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# TOWARDS HARMONIZED CARBON ACCOUNTING

## Challenges and Opportunities

POLICY PAPER

# Towards Harmonized Carbon Accounting: Challenges and Opportunities

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## Abstract

This paper discusses the challenges and opportunities associated with harmonizing current product-based carbon counting and reporting guidelines with a comprehensive product- and entity-level carbon accounting system, such as the one described in the EFI Foundation's (EFIF) October 2025 report, [Integrated Product- and Entity-Level Carbon Accounting: Putting Concepts into Practice](#). The paper is organized into five sections:

1. Understanding the distinctions between carbon counting and reporting frameworks and carbon accounting.
2. Examining the current landscape of carbon accounting and reporting frameworks, including both entity-level and product-level approaches.
3. Comparing applications of carbon counting and reporting frameworks in selected national climate policies.
4. Comparing the existing frameworks to comprehensive carbon accounting, using the EFI Foundation's October 2025 system as the model.
5. Identifying areas where comprehensive carbon accounting could improve the quality of current GHG Protocol reporting.

Counting and reporting of entity-level emissions has increasingly centered on the use of the GHG Protocol's Corporate Accounting and Reporting Standard (GHGP Corporate Standard). For example:

- The GHG Protocol Corporate Standard has served as the foundation for many international and national reporting initiatives, including CDP (formerly Carbon Disclosure Project), the Sustainable Accounting Standards Board (SASB) standards, the International Financial Reporting Standards (IFRS) S2 climate-related disclosures, the EU Corporate Sustainability Reporting Directive (CSRD), and the U.K. Streamlined Energy and Carbon Reporting (SECR).

Reporting of product-level carbon intensities, however, remains fragmented among several different guidelines. And all these guidelines suffer from the problem that product-level carbon dioxide (CO<sub>2</sub>) emissions intensity reporting cannot be reconciled with entity-level total CO<sub>2</sub> emissions in situations where an entity has multiple product lines. For example:

- The U.S. clean fuels programs rely on the Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) life cycle analysis model, developed by the U.S. Department of Energy. China has introduced a national

product carbon footprint standard based on ISO 14067, an international standard for quantifying the carbon footprint of products. The GHG Protocol Product Standard is similar to ISO 14067, providing guidelines for life cycle product CO<sub>2</sub> emissions reporting, but is much more limited in use than the GHGP Corporate Standard. The EU's Carbon Border Adjustment Mechanism (CBAM) established its own methodologies for calculating embedded emissions in products different from existing product-based approaches.

Through comparative analysis, this paper highlights key differences among the current entity-level and product-level carbon counting and reporting methodologies, including gaps and limitations in the methodologies and underlying assumptions as well as differences in organizational structures and data management protocols. The current frameworks are compared to the principles, concepts, and framework design of a comprehensive carbon accounting system. Finally, specific elements in the GHG Protocol Product Standard are identified that could benefit from the application of carbon accounting principles and practices.



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# Carbon Counting and Reporting and Carbon Accounting: Understanding the Distinctions

Understanding the difference between carbon counting and reporting and carbon accounting is an important starting point for discussion.

Current protocols and guidelines for **counting and reporting** carbon dioxide (CO<sub>2</sub>) emissions are largely based on methodologies for conducting an inventory of CO<sub>2</sub> emissions. The inventory can include CO<sub>2</sub> emissions within an entity's boundaries as well as emissions occurring outside the entity's boundaries that are consequential (but not attributable) to its activities. The inventory is typically designed to capture emissions across a product's life cycle, including emissions from past, present, and future reporting periods. The inventory is a snapshot in time, usually annually, and the elements are then combined into a report. **Carbon accounting**, on the other hand, is a transaction-based recording of carbon flows within an entity's processes that typically follows with boundaries in time and space that are aligned with the entity's organizational boundaries and financial structure. Carbon accounting also adopts many of the well-established and widely adopted principles and practices of financial accounting, providing greater accuracy, completeness, comparability, and verifiability than current carbon reporting frameworks. A comprehensive carbon accounting system also provides for the integration of product-level CO<sub>2</sub> emission intensity estimates with entity-total CO<sub>2</sub> emissions that are fully integrated with no gaps or overlaps.

The comprehensive carbon accounting model used in this paper for comparative purposes is the one described in the October 2025 EFI Foundation report *Integrated Product- and Entity-Level Carbon Accounting: Putting Concepts into Practice*. This report proposed a model ledger-based CO<sub>2</sub> emissions accounting system that combined the engineering fundamentals of carbon mass and energy balances with financial accounting principles. In parallel, the EFI Foundation has been conducting a series of case studies to reduce this model ledger-based system into practice.

The model ledger-based comprehensive CO<sub>2</sub> accounting system:

- Establishes an accounting system with a ledger for each entity within a product supply chain that records data on CO<sub>2</sub> emissions and removals only once, and transfers the data across ledgers along with materials, fuels, and products.

- Builds from engineering fundamentals of carbon mass and energy balances within defined organizational (gate-to-gate) boundaries.
- Records all time-based carbon-related transactions in a dual-sided ledger of stocks (accumulated within the entity) and flows (entering or leaving the entity’s boundary) of all forms of carbon (e.g., carbon dioxide, methane, physical carbon content) following principles derived from generally accepted accounting principles.
- Allocates CO<sub>2</sub> emissions among final products, yielding product-level CO<sub>2</sub> emissions intensity measures that can be fully integrated into a report of entity-wide total CO<sub>2</sub> and other greenhouse gas (GHG) emissions.
- Enables a wide variety of reports such as CO<sub>2</sub> emissions statements and balance sheets.

Table 1 provides a summary comparison of the key differences between carbon counting and reporting frameworks and comprehensive product- and entity-level carbon accounting.

**Table 1. Carbon counting and reporting vs. carbon accounting**

	<b>Carbon counting and reporting</b>	<b>Carbon accounting</b>
<b>Data collection</b>	Ongoing data collection with regular consolidation	Transaction-based recording
<b>Time period for data</b>	Reflects different time periods (past, present, future) drawn from life cycle assessment models	Specified time period, aligned with financial records
<b>System boundary</b>	Combines attributable direct, indirect, and consequential data, each with differing boundaries	Attributable data within defined boundaries (gate to gate)
<b>Data quality</b>	Potential for gaps in data compilation, data inconsistencies, and overlapping emissions data reporting	Data completeness and consistency framed by comprehensive carbon mass balances, rulebook, and double-entry internal crosschecks
<b>Recording device</b>	Inventory tabulation (e.g., spreadsheet) with single-entry data input	A dual-sided carbon ledger with a structured chart of accounts, supported by double-entry recording
<b>Types of reports generated</b>	No framework generates both entity-level and product-level reports	Generates fully aligned entity-level and product-level reports.

Carbon counting and reporting and comprehensive carbon accounting serve different purposes. Carbon counting and reporting frameworks were designed to assist entities in developing inventories of CO<sub>2</sub> emissions within their operations and encourage them to estimate emissions across their supply chains and customer uses. Their main purpose has been to support voluntary reporting of total CO<sub>2</sub> emissions relative to voluntary emissions targets.

Carbon accounting, by comparison, is a transactions-based framework that combines engineering practices with financial accounting principles. It is ledger-based, with CO<sub>2</sub> emissions recorded only once and transferred across each entity's ledger in the supply chain. The main purpose is to provide accurate, reliable and verifiable measures of the carbon intensity of products in a manner that can be fully integrated with entity-level CO<sub>2</sub> emissions in a manner that avoids gaps or duplication. As trade policies such as the EU's Carbon Border Adjustment Mechanism (CBAM) increasingly force multinational companies to shift from voluntary commitments to compliance-based reporting, accurately tracking carbon emissions at the product level is emerging as a core driver of product differentiation. Carbon accounting can inform supply chain agreements, investments across a range of low-carbon processes and product improvements, and reliable data on product carbon footprints for customers.

In the near term, both carbon counting and reporting and comprehensive carbon accounting will continue to play distinct roles. Existing carbon counting and reporting frameworks have made significant contributions to understanding the landscape of global emissions reduction and can continue to do so. A comprehensive carbon accounting framework provides complete, accurate, comparable and verifiable data on product-level carbon intensity. The adoption of a comprehensive carbon accounting system can also be harnessed to improve the quality of current carbon disclosure and reporting programs, as discussed later in this paper.

The growing demand for accurate product-level carbon accounting information, increasing regulatory consequences tied to emissions data, and the parallel development of multiple, only partially aligned accounting frameworks, all point to the need for a coherent, rules-based approach to carbon accounting that goes beyond inventory and disclosure. Such an approach can provide a durable foundation for policy, investment, and corporate decision-making.



