Technical Workshop: Building a Primary Product-level Emissions Data Platform

SUMMARY WHITE PAPER

In October 2025, experts from industry, central banks, international organizations, standard-setting bodies, research organizations, and academia convened in Amsterdam for a multi-day workshop on product-level carbon accounting and system architecture for dynamically tracking embedded greenhouse gas (GHG) emissions in traded products. The purpose of the workshop was to explore the statistical, accounting, chemical, computational, and governance building blocks needed for a global repository of real-time, cradle-to-gate product-level emissions data.

Participants discussed current approaches and practices to emissions reporting, with some noting that most remain entity-level and estimate-based, thus poorly suited to the details needed for product differentiation, trade compliance, and value-chain transformation required for decarbonization. The workshop therefore focused on defining what a next-generation system–anchored in primary data, causal allocation, and digital traceability–and the steps that might be needed to achieve it, widely leveraging existing expertise and data sources.

Opening remarks highlighted the distinction between disclosure and accounting. Disclosure frameworks seek to inform stakeholders through estimated or modelled data, including retrospective and prospective estimates; accounting frameworks, by contrast, focus on incurred values and must achieve representational faithfulness and reasonable assurance. Such rigor is crucial for providing a trusted basis for claims, transactions, and policy tools such as carbon border adjustments. Remarks also underlined the importance of ensuring that any new system is focused on allowing companies to differentiate their outputs from competitors while remaining interoperable across jurisdictions, credible with regulators, and practical for businesses of all sizes.

Working Session 1: Accounting Principles for Product-level Embedded Emissions

The opening working session explored the foundational accounting logic for attributing GHG emissions to products. The discussion focused on two interrelated challenges: how to allocate emissions across outputs within a facility or entity, and how to handle the timing of emissions within production and asset lifecycles.

<u>Principles for Allocation:</u> A key distinction was drawn between causal allocation, in which emissions can be directly linked to specific inputs and outputs, and joint-product cases, in which such causal links are absent or unclear. Causal allocation applies where a clear physical connection can be made between inputs, production

processes and outputs. These cases can leverage scientific knowledge, production knowledge, and cost-accounting principles, making allocation logical and reproducible.

In joint-product cases, such as when harvesting outputs from livestock (e.g., beef and dairy), forestry (e.g., timber and pulp), or oil refining (e.g., multiple fuels and petrochemical co-products), emissions must be divided according to a convention (such as mass, market value, or carbon content of output products), each leading to different results. The discussion noted that such rules should be transparent, standardized, and documented to allow comparability, even if not perfectly causal. Indirect emissions like overheads also need transparent allocation.

Timing and Lifecycle Treatment: Participants also discussed temporal allocation, i.e., how emissions that occur at different points of time in a product's lifecycle should be recorded. This includes capitalized emissions from equipment manufacture, which might be depreciated and allocated to production over time, and end-of-life emissions from decommissioning or salvage, which arise years after initial production.

These timing questions are easily manageable within a ledger-based accounting framework, much like depreciation or amortization in financial reporting. A systematic approach could specify when and how such emissions enter the emissions ledger, ensuring both completeness and intertemporal consistency.

Case Study on Electricity: Electricity was used as an illustrative case of a homogeneous commodity whose emissions cannot be objectively traced to individual inputs and production and transmission processes. Participants discussed limitations in location-based and market-based reporting methods for determining emissions from electricity generation that are passed from producers to consumers, including accuracy, completeness, timeliness, and avoidance of double-counting.

The discussion then broadened to the question of incentives and accountability. High-frequency operational data could improve accountability, but incentives for utilities to provide such data vary across geographies and ownership structures. Some participants suggested regulatory compulsion, while others pointed to market demand as a more sustainable driver. Participants emphasized that data transparency creates accountability, enabling downstream customers to demand cleaner inputs. Once emissions are allocated to products, every actor in the value chain gains a tangible incentive to reduce them.

Some participants noted that existing contractual structures, such as long-term power purchase agreements and commodity markets, may complicate or slow the transition to real-time product-level accounting for electricity. Nonetheless, progressive adoption and iterative improvements to data quality and availability as systems mature (via the principle of "recursion") can yield early benefits. Accounting functions as information to drive behavior towards lower emissions, incorporating both relevance and reliability.

Working Session 2: Statistical Methods for Aggregate and Top-down Emissions Analysis

This session examined how official statistics and models can complement bottom-up, product-level emissions accounting. Participants discussed the role of statistical offices, research institutions, and existing frameworks in producing harmonized, quality-assured datasets that can fill gaps in the process of establishing an eventual, dynamic accounting system and ensure comparability across countries and industries.

