Global Battery Alliance

Guidelines for Track & Trace service providers on ESG data declaration, exchange, and aggregation

(GHG Case)

Exchanging and aggregating GHG emissions data along the value chain to calculate the total GHG emissions of a battery.

Enabling Battery Regulation compliance

GBA INTERNAL - CONFIDENTIAL

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1. Introduction

1.1. Purpose and scope

These Guidelines for Track & Trace service providers ("Guidelines") describe the proposed way of the Global Battery Alliance (GBA) to report, declare, exchange, and aggregate ESG data along the battery value chain. The current version mainly addresses only one of multiple GBA Battery Passport (GBA BP) ESG issues and indicator – the Green House Gas emissions, however other indicators will follow in future iterations of this document

Being one of a few expected quantitative ESG indicators it demands a proper mathematical model of aggregation and summation. Other ESG issues and indicators (mainly qualitative ones) will demand different aggregation principles, however the approach, principles and mechanics of data collection and exchange will remain mostly the same.

Moreover, the principles of parallel data collection from individual companies are established to address the need of collection of company / process specific ESG data that can not be estimated, assumed or somehow else approximated with secondary type of data. Primary data is needed for accurate and transparent calculation of product (battery) level ESG metrics including the battery GHG emissions. Given anticipated dynamics in supply value chains, induced by differentiating metrics like the "GBA ESG Score" in particular and digital product passports in general, the GBA advocates for parallel approach to data collection. On contrast to single actor assessment methodology we believe that metrics of final Battery Passport should be based on individual process's (and a company behind it) reports on its ESG performance regardless of composition of a particular battery value chain. The change of a particular supplier in the process of battery manufacturing should lead to the new passport but not at cost reassembling the whole passport from scratch or diluting its information with a relatively big portion of secondary / assumed / estimated data.

The Guidelines (in the current version) aim to:

- establish individual boundaries of GHG emissions reporting on a process / company level (report on individual process performance rather than process performance and performance of all of its predecessors in the value chain);
- define how to aggregate GHG emissions data along the value chain into product level battery GHG emissions, total share of primary and secondary data involved;
- define the technical details for issuing, serialising, and exchanging product GHG emissions data between multiple Track & Trace solutions;
- define basic principles of how to make GHG declarations in particular and ESG data in general can be made verifiable and binding.

1.2. Status Quo

Currently supply chain Track & Trace solutions are already transporting relevant information from the source of the supply chain to the market ready OEM product. These existing solutions facilitate the exchange of information exclusively among supply chain actors who have implemented the same solution. To the extent of our familiarity, they do not allow the exchange of information between different Track & Trace solutions other than in a manual way. For actors such as raw material providers or pre-product manufacturers this means that they must prepare their product information for many different supply chain tools, each in different formats and with different requirements. This puts a high burden on the entire industry. As ESG regulations are increasing, digital solutions and standardisation need to be developed to simplify their fulfilment.

With these Guidelines, the GBA aims to standardize the information structure, enable information verifiability, and information authenticity, so that required Battery Passport content can be exchanged between different Track & Trace solutions in an easy, standardised and trustworthy way.

2. Content requirements

This chapter defines the terms used in the Guidelines and the minimum requirements to exchange GHG emissions information.

2.1. General Rules and Definitions

The GBA Greenhouse Gas Rulebook[1] states major content requirements to data that need to be collected for a proper Battery GHG Emissions Declaration. In addition to terms and definition of that rulebook we need to introduce a few new concepts that aim to complement the rulebook and structure individual companies and Track & Trace solution providers effort while reporting and aggregation GHG figures.

Product. When the term product is used in this document, it refers to a final product placed on the market or an intermediary product of a battery, comparable to a material or component used in a battery.

Inbound Product GHG Emissions (*short:* IB PGE). The GHG emissions associated with all direct materials and components delivered to a production site which are beyond the direct control of the supplier. For example, when producing precursor for NCM type of battery, the GHG emissions that come with manganese and cobalt is considered as the inbound GHG emissions of the product. *Note*, the *first process in a chain does not consider the inbound GHG emissions.*

Inhouse Product GHG Emissions (*short:* IH PGE) The IH PGE is the GHG emissions accrued during a specific production step in the value chain on top of the inbound GHG emissions of the production components. It encompasses all types of energy, indirect materials, etc., and that can be *directly controlled* by the production facility.

The total **Product GHG Emissions (PGE)** of a product is calculated by adding up the PGE of its pre-products under the consideration of a norm (IB PGE) plus the Inhouse GHG Emissions of the production step (IH PGE). The result in each step should be normalized to a unit of the product in a strong accordance with the GBA GHG rulebook requirements, e.g., mass unit of production, mass unit of a specific element contained in a compound (together with its concentration),, etc.

Norm. A norm (also known as utilization coefficient or conversion factor) is the value defining the material coefficients, utilization factors, or percentages of each pre-product in a newly manufactured product. For example, number of FUs of pure metal (in kg) needed for production of 1 kg of precursor, number of FUs of cathode materials (in kg) per one battery cell, number of FUs of battery cells per one battery pack, etc.

Unit of Measurement: The Product GHG Emissions of a product are stated in **kgCO2eq** (short kg) per functional unit of the product. For more information around the term "unit", please refer to the GBA GHG rule book.

Functional unit (FU): The FU is the quantified performance of a product system for use as a reference unit (ISO 14040:2006, section 3.20) and serves as input for the above-described Norm. For **Mining and Refining** the Functional Unit is 1 kg of metal contained in the respective material (with stated concentration). Only for graphite, the functional unit is 1 kg of synthetic or natural graphite. For **pCAM and CAM** the FU is supply of 1 kg or tonne of pCAM or CAM for lithium-ion batteries (e.g., 1kg of 180mAh/g NMC622 CAM). For **cell manufacturing**, FU is one piece. For **module assembly** the FU is supply of one LIB module. For **battery assembly** the FU is supply of one lithium-ion battery pack for electric vehicle assembly and/or one kWh of the total energy provided over the expected service life by the battery system (EU, 2023).

[1] GBA, GHG rulebook, Version 2.0, available at: https://www.globalbattery.org/media/publications/gba-rulebook-v2.0-master.pdf

Validated Data: Validated data in the context of these Guidelines is data that is validated by a trusted third party or by a trusted algorithm. Trusted third parties or algorithms have proven to adhere to the GBA rulebooks and guidelines and are therefore accredited. The accreditation process will be defined by the GBA in future

Primary & secondary data: The Product GHG Emissions consist of a certain percentage of primary data and secondary data. The definition of these terms can be found in the GBA GHG Rulebook.

Accredited Track & Trace Solution: A accredited track & trace solution has proven that it follows the GBA rulebooks and this guideline to calculate and aggregate GHG emissions. The solution can manually calculate the GHG emissions of the upstream supply chain but also use an algorithm that follows these Guidelines. Thus, also Track and Trace tools can receive a GBA accreditation.

2.2. GHG aggregation scenarios overview

This section describes the possible scenarios for GHG emissions aggregation, data quality, and data exchange.

Scenario 1: The GHG emissions aggregation across the entire value chain is performed in "ideal conditions". In this scenario:

- All actors are known and individually report the inhouse GHG emissions which is mostly based on primary data.
- All material flow coefficients (amounts and norms) are known and stable, with no market dynamics involved at this stage.
- Only *one* accredited Track & Trace solution is responsible for running the aggregation.

Scenario 2: The GHG emissions aggregation across the value chain is performed in "ideal conditions" with *multiple* Track & Trace solutions involved. In this scenario:

- All conditions from Scenario 1 apply.
- *Two or more* Track & Trace solutions, covering different actors of the value chain, are involved. This adds complexity around data exchange standards, identity and access management, responsibilities, and data validation.

Scenario 3: The GHG emissions aggregation across the value chain is performed with secondary data. In this scenario:

- Not all value chain actors are known nor individual "inhouse" data fully reported.
- Material flow coefficients (amounts and norms) are missing (secondary data) or unclear.
- A single Track & Trace solution is responsible for running the calculation.

Scenario 4: The GHG emissions aggregation across the value chain is performed by multiple Track & Trace actors. In this scenario:

- All conditions from Scenario 3 apply.
- Multiple Track & Trace solutions, covering different actors of the value chain, are involved. This adds complexity around data exchange standards, identity and access management, responsibilities, and data validation.

