Carbon Emission Token Protocol – Version for Public Comment

A GUIDE TO CARBON EMISSION TOKENIZATION

INTERWORK ALLIANCE

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EXECUTIVE SUMMARY

Carbon Emissions Token standards enable organizations, including enterprises, NGOs, and governments to implement programs built on a series of technical specifications. The InterWork Alliance's (IWA) Carbon Emissions Token (CET) Taskforce aims to advance emissions reporting through technical guidance, specifications, and best practices of tokenized carbon emissions and related data structures (e.g. digital measurement, reporting, and verification, or dMRV, information related to CETs).

The reporting of emissions is often complex and has challenges in data granularity, inconsistent reporting approaches that are often based on estimates, proprietary supply chain data streams, and an overall opacity to the process, for which distributed ledger technology (DLT) can help solve.

Tokenization, along with linked information through dMRV, presents an exciting opportunity to act as a public balance sheet, enabling consistency on technical structure using ledgers for their properties in auditability, discoverability, and ultimately liquidity when offsetting is applied[1]. While the CET will have requirements as to how ecological claims are made for the clarity of this document, this Taskforce will defer any technical offsetting standards to our sister Taskforce, the Voluntary Ecological Markets Taskforce.

Large number of stakeholders in the ecosystem with complex data relationships and reporting requirements

Tracking emissions is challenging across participants, regions, and value chains leading to inaccuracies and inefficiency

Validation of Scope 3 emissions data, reported emissions, and supporting data

1 https://www.hbarfoundation.org/blog-post/to-effectively-address-climate-change-we-need-innovative-green-house-gas-ghg-and-energy-accounting-methods

This Taskforce and its members see the value of leveraging DLT to enable better outcomes for emissions tracking which include:

1. Transparency, accuracy, and quality in data for inter-organizational and intra-organizational emissions following verifiable methodologies and rulesets for accounting
2. Referenceability across parties for indirect emissions reporting
3. A clear aggregate view of the ecological footprint of emitters globally

The initial CET specification standardizes definitions, behaviors, and attributes for CETs and is aimed to further dialogue around token implementations in emissions accounting, agnostic of web3 protocol. This Taskforce is recommending this paper as a guide in the discourse for specific regulator, country, or industry standards bodies that are considering how reporting may be enabled for their constituencies. This Taskforce does not attempt to define environmental accounting rules, methodologies, or the science behind them, but does focus on the implementation of these rules and best practices to achieve robust capabilities and systems that enable comparison and transparency with precise taxonomies so organizations can implement methodologies, and their rulesets, allowing for clear reporting for use in enterprise systems.

Tokenization of emissions provides the foundation for sharing and allocating emission ownership through complex value chains and enable 3rd parties to audit emission flows while preserving its lineage which is useful for the most widely adopted Greenhouse Gas Protocol[2] accounting framework, but also provides a path to evolve carbon accounting and supportinitiatives like E-liability[3].

DISCLAIMER: This document is intended as an introduction and basis for further dialogue and cooperation with all relevant stakeholders. Neither the individual taskforce members nor their organizations have agreed to or adopted this document in its entirety. The following is an incomplete, pioneering work in progress intended to cultivate further cooperative effort on the keystone elements and best practices with the intention to align around a common governance set of standards, specifications and classification systems. We encourage participation and collaboration with other organizations and actors within the industry as well as regulators and welcome their feedback and commentary for the next version. The taskforce members do not presently endorse any specific regulatory treatment, and do not formally endorse or ratify any particular independent efforts to develop market governance frameworks.

We encourage those that can join us in the GBBC/IWA, or that are already members not currently active in our group, to reach out and engage with us.

CET STANDARD PURPOSE STATEMENT, GUIDING PRINCIPLES AND SCOPING

Purpose

Define a technology- and industry-agnostic standard for carbon emissions tokenization that will facilitate interoperable emissions data referenceability across value streams and serve as a single source of truth for an organization's carbon ledger.

Guiding principles

- Educate and clearly define a token (e.g., the properties and behaviors), in non-technical and cross-industry terms using real world, everyday analogies that can be used by business, technical, and regulatory participants to speak the same language.

- Establish a base Token Classification Hierarchy (TCH) driven by metadata that is simple to understand and navigate for anyone interested in learning and discovering Tokens and underlying implementations.

- Produce standard artifacts and control message descriptions mapped to the taxonomy that are implementation neutral and provide base components and controls that consortia, start-ups, platforms or regulators can use to work together.

- Be used in taxonomy workshops for defining existing or new tokens which results in a contribution back to the framework to organically grow and expand across industries for maximum re-use.

2 https://ghgprotocol.org/
3 https://e-liability.institute/

The CET specification is **NOT**:

- Specific to any DLT protocol but applies to any shared medium - whether it be a DLT or database
- A legal or regulatory framework - but it does establish common ground
- A reporting tool - but does support reporting and validation of ESG claims
- Complete, in that it is understood to be a living document which may be modified or expanded overtime.

#	"In-scope" Items	#	"Out-of-scope" Items
1	Classification of the token	1	Reporting requirements for various jurisdictions
2	Behavior of the token	2	A Legal or regulatory framework - but it does establish common ground
3	Data elements for Token Metadata	3	Specific implementation level details
4	Data quality guidelines/expectations based on existing protocols and frameworks	4	To "reinvent the wheel" on the existing protocols and frameworks (e.g., GHG Protocol, Pathfinder Framework, ISO, etc.)
5	Emissions methodology guidelines/ expectations based on existing protocols and frameworks		
6	Examples of use cases the standard can support		
7	Methods to handle tokenization of different emission scopes		
8	Risks and challenges in implementation		
9	Supports reporting, validates ESG claims		

1.0 INTRODUCTION

Converging inter-governmental, national, and private-sector efforts to mitigate the impacts of climate change have created market pressure for increased transparency around GHG emissions and mitigation activities. This increased focus has accelerated investment in the development of market mechanisms for emissions tracking and offsetting, including voluntary offset markets and an array of climate-oriented standards and investment vehicles. It has also created competitive opportunities to market differentiated products and services that claim to have minimized their climate impact. As these offerings have grown, so have questions about the transparency, accuracy and even veracity of their climate benefits.

Market participants often lack the appropriate information to make informed investment or purchasing decisions. As a result, there is a need to develop robust, scalable technology solutions that support the traceability and transparency of these market claims. This involves solutions that target both the product and organizational level. There is also a need to reduce barriers to entry and transaction costs inherent in the current array of disaggregated GHG offset exchanges and differentiated product initiatives.

Distributed ledger technology (DLT) provides a promising means for market participants to share carbon emissions data in a transparent, immutable manner. It also offers a means to transact throughout value chains in a manner that treats GHGs as an environmental commodity that can be associated with an organization, products, services, or investments. Specifically, DLT can facilitate end-to-end supply chain transparency by collating data across the value chain participants, from materials sourcing through production and distribution, dynamically tracking GHG emissions throughout to empower decision-making related to climate impacts.

The IWA, an initiative of Global Blockchain Business Council (GBBC), envisions an ecosystem where global GHG emissions adhere to a common set of rules and behaviors designed for interoperability and transactability within a broader global marketplace. DLT technology, particularly in the form of semi-fungible, transactable CETs, provides the opportunity for a standardized and trusted approach to account, report, offset, and exchange GHG emissions across complex, multi-sector supply chains and life cycle stages.

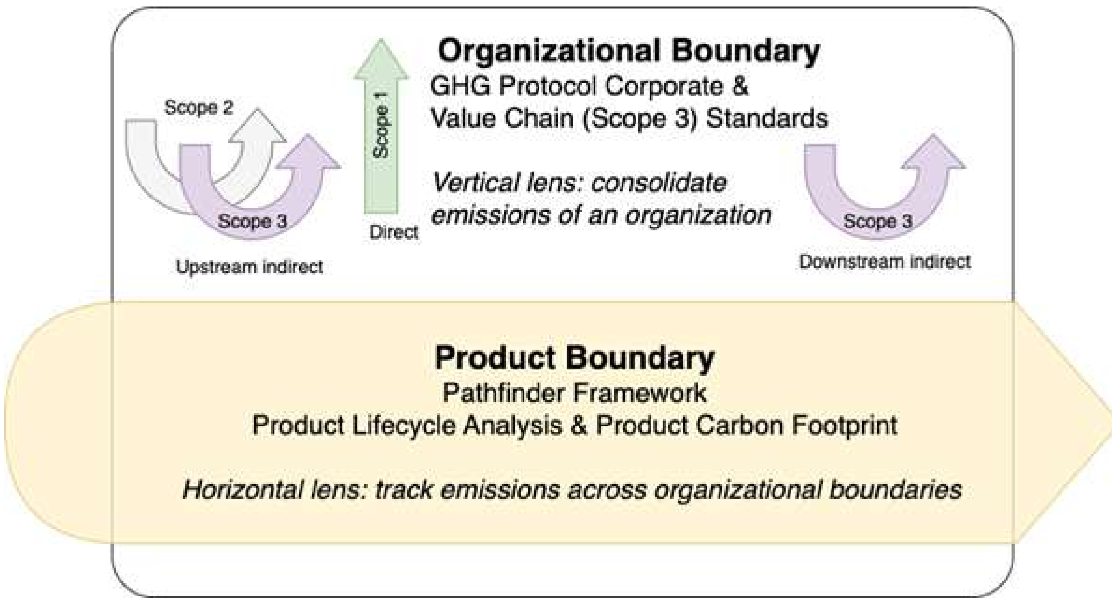
Furthermore, CETs offer a solution for digitally tracking GHG emissions and rendering them as publicly available, immutable data records for a broad range of public and private stakeholders. The CET Protocol will continue to be developed by the IWA CET Taskforce as an open-source standard designed to formalize principles of the CET and enhance interoperability by providing specifications that can operate on scales as granular as process activity data while supporting reliable transactions across markets and regions.

The ability to tokenize across various industrial processes, products, commodities, and services makes CETs a perfect complement to offset or credit tokens, such as the Carbon Reference Token (CRT) and the Carbon Reduction/Removal Unit token (CRU). Altogether, utilization of CETs and DLT technology can provide a valuable resource to support climate ambitions as well as the existing standards and frameworks of carbon, energy, and ecological markets. The purpose of this protocol is to serve as a supplemental handbook that supports the consistent application of the CET Protocol developed by the IWA Taskforce. Participants shall adhere to the standards and guidelines to promulgated in this document.

1.1 Challenges of existing GHG emissions management

Prevailing industry practice for emissions tracking and management relies on the use of internal emissions management software or spreadsheets to calculate emissions within operational boundaries. This involves applying recognized standards for organizational reporting, with the GHG Protocol Corporate Standard, introduced by the World Business Council for Sustainable Development's (WBCSD), providing a widely accepted approach for reporting an organization's emissions. The protocol introduces the concept of scope, characterizing emissions as direct scope 1, indirect scope 2 (electricity and heat) and other indirect scope 3 emissions.

FIGURE 1: PRODUCT VS. ORGANIZATIONAL BOUNDARY



The WBCSD also provides the Corporate Value Chain (Scope 3) Standard to address the complexity of measuring indirect emissions. Beyond operational boundaries, organizations are leveraging distributed data collection systems or a variety of assumptions to estimate value chain emissions with varying degrees of accuracy and success. The WBCSD provides the *Pathfinder Framework Guidance for the Accounting and Exchange of Product Life Cycle Emissions* (referred to as the *Pathfinder Framework*). Unlike the Corporate and Value Chain Standards, it is not constrained by an organization's operational boundaries. It adheres to product boundaries that capture overlaps in organizational reporting, as outlined in Figure 1.

Emissions are then disclosed in formats that are stipulated by voluntary or regulatory reporting standards.[4] These reports may include additional information to provide context, but companies often limit detail to protect proprietary information from the general public or their competitors. Outside of external reports, many companies are inundated with emissions information requests from investors or customers. These requests are often ad hoc, and companies may be hesitant to share certain types of information or struggle with navigating this wide array of requirements. Universal, sector or value chain-oriented repositories of shared information could improve the efficiency of information, but such repositories often do not exist or face technological or transactional limitations.

4 Of which there are over 600 ESG global reporting requirements, many with different interpretations and requirements. https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/sustainability/ey-the-future-of-sustainability-reporting-standards-june-2021.pdf

Beyond barriers to information, there are issues of reliability. There is no centralized regulatory body or market system for verifying and authenticating reported emissions and supporting data. As a result, investors, buyers and suppliers, and other stakeholders who are focused on environmental, social and governance (ESG) metrics and climate goals, such as decarbonization, carbon neutral products, and "greening" the value chain, must rely on piecemeal or secondary and potentially unreliable data to inform financing, purchasing, or patronage decisions. Moreover, the absence of a validated, universally-accessible repository and exchange for GHG emissions and offset credits results in a complex system of carbon emissions management and exchange markets, limiting market participation and inhibiting efficiency.

Finally, complex product supply chains and the lack of value chain-oriented emissions information repositories make it difficult for companies to track and trace cradle-to-gate and cradle-to-grave emissions. Many companies conduct life cycle assessments (LCA) on their own products to understand their carbon footprint. Tracing product cradle-to-gate and cradle-to-grave emissions is essential for organizations to achieve their climate goals and to satisfy contractual demands regarding the neutralization of product carbon footprints via carbon credits. Traceability and tokenization of GHG emissions supports this by giving organizations the data needed to analyze and manage the high-risk emitters within the supply chain and empower informed decision-making.

1.2 Opportunities for use of DLT for GHG emissions

Mitigating the impacts of climate change and reducing GHG emissions requires a system(s) for emissions measurement that supports market participants across sectors, regions and value chains. DLT and the CET standard deliver a trusted standards-based approach that helps close the gap between what exists today and what the market requires to achieve climate goals. This protocol promotes rule-based interactions to support diverse supply chains and the developing global infrastructure related to GHG emissions and climate change mitigation. This level of data transparency and traceability will facilitate and promote the implementation of LCAs (life cycle assessment) across many sectors.

Broad market adoption of the CET provides a multitude of opportunities. For investors, use of CETs ensures an independently verifiable, immutable, and publicly available record of emissions that are instantly authorized upon minting the token. For corporate market participants, it enables attributability, traceability and transactability of GHG emissions, which are crucial to a thorough understanding of carbon footprints[5] and strategic application of carbon offsets. Additionally, when put into production, CET can serve as a resource for GHG inventory tracking, targeted emission reduction to attain net-zero goals, and selective supplier relationships based on GHG intensity. The IWA CET standard and this protocol leveraged existing regulatory frameworks, protocols, and guidelines, ensuring ease of adoption by intergovernmental and regulatory agencies, thereby simplifying the reporting efforts and providing independently verifiable emissions data and reduction progress.

5 WBCSD's Pathfinder Framework guidance on Product Carbon Footprint (PCF) data https://www.carbon-transparency.com/media/jpslsujn/pathfinder-framework.pdf

1.3 Vision and Goals

Governmental, organizational, and societal pressures to reduce GHG emissions, and thus mitigate climate change impacts, demands new ideas and solutions to support existing systems and frameworks. The vision for utilizing distributed ledger technology to tokenize emissions is to standardize an industry-agnostic framework for interoperable climate data that can be reliably and transparently tracked, reported and shared as digital environmental assets.
To achieve the vision, this protocol supports the following goals of the CET Standard:

- Global GHG emissions are traceable to the relevant entities — whether they be projects, systems, facilities, public/private enterprise or communities — as scope 1, scope 2 and scope 3 emissions.
- Interoperable standard of carbon emissions demonstrating GHG emissions are linked to a tokenized DLT based asset
- DLT provides a verifiable and trusted record for tracing emissions throughout the value chain, from source to product or service output to end-of-life.
- Tokenized emissions can be locked and bundled into adjacent compositions like Product Carbon Footprints as defined by the WBCSD:PACT initiative.[6]
- Ownership of indirect emissions will be realized through CET transactions recorded on the ledger, providing unprecedented clarity around the quality and quantity of an organization's value chain emissions.
- CETs can be paired with carbon offset or credit tokens, such as Carbon Reference Token (CRT) or Carbon Reduction/Removal Unit (CRU Token), to enable participants to proactively and systematically manage net-zero targets and other climate-related goals throughout their value chain.
- CET adoption at the industry level provides a demand signal for measuring, reporting and verification (MRV) applications and organizations to incorporate the methodology in their system to provide consistent standards of measurement. Attestation providers can audit the MRV process of CET creation reducing the time, cost, and requirements for GHG attestation providers to frictionless assurances.

1.4 CET Protocol, data component development and ongoing governance

In April 2022, the IWA began exploring an initiative to develop the CET standard to complement the CRT and CRU Token standards developed in June 2021 with the goal of enabling coordination, collaboration, and interoperability across organizations and industries. A multi-stakeholder Taskforce of cross-industry companies was established in August 2022 to support the initiative. Outputs of the Taskforce include the CET standards and this accompanying protocol document outlining the reasoning for the group's decisions and providing supporting commentary. This protocol does not purport to replace existing frameworks, protocols, or industry standards, but rather supplement the resources in broader voluntary carbon, energy, or ecological markets.

1.4.1 IWA TASKFORCE

To support broad adoption of the CET standard, the IWA convened a Taskforce in August 2022 to gather input from various industries, platforms, and backgrounds, ensuring the token standard remains industry- and platform-agnostic. The participants collaborated to determine the appropriate CET classification, behaviors, and metadata, which are detailed in this document.

6 https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/SOS-1.5/Resources/Pathfinder-Framework-Version-2.0

1.4.2 LEVERAGING EXISTING PROTOCOLS, STANDARDS AND FRAMEWORKS

As part of the CET standard development, the Taskforce developed a required set of data elements, referred to as metadata. The metadata is the framework which establishes the data that shall be recorded in the token. Selection of the standardized metadata components leveraged existing protocols and frameworks, including the World Resources Institute's (WRI) *Greenhouse Gas Protocol Corporate Accounting and Reporting Standard* (referred to as the *Corporate Standard*) and the *Greenhouse Gas Protocol Product Life Cycle Accounting and Reporting Standard* (referred to as the *Product Life Cycle Standard*). Additionally, the Taskforce ensured alignment with the WBCSD *Pathfinder Framework*, the International Sustainability Standards Board's (ISSB) Exposure Draft IFRS S2 *Climate-related Disclosures*, the Global Reporting Initiative's (GRI) standards, the Taskforce on Climate-Related Financial Disclosure (TCFD) frameworks, Climate Disclosure Project (CDP), and the International Organization for Standardization (ISO) 14060 family of standards for quantifying, monitoring, reporting, and validating greenhouse gas emissions.

