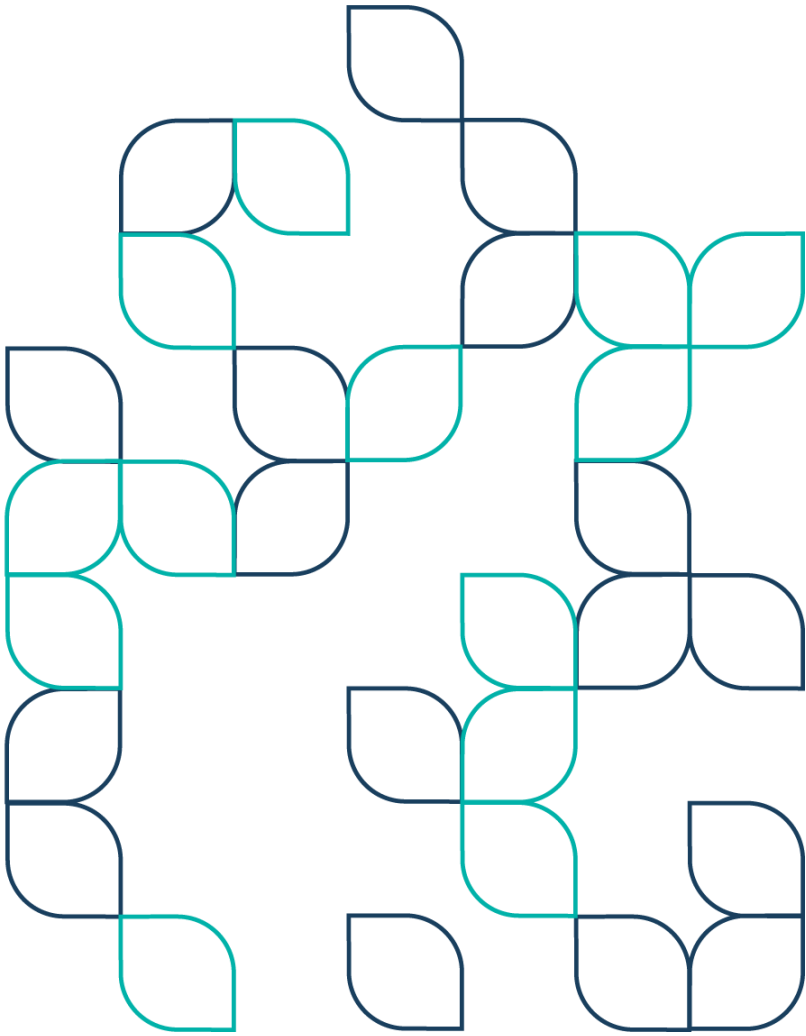
Product Carbon Footprint Calculation Methodology

A Mass-balance approach enabled by a Carbon Footprint Ledger (CFL)

Version 1.0, JULY 2024



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· Note: Comments enclosed in square brackets [x] are Dow specific requirements or supplementary detail and should not be considered part of the CFL methodology.

1 Goals and objectives

- This document describes a methodology for estimation of cradle-to-gate (partial) Product Carbon Footprints (PCFs) for purposes of customer communication.
- This methodology deploys the concept of multi-site mass balance with free attribution consistent with external standards.
- Partial PCF's may be used for informative purposes, product claims or voluntary corporate GHG reporting of Scope 3 inventories.
- Partial PCFs shall not be used for comparative assertion purposes and may not be suitable for regulatory or compliance purposes.

2 Alignment with external standards

- This methodology is in accordance with ISO 14067:2018 Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification and Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard (2011).
- Both PCF standards cite additional ISO standards on LCA (14040:2006 and 14044:2006) as reference. These standards provide additional guidance on project execution, data quality, review and communication.
- In addition, ISO 14067 encourages supplementary adoption of a relevant product category rules (PCR) when available, for example chemical industry specific guidelines for partial PCF calculations developed by Together for Sustainability (TfS).
- [Dow will follow relevant TfS guidance where applicable.]
- ERM CVS provided independent limited assurance report that this method is in accordance with the mandatory "shall" requirements within the reporting criteria in all material respects of ISO 14067:2018 and GHGP Product Standard, 2011 (Annex C).

3 Scope

- **Declared unit:** Partial PCFs will be based on a declared unit of 1 kg of unpackaged bulk product (kg CO_2eq/kg product), which refers to bulk version of a sold product as produced on its final form before it is packaged for shipment, e.g., in a tote, drum or a rail car.
    - [Sold product will be defined based on a unique Dow identifier code known as Specified Material Code (SMC) in Dow's SAP system.]
- **GHG Coverage:** Partial PCFs shall include impact of all Kyoto Greenhouse Gases (GHG) converted to CO_2 equivalences based on global warming potential over 100 years (GWP100) characterization factors from recent IPCC report (AR6).
    - [The main GHGs reported by Dow in Scope 1 emissions are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFC) Dow reports these emissions broken down in detail per each GHG in Dow's 2023 INtersections Progress Report (page 171).]
    - Weighting factors for partial PCF calculations are not used since the method utilized here is based on IPCC AR6 GWP100 characterization factors.

- **Value chain coverage:** Partial PCFs shall be calculated on a "Cradle-to-Gate" basis, incorporating all upstream and operational emissions except the exclusions and optional activities (listed in Table 1) related to the bulk production of a sold product.
  - The definition of *"Cradle-to-Gate"* shall include emissions associated with the production of sold products within the system boundary as outlined in TfS guideline Chapter 5.1.2 and 5.1.3.
  - Outbound transportation and packaging of the product to the customer is excluded since it is outside the system boundary as defined herein as *"Cradle-to-Gate"*. If outbound transportation or packaging needs to be considered due to a customer request, it may be calculated and reported separately (see Table 1 optional column).
  - [Dow considers sold product as the material invoiced and delivered to a customer. However, sold products are packaged in different sizes from bulk production. Since packaging is optional in partial PCF calculation, partial PCF calculation ends at the bulk production of the factory while delivery of the same material in different packaging types is tracked with specific Global Material Identifier (GMID) all connected to the same SMC assigned to the bulk material.]

Table 1. Partial PCF system boundary with components included, excluded or optional.

Included	Excluded	Optional
Production related raw materials[1]	Engineering, infrastructure and R&D activities	Packaging
Utilities consumed	Business air and land travel and employee commuting	Outbound transport
Energy consumption	Activities falling under cut-off criteria	
Direct emissions from manufacturing sites	Non-attributional processes e.g., overhead operations (e.g., lighting, air conditioning)	
Inbound transportation of materials		
Treatment or disposal of waste		

1. Non-production-related procurement (often called indirect procurement) consists of purchased goods and services that are not integral to the company's products but are instead used to enable operations. Non-production-related procurement may include capital goods, such as furniture, office equipment, and computers. Source: GHG Protocol Corporate Value Chain Standard.

3.1 Cut-off criteria (PCF boundary)

- A threshold shall be used to exclude immaterial emissions sources from PCF calculations, building on TfS criteria 5.2.3.
- Partial PCF calculations shall include, at minimum 98% (as per TfS criteria 5.2.3), of the total material inputs used across the production of all products, measured on the basis of mass.
- Partial PCF calculations shall include, at minimum 98% (as per TfS criteria 5.2.3), of the total energy inputs used across the production of products, measured based on higher heating value (HHV).

- Partial PCF calculations shall reflect, at minimum 95% (as per TfS criteria 5.2.3), of the total GHG emissions associated with corporate GHG inventory of cradle-to-gate production emissions (including Scope 1 (excluding energy sales), Scope 2, Scope 3.1, Scope 3.3 excluding fuel used for energy sales, Scope 3.4 and Scope 3.5)
- [A notable exclusion based on the cut-off threshold is emissions related to internal transportation between production sites which is estimated to contribute to less than 5% of average cradle-to-gate corporate footprint. Please see Annex A for more details.]