In these Guidelines we will reference to the scenarios above to give guidance around data exchange and data access between various actors.

2.3. Example Calculations for Scenario 2

This section shows an example calculation and PGE aggregation in a value chain section which is depicted in Figure 1. The diagram shows Scenario 2 where the Product GHG Emissions are calculated under optimal conditions with two different Track & Trace solutions.

A prerequisite is that accredited GHG Calculation Partners have calculated the Product GHG Emissions (PGE) and Inhouse GHG Emissions (IH PGE) of the respective pre-products and actors. Here, GHG Calculation Partner Y and Z are helping the Precursor and CAM Manufacturer to calculate their product GHG emissions (PGE).

In Step 1 of the aggregation Track & Trace vendor A providers collect those PGEs and IH PGEs from (decentral) sources, apply the norm of the product, and aggregate it to the new PGE of the precursor product (PGE 3). To collect GHG emissions data from the (decentral) sources, data vocabularies need to be defined, data exchange protocols and data verification methods need to be agreed on. Also, the Track & Trace vendor B needs the mandate from the Precursor Manufacturer to get access to the PGEs of its Tier 1 suppliers.

In Step 2 Track and Trace vendor C works in the same way and calculates PGE 5 from PGE 3, PGE 4 and the inhouse PGE of the CAM manufacturer.

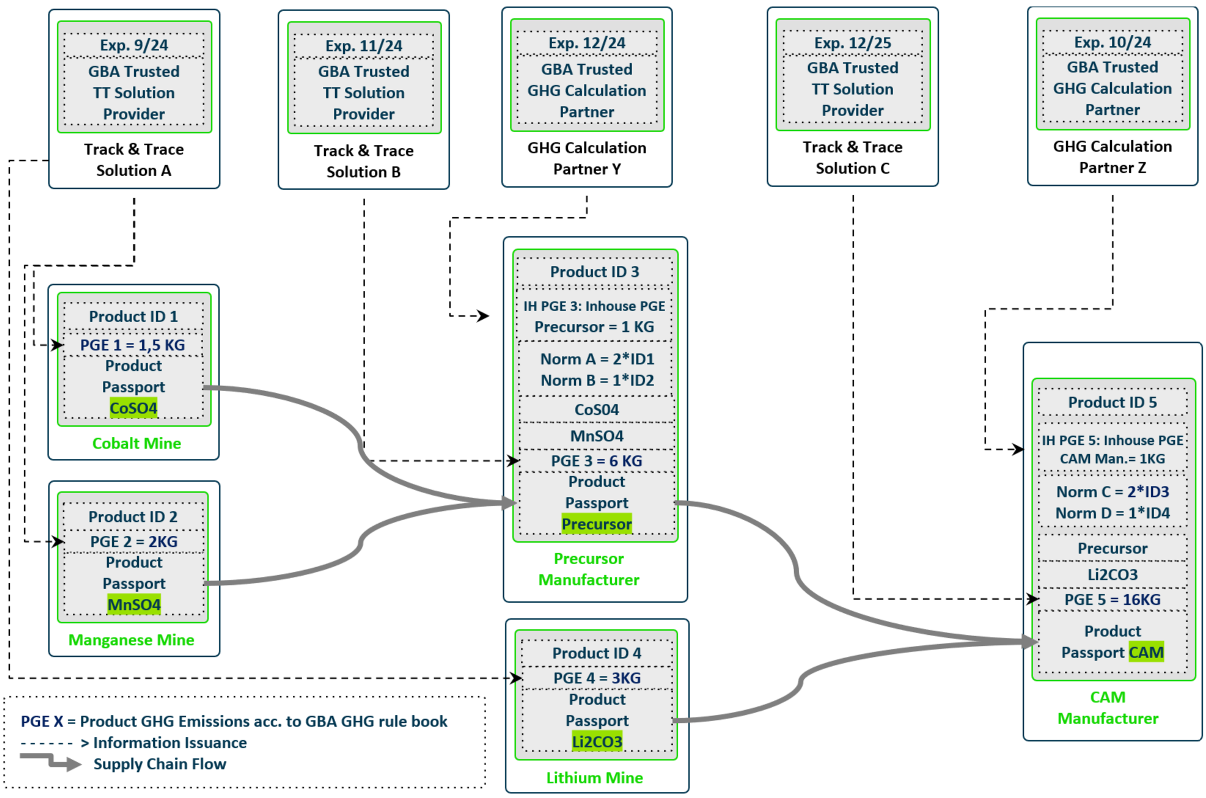

Figure 1: Supply Chain and actors in Scenario 2 (involving multiple Track & Trace solutions)

Step 1 – Calculation of the Precursor GHG Emissions. In this step,

- The cobalt product ID1 has a PGE 1 of 1,5 KG.
- The manganese product ID2 has a PGE 2 of 2KG.
- Norm A states that 2 functional units of cobalt are in the precursor product.
- Norm B states that 1 functional unit of manganese is in the precursor product.
- The Inhouse GHG Emissions (IH PGE 3) of the Precursor manufacturing step are calculated by the Track & Trace solution to be 1KG.

Thus, the total GHG emissions of the Precursor ID3 are **6 KG** (2 x **1,5 KG** + 1 x **2 KG** + **1 KG**) when using the formula below.

$$PGE3 = (NormA\ * PGE1) + (NormB * PGE2) +\ IH\ PGE\ 3$$

Figure 2: Formula for the Product GHG Emissions calculation of the Precursor Product

This formula can generalised with the following term:

$$PGE\ x = (NormA\ * PGE\ Supplier\ 1) + .. + (Norm\ Z * PGE\ Supplier\ n) +\ IH\ PGE\ x$$

Figure 3: Generalised Formula for the Product GHG Emissions calculation

Step 2 shows how the next level of the value chain is aggregated. Here the previously created precursor product and lithium are used as pre-products for the CAM product. The GHG emissions of these components are then calculated and incorporated into the overall footprint of the CAM product, along with the in-house PGE.

Step 2 – Calculation of the CAM GHG Emissions: In this step,

- The precursor product ID3 has GHG emissions of 6 KG.
- The lithium product ID4 has GHG emissions of 3 KG.
- Norm C states that 2 functional units of Precursor are in the CAM product.
- Norm D states that 1 functional unit of Lithium is in the CAM product.
- The Inhouse Product GHG Emissions of the CAM manufacturing step (IH PGE 5) is calculated by the T&T Solution to be 1KG.

Thus, the total GHG emissions of the CAM product ID5 (PGE5) is 2X 6KG + 1 x 3KG + 1KG= **16kg**

$$PGE5 = (NormC\ * PGE3) + (NormD * PGE4) +\ IH\ PGE\ 5$$

Figure 4: Formula for the Product GHG Emissions calculation of the Precursor Product

2.4. Example Calculations for Secondary Data

This section shows an example calculation and aggregation of GHG emissions data in a simple value chain as described in Scenario 3 or 4 adding the aspect of **secondary data**. Step 1 of the two-step example process is receiving the GHG emissions from a cobalt and a manganese mine to aggregate them and add them to the total GHG emissions of the precursor product.

