Comparison of Product Carbon Footprint Methodologies & Harmonization Across the Lubricants Value Chain

Whitepaper

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Introduction

The ISO standards, such as ISO 14040 for Life Cycle Assessment (LCA) and ISO 14067 for Product Carbon Footprint (PCF), provide a basic framework for calculating environmental impacts but offer significant flexibility in their application. To enhance transparency and reliability, the industry has developed specific guidelines—such as those from Together for Sustainability (TfS), the American Petroleum Institute (API), the Union of the European Lubricants Industry/ The Technical Association of the European Lubricants Industry (UEIL/ATIEL), and Catena-X (CX). These industry-specific guidelines aim to build consistency and trust by reducing ambiguities and standardizing PCF calculation approaches.

The lubricants and grease industry occupies a unique and critical position, being integral to multiple sectors, including chemical, automotive, and industrial manufacturing. Its relevance across these industries underscores the importance of harmonized PCF methodologies to ensure consistent and accurate reporting of carbon footprints, which in turn supports sustainability goals and regulatory compliance.

The ATIEL & UEIL Joint Sustainability Committee, in collaboration with an independent consultant Carbon Minds, has conducted an in-depth analysis of various PCF guidelines, including those from UEIL/ATIEL, Catena-X, TfS, and API. This white paper highlights the similarities and addresses the differences between these methodologies and advocates for the acceptance of sector specific methodologies across the value chain. The methodology documents in scope are summarized in table 1 and a detailed comparison is collected in tables in the appendix while this paper presents a summary of key findings.

Table 1. Methodology documents in scope of the study.

Owner	Name	Version
Union of the European Lubricants Industry (UEIL) The Technical Association of the European Lubricants Industry (ATIEL)	Methodology for Product Carbon Footprint Calculations for Lubricants, Greases and other Specialities	V1.1 2024/10
Together for Sustainability (TfS)	The Product Carbon Footprint Guideline for the Chemical Industry	V2.1 2024/02
Catena-X (CX)	Catena-X Product Carbon Footprint Rulebook	V3 2024/08
American Petroleum Institute (API)	Lubricants Life Cycle Assessment and Carbon Footprinting - Methodology and Best Practice	V1.0 2023/05

Shared Principles in PCF Methodologies

In examining the UEIL/ATIEL, Catena-X, TfS, and API guidelines, several shared principles emerge, underscoring their collective focus on standardization, climate impact, and data rigor.

1. **Standardization and Alignment with International Frameworks**
   Each of the guidelines prioritizes standardization by aligning with established international frameworks such as ISO 14067 and the GHG Protocol while filling the gaps of these higher level general guidelines and addressing the needs of each sector. This alignment not only provides a clear structure for PCF calculation but also enables a uniform approach across industries, facilitating an industry-wide consensus on how to measure and report carbon footprints.
2. **Exclusive Focus on Climate Change**
   Another common element is the exclusive focus on climate change as the primary impact category, with PCF as the central metric. By concentrating on this single impact category, each guideline narrows its scope to ensure consistency and enhance harmonization across assessments. This uniformity allows for detailed and reliable climate impact data, a crucial aspect for stakeholders seeking clarity and actionable insights on carbon footprints**.**
3. **Emphasis on Upstream Emissions**
   In terms of assessment scope, all guidelines place significant emphasis on upstream emissions, particularly those from raw material extraction, processing, and transport, which are recognized as substantial contributors to a product's overall carbon footprint. While API allows for both full and partial PCF assessments, all methodologies underscore the importance of upstream emissions, concentrating on cradle-to-gate analyses to align with the characteristics of each respective sector. This common focus supports a clear view of the emissions generated throughout the supply chain, enabling companies to address high-impact areas.
4. **Data Transparency and Traceability**
   Data transparency and traceability are emphasized across the guidelines, with requirements for documenting sources of emission data, calculation assumptions, and allocation methods. This focus on traceability enhances credibility, as stakeholders can verify that each data point and calculation step is grounded in documented sources and transparent methodologies. Such clarity is essential for building trust in reported carbon data, both for regulatory purposes and for customer and industry assessments.
5. **Use of highest quality Primary and Secondary Data**
   Additionally, the guidelines advocate the use of highest quality primary and secondary data. They promote the use of primary data from suppliers and processes to ensure accuracy while integrating secondary data from reputable databases to fill any data gaps.

