IDTA 02023
Carbon Footprint

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SPECIFICATION

Submodel Template of the
Asset Administration Shell

Imprint

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Version history

Date	Version	Comment
28.11.2023	0.9	Pre-Release of Submodel Template
17.09.2024	1.0	• Update from AAS Metamodel v2 to v3 • According to Battery Passport the value list of reference unit and quantity has been extended • Exemplary mapping of the PACT Framework from WBCSD • Transport Carbon Footprint removed • Update from ECLASS 13 IRDIs to ECLASS 15
25.03.2025	1.0	Release of the official Submodel template published by IDTA.

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1. General

1.1. About this Document

This document is a part of a specification series. Each part specifies the contents of a Submodel template for the Asset Administration Shell (AAS). The AAS is described in [1], [2], [3], and [6]. First exemplary Submodel contents were described in [4], while the actual format of this document was derived by the "Administration Shell in Practice" [5]. The format aims to be very concise, giving only minimal necessary information for applying a Submodel template, while leaving deeper descriptions and specification of concepts, structures and mapping to the respective documents [1] to [6].

The target group of the specification are developers and editors of technical documentation and manufacturer information, which are describing assets in smart manufacturing by means of the AAS and therefore need to create a Submodel instance with a hierarchy of SubmodelElements. This document especially details on the question, which SubmodelElements with which semantic identification shall be used for this purpose.

1.2. Scope of the Submodel Template

This Submodel template provides the means to exchange an asset`s Carbon Footprint (CF) between the partners along a value chain. The aim of this Submodel is to increase the interoperability between the parties, who are interested in documenting, exchanging, evaluating, or optimizing the environmental footprint of their assets. These parties can for example be manufacturers, users/consumers, or logistic partners. The CF might be part of larger initiatives, such as the Digital Product Passport (DPP) or the Product Environmental Footprint. It is not the scope of this Submodel template to substitute the relevant certificates. Use cases with increasing complexity are described in the following section. Version 1.0 of this document will focus on Use Cases 1,2, and 3. Additional use cases will be supported in future versions.

1.3. Use cases, Requirements and Design Decisions

1.3.1. Use Case 1 “Limited Machine-Readable Communication of Carbon Footprints”

Based on the digital nameplate of an asset, users should be able to view relevant Carbon Footprint information by scanning the product (see Figure 1). This information is provided in a limited machine-readable form, and enables users to download further information (e.g., as a PDF or a link to a website) for more detailed analysis. The machine-readable data includes essential meta-information within the AAS related to the footprint, manufacturers can simply link the existing documentation (required by ISO 14026) for this purpose. This ensures a basic level of interoperability and accessibility, allowing for efficient communication of Carbon Footprint information.

Figure 1: Use Case 1 Illustration

1.3.2. Use Case 2 “Passing Carbon Footprints through the Value Chain for Integrated Calculation”

For automated summation of the CF, additional meta-information must be available to classify the scope and quality of the footprint information. For this purpose, the ZVEI demonstrators PCF@ControlCabinet and Electro Installation were used as a field-test examples of such value networks to derive requirements for the Submodel template. These demonstrators involved the integration of more than 100 components from over 40 different manufacturers into a control cabinet and an electrical installation. The primary objective was to dynamically calculate the Product Carbon Footprint (PCF) of the cabinet based on the AAS, facilitating the exchange of sustainability information across business partners within the value network. Different calculation methods and scopes were considered to ensure comprehensive and accurate results. More information about the demonstrator and the use cases can be found in the discussion paper [7].

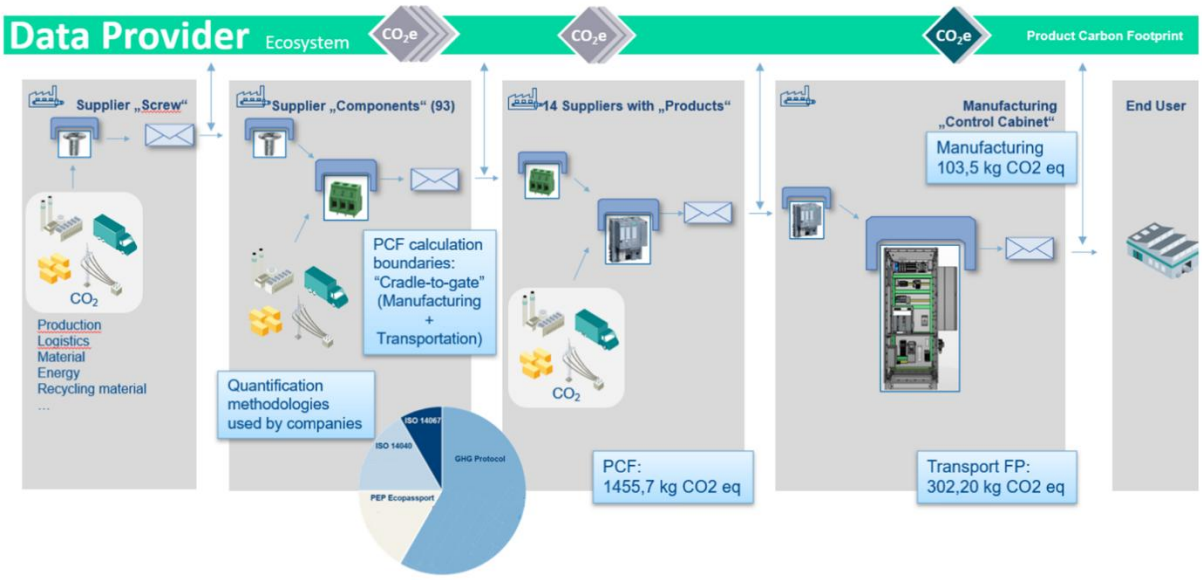

Figure 2: Use Case 2 Illustration based on PCF@ControlCabinet, Source ZVEI

1.3.3. Design Decisions for Use Case 1 and Use Case 2

Different standards and proprietary methods for calculating PCF values exist with varying complexity and different approximation assumptions. Sometimes the overall PCF, covering the entire lifecycle (“from cradle to grave”) is of interest, while other times, only the values for certain lifecycle phases are considered. Depending on the use case, certain effects need to be included or excluded from the calculation. Therefore, the Submodel template allows to provide multiple PCF values using different calculating methods and assumptions. The basic design of the Submodel template permits an unlimited number of SubmodelElementCollections (SMC) to be listed. Thereby, each SMC can address the carbon footprint using a different standard, calculation method, or assumption. This specification will list a growing number of supported standards.