1.4.3 ONGOING GOVERNANCE OF THE CET PROTOCOL

The governance of the CET protocol will be a continued effort under the guidance of the IWA. This Taskforce will operate with a period of review for each published draft. The first period for review will begin Nov. 30th, 2023, which will run through Feb. 17th, 2024 for feedback. Final publishing for the first version of the CET guidelines will be issued based on these feedback points from which future iterations of the CET will be built on.

This governance will mirror the work of the IWA's Voluntary Ecological Markets (VEM) Taskforce, which subsequently focused on dMRV, properties, and a second version of guidance along with a complete specification based on implementation findings in its follow up to initial publishing. The guidelines will be reviewed on a yearly basis for updates from member findings.

2.0 FUNDAMENTALS OF THE CET

The CET design adheres to the Token Taxonomy Framework (TTF) by the IWA, a GBBC initiative. The TTF bridges the gap between DLT developers, business executives, legal representatives and regulators fostering collaboration to redefine existing, and develop new, business models and networks based on tokens. With DLT technology and tokens being relatively nascent, there are difficulties in establishing a collective understanding across industries and organizations. The TTF was developed as a clear, unbiased, cross-functional set of guidelines around DLT and tokens. Specifically, the purpose of the TTF is to:

- Educate users, especially non-technical users. In particular, the TTF clearly defines tokens in non-technical and cross-industry terms using real-world examples, ensuring understanding and ease of participation. The TTF uses properties and behaviors to define tokens and describe their functionalities.
- Define a common set of concepts and terms that can be used by business, technical, and regulatory participants to speak the same language.
- Produce comprehensible token definitions and requirements, which are implementation neutral for developers to follow and standards organizations to validate.
- Establish a base Token Classification Hierarchy (TCH) (i.e., a logical grouping and linkage between various data elements driven by metadata, which is the background data that provides information about the visible token data component) that is simple to understand and navigate for those interested in DLT tokens and underlying implementations.
- Use terminology that is neutral to programming language and DLT.
- Encourage open and collaborative workshops to accelerate the creation of powerful vertical industry applications and innovation for platforms, start-ups, and enterprises.
- Produce standard descriptions mapped to the taxonomy that are implementation neutral and provide base components and controls that consortia, startups, platforms or regulators can use to work together.
- Encourage differentiation and vertical specialization while maintaining an interoperable base.
- Be used in taxonomy workshops for defining existing or new tokens which results in a contribution back to the framework to organically grow and expand across industries for maximum re-use.

The fundamentals of the taxonomy can be categorized into five basic types listed below.

- Base Types: the foundation of any token is its base token type.
- Behaviors: capabilities or restrictions that can apply to a token.
- Behavior Groups: a bundle of behaviors that are frequently used together.
- Property Sets: a defined property or set of properties that, when applied to a token, can support a value that can be queried - essentially, the data points contained in the token.
- Token Templates: describes the token type (e.g., Fractional Fungible Template) as well as the capabilities or restrictions to which the token created from the template would adhere.

2.1 Foundational token characteristics

The TTF uses token classifications and behaviors to prescribe the foundational characteristics of tokens. The classifications and behaviors applicable to the CET are described below.

2.1.1 CET CLASSIFICATION

The TTF classifies tokens using the five characteristics below, allowing tokens that share the same characteristics to be classified together. These are foundational concepts that can be applied to most tokens. The CET token classifications are described below.

Token Type – Fungible Unique (τF')[7]

As unique fungible tokens, the CETs can be used as a unit of account enabling emitters to granularly account for emissions used to draft reports based on real-time monitoring data. The fungibility of the token enables reporting entities to group and sum emissions, for example by scope (scope 1, 2 and 3, separately), while unique properties preserve the traceability of the emissions to source. The CET framework defines two type flags to differentiate the following accounting types:

1. Organization: CET used for compiling organizational emission inventories applying the desired reporting boundary (see section 3.5) and scope.
2. Product: CET used to construct a LCA of the carbon footprint of a product provided by an organization.

The 2 token type flags enable accurate accounting of an organization's environmental carbon footprints without losing track of the token's unique identifying characteristics. The two flags offer complementary characteristics, such as referencing product CET issued at the facility level (sub-organizational unit) to construct an organization's total emission inventory by scope.

Token Unit – Fractional

Tokens are divisible and can be subdivided or split into smaller units or parts based on a certain number of decimal places.

Fractional tokens would be required when the emissions being tokenized are not in exact multiples of 1 metric ton of carbon dioxide equivalent (mtCO_2e) or during carbon credit and emission pairing if the paired CETs are not a whole number, i.e., a multiple of 1 mtCO_2e.

Value Type – Reference

Reference value type is where a token represents a physical item like a car or house, or 'stored elsewhere' digital item like a photo, scanned document or bank balance. A CET does not have intrinsic value of itself but it is backed by the emission which gives it value; therefore, CETs have to be a Reference token.

Representation Type – Unique

As mentioned in the Token Type section, carbon emission token instances are unique and can be individually identified and traced. They are like paper bills; they are interchangeable but have unique properties like a serial number. For track and trace usage, it's important that CETs preserve their unique characteristics via their metadata. CETs will be uniquely identified while their fungibility enables CETs of equal quantities to be valued the same.

7 CETs will be fungible such that their value will be comparable and considered the same carbon equivalent with one another, but not interchangeable. Any CET, of the same class or series, will be equal in value to another CET with the same quantity. Each CET will also be unique such that they can be distinctly identified by the unique properties, like scope or emissions source, that define them.

Supply – Infinite
Tokens can be created and removed with no cap. As the number of CETs minted depends on the amount of actual emissions, there cannot be a cap on the total mintable amount.

2.1.2 CET BEHAVIOR

Behaviors are capabilities and restrictions containing logic and properties that can be common across token types. Behaviors usually have existing "non-DLT" implementations which are well understood in business contexts. The behaviors applicable to the CET are below.

Divisible
Tokens can be subdivided or split into fractions or parts based on a certain number of decimal places. Divisibility is a common behavior for cryptocurrencies or tokens of fiat currency. For example, the US Dollar is divisible to two decimal places, where a value such as 0.42 of a US Dollar is possible. Many digital assets and cryptocurrencies are also divisible.

This is a necessary behavior of the CET to accommodate fractions of emissions less than 1 mtCO_2e. The number of decimal places for the CET is determined on the industry or business level and should be a minimum of two decimal points, but is suggested to be four.

This behavior is demonstrated in the example below.

Example: Tokenized emissions data is not in exact whole numbers, i.e., 1 mtCO_2e.
Emissions collected from sensors or calculated via engineering estimates would not typically be multiples of 1 mtCO_2e. However, these emissions can be sent for tokenization as fractions of a token.

For example, if the emissions data received for tokenization during the defined temporal boundary is 15.6 mtCO_2e, then the tokenized result would be 15 CETs, representing 15 mtCO_2e, and another 0.6 CET representing 0.6 mtCO_2e.

Delegable
CETs support the delegation of token behaviors to a third-party entity or a third-party managed account, allowing the third party to invoke the tokens on behalf of the owner. This behavior is demonstrated in the example below.

Example: An entity outsources its carbon footprint management operations to a third party
Company X is a manufacturer and owns multiple factories. Since it is not Company X's area of expertise, they outsource management of their carbon footprint, including management of their CETs, to Company Y. As a result, Company X must delegate its CET responsibilities to Company Y, allowing Company Y to carry out transaction and offset activities while Company X maintains ownership of the tokens. Additionally, Company X may delegate only a portion of their CET inventory to Company Y and another portion to a separate third party, depending on Company X's requirements.

Offsetable
CETs can help track companies' efforts to compensate for hard-to-abate emissions by identifying when a validated offset has been applied to a carbon emissions token. Establishing a relationship between a CET and a carbon offset (whole or fractional) can help companies balance out their carbon footprints on a public ledger. The concept of offsetability is explored in more depth by the Voluntary Ecological Markets (VEM) Taskforce and its VEM Overview paper[8].

The mtCO_2e value associated with CETs may be reduced by an amount equal to the carbon credit value being applied.

8 https://gbbcouncil.org/wp-content/uploads/2022/09/Voluntary-Ecological-Markets-Version-2-InterWork-Alliance.pdf - Page 48

Example: A carbon credit is used to offset a set of CETs related to a product's carbon footprint to achieve a net neutral emissions goal.
Company X manufactures widgets and desires to deliver 'net neutral' widgets to the market. They implement a policy to purchase carbon credit tokens to offset each batch of widgets once process emissions total 5 $mtCO_2e$. The emissions from production of the widgets are tokenized resulting in 5 CETs, each representing 1 $mtCO_2e$. Company X offsets the carbon emissions from the widgets by applying carbon credit tokens representing a total of 5 $mtCO_2e$, thereby offsetting the 5 CETs. Once the CETs are offset, they are flagged in the DLT, indicating that the emissions have been neutralized. Note: The CET metadata does not include specifics about product information or quantities and could only be determined if CETs are allocated to products.

Roles
The roles outlined in this section are those entities who have permission to use the token behaviors (minting, burning, etc.) or whose data directly feeds into the token. Other roles in the ecosystem will be defined in Section 2.2. These roles will also be expanded upon and given additional context in the broader ecosystem.

A token can utilize role behaviors that restrict invocations to a select set of parties or accounts that are members of a role or group. This is a generic behavior that can apply to a token many times to represent various role definitions. The 'Roles' behavior defines the role(s) which can be implemented for the CET and the responsibilities of each role. The CET standard includes the optional token roles outlined below that may be implemented by CET DLT participants to fulfill specific roles per stakeholder requirements. For example, an organization may identify individuals to perform each role within the DLT system and each individual would not be permitted to undertake tasks that fall outside their purview. Implementation of the 'roles' behavior provides for this division of responsibilities.

- Owner - The Owner is the entity in possession of the token who, depending on the reason for holding and compliance regime, can Burn, Offset, Transfer, or Delegate that token
- Emitter/Indirect Emitter – The entity with the right to mint, or allow a third party to mint, the token because they are the accountable party for the emissions; can recognize a direct vs. indirect emitter
    - Direct (scope 1)
    - Indirect (scope 2)
    - Indirect Downstream/Upstream (scope 3)
- Revoker – The entity that is authorized to cancel or freeze the CET, in effect removing or suspending the CET from circulation and/or the corporate GHG inventory until it is remedied. Examples of revokers could extend to parties such as corporations or delegated entities on their behalf. As this specification evolves the taskforce anticipates further development could extend to regulating authorities within emissions reporting.
- Auditor - An entity with the right to view all token transfers but cannot perform other functions related to the token.
- Contributor(s) – An entity that is delegated a role by another party within the workflow, or in a standards or regulatory capacity, to contribute data, calculations, or adjustments to the data inputs within the value chain.

For example, Company X has employee A and employee B. Employee A is responsible for carbon emission tokenization and mints CETs when a predetermined quantity of emissions are released and specific conditions are met. In this case, Employee A is assigned the 'Minter' role. Meanwhile, Employee B is responsible for matching the CETs with tokenized carbon offsets and then retiring the tokens afterward. Employee B is assigned the 'Offsetter' role. Though both work in the same organization and in the same system, they have been assigned distinct roles in the DLT and would be unable to take actions that are not assigned to their individual roles. Partitioning of responsibilities is controlled with 'Roles' behavior.

Referenceable

The data and assets are referenceable. Referenceability involves identifying the source data used to generate the CET, as well as defining links between emissions inventories of an organization or product. CET offers one representation of previously compiled emissions data, which will require referencing the source, or specific data domain. Therefore, referencing by CET would benefit from standards defining the source data, the specific domain including where and how it could be accessed. The Open Footprint (OFP) Forum, organized by the Open Group, is currently developing the OFP Data model and reference APIs. Its objective is to facilitate the integration of emissions data across existing systems.[9] This in turn will make it easier for companies to share, and reference, the source data used to construct emission inventories and optional representation as CETs. One example of referencing across a group of organizations will also depend on the reporting boundary applied by both the primary and secondary organizations. For example, under an equity-based approach, referencing should include the CET generation event that captures the amount of CET distributed to each equity shareholder and therefore the total amount of emissions. An example of such a generation event for multiple equity shareholders is outlined in the table below. Operational control refers to the total emissions that are controlled by the operator of any given emitting facility or process.

TABLE 1: EQUITY-BASED INVENTORY MODEL

Project Type	Owner/Partner	Role	Equity Share (%)	Equity emissions (tCO_2e/yr)	Operational Control emissions (tCO_2e/yr)
LNG					
	Partner 1	Operator	47.33%	2,366,500	5,000,000
	Partner 2	Advisor	25%	1,250,000	
	Partner 3	Advisor	25%	1,250,000	
	Partner 4	Offtaker	1.25%	62,500	
	Partner 5	Offtaker	1%	50,000	
	Partner 6	Investor	0.0417%	20,850	
	Total		100%	5,000,000	5,000,000

Referencing across shareholders in a common project is a simple example. However, in many cases, referencing will involve the more complex flow of emissions data across the inventories of different organizations, as opposed to a common inventory as in the equity-based model. For example, Tokens representing the indirect scope 2 & 3 emissions of one company reference to the direct scope 1 emission from the source organization. As an example, the Scope 2 tokens of a manufacturer can reference the Scope 1 emissions associated with energy supplied by its electricity utility.

While we are referring to referencing across organizational emissions inventories, the link between organizations is typically based on product (or service) trade flows. Therefore CET defined by the product type flag offers a mechanism for referencing emissions across organizational boundaries. The product type essentially reorganizes the source data used to construct an organization-wide inventory and corresponding CETs. This requires applying a product carbon footprint reporting approach.

The Pathfinder Framework provides methodological guidance for the accounting and exchange of more accurate product-level emissions data in the form of product carbon footprints (PCFs). PCFs can be referenced by upstream to downstream partners, providing kg of CO_2e per declared unit of product.[10] Given its objective of creating a standard data model with common definitions and APIs, adoption of the OFP standard could be used as a reference for CET. The OFP Data Model will cover both organizational and product level perspectives, including direct alignment with the Pathfinder specifications.

9 https://blog.opengroup.org/2023/09/19/enabling-effective-emissions-data-management-and-sharing/
10 https://www.carbon-transparency.com/media/oymlyn4n/pathfinder-framework-version-1_final.pdf

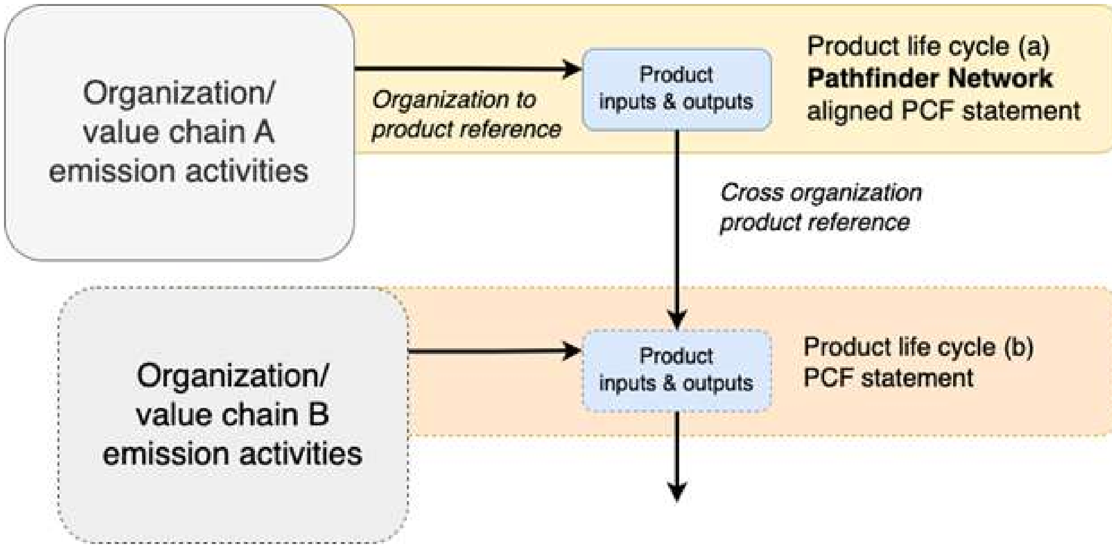


FIGURE 2: USING A STANDARD DATA MODEL TO REFERENCE ORGANIZATIONAL PCF STATEMENTS

Figure 2 illustrates how records from a standard data model (e.g., OFP) are used to both construct statements of an organization's aggregate emissions (gray boxes) or a subset of their emissions data for a specific product life cycle analysis. The latter involves analyzing part of an organization's value chain (yellow and orange boxes) to construct PCF statements based on product inputs and outputs aligned. This may be done in alignment with the specifications of the Pathfinder Network.

The PCF statement is calculated and expressed as an emission intensity relative to the declared unit. Further, the schemas supporting a product life cycle analysis can reference the PCFs of their material inputs — which can be provided by their suppliers or estimated based on Environmentally-Extended Input-Output (EEIO) factors— to account for emissions from material acquisition and preprocessing. Intermediate products, e.g, the output of Organization A, can be used as the reference for the final PCF output.

Purchasers of the final products can reference the PCF statement to support the calculation (and minting) of scope 3 emissions. The ability to share and reference PCFs and coordinate emissions data throughout supply chains can facilitate an ecosystem of dMRV data and support more accurate and transparent product and scope 3 GHG accounting. CET offers a trusted and immutable reference point within, and between, the structured data sources of organizations. Building trust and transparency, the trust chain of emissions can be traced from product purchases all the way back to the extraction and processing of raw materials.

For example, an aluminum production company, or a smelter, collects emission activity data for its corporate report, aggregating the direct and indirect sources, organization-wide. Organization scoped CETs are minted, referencing the source data as necessary (gray boxes in Figure 2). A subset of the source activity data from a particular set of facilities that produce aluminum ingots is used as inputs to calculate a PCF (in kg CO_2e/ kg Al). The PCF statement references the same source data used by the organization-wide CET, but only the subset relevant to the CET of the target aluminum production life cycle (yellow and orange boxes in Figure 2). This may exclude emissions included in the corporate CET, such as emissions occurring outside the target production facility, from a batch of ingots not covered by the PCF, or attributed to a co-product such as from waste heat sold to a district heating grid.

Downstream, a product such as a semiconductor that uses aluminum as an input can use that CET PCF to calculate emissions attributable to their upstream acquisition and preprocessing. Those semiconductors may be an intermediate product to be incorporated into a computer, and the product emission profile of the computer could reference the CET PCF of the semiconductors (kg CO_2e/chip). Further downstream, the purchaser of the computers could reference the PCF of the computers (kg CO_2e/computer) to calculate their scope 3 emissions.

Non-Transferable (tokenized asset as environmental commodity)
The 'Non-Transferable' behavior denies the owner the ability to send a CET to another party or account. CETs are non-transferable outside of the owner of an organization. However, this does not exclude ownership transfer or intra-organizational transfer. Transfer of emissions inventories data downstream is handled through token referencing, as outlined above.