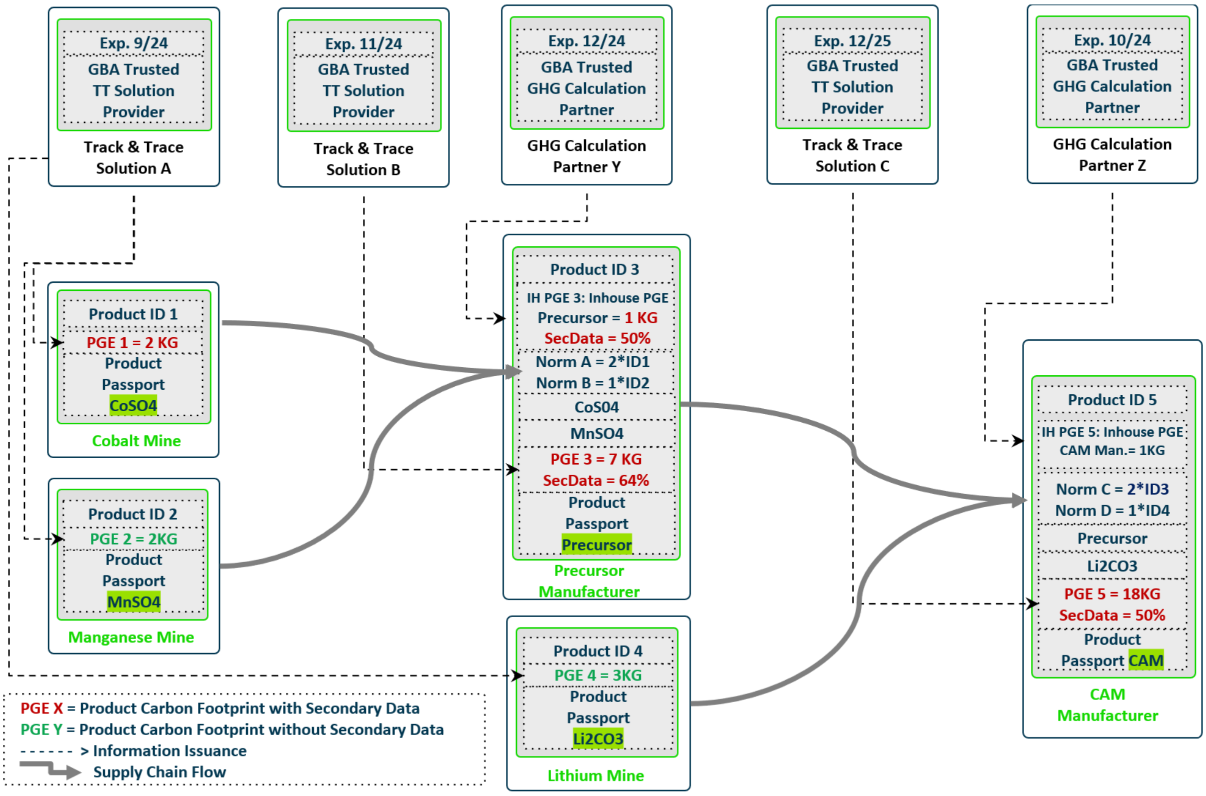

Figure 5: Aggregation of the GHG emissions data with secondary data at Level 1 (mining)

Step 1 – Calculation of the Precursor GHG Emissions with Secondary Data. In this step,

- The cobalt product ID1 has an estimated PGE of 2 KG using 100% secondary data (SecData). Secondary data naturally is higher than primary data. Therefore, we calculate with 2kg PGE for ID1 instead of 1,5 kg in the previous example.
- The manganese product ID2 has a PGE of 2KG without secondary data.
- Norm A states that 2 functional units of cobalt are in the precursor product.
- Norm B states that 1 functional unit of manganese are in the prec. product.
- The Inhouse Product GHG Emissions (IH PGE 3) of the Precursor manufacturing step is calculated by the GHG calculation partner to be 1KG using 50% secondary data.

Thus, the total GHG emissions of the Precursor ID3 are **7 KG** (2 x **2 KG** ID1 + 1 x **2 KG** ID2 + **1 KG** IH PGE3).

Secondary Data Calculation: The precursor contains of 2 parts of ID1 and 1 part of ID2. That means 4,5 kg out of 7kg of the Precursor Product's footprint is estimated taken from secondary data. That means <u>64% of precursor product </u>ID3 is calculated from secondary data. This percentage must be indicated in the PGE data sheet (`secData`). Below, please find the formula for this example calculation.

$$SecData\ PGE3 = \frac{2 *(100\%*2KG)+1 *(0\%*1KG)+(50\%*1KG)}{7KG} = 64\%$$

Figure 6: Calculation of Secondary Data for the precursor product.

When using the defined terms as placeholders, the formula looks as follows:

$$SecData\ PGE3 = \frac{NormA\ * (SecData\ PGE1 * PGE1) +\ NormB\ * (SecData\ PGE2 * PGE2) + (SecData\ IHPGE3 * IHPGE3)}{PGE3}$$

Figure 7: Calculation of Secondary Data for the precursor product.

A generalised formula that allows indefinite number (1 .. n) of suppliers suppliers looks as follows:

$$SecData\ PGEx = \frac{Norm\ n\ * (SecData\ PGE\ n * PGE\ n) +\ Norm\ (n+1) * (SecData\ PGE\ (n+1) * PGE\ (n+1) +\ \ldots .+(SecData\ IH\ PGE\ X * IH\ PGE\ X)}{PGEx}$$

Figure 8: Generalized formula to calculate the Secondary Data percentage of a product.

Step 2 shows how the next level of the value chain is aggregated. Here the above previously created precursor product and lithium are used as pre-products for the CAM product and how their GHG emissions are calculated accordingly.

Step 2 – Calculation of the CAM GHG Emissions: In this step,

- The precursor product ID3 has GHG emissions of 7 KG with 64% of secondary data.
- The lithium product ID4 has GHG emissions of 3 KG with 0% of secondary data.
- Norm C states that 2 functional units of Precursor are in the CAM product.
- Norm D states that 1 functional unit of Lithium is in the CAM product.
- The Inhouse GHG Emissions of the CAM manufacturing step (IH PGE 5) is calculated by the Track & Trace Solution to be 1KG and has 0% secondary data.

Thus, the total GHG emissions of the CAM product ID5 (PGE5) are 2 x 7KG + 1x 3KG + 1KG= **18kg**

Secondary Data Calculation: The CAM product contains 2kg of ID3 and 1kg of ID4. As shown in step 1, the PGE of ID3 is partially derived from secondary data, and, as a result, so is the PGE of the CAM product. That means that 8,96 kg out of 18kg of the CAMs' footprint is taken from secondary data which equals 50%. This percentage must be indicated in the PGE data sheet of the CAM product (`secData`).

$$SecData\ PGE5 = \frac{2 * (64\% * 7KG) + 1 * (0\% * 3KG) + (0\% * 1KG)}{18\ KG} = 50\%$$

Figure 9: Calculation of Secondary Data for the CAM product.

Note: The definition of Primary Data and Secondary Data is taken form the GBA GHG rulebook.

Note: The percentage of Secondary Data in a product can change daily due to changing suppliers in the value chain which theoretically leads to a frequently changing PGE. However, best practice is to update the GHG emissions of a (sub-) supply chain and thus of a product **once a month** However, the minimum requirement of the new EU Battery Regulation and the GBA GHG rulebook is to declare GHG emissions that are representative of the most recent available 12-month-period and to update it annually.

2.5. Multiple Track & Trace vendors with different competencies

This section describes Scenarios where multiple Track & Trace vendors are working for the same supplier but in different roles. In this example, one Track & Trace vendor has the **leading role**. This means that it has the mandate to collect GHG data from other Track & Trace vendors, from GHG calculation partners AND to calculate the total product GHG emissions. Other Track & Trace vendors "only" deliver GHG data from a sub-supply chain as shown in Figure 10 below.

In our diagram Track & Trace solution B has the leading role. On the one hand it collects data from multiple Cobalt upstream value chain partners and aggregates it to a total Cobalt GHG Emissions. On the other hand, it also has the mandate from the precursor manufacturer to collect the data of the Manganese supply chain from Track & Trace solution A, get the inhouse GHG emissions of the precursor manufacturer and to calculate (using Norm A and Norm B) the total GHG emissions of the precursor product.