4 Data collection

4.1 Primary data

- Primary data (reported for own operations or collected from suppliers with supplier's primary data) shall be used where available.
- Dow utilizes GHG protocol corporate accounting using operational control thus Dow reports direct emissions (Scope 1) from all operations that fall under operational control principles that are explained in Dow's 2023 Intersections Progress Report in GRI section 2-2 in page 74:
- [The source of primary data is mainly from Dow's SAP systems or supplier specific partial PCFs.]
- Key categories of primary data may include;
  - **Activity data:** The quantity of raw materials, fuel and energy used, and waste generated in each production facility. [Stored in Dow ERP systems]
  - **Production data**: The quantity of products produced from each facility or process with the greatest level of granularity available. [Stored in Dow ERP systems]
  - **Direct emission data**: The direct process GHG emissions (Scope 1) from each facility [reported in the WERS module of SAP in an annual basis and audited by a third party and reported externally in Dow's INtersections Progress Report and CDP disclosure]
  - **Emissions profiles**: Supplier specific partial PCFs for purchased raw materials and primary energy related e.g., combustion emissions factors.
    - Supplier partial PCFs shall be specific to the materials or inputs purchased from that supplier.
    - Supplier partial PCF calculations should follow (limited assurance) Pathfinder and/or TfS Guidelines.
    - Suppliers should report additional data points along with partial PCF, such as carbon content, biogenic content, data quality rating (DQR) and source of background life cycle inventory (LCI) databases.
    - Supplier data may be rejected if it is determined to be of low quality, lacking supporting documentation, or inconsistent with this methodology. [See Figure 1: Dow supplier data approval process

- Primary data may be used in PCF calculations for a period defined by the calculation balancing window (see 5.3.2)
- Dow operates its own energy assets and purchases energy from external parties. Dow models its own energy assets using primary data where higher heating value of fuel consumed in the energy assets on a site are allocated to electricity and steam using exergy-based allocation. This information is recorded in a ledger as described in Chapter 5.3.1. Purchased electricity and steam for each site is also recorded in the ledger then when electricity and steam is required a process node in that site only electricity and steam connected to that site is utilized from the ledger. There may be a case where multiple Dow sites are connected to same electricity grid where electricity used in each node would be chosen based upon grid connectivity described as technological compatibility as described in step 3 in Chapter 5.3.1.

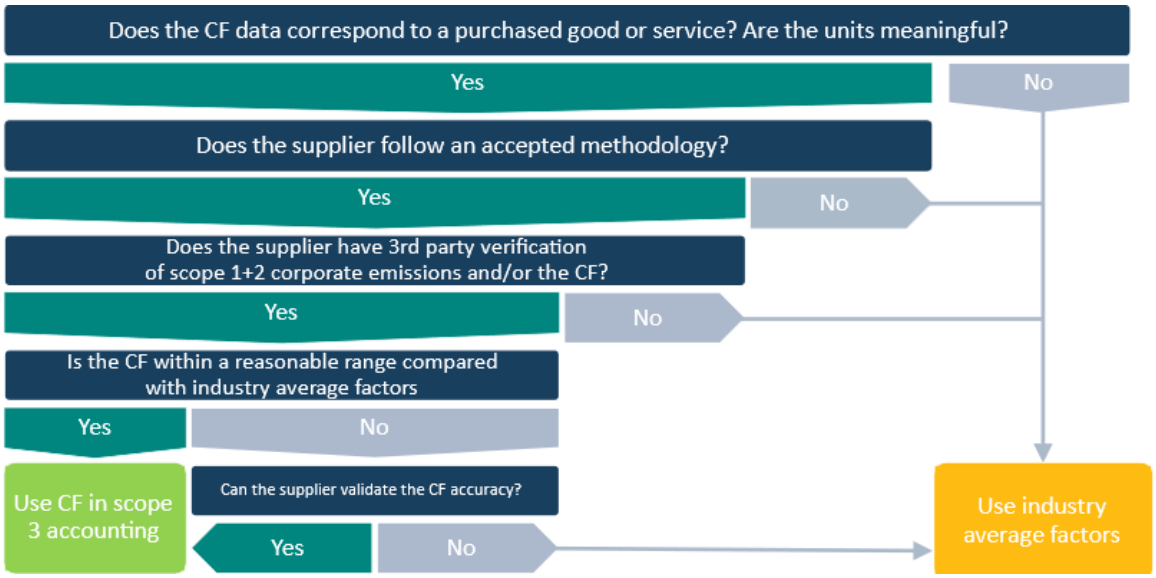


Figure 1. Supplier specific partial PCF qualification decision tree used at Dow.

4.2 Secondary data

- Secondary data may be used when primary data is not available. Specifically:
  - **Emissions profiles:** Where supplier specific partial PCFs are not available for remaining raw material, energy, fuels, and waste, then market average partial PCFs may be utilized from external LCI databases, research literature (if data is unavailable in external LCI databases) or internal LCI models.
  - [Dow utilizes the Ecoinvent database “cut-off” version of process models. The use of Ecoinvent data should be from a database that is not be more than 2 years from the release date. Other LCI databases may be used when there is no representative data in the Ecoinvent database, or if there is more granular regional data available (e.g., Carbon Minds, US LCI, GREET, GaBi). Dow may also utilize proxy data from literature when there is no representative data from LCI databases. Dow may also create its own LCI models for purchased raw materials if there is no representative data in the databases or in the literature.]

4.3 Data quality

- Dow shall assess the data quality rating (DQR) of activity data, emission factors, and/ or direct emissions data by using the data quality indicators.
- Dow's steam cracker and energy asset operations contribute significantly to Dow's partial PCF. Emissions, fuel consumption, and production volume data for these operations is collected on a regular basis to track efficiency and deliver targets set for operational excellence. Data quality improvement is also put in place to ensure accurate tracking of efficiency.
- The data shall be assessed for technological, geographical and temporal representativeness, completeness and reliability.
- TfS guideline discusses DQR and primary data share (PDS) calculation and reporting requirements in section 5.2.11(mandatory DQR and PDS reporting after year 2025).
- [Dow complies with these TfS reporting requirements on DQR but views PDS as optional since this is not required in ISO14067. PDS calculation has challenges since calculation is based on emissions from PDS divided by all emissions, thus results in underestimated PDS values when significant amount of low-carbon energy is consumed as part of PDS.]
- Since this is a partial PCF calculation which is mainly from the production phase of products, use phase and end of life stages of the cradle-to-grave PCF calculation is excluded, thus reporting of various stages of life cycle is not relevant for this methodology as only production stage is covered in the system boundary.
- Dow will use CFL PCF methodology to calculate partial PCF for all its products, thus aligned with consistency recommendation discussed in ISO14067 section 6.3.5.

5 Partial PCF calculation methodology using mass-balance approach.

PCFs shall be calculated following a six-step calculation approach:

Step		Output
1	**Product composition mapping** Defining the production steps needed to produce a product with the greatest level of data granularity.	**Process nodes:** the greatest level of data granularity available to describe a production process in a facility **Product composition map:** Overview of all process nodes which could be used to make a given product
2	**Input allocation** Sub-division of material and energy inputs, waste and direct emissions, across one, or multiple output products produced in each process node.	**Process node mass-energy balance**: A description of the inputs required (mass-energy balance) to produce 1kg of output product from a process node; stored in the ledger. **Process node capacity**: The maximum projected or actual production capacity of a process node; stored in the ledger.
3	**Emissions profile attribution** Calculation of the GHG impact of a process node by attributing emissions profiles to the mass-energy balance.	**Process node Intermediate Carbon Footprint (ICF):** The GHG impact per 1kg of intermediate product produced in a process node (used as an input to optimization, see step 4).

4	**PCF Optimization** Selection of the optimal combination of process nodes from the composition map to deliver the lowest possible PCF.	**Optimized Partial Product Carbon Footprint (PCF)**: The optimal combination of process nodes to generate the lowest possible PCF.
5	**Residual Calculation & Check** Confirmation that following an optimization calculation, the residual average ICF for primary intermediate products should not exceed a specified threshold (baseline ICFs for selected intermediates). This is optional requirement at the discretion of the company	**Residual ICF:** The average of all remaining mass-energy balances and emissions profiles used in the production of the same intermediates or final product **Journal entry**: PCF calculations which do not result in a residual ICF exceeding the threshold (baseline ICFs for selected intermediates) will be recorded in a transaction journal resulting in an update to the ledger.
6	**PCF transaction and ledger update** A PCF certificate is generated, and the inputs and node capacities used are reflected in journal entries and an updated Carbon Footprint Ledger.	**Updated ledger:** Following PCF creation, updated node capacities & emissions profiles are reflected in the ledger **Provisional PCF**: A PCF is provisional when based on forecasted or expected emissions profile / activity data **Final PCF**: When all inputs to a PCF calculation are based on historic actuals, provisional PCF's will be confirmed as final PCFs, suitable for use in corporate Scope 3 accounting or product claims

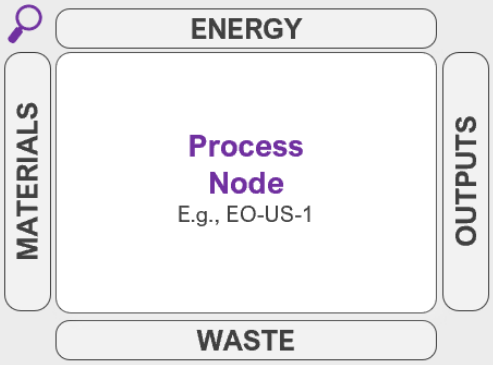
Step 1
Product composition mapping

Sold products can be decomposed into **process nodes** representing the highest level of production data granularity

e.g., PEG **Production Steps**	**Process Node = Facility X Production Step**		
Ethylene Production	Process node CR-US-1	Process node CR-EU-1	Process node CR-CA-1
EO Production	Process node EO-EU-1	Process node EO-US-1	
PEG Production	Process node PEG-EU-1	Process node PEG-US-1	