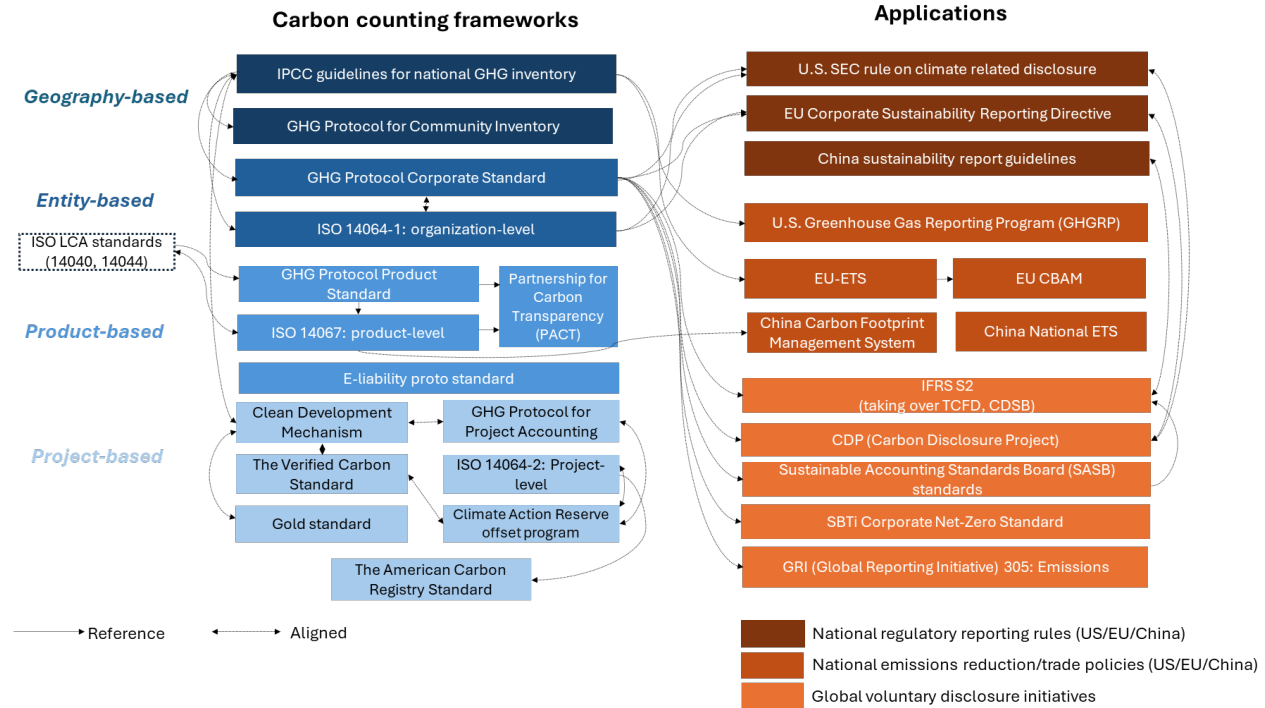
## Examining the Current Landscape: Carbon Counting and Reporting Frameworks

This section explores the current landscape of carbon counting and reporting frameworks. The current carbon counting and reporting frameworks include over a dozen separate sets of guidelines. Many were specially designed to serve a pre-defined public policy mandate or a voluntary corporate climate commitment.

These frameworks span geography-based (i.e., national inventories), entity-wide, product-based, and project-focused reporting, depending upon the purpose and objectives of the end use. Frameworks that focus on entity-level reporting are the most widely used, whereas those supporting product-based life cycle analysis are less commonly used in national policies or global voluntary initiatives.

The connections between these various frameworks and the objectives they serve are illustrated in Figure 1.

**Figure 1. Carbon counting frameworks and their applications**



*Note: The U.S. Securities and Exchange Commission (SEC) adopted climate-related disclosure rules in March 2024; however, the rules were challenged in court, and the SEC ended its defense of them in March 2025. In September 2025, the U.S. Environmental Protection Agency proposed to eliminate a substantial portion of the Greenhouse Gas Reporting Program (GHGRP). Source: EFI Foundation.*

Counting and reporting of entity-level emissions has increasingly centered on the use of the GHG Protocol’s Corporate Accounting and Reporting Standard (GHGP Corporate Standard). Figure 1 shows that the GHG Protocol Corporate Standard has served as the foundation for many international and national reporting initiatives, including CDP (formerly Carbon Disclosure Project), the Sustainable Accounting Standards Board (SASB) standards, the International Financial Reporting Standards (IFRS) S2 climate-related disclosures, and the EU Corporate Sustainability Reporting Directive (CSRD).

Reporting of product-level carbon intensities, however, remains fragmented among several different guidelines. And all these guidelines suffer from the problem that product-level carbon dioxide (CO<sub>2</sub>) emissions intensity reporting cannot be reconciled with entity-level total CO<sub>2</sub> emissions in situations where an entity has multiple product lines.

Box 1 describes the basic characteristics of the GHG Protocol Corporate Standard, the most widely adopted framework for carbon counting and reporting. The box also summarizes the principal characteristics of the major product-level carbon counting and reporting frameworks.

### **Box 1. The Status of the GHG Protocol Corporate Accounting and Reporting Standard and Other Product-Level GHG Emissions Reporting Guidelines**

**Entity-level reporting:** The GHG Protocol Corporate Standard is the most widely used carbon counting and reporting system. It is the principal framework in widespread use in the private sector and the method of choice for compliance with government requirements. The standard has undergone several sets of revisions to update the framework and methodologies to support the private and public sector purposes.

Major voluntary disclosure initiatives—such as the CDP (formerly Carbon Disclosure Project), the International Financial Reporting Standards (IFRS) S2 Climate-related Disclosures, and Science-Based Targets Initiative (SBTi)—require reporting entities to follow the GHG Protocol Corporate Standard. Consequently:

- As of 2024, 42 out of the top 50 global companies used GHG Protocol Corporate Standard for their GHG reporting and for setting emissions reduction targets, according to their annual environmental, social, and governance (ESG) reports.
- In 2023, virtually all (97%) of the S&P 500 companies reporting emissions to CDP used the GHG Protocol Corporate Standard as the basis for reporting.<sup>1</sup>
- As of April 2025, 7,559 companies participating in the SBTi have submitted voluntary reduction targets that have been validated by the SBTi. The SBTi requires adherence to the GHG Protocol for tracking and reporting progress.<sup>2</sup>

Policymakers have also relied upon the GHG Protocol Corporate Standard as the basis for assessing compliance with government mandates.

- The EU Corporate Sustainability Reporting Directive (CSRD) requires reporting entities to use the GHG Protocol standards. The EU CSRD is expected to require about 10,000 companies to report their emissions using the GHG Protocol standard.<sup>1</sup>
- The U.S. Securities and Exchange Commission (SEC) Enhancement and Standardization of Climate-Related Disclosure for Investors incorporated concepts of the GHG Protocol Scope 1 and Scope 2 reporting in its final rule (now suspended).

<sup>1</sup> Initially, approximately 50,000 companies were expected to fall within the scope of the CSRD, but the European Commission announced its plan to remove 80% of companies from the scope in February 2025.

**Product-based carbon footprint reporting:** While the focus of these efforts has been on entity-level carbon counting and reporting, there is growing attention to the need for product-based carbon reporting. Carbon embedded in internationally traded goods is expected to drive increased interest in product carbon footprints (PCFs). Two major initiatives are noteworthy:

- In August 2024, China issued a new national standard on product carbon footprints, largely based on ISO 14067, which provides requirements and guidelines for the quantification and reporting of product carbon footprints.<sup>3</sup> This new standard will serve as a basis for developing product-specific carbon footprint methodologies. China aims to develop carbon accounting standards for 200 products by 2030.
- The EU CBAM entered into force in May 2023. Rather than relying on existing Carbon Footprint of a Product (CFP) standards, the CBAM regulation established its own methodologies for calculating embedded emissions in goods, whose system boundaries are narrower than those in a CFP, to cover the same emissions covered by the EU Emissions Trading System (ETS).<sup>4</sup>
- Both of these product-based carbon footprint guidelines operate in isolation from entity-based reporting. In other words, for an entity with multiple product lines, the guidelines do not provide a mechanism to allow product-level carbon intensity estimates to be reconciled to entity-level totals.

As will be discussed in greater detail in the following section of this paper, most of these frameworks:

- Focus on reporting emissions only, and not embodied carbon in input materials or products.
- Have differing boundary conditions, limiting the ability to develop meaningful comparisons among reporting entities.
- Require counting and reporting of emissions sources that are outside the ownership and control of the reporting entity, including consequential emissions from other entities due to actions in response to activities of the reporting entity.
- Combine emissions from past, present, and projected periods into a single report without clear delineation of time period.
- Allow for or even promote multiple counting of emissions among reporting entities, preventing the individual reports from being consolidated into a total measure of emissions.

- Provide broad flexibility in the application of the guidelines, creating additional inconsistencies in reports.

Notably, no existing carbon counting framework produces reports of product-level and entity-level CO<sub>2</sub> emissions that are fully integrated. By contrast, carbon accounting generates fully aligned reports at both levels.

