



India Power E-ledgers Pilot Project Report

Background and Purpose

The E-ledgers Institute (ELI) provides pro bono support and expertise to organizations interested in piloting the E-ledgers methodology. As mutually agreed upon by the pilot organization and ELI, this Report summarizes the objectives, design, processes, and insights from the completed pilot project in a public document, accessible by the pilot organization, ELI, potential pilot organizations and their partners, and the general public.

Project Objectives

India Power Corporation Limited (“India Power”) partnered with ELI and Hygge Energy to pilot the E-liability method for measuring the emissions produced from electricity generation, transmission, and distribution in India. **The primary objective of the pilot was to lay the accounting foundation for delivering real-time, energy-source-specific emissions data to customers—a key goal for India Power.** The pilot also sought to:

- Evaluate the E-liability method as a more transparent and actionable alternative to existing carbon accounting approaches by applying it across the electricity value chain, comparing cradle-to-gate emissions from sources like coal and wind power across generation, transmission, and distribution to customers.
- Build internal skills and IT infrastructure to model and allocate capital and operational emissions for electricity generation and transmission and distribution (T&D) assets.
- Identify data gaps and better understand technical barriers across internal operations and upstream suppliers.
- Evaluate the potential to scale the E-liability approach across India Power’s broader operations in alignment with national sustainability goals.

Project Design and Scope

India Power is a leading power generation and distribution company in India, committed to delivering clean, efficient, and reliable electricity to industrial and commercial consumers. The company supplies electricity from multiple sources—fossil fuels, renewable energy, and energy storage—to industrial customers, many of whom export electricity-intensive materials, such as steel, to customers in the European Union (EU) who face product-specific carbon reporting



requirements via the EU Carbon Border Adjustment Mechanism (CBAM).

Recognizing the growing demand for accurate and verifiable emissions data, India Power wants to build a real-time model that leverages India’s 15-minute interval metering framework, already used for energy scheduling and settlement under national regulations. By integrating source-level generation data with this system, India Power aims to provide customers with real-time, energy-source-specific emissions intensity factors.

For this objective, India Power must measure the share of electricity supplied from coal, wind, solar, hydro, and other sources at 15-minute intervals, and transparently attribute the corresponding emissions to customers purchasing electricity during this time. Such real-time metering and attribution enable customers to understand their actual carbon footprint, align with international reporting and disclosure requirements (including EU CBAM and the Securities and Exchange Board of India’s Business Responsibility and Sustainability Report (BRSR) Core), and make informed energy choices. It also positions India Power as a forward-looking utility company committed to transparency, efficiency, and national decarbonization goals. Achieving this requires robust emissions accounting principles to ensure that supplier-specific data are applied to produce reliable, timely, and auditable emissions data—a core benefit from using the E-ledgers methodology.

India Power partnered with ELI to pilot the E-liability methodology on two electricity sources in its portfolio: coal-fired thermal generation and wind generation.

- **Coal facility:** India Power selected a 12 MW coal plant that it owns and operates within its distribution region. This site offers complete access to operational and emissions data, allowing for detailed bottom-up modeling. The facility’s total useful life was assumed to be 60 years, with individual systems and equipment having varying lifespans.
- **Wind facility:** The second power site was a 3 MW wind turbine, whose electricity is procured by India Power from the Solar Energy Corporation of India (SECI, the national renewable energy aggregator). Wind represents a key component of India Power’s renewables portfolio, but the company acts primarily as a purchaser and distributor of wind-generated electricity, and has limited access to primary operational data. The useful life of the wind system was assumed to be 20 years.

This pilot represented an initial iteration of applying the E-ledgers methodology in a complex, multi-tier electricity value chain. It applied the [E-liability proto-standard](#) to measure the cradle-to-gate emissions for both wind and coal generation, including raw material extraction, equipment manufacturing, plant commissioning, electricity generation, and plant decommissioning. The “gate” was defined as the point where electricity leaves the generating plant (for coal) or is received under a purchase agreement (for wind). All emissions were then allocated per megawatt-hour (MWh) of electricity generated, creating a common output metric for comparing coal and wind emissions.



The pilot did not include transmission and distribution-related emissions or electrical line losses. While these losses represent a material source of efficiency loss in grid-based electricity systems, they were excluded from this initial pilot due to data availability and attribution challenges, as discussed further in later sections of this report.