Step 2
Input allocation

Each **process node** defines two things; **production capacity** and the **Mass-energy balance** to produce one unit of output product



Mass-energy balance

Illustrative: to make 1kg EO:

1 Kg	Oxygen
1 Kg	Ethylene
1 MWh	Electricity
1 MJ	Natural Gas
1 kgCO_2e	Process CO_2

Production Capacity 100kg EO

Step 3
Emissions profile attribution

The **Intermediate Carbon Footprint** of a node is calculated by attributing **emissions profiles** to the **mass-energy balance**

"The Recipe" **Mass-energy balance**			"The ingredients" **Emissions profiles**			**Intermediate Carbon Footprint (ICF)**	
1 Kg	Oxygen	×	**0.8**	kg CO_2e/kg O2	=	**0.8**	kg CO_2e
1 Kg	Ethylene	×	**1.0**	kg CO_2e/kg Ethylene	=	**1.0**	kg CO_2e
1 MWh	Electricity	×	**0.1**	kg CO_2e/MWh	=	**0.1**	kg CO_2e
1 MJ	Natural Gas	×	**0.1**	kg CO_2e/MJ	=	**0.1**	kg CO_2e
1 kgCO_2e	Process CO_2	×	**1.0**	kg CO_2e/kg	=	**1.0**	kg CO_2e
Capacity	100 kg EO					**3.0**	**kg CO_2e**

Emissions profiles may only be attributed to a mass energy balance, if they are:

…technologically compatible…

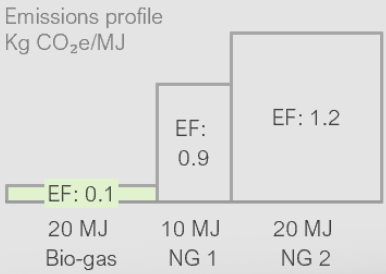
Illustrative technology compatibility matrix

Comp. substitute	Actual: Gas	Biogas	Diesel	H_2	Power
Gas					
Biogas					
Diesel					
H_2	*Partial*				
Power					*Same grid*

Used in mass-energy balance · Compatible · Partially compatible · Incompatible

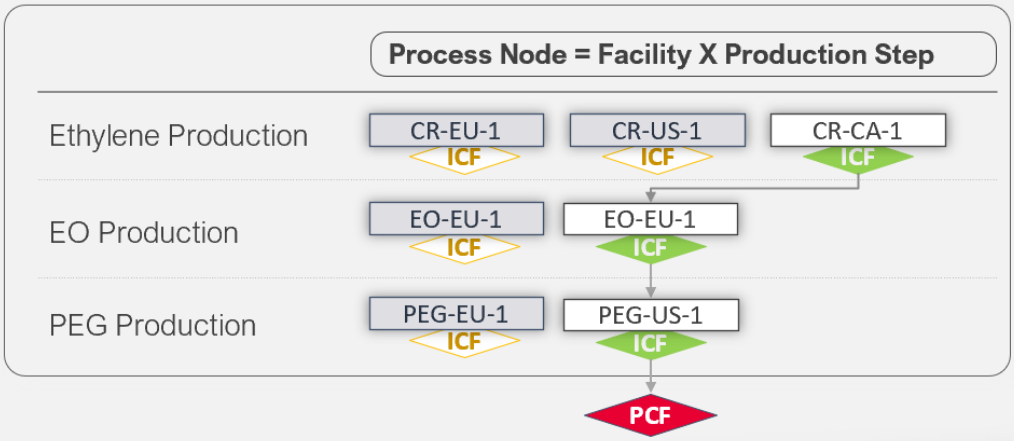
… and available in the ledger

Illustrative EF availability distribution



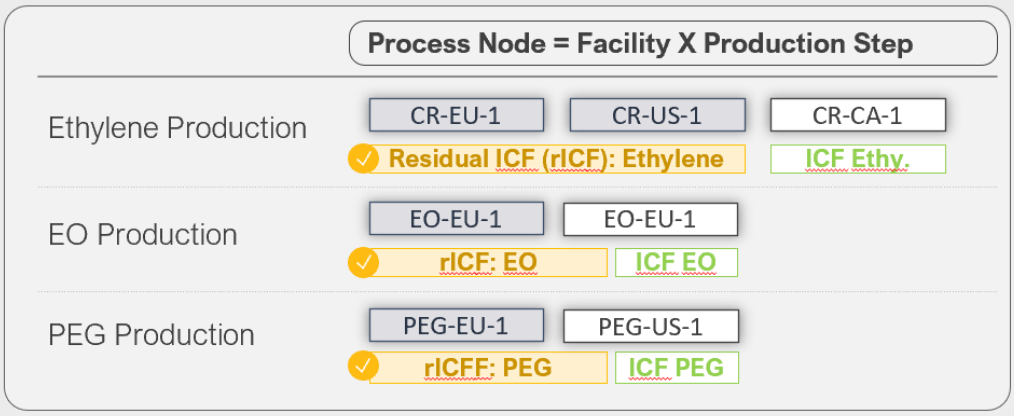
Step 4
PCF Optimization

Optimized **partial PCF** calculated by cumulatively combining the lowest GHG ICFs across the product composition map

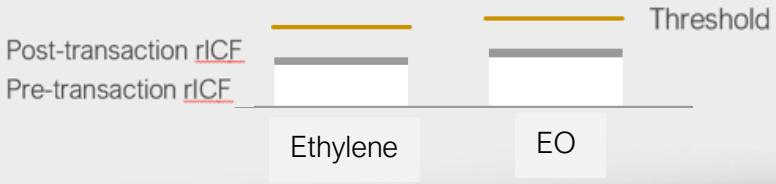


Step 5
Residual Calculation and Check

Node **capacities** and **emissions profiles** which are not utilized in CFL transactions are averaged together to form **residual ICFs**



Residual ICFs for selected intermediates are cheked against a threshold (baseline ICFs)



Step 6
PCF transaction and ledger update

All partial PCF transactions are recorded in the Carbon Footprint Ledger to ensure robust implementation without double counting

A Node mass-energy balance **B** Available node production capacity **C** Emissions profiles

Input	Variant	Supplier	EF	Starting quantity	Debit	Left	EF Code	Certificate
Power	Solar	A	0.1	100 MWh	2 MWh	98 MWh	0001	View
Power	Wind	B	0.2	50 MWh	4 MWh	46 MWh	0002	View
Gas	Fossil	C	0.01	50 MJ	2 MJ	48 MJ	0003	View
Gas	Biomass	D	0.0	10 MJ	5 MJ	5 MJ	0004	View

5.1 Product composition mapping

- Each sold product can be decomposed into a set of underlying productions steps and processes:
    - **A production step** is defined as the set of transformation activities required to produce an intermediate or sold product; each production step may comprise one or more processes.
    - **A process** is defined as the most granular level of operational activity and data (raw materials, energy, fuels, emissions, waste).
- Each facility may operate one or more production steps and hence one or more processes.
- **A process node** is defined as a specific process within a specific facility, representing the greatest level of operational and input material data granularity.
    - A process node describes the inputs (raw materials, fuel, and energy) and outputs (process emissions and waste) associated with producing 1 kg of output product from the facility and process - known as a mass-energy balance.
- **A product composition map** describes, for each sold product, an exhaustive overview of all production steps, processes and facilities, represented as process nodes, which **could** be used in production of a final sold product.

5.2 Input allocation

- A process node describes the mass-energy balance of a process: the inputs (materials and energy) and outputs (waste and process emissions) used in the production of 1 kg of output product.
- As each process node may produce multiple of the same, or multiple different output products, the primary data used to report facility and process level emissions needs to be further sub-divided (known as allocation) to develop a mass-energy balance for 1 kg of output product.
- Allocation should be avoided where possible by breaking down processes into the smallest steps possible, if appropriate data is available.
- In cases where allocation is unavoidable due to data availability or co-product is made in the same process; allocation rules shall be based on ISO14067 and the TfS allocation hierarchy described in 5.2.9 should be used when applicable.
- [Dow typically utilizes mass-based allocation for the net volume of materials consumed in each process. Waste products are not allocated a burden, but any burden associated with processing or treating waste products is allocated to remaining products and co-products on a mass basis.]

5.2.1 Allocation in a single output process node

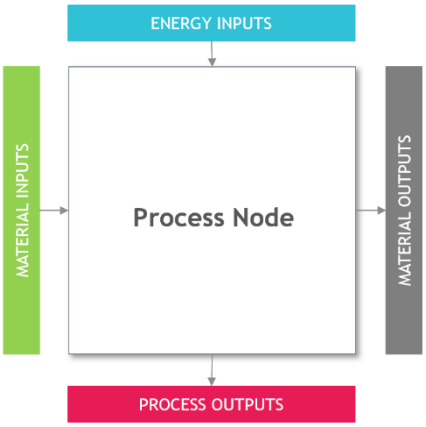
- If a process step produces only one output, then all material and energy inputs, as well as process emissions and waste burdens associated with that process step shall be proportionally allocated to each unit of product produced in the process node within the timeframe of study (typically one calendar year).