In addition to general standards for life cycle assessments (e.g., ISO 14044) and footprint calculations (e.g., ISO 14067 or Greenhouse Gas Protocol), other standards are also included in carbon footprint calculation and communication. However, these standards do not provide guidelines on determining the PCF for individual products or transport routes. Due to the absence of such rules, the carbon footprint of the same products from different companies are not yet fully comparable. The IDTA supports the introduction of product category rules for calculation in various industries to establish a consistent basis for the calculation and thus a comparability and standardized description of the products.
Therefore, the working group was guided by a step-by-step model to develop an initial specification that can integrate future levels of detail and industry- or product-specific requirements (Figure 3).

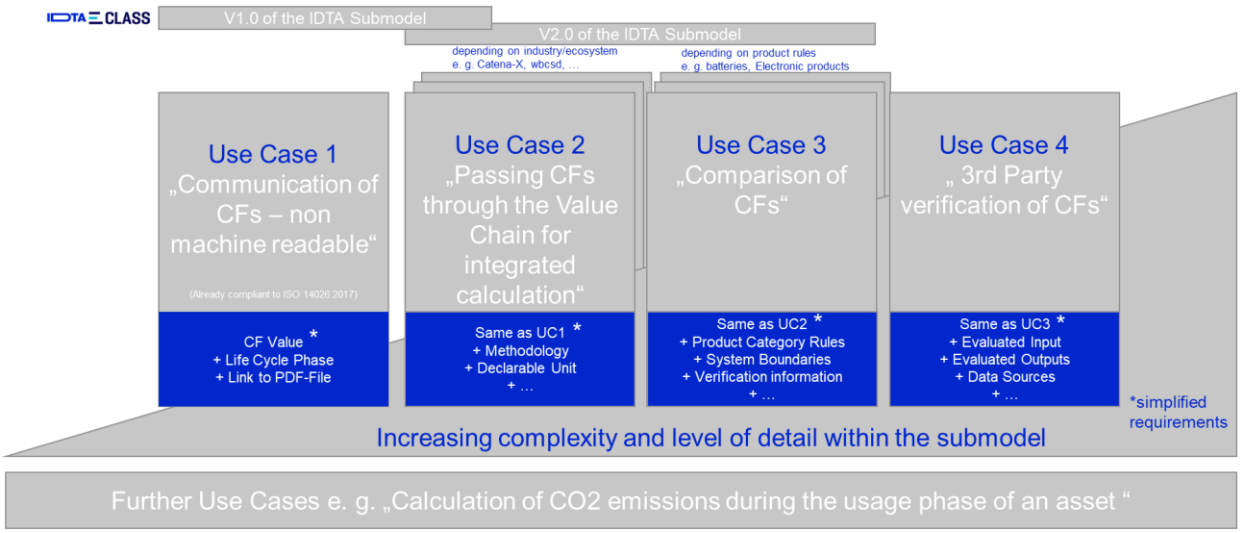

Figure 3: Stage model for carbon footprint use cases and the Submodel scope

1.3.4. Enhancements from version 0.9 to version 1.0 of the Submodel template

In the further development from version 0.9 to version 1.0 of the specification, the requirements of the Battery Passport[1] were specifically incorporated. In addition, the integration of the PACT framework (see Pathfinder Framework Version 2.0[2] and Technical Specifications for PCF Data Exchange Version 2.3.0[3]) was extended to enable seamless integration.

1.4. Relevant standards for the Submodel Template

Due to the large number of standards, some of which are being developed in parallel, this document provides only a selection of specifications that have been reviewed. Close coordination, as shown in Figure 3, is the aim within this working group.

1.4.1. ECLASS

ECLASS is a classification system for products and services maintained by the industry consortium ECLASS e.V. It supports the digital exchange of product descriptions and service descriptions, in the form of standardized data formats based on IEC 61360. As of ECLASS Release 13.0 a set of property definitions for PCF modelling is provided. As of ECLASS Release 14.0 the modelling was adapted such that these properties are part of a larger set of environmental properties, which were further enhanced in version 15.

1.4.2. ISO 14067 - Greenhouse gases – Carbon footprint of products

This document specifies principles, requirements and guidelines for the quantification and reporting of the carbon footprint of a product, in a manner consistent with the standards on life cycle assessment (LCA).

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[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32023R1542

[2] https://www.wbcsd.org/wp-content/uploads/2023/01/PACT-Pathfinder-Framework-WBCSD.pdf

[3] https://github.com/wbcsd/data-exchange-protocol/blob/main/spec/v2/index.bs

Requirements and guidelines for the quantification of a partial CF are also specified. This document is applicable to CF studies, the results of which provide the basis for different applications.

1.4.3. ISO 14040, 14044 - Environmental management – Life cycle assessment

These documents describe requirements, guidelines, principles and frameworks for life cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.