Role of the Statistical Community: The discussion outlined what the statistical community already contributes, including a suite of internationally harmonized datasets built on consistent methodologies and subject to formal quality assurance, as well as established frameworks, such as the System of Environmental-Economic Accounting (SEEA) and its Air Emissions Accounts (AEA). Such accounts enable cross-country comparison and compatibility with other statistical domains. They also provide aggregate indicators that can serve as reference points or inputs for product-level calculations when primary data is missing.

Linking Macro and Micro Data: Participants discussed how aggregated statistical data can inform value-chain and (environmental) input-output (I-O) models, which map the flow of goods and services between industries. I-O models can deliver first estimates for the cradle-to-gate carbon intensity of intermediate products and provide a means to impute emissions where company-specific data are yet unavailable. However, these averages obscure firm-level variance and cannot by themselves support competitive differentiation or trade compliance. The challenge is thus to bridge macro-level statistics with micro-level accounting over time, ensuring coherence without diluting granularity.

Case Study on Process-based Modelling in GREET: An example was provided through the GREET model, a life-cycle assessment (LCA) model with extensive databases, which integrates process-level data across hundreds of materials and energy systems. GREET distinguishes between background data (i.e., generic, system-level averages) and foreground data (i.e., facility-specific or process-specific measurements), combining them with simulations and collaborations across institutions.

The model's applications, such as evaluating electric-vehicle battery production or new energy technologies, highlight the depth of information needed for accurate product-level footprinting. GREET also illustrates that calculation and modelling are intrinsic to carbon accounting: direct measurement alone is rarely feasible, but "measurement-informed calculation" can achieve high fidelity when underlying process chemistry and energy balances are known.

Data quality, transparency, and verification: Participants highlighted the importance of consistency, transparency, and verification for statistical and model-based systems. Existing regulatory schemes, such as those of the California Air Resources Board (CARB) and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) of the International Civil Aviation Organization, provide examples: they use standardized LCA look-up tables that allow both default and actual values for specific technologies. Defaults are simple but generic, while actuals are more accurate but require from producers proprietary data and detailed methods.

Takeaways: Statistics and accounting can be mutually reinforcing: statistical methods and databases can supply harmonized frameworks, baselines, priors, and validation checks, while accounting data, especially with primary data, can gradually replace proxies with verified measurements as coverage expands. Other insights included:

- Purpose determines precision: the required accuracy depends on the use case–whether for competitive differentiation, regulatory compliance, or macroeconomic monitoring.
- Prioritization could be helpful. Efforts could first focus on key upstream materials with high emissions intensity (e.g., steel, cement, etc.) before expanding to broader product categories.
- Fungibility and comparability will drive adoption. Companies will invest in data collection when consistent metrics enable them to demonstrate advantages in trade or procurement.

The session concluded with agreement that the statistics and accounting communities must work in tandem. Official data provide scaffolding for global comparability, while accounting injects granularity and market relevance. Together, they can build the foundation for a system where product-level carbon data are both economically meaningful and scientifically credible.

Session 3: Calculating Primary Data in Practice

This session examined how primary data can be generated, allocated, and verified in complex production systems, focusing on examples from heavy industry, agriculture, and carbon-removal technologies.

Industrial production and steelmaking: The first discussion examined the steel value chain, which combines multiple production routes–blast furnace/basic oxygen furnace (BAF/BOF) and direct reduced iron/electric arc furnace (DRI/EAF)–that ultimately yield indistinguishable steel slabs. Participants noted that batch-level traceability becomes a challenge once materials are blended. Pilots using the E-ledgers method demonstrated that product-level accounting can reveal insights not possible under traditional GHG tools, such as the carbon embedded in specific batches and grades of steel.

However, collecting primary data from thousands of suppliers, synchronizing time lags between material purchase and consumption, and managing highly complex logistics networks (including company-owned rail systems) all pose major operational challenges. Decarbonization initiatives also impose high capital costs, raising questions of profitability and incentive alignment.

Some participants highlighted the need for standards to address fugitive emissions, varying GHG types, and data gaps. While Internet-of-Things (IoT) devices can help, coverage remains limited. The overarching question remains: how accurate can primary data realistically be, and what level of assurance is acceptable for market and policy use?

Agricultural emissions and methane measurement: The next discussion focused on livestock emissions as a relevant case study, particularly methane. Current methodologies estimate emissions based on metabolic weight and feed characteristics, derived from limited measurement data. This approach provides only broad averages and fails to capture variability across species, diets, and production systems.