Note from the authors: Organizations and/or Corporations can transfer internally however must be mindful of geographic boundaries and requirements. CETs cannot be transferred outside of the parent organization in which the business unit or sub company resides.

Companies' accounts and/or identifiers, which would be managed by wallets, can be managed by parent companies, business units, or contractors acting on behalf of a business entity but must maintain auditability to the CET source and required local accounting rules for that source. Inter-company and Intra-company accounting must reference the original source CET where possible.

INSET ACCOUNTING EXAMPLE

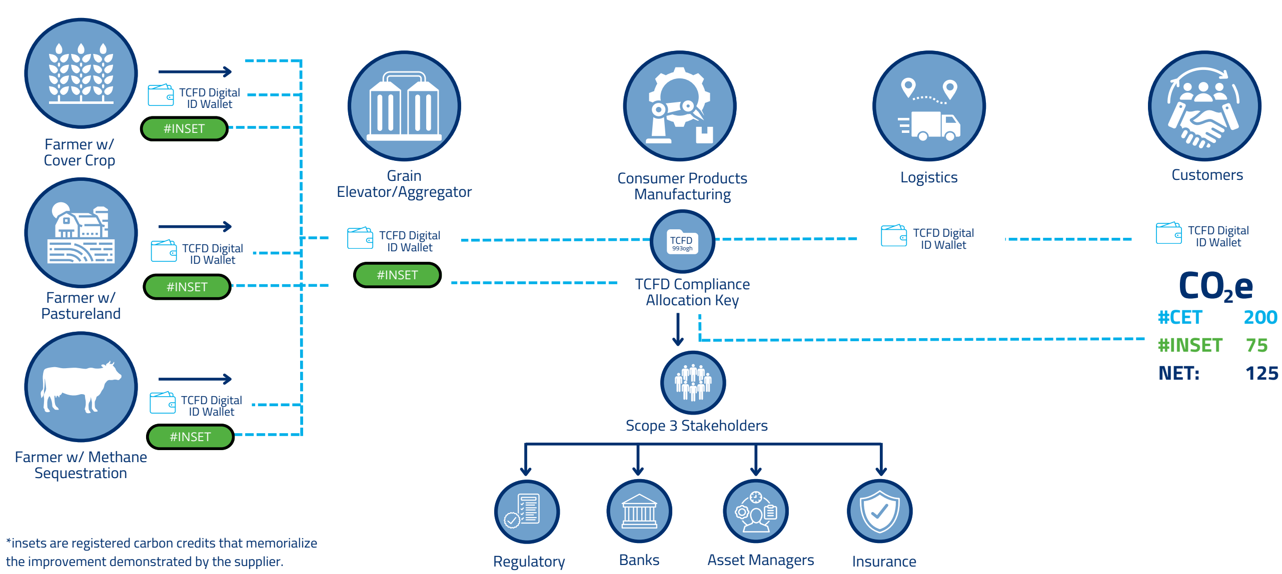
Insets pertain to specific adjustments in the calculation and reporting of carbon emissions. These adjustments are applied to ensure congruence between reported emission data and the actual environmental impact of a given activity, process, or entity. Insets play a pivotal role in providing accurate carbon emissions data.

An example of a carbon emissions reporting inset used for supply chain consideration is Life Cycle Analysis. Life cycle Insets are used to comprehensively encompass emissions throughout the entire life cycle of a product or process, spanning pivotal stages such as raw material extraction, manufacturing, transportation, utilization, and eventual disposal. This holistic methodology offers stakeholders a comprehensive perspective on the nature of emissions.

How it Works: Farming and Agriculture participants are key contributors to the consumer products supply chain for the products that are manufactured, distributed and sold in grocery stores. With CETs, carbon impacts can move from upstream participants (resulting in Scope 3 reporting) to Consumer Packaged Goods (CPG) companies.

Supply Chain Inset Summary

#CET with insets* from farmers that deliver sustainable practices result in higher prices for farmers with insets moving onto their CPG customer. Banks can offer custody, minting, lending.



*insets are registered carbon credits that memorialize the improvement demonstrated by the supplier.

A holistic GHG mitigation approach for a CPG company involves working with its upstream supply chain, such as farms, to modify their practices for the benefit of the CPG company. Farmers can utilize insets to enhance their contribution to their CPG customers through innovative methods such as soil carbon sequestration, woodland preservation strategies, and methane capture. These upstream behaviors can be inset alongside the CET for the farmer and pass along that benefit to the supplier that is purchasing that product. This can be facilitated via supply chain finance lending and with product pricing.

Farmers are increasingly pursuing sustainable practices in order to improve longevity of their soil, reduce fertilizer and manure run-off that ends up in waterways that create algae blooms that kill wildlife and impact biodiversity in the ecosystem. Each of these could result in inset supply.

Mintable

This behavior supports the minting or issuance of new tokens. New tokens can be minted to the owner's account or to another third-party account. CETs are minted according to the organization's predetermined frequency (i.e., temporal boundary) and quantity of CO_2e.

Example 1: Emissions data is collected via direct measurement and minted when emissions accumulate to 1 mtCO_2e or depending on the temporal boundary, whichever occurs first.

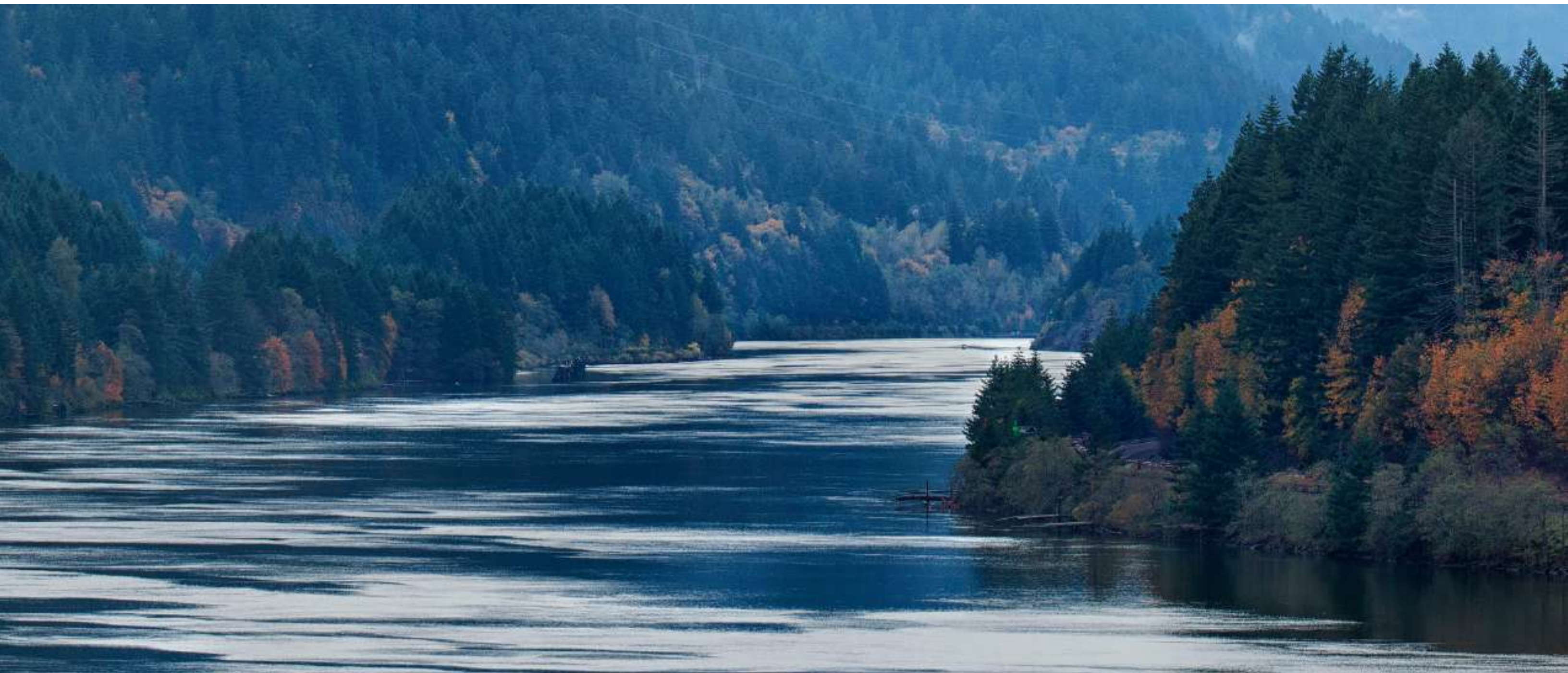
Company X manufactures widgets at a factory. Continuous emissions monitoring sensors measure emissions data from a boiler at the factory to an emission inventory platform in real time. Once cumulative emissions from the boiler equals 1 mtCO_2e, a transaction is triggered, and a CET is minted simultaneously.

Example 2: Minting of tokens is based on the predetermined temporal boundary.

Emissions data is collected over a predetermined period, such as one month. Each month, a batch process triggers the minting transaction at a specified date and time. It can be a daily, weekly or monthly trigger. For example, Company X's emissions are calculated each month based on process unit activity data in the factory. Each month the emissions calculations are executed. The emissions for the month of January 2023 total 5,000 mtCO_2e and are stored in a database. Once the emissions calculations have been gone through the quality review process, Company X initiates a batch process to mint 5,000 CETs.

Example 3: Minting of tokens is based on a predetermined process boundary.

Company X manufactures widgets at their plant. Company X installs continuous emissions monitoring sensors to measure GHG emissions data resulting from process units in their facility. Company X has established a CET minting protocol which is triggered each time a manufacturing phase is complete. As a widget passes through each phase of manufacturing, the emissions associated with the phase are minted. Note: The CET metadata does not include specifics about product information or quantities and could only be determined if CETs are allocated to products.



Revokable
The 'Revokable' behavior includes a controlling central party, i.e., the issuer, with the ability to retire tokens that it has issued, regardless of the owner. This behavior is necessary to ensure data quality as it permits issuers to revoke a CET if it is found that data was captured incorrectly.

Example 1: Incorrect metadata was entered during token generation
For example, Company X created a token based on the emissions from a specific plant recorded by a sensor. Data checks reveal that the date of the emissions generation was captured incorrectly. As a result, the existing token would be revoked, and a new token would be minted to replace the incorrect one.

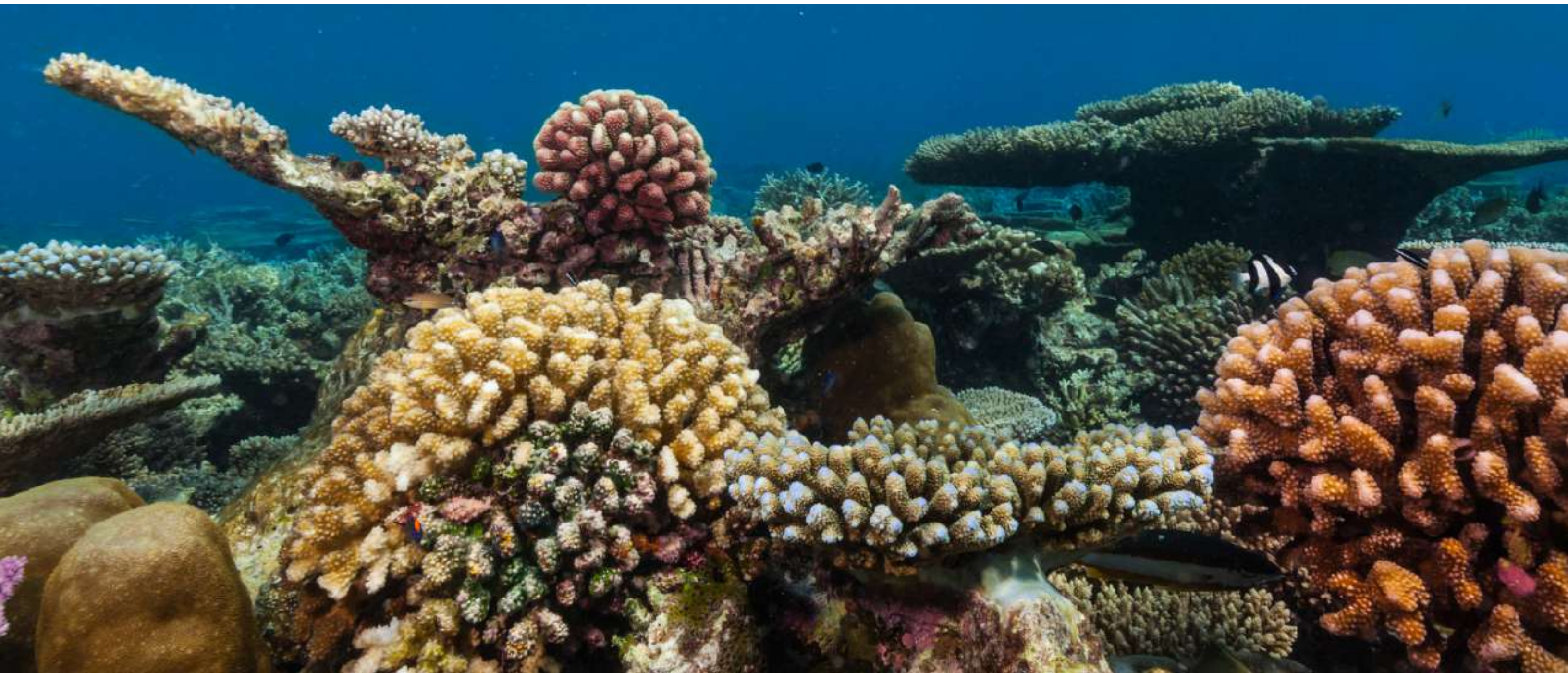
Example 2: Over or under accounting of emissions due to manual data entry errors
Emission calculations are based on activity data and industry-accepted generic emission factors. Data checks reveal that the manual data entry resulted in an overestimate of emissions. As a result, the token generated for the erroneous emissions is revoked and a new token is created with the updated emissions details.
For example, Company X estimates emissions from its internal transport vehicles with fuel activity data extracted from invoices. However, at the end of the fiscal year, Company X determines that fuel use was underestimated, resulting in fewer GHG emissions and, thus, fewer CETs. The issuer of the tokens would revoke the original tokens and create new tokens based on the emissions calculated from the updated fuel usage.

2.1.3 TOKEN PROPERTY SETS

Token property sets are logical groupings of data components associated with a token. Grouping the data components into property sets allows a set of data points to be utilized by a different token, enabling consistent data across the DLT. A property set can contain a single data point, such as a stock keeping unit (SKU), or multiple data points, such as for a mailing address. For example, if the property set represents customer information, the set would contain fields such as First Name, Last Name, Address, etc. Additionally, property sets can have nested property sets, such as the detailed address information associated to the customer which would require multiple data points. Lastly, a property set may include an identifier that is common or shared for all tokens in a class, such as an SKU, or unique for each token in the class, such as a serial number. The property sets defined for the CET are described in detail in Section 4.

TABLE 2: CET BEHAVIORS SUMMARY

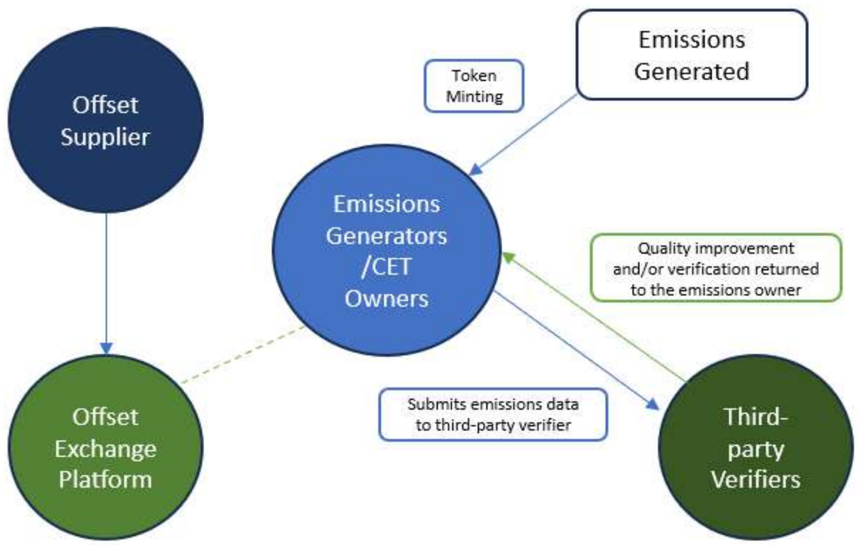
Behavior	Divisible	Delegable	Offsetable	Roles	Referenceable	Transferable	Mintable	Revokable
CET	Yes	Yes	Yes	Yes	Yes	Only within emitter's geographic boundary	Yes	Yes



2.2 CET market roles

The roles in the emission token market define an organization's responsibilities and actions in the marketplace and in the life cycle of an emission token. Participants may have multiple roles within the marketplace. Note that these roles differ (though they may overlap) from the roles discussed above in the CET behavior section of this document. The roles in the *CET behavior* section are taken with the technological lens of the token in mind while the roles discussed in this section are taken with the emissions lens in mind. Figure 3 provides a high-level overview of the relationship between the different market roles.

FIGURE 3: CET MARKET ROLES FLOW OVERVIEW



The sections below describe the market roles that a participant may assume in the emissions tokens DLT marketplace.

2.2.1 EMISSIONS GENERATOR / CET OWNERS

The owner is the original generator and owner of the tokenized emissions. Specifically, the tokenized emissions resulted from a process or action under the purview of the owner, either directly (scope 1) or indirectly (scope 2 and scope 3). The owner's information is contained in the token data as 'OrgId' and 'OrganizationName' (discussed further in Section 4).

2.2.2 THIRD-PARTY VERIFIERS

The third-party verifier is an independent third-party who assesses the owner's data collection processes and verifies emissions calculations to assure consistency and comparability in the DLT. The verification and assurance approach should be consistent with the requirements of ISO14064-3. The third-party verifier information is contained in the token data as 'ThirdPartyVerificationDone' and 'ThirdPartyVerificationDetail' (discussed further in Section 4).

