs to be considered in PCF calculation of downstream processing unit processing CFC material.

6.2.3 Audit

Audit requirements equivalent to those for ISCC PLUS traders apply. Issuance of ISCC CFC Certificate need to be based on a respective audit. During the audit incoming and outgoing amounts of CFC certified material need to be verified. If a trader is already ISCC PLUS certified, these traders must set up an additional mass balance for CFC certified materials[20].

[20] If a trader is already ISCC PLUS certified, trading entity needs to contact its certification body. The setup of an additional mass balance for the ISCC CFC certified material can be verified remotely by the auditor. Issuance of ISCC CFC certificate can be handled within the certification period similar to scope expansion. Complete audit at recertification audit.

6.2 Processing unit processing ISCC CFC material

6.2.1 Certification requirements and handling of CFC certified material

The processing unit processing ISCC CFC material need to be physically supplied with ISCC CFC certified material and need to use the CFC certified material in its production to produce a (new) product. Respective PCF claims for this (new) product can only be made under ISCC CFC, if this processing unit processing ISCC CFC material is certified under ISCC CFC.
The downstream PU needs to have an own CFC certificate as "Processing unit processing ISCC CFC material" and receives ISCC CFC PCF declarations for its ISCC CFC certified input material and issues ISCC CFC PCF declarations for its products, which incorporate ISCC CFC certified input material.

The processing unit processing ISCC CFC material can be a co-processing site: CFC material is co-processed with conventional input materials of fossil origin (depending on setup same and/or different input material) in the same assets. Due to this co-processing nature a mass balance needs to be set up to attribute CFC certified input material volumes to dedicated product volumes. To align mass balance with common LCA principles, the mass balance / attribution needs to follow the following requirements:

- CFC input material must be part of the input materials needed to produce the respective product (chemical / technical feasibility).
- Attribution of CFC input material (input feedstock) to products (output) needs to follow chemical reaction of the production. This means that the share of CFC material in the product is limited to that part of the product which is derived from specific CFC input material (no overcompensation allowed, see example in figure 7).
- Amount of CFC product is limited by amount of CFC certified input material and its consumption factor during the production of specific CFC product.
- Material losses during production need to be considered either via consumption factor or conversion factors.

6.2.2 Emission calculation

The ISCC CFC certification of the PU processing CFC material covers the PCF calculation of its product(s) which incorporate CFC input material. The system boundaries for this PCF calculation is gate-to-gate. Due to co-processing nature of conducted process, separate PCFs for products of processing unit with and without attributed CFC input material need to be calculated (although being the same chemical / material, see example in figure 7). For the EF of the incoming batches of CFC certified input material its ISCC CFC certified PCF must be used.

The PCF calculation for the products of the processing unit processing CFC material needs in general to follow TfS / ISO 14067. All emissions from feedstocks / inputs, which are physically used during production, all emissions of processing operations as well as all emission from transportation and storage need to be considered according to TfS / ISO 14067.

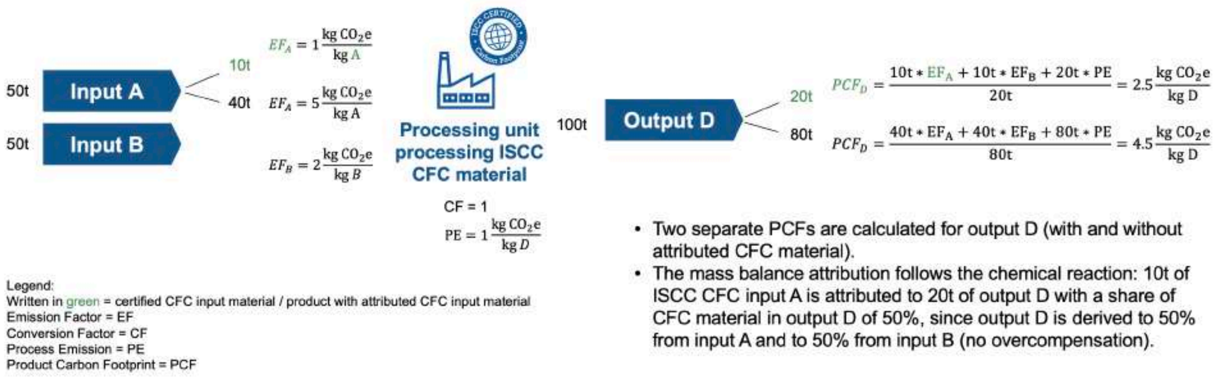

Figure 7: Example for mass balance attribution and emission calculation of ISCC CFC certified downstream material in a multi-input / single-output process.

6.2.3 Audit

During the audit for a processing unit processing ISCC CFC material it needs to be verified, if the PCF calculation of its products incorporating CFC material and the attribution of CFC input material to the respective products follow the requirements outlined in this chapter. For the verification of the mass balance the amounts of incoming CFC certified material, the conversion / consumption factor (losses of material, chemical reaction to justify used attribution) and the amounts of outgoing products with CFC certified PCF need to be verified.