As a first-iteration pilot, this work necessarily relies to a significant extent on emissions factors and secondary data sources, particularly for upstream materials and capital equipment. By starting with coal and wind, India Power aimed to establish a robust accounting blueprint that could, subsequently, be populated with higher-quality primary data and extended to other generation sources in its portfolio. Thus, the pilot was its first step on a trajectory to its long-term goal of delivering real-time, source-specific emissions data to customers.

India Power selected a project leader and team from its Digital Transformation function. Drawing on cross-functional expertise in digital transformation, sustainability, and utility operations, the project lead coordinated the pilot internally and provided access to operational data, ensured organizational alignment, and guided methodological discussions throughout the project. Hygge Energy contributed technical tools and modeling expertise to structure the emissions calculations across coal and wind energy processes. ELI offered strategic oversight, governance, and methodological direction throughout the pilot.

The pilot received endorsement from India Power's senior leadership as part of the company's broader sustainability and digital transformation goals. ELI's thought leadership helped communicate the potential value of the pilot at the C-suite level, framing it as both a learning opportunity and a step toward more transparent, granular emissions accounting in the electricity sector.

Processes and Results

Process Mapping

Project team members began by developing detailed process maps for coal-fired (*Figure 1*) and wind-based (*Figure 2*) electricity generation. The process maps split the generation process into four distinct sub-processes: raw material extraction and component manufacturing, commissioning, operations, maintenance, and decommissioning. This gave clarity on where energy inputs occur and where material quantities of greenhouse gases (GHGs) are generated, making it easier to trace and attribute emissions across each segment of the generation process.

