



Foundations of Integrated Corporate Carbon Accounting

Whitepaper No. 1

The Carbon Accounting Standards Initiative (CASI)

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October 2025

Contents

Foreword: Introducing the Carbon Accounting Standards Initiative (CASI)

Executive Summary

Foundations of Integrated Corporate Carbon Accounting

-The Quest for Corporate Carbon Accounting

-Integrated Corporate Carbon Accounting

-Core Principles

-The Road Ahead

References

Imprint

Foreword: Introducing the Carbon Accounting Standards Initiative (CASI)

As governments and companies commit to reducing their Greenhouse Gas (GHG) emissions, the ability to measure, verify and report reliable emission figures has become foundational to effective decision-making throughout the world's industrial economies.

Frameworks such as the Greenhouse Gas Protocol, ISO standards, life-cycle assessments, and national emissions inventories have provided useful starting points—establishing a common language and framework. Industry-level initiatives like Catena-X and Together-for-Sustainability have advanced these frameworks with specific suggestions for standardizing the measurement of carbon emissions within different industries.

Yet, as the energy transition increasingly shapes trade policy, financial disclosures and executive incentives, it is becoming increasingly clear that corporate emissions data too often lacks the precision and reliability required to support auditable and useful action. From climate-related financial disclosures to carbon border adjustments and emissions-based executive compensation, the need for investor-grade information about corporate carbon emissions is growing.

This whitepaper is the foundational statement for a newly formed initiative, termed the **Carbon Accounting Standards Initiative (CASI)**. We are a working group of company representatives and academics from the fields of accounting, corporate reporting, and climate sustainability. We are united by the belief that effective decarbonization depends on reliable investor-grade emissions data and that the principles of financial accounting offer a useful foundation for reliable carbon accounting at the corporate level. Ultimately, corporate carbon accounting must evolve to the point where emissions are tracked, allocated, and reported with the same rigor and structure as financial transactions.

In this first whitepaper we introduce the framework of **Integrated Corporate Carbon Accounting (ICCA)**. Such accounting systems ensure that product-level carbon footprints (PCFs) seamlessly integrate with company-level carbon footprints (CCFs). Unlike existing approaches, ICCA applies rigorous double-entry-style accounting logic to GHG emissions and offsets, thereby enabling a coherent, reconcilable, and audit-ready infrastructure for carbon reporting.

As several recent publications by our members illustrate, such carbon accounting systems are within reach. In this paper, we outline the problem as we see it, the solution we propose, and the architecture we believe can enable it. A series of further whitepapers will lay out the proposed ICCA systems in more detail and address specific carbon accounting standards.

Our proposed carbon accounting system is compatible with, and builds on, the substantial progress already made by existing frameworks and initiatives, such as the Greenhouse Gas Protocol, ISO standards, and corporate climate disclosure regimes such as the global baseline standard [IFRS S2](#) by the International Sustainability Standards Board ([ISSB](#)), the [TCFD Recommendations](#) (now folded into the IFRS Foundation), or [ESRS E1](#).

The task before us is large, and we believe the path forward is collaborative. With this paper, we invite you—whether you are a policymaker, corporate leader, standard-setter, investor, or academic—to join us in refining our approach to corporate carbon accounting. Whether through dialogue or pilot testing, your involvement at this early stage will be essential to ensuring that our initiative advances the transition to a decarbonized economy at speed and scale.

We look forward to entering a dialogue with you as we work toward a new era of corporate carbon accounting.

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Executive Summary

Businesses in a wide range of industries are increasingly considered responsible not only for their own direct carbon emissions but also the emissions embodied in their sales products. This whitepaper describes the structure of *Integrated Corporate Carbon Accounting* (ICCA) systems that track all of a company's direct (Scope 1) and indirect (Scope 2 and upstream Scope 3) emissions over time in order to calculate key periodic emission metrics.