1.4.4. EN 15804 - Building Sustainability – Environmental Product Declarations – Basic Rules for the Product Category of Building Products

The standard ensures that all Environmental Product Declarations (EPDs) for building products, building services, and building processes are derived, verified, and represented in a uniform manner. It stipulates the fundamental product category rules.

1.4.5. EN 16258 - Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)

This European Standard establishes a common methodology for the calculation and declaration of energy consumption and greenhouse gas (GHG) emissions related to any transport service (of freight, passengers, or both).

1.4.6. IEC TS 63058 - Switchgear and control gear and their assemblies for low voltage – Environmental aspects

This standard provides guidance to manufacturers of low-voltage switchgear and controlgear and their assemblies in evaluating and improving the environmental impact of their products, and in enabling effective communication using common references for environmental information throughout the supply chain.

1.4.7. GHG Protocol - Greenhouse Gas Protocol

GHG Protocol establishes comprehensive global standardized frameworks to measure and manage GHG emissions from private and public sector operations, value chains, and mitigation actions.

1.4.8. PEP Ecopassport - Product Environmental Profile Ecopassport

The mission of the non-profit P.E.P. Association is to develop internationally the Environmental declaration Program PEP Ecopassport® concerning electrical, electronic and HVAC (heating, ventilation, air-conditioning, refrigeration) products. The Ecopassport provides a reference framework in compliance with the ISO 14025 and ISO 14040 standards.

1.4.9. Catena-X

Catena-X is an integrated, collaborative, open data ecosystem for the automotive industry. It connects all players to end-to-end value chains. As part of its standardization activities a semantic data model for the PCF has been published as CX–0029 and CX-0136 (formerly CX – 0026) and can be found at Catena-X Standard Library.[4]

For version 1, the following standards have been integrated as far as possible:

1.4.10. World Business Council for Sustainable Development

The World Business Council for Sustainable Development (WBCSD) is a community of over 200 sustainable businesses working collectively to accelerate the system transformations needed for a net-zero, nature positive, and more equitable future. Among others the WBCSD creates technical specifications to enable the exchange of standardized GHG data at product level across interoperable technology solutions.[5]

1.4.11. Content Guidance on EU Battery Passport by the Battery Pass Consortium

The Battery Pass Consortium is an initiative that focuses on the development and implementation of standards for battery passports. A battery passport is an electronic record that contains information about the condition, performance and life cycle of a battery. The consortium is working to establish industry-wide standards to promote interoperability between different systems and players in the battery industry.[6]

Regulation (EU) 2023/1542 of the European Parliament and of the Council of 12 July 2023 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC (aka Battery Regulation).[7]

1.4.12. VDMA Guideline

The VDMA guideline is primarily aimed at companies in the mechanical and plant engineering sector that want to determine the product carbon footprint of their products and have already had initial contact with the topic of "PCF calculation". The guideline illustrates the procedure for PCF calculation and focuses on the underlying calculation rules and the requirements to be specified and transparently identified. The VDMA Guideline[8] is based on ISO 14067 and the GHG Protocol accounting standards.

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[4] https://catena-x.net/de/standard-library

[5] https://wbcsd.github.io/tr/2024/data-exchange-protocol-20240410/

[6] https://thebatterypass.eu/assets/images/content-guidance/pdf/2023_Battery_Passport_Data_Attributes.xlsx

[7] http://data.europa.eu/eli/reg/2023/1542/oj

[8] https://www.vdma.org/documents/34570/15397407/VDMA-Guideline_PCF-Berechnung_final.pdf/75b479e6-cba7-4a53-15b0-98a7257d8ecc?t=1671092803597

1.4.13. IDTA SMT Contact Information - IDTA02002

The snippet address information from the submodel template contact information is referenced in the template to avoid double modelling and standardization.[9]

[9] https://github.com/admin-shell-io/submodel-templates/tree/main/published/Contact%20Information/1

2. Submodel Template Carbon Footprint (CF)

2.1. Approach

The Carbon Footprint Submodel template comprises a two-part structure that distinguishes between a general, high-level footprint with few details and further sections to provide more detailed information according to a product or sector specific rule.

Thereby, each SMC can address the carbon footprint using a different standard, calculation method or assumption.

The general structure of the Submodel template is given in Figure 4.