2.2.3 EXCHANGE OR MARKETPLACE PROVIDER[11]

The exchange or marketplace provider is the organization that provides the virtual infrastructure to facilitate how a CET can be integrated with different types of carbon markets. This may include regulated markets, such as an emissions trading system (ETS), subject to cap-and trade rules, or tracking emission taxation requirements such as under the carbon border adjustment mechanism (CBAM) introduced by the EU to address carbon leakage into its national ETS. Markets may also be voluntary, such as the UNFCCC agreement to structure the international trade of emission reductions under Article 6.4 of the Paris Agreement, or the trade of performance certificates such as Certified Emissions Reductions (CERs). CET may be used as a reference by existing markets to assess applicable emissions inventories that an organization reports to the market. The CET may be used to determine emission allowances that the organization must purchase under an ETS, or the total emissions subject to a carbon tax applied in the jurisdictions where it operates. Another use is referencing transactions across carbon markets in different jurisdictions. Under some mechanisms, such as the CBAM, emissions credits, allowances and other tariffs may have an impact on the emissions and financial accounting for products that move across jurisdictions, such as from the ETS in China to one in the EU.

2.2.4 OFFSET SUPPLIERS

The offsets suppliers are the individuals or organizations which are selling tokenized carbon offset credits resulting from carbon emissions reduction or removal projects or programs, which have been validated or verified by a third-party. CET owners may seek to match up CETs with offset credits to achieve GHG emissions reductions goals.

2.3 Process overview from data collection to tokenization of emissions

The specific steps for data collection, GHG emissions calculation, and tokenization of those emissions will vary by participant.

2.3.1 DATA COLLECTION AND/OR DIRECT MEASUREMENT OF EMISSIONS

Activity data supporting emissions calculations is collected either manually or via remote metering. Emissions data may also be measured directly at the source. Organizations shall adhere to industry requirements and the Corporate Standard for data collection, meter calibration, and overall data standards and quality improvement. For allocation of emissions to a product and its co-products, companies must identify processes that are totally or partially attributable to the specific life cycle.

2.3.2 DATA STORAGE

Data collected or metered, including emissions direct measurement, is stored by the organization or a third-party (if outsourced). Data should be stored in any way that meets the organization's needs, including data warehouses, data lakes, Microsoft Excel- or Access-based, etc.

2.3.3 DATA VALIDATION

Data is validated and assessed for reasonability. Data validation is critical to ensuring emissions calculations' and results' reliability. This level of data quality checks may be done internally by the organization. Organizations shall leverage the WRI's guidance documents, including the Corporate Standard, the *GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (referred to as the *Corporate Value Chain Reporting Standard*) and the *Product Life Cycle Standard*, to manage inventory quality and ensure continuous improvement.

2.3.4 MAPPING AND CALCULATIONS

Data is mapped to process units and emission models. Calculations are executed at the frequency required by the organization and regulatory agencies. Organizations shall prioritize industry standards for emissions calculations methodology. If industry standards are not available, organizations shall refer to the applicable WRI's GHG Protocol guidance documents.

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11 https://gbbcouncil.org/wp-content/uploads/2023/09/Credible-Emissions-Reporting-InterWork-Alliance-IWA-Carbon-Emissions-Token-CET-Taskforce.pdf

2.3.5 DATA AND EMISSIONS RESULTS VERIFICATION

Emissions results and data are verified by an independent third-party verifier. The verifier examines data collection processes, data quality, and calculation methodologies. Emissions results are either verified for tokenization or recommendations are provided for quality improvement. Verification requirements for CET minting are discussed further below.

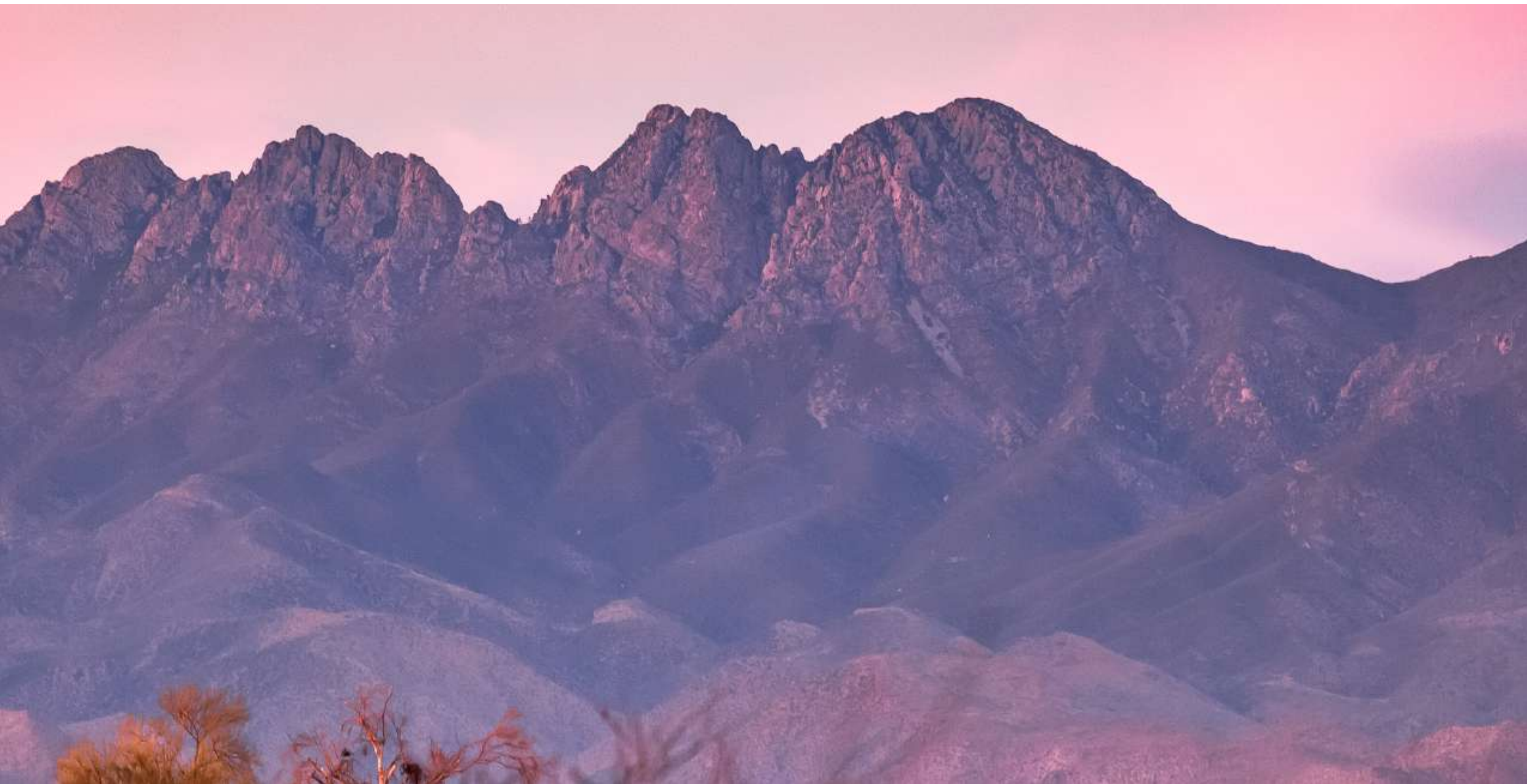
2.3.6 TOKENIZATION

In a DLT ecosystem, tokens are assets that allow information and value to be transferred, stored, and verified in an efficient and secure manner. These tokens can be programmed with unique characteristics using smart contracts that expand their usability. Security tokens, utility tokens, and cryptocurrencies have massive implications for a wide array of sectors in terms of increasing liquidity, improving transaction efficiency, and enhancing transparency and provability to assets.

Tokenization is done on DLT platforms to create tokens which represent physical or non-physical assets on the DLT. To ensure uniformity and universal acceptance, a token generally follows a set of pre-defined standards that are agreed upon and approved by a group of organizations or a community who define the usability and applicability of the token. A token standard is an interface, and a set of rules, that a smart contract must respect to be compatible with the common standards.

- Typically, token standards define how tokens can be transferred and how to keep a consistent record of those transfers on the network.
- Multiple implementations of a standard can co-exist, but they must all respect the interface and rules of the standard.
- Standards ensure that smart contracts remain compatible, so for instance, when a new project issues a token, it remains compatible with the existing decentralized exchanges, wallets, etc.

While DLT stores data in a distributed ledger in such a way that the data becomes immutable and tamper evident, there is a limit to the amount of data that can be directly fed and stored in the DLT directly due to the high cost, complexity, computational power, and time required. Thus, various other distributed storage mechanisms like IPFS (interplanetary file system), Filecoin, etc. are used in tandem with cryptography and mechanism like ZKP (Zero Knowledge Proof), Merkel tree, etc. to ensure data integrity and transactional feasibility in a DLT system.



3.0 CET PARTICIPANT REQUIREMENTS

The requirements conveyed herein shall be adhered to by participants to ensure consistent, transactable, and verifiable CETs.

3.1 Protocol and guiding principles

In alignment with established GHG accounting principles and frameworks, the emissions accounting methodology for tokenization shall adhere to the principles described below.

Relevance
The tokenized emissions are a digital representation and should accurately represent the GHG emissions of the organization and associated product.

Completeness
Organizations shall account for all emissions relevant to the level at which emissions are collected, i.e., process-, facility-, product-level.

Consistency
Organizations shall be consistent in calculation methodologies to enable comparability and transactability.

Accuracy
Organizations shall have reasonable assurance regarding emissions estimation accuracy to the best of their knowledge, reduce uncertainties where possible and attain verification from an independent third-party.

Transparency
Organizations shall document emissions calculations assumptions, maintain audit documentation and be transparent when tokens need to be revoked due to errors. Documentation shall be made available for third-party review to support token transactions as needed.

Emissions estimates, data collection, quality management, calculation methodologies, and verification shall adhere to the WRI *GHG Protocol standards*, which requires prioritization of industry-accepted standards (e.g., the American Petroleum Institute's *Compendium of Greenhouse Gas Emissions Methodologies*) and, if an industry standard is not available, the emissions estimation methodologies shall utilize the WRI's standards, guidance documents, and calculation tools as applicable.

3.2 Data quality and emissions assurance and verification

3.2.1 DATA QUALITY DEFINITIONS AND GUIDELINES

The *Product Life Cycle Standard* describes a hierarchy of data preference as follows: primary direct data, then primary indirect data followed by secondary data. Additionally, data may be provided by a third-party or may be measured by the participant directly. This standard defines these data types in Table 3 below to ensure consistency across participants.

TABLE 3: DATA QUALITY TERMINOLOGY

Category	Sub-Category	Definition
Primary direct data	Owned	Data that is measured directly at the source, e.g., continuous emissions measurement systems, metered flow measurements, gaseous fuel sampling, and product flow measurement. The data is measured or estimated by the owner of the process, activity, etc. for emissions which fall within the participant's scope 1 organizational boundary.
Primary indirect data	Owned	Data that is estimated based on industry-accepted methodologies, e.g., component counts and engineering assumptions, modeled gaseous fuel composition based on the specific process. Standardized component leakage rates, if modified based on primary direct gas compositions, would also be primary indirect data. The data is measured or estimated by the owner of the process, activity, etc. for emissions which fall within the participant's scope 1 organizational boundary.
Primary direct data	Third-party provided	Data that is measured directly at the source, e.g., metered flow measurements, gaseous fuel sampling, and product flow measurement. Data is not measured or estimated by the owner of the process, activity, etc., but is provided by a third-party, such as a fuel supplier, etc.
Primary indirect data	Third-party provided	Data that is estimated based on industry-accepted methodologies, e.g., component counts and engineering assumptions, modeled gaseous fuel composition based on the specific process. Standardized component leakage rates, if modified based on primary direct gas compositions, would also be primary indirect data. Data is not measured or estimated by the owner of the process, activity, etc., but is provided by a third-party, such as a fuel supplier, etc.
Secondary data	Third-party provided	Process and activity data that is not from specific processes which results in the emissions, e.g., proxy data.

One of the most important indicators of the quality of GHG calculations and accounting is the quality of the emission factors being used. Regarding scope 3 and product calculations, emission factors can range considerably in quality, for example from low-quality EEIO factors that represent averages across wide geographies and industries, to supplier specific PCFs that could be based on a specific batch or unit of a product or material input. Regarding scope 2 emission calculations, the granularity of electrical grid emission factors may range from country-wide emission factors to specific eGRID subregions. In addition, some grid emission factors (i.e., residual mix emission factors) account for renewable energy sales, while most do not, which results in considerable double counting of renewable energy benefits. It is also common for emission factors to be based on years-old emissions data, thus lacking temporal relevance. It is important to be able to identify the specific factors used and determine the quality of the emission factors and the resulting emission calculations.

In turn, as emission factors are calculated based on emissions data, the ability to transparently discover and reference high-quality granular emissions data (and specific attributes) can help the development of higher quality emissions factors. As higher quality emissions data become available throughout supply chains, these can support the development of better EEIO factors that are based on emission data from more specific products, suppliers, geographies, and time frames. Further, as data on energy generation and renewable energy become available at higher granularities and temporal relevance, higher quality grid emissions factors can be developed that more closely reflect the times of production and consumption as well as renewable energy that has already been sold and claimed. Higher transparency and availability of such data can help avoid double counting and support concepts such as 24/7 Carbon Free Energy[12]. Therefore, it is crucial to be able to identify and discover specific CET attributes that can support the development of better emissions factors.

The percentage of primary data used in emissions calculations shall be included in CET documentation. It is expected that the use of primary data will increase over time to improve the quality of the emissions data. Data quality, criteria and required data components are discussed further below.

CET participants shall identify and document sources of uncertainty in their reported emissions. In line with the *Product Life Cycle Standard*, a qualitative statement regarding calculation assumptions, and methodology is sufficient; however, applicable quantitative assessments are desirable for a comprehensive evaluation of data integrity and can aid in comparison of reported emissions across products, processes, or industries. Relevant qualitative disclosures and quantitative assessments of uncertainty can include information on direct emissions and activity data, emissions factor data, and methodological decisions like allocation or process scenario assumptions.

When collecting and assessing data quality, the *GHGP Product Life Cycle Standard* specifies that "companies shall collect primary data for all processes under their ownership or control" and "assess the data quality of activity data, emission factors, and/or direct emissions data by using the data quality indicators" (see Glossary for term definitions). Further, for significant processes, "companies shall report a descriptive statement on the data sources, the data quality, and any efforts taken to improve data quality."[13]

The five data quality indicators outlined by the GHGP and reiterated by the Pathfinder Framework are as follows:

- **Technological representativeness:** the degree to which the data reflect the actual technology(ies) used in the process.
- **Geographical representativeness:** the degree to which the data reflects actual geographic location of the processes within the inventory boundary (e.g., country or site).
- **Temporal representativeness:** the degree to which the data reflect the actual time (e.g., year) or age of the process.
- **Completeness:** the degree to which the data are statistically representative of the process sites.
- **Reliability:** the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable.

12 https://www.wri.org/initiatives/247-carbon-free-energy
13 https://ghgprotocol.org/product-standard

FIGURE 4: SAMPLE SCORING CRITERIA FOR PERFORMING A QUALITATIVE DATA QUALITY ASSESSMENT

Score	Representativeness to the process in terms of:				
	Technology	Time	Geography	Completeness	Reliability
Very good	Data generated using the same technology	Data with less than 3 years of difference	Data from the same area	Data from all relevant process sites over an adequate time period to even out normal fluctuations	Verified[4] data based on measurements[5]
Good	Data generated using a similar but different technology	Data with less than 6 years of difference	Data from a similar area	Data from more than 50 percent of sites for an adequate time period to even out normal fluctuations	Verified data partly based on assumptions or non-verified data based on measurements
Fair	Data generated using a different technology	Data with less than 10 years of difference	Data from a different area	Data from less than 50 percent of sites for an adequate time period to even out normal fluctuations or from more than 50 percent of sites but for shorter time period	Non-verified data partly based on assumptions or a qualified estimate (e.g., by sector expert)
Poor	Data where technology is unknown	Data with more than 10 years of difference or the age of the data are unknown	Data from an area that is unknown	Data from less than 50 percent of sites for shorter time period or representativeness is unknown	Non-qualified estimate

The table above (from the GHGP Product Life Cycle Standard) provides guidance on how each indicator can be assessed and scored qualitatively.[14]

The Pathfinder Framework adopts and builds on the requirements of the *GHGP Product Life Cycle Standard*. The Pathfinder Framework establishes a data quality hierarchy, stipulating that "activity data that is used to calculate PCF shall be company-specific", i.e., primary data and that "secondary data shall only be used when primary data is not available and be sourced from accepted global or national emission factor databases." The data hierarchy for energy and material inputs are outlined in the table below.[15]

Data Hierarchy for Energy and Material Inputs

APPROACH	ACTIVITY DATA SOURCE		EMISSION FACTOR SOURCE	
	Energy [1]	Material	Energy	Material
Best Case	In-house/primary		For on-site production: In-house/primary For supplier-specific electricity: Primary/guarantee of origin	From suppliers or via Pathfinder Network: primary
Base Case [2]	In-house/primary		Secondary databases	
Worst Case	In-house/primary		Data proxies	

1 Electricity, heating/cooling, steam

2 Prevalent approach in practice

14 https://ghgprotocol.org/product-standard

15 https://www.carbon-transparency.com/media/oymlyn4n/pathfinder-framework-version-1_final.pdf

The Pathfinder Framework also requires that companies provide the primary data share (PDS) used in calculations to be disclosed when data is exchanged. The equation for calculating PDS is shown below.[16]

$$\frac{\text{Part of PCF based on primary data } (CO_2e)}{\text{PCF } (CO_2e)} = PDS_{PCF} (\%)$$

The table below outlines the information that companies should share related to data collection and quality.[17]

Data collection, quality and exchange	
Share of primary data in the PCF	*[Share of primary data used (see Section 7.2.3)]*
Sources for primary data	*[Primary data sources used (for example, directly from suppliers or customers across the value chain) and information on which life cycle stages the sources were used for]*
Sources for secondary data	*[Secondary data sources used and information on which life cycle stages the sources were used for]*
Time period of the data collected	*[Time period of data collection of both primary and secondary data sources]*
Temporal representativeness	*[Degree to which the selected data represents the time period corresponding to the PCF]*
Geography of the data collected	*[Country or smaller area within a country]*
Geographical representativeness	*[Degree to which the selected data represents the geography of the underlying processes]*
Technological representativeness	*[Degree to which the selected data represents the underlying technological or biological processes]*
Methods of data collection and data aggregation, and data quality	*[Data collection methods, data quality and any efforts to improve data quality, including indication of data aggregation used, such as per declared unit]*
Mass balances validated (closed)	*[Yes or no]*
Cut-off rules and exemptions	*[Explanation of decisions to use cut-off rules for waste treatment and recycling processes and omit life cycle stages, unit processes or data]*
Uncertainty assessment	*[Results, key drivers and a short qualitative description of the uncertainty assessment, if applicable]*

16 https://www.carbon-transparency.com/media/oymlyn4n/pathfinder-framework-version-1_final.pdf
17 https://www.carbon-transparency.com/media/oymlyn4n/pathfinder-framework-version-1_final.pdf

3.2.2 EMISSIONS ASSURANCE AND VERIFICATION

Inaccurate or inconsistent emissions calculations present a potentially significant risk to the long-term vision discussed above. Thus, participants are strongly encouraged to obtain assurance through two methods: 1) review of the digitization and general emissions inventory approach to ensure conformance to accepted industry standards and other frameworks (e.g., *CET Protocol*, *GHG Protocol*, *Pathfinder Framework*, etc.) and 2) verification of the emissions calculations with a focus on primary and secondary data sources, calculations reliability, etc. Assurance and verification should be received from an independent third party, having GHG verification competencies relevant to the industry sector, including product life cycle and GHG emissions accounting. The verifier shall assess the organization's GHG emissions processes, data sources, procedures, and calculation methodologies.