Nuanced Differences and Sector-Specific Considerations

While the UEIL/ATIEL, Catena-X, TfS, and API guidelines share a common goal of achieving consistency in PCF calculations, there are nuanced differences in areas like scope, methodological detail, and allocation principles as well as in highlighting primary data, that may influence harmonization across sectors but are generally manageable within each framework.

1. **Scope of Assessment**
   One such difference is in the scope of assessment. While TfS, UEIL/ATIEL, and Catena-X focus on cradle-to-gate assessments, API permits both cradle-to-gate and cradle-to-grave. This flexibility allows for broader lifecycle insights but must be harmonized with cradle-to-gate assessments for common reporting. In order to account for the fact that lubricant manufacturers typically produce a variety of final lubricant products, UEIL/ATIEL believes that for this stakeholder group a cradle-to-gate scope offers benefits in terms of traceability and transparency.
2. **Methodological Detail**
   In methodological detail, Catena-X and TfS provide more comprehensive guidance especially regarding activity data requirements for e.g. energy and material use, while UEIL/ATIEL is broadly referencing ISO standards. API's broader scope options led to less precise guidance on certain aspects such as accounting for production waste. Additionally, while cut-off criteria vary across all methodologies, they all aim to minimize the exclusion of significant environmental impacts. Catena-X employing the most stringent cut-off rules.
3. **Data collection**
   In the data collection hierarchy UEIL/ATIEL emphasize data category with the highest data quality rating (DQR) while Catena X and TfS state that primary data shall be prioritized over secondary data if they fulfill DQR.
4. **Allocation Principles**
   All methodologies follow a hierarchy for allocating impacts, beginning with process subdivision and system expansion by substitution where applicable. Where not applicable, UEIL/ATIEL and API prioritize mass-based allocation, whereas TfS and Catena-X incorporate first economic allocation when the economic value ratio of co-products exceeds 5. The choice between economic and mass-based allocation can influence PCF outcomes, especially in complex production systems.

Conclusion

Overall, while the guidelines are broadly aligned, these methodological nuances underscore the importance of a sector-specific assessment, particularly for the lubricants and specialty products industries.

ATIEL & UEIL are advocating for harmonization by recognizing the similarities in PCF methodologies and advocating for the acceptance of suppliers' methodologies across the whole value chain, we can foster greater harmonization and consistency across sectors. This approach will ultimately contribute to more accurate and actionable carbon footprint data, ensuring consistent and reliable reporting.

Appendix

1. Methodology Description

UEIL/ATIEL	TfS	Catena-X	API
Name: UEIL/ATIEL Methodology for PCF Calculations of Lubricants, Greases and other Specialties Focus: PCF for Lubricant Industry Compared version: V1.1, 2023	Name: Together for Sustainability (TfS) The Product Carbon Footprint Guideline for the Chemical Industry Focus: PCF for Chemical Industry Compared version: V2.1 2024/02	Name: Catena-X Product Carbon Footprint Rulebook Focus: PCF for Automotive Industry. Compared version: V2.0, 2023/04	Name: American Petroleum Institute Product Carbon Footprint Rulebook Focus: PCF for Lubricants Industry. Compared version: V2.0, 2023/04

2. Standards and Guidelines Used

UEIL/ATIEL	TfS	Catena-X	API
Aimed consistency with: • ISO Standards 14040/44/67 • GHG Protocol Hierarchy of guidelines used for PCF calc.: 1. PCR based on ISO 14000 series for specific products/sectors, e.g. Plastics Europe. 2. TfS Sector Specific Guideline (chemical and additive industry) 3. API TR 1533 Sector Specific Guideline (for base oil industry). **4.** Use ISO 14040/44/67 or GHG PPS.	Aimed consistency with: • ISO Standards 14040/44/67 • GHG Protocol • WBSCD • BASF SE – Guideline for Product Carbon Footprint Calculations Hierarchy of guidelines used for PCF calc.: 1. PCR developed based on the TfS. 2. Product and Sector specific guidelines based on 14000 series. 3. TfS guideline. 4. ISO 14067 standard. 5. GHG protocol Product standard. PEFCR developed under the European Product Environmental Footprint.	Aimed consistency with: • ISO Standards 14040/44/67 Hierarchy of conformity: 1. ISO14067 standard 2. Automotive supply chain specific requirements as defined in Catena-X rulebook 3. Sector- and product-specific guidance as prescribed in Annex of Catena-X rulebook as drop-in standard including additional requirements.	Aimed consistency with: • ISO Standards 14040/44/67 • GHG Protocol • PAS 2050 No hierarchy of guidelines recommended by API.