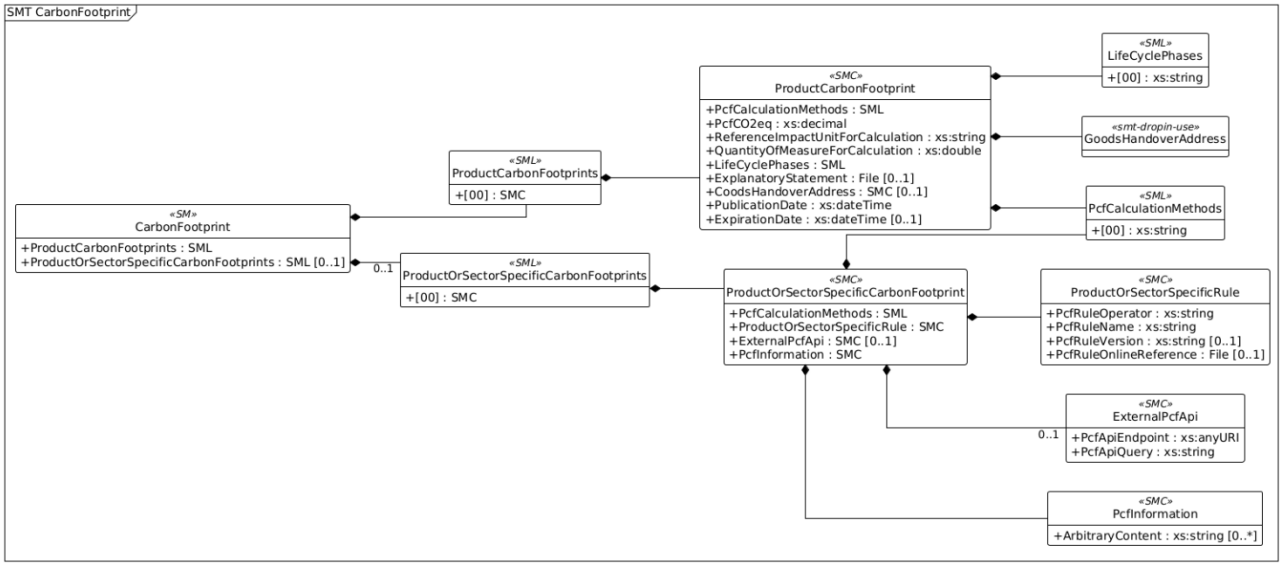

Figure 4: Submodel template overview

2.2. Carbon Footprint Submodel Template

Table 1: Carbon Footprint Submodel Template

idShort:	CarbonFootprint Note: a different idShort might be used, if it is unique in the Asset Administration Shell.		
Class:	Submodel (SM)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/CarbonFootprint/1/0		
Parent:	Asset Administration Shell, to which the Carbon Footprint shall be associated to		
Explanation:	The Submodel provides the means to access the Carbon Footprint of the asset.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SML] ProductCarbonFootprint	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductCarbonFootprints/1/0 Balance of greenhouse gas emissions along the entire life cycle of a product in a defined application and in relation to a defined unit of use.	n/a	1
[SML] ProductOrSectorSpecificCarbonFootprints	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificCarbonFootprints/1/0 Product Carbon Footprint, which is determined in accordance with sector or product group-specific rules or guidelines and covers the life cycle or parts of a product life cycle.	n/a	0..1

2.2.1. SML ProductCarbonFootprints

Table 2: SML ProductCarbonFootprints

idShort:	ProductCarbonFootprints		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductCarbonFootprints/1/0		
Parent:	CarbonFootprint Submodel (IRI https://admin-shell.io/idta/CarbonFootprint/CarbonFootprint/1/0)		
Explanation:	Balance of greenhouse gas emissions along the entire life cycle of a product in a defined application and in relation to a defined unit of use.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] ProductCarbonFootprint	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductCarbonFootprint/1/0 Balance of greenhouse gas emissions along the entire life cycle of a product in a defined application and in relation to a defined unit of use.	n/a	1

2.2.2. SML ProductOrSectorSpecificCarbonFootprints

Table 3: ProductOrSectorSpecificCarbonFootprints

idShort:	ProductOrSectorSpecificCarbonFootprints		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificCarbonFootprints/1/0		
Parent:	CarbonFootprint Submodel (IRI https://admin-shell.io/idta/CarbonFootprint/CarbonFootprint/1/0)		
Explanation:	Product Carbon Footprints, which is determined in accordance with sector or product group-specific rules or guidelines and covers the life cycle or parts of a product life cycle.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SMC] ProductOrSectorSpecificCarbonFootprint	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificCarbonFootprint/1/0 Product Carbon Footprint, which is determined in accordance with sector or product group-specific rules or guidelines and covers the life cycle or parts of a product life cycle.	n/a	0..1

2.2.3. SMC Product Carbon Footprint Calculation (PCF)

This SMC enables access to the PCF of an asset. If multiple calculation methods or lifecycle phases are to be supplied with the Submodel template, multiple instances of this SMC shall be instantiated.

In this SMC, the PCF must specify the appropriate lifecycle phase for which the CO_2-equivalent has been calculated. Since not all standards support all life cycle phases, it is possible to create an inconsistent model by stating standard and lifecycle phases that do not align. (The template does not contain a cross-check for this.) It is assumed that the creator of the respective model instances is knowledgeable in the field.

Table 4: SMC Product Carbon Footprint

idShort:	ProductCarbonFootprint Note: a different idShort might be used, if it is unqiue in the Submodel.		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductCarbonFootprint/1/0		
Parent:	SM CarbonFootprint (https://admin-shell.io/idta/CarbonFootprint/CarbonFootprint/1/0)		
Explanation:	Balance of greenhouse gas emissions along the entire life cycle of a product in a defined application and in relation to a defined unit of use		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**Example**	
[SML] PcfCalculationMethod	[IRI] https://admin-shell.io/idta/CarbonFootprint/PcfCalculationMethods/1/0 Standards, methods for determining the greenhouse gas emissions of a product.	n/a	1
[Property] PcfCO2eq	[IRDI] 0173-1#02-ABG855#003 Sum of all greenhouse gas emissions of a product according to the quantification requirements of the standard.	[decimal] 17.2	1
[Property] ReferenceImpactUnitForCalculation	[IRDI] 0173-1#02-ABG856#003 Quantity unit of the product to which the PCF information on the CO_2 footprint refers. Value List based on ECLASS Version 15 (see 2.6) Note 1: The usage of values that are not given in this table is possible, but not recommended as it may reduce compatibility.	[string] “piece”	1
[Property] QuantityOfMeasureForCalculation	[IRDI] 0173-1#02-ABG857#003 provides the quantity number of pieces or mass or volume to compute the impact of climate change or product carbon footprint.	[double] 5.0	1
[SML] LifeCyclePhases	[IRI] https://admin-shell.io/idta/CarbonFootprint/LifeCyclePhases/1/0 List of Life cycle stages of the product according to the quantification requirements of the standard to which the PCF carbon footprint statement refers.	n/a	1