5.2.2 Allocation in a multi output process node

- If a process node produces more than one output, then an allocation method shall be used to assign material and energy inputs, as well as direct “process” emissions and GHG emissions (Scope 3 category 5) associated with treatment of waste from operations based on guidelines from ISO14067 (and TfS section 5.2.8.4, 5.2.9 when applicable).
- The default allocation method shall be based on mass: the inputs used in each process node shall be proportionally allocated per unit mass of output.
- Exceptions to mass allocation may occur in case when there is a product category rule (PCR) or specific allocation agreed by the sector. In these instances, PCRs should be clearly communicated and shall be supported by external standards or reference documents.
- [Dow uses Plastics Europe’s recommendations for steam cracker allocation. However, this allocation rule is subject to change due to ongoing discussion regarding regional reporting requirements. Dow uses the approved PCR list cited in TfS guidelines table 5.2.]
- In situations where multiple inputs are allocated to multiple outputs, the relative distribution of inputs in each output product shall be consistent with that of the overall process.
  Allocation methods shall be representative of physical constraints and limitations associated with a multi-output production process where amount of each unique output from multi-output process shall not be exceeded. For example, a steam cracker product slate defines the maximum production capacity of a given output co-product in a process. Allocation of inputs shall only occur within the boundaries of the maximum production capacity of output products.

5.3 Emissions profile attribution

- The GHG impact of each process node shall be calculated by attributing emissions profiles to node inputs described by the mass-energy balance “recipe” (Figure 2).
- When the output of the process node is an intermediate product, the GHG impact of the node is known as an Intermediate Carbon Footprint (ICF). When the output of a process node is a final product, the carbon footprint is known as a partial Product Carbon Footprint (pPCF), which is reported to the customer:
  - **Intermediate Carbon Footprint (ICF)** describes the c*radle-to-gate* emissions for 1 kg of output from an individual process node.
  - **Partial Product Carbon Footprint (pPCF)** is the same as an ICF, but for a sold product; representing the cumulative *cradle-to-gate* emissions associated with all *production steps and processes* used in production.
- **ICFs and PCFs are created by attributing emissions profiles to node mass-energy balances.**



	Mass-energy balance *Unit*		Emissions Profile *kgCO2e/unit*	Emissions *kgCO2e*
ENERGY INPUTS	Electricity	1 kWh	0.1	0.1
	Natural Gas	1 MJ	0.1	0.1
MATERIAL INPUTS	Ethylene	1 kg	1.0	1.0
	Oxygen	1 kg	0.8	0.8
PROCESS OUTPUTS	Process emissions	1 Kg	1	1.0
MATERIAL OUTPUTS	Final product (Ethylene Oxide)	1kg		3.0kgCO2e

Figure 2. Illustrative example of a GHG attribute calculation for a process node.

5.3.1 Sourcing emissions profiles:

- **Emissions profiles** represent the cradle-to-gate GHG impact of each input.
- Emissions profiles are referred to as ICFs if the input material or energy is self-generated in a prior process node, or partial PCFs if the attribute is from a 3rd party.
    - ICFs representing the emissions profile of self-produced products may be based on produced or forecasted volumes.
    - Partial PCFs or emission profiles from third parties may be based on received material or energy inputs, respectively, or forecasted inputs where a valid purchase order is in place.
- [Dow requests all suppliers confirm their final PCFs for purchased products by calendar year end, allowing Dow to also provide confirmed PCFs to its customers at this time.]
- While provisional forecasted data may be used in input attribution calculation, final PCFs should not be confirmed until all underlying data is based on historic actuals (see 5.6).
- Forecasted data shall be updated based on the most accurate available information. If forecasted data is updated, provisional PCF calculations shall also be adjusted accordingly (although re-communication to customers is not required until a final PCF is available based on actual data).
- A reconciliation process will ensure that PCFs are updated, and any gaps closed between forecasted and actual data at the end of the year/balancing period.
- A carbon footprint ledger (CFL) will be used to store and track primary and secondary data associated with generation of ICFs or PCFs.

5.3.2 Introduction to the mass-balance approach for input attribution

- Some PCF methodologies require that only emissions profiles associated with the physical material or energy inputs used in a processing step are suitable for PCF calculations.
- However, this methodology deploys the concept of multi-site mass balance with free attribution for purposes of emissions profile attribution to mass-energy balances.
- This approach builds on existing market precedents for the use of mass balance in GHG, biogenic and circularity accounting including guidelines detailed by ISCC PLUS, The Ellen McArthur Foundation, The EU PPWR directive and ISO 14067 and ISO 22095 standard (Chain of custody - General terminology and models, section 5.4.2.2).
- Mass balance is a chain of custody approach used for tracking the flow of low carbon inputs through a production process or value chain in situations where they are mixed with conventional inputs.
- In these instances, the mass of the inputs and outputs of the system are recorded such that the total volume of sustainable materials claimed in output products plus losses are equivalent to the total volume of low carbon inputs which could be used in the system under study.
- Additional rationale and scientific basis for use of mass-balance in the calculation of PCFs is detailed in Annex B.
- Mass balance calculations are typically implemented in a three-step approach:

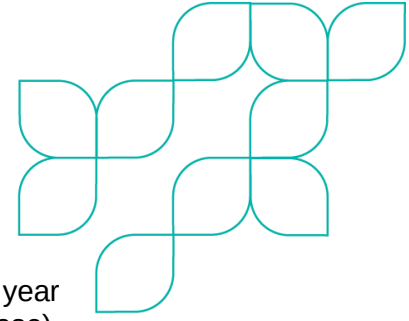
I. **Calculate the conversion factor:** Conversion factors describe the volume of each input (raw materials, fuel, and energy) needed to produce 1 kg of output. In this instance, the conversion factor is determined based on the input allocation methodology (see above), whereby the mass-energy balance in each process node defines the volume of inputs require to produce 1 kg of output product.

II. **Establish an inventory of attributes to balance**: while many mass-balance standards focus on bio- or circularity- attributes of feedstocks, this methodology implements mass-balance as a mechanism to trace GHG attributes, known as emissions profiles across all types of input. Emissions profiles (EPs) include partial PCFs for purchased material (which may include circular and bio-based inputs), and emissions factors for fuel and energy inputs and ICFs of self-produced products (outputs of prior process nodes).

III. **Define system boundaries (5.3.2) and attribution method (5.3.3):** The system boundary for balancing of input attributes to output products may vary in both space and time.

5.3.3 System boundary definition:

- As per ISO 14067, a system boundary is defined as “the basis used to determine which unit processes are included within the [PCF] study”.
- **Space**: Multi-site mass balancing
    - Some mass balance guidelines consider a system boundary to be limited to a single asset or production site whilst others consider a wider system boundary approach.
    - ISCC Plus considers a system boundary to cover multiple sites within a jurisdiction / neighbouring jurisdiction (e.g., ISCC Plus), whilst ISO 14067 (6.3.5) considers site-specific data used in a PCF study to be collected from “a specific site or can be averaged across all sites that contain the process within the system under study.”
    - This methodology defines a system boundary across all technically equivalent processes for the product under study, within an organization boundary.
    - Emissions profiles may be attributed to any technologically compatible mass-energy balance regardless of the geographic location of the process step or the facility to which the input material or energy associated with the emissions profile was physically linked.
    - Technological compatibility is defined based on both infrastructure limitations and usage limitations. Technological compatibility should be defined and documented at the level of each process node.
        - Example – infrastructure limitations: emissions profiles for electricity may only be attributed to mass-energy balances from process steps located within the same power grid network and only for sites that are a net-importer of electricity.
        - Example – usage limitations: A biomethane emissions profile may be attributed to an energy balance of Natural Gas but may not be attributed to an energy balance of Diesel.
        - Example – equipment limitations: Emissions profiles from Hydrogen combustion may only be attributed to an energy balance requiring Natural Gas if the combustion equipment is technically capable of utilizing both Hydrogen and Natural Gas.
    - In contrast, site specific mass-balance would require physical transportation of chemically identical products with different GHG attributes, resulting in additional cost, complexity and transport related emissions.
    - As GHG attributes are not inherent to physical products (rather they represent the GHG impact associated with production of a product), physical connectivity should not be seen as a requirement of PCF calculations. However, physical traceability should be preserved to ensure accurate and credible reporting.
- **Time**: balancing window
    - Partial PCFs and emissions factors associated with material and energy inputs, respectively, or ICFs from prior processing steps may be attributed to subsequent process steps within a specified timeframe referred to as a balancing window.
    - The balancing window will open on the date which purchased inputs and their associated partial PCFs or emissions factors are delivered to Dow, or intermediate products are produced by Dow.