3. System Boundary

UEIL/ATIEL	TfS	Catena-X	API
• Cradle-to-gate, gate as factory outbound gate. • All inbound transportation is included • Outbound transport excluded. Additional and separate reporting optional • Packaging excluded. Additional and separate reporting optional	• Cradle-to-gate, gate as factory outbound gate • All inbound transportation is included • Outbound transport excluded. Additional and separate reporting optional • Packaging included or excluded depending on mass contribution and environmental significance (see cut-off)	• Cradle-to-gate, gate as supplier outbound gate.[1] • All inbound transportation is included • Outbound transport is generally excluded. If outbound transportation is operated by supplier, PCF of outbound transport must be reported separately. • Packaging of vehicle parts and components included.	API defines system boundaries based on following scopes: • Cradle-to-grave, it includes all stages of lubricant life cycle. • Cradle-to-gate + logistics, gate as customer gate. • Cradle-to-gate, gate as factory outbound gate. • Life cycle stages included or excluded depends on scope.

4. Declared Unit

UEIL/ATIEL	TfS	Catena-X	API
1 kg of unpackaged lubricant.	1 kg of unpackaged (or packaged) products.	• For countable products: one piece including a defined weight and part-ID. • For materials: 1 kg of products. • For packaging – 1 kg or 1 piece of unpacked product.[2]	• Cradle-to-grave emissions in kg CO_2-eq/ kg of lubricant. • Cradle-to-gate emissions in kg CO_2-eq/kg of lubricant (for intermediate materials). • The final choice of unit depends on the goal and scope of the study.

5. Temporal Scope

[1] Supplier outbound gate includes inbound transportation to supplier owned logistic centers.

[2] For clarity: the declared unit excludes packaging weight; methodology considers 1 kg or 1 piece of the unpacked product.

UEIL/ATIEL	TfS	Catena-X	API
• Primary data not older than 5 years. • Secondary data not older than 10 years. • Apply averages, yearly or over max. 3 years (3 years when irregular/non-continuous production), • PCF result valid up to max. 5 years.	• Primary data not older than 5 years. • Secondary data not older than 10 years. • Apply averages, yearly or over max. 3 years (3 years when irregular/non-continuous production). • PCF result valid up to max. 5 years.	• Temporal scope is not individually considered in methodology, but higher requirements from DQR (see below) • All data shall by default be reported for the most recent year of the assessment • Apply averages for emissions, yearly or over max. 3 years • All deviations shall be justified. • An update of data is mandatory if the reported emissions increase by 5 % or more	Not specified in this methodology.

6. Cut-offs

UEIL/ATIEL	TfS	Catena-X	API
• Cumulative total mass/energy input of at least 95% (recommended 98%) shall be included. • Apply generic figures where input and influence on the PCF is unclear (iterative approach). • Input material with considerable environmental footprint should be considered. • Not more than 5% of the total PCF shall fall under cut-off criteria	• Cumulative total mass/energy input of at least 95% (recommended 98%) shall be included. • Apply generic figures where input and influence on the PCF is unclear (iterative approach). • Input material with considerable environmental footprint should be considered.	• No specific cut-off rules for mass or energy are provided. • Apply a screening step before applying any cut-off, where no cut-off is permitted, and no data gaps should be indicated.[3] • At least 99% of total emissions must be covered, using the sum of all collected PCF data and emission factors as the full 100%.	Mass or energy thresholds contributing no more than 2% individually and no more than 5%.