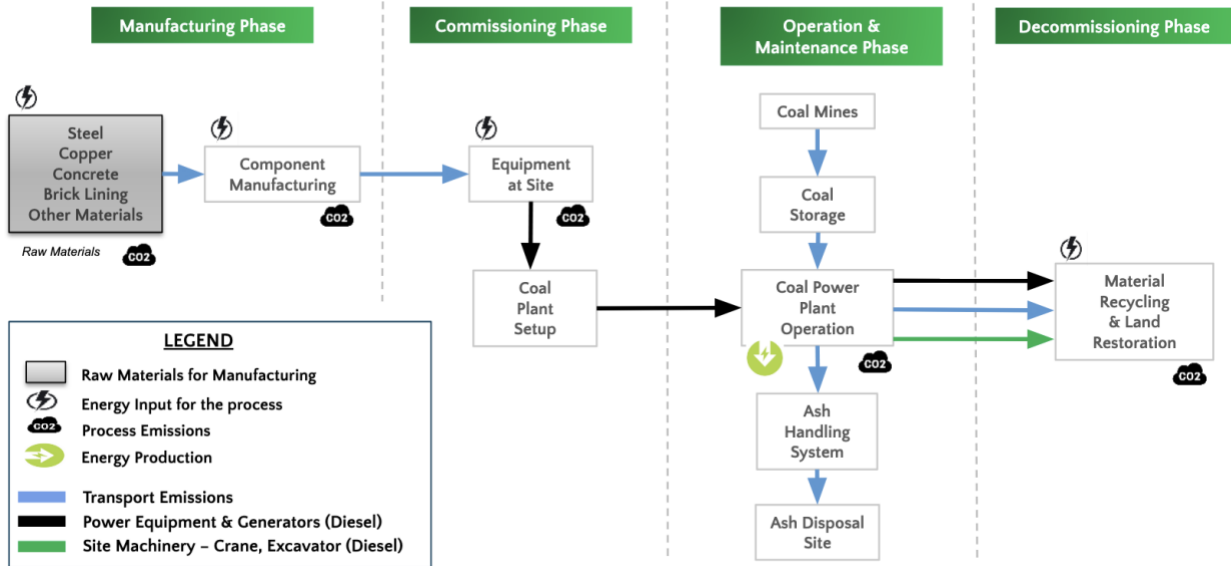


Figure 1: Coal process map

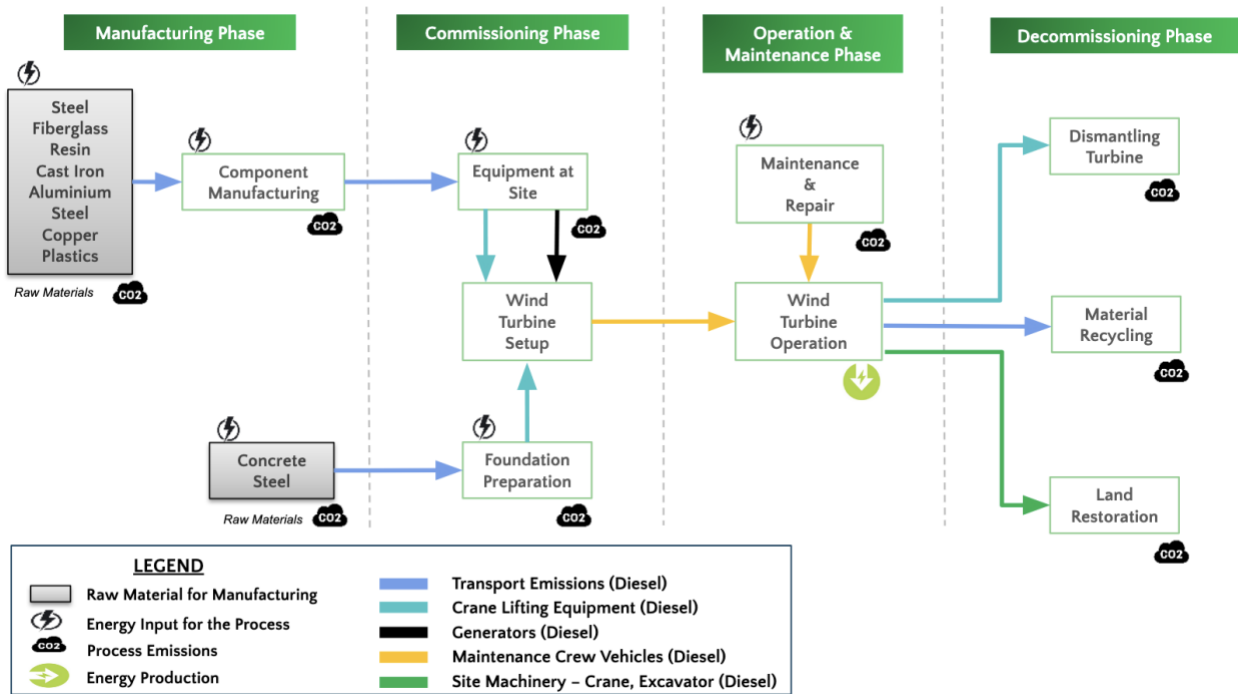


Figure 2: Wind process map

Data Collection

Data collection for the pilot combined India Power's internal operational records with publicly available datasets and credible secondary sources. The data strategy for the pilot reflects a



deliberate, twofold approach to improving data quality over time. First, consistent with the “Willie Sutton principle,” the team focused on obtaining primary data for the most emissions-intensive activities. This included key procurement and operational drivers such as coal quality (where characteristics like calorific value, moisture, ash content, and mineral composition directly influence both energy output and GHG emissions), as well as major capital assets under India Power’s direct control.

Second, the pilot was designed as the first step in a recursive process; successive iterations would include additional suppliers and partners within the accounting boundary. Experience from similar pilots suggests that once suppliers observe tangible results from early iterations, they are more likely to overcome initial resistance or hesitation to invest in producing primary, product-level emissions data.

For wind, where India Power is a purchaser (rather than a *generator*) and distributor, internal data were limited to procurement volumes and billing records from contracted wind projects. The project team obtained generation-related data, including emissions from turbine manufacturing, raw material inputs (e.g., steel and copper), installation, and commissioning, from secondary data sources such as Life Cycle Assessments (LCAs), Original Equipment Manufacturer (OEM) websites, and peer-reviewed studies. The team collected data on some operational activities (e.g., maintenance) directly from similar facilities.

For coal, where India Power operates as both *generator and distributor*, internal data came from India Power’s operational sites. On-ground technical teams provided primary data for operational parameters, including plant capacity, equipment lifespan, average energy generation, coal quality, maintenance schedules, and transport logistics. This formed the backbone of the coal emissions model and was supplemented by secondary data on capitalized emissions. Where site-specific data was unavailable, the team relied on existing secondary sources, including LCAs, industry sustainability disclosures, and equipment specifications, as a foundation for estimates.

