



# An Accounting Architecture for CO<sub>2</sub>-Statements

**Stefan Reichelstein, Amadeus Bach, Christoph Ernst, and  
Gunther Glenk**

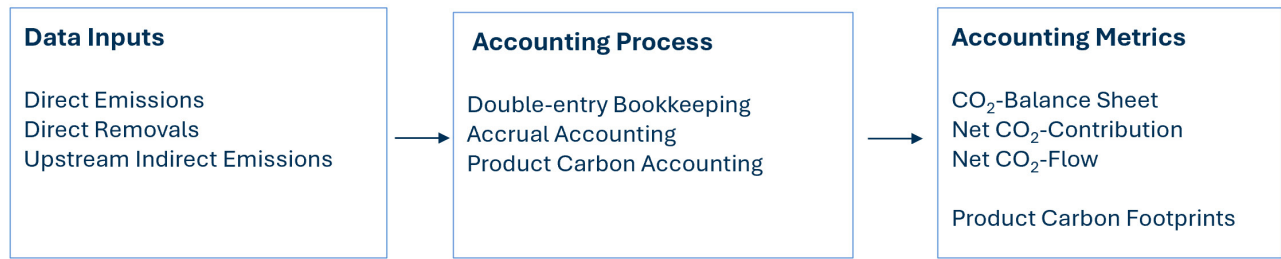
*Here we argue that financial accounting offers an architectural template for corporate carbon accounting systems consistent with current reporting frameworks for carbon emissions. The resulting CO<sub>2</sub>-statements yield a measure of a company's current corporate carbon footprint, while stock variables on the CO<sub>2</sub>-balance sheet convey summary information about an entity's past emissions performance and any recent changes therein. Taken together, CO<sub>2</sub>-statements enable a unified, comprehensive, and temporally consistent assessment of the direct and indirect emissions of a business entity and its sales products. The similarities to existing financial accounting systems are bound to facilitate the adoption of such statements from both an enterprise software and an assurance perspective.*

The Greenhouse Gas (GHG) Protocol is the globally recognized reference framework for reporting corporate carbon emissions. Classifying different emission inventories into direct and indirect, as well as upstream and downstream emissions, the GHG Protocol takes a comprehensive life-cycle approach to assessing a company's overall Scope 1-3 emissions (GHG Protocol, 2004). While this framework has been adopted by organizations worldwide and included in disclosure mandates, multiple stakeholder groups have been clamoring for more comprehensive and more reliable information about the carbon footprint of corporations and their sales products (Bjørn et al., 2022; Klaafßen and Stoll, 2021; Fankhauser et al., 2022). In response, the GHG Protocol has recently launched a comprehensive revision of its guidance documents, scheduled for completion by 2027.

This perspective article argues that financial accounting offers a practical template for carbon accounting systems that are consistent with existing emissions reporting frameworks

(Reichelstein, 2024). Similar to financial statements, the proposed system for carbon accounting results in CO<sub>2</sub>-statements, comprising a CO<sub>2</sub>-balance sheet and periodic statements showing the emissions an entity and its supplier network have contributed to the atmosphere in the current period. We argue that CO<sub>2</sub>-statements provide analysts with a comprehensive and temporally consistent assessment of an entity's Scope 1, 2, and upstream Scope 3 emissions. The CO<sub>2</sub>-balance sheet records stock variables that effectively summarize an entity's past emissions performance and any improvements thereof. In contrast, the net CO<sub>2</sub>-contribution metric provides a measure of an entity's periodic corporate carbon footprint. All accounting metrics emerge from the same ledger based on a transactional system of double-entry bookkeeping, with the unit of measurement being one ton of CO<sub>2</sub> (see Figure 1).

Several multinational companies have recently adopted internal product carbon accounting systems to determine the



**Figure 1. Illustration of corporate carbon accounting.** This figure illustrates how the accounting process converts data inputs to accounting metrics.

so-called cradle-to-gate product carbon footprints (PCFs) of their sales products. Such footprint measures seek to capture the total direct carbon emissions that have been incurred at the different stages of production in a supply network. Earlier studies have pointed to both efficiency gains and reliability advantages if cradle-to-gate PCFs are assessed in a sequential and decentralized manner (Kaplan and Ramanna 2021; Kaplan et al. 2023). Accordingly, each firm in a supply network operates its own product carbon accounting system in order to determine the PCFs of its sales products and services on the basis of primary data for the PCFs of inputs received from its Tier 1 suppliers as well as its own direct (Scope 1) emissions.