[File] ExplanatoryStatement	[IRI] https://admin-shell.io/idta/CarbonFootprint/ExplanatoryStatement/1/0 Explanation required or provided to ensure that a footprint communication can be properly understood by a purchaser, potential purchaser, or user of the product.	Statement.pdf	0..1
[SMC] GoodsHandoverAddress	[IRI] https://admin-shell.io/zvei/nameplate/1/0/ContactInformations/AddressInformation supplementalSemanticId: https://admin-shell.io/smt-dropin/smt-dropin-use/1/0 ; 0112/2///61360_7#AAS002#001 ; 0173-1#02-AAQ837#008 indicates the hand-over address of the goods transport. Note: this set of information is defined by SMT drop-in “Address Information”	n/a	1
[Property] PublicationDate	[IRI] https://admin-shell.io/idta/CarbonFootprint/PublicationDate/1/0 The UTC timestamp on which a Product Carbon Footprint (PCF) - a calculation of a product's total greenhouse gas emissions - was created and published	[dateTime]	1
[Property] ExpirationDate	[IRI] https://admin-shell.io/idta/CarbonFootprint/ExpirationDate/1/0 End date up to which a study or data collection for calculating an ecological footprint is considered current and valid before an update or new calculation is required.	[dateTime]	0..1

2.2.4. SML PcfCalculationMethods

Table 5: SML PcfCalculationMethods

idShort:	PcfCalculationMethods		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/PcfCalculationMethods/1/0		
Parent:	SMC ProductCarbonFootprint (https://admin-shell.io/idta/CarbonFootprint/ProductCarbonFootprint/1/0)		
Explanation:	List of Standards for determining the greenhouse gas emissions of a product.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**Example**	
[Property] PcfCalculationMethod	[IRDI] 0173-1#02-ABG854#003 Standard, method for determining the greenhouse gas emissions of a product. Value List (0173-1#09-AAO115#003) based on ECLASS Version 15 (see 0) Note: Further values with corresponding semanticIds can be added to the Value List. Note: For values not given in the table, use SMC „ProductOrSectorSpecificRule“.	[string] “ISO 14067”	1

2.2.5. SML LifeCyclePhases

Table 6: SML LifeCyclePhases

idShort:	LifeCyclePhases		
Class:	SubmodelElementList (SML)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/PcfCalculationMethods/1/0		
Parent:	SMC ProductCarbonFootprint (https://admin-shell.io/idta/CarbonFootprint/ProductCarbonFootprint/1/0)		
Explanation:	List of life cycle stages of the product according to the quantification requirements of the standard to which the PCF carbon footprint statement refers		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**Example**	
[Property] LifeCyclePhase	[IRDI] 0173-1#02-ABG858#003 Life cycle stages of the product according to the quantification requirements of the standard to which the PCF carbon footprint statement refers. Value list based on ECLASS Version 15 (see 2.7)	[string] “C4 - landfill”	1

2.2.6. SMC ProductOrSectorSpecificCarbonFootprint

This SMC supplies a structure for denoting product group or sector specific PCFs.

Table 7: SMC ProductOrSectorSpecificCarbonFootprint

idShort:	ProductOrSectorSpecificCarbonFootprint Note: a different idShort might be used, if it is unique in the Submodel.		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificCarbonFootprint/1/0 Note: a supplementalSemanticId might be used for a product group or sector specific PCF		
Parent:	CarbonFootprint (SM)		
Explanation:	Product Carbon Footprint, which is determined in accordance with sector-specific or product group-specific rules or guidelines and covers the entire life cycle or specific parts of a product's life cycle.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SML] PcfCalculationMethod	[IRI] https://admin-shell.io/idta/CarbonFootprint/PcfCalculationMethods/1/0 Standards, methods for determining the greenhouse gas emissions of a product.	n/a	1
[SMC] ProductOrSectorSpecificRule	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificRule/1/0 Contains further information on the product-specific or sector-specific rule used to calculate the carbon footprint.	n/a	1
[SMC] ExternalPcfApi	[IRI] https://admin-shell.io/idta/CarbonFootprint/ExternalPcfApi/1/0 An external service that provisions carbon footprint information via an interface, allowing on-demand retrieval of this data.	n/a	0..1
[SMC] PcfInformation	[IRI] https://admin-shell.io/idta/CarbonFootprint/PcfInformation/1/0 A section in which further content is listed according to the calculation method for the Product Carbon Footprint.	n/a	1

2.2.7. SMC ProductOrSectorSpecificRule

This SMC supplies a structure for denoting product group or sector specific rules.

Table 8: SMC ProductOrSectorSpecificRule

idShort:	ProductOrSectorSpecificRule		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificRule/1/0		
Parent:	ProductOrSectorSpecificCarbonFootprint (SMC)		
Explanation:	Contains further information on the product-specific or sector-specific rule used to calculate the carbon footprint.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] PcfRuleOperator	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificRule/Operator/1/0 Organization that defines and implements specific instructions and methods for calculating and monitoring the carbon footprint of a product or sector.	[string] WBCSD	1
[Property] PcfRuleName	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificRule/Name/1/0 Standard, method for determining the greenhouse gas emissions of a product	[string]	1
[Property] PcfRuleVersion	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificRule/Version/1/0 Specific version or revision of the rule used to calculate the carbon footprint of a product.	[string]	0..1
[File] PcfRuleOnlineReference	[IRI] https://admin-shell.io/idta/CarbonFootprint/ProductOrSectorSpecificRule/OnlineReference/1/0 Online PCF calculation methodology reference that provides detailed instructions and guidelines for calculating a product's carbon footprint.	[string]	0..1

2.2.8. SMC ExternalPcfApi

This SMC supplies a structure for denoting a external footprint API.