The team then applied usage- and inventory-based techniques to calculate emissions from direct operating activities. For example, diesel use was estimated from equipment draw rates, and transport emissions were modeled using assumed trip distances and loads. The team used emission factors from globally recognized databases and organizations, such as Worldsteel and the International Copper Association (ICA).

Emissions Allocation and Analysis

Capitalized emissions (e.g., from the steel, concrete, and diesel used to manufacture turbines, and to commission the coal plant) were amortized over the expected useful life of each asset and allocated per megawatt-hour (MWh) of electricity generated, with adjustments for expected system replacements.



The team used inventory- and activity-based costing, wherever possible, to allocate operational emissions to the specific processes/activities (e.g., from combustion, mining, and transportation) used to produce output products and services.

Emissions were then compared on a per MWh basis to assess differences between coal and wind generation.

Modelling Tools

The project used Microsoft Excel to develop modular, editable spreadsheets. The spreadsheets were designed to be user-friendly, allowing for the adjustment of key input variables as more and better data become available in the future. The model provides a foundation for future transition to dynamic and automated emissions tracking platforms, which can reflect real-time changes in procurement and operational decision-making, as well as data generation.

Pilot Results and Insights

The pilot confirmed that generation-related emissions from wind and coal power are heavily concentrated in different phases of the value chain, and revealed key emissions drivers with greater accuracy.

Wind Analysis

Wind power's capital emissions account for the majority (98.4%) of this source's total emissions per MWh (*Figure 3*). Nearly 70% stemmed from the energy-intensive manufacturing of turbine components, primarily driven by production of steel (51%) and concrete (30%). Wind turbines' relatively short (20 years) operational lifetime, as well as wind plants' lower capacity factor, relative to coal, further amplifies this burden. Wind power's large upfront capital emissions are distributed over fewer years and fewer hours of operation per year compared to coal.

Less than 5% of total emissions came from diesel use during installation, operations, maintenance, and decommissioning.

Decarbonization opportunities in wind, therefore, lie primarily in reducing the carbon intensity of steel and concrete, improving material efficiency, and lowering the energy intensity of turbine manufacturing processes. Extending asset lifetimes (i.e., through repowering, better maintenance, and improved recycling) could also further reduce the carbon intensity of renewables in the long run.