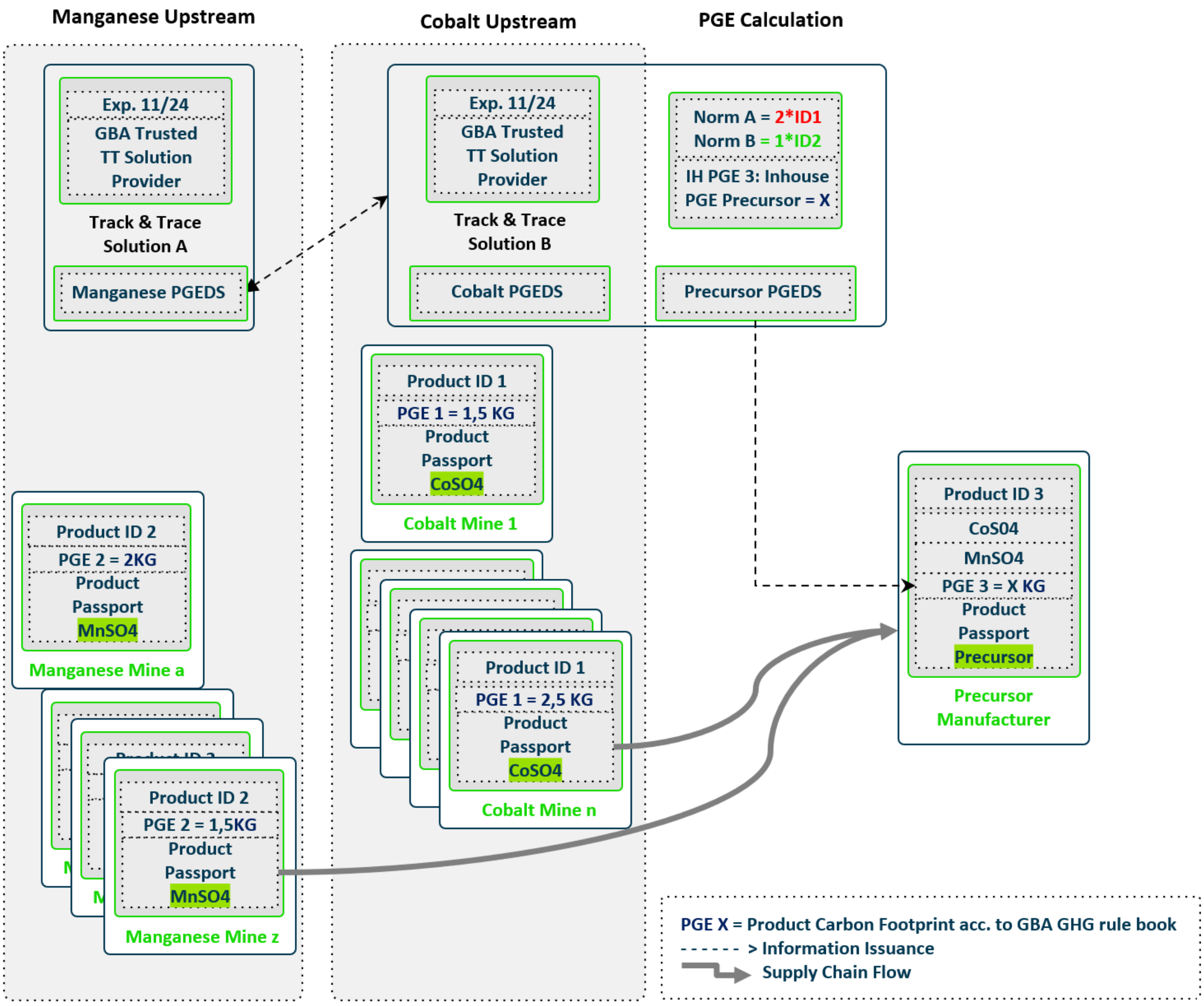

Figure 10: Calculation of Precursor PGE with two Track & Trace vendors

Note, the aggregation detail or granularity detail that Track & Trace solution A needs to share with Track & Trace solution B is not defined in these Guidelines. Supply chain actors will be incentivised to rather show more data than less. The granularity level can also change over time. It is possible that Track & Trace solution provider B only gets access to the **aggregated** value of the Manganese "Cluster", however, to validate the aggregated value of the manganese cluster and to avoid double counting it might be necessary to get access to some lower-level information.

3. Technical requirements

3.1. Product GHG Emissions Data Sheet Specification

The GHG Emissions Data Sheet of a product must include the following information. This Data Sheet can only be used for GHG emissions calculated following the GBA GHG rulebook.

Data Attribute	Key	Description	Data Type	Example Values
1. Product Identifier	productID (mandatory)	This is a globally unique product identifier in GTIN or DID format.	String	2211564566668, did:web:uuid: 123456
2.Product GHG Emissions	ghgEmissions (mandatory)	This is the total GHG Emissions of a product per product unit in kgCO2eq per unit, including Inbound – and Inhouse GHG Emissions following the GBA GHG rulebook.	Real	31.4
3.GHG emissions Unit of Measure	unit (mandatory)	The unit allowed is kg CO2eq.	String	kg
4.Functional Unit (FU)	fu	The functional unit describes one unit of a product, which can be used as input for the Norm calculation. E.g. for Mining the FU is 1kg of metal, for cell manufacturing the FU is one piece.	String	One piece
5.GBA GHG rulebook version	gbaRBVersion (mandatory)	This indicates the GBA GHG rulebook version that has been applied to this PGE data sheet.	Integer	1, 2
6.Secondary Data	secData (mandatory)	Percentage of Secondary data in the carbonFootprint	Real <=100	64 %
7. GHG Calculation Partner	ghgCalcPartner (mandatory)	Identifier that uniquely identifies the entity of the GHG Calculation Partner certified by the GBA to correctly apply the GBA GHG rulebook (DID, LEI).	String	8945003ZI7FAXE0E BY18
8.Product Manufacturer ID	manufacturerID (mandatory)	Identifier that uniquely identifies the entity of the manufacturer, accepted are DID and LEI. The LEI code of the EV Metals Group is 213800UN52KHL2C7IM29	String	213800UN52KHL2 C7IM29
9.T & T Solution Provier	ttSolution (mandatory)	This is a globally unique identifier of the T&T solution which has been accredited by the GBA to correctly apply the GBA GHG rulebook (DID, LEI).	String	did:web:dpp:rcsglo bal.com, 213800VAFP4NJEB QDX98
10.Issuance Date	iDate (mandatory)	Date on which the GHG emissions were issued by the Track & Trace solution provider which is after one year according to the EU battery regulation and the GBA GHG rule book.	DateTime	2024-01-01T10:15:00Z

11.Expiry Date	eDate (optional)	Date on which the GHG emissions credential expires. According to the EU Battery Regulation and the GBA GHG rulebook this is iDate + 1 year.	DateTime	2025-01-01T10:15:00Z
12.Version of Specification	pgedsVersion (optional)	Version of Track & Trace Guideline of this PGE data sheet vocabulary that has been used.	Integer	1
13.Comment	comment (optional)	General description or comment about this PGE data sheet credential	String	“A comment!”

Table 1: GHG Emissions Data Sheet Vocabulary

3.2. Product GHG Emissions Data Ontology Definition

This section describes the product GHG emissions data ontology. It outlines the relations between the data attributes to allow a better interpretation, automated processing and understanding of the given data.

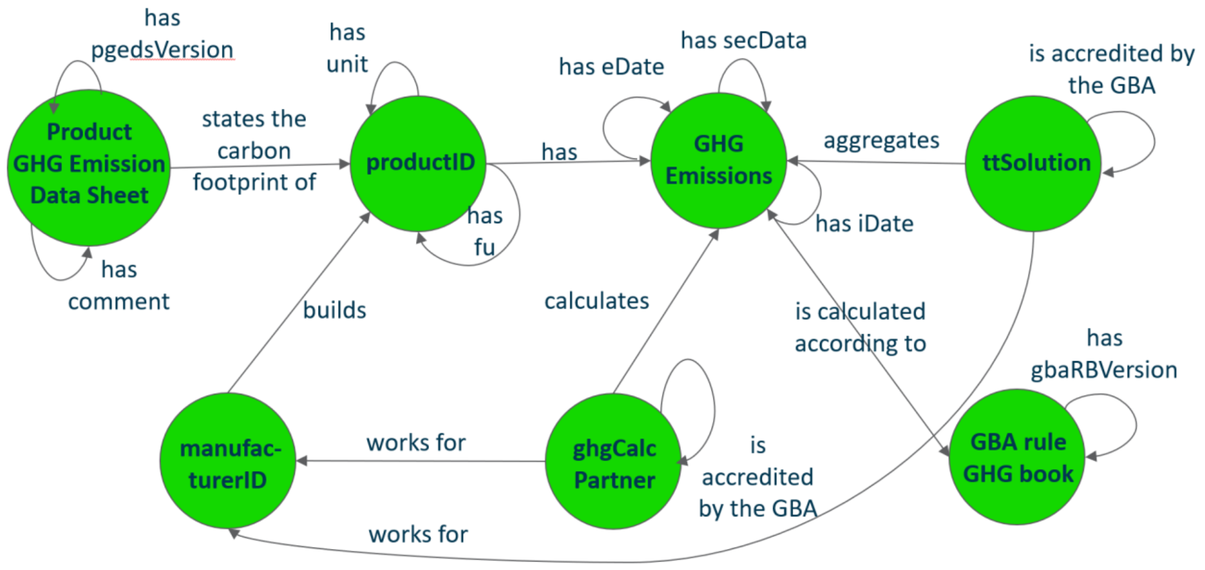

Figure 11: Product GHG Emissions Data Ontology

The GHG Emissions Data Sheet Ontology consists of the following triples.