Akin to product costing in financial accounting, ICCA systems determine the cradle-to-gate Product Carbon Footprints (PCFs) of products sold in the current time period on the basis of the company's actual direct emissions, its actual operational activities and the PCFs attributed to production inputs sourced from suppliers. The PCFs of products sold then become a central building block for determining a company's periodic Corporate Carbon Footprint (CCF). By separating carbon stock variables from carbon flow variables, ICCA systems can track emissions in a consistent manner across different time periods. Double-entry bookkeeping enables a particular ICCA architecture that records the carbon stock variables on a CO₂ balance sheet, resulting in overall CO₂ statements that are structurally similar to financial statements.

Provided ICCA systems are increasingly adopted by companies within a supplier network, the reported carbon PCF and CCF metrics will increasingly reflect primary data regarding actual emissions incurred within the network. The many parallels between integrated carbon accounting and traditional financial accounting facilitate the embedding of ICCA systems in automated enterprise resource planning systems and also aid auditors in the task of certifying that key carbon metrics have been determined in accordance with well-established carbon accounting standards (to be developed in subsequent CASI whitepapers). Taken together, ICCA systems have the potential to result in investor-grade information about a company's carbon emissions performance.

The Quest for Corporate Carbon Accounting

With the ten-year anniversary of the Paris Climate Agreement upon us, there is growing concern that global greenhouse gas emissions still continue to increase year after year. The challenge of meeting the goals set by the Paris agreement therefore becomes ever more acute. While governments around the world and most of the Fortune 1000 firms have articulated net zero targets, frequently anchored to the year 2050, it is far from clear that the world is on track to stay within the global warming limits set by the Paris agreement.

The basic proposition of the *Carbon Accounting Standards Initiative* (CASI) is that an integrated system of transaction-oriented carbon accounting, implemented at the level of individual companies, will lead to much needed corporate accountability for current emissions performance and any improvements therein over time. Such accountability is being demanded increasingly by regulators as well as investors, corporate customers, consumers and the general public.

More than 30 jurisdictions around the world, including the European Union, China and the state of California are currently in the process of adopting reporting mandates for corporate carbon footprints. While the details of these mandates are still to be finalized, both the EU and California appear to adopt the general classification of the Greenhouse Gas (GHG) Protocol. The framework of the GHG Protocol -- illustrated in Figure 1 -- envisions companies accounting for both their direct (Scope 1) and their indirect (Scope 2 and Scope 3) emissions.