- The balancing window will extend from the half year prior to purchase of the inputs, through to the first quarter of the year following purchase (i.e., -6 to + 15 months from the date of purchase). This balancing window is based on external precedents in the renewable energy markets, e.g., Green-e Renewable Energy Certificates.
- Material partial PCFs or energy emissions factors that are not balanced within the balancing window will automatically be proportionally attributed to residual average ICFs or partial PCF calculations generated in the year in which the balancing window expires.

5.3.4 Free attribution

- Mass-balance calculations enable attribution of emissions profiles to the inputs used to produce a product:
  - Average attribution: e.g., in a simplified single input process, if 10% of raw materials are considered to have zero GHG emissions, this attribution would assume that all output products report an average 10% lower PCF.
  - Free attribution: e.g., in the same simplified single input process, if 10% of raw materials are considered to have zero GHG emissions, free attribution assumes up to 10% of output products report a zero carbon PCF, while the other 90% of products report a PCF based on only the GHG attributes of the traditional input.
- This methodology enables emissions profiles to be freely attributed to the mass-energy balance of valid process nodes.
- This principle allows an attribute to be represented in an output product in a higher share than is proportional to all inputs in a process (although should not be beyond the stoichiometric amount presented in the recipe).
- Free attribution can be based on demand, allowing concentration of low-carbon inputs in those products that have demand for a lower PCF.

5.4 PCF Optimization

- Once product composition networks have been generated, the lowest GHG PCF can be identified by optimizing the application of emissions profiles (attribution) to the mass-energy balances of each possible node (allocation).
- A combination of nodes may be required to make a final product. In these instances, partial PCFs may be calculated through combination of the most optimal, but technologically compatible process nodes, working from upstream to downstream i.e., the lowest ICF node in the first production step will be used as the input to the most optimal mass-energy balance and emissions profile combination in the second production step.
- An optimal PCF can be calculated through this mechanism. Once a PCF transaction has been initiated, the mass-energy balances (node capacity) and emissions profiles used (both ICFs and EFs) are recorded in the journal and debited from the ledger, avoiding any double counting in subsequent transactions.
- The creation of low GHG PCFs will only occur in response to a transaction requested by the customer; the PCF offered to customers who do not request a low GHG version will be based on the residual average of all un-used mass-energy balances and emissions profiles (see section 5.5).

5.5 Residual ICF check

5.5.1 Residual ICF calculation

- Once a low carbon partial PCF has been generated, the available production capacity of process nodes, and the inventory of emissions profiles, will be impacted.
- In situations where low carbon partial PCFs are not requested by a customer, a residual average partial PCF is calculated based on remaining capacities of process nodes and emissions profiles.
- Residual ICFs will be calculated at the level of selected intermediate or sold products, by averaging the mass-energy balances and remaining emissions profiles associated with the production of each intermediate or final product (Figure 3).
- [Dow will calculate residual average ICFs for the main intermediate products; ethylene, propylene, benzene, ethylene oxide, propylene oxide, acrylic acid, 1-butanol, and methyl methacrylate. This list will be updated if Dow's internal production of intermediates changes due to mergers and divestures.]

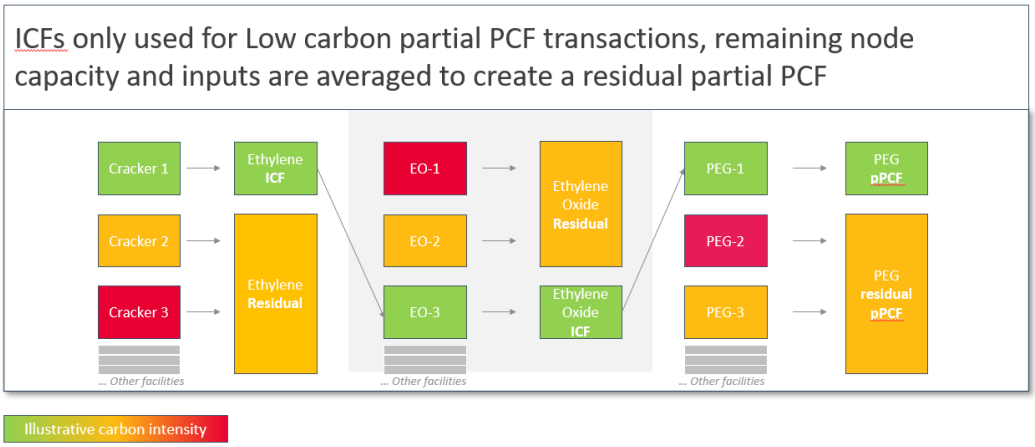


Figure 3. Schematic showing example calculation of low carbon partial PCF of PEG and remaining residual partial PCF

5.5.2 Residual ICF check

- One of the guiding principles discussed in Annex B is to accelerate decarbonization through incentivizing investment in additional decarbonization projects. Thus, the residual average ICF for primary intermediate products should not exceed a specified threshold (baseline ICFs for selected intermediates, which are noted in section 5.5.1).
- [Baseline ICFs for selected intermediates could be industry average from external LCI databases. However, these ICFs vary widely depending on data sources. Thus, baseline ICFs for selected intermediates for Dow will be representative global average ICFs made and purchased by Dow around baseline year.]
- The residual ICF check is conducted for every product requested in a CFL calculation. The customers will be offered the lowest PCF possible without exceeding the threshold (baseline ICFs for selected intermediates).
- Every time a low-carbon partial PCF is promised to a customer at projected volume request for the year, the residual ICF of all impacted intermediate products is checked to ensure residual ICFs do not exceed the equivalent ICF values in the baseline year.

- The intermediates that would be checked against a threshold account for significant portion of cradle-to-gate emissions in Dow's operations. This method would ensure that residual partial PCFs for the remaining products are in line with the baseline partial PCFs the customer may have already received.
- At the end of the year, a further check will be applied to confirm correct functioning of the ledger and avoidance of double counting; aggregation of all sold PCFs (low GHG and residual average) multiplied by associated sold product volumes should equal the total corporate Scope 3 emissions included in the PCF boundary and cut-off criteria (i.e., 95% of S1 excl. energy sales, S2, S3.1, S3.3 excl. energy sales and S3.4).
- At the end of each calendar year, partial PCFs are confirmed and residual ICFs are once again checked against the prior year ensuring partial ICFs do not exceed baseline ICFs for the selected intermediates and products.
- The application of a residual average check is discretionary - in situations where the residual averages vary due to un-controllable factors, for example, planned maintenance, changes to 3rd party emissions factor calculation methodologies or regulation, the residual average may temporarily exceed the threshold (baseline ICFs for selected intermediates).

5.6 PCF status and confirmation

Transactions in the Carbon Footprint Ledger will have two types of status depending on whether data used in the calculations are historic actuals or forecasted values:

1. *Provisional partial PCFs*: These are partial PCFs promised to the customer based on forecasted production volumes and the availability of low carbon inputs. Projections may be based on prior year data, forecasting models (e.g., including known expansion projects) or agreed purchasing orders of low carbon inputs.
2. *Confirmed partial PCFs*: Partial PCFs move from provisional to confirmed status once primary and secondary data has become historic actuals, rather than forecasted values. Confirmed partial PCFs should only be issued after necessary audit procedures have taken place to validate the integrity of third-party emissions profiles as well as internal GHG accounting practices.
   [For Dow, audits usually occur in the middle of calendar year following that in which the PCF was generated].

Once PCFs have been confirmed, they should not be retrospectively adjusted, even if the product delivery date falls within the balancing window of newly procured energy emissions factors or material ICFs or partial PCFs. There may be exceptions to this rule in case significant changes happen in standards, background data or allocation rules that trigger baseline recalculation for corporate accounting in Scopes 1, 2, 3 especially when customers use CFL PCF data for their target setting baseline.

6 [Dow approach to specific cases]

- Partial PCF calculation and reporting for products containing bio-based raw materials and/or made by consuming biofuels.
- Partial PCF calculation and reporting for products containing land use changes and aircraft emissions.
- Partial PCF calculation and reporting for products containing circular fossil carbon content from mechanical or chemical recycling.
- Partial PCF calculation and reporting for products made by using Carbon Capture and Storage (CCS) technologies.
- Partial PCF calculation and reporting for products made by using Carbon Capture and Utilization (CCU) technologies.
- Carbon neutral product claims using with offsets and removals.