- The Product GHG Emissions Data Sheet states the GHG Emissions of a `productID`.
- The Product GHG Emissions Data Sheet has a `cgedsVersion`.
- The Product GHG Emissions Data Sheet has a `comment`.
- A ProductID has a Product GHG Emissions (`ghgEmissions`).
- A GHG emissions has a percentage of secondary data (`secData`).
- A ProductID has a product `unit` of measure.
- A ProductID has a functional unit (`fu`).
- The manufacturer builds the `productID`.
- The Track &Trace Solution Provider (`ttSolution`) works for the `manufacturerID`.

- The Track &Trace Solution Provider is `accredited` by the GBA.
- The Track & Trace Solution aggregates GHG emissions data.
- The GHG Calculation Partner (`ghgCalcPartner`) works for the Product `manufacturerID`.
- The GHG Calculation Partner is `accredited` by the GBA.
- The GHG Calculation Partner calculates Product `GHG emissions`.
- The Product GHG emission is calculated according to the GBA GHG rulebook version (`gbaRGVersion`).
- The Product GHG emission data has an issuance Date (`iDate`).
- The Product GHG emission data has an expiry Date (`eDate`).

3.3. Implementation Profile Requirements

Implementation Profiles shall help actors in the value chain to exchange data with each other. Two parties implementing the same implementation profile are interoperable, i.e. can easily exchange, verify, and process PGE data sheets between them. This version of Guidelines defines one implementation profile. Other profiles can be added when at least two GBA members are supporting the profile.

General Requirements:

- Data confidentiality. Data is an asset that has value to the enterprises involved. Implementation profiles shall manage company data accordingly.
- Cloud solutions. Reusable Cloud-based solutions are preferred. Beyond the specific benefits of cloud-based solutions (cost efficiency, infrastructure and operation footprint, fast delivery, etc.), cloud-based solutions are most appropriate to exchange Product GHG emissions data sheets between supply chain actors.
- Ease of integration with third parties. Solution shall use standards and simple interfaces to make integration with 3rd parties easy with existing legacy infrastructures such as IAM, API Gateways, and Web Servers.
- Use of standards, no vendor lock-in. The solution should conform to defined standards that promote interoperability and portability for data, applications, and technology. The solution should be designed to allow interoperability with various implementations and shall not rely on a single vendor. Technology proposed in implementation profiles must be permissionless, that means that no party can discriminate another party and prevent it to offer a service that follows the implementation profile specifications. A profile preferably refers to open-source, free of charge technology implementations as the technological barrier for supply chain actors to make their PGE data sheets available should be as low as possible.

Figure 12 shows the overall technical architecture for exchanging PGE data sheets between the involved parties. Every participant needs to create a verifiable company identifier and anchor it to a trust ledger to participate at the ecosystem. Every company also needs to have a (signing) tool to create authentic and verifiable PGE data sheets and to handle the access control flows.

Track & Trace Solution A issues the Product GHG emissions data sheet for the Cobalt Mine and the Manganese Mine using the GHG emissions data sheet specification of this document. Track & Trace Solution B makes an access request to those data sheets, verifies them, fetches the Inhouse GHG emissions of the Precursor Manufacture, calculates the GHG emissions according to these Guidelines and then issues the Product GHG emissions data sheet for the Precursor Product. Track & Trace

Solution C can now request access to the Precursor Product GHG emissions to include them in the PGE of next supplier in the supply chain. The GBA accredits trusted GBA calculation partners and Track & Trace solutions (today still in a non-technical way).

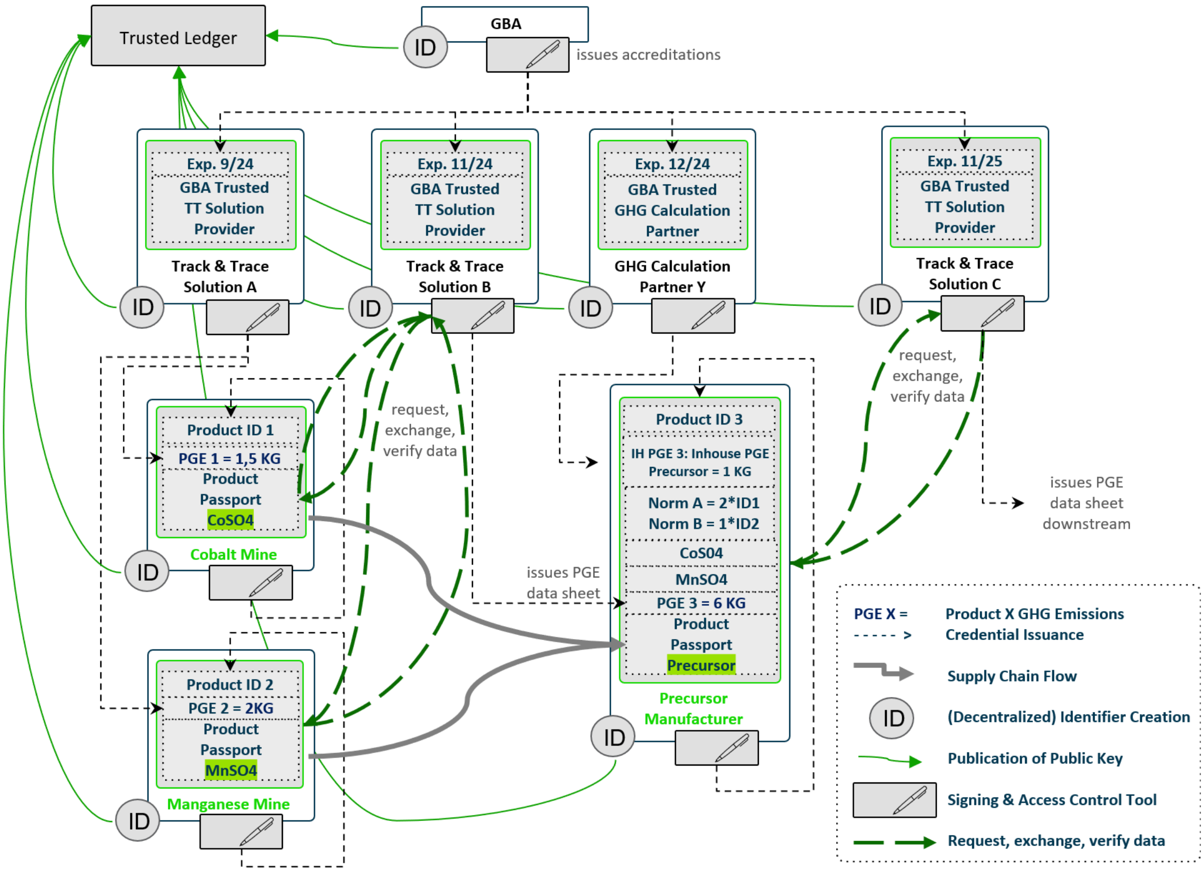

Figure 12: Overall PGE data sheet exchange architecture.

To achieve interoperability, standards must be applied in all areas. Standardization areas are (data carriers,) unique identifiers, access rights management, semantic standards, data processing and data exchange, (decentralized) storage, data authentication, as defined for example by the Stand.ICT Landscape of DDP Standards[2].

For the GBA Track & Trace Guidelines we define the following mandatory requirements in those standardization areas:

0. **Data carriers.** Data carriers are *not applicable* to these Guidelines as it targets B2B data exchange and neither interaction with QR codes nor NFC chips are planned to establish a data exchange connection.
1. **Unique Identifiers.** To exchange data electronically unique identifiers must be defined for companies and products. This way PGE data sheets can be issued for an unambiguous battery pre-product from a globally unique and identifiable company. Electronically verifiable companies can request access to the PGE data sheet.
2. **Access Control Mechanism**. The access control mechanism must specify how access to the PGE data sheet of a given supply chain actor is managed. Track & Trace solutions need to request access for the purpose of aggregating the total GHG emissions of a battery. The PGE data sheet is seen as highly confidential data by GBA members; an access control mechanism is therefore crucial for these Guidelines. Track & Trace solutions need a valid GBA Track &

[2] Stand.ICT Standard Landscape Report on Digital Product Passports, available at: Stand.ICT Landscape of DDP

Trace accreditation license (to access PGE data sheets of supply chain actors or other T&T solutions and to issue PGE data sheets).