Table 9: SMC ExternalPcfApi

idShort:	ExternalPcfApi		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/ExternalPcfApi/1/0		
Parent:	ProductOrSectorSpecificCarbonFootprint (SMC)		
Explanation:	An external service that provides carbon footprint information via an interface, allowing on-demand retrieval of this data when required.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[Property] PcfApiEndpoint	[IRI] https://admin-shell.io/idta/CarbonFootprint/ExternalPcfApi/Endpoint/1/0 Specific URL or address that can be used to retrieve data from external sources to calculate the carbon footprint of a product.	[string]	1
[Property] PcfApiQuery	[IRI] https://admin-shell.io/idta/CarbonFootprint/ExternalPcfApi/Query/1/0 Specific query that can be used to retrieve data from external sources to calculate the carbon footprint of a product.	[string]	1

2.2.9. SMC PcfInformation

This SMC supplies a structure for denoting further content according to a calculation method for the Product Carbon Footprint information.

Table 10: SMC PcfInformation

idShort:	PcfInformation		
Class:	SubmodelElementCollection (SMC)		
semanticId:	[IRI] https://admin-shell.io/idta/CarbonFootprint/PcfInformation/1/0		
Parent:	ProductOrSectorSpecificCarbonFootprint (SMC)		
Explanation:	A section in which further content is listed according to the calculation method for the Product Carbon Footprint.		
[SME type]	**semanticId = [idType]value**	**[valueType]**	**card.**
idShort	**Description@en**	**example**	
[SME] ArbitratyContent	[IRI] https://admin-shell.io/SMT/General/Arbitrary Free area for structured collection of specific items of a specific PCF.	n/a	0..n

2.3. Exemplary mapping of PACT to the SMT

The specification allows for the inclusion of additional standards and PCF exchange formats. For example, PACT 2.2, as illustrated in Figure 5, can be mapped into the SM. For this purpose, the PACT JSON exchange format[10] was included into the structure of the AAS Submodel. In addition, a PACT-compliant API including query parameters was linked to the ExternalPcfApi SMC of the Submodel so that client applications compliant with the PACT exchange format can load the JSON format directly.

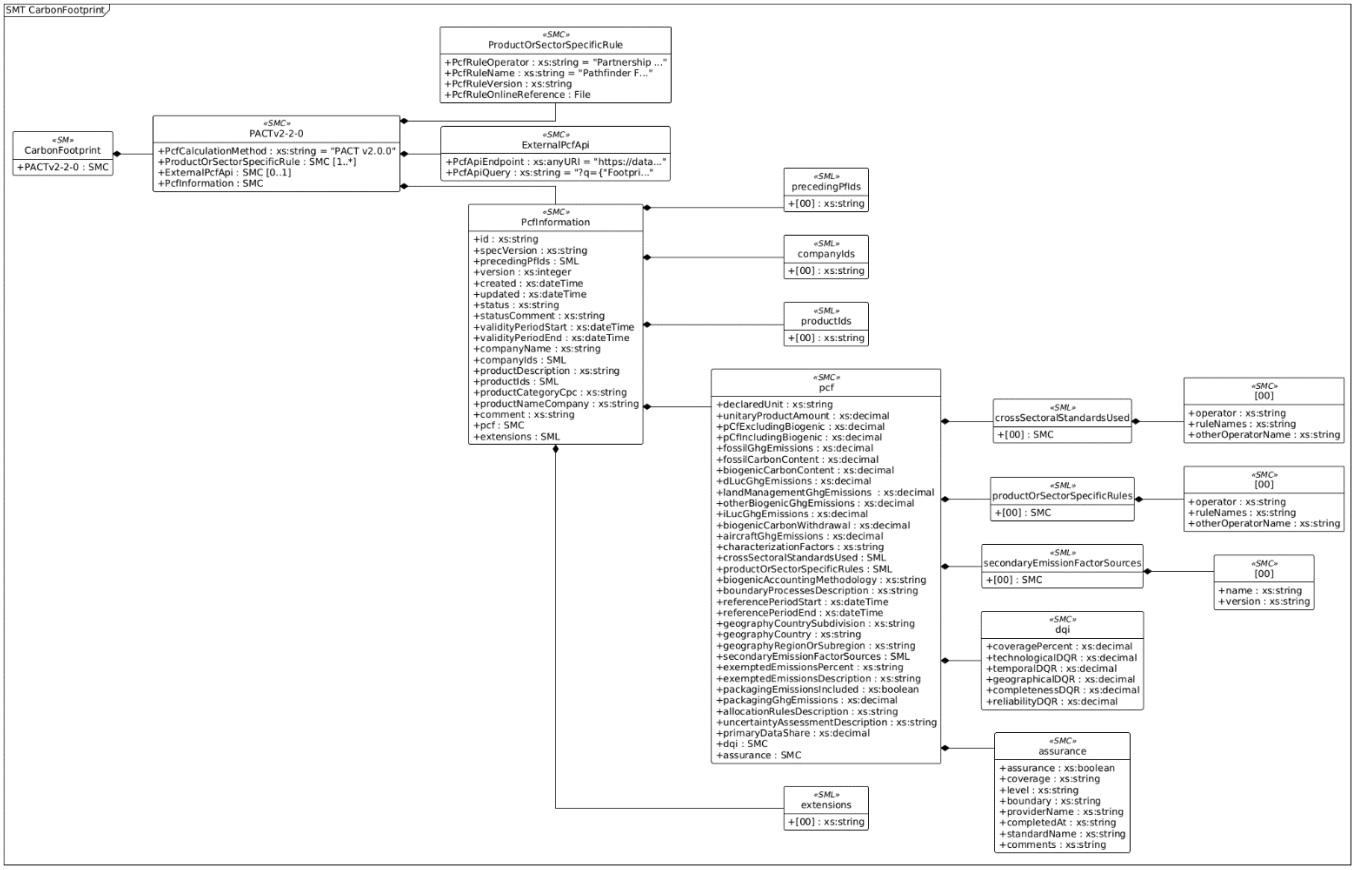

Figure 5: PACT v2.2 Mapping to the Submodel Carbon Footprint

[10] https://wbcsd.github.io/tr/2024/data-exchange-protocol-20240410/#elementdef-carbonfootprint