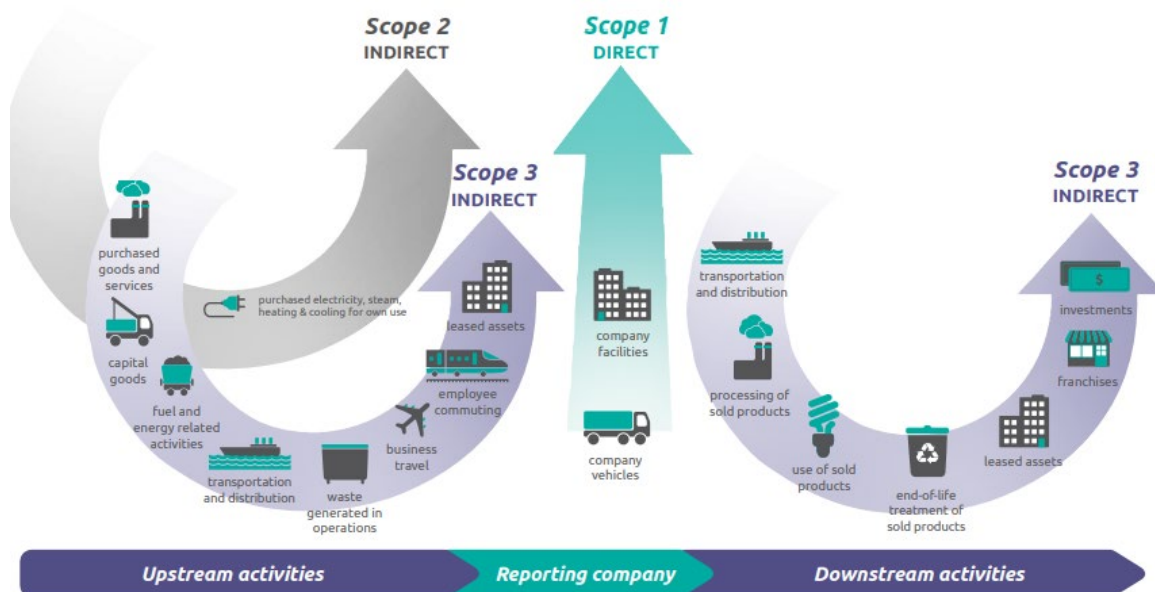


Figure 1: Framework of the Greenhouse Gas Protocol

Source: WRI (1998)

Beyond *Corporate Carbon Footprints* (CCFs), there is also a growing demand for reliable assessments of the *Product Carbon Footprints* (PCFs) of individual products and services. A variety of recent regulations in the EU and the U.S. have tied cash subsidies and income tax

credits to the assessed *cradle-to-gate PCFs*—that is, the entire supply chain emissions incurred in the production and delivery of the product in question. Further, beginning in 2026, the EU will initiate a *Carbon Border Adjustment Mechanism* (CBAM) that imposes tariffs on a broad set of goods to be imported to the EU depending on the assessed PCFs of those goods.

In addition to regulatory requirements, producers in carbon-intensive industries face increasing demands from their customers to provide reliable information on the cradle-to-gate PCFs of products sold. The reliability of these voluntary disclosures will be significantly strengthened if companies adopt their own in-house carbon accounting systems in accordance with established carbon accounting standards, enabling the resulting disclosures to be certified by external auditors.

Lacking their own in-house carbon accounting system, it is currently common practice for companies to estimate their direct and indirect emissions voluntarily in accordance with the simple flow-accounting framework illustrated in Figure 2.

- Among the line items shown in Figure 2, the assessment of Scope 1 emissions is generally considered to be relatively straightforward, particularly in jurisdictions that have adopted a formalized MRV (Measurement, Reporting and Verification) framework in order to determine carbon taxes and/or allowance requirements for Scope 1 emissions. From the assessed direct emissions, companies can subtract any direct CO₂ removals that may have been undertaken by third parties under a contractual agreement. The difference between direct emissions and direct removals yields the company’s *net direct emissions*.
- To estimate the indirect Scope 2 and upstream Scope 3 (Scope 3.1) emissions incurred in connection with goods acquired and services consumed from suppliers, most companies rely on Life-Cycle Analysis (LCA) conducted either in-house or by external consultants.

Carbon emissions embodied in goods acquired in current period (Scope 2 and upstream Scope 3) + Entity’s current direct carbon emissions (Scope 1) – Entity’s current direct carbon removals (– Scope 1) = Entity’s Net Carbon Flow for the current period

Figure 2: *Statement of an entity’s current Net Carbon Flow*

To cover an entity’s full Scope 1, 2, and 3 emissions in accordance with the framework laid out by the GHG Protocol, the net carbon flow measure in Figure 2 can be supplemented with emission *estimates for the use phase of products* sold in the current period. Depending on the

nature of the products, such estimates must by their very nature remain speculative, for instance, the sale of an aircraft to an airline.

The calculation of the net carbon flow measure illustrated in Figure 2 does not require a corporate carbon accounting system that assigns incoming indirect emissions and direct emissions incurred to different activities, sales products, or future time periods. Instead, the Net CO₂ Flow metric simply sums up the raw aggregate carbon emission flows that have been incurred in connection with current production activities and operations.

The practice of assessing and reporting corporate carbon footprints as described here, and summarized in Figure 2, has led to widespread reliability concerns. Auditors have generally provided only *limited assurance* for these reports. The lack of reliability appears to be a direct consequence of companies having to resort to secondary data in order to assess the emissions embodied in goods and services acquired from suppliers. These secondary data are typically based on industry-wide historical averages and estimates.