3. **Semantic Standards**. Apart from what is already defined in 2.5. and 2.6 of these Guidelines, implementation profiles must suggest a file format for the Product GHG emissions data sheet. This file format must link to a schema definition, such as an XML-schema definition, for the syntactical validation of the PGE data sheet file. Additional definitions, such as SHACL are desirable to also validate the entered content and thus increase the data quality of the PGE data sheet.
4. **Data processing, data exchange, and data verification**. Implementation profiles MUST specify how a first connection between a data provider and a data user is established and how the PGE data sheet is securely exchanged. Error codes must be defined and a sequence diagram for the data flow must be provided. The issuer and the integrity/authenticity of the Product GHG emissions Data Sheets must be electronically verifiable. That means that PGE data sheet must be e.g. signed with a digital signature. Accepted signing mechanism are centralized and decentralized Public Key Infrastructure (PKIs) that hold the public keys on a Trusted Ledger. Voluntarily, solution providers can provide multi-tier confidentiality mechanisms to proof the authenticity of the PGE data, with e.g. validate the secondary data calculation with Zero-Knowledge-Proofs (ZKP). Those mechanisms can help improve business confidentiality of supply chain actors.

   Issuer verification: As an additional trust layer the requestor and issuer of PGE data sheets (Track & Trace solution) must be verifiable as an accredited GBA partner. Therefore, Track & Trace solutions need a valid GBA accreditation that is connected to the identity of the Track & Trace solution (e.g. a (verifiable) Legal Entity Identity).

5. **Decentralized Storage.** Going forward PGE data sheets SHOULD be decentrally stored and stay with their corresponding supply chain actor for data sovereignty. This avoids data pooling, data misuse, data redundance, and increases data timeliness. However, established central platforms, such as IMDS and other industry databases, should remain usable as long as the data is under the control of the supply chain actor and the data is verifiable.

Detailed technical specifications to fulfil these interoperability requirements must be provided in the Implementation Profiles in the Annex(es) of this document.

The total GHG emissions in the battery passport must be calculated according to the rules of the Greenhouse Gas rulebook Version 2.0 by the GBA.

3.4. Actors and Governance

The following table describes actors of the System Diagram in more detail:

Actor Name	Activities	Use Cases	Access rights / obligations
Supply Chain Actor	Make emissions available	Supply Chain actors are companies such as miners, refiners, CAM producers etc. of the Battery Value chain.	Make their data available for PGE calculation to GHG Calculation Partner.
GHG Calculation Partner	PGE calculation	Get data from Supply Chain actors to calculate the Inhouse PGE and issue an Inhouse PGE data sheet.	Access to internal data which is relevant to calculate the PGE via Supply Chain Actor Mandate

Track & Trace solution	PGE calculation upstream	Get PGE data from Supply Chain actors, GHG calculation partners or other T&T solutions. Calculate the upstream PGE and issue new PGE data sheet for downstream use.	Get access to PGE data sheets via OEM or Cell Manufacturer mandate.
	PGE aggregation of multiple T&T solutions	Manufacturer A has multiple T&T solutions for different arms of the value chain. Only one T&T has the **leading role** to aggregate the results from multiple T&T solutions to create the aggregated PGE of Manufacturer A.	Get access to PGE data sheets via OEM or Cell Manufacturer mandate.
GBA	Governance	Rulebook definition and further development. T&T solution and GHG calculation partner accreditation.	Access to PGE data in Battery Passport

Table 2: Track & Trace IT System Actors

The Governance describes the non-technical requirements and rules of the GBA PGE data sheet handling.

Track & Trace Solution Accreditation: Track & Trace Solutions are accredited by the Global Battery Alliance. To be accredited those partners need to understand and work according to the GHG Aggregation Guidelines set out in this document.

GHG Calculation Partner Accreditation: GHG Calculation Partners are accredited by the Global Battery Alliance. To be accredited those partners need to understand and work according to the latest version of the GBA GHG Rulebook.

Trust Lists: Accredited Track & Trace solutions and GHG Calculation Partners are published on a respective trust list by the GBA. This trust list is non-technical for the time being. For future iterations of these Guidelines a technical trust lists and the use of electronically verifiable credentials for accredited companies is taken into consideration.

Abbreviations

Abbreviations used as part of the rulebook and its process description are described here.

Abbreviation	Meaning
B2B	Business to Business
DID	Decentralized Identifier
GBA	Global Battery Alliance
GHG	Greenhouse Gas
HTTPS	Hypertext Transfer Protocol Secure
IAM / IDAM	Identity Access Management
JSON	JavaScript Object Notation
JWT	JSON Web Token
OEM	Original Equipment - / Car Manufacturer
PGE	Product GHG Emissions
VCI	Verifiable Credential Issuer
SSI	Self-Sovereign Identity
TLS	Transport Layer Security
UI	User Interface
VC	W3C Verifiable Credential
VP	W3C Verifiable Presentation
W3C	World Wide Web Consortium

Table 4: Abbreviations

Annex I – SSI Implementation Profile

Introduction

This implementation profile shall be interoperable with other efforts of the battery industry, such as Catena-X, CIRPASS, Battery Pass, and the United Nations Transparency Protocol. All these projects are based on decentralized identity concepts that enable self-sovereign identity (SSI) management in the supply chain, meaning that actors stay in control over their data in a decentralized setup.

SSI-Architecture with did:web

Below please find the architecture diagram for the SSI-Implementation Profile. It uses did:web as DID-Method, where the DID document is stored on the domain of the respective supply chain actor. This way no ledger technology (blockchain protocol) is required.

Track & Trace solution A creates Product GHG emissions data sheet for the Cobalt Mine and the Manganese Mine using the GHG emissions data sheet specification of this document. The PGE data sheets are signed with the public key of Track & Trace Solution A to ensure their authenticity, i.e. other participants of the ecosystem can verify that the data sheets really have been issues by Track & Trace Solution A and have not been modified since their creation. The Cobalt Mine and the Manganese Mine can now make those data sheet available on their websites, which functions as verifiable credential store.

Track & Trace Solution B gets the decentralised product identifiers of the Cobalt and Manganese products and finds their respective DID documents via a DID-resolver (not shown in the diaram). The DID-documents point the Solution B the credential store of the PGE data sheets. Track & Trace solution B now makes an access request to those data sheets and verifies them. The verification process is performed by getting the public key from the DID-document and verifying the PGE data sheet signature with it.

The Track & Trace Solution B now fetches the Inhouse GHG emissions of the Precursor Manufacturer, which have been issued by GHG Calculation Partner Y, calculates the GHG emissions according to these Guidelines and then signs and issues the Product GHG emissions data sheet for the Precursor Product. Track & Trace Vendor C can now request access to the Precursor Product GHG emissions to include them in the PGE of next downstream supplier.