In accordance with the GHG Protocol’s guidance to report an entity’s emissions on a life-cycle basis, cradle-to-gate PCFs can be supplemented with estimates of the emissions to be incurred in the use phase of a product. For mass-produced consumer goods, like automobiles, car manufacturers will be able to draw on precise statistical information regarding average product usage and the emission factors associated with usage in different locations. The resulting cradle-to-grave PCFs then combine assessments for the Scope 1, 2, and upstream Scope 3 emissions that have been incurred thus far with forecasts of the downstream Scope 3 emissions expected to materialize during the product’s use phase, thereby enabling cradle-to-grave life cycle assessments.

Reliable PCF figures are increasingly demanded not only by consumers but also by corporate customers seeking to decarbonize their supply chains. Even more urgent, standardized PCF calculations become indispensable in jurisdictions where subsidies and tax breaks for “green” technologies are tied to the assessed carbon footprint of a product. In a similar vein, the Carbon Border Adjustment Mechanism to be implemented by the European Union in 2026 requires an assessment of the carbon dioxide emissions embodied in goods delivered to the gates of the European Union.

The cradle-to-gate PCFs of goods and services sold in the current time period become a key building block of the CO<sub>2</sub>-contribution metric (see Figure 2). Just as Cost of Goods Sold is a key component of the measure of financial income, Carbon Emissions in Goods Sold conveys the total emissions embodied in goods and services sold in the current period. Certain expense items not closely related to the production process, such as the emissions associated with business travel conducted in the current period, can be added as separate line items to the CO<sub>2</sub>-contribution. Direct carbon removals undertaken by a company, or a contractor acting on its behalf, are a source of “revenue.” We interpret the bottom-line net CO<sub>2</sub>-contribution as the entity’s current corporate carbon footprint, as it conveys the net tonnage of carbon dioxide an entity’s operations have contributed to the atmosphere in the current accounting period.

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

**Figure 2. Net CO<sub>2</sub>-Contribution.** This figure displays CO<sub>2</sub>-contribution statement.

CO <sub>2</sub> in Assets		CO <sub>2</sub> Liabilities & Legacy	
Buildings	$BLD_t$	$ETI_t$	Indirect CO <sub>2</sub> Emissions Transferred In
Machinery & Equipment	$M\&E_t$	$DE_t$	Direct CO <sub>2</sub> Emissions
Materials	$MAT_t$	$(DR_t)$	Direct CO <sub>2</sub> Removals
Work-in-Process	$WIP_t$	$LEG_t$	Legacy CO <sub>2</sub> Emissions
Finished Goods	$FG_t$		

Figure 3. CO<sub>2</sub>-balance sheet. This figure illustrates an opening CO<sub>2</sub>-balance sheet.

The CO<sub>2</sub>-balance sheet carries stock variables that are updated from one accounting period to the next (see Figure 3). The left-hand side of this balance sheet records the emissions embodied in the entity's operating assets. These emissions have arrived at the entity's gates, or have been incurred within its gates, but have yet to be recognized as part of the current CO<sub>2</sub>-contribution. The liability side of this balance sheet records the accumulated emissions embodied in goods and services received from the entity's suppliers as well as the entity's cumulative direct (Scope 1) emissions, less any accumulated direct removals. Each period's net CO<sub>2</sub>-contribution is reconciled with the balance sheet through an account that carries the entity's accumulated past net CO<sub>2</sub>-contributions. This feature is again in direct analogy to financial balance sheets, where owners' equity records an entity's past retained earnings.

The calculation of a company's net CO<sub>2</sub>-flow, the third module of CO<sub>2</sub>-statements, does not require product carbon accounting (see Figure 4). This metric only includes the "raw" flows corresponding to a company's current direct emissions, net of current direct removals, plus the Scope 2 and upstream

Scope 3 emissions associated with all incoming production inputs. As such, it comprises the emissions companies seek to report today under the GHG Protocol. However, in order for the incoming indirect emissions to be assessed on the basis of primary data about emissions actually incurred, the upstream suppliers have to maintain their own in-house product carbon accounting. If no company in a supply network were to calculate its own PCFs, all parties would need to estimate their indirect emissions (Scope 2 and upstream 3) on the basis of secondary data reflecting recent industry averages. This would result in a major duplication of estimation efforts and severely limit a company's incentives to reduce its direct and indirect emissions.