The use of secondary rather than primary emissions data raises two concerns.

- When a company's customers continue to gauge the PCFs of acquired products on the basis of historical industry averages, any successful decarbonization efforts by the company itself will at best be imperfectly reflected in the data bases used by the company's customers, and if so, only subject to delay. Critically, this dilution diminishes the incentives for the supplier to take costly measures that either reduce its own direct emissions or result in input acquisitions with lower carbon content. Yet, as companies seek to progress on their decarbonization pathways, they want to hold their suppliers accountable not only for price and quality but also the carbon emissions actually embodied in inputs purchased (Kurtz, 2022).
- The current practice of estimating indirect emissions based on historical industry averages is highly duplicative insofar as every link in a supply chain replicates the estimation efforts of all its predecessors in the chain (Becker, 2025). The costs of such duplicative practices can be substantially reduced by transitioning to a system in which PCF information is determined on the basis of company-level data, and upon verification, the PCF information is then passed on to customers.

Integrated Corporate Carbon Accounting

The starting point for a gradual transition to reliance on primary emissions data is the adoption of in-house carbon accounting systems that enable companies to determine the *cradle-to-gate PCFs* of their own sales products on the basis of their *own actual direct emissions*. As the set of adopters of such systems in a supply network grows, there will be a valuable reliability effect in terms of increased reliance on primary data throughout the supply network (BASF, 2022; Kaplan and Ramanna, 2021; Kurtz 2022).

Figure 3 illustrates the concept of *Integrated Corporate Carbon Accounting* (ICCA) systems. In effect, such systems provide a mapping from data inputs to carbon metrics that comprise both the entity's CCF and the PCFs of the entity's sales products. This mapping is routed through a carbon ledger, a collection of accounts that carry carbon balances.¹ The accounts of the ledger correspond to both carbon *stock variables*, e.g., emissions embodied in fixed assets, as well as carbon *flow variables*, e.g., the current CCF account. Bookkeeping entries for these accounts are determined by the operations and transactions undertaken by the business during the accounting period as well as the underlying accounting standards. In order to qualify as *integrated*, a corporate carbon accounting system must meet the following criteria:

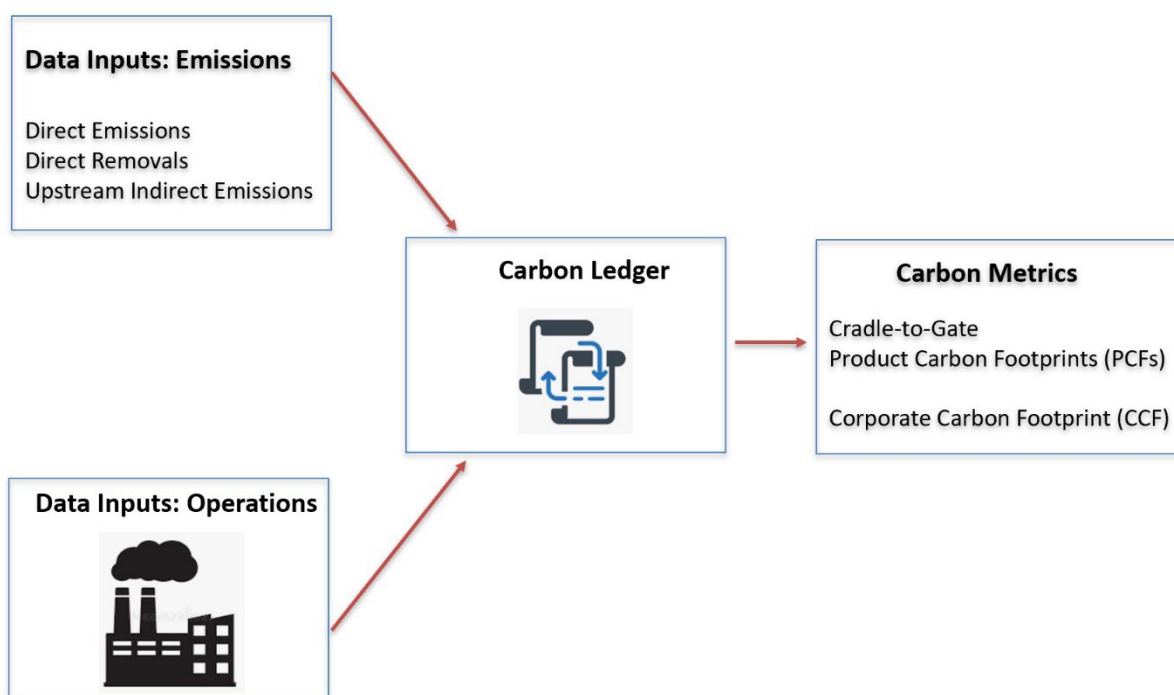


Figure 3: *Integrated Corporate Carbon Accounting*

- i. The CCF and the individual cradle-to gate PCFs are derived from the same data inputs regarding emissions and the entity's operating activities in the current period.
- ii. The CCF and individual cradle-to-gate PCFs are determined according to the same accounting standards.
- iii. The CCF metric comprises the cradle-to gate PCFs of products and services sold in the current period as well as other general and administrative carbon emissions attributed to the current period.

¹We have referred to "carbon emissions" thus far, mainly for brevity. The actual unit of measurement for the accounting system is emitted tons of CO₂ equivalents (or CO₂e). Thereby greenhouse gases other than carbon dioxide (CO₂) are made comparable to CO₂ itself by applying a commonly accepted multiplier which equals one if the greenhouse gas in question is CO₂.

Criterion iii) above specifies that the emissions embodied in sales products are recognized in the periodic CCF statement upon sale of a product, even though the emissions embodied in raw materials, fixed assets and other production inputs may have arrived at the company's gates in earlier accounting periods. Our approach to temporal matching ensures that the recognition of emissions in the CCF metric will coincide with the point in time at which the PCFs of products sold are recognized by the entity's customers in their carbon ledger.

Criterion iii) above says the CCF metric is to include *Carbon Emissions in Goods Sold* (CEGS); see Figure 4 below. In direct analogy to Cost of Goods Sold in a firm's income statement, the CEGS metric simply aggregates the emissions attributed to different product lines, that is the total of each PCF (expressed in tons of CO₂e per unit) multiplied by the sales volume of the corresponding product. In addition to CEGS, the CCF statement in Figure 4 also contains a line-item for General & Administrative Emissions. The emission items recorded there are considered too far removed from the production process to be included in PCF calculations, yet they arguably belong to the current accounting period. Applicable examples here include items like the emissions associated with current travel by executives.²

$PCF_1 \cdot s_1$	=	Carbon Emissions in Current Sales of Product 1
$PCF_2 \cdot s_2$	=	Carbon Emissions in Current Sales of Product 2
.	=	.
.	=	.
.	=	.
$PCF_n \cdot s_n$	=	Carbon Emissions in Current Sales of Product n
$\sum PCF_i \cdot s_i$	=	Carbon Emissions in Goods Sold (CEGS)
Y	=	General & Administrative Carbon Emissions
<i>Less</i>		
X	=	Current Direct Carbon Removals
$\sum PCF_i \cdot s_i + Y - X$	=	Corporate Carbon Footprint (CCF)

Figure 4: *Corporate Carbon Footprint Statement*

The CCF statement shown in Figure 4 further includes direct carbon removals for the current period as a separate line item. Our treatment here posits that in contrast to direct emissions,

² The Product Life-Cycle Accounting and Reporting Standard of the Greenhouse Gas Protocol (2011) specifies that emissions associated with activities like business travel not be included in PCF calculations.

direct removals are not included in the PCF calculations. Future CASI whitepapers will address alternative accounting standards for the recognition and treatment of carbon removals. One simple alternative to the treatment shown in Figure 4 is to allow for direct removals to be netted against direct emissions with the consequence that only net direct emissions would be included in PCF calculations.³

The CCF metric derived in Figure 4 takes a historical cost perspective insofar as it captures only emissions that have already been incurred. Companies that seek to comply with the corporate standard of the GHG Protocol (as illustrated in Figure 1), companies could calculate an expanded “Comprehensive CCF” metric by supplementing the cradle-to-gate PCF metrics with an estimate of the downstream Scope 3 emissions to be incurred during the use phase of a product. Thereby, the cradle-to-gate PCFs referred to in Figures 3 and 4 will effectively become metrics for the cradle-to-grave emissions associated with a product (Lu et al. 2024).