7. Data types and sources

[3] Catena-X requires an initial LCI assessment focusing on data quality and Global Warming Potential, where no cut-offs are allowed and no data gaps are indicated, ensuring 99% coverage with available data.

UEIL/ATIEL	TfS	Catena-X	API
Primary data: Company specific data which is directly measured/collected/calculated from the company's activities in the product's lifecycle. Hierarchy of collecting primary data • No specific hierarchy for primary data collection	Primary data: Company specific data which is directly measured/collected from the company's activities. Hierarchy of collecting primary data • (1) Process specific data, (2) facility specific data, and (3) site specific data.	Primary data: Quantified value of a process or an activity obtained from direct measurement or calculations. Hierarchy of collecting primary data • (1) Activity specific data, (2) site specific data, and (3) company specific data.	Primary data: Quantified value of a process or an activity obtained from a direct measurement, or a calculation. Hierarchy of collecting primary data • (1) Site specific data, (2) data from a different but representative product system.
Secondary data: Supplier specific or technology specific data at site level, market reports, patents, industry averages, LCI databases, expert proxies.	Secondary data: Supplier specific or technology specific data at site level, e.g. market reports, patents, industry averages, LCI databases, expert proxies, estimations.	Secondary data: Used to ensure continuity of information chain of PCF. Secondary data requirements: conservative, representative, and accessible.	Secondary data: Recognized LCA databases and software, published scientific literature, and industry sources for processes under investigation.
Proxy Data: Substitute or approx. data for primary or secondary data that reflects similar processes or products.	Proxy Data: Proxy data are data from similar processes that are used as a stand-in for a specific process. Proxy data can be extrapolated, scaled up, or customized to represent the given process	Hierarchy of using secondary data: (1) industry associations, (2) LCA databases, (3) others, e.g. scientific literature Proxy Data: If no data is available, proxy data may be used.	Proxy Data: Secondary data from proxy processes or estimates.
Estimated Data: Use when none of the above are available, to estimate the missing data.	Estimated Data: Use when none of the above are available, to estimate the missing data.		
Hierarchy of collection: Use data category leading to highest DQR	Hierarchy of collection: Primary data shall be prioritized over secondary data if the DQR is high. Avoid using proxy and estimated data if possible.	Hierarchy of collection: Primary data shall be prioritized over secondary data if they fulfill DQR	Hierarchy of collection: Primary data prioritized over secondary data and proxy data

8. Activity data requirements (electricity and thermal energy)

UEIL/ATIEL	TfS	Catena-X	API
GHG emissions should include upstream emissions from energy supply system, direct emissions during energy generation, and downstream emissions.[4] No further details	GHG emissions should include upstream emissions from energy supply system, direct emissions during energy generation, and downstream emissions.[4] Self-Generated Energy • Thermal Energy: Use primary data for activity and direct emissions via a bottom-up approach. • Electricity: Calculate emissions using the market-based approach per GHG Protocol Scope 2 Guidance. Purchased Energy • Thermal Energy: Use supplier-specific GHG emission factors (market-based). If only CO_2-eq. factors for direct emissions are available, add upstream emissions based on fuel supply. Electricity hierarchy: from supplier (1) via dedicated transmission line, or (2) from grid or specific contract with supplier on energy mix. Unknown supplier use (3) residual mix, (4) national grid mixes	GHG emissions should include upstream emissions from energy supply system, direct emissions during energy generation, and downstream emissions.[4] Self-Generated Energy • Electricity: Use the specific emission factor for electricity produced on-site if no contractual instruments are sold to third parties; otherwise, use the country-specific residual grid mix. • Verification: Provide proof of the installation, meter readings, and third-party confirmation for on-site generation. Purchased Energy • Electricity: Follow a hierarchy for the electricity mix - use: (1) supplier-specific electricity product, (2) supplier specific electricity mix, (3) use country-specific residual grid mix, (4) regional residual grid mix, (5) grid-specific consumption mixes • Contract types: (1) Utility tariffs, (2) Energy Attribute Certificates (EACs), (3) Power Purchase Agreements (PPAs)	GHG emissions should include upstream emissions from energy supply system, direct emissions during energy generation. No further details

9. Activity data requirements (raw materials)

[4] e.g. the treatment of waste as ashes arising from the operation of coal fired power plants.