Recently, there has been growing interest in improving carbon counting, reporting, and accounting and in harmonizing existing frameworks. In September 2025, the International Organization for Standardization (ISO) and GHG Protocol announced a strategic partnership to harmonize their existing portfolios of GHG standards and jointly develop new standards for GHG accounting.<sup>5</sup> In October 2025, Carbon Measures—a global coalition of businesses—was launched to develop a global framework for product-level carbon accounting.<sup>6</sup> At the same time, multiple initiatives, including from the EFI Foundation, the E-Ledgers Institute, and the Carbon Accounting Standards Initiative (CASI), are advancing efforts to design and operationalize carbon accounting systems.<sup>7,8,9</sup> Because these efforts are still in their early stages, early coordination and alignment across initiatives will be critical to ensure they move in the same direction and avoid fragmentation.

# Comparing Policy Applications of Carbon Counting Frameworks

This section compares the methodologies employed in selected national climate policies. While the GHG Protocol Corporate Standard has been the dominant framework for entity-level emissions reporting policies (e.g., EU CSRD, U.K. SEC), there is no widely adopted framework for other types of national climate policies—such as facility-level emissions reduction programs and incentives or regulations for low-carbon products. Instead of relying on existing frameworks, each policy tends to develop its own approach to quantifying emissions. Four specific policy applications and their underlying counting and reporting methodologies include:

- U.S. Greenhouse Gas Reporting Program (GHGRP), which requires the reporting of GHG data and other relevant information from large GHG emission sources, fuel and industrial gas suppliers, and CO<sub>2</sub> injection sites in the United States.
- EU Emissions Trading System (ETS), a carbon emissions trading scheme that limits emissions within the EU and allows facilities to trade emission allowances.
- EU CBAM, which puts a carbon price on carbon-intensive products imported into the EU.
- China National Standard for Carbon Footprint of Products (GB/T 24067-2024), which establishes principles, requirements, and guidelines for the quantification and reporting of carbon footprint of a product.

## Comparison of Key System Elements

The four policies adopt methodologies that differ significantly across key system elements. Each defines a distinct scope of reporting, reporting boundaries, and carbon coverage tailored to its purpose, and designates specific reporting entities with direct access to site-specific carbon data. The key differences are summarized below and presented in Table 2:

- **Reference/alignment:** China's National Standard for Carbon Footprint of Products (CFP) closely follows ISO 14067, with limited additional guidance—such as specific cut-off criteria, a CFP calculation formula, and a reporting template. In contrast, other policies develop their own methodologies with limited reference to U.N. Intergovernmental Panel on Climate Change (IPCC) guidelines.
- **Scope of reporting:** The methodologies for the U.S. GHGRP and EU ETS support facility-level or entity-level reporting, whereas the methodologies for EU CBAM and

China’s National Standard for CFP support product-level reporting. No methodology supports both facility-level and entity-level reporting.

- **Reporting entity:** The U.S. GHGRP and EU ETS require entities with direct access to site-specific data to report emissions. For example, under the U.S. GHGRP, direct-emitting facilities report their direct emissions, fuel suppliers report the carbon content of their fuels, and CO<sub>2</sub> injection facilities report the amount of CO<sub>2</sub> stored. The EU CBAM requires exporters of CBAM-covered goods to provide embedded emissions data to the reporting declarant, who is responsible for submitting the emissions report to the European Commission. China’s National Standard for CFP does not specify the reporting entity but requires that the CFP report include information about the producer of the reported product.
- **Reporting time period:** Except for China’s National Standards for CFP, all policies require periodic reporting. The U.S. GHGRP and EU ETS require annual reporting, while the EU CBAM mandates quarterly reporting.
- **Reporting boundaries:** Except for China’s National Standard for CFP—which sets cradle to grave as the default boundary—all other policies establish detailed reporting boundaries tailored to different groups of reporting entities. The U.S. GHGRP defines separate boundaries for three categories: direct-emitting facilities, fuel suppliers, and CO<sub>2</sub> injection facilities. The EU ETS sets distinct boundaries for installations in the energy and industry sectors, as well as for the aviation and maritime transport sectors. The EU CBAM defines detailed boundaries for each industrial subsector.
- **Carbon coverage:** Each policy has different carbon coverage depending on the purpose of the policy. While all policies include direct emissions and direct removals, the treatment of attributed emissions and carbon content varies. The U.S. GHGRP requires carbon content data only from fuel suppliers. The EU ETS does not cover either attributed emissions or carbon content. The EU CBAM requires data on attributed emissions from electricity use, and embedded emissions from selected input materials. China’s National Standard for CFP requires emissions and removals data across the full cradle-to-grave product system.

**Table 2. Comparison of key system elements across carbon counting and reporting methodologies used for national climate policies**

	<b>U.S. GHGRP<sup>10</sup></b>	<b>EU ETS<sup>11, 12, 13, 14</sup></b>	<b>EU CBAM<sup>15, 16</sup></b>	<b>China National Standard for Carbon Footprint of Products<sup>17</sup></b>
<b>Reference / alignment</b>	Consistent with 2006 IPCC Guidelines	References IPCC emission factors	Measurement, reporting, and verification (MRV) rules designed based on the MRV system of the EU ETS	Mainly based on ISO 14067
<b>Scope of reporting</b>	Facility level	Facility level; Entity level for aviation and maritime transport	Product level	Product level
<b>Reporting entity</b>	<ul style="list-style-type: none"> <li>• Direct-emitting facility</li> <li>• Fuel supplier</li> <li>• CO<sub>2</sub> injection facility</li> </ul>	<ul style="list-style-type: none"> <li>• Installation (facility) in the energy and industry sectors</li> <li>• Company in aviation and maritime transport</li> </ul>	<ul style="list-style-type: none"> <li>• The “reporting declarant” (importer) reports embedded emissions of the goods to the European Commission</li> <li>• The operator of an installation producing CBAM-covered goods outside the EU (exporter reports the embedded emissions to the reporting declarant)</li> </ul>	Each producer (company) of a product
<b>Reporting time period</b>	<ul style="list-style-type: none"> <li>• Annual reports covering emissions from the prior calendar year are due by the end of March each year</li> </ul>	<ul style="list-style-type: none"> <li>• The compliance cycle, including MRV of emissions, is annual</li> </ul>	<ul style="list-style-type: none"> <li>• The reporting declarant (importer) is required to report the embedded emissions in goods imported on a quarterly basis</li> <li>• Installation operators report on an annual basis</li> </ul>	The time period for which a carbon footprint of a product (CFP) is representative shall be specified, justified, and reported

	U.S. GHGRP <sup>10</sup>	EU ETS <sup>11,12,13,14</sup>	EU CBAM <sup>15,16</sup>	China National Standard for Carbon Footprint of Products <sup>17</sup>
<b>Reporting boundaries</b>	<p>Differs across reporting entity groups:</p> <ul style="list-style-type: none"> <li>• Direct-emitting facility: all direct emissions within the boundary of the facility</li> <li>• Fuel supplier: emissions that would result from the complete combustion of products sold</li> <li>• CO<sub>2</sub> injection facility: CO<sub>2</sub> stored, direct emissions from operations</li> </ul>	<p>Differs across reporting entity groups:</p> <ul style="list-style-type: none"> <li>• Energy/industry installation: all direct emissions within the boundary of the installation</li> <li>• Aviation: all flights depart from or arrive in EU jurisdiction</li> <li>• Maritime transport: emissions from ship voyages to and from EU ports</li> </ul>	<p>Industry specific; detailed guidance on which processes are within the boundaries by industry (cement, hydrogen, fertilizer, steel, aluminum)</p>	<p>Cradle to grave; exclusion of any life cycle stages is permitted if they do not significantly change the overall conclusions of the CFP study</p>
<b>Carbon coverage</b>	<p>Differs across reporting entity groups:</p> <ul style="list-style-type: none"> <li>• Direct-emitting facility: fuel combustion and process emissions</li> <li>• Fuel supplier: emissions from (future) fuel use</li> <li>• CO<sub>2</sub> injection facility: the quantity of CO<sub>2</sub> that they receive for injection</li> </ul>	<p>Differs across reporting entity groups:</p> <ul style="list-style-type: none"> <li>• Energy/industry installation: fuel combustion and process emissions</li> <li>• Aviation/maritime transport: emissions from fuel combustion</li> </ul> <p>Captured CO<sub>2</sub> is subtracted from the installation’s emissions if the CO<sub>2</sub> is transferred out for storage or permanently stored in a product</p>	<ul style="list-style-type: none"> <li>• Direct emissions, including emissions from production of heating and cooling</li> <li>• Indirect emissions from the production of electricity</li> <li>• Embedded emissions of the input materials listed as relevant in the guidance</li> <li>• Emissions from transport are NOT covered</li> <li>• CCS and CCU are taken into account for determining actual embedded emissions</li> </ul>	<ul style="list-style-type: none"> <li>• Emissions and removals in a product system (cradle to grave)</li> <li>• Carbon offsetting is not allowed in the quantification of a CFP</li> </ul>