Core Principles of Integrated Corporate Carbon Accounting

The preceding conceptual discussion suggests that standards for integrated corporate carbon accounting ought to comply with the following core principles.

- **Completeness:** In accordance with the framework of the GHG Protocol, companies account and assume responsibility for their own direct (Scope 1) emissions and the indirect emissions embodied in acquired inputs and services (Scope 2 and Scope 3.1) during an accounting period. A complete ICCA records all direct and indirect emissions an entity is responsible for in the carbon ledger.
- **Timely Recognition:** Direct (Scope 1) emissions and direct removals are recorded in the carbon ledger for the accounting period in which they occur. Indirect (Scope 2 and Scope 3.1) emissions are recorded in the carbon ledger in the same time period in which suppliers acquire (take control of) goods and services. The carbon ledger must include accounts for carbon stock variables that capitalize any incoming emissions that are not recorded directly in the current CCF metric.⁴
- **Temporal Consistency:** In each accounting period, the ending balances of the carbon stock variable accounts become the beginning balances in the subsequent accounting period. In conjunction with the principles of Completeness and Timely Recognition, Temporal Consistency ensures that over the lifetime of a business the sum of all CCFs will be equal to the sum of all net carbon flows, as defined in Figure 2.⁵

³Alternatively, the applicable accounting standards could entail limited discretion in assigning direct removals to individual production sites, activities, or even products. Such discretion may be instrumental in providing incentives for companies to undertake costly removals in the first place.

⁴ Under the CO₂-statement approach, the accounts for these stock variables are represented as the left-hand side of a CO₂-balance sheet (→ CASI Whitepaper No.2).

⁵ For a formal demonstration of this accounting identity, see Reichelstein et al. (2025).

- **Accuracy:** ICCA systems become more accurate as data inputs about indirect supply chain emissions are increasingly based on primary data that represent the actual emissions incurred in the supply chain. Accuracy will therefore improve as more companies in an entity's supply network adopt their own ICCA systems. Accuracy has been quantified by means of a Data Quality Scoring (DQS) index.⁶
- **Unbiasedness:** In most industries, the calculation of CCFs and PCFs requires pools of overhead emissions to be prorated (allocated) among different time periods and products. Such pools of overhead emissions frequently emerge in connection with Scope 1 and Scope 2 emissions. The principle of unbiasedness requires the applicable allocation rules to capture the *causal link* between emissions associated with specific production activities and the extent to which different products require these activities. While this causal link principle is intended to limit selective greenwashing, it will generally leave companies with limited discretion in choosing among multiple eligible allocation rules.

The Road Ahead

As introduced here, ICCA systems have multiple features in common with traditional financial and management accounting systems. In direct analogy to inventory costing for goods produced and sold, the product carbon accounting component of an ICCA system determines the emissions included in different sales products. The CCF statement, in turn, is the effective carbon equivalent of a Profit & Loss (Income) statement.

CASI's Whitepaper No.2 describes specific architecture for ICCA systems based on double-entry bookkeeping. The accounts representing the stock variables in the carbon ledger can then be represented as "CO_{2e} in Assets" on the left-hand side of a CO₂-balance sheet. Further the periodic CCFs will reconcile to the CO₂-balance sheets via an account that captures the entity's legacy emissions and can be viewed as the carbon equivalent of the account Owners' Equity on a financial balance sheet. Taken together, the CO₂-statements emerging from the periodic CCFs and the CO₂-balance sheet provides analysts with comprehensive information about an entity's current carbon emissions performance and any improvements thereof relative to the recent past.