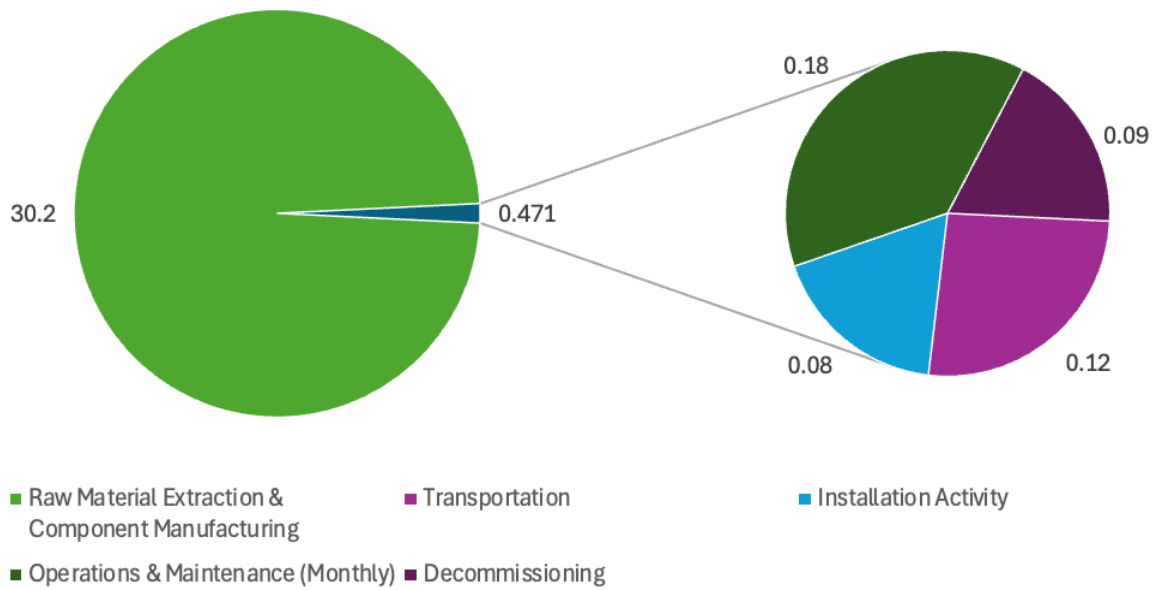


Figure 3: Wind generation emissions per MWh (kgCO_{2e}) for each process phase

Coal Analysis

In contrast, the coal-based power generation model showed that ~99% of total emissions came from the combustion of coal during operations. Beyond combustion, emissions also came from coal mining and transport, as well as capitalized infrastructure (e.g., boilers, turbines), but these were significantly lower on a per-MWh basis (~30.21 kgCO_{2e} per MWh for wind versus ~1.44 kgCO_{2e} per MWh for coal) due to the longer assumed operational life of the coal plant (60 years) (Figure 4).

The emissions associated with a MWh of electricity generated by coal totaled around ~1,520 kgCO_{2e} per MWh, around 50x more emissions intensive than wind generation (~30.7 kgCO_{2e} per MWh).

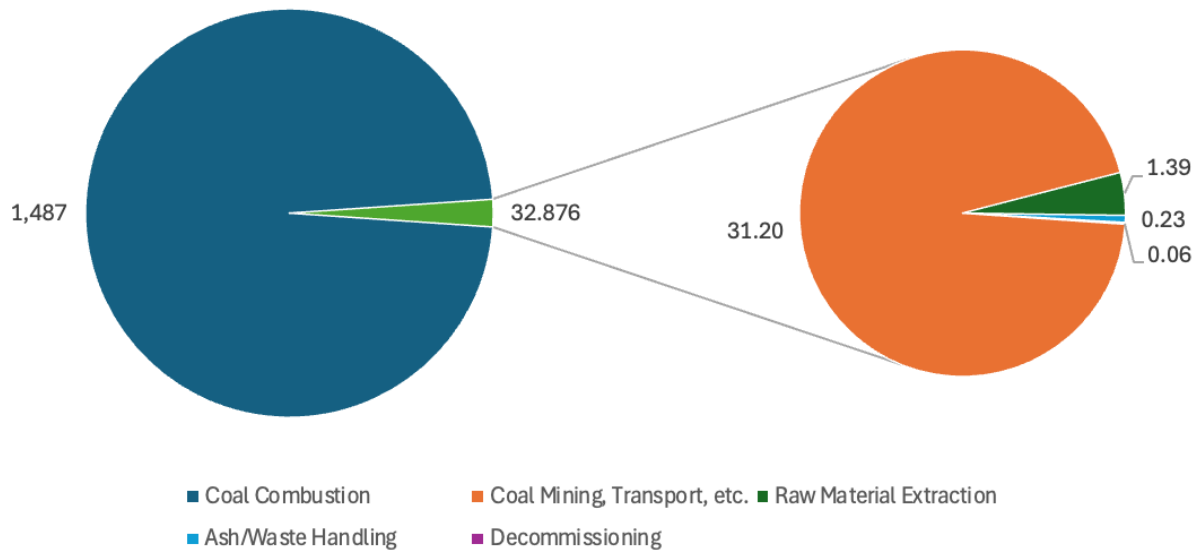


Figure 4: Coal generation emissions per MWh (kgCO_{2e}) for each process phase

Cross-Cutting Insights

Across both wind and coal, several broader insights emerged. The analysis highlighted high-heat industrial processes, such as steel and cement production, as critical drivers of embedded emissions in both coal and wind infrastructure. While electrification of these processes is often cited as a decarbonization pathway, its effectiveness is highly dependent on the carbon intensity of the underlying power grid. In jurisdictions such as India and China, where marginal electricity supply remains predominantly coal-based, electrifying high-heat processes may deliver limited (and in some cases negative) emissions benefits relative to efficient fossil-based alternatives. This underscores the importance of coupling process-level electrification with broader grid decarbonization and reinforces the value of source-specific emissions accounting to accurately assess real-world decarbonization opportunities and outcomes.

Together, these results gave India Power deeper insight into how to make more informed procurement decisions and communicate more transparently with customers about current and future emissions.