Participants debated whether emissions must be measured at the level of each animal, herd, or farm, noting that current measurement costs can exceed the value of the livestock itself. Moreover, the cattle value chain (spanning breeding, growing, and fattening stages) complicates traceability. Allocation of emissions among multiple co-products (e.g., beef, dairy, hides) further challenges consistency.

Participants agreed that while direct measurement of methane is scientifically feasible, sampling intensity and representativeness must be standardized to balance cost and accuracy. Farm-level traceability systems and national monitoring frameworks could play a role in scaling such approaches.

Lessons from carbon capture and engineering: The last discussion turned to direct air capture (DAC). The discussion outlined how the DAC process entails removals and emissions, which can be represented on a ledger: for example, the capture of 10 units of CO_2 from air creates an asset but also entails 2 units of emissions liabilities across capture, process, and transport stages that must be netted.

Takeaways: The discussion identified several cross-cutting challenges:

- Achieving accuracy and representativeness in diverse production systems (i.e., “measurement-informed calculation”) at the appropriate level of fidelity;
- Managing system boundaries and allocation of mixed inputs;
- Ensuring verification that is rigorous yet affordable, especially for small and medium-sized enterprises;
- Leveraging technologies such as IoT and AI to automate data capture; and
- Building incentives for suppliers to provide trustworthy data.

The discussion noted that a ledger-based accounting model, which records inputs, emissions, and outputs at each step, could solve many traceability and allocation problems while embedding incentives for emission reductions through market demand.

Working Session 4: Computational Principles and Design of a Global Product-Level Primary Data Hub

The fourth session shifted to system design: what computational principles should underpin a global data hub for product-level emissions? Two guiding concepts emerged–representational faithfulness (data must reflect physical reality) and reasonable assurance (data must be verifiable to a defined standard).

Distributed ledger technologies and tokenization: Participants explored how a distributed ledger could serve as the backbone of an emissions data infrastructure. Such a ledger would not be an accounting ledger in the traditional sense; rather, it would be a distributed record of verified data proofs, potentially using blockchain or similar technologies. The goal is to move beyond paper-based reporting (e.g., PDFs, invoices, spreadsheets) toward a system where data is digitally chained from IoT sensors to facility-level records to verified claims.

Different ledger architectures were discussed: public blockchains, permissioned enterprise systems, and private ledgers. Each presents trade-offs in accessibility, privacy, and interoperability. Participants stressed the need for late binding but not late allocation. Data can be linked to transactions later in the chain, but emissions must be causally allocated at the point of generation to preserve physical lineage.

A recurring question was how to handle data corrections when upstream information changes, ensuring that any "correction cascade" remains auditable. Participants also debated whether the ledger should anchor to invoices, delivery documents, or other proofs of transaction.

Artificial intelligence (AI) and baseline modelling: Discussions also considered the role of AI in building baseline models and detecting anomalies in reported data. For sectors lacking detailed process data, AI could estimate emissions based on logistics information, operational data, or satellite observations. Over time, these models could improve as primary data becomes available, providing a pragmatic path toward coverage across industries.

The idea of starting with minimum viable products (MVPs) featured prominently. Participants proposed beginning with relatively simple, sector-specific pilots (e.g., steel, cement, agriculture) using existing technologies–including spreadsheet-based systems–before migrating to more sophisticated digital ledgers.

Assurance and scalability: A major theme was the continuum between limited and reasonable assurance. Moving from limited to reasonable assurance greatly increases verification costs but also data reliability requirements. Some participants suggested a stepwise approach: start with limited assurance (annual verification), then progress toward higher-frequency and higher-assurance regimes as systems mature.

Auditors could initially verify the integrity of models and algorithms rather than the raw data itself, providing a practical on-ramp. Metadata such as time stamps, audit status, and data type (primary, secondary, hybrid) could be tagged to each data token to indicate quality and confidence levels.

Key design principles: Across the discussion, three principles recurred:

1. Simplicity: systems must be accessible across geographies and sizes, and also low-cost to ensure participation.
2. Correctness: data lineage must be causally sound, ensuring emissions are neither double-counted nor omitted.

3. Privacy: design choices must recognize the proprietary nature of underlying data, ensuring only the necessary information is shared in value chains, with regulators, and publicly.

Participants concluded that existing technologies are sufficient to begin implementation. The challenge is not technical feasibility but coordination, governance, and alignment of incentives.