UEIL/ATIEL	TfS	Catena-X	API
GHG emissions should include all upstream life cycle emissions from production, transport and packaging of raw materials needed to meet the defined reference flow of the product Data for calculation: • Not further specified Data Requirements • Primary and secondary data can be used. • Data with highest DQR shall be used	GHG emissions should include all upstream life cycle emissions from raw material supply, including material acquisition, pre-processing, and disposal of production waste. Data for calculation: • External Source: Use PCF from suppliers, averaging PCFs by purchased volume. • Company Source: Use bill of material (BOM) from the same company or inter-company transfers. • Mixed Source: Combine BOM data from internal and external sources. Data Requirements • Primary or secondary data can be used.	GHG emissions should include all upstream life cycle emissions from resource extraction, raw material sourcing, production and packaging of materials and vehicle parts, disposal of production waste and transport. Data for calculation: • Not further specified Data Requirements • Primary data should be used • Secondary data can be used if no primary data are available Additional: Homogenous parts • Linear regression to interpolate for similar homogeneous parts is allowed if they have same function, product standard, technology, materials, supply routes.	The cradle to gate PCF should include all relevant upstream LC stages from raw material extraction, intermediate stages of processing, production and packaging, transportation, use-phase and end-of-life depending on scope of study. Data for Calculation: • Detailed data collection schemes are provided for individual life cycle stages with special focus on raw materials Data Requirements: • Prioritize primary data for Scope 1 and Scope 2 emissions, supplemented by secondary data where necessary. Ensure an iterative approach to refine data quality over time.

10. Activity data requirements (transport)

UEIL/ATIEL	TfS	Catena-X	API
Transportation Activities: • Include transportation within supply chain • Include in-bound transportation • Include inter-site transportation • Exclude outbound transportation Data for Calculation • Not further specified • Use data leading to highest DQR Additional Considerations • Aircraft Emissions: may be neglected due to the minor significance of aircraft transportation.	Transportation Activities: • Include transportation within supply chain • Include in-bound transportation • Include inter-site transportation • Exclude outbound transportation Data for Calculation • Primary data: Use fuel usage data for actual transportation mode, distance, and vehicle load, covering full round trips. Allocate emissions based on product mass or volume. • Third-Party Data: Use product-specific transportation emissions • Estimated Data: Use mass and distance with relevant emission factors per transport mode Additional Considerations • Emission Factors: Apply well-to-wheel emission factors Aircraft Emissions: report separately if applicable	Transportation Activities: • Include transportation within supply chain • Include in-bound transportation • Include inter-site transportation • Include outbound transportation if operated by supplier (report separately) Data for Calculation • Primary data: Measure fuel and energy consumption for each trip, using onboard data collection systems when available • Modeling Data: Follow GLEC Framework V3.0 for transport emissions, prioritizing actual distance, shortest feasible distance (SFD), and great circle distance (GCD) for transport distances Additional Considerations • Emission Factors: Full upstream emission factors of fuel/energy	Transportation Activities (depend on scope of study): • Include transportation within supply chain • Include outbound transportation to the customer gate. • Include transport to waste treatment Data for Calculation: • Mass of product transported • Distance • Mode of transport used, including fuel type. Additional Considerations • Emission factors: Can be sourced on variety of public sources for different modes of transport. • If available, use primary data on fuel consumption for calculations. (Apply well-to-wheel emission factors) • Other activities contributing to additional emissions could be included.