As is expected by other GHG and life cycle protocols and frameworks, the third-party verifier shall be properly accredited to provide assurance and shall have access to evidence including data sources, databases, and any other systems or models used to calculate and allocate emissions, as applicable. An opinion letter disclosing the level of assurance must be issued by the verifier, and the letter must include the CET's unique GHG identification number (i.e., GHGId, see Section 4 for details). This letter and other verification documentation would be accessible upon request with the Id path under 'ThirdPartyVerificationDetail' (see Section 4 for details). A Verification Process Agreement is between the emitting organization, applied standard, and the auditor for the collection and verification of emissions data. Here the terms and conditions of the verification process are agreed to and documented. All artifacts in the emissions data collection process are linked to this agreement. The emitter may choose to switch standards or auditor and create a new agreement for verification.

As would be the case for any company that uses audited financials for financial reporting, those same inputs (i.e., accounts payable invoices from suppliers and vendors) can be used as attribution for indirect primary data that is third-party sourced. Because this data is used for assurance for financial reporting, it too can be relied upon for assurance for climate reporting, thereby accelerating and expediting the assurance process for climate reporting. Careful consideration should be taken regarding implementation and actionable token behaviors prior to receiving assurances of the digitization and calculation methodology. In this framework, data sources refer to the multiple origins from which relevant climate and financial data are collected. These could include, but are not limited to, direct monitoring equipment, supplier invoices, activity data meters (e.g. flow meters for fuel consumption), third-party audits, and public or private databases. All data undergoes a stringent verification process in line with industry best practices, ensuring its reliability and credibility for various use cases. The mechanism for data sources and collection would inform the overall data quality. The mechanism for data collection and verification serves as a key indicator of the data's reliability. By providing a clear, auditable path from data acquisition to data usage, the mechanism ensures the data's integrity.

For more on this topic see the discussion on referenceability and accuracy of data in section 5 and a hierarchy of risks faced by CET.

3.2.3 REPORTING

Distributed Ledger Technology keeps records of all transactions recorded securely without the possibility of tampering, which may provide efficiencies in reporting and ultimately verification of carbon emissions distributed processes across parties such as an emitting organization, auditors, and parties such as reporting standards bodies, government organizations, and consumers. DLT transaction concepts are discussed below prior to delving into the nuances.

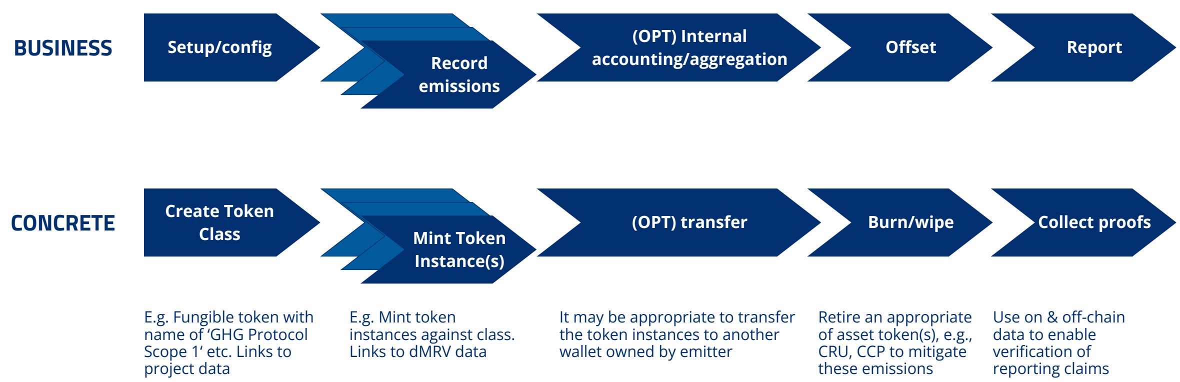
- Digital credentials, in the form of cryptographic private keys, manage tokens and, in some cases, identifiers and identities. Each credential has a corresponding public address or account ID that allows its owner to receive assets, similar to an email address. Anyone can create multiple credentials and use them for different purposes.
- A digital wallet, or wallet, is a digital safe storing digital credentials. The owner of the credentials can create and control a wallet directly (self-custodial wallet) or delegate its management to a third party (custodial wallet). The wallet's controller unlocks the wallet and uses the credentials inside to initiate transactions.
- A transaction ID, usually a hash, uniquely identifies each transaction so anyone can leverage that ID to retrieve transaction data provably.

- Token transfer transactions involve a "From" and a "To" address or account ID. The "From" address is where the tokens originated in the transaction, representing a person, organization, or entity. The "To" address is the recipient of the tokens. Addresses may or may not be linked to identities and decentralized identifiers.
- In a particular system, there may be multiple tokens that have different uses in accounting.

In adherence with the CET, the following activities/methods may occur:

- Mint – When a new token is minted against a class. For a minting transaction, the "From" address is 0 and the "To" address is the wallet address of the token minting entity.
- Burn – When a token is removed from the supply on the ledger. It should be noted that the token will preserve all of the historical details like metadata (and if allowed) transfer history, which will be useful for audit and assurance purposes.
- Offset[18] – When a token is retired after pairing it with a carbon credit.
- Transfer – When there is a transfer of the token from one party to another, however, Scope 1 Carbon Emissions are Transferable *within the corporate and geographic boundary* and Referenceable outside those boundaries as indirect emissions types.

Below is a representation of the life cycle for a CET token - differentiating between the business activities and how those concretely manifest on a DLT.



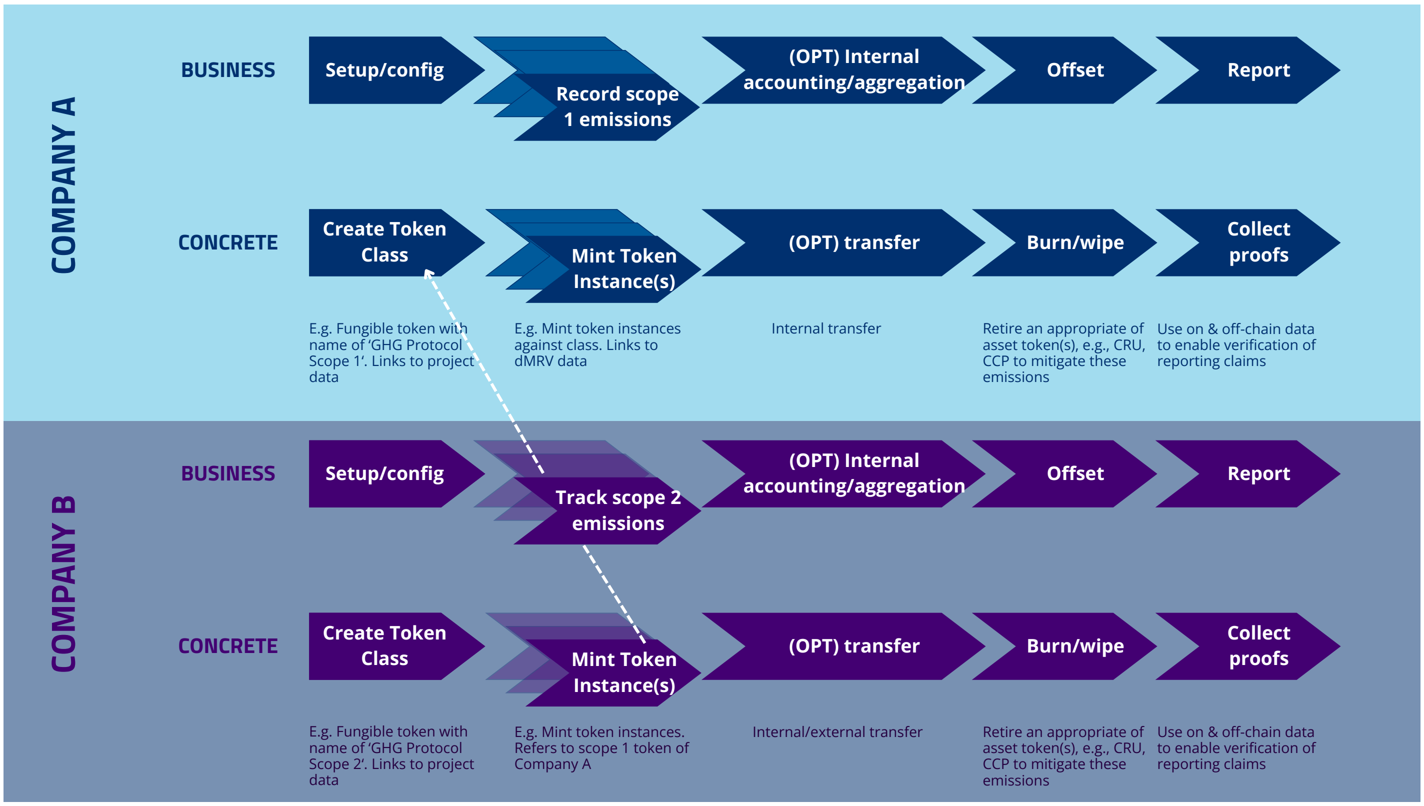
The first step is to create a token class with properties as defined by this specification, e.g. fungible, infinite supply etc . It will be subsequently minting token instances against this token class for emissions which are recorded. Minting may manifest differently on different DLTs, e.g. via a smart contract or via native support. The account into which these token instances are subsequently placed effectively owns the associated emissions and the responsibility to mitigate them (or at minimum report them). It may be appropriate for that entity to aggregate such token instances with other CET instances corresponding to different business processes or business units, but such transfers should not cross the organizational boundary. When appropriate, the entity that owns the token instances may choose to offset them by matching with an appropriate number of other tokens that represent an environmental asset - with the end result that both the CET and asset token are removed from their respective supplies. This offsetting and associated retirement of the asset token(s) may manifest differently on different DLTs. Finally, the full life cycle, from minting through to offsetting, can be included in the entity's sustainability reporting - with appropriate proofs from the DLT as evidence.

18 https://gbbcouncil.org/wp-content/uploads/2022/09/Voluntary-Ecological-Markets-Version-2-InterWork-Alliance.pdf - Page 48

Below is a version of the above diagram that incorporates the referencing aspect.

For a specific address, the number of tokens in the wallet would increase if a participant:
- Mints a scope 1 emission token

For a specific address, the number of tokens in the wallet would decrease if the participant:
- Burns a scope 1 emission token due to wrongful minting/changes, such as after an audit;



3.3 Temporal boundary

Tokens shall have an associated temporal boundary of 12 months or less contained within the 'Carbon Emission Scope and Properties' property set outlined in Section 4 which reflects the time frame during which the emissions were generated, i.e., the time during which the activity-causing emissions occurred. The Tokens should be minted within the temporal boundary and should be both created and minted as close to the time of emission as possible to ensure referenceability by indirect emitters. As such, the total emissions within a given temporal boundary shall be allocated to the outputs or measured values within that same boundary.

3.4 Scope and categories

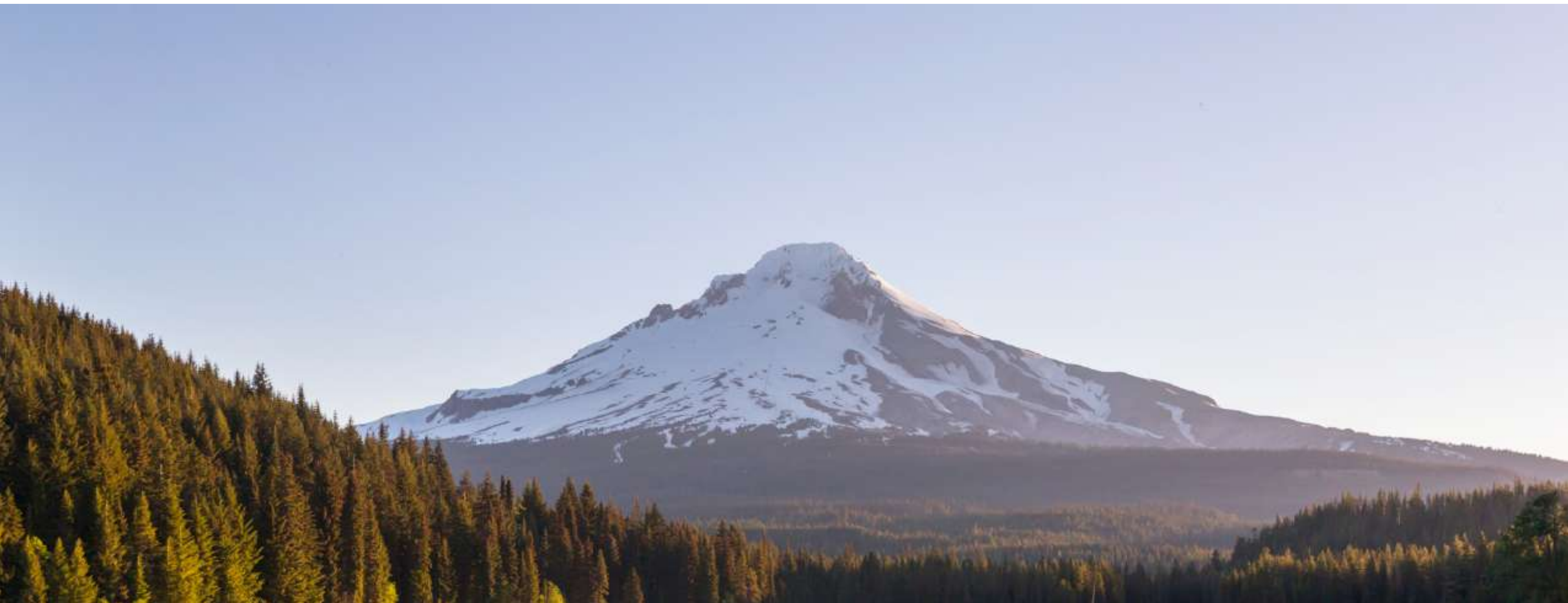
Redundant emissions resulting from minting scope 2 and scope 3 emissions present a significant risk to the universal trusted repository of GHG emissions. Tokens shall be minted only to the three designations of the GHG classification system: scope 1, scope 2 and scope 3 emissions. The emissions scope shall be captured in the 'Scope' data component and shall be immutable.

Companies are responsible for minting their own CETs for direct, scope 1 emissions. As scope 1 CETs are allocated to outputs or products throughout the value chain or referenced by third parties, the scope 1 CETs must retain their original scope and minting organization information (i.e., OrgId and OrgName). However they would represent the scope 3 CETs for member companies of the studied value chain, either upstream or downstream. Note that third-party referencing may include financial products supplied to a project as an input. In this case financial inputs may reference CET balances of the primary organization to determine the financial interests. This could be achieved using different accounting methodologies, such as the financial control or equity based reporting boundaries discussed in Section 3.5.

If suppliers or utility companies do not participate in the DLT ecosystem, companies may mint scope 2 and scope 3 CETs to provide the full scope of emission footprints related to a facility, process, output or product. However, similar to scope 1 emissions, these indirect scope 2 and 3 CETs may not be transferred to avoid redundant emissions in a wallet. The 'Scope or PCF' data component of scope 3 tokens shall document the relevant scope 3 category (i.e., Category 1 through 15 from the WRI's *Corporate Value Chain Reporting Standard*).

3.4.1 SCOPE 2 CALCULATION METHODOLOGY

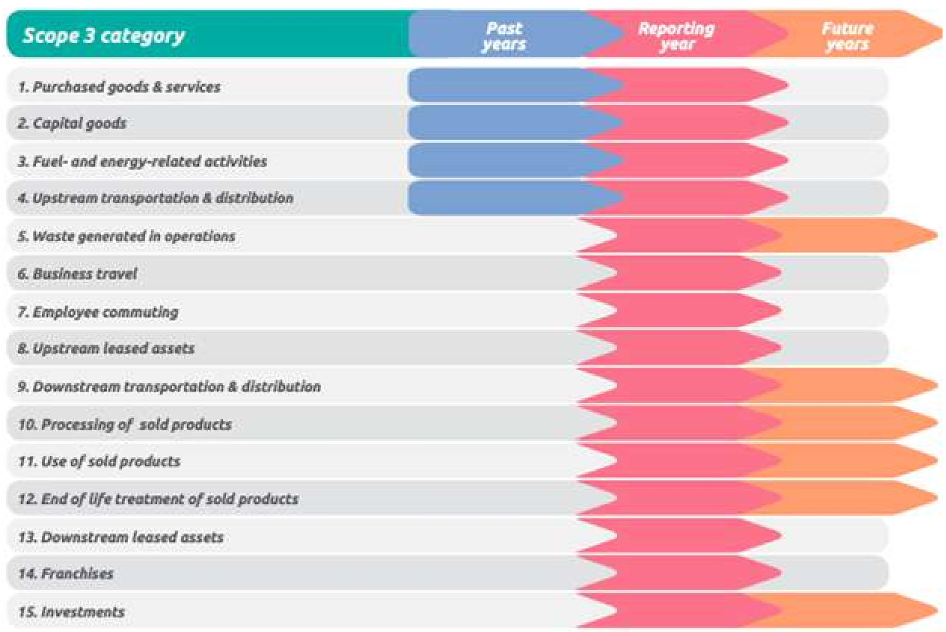
Following issuance of the *Corporate Standard*, organizations found difficulty in accounting for renewable energy purchases when accounting for scope 2 GHG emissions. As a result, the WRI published the *GHG Protocol Scope 2 Guidance, An Amendment to the GHG Protocol Corporate Standard* (referred to as the *Scope 2 Guidance*) to provide guidance and standardization regarding reporting scope 2 emissions in markets with product or supplier-specific data in the form of contractual instruments. For consistency, participants shall calculate scope 2 emissions in accordance with the *Scope 2 Guidance*. Specifically, organizations with operations in markets which provide product or supplier-specific data in the form of contractual instruments shall account and report emissions according to both the location-based and market-based methodologies as outlined in the *Scope 2 Guidance* section 7.1. CETs may be minted according to either the market-based or location-based methodology, and accompanying token metadata shall specify which methodology was used and shall also specify the result calculated according to the alternative methodology. Calculations performed under the market-based methodology must follow the quality criteria assessment of contractual instruments outlined in the *Scope 2 Guidance*. If the contractual instruments do not meet the minimum necessary features, they should not be included in the calculations for scope 2 emissions. Organizations with operations located in markets that do not provide product or supplier-specific data, or other contractual instruments, shall utilize the location-based method to calculate scope 2 emissions and mint CETs.