## Comparison of Data Collection and Recording

The four policies are more aligned in terms of data collection and recording than key system elements. All policies provide for some flexibility by allowing multiple options for quantifying emissions, including direct measurement, calculation using site-specific data, and using default values or secondary data. The flexibility, however, diminishes the degree of comparability across products. The EU CBAM has more specific rules regarding product classification and the allocation of emissions. The key differences are summarized below and presented in Table 3:

- **Data quality:** All policies provide for significant flexibility for the entity's selection of calculation methodologies and data. The U.S. GHGRP provides several options to calculate emissions, including employing a continuous emission monitoring system (CEMS), using fuel-specific data, and using default values. The EU ETS also allows the use of measurement-based, calculation-based, or mixed approaches, and allows small emission sources to use default calculation factors without requiring sampling and analysis. The EU CBAM allows the use of default values when actual emissions data is unavailable. China's National Standard for CFP follows the same data quality hierarchy as ISO 14067, which requires using secondary data only when the primary data collection is impracticable or of minor importance.
- **Product classification:** The EU CBAM uses the Combined Nomenclature (CN), the EU's eight-digit coding system for classifying goods, based on the World Customs Organization's six-digit Harmonized System (HS), with EU-specific subdivisions. China's National Standard for CFP does not specify a classification system and requires the CFP report to include the product's name, function, model, and an image.
- **Allocation to products:** The EU CBAM guidelines specify the allocation of emissions to each production process. When specific data for each process is unavailable, emissions are allocated as follows:
  - For sequential production, based on the annual usage time for each good.
  - For parallel production, based on the mass or volume of each good, the ratio of free reaction enthalpies of the chemical reactions involved, or another scientifically justified methodology.
  - China's National Standard for CFP follows the same allocation method hierarchy as ISO 14067, which prioritizes avoiding allocation, followed by physical allocation, and then economic or other allocation method.

**Table 3. Comparison of data collection and recording across carbon counting and reporting methodologies used for national climate policies**

	<b>U.S. GHGRP</b> <sup>18</sup>	<b>EU ETS</b> <sup>19,20, 21, 22</sup>	<b>EU CBAM</b> <sup>23,24</sup>	<b>China National Standard for Product Carbon Footprint</b>
<b>Data quality</b>	Selection of four different methodologies to calculate mass CO <sub>2</sub> emissions from combustion: employing a continuous emission monitoring system; using fuel-specific data; using a mix of fuel-specific and default data; using default values	Each operator of an installation is allowed to choose among calculation-based, measurement-based, or a mix of these two approaches; larger emission sources must meet higher tiers, which involve sampling and analysis to get calculation factors	When actual emissions cannot be determined, the embedded emissions can be determined by reference to default values, based on reliable and publicly available information	Order of priority: site-specific data, non-site-specific primary data, secondary data
<b>Product classification</b>	Not applicable	Not applicable	The Combined Nomenclature classification system: eight-digit system including the first six digits are the HS code and the remaining two digits are EU-specific.	Classification system not specified in guidance; product name, function, model, and picture are required in report
<b>Allocation to products</b>	Not applicable	Not applicable	Emissions attributed to each production process. If data is unavailable: <ul style="list-style-type: none"> <li>• Sequential production: emissions allocated by annual usage time</li> <li>• Parallel production: emissions allocated by mass/volume, enthalpy ratios, or other scientifically justified method</li> </ul>	Order of priority: no allocation; physical allocation; economic allocation or other

Harmonizing emissions quantification methodologies across national climate policies is inherently difficult. Each methodology has been designed within a particular context to serve distinct policy objectives within that particular jurisdiction, creating an impediment that governments will substantially revise their approaches to align with those of other countries.

A more practical path forward is to focus on harmonizing the carbon accounting systems that reporting entities use. The next section compares existing frameworks, including a comprehensive carbon accounting system, to assess whether they could serve as a basis for building a harmonized carbon accounting system for reporting entities.

# Comparing Existing Frameworks to Comprehensive Carbon Accounting

This section provides a comparative assessment of the characteristics of carbon accounting and current carbon counting and reporting frameworks. The assessment examines their governing principles, organizational structures, and data collection and recording practices. The comparative assessment provides the foundation to explore how such a comprehensive carbon accounting system can help improve existing frameworks and foster greater alignment.

This section focuses in greater detail on the comparison of a comprehensive carbon accounting system, detailed in the EFI Foundation report, *Integrated Product- and Entity-Level Carbon Accounting: Putting Concepts into Practice*, and five existing carbon counting and reporting systems:

- *A comprehensive product- and entity-level carbon accounting system*, which provides a set of principles, conventions, and rules for identifying, quantifying, organizing, and recording transactions involving all forms of carbon in all activities contributing to product development under the ownership and control of the reporting entity.<sup>25</sup>
- *GHG Protocol Corporate Accounting and Reporting Standard*, which provides requirements and guidance for entity-level reporting of GHG emissions.<sup>26</sup>
- *GHG Protocol Product Life Cycle Accounting and Reporting Standard (GHG Protocol Product Standard)*, which provides requirements and guidance to quantify and report an inventory of GHG emissions and removals associated with a specific product.<sup>27</sup>
- *ISO 14067*, which provides a generic standard for the quantification of the carbon footprint of products.<sup>28</sup>
- *Partnership for Carbon Transparency (PACT) Methodology*, developed as a supplement to existing standards to enhance consistency, data integrity, and comparability of product-level carbon accounting.<sup>29</sup>
- *R&D GREET life cycle assessment model*, which assesses the energy use and environmental impacts of vehicles, fuels, chemicals, and materials along their life cycles.

The comparisons are grouped into three areas of discussion:

1. Comparison of core governing principles.
2. Comparison of organizational frameworks.

3. Comparison of data collection and recording.

## Comparison of Core Governing Principles

Harmonizing the core principles of carbon accounting systems could be a first step toward aligning frameworks, as these principles guide the design and implementation of each system—and many frameworks already share significant similarities at the level of principles.

This section compares the systems against governing principles—commonly included in current carbon accounting and reporting guidelines. For example:

- In 2006, the IPCC Guidelines for National Greenhouse Gas Inventories adopted five principles to govern the reporting of country-level greenhouse gas emissions (transparency, completeness, consistency, comparability, and accuracy).<sup>30</sup>
- The Greenhouse Gas Protocol (GHGP) adopted five principles that are intended to govern its reporting guidelines for both entity-wide and product-specific emissions reporting (relevance, completeness, consistency, transparency, and accuracy).<sup>31</sup>
- ISO 14064-1, an entity-level GHG emissions quantification and reporting standard, follows these same five principles.<sup>32</sup>

The principles should also reflect the qualitative characteristics of useful financial information as defined by the Financial Accounting Standards Board (FASB). The FASB’s qualitative characteristics for useful financial information include two fundamental characteristics (relevance, faithful representation) and four enhancing characteristics (comparability, verifiability, timeliness, and understandability).<sup>33</sup>

Drawing from these lists, this report applies a set of eight core principles for comparative analysis (Table 4). The eight principles provide a comprehensive basis for evaluation, while the comprehensive carbon accounting framework consolidates them into five overarching principles, combining related concepts to focus on a core set without overlap or unnecessary complexity.

**Table 4. Core governing principles for carbon accounting**

Core principles for carbon accounting	Principles for comparative analysis	Definition
Relevance	Relevance	Includes all information necessary to support decision making of the users
	Materiality	Contains a threshold level for disaggregation of data
Faithful representation	Accuracy	Has a minimum uncertainty of data
	Unbiasedness	Collects and records data in a neutral manner

	Completeness	Includes carbon data from all carbon sources and related activities
Transparency		Includes all supporting documentation for the recorded carbon data
Comparability		Produces comparable results across products and entities
Verifiability		Enables assurance by third party reviewers

The comparative analysis revealed substantial alignment among the systems regarding their principles. While most of the principles are reflected across the systems, the degree of adherence varies by principle: completeness and comparability show the largest gaps in adherence, while the other principles are relatively well upheld. Key similarities and differences are summarized below and presented in Table 5:

- Relevance:** All systems except the R&D GREET include a statement of the principle of relevance, which supports the decision-making needs of information users. However, flexibility within a system can undermine adherence to this principle. For example, the GHG Protocol Corporate Standard permits selective reporting of emission scopes, which risks omitting information that may be critical for users’ decision making.
- Materiality:** Neither the GHG Protocol nor ISO explicitly includes a statement on the principle of materiality in its list of principles; however, the detailed guidelines allow for threshold cutoffs in reporting of information based on availability of data. The GHG Protocol and ISO allow entities to define insignificant emissions or removals, which are allowed to be excluded from emissions accounting. The PACT methodology offers more detailed guidance—allowing the exclusion of processes that represent less than 3% of the total cradle-to-gate product carbon footprint emissions.
- Accuracy:** All systems except the R&D GREET discuss the principle of accuracy. However, the adherence to accuracy could be limited in the aggregation of the detailed guidelines. For example, the GHG Protocol and ISO specifying a cradle-to-grave boundary requires future predictions for gate-to-grave emissions that have much higher levels of inaccuracy and uncertainty.
- Unbiasedness:** All systems, except R&D GREET, discuss the principle of unbiasedness by specifying that reporting should reduce bias and uncertainty.
- Completeness:** Although all systems except the R&D GREET discuss the principle of completeness, they do not necessarily adhere to it. The GHG Protocol, ISO, PACT, and R&D GREET do not incorporate a full carbon mass balance. In addition, entities reporting under the GHG Protocol Corporate Standard often provide only partial reporting of their Scope 3 emissions.

