

ASSESSING THE MATERIALITY OF VALUE-CHAIN EMISSIONS FOR ORGANIZATIONAL DECARBONIZATION STRATEGY DEVELOPMENT: A CASE STUDY OF THE AUTOMOTIVE INDUSTRY

UPENDRA ARJEEWANI WEERATHUNGA DON MERENCHIGE & SHOUXUN JI
Brunel Centre for Advanced Solidification Technology, Brunel University of London, London

ABSTRACT

Industrial decarbonization strategies increasingly require organizations to measure emissions throughout their entire value chain, not just from direct operational sources. While corporate greenhouse gas accounting frameworks offer structured reporting methods, the significance of upstream supply-chain emissions is often poorly understood across many industrial sectors, especially in material-intensive manufacturing. This study evaluates the greenhouse gas inventory of an automotive parts manufacturer to assess the relative impact of value-chain emissions on organizational decarbonization efforts. By combining company-specific operational data with established emission factors, emissions were calculated across Scopes 1–3 to pinpoint the main sources within production and supply networks. Results reveal that over 90% of total emissions come from upstream supply-chain activities, with raw material production being the largest contributor to climate impact. Direct manufacturing processes and electricity use have smaller shares. These results emphasize that improving operational efficiency alone is not enough for significant emissions reductions. Instead, supply-chain strategies, material choices and procurement policies are the most effective leverage points for decarbonization. The study underscores the importance of understanding value-chain emissions for industrial climate management and provides evidence supporting increased focus on supplier engagement and material decarbonization in corporate sustainability plans. This approach offers practical insights for organizations with complex manufacturing supply chains looking to align operational decisions with long-term climate goals.

Keywords: greenhouse gas accounting, value chain, manufacturing, industrial decarbonization.

1 INTRODUCTION

Industrial decarbonization increasingly requires organizations to quantify emissions across their entire value chain rather than focusing only on direct operational sources. While corporate greenhouse gas accounting frameworks such as ISO 14064-1 [1] and the GHG Protocol [2] support organizational reporting, value-chain emissions (Scope 3) are often only partially quantified due to methodological complexity and data limitations [3]–[5].

This challenge is especially relevant in the automotive manufacturing sector, where globally distributed supply chains and material-intensive production processes can produce substantial upstream emissions. In many cases, compliance-driven reporting frameworks focus on direct operational emissions, thereby obscuring the significance of supply-chain emissions and limiting the effectiveness of corporate decarbonization efforts.

This study thus evaluates the complete greenhouse gas inventory of an automotive component manufacturer, with particular focus on the materiality of value-chain emissions and their implications for organizational decarbonization planning. Using company-specific activity data combined with established emission factor sources, the analysis measures emissions across Scopes 1–3 and identifies main contributors throughout the product life cycle and supply chain.



2 STATE OF THE ART

International greenhouse gas accounting is supported by a structured hierarchy of methodological guidance across national, organizational, and programmatic levels. The 2006 IPCC Guidelines serve as the primary methodological foundation for national greenhouse gas inventories, outlining sector classification systems and principles for quantifying emissions. At the organizational level, the ISO 14060 family, especially ISO 14064-1, sets requirements for corporate greenhouse gas accounting, monitoring, reporting, and verification. Complementing these standards, the GHG Protocol Corporate Accounting and Reporting Standard provides widely adopted guidance for developing and disclosing corporate inventories [1], [2], [6].

Beyond technical accounting frameworks, policy-oriented guidance, such as the Guide for Designing Mandatory Greenhouse Gas Reporting Programs, developed by the World Resources Institute and the World Bank, supports the implementation of reporting infrastructure and registry systems [7]. Collectively, these frameworks form an interconnected system linking national methodologies, corporate accounting standards, and reporting programs. Fig. 1 illustrates the hierarchical connection between national inventory methodologies, entity-level accounting standards, and reporting frameworks, highlighting the institutional framework underpinning contemporary greenhouse gas accounting methods.