6.1 Bio-based raw materials and fuels

- Plants convert atmospheric CO_2 through photosynthesis into biomass, which are then used as raw materials for chemical production, for example, ethanol, wood pulp, and palm oil. Elemental carbon in biomass is also called biogenic carbon, thus there could be atmospheric CO_2 uptake in bio-based chemicals. Biogenic CO_2 emissions can occur during processing or at product's end-of-life.
- ISO14067 requires biogenic CO_2 emissions and removals to be tracked and reported separately from other anthropogenic GHG emissions. TfS guideline (section 5.2.10) provides more detailed guidance on how to report biogenic CO_2 emissions and removals, also aligned with ISO14067. Dow follows ISO14067 and TfS guideline where applicable for calculating and reporting partial PCFs for bio-based materials.
- Since the scope of partial PCF considers biogenic carbon uptake stored in the product, the biogenic carbon content contained in Dow products shall be reported separately from partial PCF with the aim to close the biogenic carbon balance in further downstream calculations or at the end-of-life. TfS require mandatory reporting of biogenic carbon content after the year 2025..
- Separate reporting of biogenic uptake and emissions for partial PCF is not required if the product contains less than 1% biogenic carbon.
- Partial PCF calculation for bio-based materials could be conducted using CFL mass-balance method described in this document given that third party chain of custody certification systems' requirements for bio-based materials are followed (such as ISCC PLUS, REDcert2, UL ECVP 2809, RSB Advanced Materials, FSC, RSPO, or equivalent).
- When calculating partial PCFs for bio-based products with the CFL methodology, residual ICF check (described in section 5.5.2) is not required. Multi-site mass balancing for bio-based products may follow additional certification requirements. Only sites certified under the chain of custody systems (noted above) could be mass-balanced with some restrictions (for example, at the same continent or bordering nations depending on the certification systems).

6.2 Land use changes and aircraft emissions

- In accordance with ISO14067, GHG emissions and removals occurring because of direct land use change shall be included in partial PCF calculation and shall be declared separately. GHG emissions and removals as a result indirect land use change can be considered for inclusion and – if calculated - shall be documented separately.
- In accordance with ISO14067, GHG emissions from aircraft emissions shall be included in partial PCF calculation and shall be declared separately in the documentation. For the most cases, transport emissions are below total 5% total cut-off rule and excluded from the partial PCFs (Annex A for more details).

6.3 Circular materials

- Dow products may contain recycled materials mixed with conventional materials. Partial PCFs for recycled materials are calculated using CFL method described in this document given that third party chain of custody certification systems' requirements for bio-based materials are followed (such as ISCC PLUS, REDcert2, UL ECVP 2809, RSB Advanced Materials, FSC, RSPO, or equivalent).
- When calculating partial PCFs for recycled products using the CFL methodology, a residual ICF check (described in section 5.5.2) is not required. Multi-site mass balancing for recycled products may follow additional certification requirements. Only sites certified under the chain of custody systems (noted above) could be mass-balanced with some restrictions (for example, at the same continent or bordering nations depending on the certification systems).
- [Restrictions for mass-balancing of circular content used by Dow are specifically detailed in ISCC PLUS guidelines]
- Dow may also communicate the benefit of recycled materials beyond Dow's gate using the circular content cut-off approach described in Dow's 2023 INtersections Progress Report (page 172). This is a similar concept to what is described in TfS guideline (cut-off plus approach depicted in Figure 5.13 on page 62).

6.4 Carbon capture and storage (CCS)

- For fossil-based CO_2 storage (CCS), TfS guideline (section 5.2.10.4) describes how a partial PCF may be calculated with CCS included in the system boundary (Figure 5.20).
- The CFL methodology recognizes the impacts of CCS through the accounting of intermediate or final products produced in a production step; CCS benefits accrue to these intermediate products rather than being internally transferred in the form of credits – this ensure the benefits are utilized within the same product system boundary (noted herein section 5.3.3).
- If sequestered CO_2 represents a net removal of atmospheric carbon (e.g., due to the source of the CO_2 originated from direct air capture or biogenic uptake), then it may be considered a carbon removal mechanism and should be separately tracked (noted herein section 6.1).
- Chain of custody systems for mass-balancing of CCS credits are still in development stages (ISCC CFC or SCS-115 mentioned a new module for CCS) which will give more guidance regarding how to use fossil CCS credits. The CFL method may be updated when additional guidance becomes available.

6.5 Carbon capture and utilization (CCU)

- If utilized CO_2 is biogenic, which can be captured from air (direct air capture) or from biogenic sources, then it should be separately tracked as noted in section 6.1.
- If utilized CO_2 is from fossil sources (for example, fossil ethylene oxide process emissions, hydrogen production emissions from fossil methane, etc.), the first product system should not account for CO_2 using the cut-off approach. This is similar to the logic used in plastic recycling where emissions from collection, processing and recycling of plastic waste is not allocated to prior plastic production system. Thus, CO_2 can be considered as its own product system where the capture unit burden is allocated to that unit of CO_2. Similar to recycling, Dow may also communicate the benefit of recycled CO_2 into materials beyond Dow's gate using circular content cut-off approach described in Dow's 2023 INtersections Progress Report (page 172).This is a similar concept also described in TfS guideline (cut-off plus approach depicted in Figure 5.13 on page 62).
- Chain of custody systems for mass-balancing of CCU-based products are still in development stages (ISCC CFC). Thus, this guidance will be updated accordingly when additional guidance becomes available.

6.6 Offsets and removals

- Dow may utilize offsets and removals for carbon neutrality claims for some products under PAS2060 or ISO14068-1 standards. Since ISO14067 states that the PCF and the partial PCFs shall not include carbon offsetting, Dow reports use of offsets separately from partial PCFs.
- Dow currently does not claim carbon removals in its own operations (subject to change based on updated external guidance).

7 Calculation method and tools

- Multiple tools exist for calculation of Partial Product Carbon Footprints without using mass-balance Tool options for products that are not affected by CFL method and do not conduct mass-balancing of low-carbon inputs include:
    - Microsoft Excel, a manual process (useful for quick calculations of simple processes) - Excel tools are not utilized for official annual partial PCFs reported to the customer.
    - SimaPro by Pre, which contains various databases including Ecoinvent that is the most utilized background LCI database within Dow.
    - LCA for Experts by Sphera, which has its own database LCI database called Managed LCA Content (MLC) formerly known as GaBi database. It also has Ecoinvent LCI database.
    - GREET or OpenLCA, which are free software and have access to publicly available LCI databases.
- Calculation for materials that fall under ITAR (International Traffic in Arms Regulations, US) shall be done using tools and systems within Dow that are consistent with those rules.
- Mass-balance PCF calculations may require novel tooling, in particular use of a digital ledger technology to robustly implement this methodology at scale, without risk of double counting..

8 Documentation and confidentiality and revisions

- Dow aims to report partial PCFs to its customers annually once the CFL method is deployed across Dow.
- Since CFL is based on a mass-balancing scheme, partial PCFs provided via CFL method should be assured by a third party on an annual basis to ensure the CFL method is practiced accordingly.
- The default communication of PCF shall be based on global weighted residual average partial PCF for the product of interest. However, Dow will report PCFs at a more granular level (by region or site) if regulations require.
- Communication of PCF must be done under a non-disclosure agreement with the customer. This protects against misuse of the information and enables the reporting to be consistent with ISO14067 or the GHGP, without the need of a “product carbon footprint study report” (CFP, ISO’s terminology).
- Dow will only provide cradle-to-gate PCF to its customers and will not provide gate-to-gate PCF results due to confidentiality concerns (some of Dow customers are also direct competitors who operate similar processes).
- Public disclosure of PCF shall not claim to “follow ISO14067” or “follow GHGPPS” unless documents are prepared that are consistent with those standards.
- PCFs shall not be used to make comparative claims of environmental superiority to competing products or to support marketing claims. Such claims would need to be supported by work and reporting consistent with ISO standards14067, 14040 and 14044.
- In the event of revisions to the ISO14067 standard, Dow shall ask its assurance provider to see if this triggers new assurance evaluation.
- In the event of revisions to the TfS guidelines, Dow shall evaluate if changes warrant a revision of this methodology document and conduct the revision and ask its assurance provider for recommendation if this triggers a new assurance evaluation.

9 Annex A: Sensitivity analysis

In alignment with ISO14067, in order to test the robustness of the PCF results, sensitivity analyses with different modelling choices (e.g., another dataset for a raw material, another allocation method for the foreground product system) should be performed on the system level, but when reporting partial PCFs to the customers, the same allocation method and secondary datasets shall be utilized to provide consistency of the results to Dow's customers.

9.1 Cut-off analysis for transportation

- Sensitivity analysis for internal transportation is conducted, which is estimated to be less than 5% of weighted average partial PCF of all Dow products (see Table 2 below). Thus, internal transportation is excluded from partial PCF calculations according to cut-off criteria discussed in section 3.1. The reason that transport within the company is excluded is because of the complexity of incorporating data into the CFL calculation. Dow may opt to include internal transport as a single global weighted average burden for each kg of sold product, which would be 2-3% increase in partial PCF of each product.

Table 2. Contribution analysis to weighted average partial PCF of all Dow products from internal transport within company. Data used in this analysis is deducted from Dow's 2023 INtersections Progress Report published in June 2024 in page 169 and 172. Herein, only a portion of Scope 3.4 is covered as internal transport within company since outbound transport is out of system boundary and optional (upon customer request), which would be separately reported. Similarly, only a portion of Scope 3.3 is covered here where fuel used for energy sales are excluded.