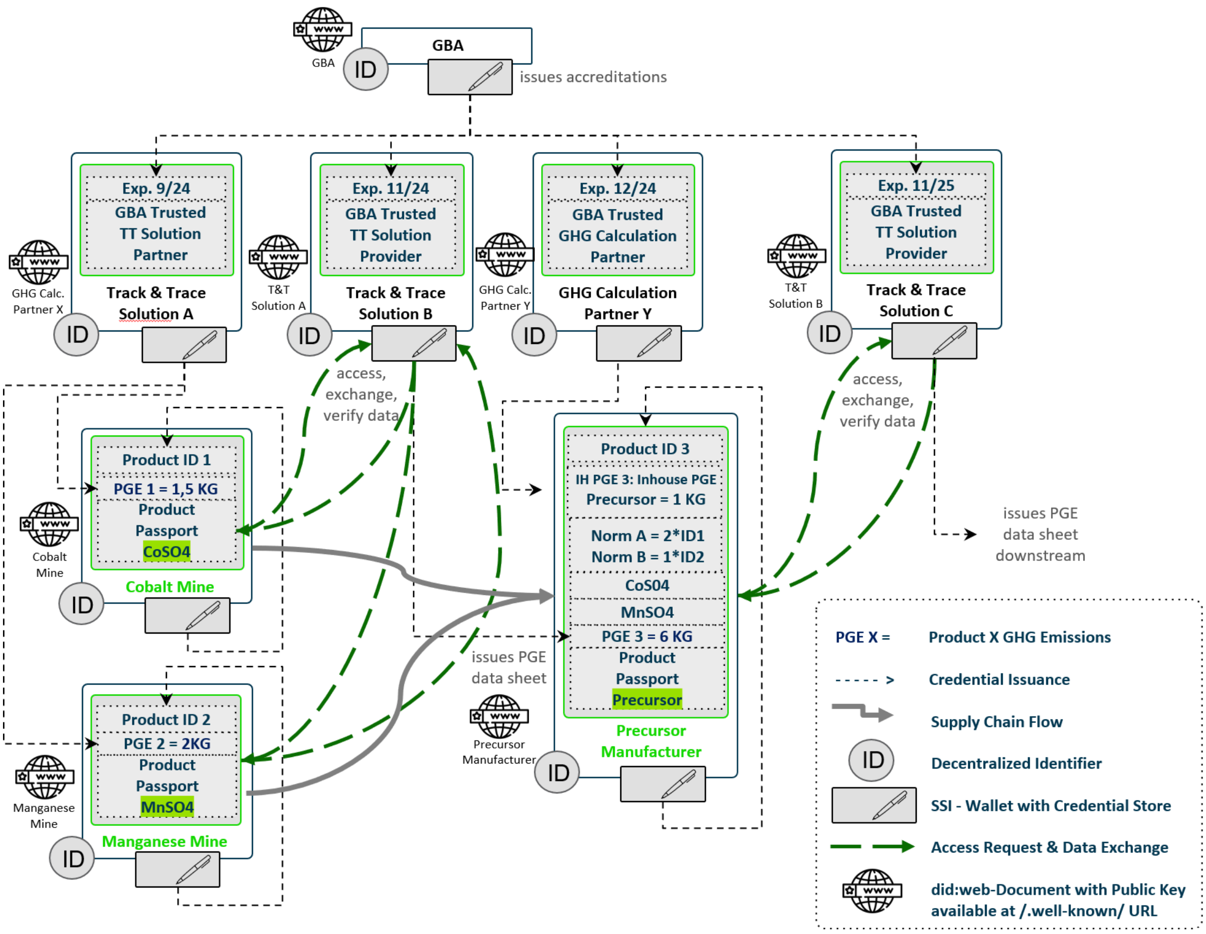

Figure I-1: IT System Architecture of the SSI-Implementation

Please find an explanation of all system components in the next section.

Components:

The following table describes all system components of the SSI-Implementation Profile:

System Name	System Description	System Type	System Owner
Trusted Ledger	DID-documents are stored at the secure web domain of each party.	Existing Web Server of Party	The respective participating party (Supply Chain Actor, T&T solution, GHG Calculation Partner, or GBA)
SSI Wallets	Wallet creating decentralized identifiers, managing keys, managing credentials, performing enterprise identity issuing, requesting access to and verifying credentials.	Enterprise Identity Wallet, e.g. an Aries JavaScript Framework instance (open source) with Storage (for credentials) and open-source tool (e.g. EECC verifier) for verification	The respective participating party (Supply Chain Actor, T&T solution, GHG Calculation Partner, GBA) or engaged SaaS Identity Wallet Provider
Verifiable Credential Store	(Decentral) Storage	Service endpoint with IAM and storage, Existing Web Server of Party	The respective participating party (Supply Chain Actor, T&T solution, GHG Calculation Partner, or GBA)
DID resolver	A DID-resolver (not shown in Figure I-1) finds and returns the DID-document of a supply chain actor on request. Various DID resolvers are available today.	Third Party Web Service	DID resolver SaaS provider

Table I-1: System components of the SSI-Implementation Profile

Tools

This section points to the tools that can implement the System components defined in the previous section. Using this technology selection allows interoperability between any actor worldwide.

Identity Wallet: Open-source tools are available to handle the recommended technology stack, i.e. to issue credentials, resolve DIDs, discover credentials, and verify credentials. One popular open-source tool that can function as Identity Wallet and Verifier Tool is Credo (f.k.a. Aries JavaScript Framework using Interop Profile 2.0 (see https://credo.js.org/).

Credential Verifier: The verification of verifiable credentials is often part of the Identity Wallet, however, in some roles, e.g. as a market surveillance company that only validates credentials but not issues credentials, a full wallet is not required. A sole verifier tool is sufficient. A free running and open-source Verifier is made available e.g. by EECC here: https://id.eecc.de/products/vc_verifier.html.

DID resolver: Numerous deployed DID resolvers or open-source implementations of DID resolvers are available. A free running DID-resolver can be found here: https://dev.uniresolver.io/. A commercial, production grade solutions is for example GoDiddy (at http://godiddy.com).

Use case description and flow diagram

The flow diagram below shows the interactions between Track & Trace Solution Partners and supply chain actors.

First the Track & Trace solution A calculates the GHG emissions of the Cobalt Mine and the Manganese Mine and issues the respective Product GHG emissions data sheets to both mines. In this profile the PGE data sheets are made available as a publicly accessible resource on the web site of the mine, which can be pointed to as the Service Endpoint in the DID documents (see next section).

Now Track & Trace solution B can collect the PGE data sheets of both mines, aggregate the mine's GHG emissions together with the Inhouse Product GHG emissions of the Precursor Product and issue the product GHG emissions data sheet of the precursor product. This PGE data sheet is again stored as a publicly available resource on the precursor's domain and can now be used by Track & Trace solutions that work further downstream, e.g. to calculate the GHG emissions of the CAM product. All the CAM Track & Trace solution needs to know to access the precursor PGE data sheet is the decentralised identifier of the precursor product which is "`did:web:precursor.com:PrecursorProduct123456`" in the example below.

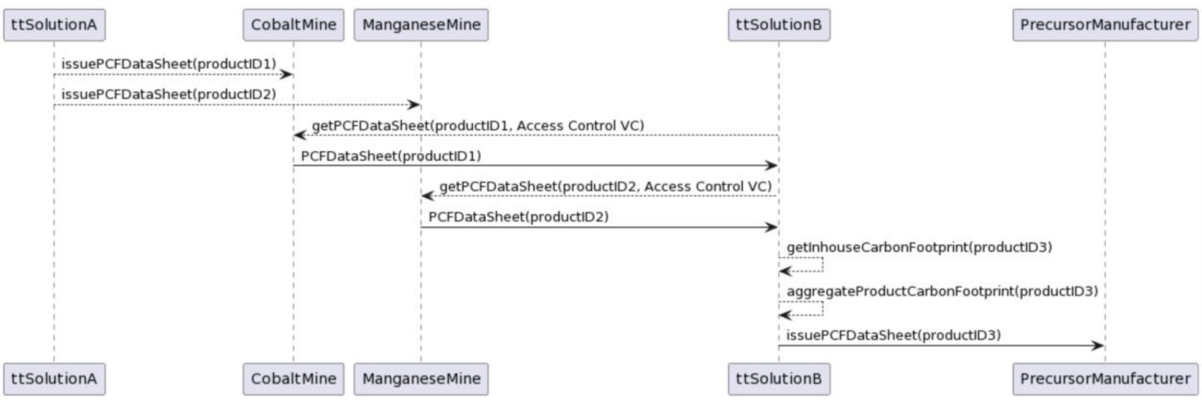

Figure I-2: Flow Diagram of a typical PGE data sheet Exchange Calculation

As a prerequisite for this flow the GHG calculation partners must calculate the Inhouse Product GHG emissions of the mining product and the precursor product (not shown in the flow diagram). It makes sense that in future iterations of this profile, Inhouse GHG emissions data sheets are defined in the same way as the PGE data sheets for automatic exchange.

Product GHG Emissions Data Sheet in JSON-LD

The data of the GHG emissions data sheet must be issued by the manufacturer or the Track & Trace solution in a machine-readable format. Here is a serialization example of the precursor PGE data sheet as verifiable credential in JSON-LD.