Double counting of emissions is a commonly voiced concern in connection with the framework of the GHG Protocol. In terms of emissions reflected in companies' CCF metrics, double counting is an unavoidable consequence of the above Completeness Principle: one party's indirect emissions must, by definition, be another party's direct emissions. *Net direct emissions* is the only company-level metric that can be aggregated properly across parties in an economy

⁶ The "Rulebook" prepared by Catena-X (2024) describes a methodology for calculating a DQS index. See also Tfs (2024).

without double counting. We note that while a company's direct emissions and direct removals cannot be inferred from the CCF statement, the net direct emissions metric is a separate line item in the CO₂-liabilities section of the CO₂-balance sheet.

In contrast to the CCF metric, the emerging cradle-to-gate PCFs are principally not subject to double counting. Provided all parties along a supply network adopt their own in-house ICCA system, the emissions accumulated in products comprise a share of the direct actual emissions incurred by the company in question, a share of the actual direct emissions incurred by the company's Tier 1 suppliers, a share of the actual direct emissions incurred by the company's Tier 2 suppliers and so forth. At the same time, there will be *undercounting* of the aggregate direct emissions attributed to a product whenever companies along a supply chain do not include certain emission items in their PCF calculations, but instead, as illustrated in Figure 4, charge those items as General & Administrative CO₂ Emissions to the entity's periodic CCF.⁷

While this whitepaper has focused on the architectural structure and core principles for integrated corporate carbon accounting, future CASI whitepapers will address specific carbon accounting standards. The boundaries of emissions to be included in PCFs are likely to be one central standard in this regard, particularly as individual companies and NGOs, including the GHG Protocol, ISO rules, Together-for-Sustainability, Catena-X, or E-Ledgers have articulated conflicting positions on this issue.⁸ Moving further afield, future CASI whitepapers will delineate accounting standards for issues such as the recognition and treatment of carbon removals (and more broadly carbon credits), the use of market-based approaches for the emissions associated with electricity purchases, and alternative methods for allocating overhead emissions.

Once auditors are in a position to provide reasonable assurance that key carbon metrics have been determined in accordance with clearly established carbon accounting standards, the reported carbon metrics have the potential to become investor-grade information on par with audit-certified financial information. Auditor certification will also be facilitated if carbon ledgers are integrated into existing enterprise resource planning systems and possibly exhibit a substantial degree of connectivity with financial bookkeeping (Distler et al., 2024). Finally, like financial and managerial accounting reports, the resulting carbon emission reports should prove to be a management tool for corporate leadership in terms of planning, incentivizing and controlling a company's efforts on its pathway towards decarbonization.

⁷For a closed network economy, the following identity holds provided all direct and upstream indirect emissions are included in PCF calculations: When the resulting CEGS figures (which then coincide with the CCF figures) are aggregated across all firms in the economy over its entire lifetime, the total will be equal to the total net direct emissions incurred in the economy over its entire lifetime (Reichelstein, 2024).

⁸ See GHG Protocol (2004, 2011), ISO (2018), TfS (2024), Catena-X (2023) and Ramanna (2024).

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About CASI

The Carbon Accounting Standards Initiative (CASI) is a coalition of academics and company representatives from the fields of accounting, corporate reporting, and decarbonization. CASI's mission is to advance rigorous and decision-useful carbon accounting at the company level.

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Publication Details

CASI Whitepaper No.1: *Foundations of Integrated Corporate Carbon Accounting*, Version 1.0, October 2025

Suggested citation: CASI (2025), CASI Whitepaper No.1: Foundations of Integrated Corporate Carbon Accounting, Carbon Accounting Standards Initiative. Available at [link to CASI website] and [link to SSRN].

Acknowledgments

We thank Amadeus Bach, Gunther Glenk, Jochen Kurtz, Julie Mulkerin and Mykola Vlasov for their many helpful comments and suggestions.

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