	Annual GHG emissions reported, million metric tons of CO_2eq			
Included in partial PCFs	**Year 2023**	**Year 2022**	**Year 2021**	**Year 2020**
Scope 1, excluding energy sales	21.48	21.84	22.55	23.02
Scope 2, market based	3.20	4.19	5.80	6.22
Scope 3.1	40.64	42.00	45.54	46.44
Scope 3.3, excluding energy sales (portion of what is reported in Intersections Progress Report)	3.23	3.04	3.75	3.30
Scope 3.4, excluding outbound transport to customer (portion of what is reported in Intersections Progress Report)	1.69	2.12	2.43	2.64
Scope 3.5	0.35	0.41	0.38	0.41
Total GHG emission (million metric ton of CO_2eq) as part of partial PCFs	70.59	73.60	80.44	82.03
% of partial PCF for internal transport	2.4%	2.9%	3.0%	3.2%

10 Annex B: Rationale and basis for mass-balance as an input attribution mechanism

10.1 Context

10.1.1 The Scope 3 challenge

- Companies are facing increasing pressure from investors, customers, and the public to reduce their GHG emissions. As a result, businesses globally are setting ambitious targets to reduce their Scope 1, 2 and 3 corporate GHG inventory over time.
- Upstream (e.g., cradle-to-gate impact of purchased goods) and downstream (e.g., impact from use of sold products) Scope 3 emissions drive >75% of corporate GHG inventories and are included in >96% of SBTi targets.
- Hence, Scope 3 emissions are material and challenging to both estimate and mitigate, given the lower degree of influence a company has over their value chain in comparison to their own operations (Scope 1 and 2).

10.1.2 Approach to estimating upstream Scope 3 emissions:

- Upstream Scope 3 emissions are estimated by multiplying the volume of purchased goods, services, energy and transportation used by a company with emissions profiles representing the upstream “cradle-to-gate” GHG impact of the input.
- Emissions profiles may either be market averages (e.g., EEIO databases, Ecoinvent, EPA, etc.), or supplier specific (partial PCF - GHGP Product Standard[1] and ISO 14067[2]). TfS provides detailed guidance regarding how Scope 3.1 could be calculated in its chapter 4.
- Most Scope 3 targets require companies to reduce their corporate GHG inventory relative to a baseline year.
- To measure Scope 3 impact, two accounting archetypes can be used:
    - **Inventory / attributional accounting**: Quantifies the lifecycle GHG emissions associated with all inputs and operations used by a company. Typically used for calculation of a GHG inventory, representing the actual emissions associated with company operations, for example, in the setting and assessment of corporate Scope 3 targets.
    - **Project / consequential accounting**: Quantifies the GHG impact of a project relative to a “counterfactual” baseline. Typically used to inform investment decisions, assessing the potential or achieved impact of a GHG reduction project, or for transferring the impact of projects within the value chain (insets) or outside of the value chain (offsets).
- Both accounting mechanisms are valuable, however, based on GHG Protocol Corporate Standard and ISO 14067, as well as a broader ecosystem of GHG reporting literature, it is recommended that attributional and consequential are not mixed for purposes of impact reporting. For example, while credit mechanisms are suitable for carbon neutrality claims, they should not be used as a mechanism to demonstrate a reduction in a GHG inventory.

[1] Greenhouse Gas Protocol: The product life cycle accounting and reporting, https://ghgprotocol.org/product-standard

[2] ISO14067, Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification; 2018; International Organization for Standardization (ISO): https://www.iso.org/standard/71206.html

[5] Greenhouse Gas Protocol, FAQ, https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf

- As most company targets are based on an attributional archetype, typically mitigation strategies deploy three categories of lever:
    a. Using less raw material inputs, for example, making thinner/lighter bottles.
    b. Using different inputs which are lower GHG intensity, for example, switching from coal-based power to renewable power.
    c. Using decarbonized / lower GHG inputs, for example, using low carbon feedstocks.

10.1.3 Sourcing lower GHG inputs

- To achieve a reduction in a corporate Scope 3 inventory, companies may seek to procure material and energy inputs with lower Cradle-to-Gate GHG intensity compared to that which they used in the baseline year
- Procurement of low carbon inputs requires suppliers to generate partial PCF certificates which are differentiated from the market average (note: emissions attributed to customers via partial PCF certificates should be excluded from market average calculations).
- However, today suppliers experience four key challenges with generating PCF certificates to meet customer needs:
    - **Comparability:** PCF accounting guidelines are emerging with the objective of standardizing supplier specific reporting, however, many of these standards and guidelines leave grey areas for interpretation (e.g., sources of secondary data, allocation approaches, mass-balance design choices). Without standardization of PCF accounting, the ability to assign value to a low carbon PCF certificate is limited; and customers need to be able to compare across suppliers.
    - **Physical proximity:** Customers demanding (and willing to pay) for low carbon products may not be geographically close to a supplier's decarbonized asset. In many situations physical transportation of low carbon products across geographies leads to additional cost, GHG emissions and complexity. In other instances, physical segregation is not possible (e.g., if a product is transported via mixed pipelines).
    - **Impact dilution:** Production facilities often produce large quantities of output products, of which only a portion will see demand for a low carbon alternative. However, a small volume of low carbon inputs used in a large production process results in significant impact dilution.
    - **Value chain complexity:** sometimes the underlying demand for low carbon products comes not from a direct customer, but from a customer several tiers down a value chain. In these instances, value chain complexity limits the ability to efficiently transact low carbon PCFs, as it requires multiple transactions and detailed reporting to pass GHG attributes across tiers.
- Addressing these challenges is critical to unlocking the ability for suppliers to transact low carbon PCFs and monetize their decarbonization investments.
- Monetizing decarbonization is critical for accelerating the transition by securing the business case for further investments.

10.2 Fundamental principles of the Carbon Footprint Ledger approach

10.2.1 CFL is an attributional PCF accounting approach based on the mass-balance chain of custody mechanism.

- Corporate Scope 3 inventories are estimated using an attributional accounting approach whereby purchased inputs are multiplied by emissions profiles.
- A PCF is a supplier specific emissions factor used to evaluate the lifecycle GHG impact of a product.
- It is therefore a critical part of product-level GHG accounting, and typically forms the main building block for the corporate GHG inventories.
- Guidelines like ISO 14067:2018[3] and the Pathfinder framework from WBCSD provide a commonly followed approach to structure the PCF calculation,[4] in accordance with international standards on life cycle assessment (LCA), and ISO 14040 and ISO 14044.[5]
- However, PCF accounting standards leave areas for interpretation, specifically regarding chain of custody models which track and trace GHG attributes of low carbon processes where they are physically mixed with traditional inputs.
- The CFL methodology presents a product-level chain of custody GHG accounting mechanism building on existing PCF standards.
- The approach is based on an interpretation of the well-known chain of custody model, mass-balance described in ISO22095 and is consistent with both ISO 14067 and GHG Protocol Product Standards, enabling customers to utilize CFL PCFs for purposes of Scope 3 corporate accounting.

10.2.2 Mass-balance design choices

1. System boundary: Multi-site

Matching concentrated supply with fragmented demand and eliminating physical transportation

- As per ISO 14067, a system boundary is defined as “the basis used to determine which unit processes are included within the [PCF] study”.
- Multiple guidelines exist; some consider a system boundary to be limited to a single asset or production site while others consider a wider system boundary approach.
- ISCC Plus considers a system boundary to cover multiple sites within a jurisdiction/neighbouring jurisdictions (e.g., ISCC Plus), while ISO 14067 (6.3.5) considers site-specific data used in a PCF study to be collected from “a specific site or can be averaged across all sites that contain the process within the system under study.”
- CFL sets a multi-site system boundary within a single company for mass balance enabling GHG attributes of physically equivalent inputs to be used in PCF calculations across locations.

[3] ISO14067, Greenhouse gases - Carbon footprint of products - Requirements and guidelines for quantification; 2018; International Organization for Standardization (ISO): https://www.iso.org/standard/71206.html

[4] WBCSD, Pathfinder Framework, Guidance for the Accounting and Exchange of Product Life Cycle Emissions, 2021

[5] ISO14040, Environmental management - Life cycle assessment - Principles and framework; 2006; International Organization for Standardization (ISO): https://www.iso.org/standard/37456.html; ISO14044, Environmental management - Life cycle assessment - Requirements and guidelines; 2006; International Organization for Standardization (ISO): https://www.iso.org/standard/38498.html

- In contrast, site specific mass-balance would require physical transportation of chemically identical products with different GHG attributes, resulting in additional cost, complexity and transport-related emissions.
- As GHG attributes are not inherent to physical products (rather they represent the GHG impact associated with production of a product), physical connectivity should not be seen as a requirement of PCF calculations. However, physical traceability should be preserved to ensure accurate and credible reporting.