Example:


```
{
"@context": [
          "http://www.w3.org/2018/credentials/v1",
          "https://schema.org",
          "https://globalbattery.org/contexts/PGEDS.jsonld",
          "
]
“type”: [
          „VerifiableCredential“
          “GBA_carbon_footprint_data_sheet”
]
“issuer”: {
     "id": "did:web:dpp:ttSolution.com",
     "name": "T&T Solution Inc"
   },
"credentialSubject": {
          „id": „did:web:precursor.com:PrecursorProduct123456",
          „carbonFootprint": „31.4",
          „secData“: „60%“,
          „unit": „kg",
          „gbaRBversion": „1.0",
          „ghgCalcPartner": „8945003Zi7AXE0EBY18",
          „manufacturerID": „213800UN52KHL2C7IM29",
          „ttSolution": „213800UN52KHL2C7IM29",
          „iDate": „2024-01-01T10:15:00Z",
          „eDate": „2025-01-01T10:15:00Z",
          „pgedsVersion": „1.0"
          „comment": „This is a comment!",
}
"proof": {
     "type": " Ed25519Signature2020",
     "created": "2021-04-09T20:24:54.876Z",
     …
 }}
```


Note that ‘@context’, type, issuer, credentialSubject, and proof are implementation specific attribute. All other attributes in the credentialSubject are defined in Section 2.5 in the Product GHG Emissions Data Sheet Specification.

The corresponding DID document of the Precursor Producer can be found below. It directly leads to the verifiable credential, which is also located on the Precursor Producer’s website.


```
{
  "@context": [
    "https://www.w3.org/ns/did/v1",
    "https//w3id.org/security/suites/ed25519-2020/v1"
  ],
  "id": " did:web:precursor.com:PrecursorProduct123456",
  "verificationMethod": [{
    "id": " did:web:precursor.com:PrecursorProduct123456#_Qq0UL2Fq651Q0Fjd6TvnYE-
faHiOpRlPVQcY_-tA4A",
    "type": "Ed25519VerificationKey2020",
    "controller": " did:web:precursor.com:PrecursorProduct123456",
    "publicKeyMultibase": "VCpo2LMLhn6iWku8MKvSLg2ZAoC-nlOyPVQaO3FxVeQ"
    }
```

```
  }],
  "service": [
    {
      "id": " did:web:precursor.com:PrecursorProduct123456#credential-registry",
      "type": "CredentialRegistry",
      "serviceEndpoint": ["https://precursor.com/PrecursorProduct123456"]
    },
  ]
}
```

The service endpoint returns all verifiable credentials associated with the Precursor Producer according to the W3C Specification "Decentralised Identifiers (DIDs) V1.0"[3].

Unique Identifiers and DID Method

In this implementation profile, **decentralized identifiers** are defined as product identifiers and company identifiers. Decentralised are globally unique and can be created free of charge by open-source tools, such as Identity Wallets (see Section Tools). Decentralised Identifiers are created following the Decentralised Identifiers (DIDs) V1.0"[3]. Speficiation.

Various DID-methods are existing. They define how to exchange public key information to validate cryptographic signatures. Alternatives are:

- did:ethr[4]
- did:sov[5]
- did:web
- did:ebsi[6]

For the ease of implementation, in this profile did:web is used as the DID Method as it does not involve a block-chain (see also Architecture Decisions). There are some drawbacks to did:web, e.g. a missing key rotation routine. Experts identified the improvement potential of did:web and are currently working on new iterations of this DID-Method (please see: did:webs[7]). Examples how to implement data exchange with DID-web identifiers and verifiable credentials/presentations can be found at the Decentralised Identity Foundation Github[8]:

Encryption Algorithm

This section describes the encryption algorithms that can be used to digitally sign the GHG Emissions Data Sheet Credential. The recommended signature algorithm for signing PGE data sheet verifiable credentials is shown in the table below.

Algorithm Type	Algorithm
Asymmetric Encryption	Ed25519Signature2020

[3]W3C, "Decentralised Identifiers (DIDs)" v 1.0, https://www.w3.org/TR/did-core/ - An explanation of the DID document syntax with human readable comments can be found here: https://www.w3.org/TR/did-spec-registries/#credentialregistry

[4]did:ethr, U-Port, https://github.com/uport-project/ethr-did

[5] Sovrin DID-Method Specification (did:sov), https://sovrin-foundation.github.io/sovrin/spec/did-method-spec-template.html.

[6] EBSI Hub, DID-Method for Legal entities, https://hub.ebsi.eu/vc-framework/did/legal-entities.

[7] Hyperledger Foundation, did:webs Method, https://labs.hyperledger.org/labs/didwebs.html.

[8] Github, Decentralised Identity Foundation, available at https://github.com/decentralized-identity

Communication Protocol

This section suggests the communication protocol with which the GHG emissions data sheet credential is exchanged. For the exchange of PGE data sheets without access control only regular web protocols (HTTP) are used. The above-mentioned Credo (Aries JavaScript) Framework is additionally supporting DIDComm and Open ID for VCs/VPs which might be used in more advanced implementations incorporating access control flows.

Access Control Mechanism

This section describes the access control mechanism that is used to access the PGE data sheet on the supplier side.

In this first version of the SSI Implementation-Profile, no access control mechanism is defined /made mandatory to simplify the pilot implementations planned for 2024 (see also Architecture Decisions below). In future iterations of this profile alternatives for access control mechanisms are:

- Simple username / password checks when accessing the credential store for a certain credential. However, this method has the disadvantage that parties must exchange that username and password in a separate process and cannot retrieve PGE data sheet files ad-hoc.
- Exchanging the GBA, the GBA Track & Trace solution provider credential, or the GBA GHG Calculation Partner Credential for authentication. Those credentials allow ad-hoc, trusted data exchange and are planned for future iterations of this SSI Implementation Profile as they add complexity for the implementation.

Verification Process & Error Codes

This section defines the error codes that can be used for analysing issues when working with this profile.

ErrorCode	Description
InvalidAuthVC	Authentication Credential was not valid (expired or revoked)
Access Denied	Access Denied for given Credential
NoSuchPGEDS	Requested Product GHG emissions data sheet is not available.
InvalidPGEDS	Requested Product GHG emissions data sheet is expired, revoked.
SignatureError	Signature of Requested PGE data sheet could not be validated.
InternalError	An internal or unexpected error has occurred.
InvalidType	Requested Credential Type not available.

Architecture Decisions and future iterations of the SSI Implementation profile

The following table summarizes the Architecture Decisions taken during the Architecture discussions.

ID	Decision
D-001	DID method DID:web[9] will be used for first SSI profile implementations, pilots, and testing due to the ease of handling and no costs for the trusted ledger.
D-002	Credential revocation is not yet defined by this version of the rulebook and subject to future versions.
D-003	Exchange Protocol Considerations: OpenID Connect for Verifiable Credentials might be used in future iterations of this profile because its growing acceptance, ease of integration in existing protocol landscape and its recommendation by the Architecture Reference Framework[10] for Human Identities in the EUDI project.
D-004	Exchange Protocol Considerations: DIDComm [11]might be used in future iterations of this implementation profile due to its acceptance in the battery industry, e.g. by the British Columbia Government.
D-005	Credentials for Track & Trace Solution Providers and GHG calculation partners will be introduced in future iterations of this profile to enable automated validation of the GHG emission data.
D-006	Access Control mechanisms based on Credential Exchange will be added in future iterations of this profile.
D-007	Other initiatives in this area, such as WBCSD PACT and Catena-X are known and have been reviewed from the GBA Track & Trace Group. It is currently planned to work towards a harmonisation of the GHG emissions Calculation and therewith data exchange once the JRC "Rules for the calculation of the Carbon Footprint of Electric Vehicle Batteries (CFB-EV)" is finalised.[12]

Table I-2: SSI-Implementation Profile Architecture Decisions

[9] W3C, DID:web Method Specification, May 2023. available at https://w3c-ccg.github.io/did-method-web/.

[10] European Commission, **The European Digital Identity Wallet Architecture and Reference Framework, February 2023, available at: https://digital-strategy.ec.europa.eu/en/library/european-digital-identity-wallet-architecture-and-reference-framework.**

[11] Decentralised Identity Foundation, DIDComm Messaging, available at: https://identity.foundation/didcomm-messaging/spec/

[12] European Commission, JRC Science for Policy Report, Rules for the calculation of the Carbon Footprint of Electric Vehicle Batteries (CFB-EV), Draft Version available at: https://eplca.jrc.ec.europa.eu/permalink/battery/GRB-CBF_CarbonFootprintRules-EV_June_2023.pdf