2.4. Exemplary mapping of Catena-X to the SMT

The Catena-X Product Carbon Footprint Rulebook focusses one production of vehicles and, thus, PCF accounting spans from cradle-to-(factory)gate for vehicles and components and all intermediate products. A SMT “Pcf” with semanticId “urn:samm:io.catenax.pcf:7.0.0#Pcf” has already been published for this sector.[11] (see Figure 6)

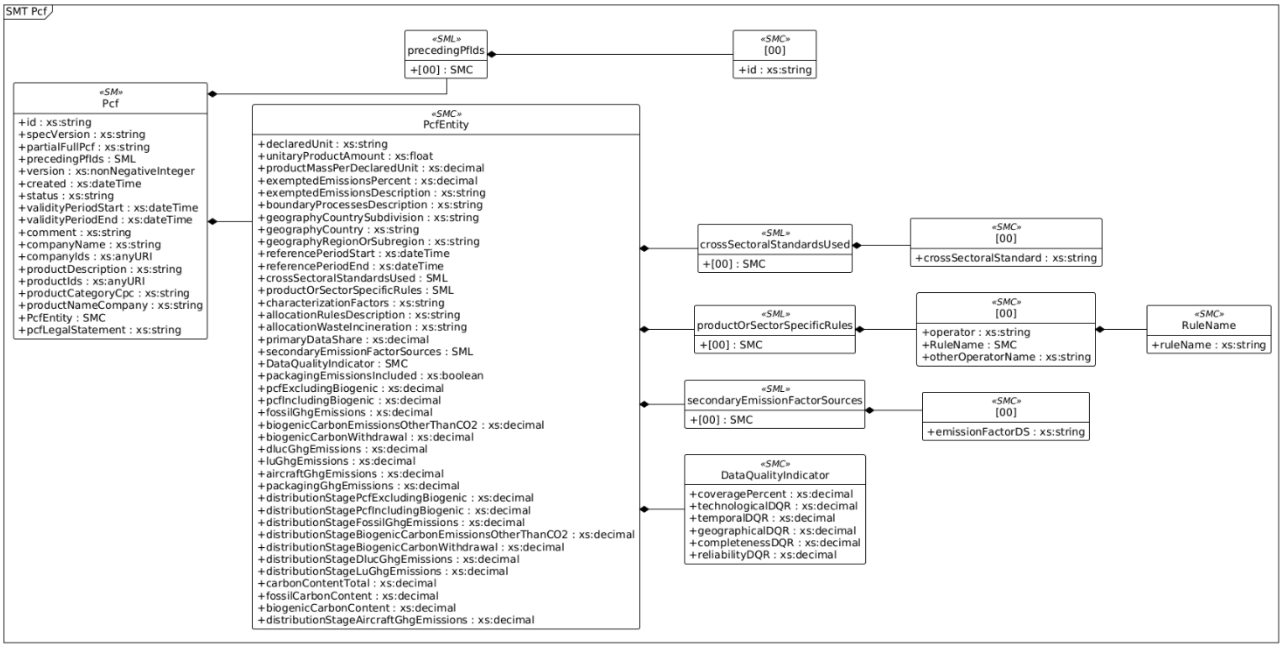

Figure 6: Catena-X SMT Pcf

If mapping is to be done in this submodel, the Catena-X SMT Pcf would be classified as SMC PcfInformation within the SML ProductOrSectorSpecificRule (see Figure 7).

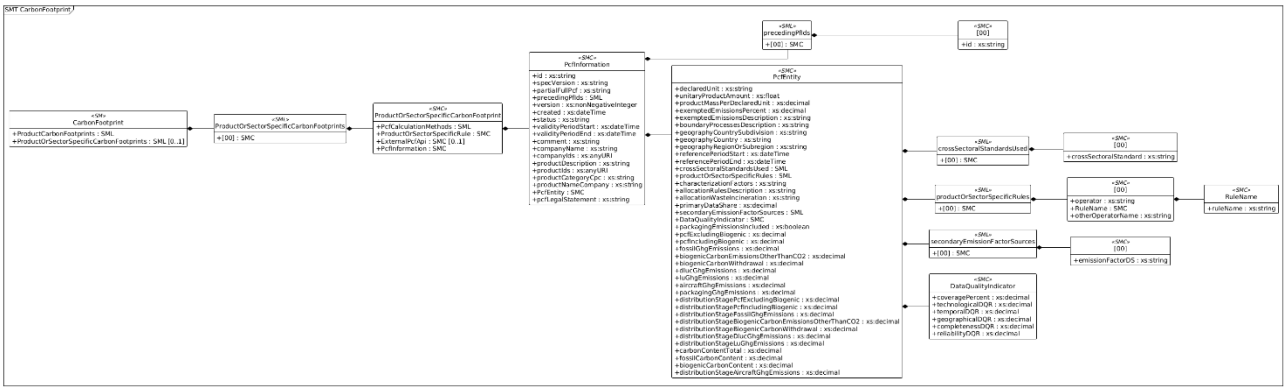

Figure 7: Catena-X SMT Pcf mapped as SMC within SMT Carbon Footprint

Note – For the automotive sector it is recommended to use the Catena-X SMT independently and to use this CarbonFootprint SMT as a supplement.