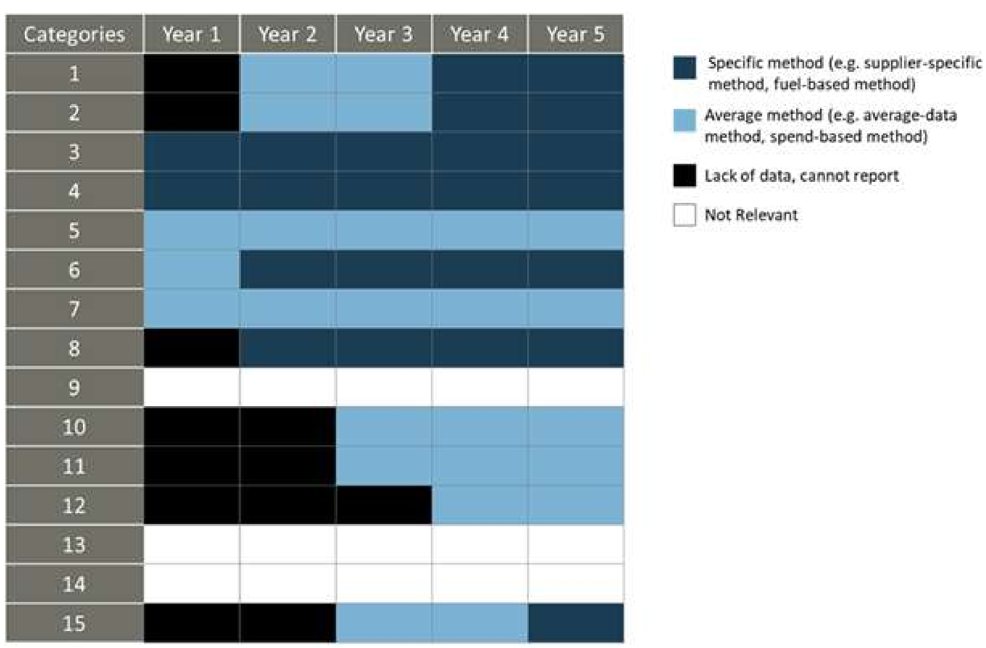
3.4.2 SCOPE 3 OR VALUE CHAIN EMISSIONS

Scope 3 emissions, or value chain emissions, result from activities not owned or controlled by the emitting organization. These can be considered indirect emissions not accounted for in Scope 1 or Scope 2 reported emissions. There are 15 categories defined in the GHG Protocol's [Corporate Value Chain (Scope 3) Accounting and Reporting Standard](). Scope 3 emissions happen both upstream and downstream to the specific emitters gate to gate calculation. These emissions generally are not in the organizations direct control, but organizations that emit may be able influence vendors, partners, and adjacent organizations to reduce these emissions.

Figure [5.3] Time boundary of scope 3 categories



Each category generally has multiple acceptable accounting approaches, but, as data becomes more available, the acceptable approach may change over time.[19] For the CET it is recommended that each category is reported and a token is minted, even with a zero value, representing the acceptable approach. In the context of specific methods, we recommend referenceable data is used.



19 https://www.epa.gov/climateleadership/scope-3-inventory-guidance#:~:text=Scope%203%20emissions%20are%20the,-scope%201%20and%202%20boundary

3.5 Organizational boundary

The WRI *Corporate Standard* provides several consolidation approaches for companies to report emissions on either a control basis or an equity share basis that naturally fits their visibility into emissions producing activities. In the operational control case, this allows companies to emphasize emissions they have direct control over and are, thus, in a better position to reduce. The risk of redundant emissions reporting within a CET framework can occur if two organizations apply different and overlapping reporting boundaries. However, as is further detailed in Section 5 on the risks facing CET, double counting from overlapping reporting boundaries is labeled as an allowed or permitted risk. This is expected to occur based on the needs of different organizations.

Given the different approaches used for different reporting use cases, it is important that organizations specify the method used when using the CET DLT ecosystem. Consistency across participants that hold interests in the same operation is important. This can be achieved by coordinating the minting of CET through a Verification Process Agreement that applies the same consolidation approach for multiple organizations. For example the equity share approach provides a consistent method to distribute scope 1 and 2 emissions across organizations that control an operation, and others that only carry an equity stake.

For example, real estate Company A has a 30% stake in a commercial office building, while Company B maintains a 70% stake. Company B has operational control of the office building. In this scenario, Company A is responsible for, and thus would mint, 30% of the total scope 2 emissions from the commercial office building and Company B would mint the other 70% of the scope 2 emissions. If Company B were to use an operational control approach, Company B would account for 100% of the scope 2 emissions. Thus, consistency of the consolidation method selected minimizes the risk of duplicate tokenized emissions on the DLT.

The CET does not rule out the application of different boundaries, as different organizations may have different requirements. In addition, the same organization may apply different consolidation approaches in different contexts, including satisfying the requirements of different stakeholders. The main risks that need to be avoided are conflict in financial interests or regulatory compliance, such as under an emissions trading scheme. Therefore, consistent boundary requirements may be set based on the needs of the reporting entities in a particular context or application.

According to the GHG Protocol, "When two or more companies hold interests in the same joint operation and use different consolidation approaches (e.g., Company A follows the equity share approach while Company B uses the financial control approach), emissions from that joint operation could be double counted."[20]

If the focus is on financed emissions, the Partnership for Carbon Accounting Financials (PCAF) requires using the financial control approach to report all loans and other investments as scope 3 category 15 (investments) of the Corporate Standard.[21] This PCAF standard was recommended under the guidance of the Science Based Target initiative (SBTi) and reported by the Task Force on climate-related Financial Disclosures (TCFD)[22].

It avoids inconsistencies in the reporting of financed emissions under different scopes defined by the WRI. An example of an inconsistency is the exclusion of the equity share of scope 1 and 2 emissions from scope 3 category 15, which would be reported as scope 1 and 2 under the equity approach, separate from other financial instruments, such as debt.

Financial and operational control are commonly used for regulatory reporting, such as applied to direct emissions under an emissions trading scheme. However, there may be situations where both the partial (equity basis) and total (financial/operational control) reporting base are needed:

- requirement to report on the equity boundary as a partial shareholder in emission reduction projects whether it has financial control over them or not(e.g., a future SEC/FINRA requirement);
- an organization operating a project needs to report the operational control boundary (e.g., to comply with performance based financing).

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20 https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf
21 Page 3 Box A1: https://www.fsb.org/wp-content/uploads/P141021-2.pdf
22 See section 4.2 of the Financed Emissions Standard: https://carbonaccountingfinancials.com/en/standard#the-global-ghg-accounting-and-reporting-standard-for-the-financial-industry

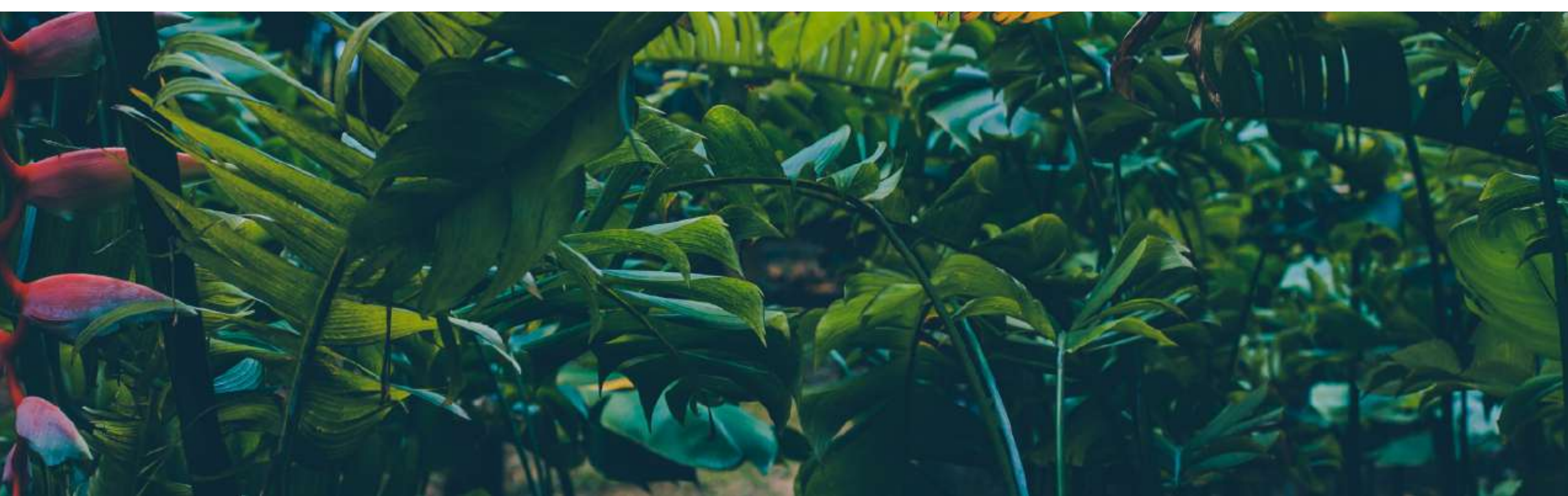
3.6 Global Warming Potential

The GHGs covered by the Kyoto Protocol, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs), shall be calculated (as applicable) separately and then converted to CO_2 equivalents (CO_2e) for tokenization. For conversion to CO_2e, organizations shall use the 100-year Global Warming Potential (GWP) factors from the most recent Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR) within one year of its release. Token data shall include the breakdown of the CO_2e component emissions, including CO_2, CH_4, N_2O, SF_6, NF_3, HFCs, PFCs.

In cases where the CO2e conversion factors are embedded in the industry-provided emission factor, and the emission factor is not updated in a timely manner to reflect the updated IPCC AR, the organization shall use the most updated emission factor available to them.

There may be cases where another GWP factor needs to be applied for reporting purposes driven by a regulatory requirement, for example to emphasize the short-term impacts of GHGs. The CET does not enforce a particular GWP assumption for reporting purposes. Conforming to the most recent IPCC AR 100-year GWP enables easy conversion across various CET implementations. Also see the GWP Factor Adjustment in Section 4.3 Table 6 (Carbon Emission Attributes) to support documentation of different GWP reporting requirements.

Differences in GWP may be minor or major, depending on the time scale considered. An organization may apply a slightly different GWP than used to consolidate national inventories by a regional government. The IPCC AR 100-year GWP calculates the average warming potential of GHGs with a much shorter lifespan in the atmosphere, compared to CO_2, around 28 times for methane (CH_4). However given the very short lifespan of CH_4, its GWP may be reported over a much shorter time period. For example, a project accounting for the impacts of methane venting or leakage events, independent of other CO_2 emissions, may be concerned with offsetting the GHG impact over the next 20 years. In this case the GWP is around 86, accounting for 3 times more than the 100-year GWP. Ensuring the validity, or insuring, an offset purchase over a 20 year period may be more realistic than the 100-year equivalent.



4.0 CET DATA ELEMENTS SUMMARY

The IWA Taskforce identified basic data components necessary to describe the origin, GHG emission properties, and attributes of each CET. These data components were logically grouped into three sets of token properties: Carbon Emission Generator Object, Carbon Emission Scope and Properties, and Carbon Emission Attributes. As discussed above, the components, or property sets, are generic to enable their application to other token initiatives. The description of each property set, and the relevant data components classified under the set, are outlined below. Numeric value of metric tonnes emitted is quantified in the token quantity.

4.1 Carbon Emission Generator Object (EGO)

A token class that implements this set of properties will have a Carbon Emission Generator Object (EGO) with a Read/Query and Set control. An EGO has two fields that are used to identify the object to which the carbon emissions are attributed. This is useful when referencing or accounting for a fractional CET resulting from value chain emissions attributed to a specific workload or asset.

TABLE 4: CARBON EMISSION GENERATOR OBJECT

EGO Property	Output Data	Sample Data
EGOId	Unique number or identifier given to each EGO. (Refer to the EGOName parameter description for details.)	IS122504
EGOName	Name and/or description of the process, facility, output or value which resulted in or generated the tokenized emissions. It can be the name of the process or the product or the facility associated with the emission. Essentially, the EGO is the emission generator and can refer to any level (e.g., process, facility, product, or value) based on the situation and requirements.	natural gas
Organization	Output Data	Sample Data
OrgId	ID of the organization that is accountable for the tokenized emissions.	C12786
OrgName	Name of the organization associated with the OrgId that is accountable for the tokenized emissions.	Upstream Oil, Inc.
Site Information	Output Data	Sample Data
SiteId	ID of the site or facility where the emissions were generated	C12786-1
SiteName	Name of the facility where the emissions were generated	Gathering and Boosting 1

4.2 Carbon Emission Scope and Properties

A token class that implements this set of properties will have the properties related to the generation of the greenhouse gas emissions, including the emission quantity, data collection period, and scope. The property set will have details regarding the scope of the emissions, i.e., Scope 1 (direct), Scope 2 (indirect), or Scope 3 (indirect), and if emissions are attributed to Scope 3 sources, the emissions should be categorized according to the WRI's *Corporate Value Chain Reporting Standard* (i.e., Category 1 through 15).

TABLE 5: CARBON EMISSION SCOPE AND PROPERTIES

Emission Property	Description	Sample Data
GHGId	Unique alphanumeric identifier given to a particular set of emissions, e.g., 1 metric ton CO_2e, generated from a single source.	GIDIS122504
Scope or PCF	Per the WRI *Corporate Standard*: Scope 1: Direct GHG emissions Direct GHG emissions occur from sources that are owned or controlled by the organization, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.; emissions from chemical production in owned or controlled process equipment. Scope 2: Indirect GHG emissions from grid-supplied electricity Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the organization. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the entity that is tokenizing emissions. Scope 2 emissions physically occur at the facility where electricity is generated. Scope 3: Indirect GHG emissions from other sources, outside of scope 2. Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services. Refer to Section 3.5 for further details on the scope and safeguards to manage redundant emissions accounting. The number following the decimal for Scope 3 emissions represents the category of Scope 3 emission (e.g. Scope 3.15 would be Scope 3, Category 15).	3.15 OR PCF
Date Range	**Description**	**Sample Data**
StartDate	Temporal boundary (start date related to activity data) of the emissions which minted the token.	4/1/2022
StartTimeStamp	Temporal boundary (start time related to activity data) of the emissions which minted the token.	00:00:00 HRS
EndDate	Temporal boundary (end date related to activity data) of the emissions which minted the token. Note: The time between the start date and time and end date and time shall be no more than 12 months.	4/30/2022
EndTimeStamp	Temporal boundary (end time related to activity data) of the emissions which minted the token.	23:59:59 HRS

4.3 Carbon Emission Attributes

A token class that implements this set of properties will include attributes of the GHG emissions to support verification such as Primary Data Share, third-party verification, and supporting documentation. Additionally, the properties include details of the greenhouse gasses which comprise the CO_2e emissions, geo-location, and factors of global warming potential.

TABLE 6: CARBON EMISSION ATTRIBUTES

Emission Data Quality	Description	Sample Data
PrimaryDataShare	Refers to the percentage of primary data used in emissions calculations.	75%
Third-Party Verification	**Description**	**Sample Data**
ThirdPartyVerification-Done	Confirmation of third-party verification.	Yes
ThirdPartyVerifierDetails	Name or details of the third-party verifier.	EY
Verified Link	**Description**	**Sample Data**
LinkText	Contains the link to any relevant documents related to the emission, such as calculation spreadsheets or other related documents. Should include references to standards, methodologies, assumptions, emission factors and sources, and/or calculation tools used. Should also include the verification contract/processedClaims/ProcessedClaimId	<reference>
LinkSigned	Returning the value of the signed link. Usually an encoded string of text.	
PublicKey	Contains the PublicKey used to sign the link.	0x1b31F-2dCd-8C5 0De80f165 930-5e33e
CalculationDetailsRefer-ence	Reference documentation on sources, methodologies, and supporting documents with represented emissions factors.	
Geo-Location	**Description**	**Sample Data**
Longitude	Site location in longitude degrees	41.39
Latitude	Site location in latitude degrees	-87.54
GeographicArea	List the regulatory jurisdictions that apply to these emissions.	TCEQ, US EPA
GeographicAreaFileLink	Link to File in acceptable data format for geographic area	See "creden-tialSubject" section here.
Emission Composition	**Output Data**	**Sample Data**
CO_2	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gasses: CO_2 (and biogenic CO_2), CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. This element captures the quantity of CO_2 emissions associated with the CO_2e emissions.	0.14 mt
Biogenic CO_2	This element captures the quantity of CO_2 emissions from the decomposition of plant and animal matter, or the combustion of biofuels produced from plants. Defined as carbon neutral, and reported separately from other CO_2e emissions.	--

CH_4	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gases: CO_2 (and biogenic CO_2), CH_4, N_2O, HFCs, PFCs, SF6, and NF3. This element captures the quantity of CH4 emissions associated with the CO_2e emissions.	0.02 mt
N_2O	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gases: CO_2 (and biogenic CO_2), CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. This element captures the quantity of N_2O emissions associated with the CO_2e emissions.	--
HFCs	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gases: CO_2 (and biogenic CO_2), CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. This element captures the quantity of HFC emissions associated with the CO_2e emissions.	--
PFCs	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gases: CO_2 (and biogenic CO_2), CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. This element captures the quantity of PFC emissions associated with the CO_2e emissions.	--
SF6	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gases: CO_2 (and biogenic CO_2), CH_4, N2O, HFCs, PFCs, SF_6, and NF_3. This element captures the quantity of SF_6 emissions associated with the CO_2e emissions.	--
NF3	Decompose CO_2e into quantities of CO_2, CH_4, N_2O, at a minimum, but where applicable, include the following greenhouse gases: CO_2 (and biogenic CO_2), CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3. This element captures the quantity of NF3 emissions associated with the CO_2e emissions.	--
GlobalWarmingPotential-Factors [Not Optional]	GWP factors refer to the relative ability of each greenhouse gas to trap heat in the atmosphere over time (such as 100 years). Carbon dioxide is the reference gas with a GWP of 1. Within one year of its release, participants should use the GWP rates from the most recent IPCC Assessment Report based on a 100-year timeline to summarize greenhouse gas emissions in terms of carbon dioxide equivalents unless otherwise bound by regulatory requirements. This must be updated at the beginning of the most recent temporal boundary to the current IPCC Assessment Report. Any deviations from the most recent IPCC AR require a GWP Factor Adjustment.	IPCC AR5
GWPFactorAdjustment [Contingent]	This is a contingent field to represent the required adjustment factor due to a deviation from the current AR GWP based on a local jurisdiction requirement to calculate CO2e with a prior GWP factor or non-GWP factor from a regulator or industry standard. This would be defined prior to minting in the accounting methodology based on rules at the time of minting. This should reference the regulatory regime (e.g., EPA) and GWP factors and is meant to address interjurisdictional accounting adjustments where one party references one GWP Factor and another party references a different standard and factor. This could be a publishing of each emission composition output data outlined in Section 4.3	EPA, 25x, 33x

5.0 KEY RISKS AND CHALLENGES TO THE DLT CET ECOSYSTEM

The Taskforce has identified and classified different challenges faced by a DLT CET ecosystem that can be characterized into two sets of risks for the ecosystem users. A first set of risks deals with **design** challenges that can have a direct impact on CET adoption and implementation. A second set of risks are more **operational** in nature and deal with how CETs are used in practice. We also consider the implications for specific CET stakeholders, characterized as the issuer, primary holder, and secondary consumer.