- **Transparency:** All systems except the R&D GREET discuss the principle of transparency by specifying clear documentation.
- **Comparability:** Comparability encompasses both the dimension of comparability across products and comparability of reporting over time for a single product:
  - **Comparability across products:** The flexibility provisions in the GHG Protocol and ISO standards inherently limit comparability across products. For example, ISO 14067 recognizes that methodological choices, such as the selection of functional unit or allocation procedures, may result in a less sound basis for comparisons. The GHG Protocol Corporate Standard limits comparability across entities due to its flexibility in setting boundaries, selecting emission scopes, and choosing data collection methods. By comparison, a comprehensive carbon accounting system would achieve greater comparability across products by requiring all entities to follow a standardized, ledger-based bookkeeping system.
  - **Comparability over time for a single product:** The GHG Protocol and ISO standards do focus on the need for consistent reporting across time periods. The GHG Protocol Product Standard explicitly states that it is intended “to support performance tracking of one product over time” rather than cross-product comparison.
- **Verifiability:** Verifiability in a comprehensive carbon accounting system is achieved through the use of the ledger, backed by double-entry bookkeeping. The ledger system is designed to enable a third-party finding of “reasonable assurance” of the accounting data. By comparison, both the GHG Protocol and ISO standards do not adhere to the principle of reasonable assurance and instead allow for self-verification of the reported information.

Although not a governing principle per se, recursiveness should be a characteristic of carbon accounting that serves as an enabler for all of the core governing principles. For model comprehensive carbon accounting, the system design elements, the detailed rules-based protocols, and methodologies allow for continuous improvement in the scope and quality of the data being collected and recorded over time. Sharing of data among entities is another way to enable recursiveness. The PACT methodology, for example, includes specific language encouraging continuous improvement of the system by requiring companies to exchange data on product carbon footprint through the PACT Network, through which stakeholders are collaborating on developing a platform for the exchange of emissions data.

Table 5. Comparison of the application of core principles across carbon counting frameworks

	A product- and entity-level comprehensive carbon accounting system	Existing frameworks			
		GHG Protocol Corporate Standard	GHG Protocol Product Standard / ISO 14067	PACT methodology	Life Cycle Analysis R&D GREET Model
<b>Relevance</b>	Follow FASB standard, including the full scope of information needed; no information excluded that would affect the outcome of a decision	GHG emissions that serve the decision-making needs of both internal and external users; guidance allows flexibility for selective scope of reporting	GHGP: includes information that serves the need of the intended user; ISO: selects data and methods appropriate to the assessment of GHG emissions and removals	Aligns with the GHGP's principle of relevance	No specific guidance
<b>Materiality</b>	Follow FASB guidance for materiality in financial accounting	Rule of thumb threshold that omitted or erroneous data should not be more than 5% of total inventory	GHGP: reporting entity sets level of insignificance, including a rule of thumb threshold; ISO: allows excluding insignificant emissions or removals, determined by cut-off criteria set by reporting entity	Sets rule for materiality; allows excluding processes representing less than 3% of total cradle-to-gate emissions	No specific guidance
<b>Accuracy</b>	Accurate information through recording every transaction via double-entry bookkeeping	General guidance that GHG measurement, estimates, calculations should be systematically neither over nor under the actual emissions value	GHGP: same principle as the GHGP Corporate Standard; ISO: states general guidance requiring accurate, verifiable, relevant, and not misleading quantification	Enhances accuracy by offering more detailed methodologies and requiring data exchange	Depends on users as it allows flexibility for data inputs

	A product- and entity-level comprehensive carbon accounting system	Existing frameworks			
		GHG Protocol Corporate Standard	GHG Protocol Product Standard / ISO 14067	PACT methodology	Life Cycle Analysis R&D GREET Model
<b>Unbiasedness</b>	FASB guidance on neutral depiction of information with no deliberate or systemic bias	A rule of thumb: an error is considered to be materially misleading if its value exceeds 5% of the total inventory	GHGP: the guideline for transparency also states that the reporting entity should avoid bias; ISO: the principle of accuracy requires reducing bias and uncertainties as far as practicable	Aligns with the GHGP's principle of transparency	No specific guidance
<b>Completeness</b>	Reflects complete carbon mass balance	Reporting entities generally report only portions of Scope 3 emissions; Scope 3 includes emissions that fall outside an entity's ownership or control; guidance does not require full carbon mass balance within scope boundaries	In some instances, it does not incorporate all units of carbon that otherwise comprised full carbon mass balance; in other instances, it includes collected sources of emissions that fall outside a product mass balance		
<b>Transparency</b>	Ledger-based reporting of all carbon-relevant information	All information disclosed in clear, factual, and understandable manner	Addresses and documents all relevant issues in a clear and coherent manner	Requires evidence including data, methodology, and governance for verification	No specific guidance

	A product- and entity-level comprehensive carbon accounting system	Existing frameworks			
		GHG Protocol Corporate Standard	GHG Protocol Product Standard / ISO 14067	PACT methodology	Life Cycle Analysis R&D GREET Model
<b>Comparability</b>	Easily compared across products as all entities adopt the same ledger-based bookkeeping	Difficult to compare across entities due to flexibility in boundary setting and scope of emissions to report; information should be internally consistent and comparable over time within the reporting entity	GHGP: supports tracking one product over time, but not product comparison; ISO: acknowledges that allowing flexibility results in less sound basis for comparison	Enhances comparability across products and entities by requiring data exchange across entities, supply chains	Could be less comparable depending on the users' data input and assumptions
<b>Verifiability</b>	FASB guidance requires faithful representation that allows independent observers to reach consensus on reports	Provides confidence to users that the information represents a faithful, true, and fair account of entity's GHG emissions; Verification can be either internal or external	GHGP: requires assurance internally (first party) or externally (third party); ISO: no requirement of verification	Independent third-party verification is required	No specific guidance
<b>Recursiveness</b>	Continuous improvement by phased implementation	No specific guidance	No specific guidance	Continuous improvement through data exchange among entities	No specific guidance

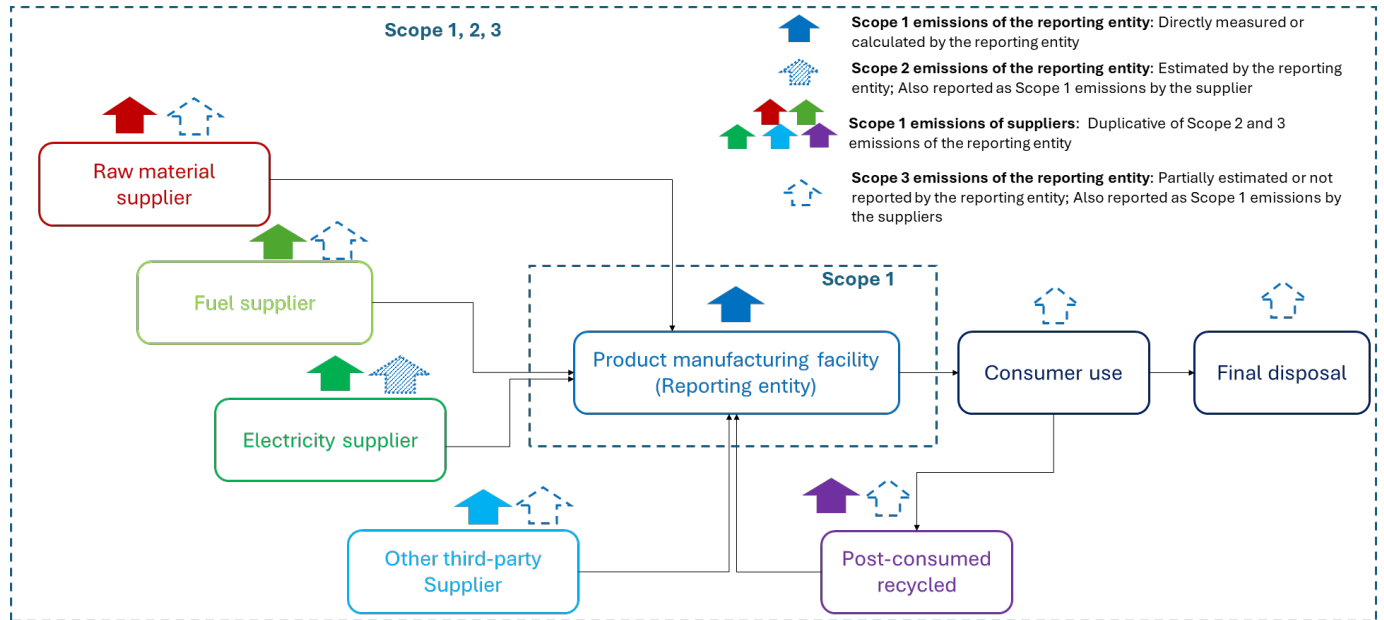
## Comparison of Organizational Frameworks