The main focus of this paper is on general principles for structuring CO<sub>2</sub>-statements, rather than the specific accounting rules that ought to apply in their preparation. The central principle we advocate for is to separate stock from flow variables by means of balance sheets and periodic net contribution statements. Various organizations have in recent years proposed detailed carbon accounting rules. The architecture of the CO<sub>2</sub>-statements described here is

Q	=	Current Direct CO <sub>2</sub> Emissions
Z	=	Indirect CO <sub>2</sub> Emissions Transferred In
Less		
X	=	Current Direct CO <sub>2</sub> Removals
$Q + Z - X$	=	<b>Net CO<sub>2</sub>-Flow</b>

Figure 4. Net CO<sub>2</sub>-Flow. This figure shows the statement of net CO<sub>2</sub>-flows.

sufficiently flexible so as to be compatible with any of these rules or some combination thereof. This flexibility pertains in particular to issues of product and entity boundaries as well as alternative rules for allocating pools of overhead emissions. In the absence of mandated carbon accounting rules, adopters of the CO<sub>2</sub>-statement approach can disclose separately the specific rules that have been followed in preparing their statements.

The CO<sub>2</sub>-statements described here are in particular compatible with existing frameworks, such as the GHG Protocol or ISO 14064, and disclosure mandates, such as

IFRS S2 and the EU's Corporate Sustainability Reporting Directive. The many parallels between financial statements and CO<sub>2</sub>-statements suggest that their adoption is neither overly complex nor costly. Recent software innovations show that existing financial systems can readily be expanded to run a ledger of carbon accounts. Further, the underlying structure of double-entry bookkeeping and the relations that link the different components of CO<sub>2</sub>-statements should facilitate the task of auditors in providing reasonable assurance that the statements were prepared in accordance with specific carbon accounting rules.

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*Link to the full working paper discussed in this brief:*

Reichelstein, S., Bach, A., Ernst, C. and Glenk, G. (2025), "An Accounting Architecture for CO<sub>2</sub>-Statements," [MIT CEEPR Working Paper 2025-16](#), August 2025.

## About the Authors



**Stefan Reichelstein** is the William R. Timken Professor of Accounting, Emeritus at Stanford Business School, and director of the Mannheim Institute for Sustainable Energy Studies (MISES). His research focuses on cost and profitability analysis, decentralization, internal pricing, and performance measurement. His research projects span analytical models, empirical work, and field studies. Insights from his research have been applied by a range of corporations and government agencies. In recent years, he has also studied the cost competitiveness of low-carbon energy solutions with a particular focus on solar PV and carbon capture by fossil fuel power plants. Professor Reichelstein received his Ph.D. from the Kellogg School of Management at Northwestern University in 1984. Prior to that, he completed his undergraduate studies in economics at the University of Bonn in Germany.



**Amadeus Bach** is an Assistant Professor of Accounting at the Mannheim Institute for Sustainable Energy Studies, University of Mannheim. His research focuses on accounting, sustainability, and climate-related technologies. Current projects address the market for second-life batteries, carbon accounting, and environmental regulation. He received his B.Sc. and M.Sc. in Business Administration and Economics from Goethe University Frankfurt and his Doctorate in Accounting from the University of Mannheim, including a research stay at the Wharton School of the University of Pennsylvania



**Christoph Ernst** is an experienced executive with extensive experience in financial solutions. As Head of SAP Global Product Management for Finance & Risk, he led strategic innovation for five years, enabling Cloud-, Analytics- and AI-based transformation at customers. After joining SAP in 1999 as an Education Consultant, he successfully led the Presales Organization before shaping SAP's global solution strategy. He later founded SAP's CFO Product Management, spearheading major innovations, including the SAP Green Ledger—a finance-grade, double-entry bookkeeping solution that enables businesses to track carbon quantities, comply with emerging regulations, and navigate the path to net-zero. As of 1 April, 2025, he is a Senior Researcher at the Mannheim Institute for Sustainable Energy Studies at the University of Mannheim. He holds a Doctorate in History from Trier University, where his research focused on the evolution of sustainable forest management in 18th-century Germany.



**Gunther Glenk** is an Assistant Professor of Business Administration at the University of Mannheim. His research examines the managerial economics of climate and sustainability. Topics include the accounting for corporate emissions, the cost of corporate decarbonization, and the incentives for climate action. Recent work has focused on the competitiveness of climate technologies, such as green hydrogen, energy storage, and electric mobility. Professor Glenk received his B.Sc., M.Sc., and Doctorate in Management and Technology from the Technical University of Munich.



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