We first provide a hierarchical list of the risks discussed in more detail below. We use the type and user labels to assist in classifying risks. Note, this is a simplification to assist in characterizing risk impact, however these are not rigid or mutually exclusive.

5.1 Hierarchy of Risks

1. **Transferable Benefits Accounting and LCA's (*type*: operational; *user*: primary holder & secondary consumer) -** the ability to transfer and track both the environmental commodity [CET] and corresponding offset [or its equivalent mitigation asset] that has been retired.There is a tradeoff between using estimates and access to data to measure benefits through Life Cycle Analysis (LCA). The taskforce acknowledges there is a large risk of scale for supply chain coordination failures.

2. **Double Counting (*type*: operational; *user*: issuer, primary holder) -** addresses the accounting of either emissions inventories, associated offset or reduction credits and financial expenditures. This can be split into avoided, carries a higher degree of risk, and allowed as double counting that may occur but is acceptable in some situations.

    Avoided
    a. Double counting of financial expenditures tied to CET data, such as in a carbon taxation or other mandated reporting schemes.
    b. Double counting of offsets linked to CET through an Inset Project, and other direct emissions reduction claims

    Allowed
    c. Minting of CET representing the same emissions as different scopes due to overlapping reporting boundaries.
    d. Double counting of the same scope 3 emissions by multiple organizations.

3. **Data privacy (*type*: design; *users*: issuer, primary holder) -** addressing privacy concerns regarding primary data, commercial and financial interests of users.

4. **Accessibility & accuracy (*type*: design,*users*: all) -** addressing access to and trust in primary and referenced CET attributes.

The design risks deal primarily with availability, accuracy and privacy of information referenced or stored within a blockchain network. While a blockchain network can facilitate these characteristics it does not inherently regulate or guarantee them. A public immutable network can raise privacy concerns and risks related to an organization's commercial and financial interests. While these risks are exposed during regular operations, design and planning will play an important role in mitigating them and can influence a user's, or organization's, decision and willingness to participate in a CET ecosystem.

The operational risks listed above deal primarily with challenges in how information is issued and communicated across users. While design may play a role in mitigating these risks, operational protocol and coordination across users are primary. One should consider all of these risks carefully, keeping in mind that carefully addressing design risks will provide a stronger foundation to manage operational risks around transferable benefits and double counting.

5.2 Transferable Benefits Accounting

Transferable benefits accounting deals with the communication of emission reductions to the consumers of products and services, or the organizations financing them. In a CET framework transferable benefits can occur in two ways:

- explicitly, for example, when an organization purchases en emission reduction benefit directly against the indirect emissions outside its control;
- implicitly, by referencing them during the exchange of goods and services.

The purchase of offsets is a common example of a direct transferable benefit. The risk here lies in the ability of an organization to accurately measure, without overestimating the necessary benefits that may have already been implemented upstream. From a climate mitigation perspective, such oversubscription is a positive outcome. However this can negatively affect the financial interests and effectiveness of organizations to achieve their disclosed goals using the CET framework.

The implicit transfer of benefits within a CET ecosystem can help overcome these issues by matching an environmental commodity (e.g., emissions) to an offset or reduction. A real world example of this is attaching a certified emission reduction to the sale of product or service, relaying the benefits to the buyer without transferring it. This can facilitate a more detailed LCA based approach to tracking value chain emissions. However, the LCA approach can be challenging to implement and is not as widely used as estimating emissions with the direct transfer of benefits.

The second stated outcome of the CET framework, referenceability across parties for indirect emissions reporting, would greatly benefit from the implicit transfer of benefits. However, achieving this requires overcoming at least two important barriers. First, organizations need to embrace a culture of more comprehensive accounting methods like LCA. Second, the outputs of this accounting must be packaged into standard results that are easy to identify and communicate across supply chain counterparties.

Initiatives such as the common data model developed by the Open Footprint Forum for information exchange by the energy industry offer tools to help advance the CET framework in this direction. The organizational LCA initiative of the UN Environmental Program also provides some guidance complementing the product-focused LCA approach.[23] It can help organizations address the challenge of balancing multiple product life cycles at the organizational level.

23 https://link.springer.com/article/10.1007/s11367-015-0912-9

5.3 Double Counting

As summarized in the risk hierarchy, double counting can occur in multiple ways, with the level of the risk dependent on specific situations and contexts. Transparency is key to identifying double counting risks that commonly occur in the following two scenarios:

- Financial Coordination: some stakeholders (banks, asset managers) will apply their CET based on equity and debt allocations as financed emissions. This allows the firms to aggregate and report based on attribution methodologies.
- Supply Chain (operational) Coordination: attribution occurs at the product level collecting environmental commodities upstream and then pushing them downstream as aggregate supply chain impacts for the final product.

The two scenarios will overlap exposures and require using different reporting boundaries, that may result in double counting of emissions. This is defined as a lower priority risk, labeled as allowed in the risk hierarchy. Such overlaps are expected as different applications of the CET will require non-consistent reporting boundaries based on their specific requirements (see section 3.5). Another example of an allowed risk is when a producer and retail company both account for the emissions from transportation.

Attribution under either financial or supply chain coordination is where double counting risks need to be avoided. On the supply chain side, double counting of emission reductions against CET is a major risk within transferable benefits accounting. Double counting of an emissions reduction, such as an inset claimed by a producer and offset sold to external parties is a major risk in the explicit transfer of benefits. The risk of double counting emission reductions should be managed through independently verified registries. Unique referencing of emission reduction claims assigned to specific CET can also help address this risk.

The implicit transferable benefits mentioned above can help reduce the occurrence or need of double counting. In such a transfer the environmental benefits are shared across supply chain actors. This requires building an indirect emissions referencing protocol that faces its own set of challenges as documented in the previous section.

Double counting of financial impacts and expenditures tied to CET data is considered a high priority. These should be avoided, and will typically require using consistent reporting boundaries. This includes both financial reporting, carbon taxation or other mandated reporting schemes. For example, the application of emission trading only to direct scope 1 emissions.

Cross border carbon taxation policies introduce a specific risk linked to pricing the embodied (scope 2 or 3) emissions in international trade. Such mechanisms have adjustment protocols to avoid double counting of emissions taxed both internal and external to an organization. The CET framework is well suited to identifying overlapping reporting boundaries, and financial impacts, between the producers that export goods and the importers subject to the carbon border tax. Again, this risk deals with the issue of transferable benefits (in this case previously paid carbon taxes) and the referenceability of indirect emissions.

5.4 Data availability and accuracy

Data availability deals with managing the interests across the parties that issue, hold and view CET. Availability of information on the issuer of a token is a question of trust in the data. A CET in itself does not guarantee the accuracy of data. However, availability of information on who issued a CET, as well as the policy framework used to generate it, provides important information to assess the accuracy of, and confidence in, the underlying data. Therefore, availability risks relate to the identities and credentials of the parties issuing CET.

Availability risk also deals with the access to information used to measure the final CET quantities. In many use cases CET issued to the holder account will represent an organization's public disclosure of its emission inventories. An organization may use CET from different DLT protocols to compile a final inventory report, which could cause availability issues.

While public blockchains, by design, are well suited to public disclosure, other primary risks reside in the availability and access to non-public metrics used by the issuer. The issuers may be granted access to some or all of the relevant metrics and procedures. For example the various ISO Standards, clauses and processes used by auditors to assess the environmental and GHG emissions impacts of the organization.

The issuer, as well as third-party viewers, may require access to non-emissions data of importance to the holder, such as a carbon price or the financial data associated with CET. For commercial and legal reasons this information may not be included in the token metadata. Selective disclosure mechanisms may be required, and will involve managing risks associated with transmitting sensitive information referenced to, or by, a CET. How the CET implementation is designed to handle this will be a high priority for token holders.

Selective disclosure may be used by the third-parties to confirm that minted CET conforms to a set of standards. It can also apply to granting third parties access to financed emissions data that may be considered high risk in safeguarding the commercial interests of the holders. Tools such as Zero Knowledge Proofs, and the design of other services that operate in parallel to the blockchain infrastructure will play an important role in managing these risks.

6.0 CONFIDENTIALITY IN ATTRIBUTES & ASSET GENERATION

Data associated with emissions MRV that leads to tokenization, may be relevant to reputation, but will also likely be limited due to privacy and confidentiality considerations.

To enable confidentiality in MRV data, there are multiple approaches to privacy; however, there are specific requirements to enable this in the requirements of an MRV workflow. The below example is not an endorsement of a specific approach, but shows an example reference based on W3C standards.

Reference Example

In a reference example for generating Digital Environmental Assets, the Hedera Guardian uses the W3C standards of Decentralized Identifiers (DIDs), Verifiable Credentials (VCs), and Verifiable Presentations (VPs) in order to capture digitally signed documents that are stored on the decentralized InterPlanetary File System (IPFS).

Guardian uses VCs & VPs for a variety of data types - particularly:

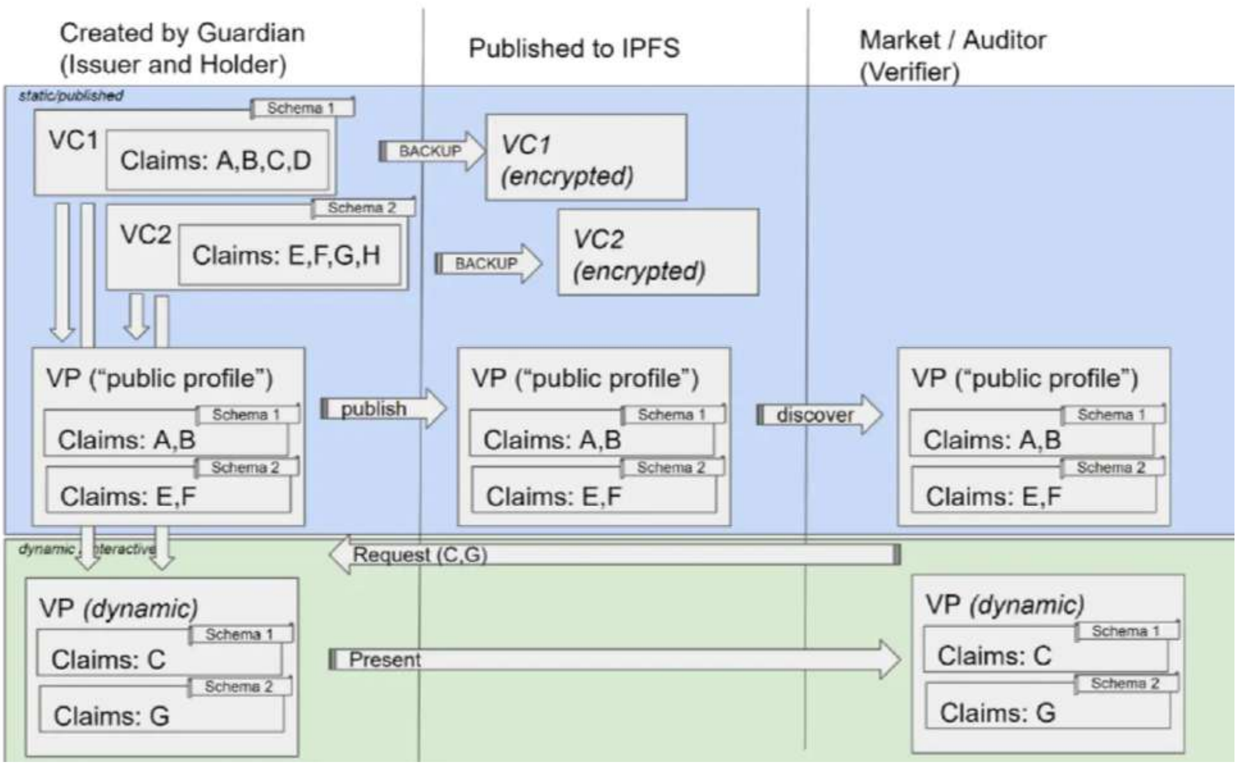
- Monitoring, Reporting & Verification (MRV) data capturing the emissions reported.
- The policies that digitize the methodology. In this context of emissions, a methodology is a framework document that defines the rules governing the MRV process and the criteria for minting tokens corresponding to that MRV process.

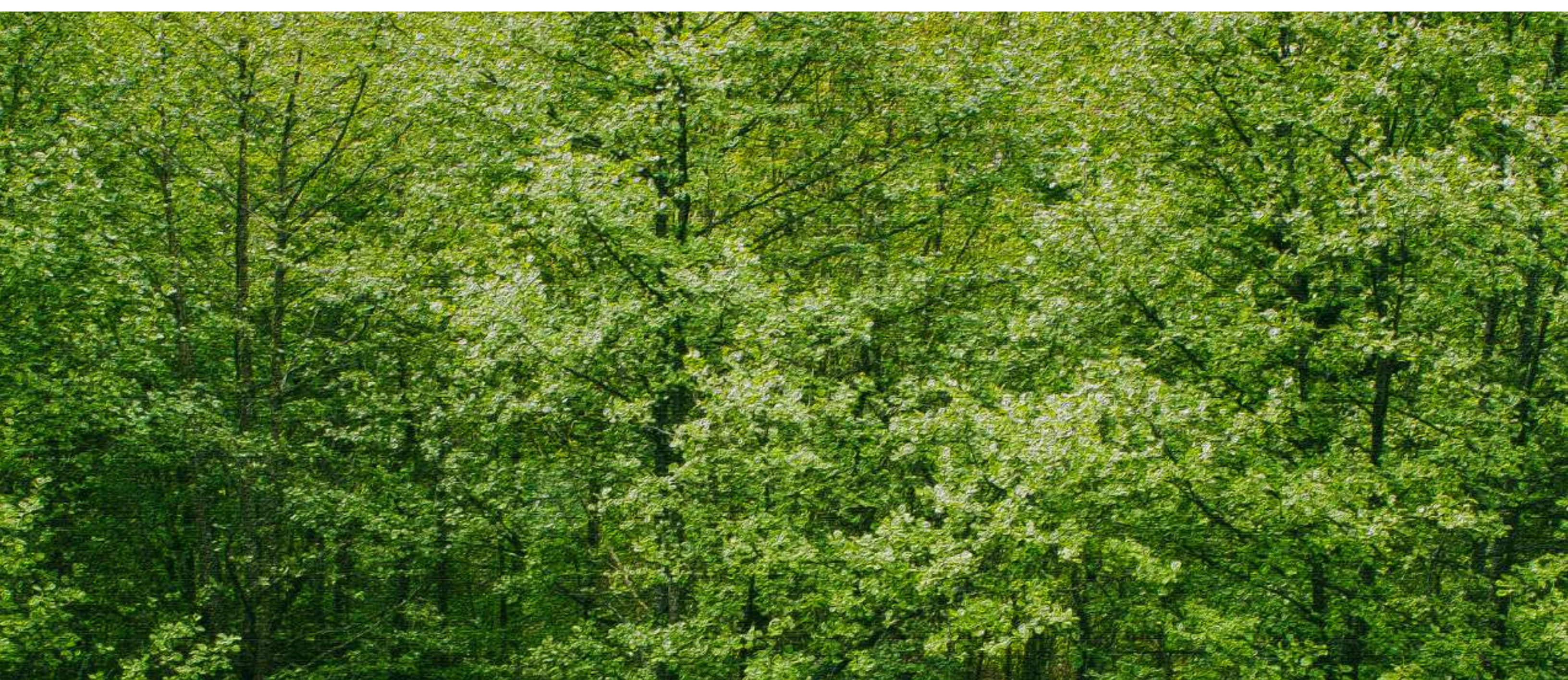
The current Guardian model publishes MRV data as a VC and creates a corresponding VP, apriori from that VC, and stores the VP on IPFS or equivalent data storage solution. The VP (and the VC within) can be retrieved from IPFS at any time and are, by default, unencrypted.

While this default transparency enables easy validation of provenance chains, it may not be acceptable to all enterprises considering using Guardian to track emissions of their manufacturing processes. While a business may recognize the need to be fully transparent about the amount of CO2 emissions associated with their business processes, they may wish to keep some details of those processes less than fully public to protect associated intellectual property and confidentiality. Separately, but equally important, confidentiality may be required to protect an individual’s information.

This sort of confidentiality can be challenging to reconcile with the desired transparency and composability and the fundamental choice of using a public Distributed Ledger Technology (DLT), like Hedera, to track the provenance of Digital Environmental Assets.

Below is an example of attestations with selective disclosure. This model enables delivery of digital MRV generated attributes that include information which may not be publicly disclosed due to confidentiality concerns.





7.0 EMISSION ALLOCATION PROTOCOL

Although emission allocation is critical to understanding the carbon footprint of a studied product or a functional unit, the CET itself does not conduct allocation or contain allocation metadata.

A decentralized, public ledger would support mapping CETs to product tokens to enable emissions allocation. Organizations who choose to attribute CETs to a well-defined unit of analysis or a functional unit shall adhere to the WRI's Product Life Cycle Standard, the Pathfinder Framework, ISO 14044 Standard (Environmental management – Life cycle assessment – Requirements and guidelines) and the ISO 14067 Standard (Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification) when determining and applying the allocation approach and assessing life cycle GHG emissions.

8.0 MOVING FORWARD

Thank you to all of the members of GBBC who have contributed to this effort, and a special thank you to individual contributors: Alison Campestre, Bertrand Rioux, and Tom Garlick, as well as Jackson Ross who helped coordinate and facilitate the Taskforce through its deliberations. Additionally, thank you to Wes Geisenberger for chairing the Taskforce and driving this work forward.