The organizational frameworks show significant divergence—including scope of reporting, reporting boundaries, reporting entity, reporting time period, and carbon coverage. Key similarities and differences are summarized below and presented in Table 6:

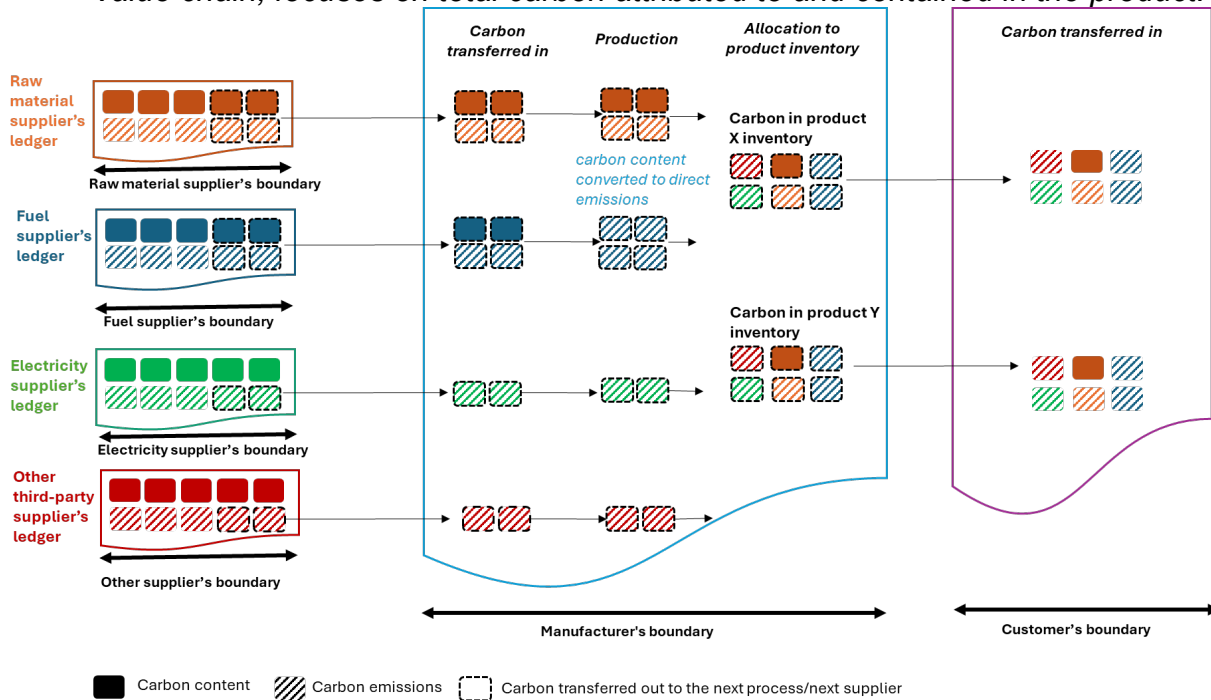
- **Scope of reporting:** Existing frameworks focus on either the entity level or the product level, but not both. The GHG Protocol product-based reports cannot be correlated with the GHG Corporate Protocol reports for the same entity. By comparison, a comprehensive carbon accounting system supports accounting and reporting at the product level in a manner that also can be aggregated to the entity level.
- **Reporting boundaries:** The GHG Protocol Corporate Standard and the R&D GREET model adopt a cradle-to-grave boundary, encompassing the entire life cycle of a product. The PACT methodology follows a cradle-to-gate approach, which excludes emissions from product use and end-of-life stages. The GHG Protocol Product Standard and ISO 14067 allows either cradle to gate or cradle to grave. The cradle-to-grave reporting boundary for the GHG Protocol Corporate Standard provides considerable flexibility in how the boundary is implemented in practice, diminishing the value of entity-to-entity comparisons. The cradle-to-grave boundary also imposes requirements on the reporting entity that extend beyond its ownership and control, which can affect the accuracy and completeness of reporting. By comparison, a comprehensive carbon accounting system employs a gate-to-gate boundary, requiring each entity to quantify only its own carbon and emissions, and to transfer those out—along with the outputs that the carbon and emissions embodied within—to the next entity in the supply chain. Figure 2 illustrates the difference between the GHG Protocol Corporate Standard and a comprehensive carbon accounting system. The difference in reporting boundaries among the product-based frameworks also makes it nearly impossible to compare the carbon intensity of the same product originating from competing entities.

**Figure 2. Comparison of reporting boundaries in the comprehensive carbon accounting system and the GHGP entity-based emissions reporting framework**

a) *GHG Protocol entity-based emissions reporting: Entity-based life cycle reporting with overlapping reporting responsibilities, focusing on emissions but excluding physical carbon content.*



b) *Comprehensive carbon accounting system: Gate to gate by each entity in the product value chain, focuses on total carbon attributed to and contained in the product.*



- **Reporting entity:** Existing frameworks typically require the reporting entity to report GHG emissions across the entire supply chain. In contrast, a comprehensive carbon accounting system assigns responsibility to each participant in the supply chain—such as a raw material supplier—to account for its own carbon emissions. This encourages each entity in the product value chain to directly request carbon data embodied in the products it receives from its suppliers. Suppliers are incentivized to provide this data, as it enables them to transfer out the associated carbon and emissions.
- **Reporting time period:** No existing framework mandates a specific reporting time period, although they do require reporting entities to disclose the period covered. Requirements for reporting periods are typically found in regulatory disclosure rules or global voluntary initiatives, rather than in the frameworks themselves. By contrast, a comprehensive carbon accounting system requires entities to establish fixed reporting time periods more frequent than annually. Since the entries are transaction based, the most logical requirement is to align carbon accounting time periods with financial accounting periods.
- **Carbon stocks and flows:** The GHG Protocol Corporate Standard focuses on the flows of GHG emissions during the reporting period. It does not account for emissions embodied in the company's assets or those embodied in purchased goods and services. The absence of stock variables, along with the distinction between stock and flow variables, limits the ability to fully capture a company's historical and periodic carbon performance.<sup>34</sup> By contrast, a comprehensive carbon accounting system captures the complete carbon balance of all forms of carbon, enabling entities to account for both carbon stock and flows.
- **Administration:** All existing frameworks are challenging for reporting entities to implement independently. Organizations commonly rely on external consultants to develop their GHG inventories or calculate product carbon footprints. By contrast, a comprehensive carbon accounting system is designed for direct implementation by companies.

Table 6. Comparison of organizational frameworks across carbon counting frameworks

	A Product- and Entity-Level Comprehensive Carbon Accounting System	Existing Carbon Counting and Reporting Frameworks			
		GHG Protocol Corporate Standard	GHG Protocol Product Standard / ISO 14067	PACT methodology	Life Cycle Analysis R&D GREET Model
<b>Scope of reporting</b>	Product level that can be aggregated to entity level	Entity level only	Product level only		
<b>Reporting boundaries</b>	Gate to gate, most likely the same as entity accounting boundaries; Suppliers for input gate data	Cradle to grave plus ancillary impacts (e.g., employee commuting)	Cradle to grave or cradle to gate with ancillary impacts (e.g., land use)	Cradle to gate	Cradle to grave
<b>Reporting entity</b>	Each owner in the product supply chain is responsible for its own accounting	A single reporting entity for the entire scope			Any entity in the supply chain
<b>Reporting time period</b>	Fixed time periods, most likely aligned with the time period for financial reporting, e.g., annual, quarterly, monthly	Reporting period to be aligned with product life cycle; Reporting entity sets and discloses the reporting period covered; For GHG protocols, the data from past, present, and future periods treated as all occurring within same time frame			One-time life cycle assessment snapshot combines data from past, present, and future periods
<b>Carbon stocks and flows</b>	Records stocks and flows of all forms of carbon within an entity and embodied carbon in products; removals and environmental attributes recorded separately and can be allocated as credits to final product carbon intensity	GHG emissions only; removals are not credited as an offset to final inventory; RECs are credited as offset to Scope 2 emissions	GHG emissions and select product carbon content; GHGP cradle-to-grave reporting includes carbon stored in product not released to the atmosphere during waste treatment, for cradle to gate, carbon content in intermediate product should be reported; ISO requires reporting biogenic carbon in products separately if calculated; removals and environmental attributes are not credited as offset to final carbon product values, but can be reported separately		GHG emissions and other environmental parameters reported; embodied carbon not reported
<b>Administration</b>	Designed for companies' direct implementation	Entities often rely on external consultants for implementation			