11. Activity data requirements (waste treatment in end-of-life)

UEIL/ATIEL	TfS	Catena-X	API
Any discarded substance or object, as per the European Waste Framework Directive. GHG emissions from waste disposal are accounted to producer according to “Polluter pays principle”.	Any discarded substance or object, as per the European Waste Framework Directive without economic value. GHG emissions from waste disposal are accounted to producer according to “Polluter pays principle”.	Waste is any material or process output which is not deliberately produced as an integral part of a multioutput production process. GHG emissions from waste disposal are accounted to producer according to “Polluter pays principle”.	Waste is anything which enters end-of-life (used oils and primary packaging). GHG emissions from waste disposal are accounted to producer.
Waste Treatment Activities • Not specifically stated within methodology • One example for waste treatment via incineration without energy recovery is provide	Waste Treatment Activities • Preparatory steps including collection, transportation, sorting, dismantling and shredding • Final disposal in landfill or incineration without energy recovery	Waste Treatment Activities • Preparatory steps including collection, transportation, sorting, dismantling and shredding • Final disposal in landfill or incineration without energy recovery	Waste Treatment Activities (for used oils) • Disposal in landfills • Disposal by incineration
Data for Calculation (Hierarchy) • Primary Data: Use primary data on waste type and composition for calculating GHG emissions. • Secondary Data: If primary data is unavailable, use secondary data and accepted databases to estimate emission factors.	Data for Calculation (Hierarchy) • Primary Data: (1) Use internal primary data if waste is treated internally. (2) Use emissions factors of treatment provider if waste is treated by third party • Secondary Data: (3) Estimate emission factors using available information on waste composition and process technology. (4) Use emission factors from accepted secondary databases. • Estimation: (5) Develop proxies for landfilling and wastewater treatment as suggested in methodology annex	Data for Calculation (Hierarchy) • Primary Data: Use data on waste type, composition, and treatment activity for GHG emission calculations. • Secondary Data: Use emission factors from accepted secondary databases. • Estimation: If primary data from third-party facilities is inaccessible, estimate emissions using primary data on waste type and specific emission factors based on waste treatment method	Data for Calculation (Hierarchy) • Country level data should be obtained to provide additional granularity over regional/global averages.

12. Activity data requirements (waste treatment in material recovery)

UEIL/ATIEL	TfS	Catena-X	API
Material recycling processes derive secondary material from waste for manufacturing new products. Within System Boundary • Closed Loop: If the material is used directly in the product process, no allocation is required. All emissions from recycling are attributed to the product. Outside System Boundary (Allocation) • Cut-Off Approach: Impact of waste treatment including preparatory steps allocated to the user of secondary material	Material recycling processes derive secondary material from waste for manufacturing new products. Within System Boundary • Closed Loop: If the material is used directly in the product process, no allocation is required. All emissions from recycling are attributed to the product. Outside System Boundary (Allocation) • If no subdivision or existing Product Category Rule (PCR) is applicable apply cut-off. In addition, Upstream System Expansion (USE) Approach can be used: • Cut-Off Approach: Impact of waste treatment including preparatory steps allocated to the user of secondary material. • USE Approach: Credits are given for avoided waste treatment from the first life cycle. Burdens from preparatory steps are accounted to secondary material Additional requirements: • Additional reporting from End-of-life (EoL) emissions is required	Material recycling processes derive secondary material from waste for manufacturing new products. Within transition phase • Cut-Off Approach: Impact of waste treatment including preparatory steps allocated to the user of secondary material. • If overall acceptance of a PCF sector-guidance as a drop-in standard for Catena-X is reached during the transition phase, this shall apply to the respective sector.	Material recycling processes derive secondary material from waste for manufacturing new products. Outside System Boundary (Allocation) • Cut-Off Approach: Impact of used oil and packaging waste treatment shall be attributed to user of secondary material.

13. Multi-output processes

UEIL/ATIEL	TfS	Catena-X	API
Hierarchy to attribute impacts 1. Process subdivision 2. System expansion by substitution 3. Allocation according to physical relationship 4. Allocation according to mass Additional information: • Acknowledges that some products within the lubricant manufacturer's value chain apply to other PCF methodologies, guidelines, or PCRs	Hierarchy to attribute impacts 1. Process subdivision 2. System expansion by substitution 3. Approved/aligned sector specific guidance or product category rules (PCRs) 4. Economic allocation[5] 5. Allocation according to physical relationship (in doubt by mass) 6. Allocation according to other criteria e.g. economic Additional information: • CO_2 is not an allocatable product, shall be modeled as system expansion via avoided burden using a direct air capture as reference process • Hydrogen to be allocated by heating value	Hierarchy to attribute impacts 1. Approved/aligned sector specific guidance or product category rules (PCRs) 2. Process subdivision 3. System expansion by substitution 4. Economic allocation[5] 5. Allocation according to physical relationship (in doubt by mass) 6. Allocation according to other criteria e.g. economic Additional information: • Currently in alignment with TfS and WBCSD	Hierarchy to attribute impacts 1. Process subdivision 2. System expansion by substitution 3. Allocation according to physical relationship (by mass for non-energy products) 4. Allocation according to other relationships e.g. economic value. Additional information: • For additives follow TfS guideline. • Mixing of allocation approaches should be avoided.