This is an evolving document and further collaboration on the topic will lead to more robust standards and guidance. To that end, we welcome your feedback on this paper as the group continues to refine and iterate on the CET use case.

Please submit any comments or feedback to iwa@gbbcouncil.org **by February 17, 2023**.

APPENDICES

InterWork Alliance
A Global Blockchain Business Council Initiative

APPENDIX A. SCOPE 3 EMISSIONS CATEGORIES[24]

Category	Description	Minimum Boundary
1. Purchased goods and services	Extraction, production, and transportation of goods and services purchased or acquired by the reporting company in the reporting year, not otherwise included in Categories 2 - 8	All upstream (cradle-to-gate) emissions of purchased goods and services
2. Capital goods	Extraction, production, and transportation of capital goods purchased or acquired by the reporting company in the reporting year	All upstream (cradle-to-gate) emissions of purchased capital goods
3. Fuel- and energy-related activities (not included in scope 1 or 2)	Extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company in the reporting year, not already accounted for in scope 1 or scope 2, including: a. Upstream emissions of purchased fuels (extraction, production, and transportation of fuels consumed by the reporting company) b. Upstream emissions of purchased electricity (extraction, production, and transportation of fuels consumed in the generation of electricity, steam, heating, and cooling consumed by the reporting company) c. Transmission and distribution (T&D) losses (generation of electricity, steam, heating and cooling that is consumed (i.e., lost) in a T&D system) – reported by end user d. Generation of purchased electricity that is sold to end users (generation of electricity, steam, heating, and cooling that is purchased by the reporting company and sold to end users) – reported by utility company or energy retailer only	a. For upstream emissions of purchased fuels: All upstream (cradle-to-gate) emissions of purchased fuels (from raw material extraction up to the point of, but excluding combustion) b. For upstream emissions of purchased electricity: All upstream (cradle-to-gate) emissions of purchased fuels (from raw material extraction up to the point of, but excluding, combustion by a power generator) c. For T&D losses: All upstream (cradle-to-gate) emissions of energy consumed in a T&D system, including emissions from combustion d. For generation of purchased electricity that is sold to end users: Emissions from the generation of purchased energy

24 https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf

4. Upstream transportation and distribution	Transportation and distribution of products purchased by the reporting company in the reporting year between a company's tier 1 suppliers and its own operations (in vehicles and facilities not owned or controlled by the reporting company) Transportation and distribution services purchased by the reporting company in the reporting year, including inbound logistics, outbound logistics (e.g., of sold products), and transportation and distribution between a company's own facilities (in vehicles and facilities not owned or controlled by the reporting company	The scope 1 and scope 2 emissions of transportation and distribution providers that occur during use of vehicles and facilities (e.g., from energy use) Optional: The life cycle emissions associated with manufacturing vehicles, facilities, or infrastructure
5. Waste generated in operations	Disposal and treatment of waste generated in the reporting company's operations in the reporting year (in facilities not owned or controlled by the reporting company)	The scope 1 and scope 2 emissions of waste management suppliers that occur during disposal or treatment Optional: The life cycle emissions associated with manufacturing vehicles or infrastructure
6. Business travel	Transportation of employees for business-related activities during the reporting year (in vehicles not owned or operated by the reporting company	The scope 1 and scope 2 emissions of transportation carriers that occur during use of vehicles (e.g., from energy use) Optional: The life cycle emissions associated with manufacturing vehicles or infrastructure
7. Employee commuting	Transportation of employees between their homes and their worksites during the reporting year (in vehicles not owned or operated by the reporting company)	The scope 1 and scope 2 emissions of employees and transportation providers that occur during use of vehicles (e.g., from energy use) Optional: Emissions from employee teleworking
8. Upstream leased assets	Operation of assets leased by the reporting company (lessee) in the reporting year and not included in scope 1 and scope 2 – reported by lessee	The scope 1 and scope 2 emissions of lessors that occur during the reporting company's operation of leased assets (e.g., from energy use) Optional: The life cycle emissions associated with manufacturing or constructing leased assets

9. Downstream transportation and distribution	Transportation and distribution of products sold by the reporting company in the reporting year between the reporting company's operations and the end consumer (if not paid for by the reporting company), including retail and storage (in vehicles and facilities not owned or controlled by the reporting company)	The scope 1 and scope 2 emissions of transportation providers, distributors, and retailers that occur during use of vehicles and facilities (e.g., from energy use) Optional: The life cycle emissions associated with manufacturing vehicles, facilities, or infrastructure
10. Processing of sold products	Processing of intermediate products sold in the reporting year by downstream companies (e.g., manufacturers)	The scope 1 and scope 2 emissions of downstream companies that occur during processing (e.g., from energy use)
11. Use of sold products	End use of goods and services sold by the reporting company in the reporting year	The direct use-phase emissions of sold products over their expected lifetime (i.e., the scope 1 and scope 2 emissions of end users that occur from the use of: products that directly consume energy (fuels or electricity) during use; fuels and feedstocks; and GHGs and products that contain or form GHGs that are emitted during use) Optional: The indirect use-phase emissions of sold products over their expected lifetime (i.e., emissions from the use of products that indirectly consume energy (fuels or electricity) during use)
12. End-of-life treatment of sold products	Waste disposal and treatment of products sold by the reporting company (in the reporting year) at the end of their life	The scope 1 and scope 2 emissions of lessors that occur during the reporting company's operation of leased assets (e.g., from energy use)
13. Downstream leased assets	Operation of assets owned by the reporting company (lessor) and leased to other entities in the reporting year, not included in scope 1 and scope 2 – reported by lessor	The scope 1 and scope 2 emissions of lessees that occur during operation of leased assets (e.g., from energy use). Optional: The life cycle emissions associated with manufacturing or constructing leased assets
14. Franchises	Operation of franchises in the reporting year, not included in scope 1 and scope 2 – reported by franchisor	The scope 1 and scope 2 emissions of franchisees that occur during operation of franchises (e.g., from energy use) Optional: The life cycle emissions associated with manufacturing or constructing franchises
15. Investments	Operation of investments (including equity and debt investments and project finance) in the reporting year, not included in scope 1 or scope 2	See the description of category 15 (Investments) in section 5.5 for the required and optional boundaries

APPENDIX B. FUTURE OPPORTUNITIES

In the context of advancing emissions verification methodologies, it is worth noting that direct measurements of GHG fluxes between the terrestrial surface and the atmosphere offer a promising avenue for improving emissions reporting. The GHG Protocol guidelines currently widely used in private sector contexts incorporate IPCC guidelines as "third-party" guidance. Like the GHG Protocol, the IPCC guidelines primarily focus on the use of activity-based methods using emission factors – albeit for national GHG inventory preparation. The IPCC's quality assurance guidelines also explicitly promote the independent verification of these activity-based estimates with data obtained through atmospheric-based methods.

In fact, comparative peer-reviewed studies have exposed substantial disparities between activity-based (i.e. emission factor-based) estimates and atmospheric data, particularly when emission sources and sinks are dynamic, diverse and/or spatially extensive. Such contexts, in which activity-based estimates are inconsistent with atmospheric-based measurements, include oil and gas production [1], urban areas [2,3], agriculture [4], landfills [5], and nature-based carbon sinks [6,7].

A pivotal distinction between activity-based and atmospheric-based methods is that the latter quantifies the actual tons of CO2 or equivalent GHGs released into or withdrawn from the atmosphere by a specific entity or activity in near real-time. This is achieved through the deployment and continuous operation of in situ GHG monitoring infrastructure, enabling the acquisition of observation-based GHG flux quantities at various scales ranging from individual facilities to urban and landscape dimensions, with numerous examples documented in the scientific literature.

Atmospheric GHG monitoring infrastructure is being used by some countries for validating national GHG inventories submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Atmospheric-based monitoring can similarly be employed by individual entities to encompass scope 1, 2, and 3 emissions, as well as removals, contingent upon the installation of suitable observing infrastructure capable of delivering the requisite precision in flux measurements from the relevant activities.

In summary, the integration of atmospheric-based monitoring methods offers a significant opportunity to enhance the accuracy and credibility of emissions verification procedures, especially in scenarios marked by dynamic and diverse emission sources and sinks. This approach not only complements existing activity-based estimations but also facilitates a near-real-time, precision assessment of GHG fluxes across a range of spatial scales.

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APPENDIX C. LIST OF ACRONYMS

AR	Assessment Report
CDP	Carbon Disclosure Project
CET	Carbon Emission Token
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalents
CRT	Carbon Reference Token
CRU	Carbon Reduction/Removal Unit
EGO	Emission Generator Object
GBBC	Global Blockchain Business Council
GHG	Greenhouse gas
GWP	Global warming potential
HHV	Higher heating value
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
IWA	InterWork Alliance, Inc.
mmBtu	Metric million British thermal unit
$mtCO_2e$	Metric ton carbon dioxide equivalents
N2O	Nitrous oxide
PFCs	Perfluorocarbons
SASB	Sustainability Accounting Standards Board
SF_6	Sulfur hexafluoride
SKU	Stock keeping unit
TCFD	Task Force on Climate-Related Financial Disclosures
TCH	Token Classification Hierarchy
TTF	Token Taxonomy Framework
WBCSD	World Business Council for Sustainable Development
WRI	World Resource Institute

APPENDIX D. GLOSSARY

Activity data	The quantitative measures of a level of activity that results in GHG emissions or removals; can be measured, modeled, or calculated. Activity data are ideally measured but may be estimated based on assumptions.[25]
Allocation	Partitioning emissions from a common process between a product, output, or value and any co-products, -outputs, or -values.
Assurance	The level of confidence that the inventory results and report are complete, accurate, consistent, transparent, relevant, and without material misstatements.[26]
Attributable processes	Service, material and energy flows that become the product, make the product, and carry the product through its life cycle. [27]
Carbon dioxide equivalents (CO2e)	A universal unit of measurement used to compare GHGs based on their global warming potential (radiative forcing).
Carbon footprint	Service, material and energy flows that become the product, make the product, and carry the product through its life cycle.[28]
Carbon Removal Units	A non-fungible token that represents a specified volume of metric tons of GHG emissions reduced or removed by a project or program.[29]
Carbon offset	Mechanism for compensating for all or for a part of the carbon footprint of a product or the partial carbon footprint of a product through the prevention of the release of, reduction in, or removal of an amount of greenhouse gas emissions in a process outside the product system.[30]
Contingent	A contingent token property - or data point - as it relates to CET, is one which is optional unless a specific criteria is met, in which case it becomes mandatory for inclusion in the token under the CET guidance. For example, a GWP Factor Adjustment is not required for CET tokens unless it deviates from the current IPCC Assessment Report GWP factors.
Co-product	A product exiting the common process that has value as an input into another product's life cycle.[31]
Cradle-to-gate	A partial life cycle of an intermediate product, from material acquisition through to when the product leaves the reporting company's gate (e.g., immediately following the product's production).[32]
Cradle-to-grave	Removals and emissions of a studied product from material acquisition through to end-of-life.[33]
Core Carbon Principles	A fungible token that represents a specified volume of metric tons of GHG emissions reduced or removed by a project.[34]
Direct measurement	A type of primary data that is collected directly at the source. It is often gathered through metering of flow streams (e.g., metering of gas volume burned in a boiler), monitoring of exhaust streams for emissions data, or other processes.

25 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
26 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
27 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
28 PAS 2060:2014
29 InterWork Alliance – Sustainability Business Working Group. "Voluntary Ecological Markets." InterWork Alliance. May 2021. https://interwork.org/wp-content/uploads/2021/05/Voluntary_Ecological_Markets_Overview_Revised.pdf.
30 ISO 14067:2018
31 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
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33 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
34 IInterWork Alliance – Sustainability Business Working Group. "Voluntary Ecological Markets." InterWork Alliance. May 2021. https://interwork.org/wp-content/uploads/2021/05/Voluntary_Ecological_Markets_Overview_Revised.pdf.

Emission factor	GHG emissions per unit of activity data.
Equity share	Typically related to a stakeholder's economic interest in a corporation; the ownership interest used to calculate the share of greenhouse gas emissions attributed to a corporation.
Functional unit	The quantified performance of the studied product.[35]
Global Warming Potential (GWP)	A factor used to calculate the cumulative radiative forcing impact of multiple specific GHGs in a comparable way.[36]
Greenhouse gas (GHG)	Gasses that absorb and emit radiation within the thermal infrared range, contributing to the greenhouse effect. The gasses included in the Kyoto Protocol are CO2, CH4, N2O, SF6, NF3, HFCs and PFCs.
GHG Protocol	A multi stakeholder partnership of businesses, non-governmental organizations (NGOs), governments, and others convened by the WRI.
InterWork Alliance, Inc.	An association of private sector organizations, governments, academics and civil society at large that share the vision of a world of collaboration built on the digital interchange of tokenized items of value.[37]
Life cycle	Consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to end-of-life.[38]
Life cycle assessment (LCA)	Compilation and evaluation of inputs, outputs and potential environmental impacts of a product system throughout its life cycle.[39]
Life cycle stage	A useful categorization of the interconnected steps in a product's life cycle for the purposes of organizing processes, data collection, and inventory results.[40]
Net-zero	Balancing of anthropogenic emissions of greenhouse gasses to the atmosphere by anthropogenic removals over a specified period.[41]
Organizational boundary	In determining a GHG inventory, reporting entities assess this to select a method by which they will consolidate their emissions inventory, using either the equity share or control approach. The organizational boundary is a representation of the emissions responsibility of the reporting entity. The CET protocol requires use of the equity share approach to improve data quality and avoid double counting of emissions.
Primary data	Quantified value of a process or an activity obtained from a direct measurement or a calculation based on direct measurements.[42]
Primary direct data	Direct primary data, such as metered flow measurements, gaseous fuel sampling, and product flow measurement.[43]
Primary indirect data	Indirect primary data, such as component counts and engineering assumptions, modeled gaseous fuel composition based on the specific process. Standardized component leakage rates, if modified based on primary direct gas compositions, would also be primary indirect data.[44]
Process activity data	Physical measures of a process that result in GHG emissions or removals. Examples include volume of gas burned, distance traveled, energy consumed, etc.[45]

35 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
36 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
37 InterWork Alliance, A Global Blockchain Business Council Initiative. "Who We Are." IWA, https://interwork.org/about-us/. Accessed 14 June 2022.
38 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
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40 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
41 IPCC
42 ISO 14067:2018
43 Appendices-covers.pdf (giignl.org)
44 Appendices-covers.pdf (giignl.org)
45 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)

Quantitative assessment	Characterizing input data "parameters", e.g., activity data, measured emissions data, emission factors, etc., by the dispersion of the respective values that are used in their derivation. Quantitative uncertainty of input data can be represented by a probability distribution or as a range. There are different approaches to quantifying the uncertainty of a parameter.[46]
Scope 1 emissions	The set of direct emissions from sources that are within the reporting entity's organizational boundary. For example, these emissions may include emissions from burning diesel in an emergency generator or gasoline in a company-owned vehicle.
Scope 2 emissions	The reporting entity's set of indirect emissions from grid-supplied electricity.
Scope 3 emissions	The set of indirect emissions (other than those covered in scope 2) that occur outside the organizational boundary of the reporting entity but that are a result of activities that occur throughout the product or entity's value chain. For example, these emissions may include transportation of inputs, employee commuting, employee business travel, distribution of outputs, etc.
Scope 3 emissions categories	Indirect scope 3 emissions are categorized into 15 possible categories defined in the WRI Corporate Value Chain Reporting Standard. Examples of these categories include, Purchased goods and services, Capital goods, and business travel, etc.
Secondary data	Process data that are not from specific processes of the studied emissions source.[47]
Temporal boundary	With regard to the token data component, this is the timeframe during which the tokenized emissions were generated at the emissions source. When assessing a product's life cycle emissions, this is the period of time when attributable processes occur during the studied product's life cycle, from when materials are extracted from nature until they are returned to nature at the end-of-life or leave the studied product's life cycle.
Token	A tradeable digital representation of a certain unit of value, which resides on the DLT.
Token classification hierarchy	A logical grouping and linkage between various data elements driven by metadata, which is the background data that provides information about the visible token data component.
Token taxonomy framework	A framework developed by the IWA which intends to clearly define a token in non-technical and cross-industry terms. It establishes a common set of terms for the implementation of neutral token definitions with clear requirements that developers can follow.[48]
Unit of analysis	The basis on which the inventory results are calculated; the unit of analysis is defined as the functional unit for final products and the reference flow for intermediate products.[49]
Verification Process Agreement	A Verification Process Agreement is between the emitting organization, applied standard, and the auditor for the collection and verification of emissions data. Here the terms and conditions of the verification process are agreed to and documented. All artifacts in the emissions data collection process are linked to this agreement. The emitter may choose to switch standards or auditor and create a new agreement for verification.

46 https://www.ipieca.org/resources/addressing-uncertainty-in-oil-and-natural-gas-industry-greenhouse-gas-inventories-technical-considerations-and-calculation-method
47 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)
48 Token Taxonomy Initiative Inc. Token Taxonomy Framework (TTF) Moving Tokens Forward. 2019
49 Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf (ghgprotocol.org)

WBCSD Pathfinder Framework	A guidance document developed by the WBCSD for the accounting and exchange of product life cycle emissions across value chains.
WRI's GHG Protocol Corporate Accounting and Reporting Standard	A standardized methodology for companies to quantify and report their corporate GHG emissions.
WRI's GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard	A standardized methodology for companies to quantify and report their corporate value chain (scope 3) GHG emissions.
WRI's GHG Protocol Product Life Cycle Accounting and Reporting Standard	A standardized methodology that provides requirements and guidance for companies and other organizations to quantify and publicly report an inventory of GHG emissions and removals associated with a specific product.

APPENDIX E. MISCELLANEOUS REFERENCES

Ethereum.org

Interwork Alliance *Token Taxonomy Framework*, January 2022. https://github.com/InterWorkAlliance/TokenTaxonomyFramework/blob/main/token-taxonomy.md.

Interwork Alliance - Sustainability Business Working Group. *Voluntary Ecological Markets Overview*. 2021. https://interwork.org/wp-content/uploads/2021/05/Voluntary_Ecological_Markets_Overview_Revised.pdf

WBCSD *Pathfinder Framework Guidance for the Accounting and Exchange of Product Life Cycle Emissions*

WRI *GHG Protocol Corporate Accounting and Reporting Standard, Revised Edition*. https://ghgprotocol.org/corporate-standard.

WRI *GHG Protocol Scope 2 Guidance, An amendment to the GHG Protocol Corporate Standard*. 2015. https://ghgprotocol.org/scope_2_guidance.

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