## Comparison of Methodologies for Data Collection and Recording

The frameworks show significant divergence in data protocols. The data protocols for a comprehensive carbon accounting system are rules based, providing for a greater degree of precision and uniformity in carbon accounting and reporting. By comparison, the data protocols for the current entity-level and product-specific carbon reporting frameworks embody a significant degree of flexibility, leading to larger variations in the completeness, accuracy, and comparability of reporting. Key similarities and differences are summarized below and presented in Table 7:

- **Standards or guidance:** All existing frameworks offer reporting entities considerable flexibility in selecting methods, such as types of data or allocation rules for emissions to individual products. In contrast, a comprehensive carbon accounting system adopts a rules-based approach, akin to the structure of U.S. Generally Accepted Accounting Principles (GAAP) in financial accounting.
- **Data quality:** All frameworks encourage an entity to use reliable data based on direct measurement or calculation. For example, the GHG Protocol Product Standard states that “primary data is always better than secondary” and requires an entity to assess data quality using specific indicators.<sup>35</sup> Similarly, the ISO 14067 standard requires using secondary data only when the primary data collection is impracticable or of minor importance.
- **Allocation processes:** The GHG Protocol Product Standard, ISO 14067, and the PACT methodology require companies to avoid allocation between the studied product and co-products whenever possible. If allocation is unavoidable, they recommend prioritizing a physical relationship, and using an economic relationship or other relationships as a last resort. The R&D GREET structure offers multiple allocation options—mass based, energy based, and market value based. A comprehensive carbon accounting system requires following causal relationships, including both physical and economic relationships. Unallocated residuals may be permitted, but their magnitude and underlying rationale should be transparently reported to ensure that the sum of the residual and the emissions allocated to products equals the entity-level emissions.
- **Data collection:** The GHG Protocol Product Standard, ISO 14067, and the PACT methodology build on life cycle assessment (LCA) standards, and follow steps similar to those in an LCA: defining the scope, setting boundaries, collecting data and assessing its quality, allocation, assessing uncertainty, calculating results, assurance, and reporting. This LCA approach relies on various types of data—such as site-specific process activity data, direct emissions data, modeled data, and industry averages and estimates—collected by the reporting entity, not necessarily on a periodic basis. By contrast, a comprehensive carbon accounting system requires recording transactions rather than collecting data. Since each transaction related to

carbon stock and flows is recorded in a carbon ledger, an entity does not need to collect a large volume of data at the time of reporting.

Table 7. Comparison of methodologies for data collection and recording

	A product- and entity-level comprehensive carbon accounting system	Existing frameworks				
		GHG Protocol Corporate Standard	GHG Protocol Product Standard	ISO 14067	PACT methodology	Life Cycle Analysis R&D GREET Model
<b>Standards</b>	Rules-based accounting	General guidance, with flexibility in application				
<b>Data quality</b>	Sets rules-based chart of accounts based on causal logic and guidelines for data quality	General guidance for inventory quality management system; experts' judgement allowed	Primary data for all processes under the entity's control; Secondary data allowed for all others; Includes five data quality indicators and methods	Order of priority: site-specific data, non-site-specific primary data, secondary data; includes 10 factors to characterize data quality	Collects primary data for all processes; secondary data is allowed if primary data is unavailable	Flexible with data inputs or using default values
<b>Allocation processes</b>	Follows causal relationship with physical or economic allocation; possible unallocated residual if no causal relationship found	Not needed	Order of priority: no allocation; physical allocation; economic allocation or other		Focuses on sectoral guidance; otherwise, same order of priority with ISO/GHGP	Offers multiple allocation methods: mass based, energy based, and market value based
<b>Data collection</b>	No need to collect large volume of data at the time of reporting as each transaction is recorded timely	Need to collect large volume, various types of data at the timing of reporting				

# Identifying Areas Where Comprehensive Carbon Accounting Could Improve the Quality of Current GHG Protocol Reporting

A comprehensive product- and entity-level carbon accounting system and the current GHG Protocol are perceived as conflicting systems by their respective supporters. Some advocates for comprehensive carbon accounting, for example, argue for complete replacement of the GHG Protocol. At the same time, the governing boards of the GHG Protocol and the ISO are undertaking major efforts to garner more support for the Protocol, including measures to upgrade the methodology and harmonize the Protocol and ISO standards. Would it be possible to incorporate specific elements of carbon accounting methodologies into GHG Protocol guidelines in a way that moves toward harmonization?

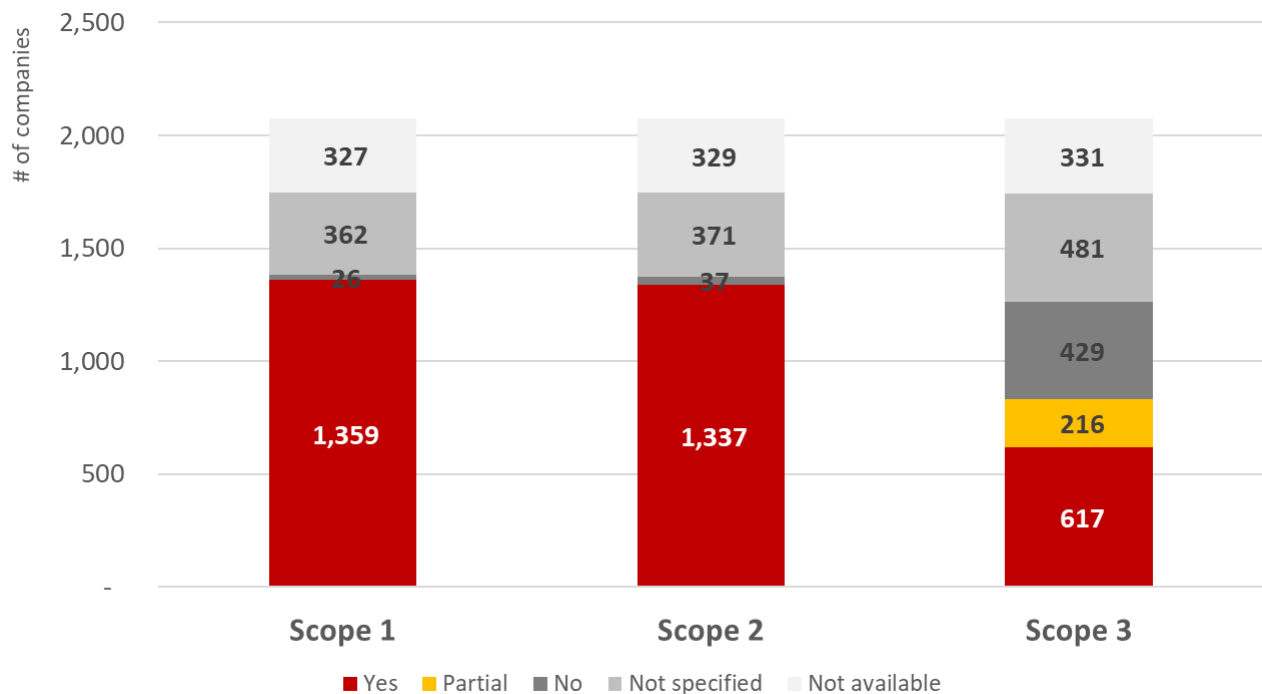
A comprehensive carbon accounting system, as described earlier, is a ledger-based system that incorporates carbon mass and energy balances in alignment with financial accounting principles and practices, integrating product-level data on carbon stocks and flows with corresponding entity-level totals. Although this architecture is fundamentally different from the implementing guidelines for the GHG Protocol Corporate Standard, the underlying ledger has sufficient disaggregation of the data to allow for the data to be combined in a manner that can support reporting under the current Protocol format. While this can improve the quality of the data reported under the Protocol, it will not override some fundamental flaws in the Protocol structure. In short, a comprehensive carbon accounting system can improve the quality of reporting under the GHG Protocol, but the design limitations of the Protocol cannot support product-based carbon accounting.

The limitations of the GHG Protocol Corporate Reporting stem from its basic structure that categorizes an entity's emissions into three unique but overlapping scopes: Scope 1 (direct emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (all other indirect emissions throughout the organization's value chain). The structural issues that arise from the three-scope system can lead to incomplete, inconsistent, duplicative, and inaccurate reporting.

- **Duplication by multi-counting of emissions in the same value chain:** The three-scope design results in multiple counting of the same emissions by different companies within a single value chain. One company's Scope 1 emissions may appear as another company's Scope 3 emissions in the same value chain. The GHG Protocol claims that multi-counting is not necessarily a flaw, but rather an opportunity to encourage collective action, as multiple companies share responsibility for the same emissions.<sup>36</sup> Shared responsibilities, however, often lead to reticence to take the initiative for action.