Challenges and Questions

As the pilot concluded, the focus shifted from proof-of-concept to implementation readiness. While the pilot successfully established the *accounting* foundation for delivering real-time, energy-source-specific emissions-intensity data—a key milestone toward India Power’s vision—moving from today’s static, Excel-based model to a dynamic platform capable of allocating emissions every 15 minutes presents several critical challenges.



Availability of primary data

The pilot clearly revealed the limited availability of high-quality, supplier- and facility-specific emissions data. Much of the information for raw materials and capital equipment, such as steel, copper, and concrete, came from global databases that fail to reflect the specific Indian manufacturing context or local logistics. In both coal and wind, many upstream partners were not equipped to provide product-level emissions information to India Power. The pilot's reliance on secondary or proxy data reduced the accuracy of its cradle-to-gate accounting.

India Power intends to strengthen supplier engagement, encouraging upstream partners to adopt emissions tracking practices and begin to replace generic emission factors with localized, facility-specific data. Repeated use of the E-liability framework, combined with visible outputs, peer participation, and clearer value propositions for suppliers, will, over time, shift the balance from generic factors toward localized, facility-specific primary data, which will increase data accuracy and auditability.

Developing a technology platform for dynamic allocation

The pilot's spreadsheet-based models provided a useful starting point but did not have the capability to deliver dynamic, real-time allocation of emissions across multiple generation sources. They assumed a uniform and continuous generation profile across the lifetimes of coal and wind plants, whereas actual generation is highly variable, influenced by weather patterns, outages, demand fluctuations, and real-time energy market purchases. Attribution challenges are particularly acute in the Real-Time Market, where purchased electricity is not always accompanied by source-level information, limiting the ability to tie emissions to specific generators.

The pilot highlighted the potential value of a digital system capable of linking high-frequency metering with source-level generation and emissions data. Such a system could support automated calculations, provide more timely and detailed allocation of emissions to customers, and enhance transparency. Additionally, expanding the model beyond CO₂ to also include methane (CH₄), sulfur oxides (SO_x), and nitrogen oxides (NO_x) would further enhance accuracy and align the methodology with broader climate reporting standards.

Extending the cradle-to-gate scope through transmission and distribution

The scope of the pilot was limited to generation emissions and did not extend to transmission and distribution due to data challenges. High-level modelling of transmission and distribution-related emissions, including technical losses, was undertaken by comparing total energy received from generators with billed customer consumption. The analysis revealed transmission losses between 20-30%. The losses, however, could not be modeled in detail due to the inherent complexity of distribution networks, which involve multiple feeders, voltage levels, and load centers that make plant-level attribution of emissions highly challenging. In addition, the lack of granular, source-attributed data on theft, wastage, and technical losses further restricts the feasibility of precise



CO₂ allocation in a pooled grid system. In summary, with grid losses incorporated, emissions associated with each MWh of delivered electricity will increase significantly. This increases the urgency to develop methods that can identify, quantify, and allocate T&D losses to customers.

Additionally, clarifying how existing market instruments such as Power Purchase Agreements (PPAs), Renewable Energy Certificates (RECs), and offsets interact with cradle-to-gate accounting will also be an important step in refining the methodology for future iterations.

Learnings, Insights, and Next Steps

The pilot demonstrated that the E-liability methodology can be successfully applied to utility-scale electricity generation, validating both its technical feasibility and its strategic value for India Power. Beyond confirming anticipated emissions patterns, the pilot delivered new granularity into the specific processes and materials that drive emissions intensity (such as steel, concrete, and energy consumed in upstream manufacturing). This deeper visibility equips India Power to make more informed procurement and operational decisions, while also enabling more transparent communication with customers about the sources of their emissions. Just as importantly, the pilot establishes a practical foundation for scaling E-liability accounting beyond an initial proof of concept.

Building on this foundation, the next phase of work should focus on systematically expanding both the accuracy and scope of the system. This includes incorporating more primary supplier data, extending coverage across additional generation technologies (e.g., solar, gas, hydro, and nuclear) with their distinct emissions profiles; broadening the boundary of analysis to include transmission, distribution, and end-use customers; and developing an audit-ready digital tool capable of integrating 15-minute interval metering with source-specific emissions data.

Taken together, these next steps position the pilot as the first iteration in a recursive process that will, over time, through subsequent phases, deliver increasingly comprehensive and decision-useful product-level electricity emissions data aligned with emerging standards such as the EU CBAM.