14. Additional rules – Biogenic carbon emissions and removals

[5] According to guidance by World Business Council for Sustainable Development (WBCSD). If the ratio of economic value to each co-product is higher than 5, use economic allocation. Economic allocation factors should be calculated based on stable market prices, as a yearly average or over multiple years in case of high fluctuation (e.g. >100%) of prices to average out high fluctuations if prices, influencing the outcome of an allocation process based on economic values as prices.

UEIL/ATIEL	TfS	Catena-X	API
Biogenic removals from CO_2 uptake during biomass growth and biogenic emissions shall be included and reported separately. Characterization factors for biogenic CO_2 • +1 kg CO_2-eq. / kg $CO_{2,bio}$ for biogenic emissions • -1 kg CO2-eq. / kg CO2,bio for biogenic uptake Additional requirements • Reporting of the biogenic carbon content (BCC) and total carbon content (TCC) of the product is mandatory.	Biogenic removals from CO_2 uptake during biomass growth and biogenic emissions shall be included and reported separately. Characterization factors for biogenic CO_2 • +1 kg CO_2-eq. / kg $CO_{2,bio}$ for biogenic emissions • -1 kg CO_2-eq. / kg $CO_{2,bio}$ for biogenic uptake Additional requirements • Reporting of the biogenic carbon content (BCC) of the product is mandatory. • BCC shall be reported per certified mass balance attribution and physical content. • BCC before 2025 based on analytical, measurement, calculation or estimate. • BCC shall be corrected after any economic allocations applied in the supply chain. • BCC of packaging (optional) shall be excluded or reported separately. • Due to transition phase and other existing methodologies PCF without biogenic emissions and removal shall be reported separately using the 0/0 approach.	Biogenic removals from CO_2 uptake during biomass growth and biogenic emissions shall be included and reported separately. Characterization factors for biogenic CO_2 • +1 kg CO_2-eq. / kg $CO_{2,bio}$ for biogenic emissions • -1 kg CO_2-eq. / kg $CO_{2,bio}$ for biogenic uptake Additional requirements • Reporting of the biogenic carbon content (BCC) and total carbon content (TCC) of the product is mandatory.	Biogenic removals from CO_2 uptake during biomass growth and biogenic emissions shall be included and reported separately. Characterization factors for biogenic CO_2 Not specified further Additional information: • For Cradle-to-gate approach the temporarily sequestered CO_2 in the form of biogenic carbon can be subtracted from the total kg CO_2-eq/kg product. • For Cradle-to-grave approach there is no net contribution of biogenic CO_2 emissions to PCF.

15. Additional rules – Direct land use change

UEIL/ATIEL	TfS	Catena-X	API
Direct land use change (dLUC) refers to a change from one land use to another land use. Emissions and removals from LUC shall be reported separately. Characterization factors for LUC • +1 kg CO_2-eq. / kg $CO_{2,bio}$ released from biogenic stock or soil • -1 kg CO_2-eq. / kg $CO_{2,bio}$ stored from biomass stock or soil	Direct land use change (dLUC) refers to a change from one land use to another land use. Emissions and removals from LUC shall be reported separately. Characterization factors for LUC • Not further specified Additional requirements The GHG emissions and removals occurring because of dLUC within the last decades shall be assessed	Direct land use change (dLUC) refers to a change from one land use to another land use. Emissions and removals from LUC shall be reported separately. Characterization factors for LUC • Not further specified	Direct land use change (dLUC) refers to a change from one land use to another land use. Emissions and removals from LUC shall be reported separately. Characterization factors for LUC • Not further specified Additional requirements • Hierarchy for accounting for dLUC : 1. Site Specific studies 2. IPCC guidelines 3. PAS 2050 ,section 5.6

16. Additional rules – Emission offsets

UEIL/ATIEL	TfS	Catena-X	API
Avoided emissions shall not be subtracted from the total inventory results of the PCF.	Avoided emissions shall not be subtracted from the total inventory results of the PCF.	Avoided emissions shall not be subtracted from the total inventory results of the PCF.	Avoided emissions shall not be subtracted from the total inventory results of the PCF.