Working Session 5: Governance Models for the Product-Level Emissions Data Hub

The fifth session addressed institutional design and governance. The discussion emphasized that trust in a data hub depends on institutional legitimacy, operational transparency, and neutral governance. The goal is not simply to host data but to establish the rules, principles, and funding models that ensure long-term credibility and use.

Governance considerations: A global data hub would need to determine:

- Which data is collected and at what aggregation level;
- How data quality is controlled and verified;
- How ownership and privacy are managed; and
- How the platform is funded and maintained over time.

Some participants referenced existing models such as the Network for Greening the Financial System's (NGFS) Data Directory, which aims to harmonize data access and promote standardization. The hub could evolve in stages: from enabling search and discovery of comparable datasets to facilitating data generation and publication, and ultimately serving as an authoritative source for verified product-level data.

Integration and institutional legitimacy: The discussion underscored the need for institutional neutrality, possibly through collaboration among national statistical offices, accounting standard setters, and international organizations. Statistical institutions bring methodological rigor but may lack the mandate to govern non-official data. Conversely, non-governmental bodies can innovate quickly but may lack regulatory legitimacy. A hybrid model, also involving international organizations, could combine both strengths: national or regional governance, coordinated through an international framework.

Data purpose and funding: The discussion acknowledged tensions between the hub's public-good function and the commercial incentives of data providers. Possible funding models include subscription fees, sale of analytics, or grant funding, each with trade-offs between sustainability and accessibility. Several participants agreed that neutrality and open access are essential for credibility, but these goals must be balanced against the need for financial viability.

Integration with existing databases was also seen as critical. Product-level data must connect upward to entity-level, jurisdictional, and global emissions inventories to ensure coherence. The discussion envisioned the hub as both a repository and a catalyst, enabling procurement, policy, and market mechanisms to use verified emissions data in decision-making.

Closing Remarks and Next Steps

The closing discussions reflected emerging consensus on direction and priorities. Several participants agreed that the shift from disclosure to accounting is both necessary and achievable. The focus should now be on building the technical and institutional foundations for ledger-based, product-level carbon accounting that delivers representational faithfulness and reasonable assurance.

Path forward: Some participants proposed a stepwise implementation pathway:

1. Start with high-emission sectors, such as steel, cement, and fossil fuels, where economic incentives and data availability are strongest.
2. Develop a prototype standard specifying how emissions are recorded on a ledger, including treatment of direct, transferred, and default values.
3. Build an initial data hub using existing technologies, models, and data sources, ensuring interoperability with enterprise systems and reporting frameworks.
4. Establish governance structures that ensure neutrality, inclusivity, and alignment with national and regional systems.

The prototype phase could be completed within six months, enabling exporters to demonstrate product-level advantages in the context of emerging carbon border and trade policies. Over time, regional developments–particularly in the United States, European Union, and Asia-Pacific–are expected to proceed in parallel, coordinated through common international principles.

Conceptual clarity: Several conceptual distinctions were reaffirmed:

- Disclosure vs. accounting: accounting measures, allocates, and records verified quantities suitable for assurance, which is distinct from but complementary to disclosure.
- Net zero claims: only global or geological net zero has conceptual validity; company- and country-level net zero entails overidentification of the problem, impeding real solutions, and may cause significant carbon leakages among entities and across different jurisdictions.

Participants also discussed governance differentiation: standard setting should remain distinct from data management. Standard setters define equivalence and assurance criteria; the data hub aggregates and distributes data under those standards. Political realities mean that some standard-setting may need to occur within specific jurisdictions (e.g., the European Union and the United States), while data repositories can operate globally so long as integrity is preserved.

Collaboration and communication: Several participants stressed the need for constructive communication and for strong international cooperation to maintain interoperability and trust. The workshop underscored the importance of shared language, mutual recognition, and continuous learning as the community builds practical experience.

Conclusion

The workshop demonstrated that while technical, institutional, and political challenges remain, there is growing convergence on the principles required for a credible, scalable system of ledger-based product-level carbon accounting. Such a system would rest on four pillars:

- Causal, ledger-based accounting linking emissions to products through a chain of custody;
- Digital infrastructure enabling data interoperability and assurance;
- Neutral governance balancing public legitimacy with operational agility; and
- Progressive implementation–from simple pilots to gradual global coverage.

The workshop aimed to create a shared sense of momentum and responsibility: to begin building, iterating, and refining a system that can underpin the next generation of carbon accountability and fair economic competitiveness. The path to accurate, robust, and dynamic product-level emissions accounting will be incremental, but it is now clearly in view.