[11] https://github.com/eclipse-tractusx/sldt-semantic-models/blob/main/io.catenax.pcf/7.0.0/gen/Pcf.aasx

2.5. Value List PcfCalculationMethods

This Value List is based on ECLASS 15 with IRDI 0173-1#09-AAO115#003

Table 11: Value List PcfCalculationMethods

value	valueId
EN 15804	0173-1#07-ABU223#003
GHG Protocol	0173-1#07-ABU221#003
IEC TS 63058	0173-1#07-ABU222#003
IEC 63366	0173-1#07-ACA792#002
ISO 14040, ISO 14044	0173-1#07-ABV505#003
ISO 14067	0173-1#07-ABU218#003
PEP Ecopassport	0173-1#07-ABU220#003
PACT v2.0.0	0173-1#07-ACC003#001
PACT v1.0.1	0173-1#07-ACC004#001
PACT v3.0.0	0173-1#07-ACC012#001
TFS v2	0173-1#07-ACC005#001
TFS v3	0173-1#07-ACC010#001
Catena-X v2	0173-1#07-ACC006#001
Catena-X v1	0173-1#07-ACC007#001
Catena-X v3	0173-1#07-ACC011#001
BS PAS 2050	0173-1#07-ACC008#001
IEC 63372	0173-1#07-ACC019#001
…	Note: Further values with corresponding semanticIds can be added.

2.6. Value List PCFReferenceValueForCalculation

This Value List is based on ECLASS 15 with IRDI 0173-1#09-AAO323#003

Table 12: Value List PCFReferenceValueForCalculation

value	valueId
g	0173-1#07-ABZ596#003
kg	0173-1#07-ABZ597#003
t	0173-1#07-ABZ598#003

ml	0173-1#07-ABZ599#003
l	0173-1#07-ABZ600#003
cbm	0173-1#07-ABZ601#003
qm	0173-1#07-ABZ602#003
piece	0173-1#07-ABZ603#003
kWh	0173-1#07-ACB997#001
…	Note: Further values with corresponding semanticIds can be added.

2.7. Value List LifeCyclePhase

This Value List is based on ECLASS 15 with IRDI 0173-1#09-AAO113#003

Table 13: Value List LifeCyclePhase

value	valueId
A1 - raw material supply (and upstream production)	0173-1#07-ABU208#003
A1-A3	0173-1#07-ABZ789#003
A2 - cradle-to-gate transport to factory	0173-1#07-ABU209#003
A3 - production	0173-1#07-ABU210#003
A4 - transport to final destination	0173-1#07-ABU211#003
A4-A5	0173-1#07-ACC013#001
A5 - Installation	0173-1#07-ACC016#001
B1 - usage phase	0173-1#07-ABU212#003
B1-B7	0173-1#07-ACC014#001
B2 - maintenance	0173-1#07-ABV498#003
B3 - repair	0173-1#07-ABV497#003
B4 - Replacement	0173-1#07-ACC017#001
B5 - update/upgrade, refurbishing	0173-1#07-ABV499#003
B6 - usage energy consumption	0173-1#07-ABV500#003
B7 - usage water consumption	0173-1#07-ABV501#003
C1 - reassembly	0173-1#07-ABV502#003
C1-C4	0173-1#07-ACC015#001
C2 - transport to recycler	0173-1#07-ABU213#003
C2-C4	0173-1#07-ACC018#001
C3 - recycling, waste treatment	0173-1#07-ABV503#003
C4 - landfill	0173-1#07-ABV504#003
D - reuse	0173-1#07-ABU214#003

Annex A. Explanations on used table formats

1. General

The tables used in this document outline information as concisely as possible. They do not convey all information about Submodels and SubmodelElements. For this purpose, the definitive definitions are provided in a separate file in the form of an AASX file of the Submodel template and its elements.

2. Tables on Submodels and SubmodelElements

For clarity and brevity, a set of rules is applied to the tables describing Submodels and SubmodelElements:

- The tables follow in principle the same conventions as in [5].
- The table heads abbreviate 'cardinality' with 'card'.
- The tables often place two pieces of information in different rows of the same table cell. In this case, the first information is marked out by sharp brackets [] form the second information. A special case is the semanticIds, which are marked out by the format: (type)(local)[idType]value.
- The types of SubmodelElements are abbreviated:

SME type	SubmodelElement type
Property	Property
MLP	MultiLanguageProperty
Range	Range
File	File
Blob	Blob
Ref	ReferenceElement
Rel	RelationshipElement
SMC	SubmodelElementCollection

- If an idShort ends with '__00__', it indicates a suffix of the respective length (here: 2) of decimal digits to ensure the idShort is unique. A different idShort might be chosen, as long as it remains unique within the parent's context.
- The Keys of semanticId in the main section feature only idType and value, such as: [IRI]https://admin-shell.io/vdi/2770/1/0/DocumentId/Id. The attributes "type" and "local" (typically "ConceptDescription" and "(local)" or "GlobalReference" and (no-local)") need to be set accordingly; see [6].
- If a table does not contain a column with the "parent" heading, all represented attributes share the same parent. This parent is denoted in the the table' header.
- Multi-language strings are represented by the text value followed by the '@'-character and the ISO 639 language code: example@EN.
- The [valueType] is provided only for properties.
- For some properties, a valueList is given, meaning that only values from this list should be used. It is recommended to use the given valueID as a reference. If both the value and the valueId are present, the value must be identical to the value of the referenced coded value in valueId.

3. Abbreviations

- EPD Environmental Product Declarations
- GHG Greenhouse Gas
- IRDI International Registration Data Identifier
- PCF Product Carbon Footprint
- TCF Transport Carbon Footprint
- WBCSD World Business Council for Sustainable Development

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