17. Additional rules – Chain of custody

UEIL/ATIEL	TfS	Catena-X	API
Acknowledges PCFs calculated by the mass balance approach, as per ISO 22095 for sustainable material	A mass-balanced chain of custody might be used when assessing the impact of fossil raw materials that are replaced by alternative raw materials. Requirements for use of MMBCA • Follow a transparent and verified certification standard • LCA of manufacturing process shall be in conformance with ISO 14044 Double counting must be avoided	Multiple chain of custody models might be used when assessing the impact of fossil raw materials that are replaced by alternative raw materials. Requirements for choice of chain of custody model • Use shall achieve significant changes and an effective transition towards a more circular value chain. • Follow a transparent and verified certification standard • Double counting must be avoided • Labels and claims shall fulfill strict requirements[6] • Operating sites for mass balancing to be in control of operating company/corporate group/joint venture • Technical feasibility of production • Applied emission factors for the mass-balance system shall be product and process specific	A mass balance chain of custody model could be used for assessing the biogenic carbon in intermediate components or finished lubricants as per Section 5.4.2 of ISO 22095:2020

18. Data quality – Primary data sharing (PDS)

[6] (1) description of the chain-of-custody approaches and models, (2) accurate and appropriate implementation of the chain-of-custody model, (3) compliant with existing standards and regulations, (4) non-misleading

UEIL/ATIEL	TfS	Catena-X	API
No primary data share calculation proposed	PDS indicates the percentage of GHG impact from primary data. Key Points: • Both activity data and emission factor must be primary for a process to count as primary. • Obtain primary data from upstream suppliers whenever possible. Multiply PDS of each component by its contribution to the PCF and sum the values for the overall PDS.	PDS indicates the percentage of GHG impact from primary data. Key Points: • Calculate PDS by assessing the proportion of PCF in kg CO_2-eq. that uses primary data. • Sum the contributions of each part's PDS to the overall product's PDS.	No primary data share calculation proposed.

19. Data quality – Data quality assessment and rating (DQR)

UEIL/ATIEL	TfS	Catena-X	API
• Calculation of data quality rating (DQR) is proposed based on 5 data quality criteria[7] and 3 quality levels[8] • Reporting of DQR might become mandatory in future. • Only a single DQR is reported. • When reporting, a qualitative explanation of data quality along with quantitative DQR should be provided.	• Calculation of data quality rating (DQR) is proposed based on 5 data quality criteria[7] and 3 quality levels[8]. • Reporting of DQR becomes mandatory after 2025. • Only a single DQR is reported.	• Calculation of data quality rating (DQR) is proposed based on 3 data quality criteria TeR, GeR and TiR [7] and 5 quality levels ranging from best to worth • Reporting of DQR is mandatory. • Only a single DQR is reported.	Data quality should be assessed based on the 5 data quality indicators[7] according to GHG Protocol, (2011).

20. Verification – Quality assurance

[7] Data quality criteria for all methodologies are equal and include 1) Technological representativeness (TeR), 2) Geographical representativeness (GeR), 3) Temporal representativeness (TiR), 4) Completeness (C), and 5) Reliability (R)

[8] Data quality levels ranging from 1) 'Good', 2) 'Fair', and 3) 'Poor' but are characterized slightly differently.

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Verification in comparative assertions recommended to be performed according to ISO 14071 and ISO 14044.	Verification is mandatory to ensure the accuracy and reliability of PCF data. Requirements: • 4-eyes principle with internal (LCA expert) or external reviewer (auditor) for (1) goal and scope, (2) calculation rules, (3) system boundaries, (4) data quality	No methods for verification and validation described.	Verification of the calculations undertaken by an independent verification body is recommended. Verification in comparative assertions is mandatory according to ISO 14071 and ISO 14044.