2. Attribution method: Free

Concentration of value into products customers demand to reduce impact dilution

- Mass-balance calculations enable attribution of emissions profiles to the inputs used to produce a product:
    - Average attribution: e.g., in a simplified single input process, if 10% of raw materials are considered to have zero GHG emissions, this attribution would assume that all output products report an average 10% lower PCF.
    - Free attribution: e.g., in the same simplified single input process, if 10% of raw materials are considered to have zero GHG emissions, free attribution assumes up to 10% of output products report a zero carbon PCF, while the other 90% of products report a PCF based on only the GHG attributes of the traditional input.
- CFL applies free input attribution to concentrate the impact of decarbonization efforts in a subset of products.
- This principle allows an attribute to be represented in an output product in a higher share than is proportional to all inputs in a process (although should not be beyond the stoichiometric amount presented in the recipe).
- Free attribution can be based on demand, allowing concentration of low-carbon inputs in those products that have demand for a lower PCF.

10.2.3 Safeguards:

To ensure adherence and compatibility with other PCF accounting standards, the CFL mass-balance design choices are supplemented with implementation guardrails.

1. **Technological compatibility: Multi-site balancing within physical constraints**
   Multi-site mass balance with free attribution should only be used within the physical limitations of value chains. As such, CFL allows balancing low-carbon products from one site with physically identical products from another site. Alternatively, energy inputs (fuel or electricity), process decarbonization like CCS or purchased materials (affecting Scope 3) can only be balanced between production processes if they share technological compatibility (e.g., balancing hydrogen with natural gas if both furnaces are compatible with each gas). As a result, the source of low-carbon inputs remains traceable while the need for physical transport is avoided. This approach is also consistent with existing precedents like Sustainable Aviation Fuel certificates (SAFc)[6].

[6] Clean Skies for Tomorrow and World Economic Forum. Powering Sustainable Aviation Through Consumer Demand: The Clean Skies for Tomorrow Sustainable Aviation Fuel Certificate (SAFc) Framework. 2021.

2. **Limited free attribution: Free input attribution only up to the physical maximum**
   CFL adopts free input attribution, allowing attribution of low-carbon inputs to a subset of products based on demand. This results in a higher PCF reduction for the selected subset, and a lower PCF reduction for the remaining products. The attribution should not go beyond what is present in the recipe (mass energy balance); the PCF reduction following attribution of low-carbon inputs to a subset of products should not result in a PCF increase for the remaining selected intermediate products beyond their original levels (i.e., without the inclusion of low-carbon inputs). This method aligns with physically feasible scenarios, where production facilities could hypothetically be "split" into a decarbonized segment (using the low-carbon inputs) and a non-decarbonized segment. Free attribution is already being used for bio-based claims by ISCC PLUS.[7]

3. **Global balancing of intermediate/end products, fuel inputs and purchased product components, but regional restrictions for electricity & steam**
   Balancing of intermediate/end products, fuel inputs and purchased product components on a global scale replaces the need for physical transportation, saving transport-related emissions and costs. Today, ISCC PLUS already allows the balancing of inputs within national borders or within neighbouring countries (sharing an inland border) if sites are certified and the sustainable attributes are identical within the same company.[7] The balancing of electricity and steam remains restricted to regional boundaries, maintaining a physical connection with the electricity grid. The latter is aligned with grid-related restrictions for balancing renewable electricity in existing market-based mechanisms like RECs and Guarantees of Origins (GOs).

4. **Additionality: Free attribution limited to additional decarbonization efforts**
   CFL provides the ability to freely attribute low-carbon inputs from third party purchased products or decarbonized internal processes. However, to minimize the risk that PCFs are created by de-averaging production facilities rather than investing in additional decarbonization efforts, a residual ICF check is recommended as an optional guardrail. The residual PCF check states that the residual average PCF that remains following creation of a low GHG PCF should not exceed the equivalent company average in a baseline year. This check ensures that only decarbonization following the baseline year can be concentrated and valued in low carbon products.

5. **Physical traceability**
   CFL emphasizes physical traceability without a necessary physical connection between the processes which are balancing inputs. Physical traceability still protects auditability through third-party certification (e.g., REDcert²) [8] and is consistent with the physical transaction without the physical transportation. Physical traceability without a necessary physical connection is applied today by market-based instruments like Unbundled Renewable Energy Certificates (RECs)[9] and SAFc[10].

[7] ISCC PLUS, Version 3.4.2. 2024. https://www.iscc-system.org/wp-content/uploads/2024/03/ISCC-PLUS_v3.4.2.pdf
[8] REDCert², Scheme principles for the certification of sustainable material flows in the chemical industry. 2023.
[9] International Renewable Energy Certificate. What are RECs? https://www.irecstandard.org/what-are-recs/.
[10] Clean Skies for Tomorrow and World Economic Forum. Powering Sustainable Aviation Through Consumer Demand: The Clean Skies for Tomorrow Sustainable Aviation Fuel Certificate (SAFc) Framework. 2021.

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11. Annex C:

Independent Limited Assurance Report to Dow Inc.

ERM Certification & Verification Services Incorporated ("ERM CVS") was engaged by Dow Inc. ("Dow") to provide limited assurance in relation to the selected information set out below and presented in the Dow Inc. Product Carbon Footprint Calculation Methodology Version 1.0 July 2024 (the "Methodology").

Engagement summary	
Scope of our assurance engagement	Whether the Product Carbon Footprint Calculation Methodology Version 1.0 July 2024 is in accordance with the mandatory "shall" requirements within the reporting criteria.
Reporting period	Not Applicable
Reporting criteria	ISO 14067:2018 Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification; and Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard (2011)
Assurance standard and level of assurance	We performed a limited assurance engagement, in accordance with the International Standard on Assurance Engagements ISAE 3000 (Revised) 'Assurance Engagements other than Audits or Reviews of Historical Financial Information' issued by the International Auditing and Assurance Standards Board. The procedures performed in a limited assurance engagement vary in nature and timing from, and are less in extent than for a reasonable assurance engagement and consequently, the level of assurance obtained in a limited assurance engagement is substantially lower than the assurance that would have been obtained had a reasonable assurance engagement been performed.
Respective responsibilities	Dow is responsible for preparing the Methodology and for the collection and presentation of the information within it, and for the designing, implementing and maintaining of internal controls relevant to the preparation and presentation of the Methodology. ERM CVS' responsibility is to provide a conclusion to Dow on the agreed scope based on our engagement terms with Dow, the assurance activities performed, and exercising our professional judgement.

Our conclusion

Based on our activities, as described below, nothing has come to our attention to indicate that the Methodology is not in accordance with the mandatory "shall" requirements within the reporting criteria in all material respects.

Our assurance activities

Considering the level of assurance and our assessment of the risk of material misstatement of the Methodology a multi-disciplinary team of sustainability and assurance specialists performed a range of procedures that included, but was not restricted to, the following:

- Evaluating the Methodology against the "shall" requirements of the ISO 14067:2018 Carbon Footprint of Products and the Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard (2011);
- Interviewing the Dow team and external consultants to understand the application of the Methodology, management of system boundaries, functional / declared units, cut-off criteria, data quality, and general clarifications on the Methodology;
- Evaluating suitability of reporting criteria and reasonableness of assumptions, including application of the Methodology to resolve boundaries, technical basis, and chain of custody approaches (e.g. geographic challenge, dilution challenge, and other relevant considerations);
- Reviewing completeness and auditability of Methodology, including clarity, consistency, and relevance; and
- Reviewing of additional evidence as provided by Dow regarding internal procedures, guidance documents, and annual reports related to the PCF development process.

The limitations of our engagement

The reliability of the assured information is subject to inherent uncertainties, given the available methods for determining, calculating or estimating the underlying information. It is important to understand our assurance conclusions in this context.

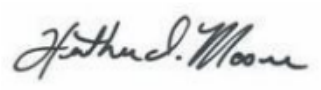
Dow and its Clients shall not infer any output from the use of the Methodology as independently assured or verified. Any partial PCF may also be independently assured to ascertain conformance to the Methodology.

Our independence, integrity and quality control

ERM CVS is an independent certification and verification body accredited by UKAS to ISO 17021:2015. Accordingly we maintain a comprehensive system of quality control, including documented policies and procedures regarding compliance with ethical requirements, professional standards, and applicable legal and regulatory requirements. Our quality management system is at least as demanding as the relevant sections of ISQM-1 and ISQM-2 (2022).

ERM CVS applies a Code of Conduct and related policies to ensure that its employees maintain integrity, objectivity, professional competence and high ethical standards in their work. Our processes are designed and implemented to ensure that the work we undertake is objective, impartial and free from bias and conflict of interest. Our certified management system covers independence and ethical requirements that are at least as demanding as the relevant sections of the IESBA Code relating to assurance engagements.

ERM CVS has extensive experience in conducting assurance on environmental, social, ethical and health and safety information, systems and processes, and provides no consultancy related services to Dow in any respect.



Heather I. Moore, P.E.
Partner, Corporate Assurance
Malvern, PA
23 July 2024

On behalf of:

ERM Certification & Verification Services Incorporated
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