- Incomplete and inconsistent emissions information:** Entities tend to partially report or entirely omit Scope 3 emissions from their reporting. In 2017, only a quarter of the companies reporting Scope 3 emissions disclosed all categories of Scope 3 emissions.<sup>37</sup> Companies are allowed to cherry-pick the scope of emissions according to the purpose of reporting. One study found that French companies often reported lower GHG emissions in their corporate reports than in their submissions to the CDP by partially or completely omitting Scope 3 emissions.<sup>38</sup> Another study identified that half of 56 tech companies examined reported lower Scope 3 emissions in the corporate report compared to their CDP responses.<sup>39</sup> Among the 2,074 largest publicly traded companies worldwide, only 612 companies—approximately 30%—quantify all categories of Scope 3 emissions (Figure 3).<sup>40</sup> Given the challenges large companies face in addressing Scope 3 emissions, small and medium-sized enterprises are likely to encounter even greater challenges. Figure 3 further illustrates the inconsistencies in reporting entity-level emissions.

**Figure 3. Largest global companies’ coverage of Scope 1, 2, and 3 emissions, 2024**



Data from John Lang, et al., *Net Zero Tracker*. Energy and Climate Intelligence Unit, Data-Driven EnviroLab, NewClimate Institute, Oxford Net Zero. 2024.

- Lack of uniform system boundaries for reporting:** The GHG Protocol provides companies with flexibility in defining their organizational and operational boundaries, allowing them to strategically determine what to include in their emissions reporting. For example, multinational firms can exclude emissions from overseas operations by

setting their organizational boundary to cover only domestic activities.<sup>41</sup> While the standard is useful for tracking progress within a single company it may not be well suited for comparing emissions performance across different entities.<sup>42</sup>

- **Inaccurate emissions information:** Scope 2 and Scope 3 emissions are largely estimates rather than actual emissions. As companies typically lack operational data for these emissions, they are often estimated based on exemplary production processes or industry averages.<sup>43</sup> Downstream Scope 3 emissions, in particular, are forward-looking estimates of future activity. For companies with complex, global supply chains, acquiring the necessary data to accurately quantify Scope 3 emissions is especially challenging. The reliance on secondary data and industry averages makes verification of Scope 3 emissions difficult, and currently, no emissions trading systems include Scope 3 emissions.<sup>44</sup> The widely used market-based accounting for Scope 2 emissions has raised concerns about the accuracy of GHG inventories, since companies could claim zero Scope 2 emissions based on their purchase of renewable energy certificates, which do not have an impact on emissions within the operation of the product value chain. Further, if the emissions are double-counted, there is no net reduction of emissions.<sup>45,46,47</sup>
- **Differences in data protocols:** The GHG Protocol Corporate Standard offers considerable discretion in choosing data and emissions factors. For instance, when calculating emissions from employee business travel, a company can choose among three methods: the fuel-based method, the distance-based method, or the spend-based method—each relying on different activity data and emissions factors. This flexibility in methodology means that users of emissions data may find it difficult to determine whether differences between companies' reported emissions are due to actual operational performance or simply differences in accounting choices.<sup>48</sup>

Significant progress has been made over time in the evolution of new and updated implementation guidelines and data protocols supporting the GHG Protocol. However, as the assessment above illustrates, these improvements fall short of addressing the fundamental structural issues with the Corporate Protocol. A comprehensive carbon accounting system, however, can improve the quality of entity-level carbon reporting under the protocol across all three scopes. In particular, the boundaries of a comprehensive carbon accounting system do include the emissions from upstream value chain activities as part of the product-based accounts, rather than as a voluntary category within Scope 3 of the GHG protocol. The potential application of ledger data from product-based carbon accounting data to the individual categories of GHG Protocol Scope 3 emissions is summarized in Table 8. (The categories follow those defined in the GHG Protocol Corporate Standard and ISO/TR 14069, which provides guidance for the application of ISO 14064-1.)

**Table 8. Application of the model comprehensive carbon accounting system to address GHGP Scope 3 emissions reporting**

Scope 3 categories in GHGP Corporate Standard and ISO/TR 14069		Application of a comprehensive carbon accounting system
<b>Upstream categories</b>	GHGP1. Purchased goods and services ISO9. Purchased products	Included in the carbon accounting of suppliers and passed through to the entity’s carbon accounting ledger if the emissions are significant enough to be material.
	GHGP2. Capital goods ISO10. Capital equipment	Included in the carbon accounting ledger and amortized over time in plant operations.
	GHGP3. Fuel and energy-related activities not included in Scope 1 or Scope 2 ISO8. Energy-related activities not included in direct and indirect energy	Included in the carbon accounting of value chain suppliers and passed through to the entity’s carbon accounting ledger.
	GHGP4. Upstream transportation and distribution ISO12. Upstream transport and distribution	Included in the carbon accounting of suppliers and passed through to the entity’s carbon accounting ledger.
	GHGP5. Waste generated in operations ISO11. Waste generated from organizational activities	Included in the carbon accounting of the entity’s carbon accounting ledger. Those of suppliers are included in their ledgers and passed through to the entity’s carbon accounting ledger.
	GHGP6. Business travel ISO13. Business travel	May be de minimis in the product-based carbon intensity, or may be included in the “general and administrative” account in the entity’s carbon accounting ledger.
	GHGP7. Employee commuting	NOT included in the entity’s product-based carbon accounting ledger. Commuting emissions are outside the boundaries of the entity’s carbon accounting ledger, and dependent upon factors not under the direct control of the entity, such as facility

	ISO22. Employee commuting	location relative to population centers, highway networks, and availability of mass transit.
	GHGP8. Upstream leased assets ISO14. Upstream leased assets	If assets are controlled by the entity, emissions are included in the entity’s carbon accounting ledger. If part of the value chain supplier, emissions would be included in the carbon accounting ledger of the supplier and passed through to the entity’s carbon accounting ledger.
<b>Downstream categories</b>	GHGP9. Downstream transportation and distribution ISO17. Downstream transport and distribution	If these activities are owned or controlled by the entity, and if the products in transit are in the chain of custody of the entity, then the emissions would be included in the entity’s carbon accounting ledger.
	GHGP10. Processing of sold products ISO18. Use stage of the product	After sale and transfer of custody, emissions associated with subsequent processing would be included in the ledger of the customer that has taken ownership of the products. Customers have data to quantify emissions from their use as they receive the data on carbon content in the products at the time of purchase.
	GHGP11. Use of sold products ISO18. Use stage of the product	The timing and nature of the use of sold products is outside the control of the entity and may occur in time periods beyond the time periods established for the ledger. Customers have data to quantify emissions from their use as they receive the data on carbon content in the products at the time of purchase.
	GHGP12. End-of-life treatment of sold products ISO19. End of life of the product	The timing and nature of end-of-life treatment of sold products is beyond the knowledge or control of the entity and would not qualify for entity’s reporting. The entity could continue to report estimates separately on a voluntary basis, as is currently the case.
	GHGP13. Downstream leased assets	Leases of unrelated assets outside the boundaries of the product value chain would not be relevant to the entity’s carbon accounting.

	ISO21. Downstream leased assets	
	GHGP14. Franchises ISO20. Downstream franchises	The sale of the product to a franchisee would transfer the carbon content of the product from the entity to the franchisee. If the franchise agreement gives significant controls to the entity over the operation of the franchisee in the sale of the product to ultimate consumer, the entity could consider inclusion in its carbon accounting, or could report emissions separately on a voluntary basis, as is currently the case.
	GHGP15. Investments ISO15. Investments	Investments by the entity in unrelated assets or activities outside the boundaries of the product value chain would not be relevant to the entity's carbon accounting.
	GHGP N/A ISO16. Client and visitor transport	NOT included as these emissions are out the boundaries of the carbon value chain owned and controlled by the entity.
	GHGP N/A ISO23. Other indirect emissions or removals not included in the other 22 categories	CO <sub>2</sub> removals are recorded in a separate category. Removals can be netted against emissions when sequestration is completed.



## Conclusion: A Harmonized Approach to Carbon Accounting

This paper provides a comparative analysis of carbon counting and reporting systems relative to a comprehensive product- and entity-level carbon accounting system. The analysis highlights both the challenges and opportunities in harmonizing carbon counting and reporting systems, both among themselves and together with a comprehensive carbon accounting system.

Harmonization can begin with the alignment of core principles. As the comparative analysis shows, there is large overlap in the stated core principles, but these need to be defined more rigorously and applied in a consistent and comprehensive manner. Refining their definitions and applying them rigorously would provide the initial foundation.

The next step is harmonizing data protocols. A comprehensive carbon accounting system provides a framework to foster improved data quality and data management through reliance on comprehensive carbon mass and energy balances that add discipline to the completeness, accuracy, and comparability of the data within defined boundaries of time and space. Adoption of this approach would enhance the data protocols of existing counting and reporting frameworks to improve Scope 1 emissions reports in particular.

The greatest challenge lies in harmonizing organizational structures since current systems substantially differ in scope, reporting boundaries, reporting entities, time periods, and carbon coverage. A comprehensive carbon accounting framework can serve as a common reference for the other systems due to its comprehensiveness. For example, adopting gate-to-gate boundaries for each entity in the supply chain supports a rigorous accounting of cradle-to-gate emissions that can improve the completeness of Scope 1 and 2 reporting. Finally, by explicitly accounting for physical carbon content in products (as well as attributed emissions), comprehensive carbon accounting can enhance the reporting of downstream Scope 3 emissions.

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