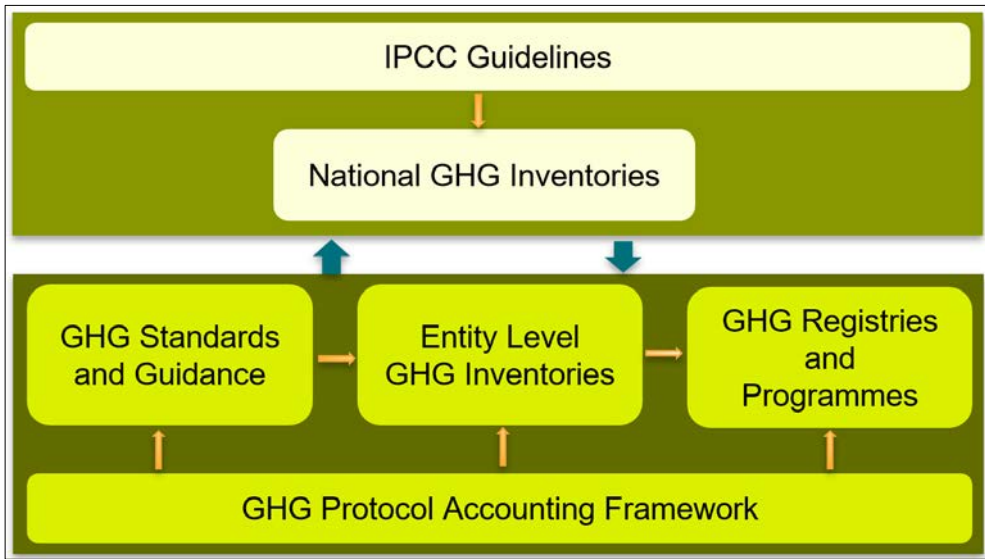


Figure 1: Hierarchical structure of greenhouse gas accounting frameworks linking national inventory methodologies, organizational standards, and reporting programs.

3 METHODOLOGY

3.1 Organizational boundary and emission classification

The greenhouse gas inventory was prepared in accordance with ISO 14064-1 and the GHG Protocol Corporate Standard. Organizational boundaries were defined using the operational control approach, which included emissions from activities under the company’s operational

authority. The operational boundary adopted in this study follows the scope classification shown in Fig. 2.

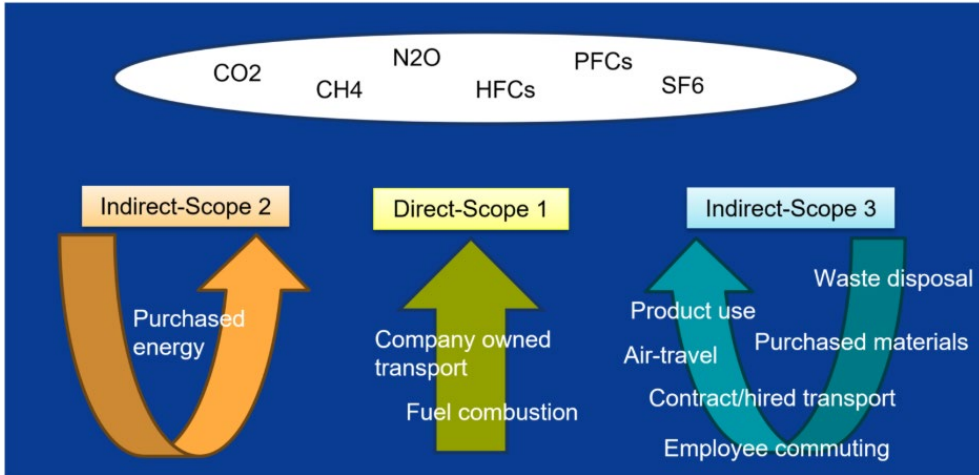


Figure 2: Organizational emission boundary showing Scope 1, Scope 2 and Scope 3 emission sources and associated greenhouse gases.

3.2 Data collection

Activity data for the baseline year, 2024, were collected using a bottom-up approach. Key datasets included energy meter readings, procurement records, production logs and transportation data. These were validated by cross-checking invoices and supplier documentation. Emission factors were selected according to a hierarchy that prioritized supplier-specific environmental product declarations, established life-cycle inventory databases and country-specific UK emission factors. This method ensured both geographic relevance and methodological consistency. Emissions were calculated by multiplying the standard activity data by the appropriate emission factor for each source as indicated below. Total emissions were aggregated by source category and normalized for comparative analysis.

3.3 Case study description

The case study organization is an automotive component manufacturer that supplies metal-based products to original equipment manufacturers. Its production processes include metal forming, machining, coating, and assembly. Manufacturing operations use significant amounts of materials, especially steel and aluminium, as well as electricity, natural gas and inbound logistics. The company operates within a globally distributed supply chain, with multiple material suppliers and international transportation routes.

4 RESULTS

The greenhouse gas inventory shows that value-chain emissions mainly drive the organization's climate impact. Scope 3 emissions account for over 90% of total emissions, while direct operational emissions (Scopes 1 and 2 combined) represent only a small portion.



This confirms that upstream supply chain activities are the primary cause of the organization’s carbon footprint. Fig. 3 presents the organizational emissions by scope category for the baseline year 2024.

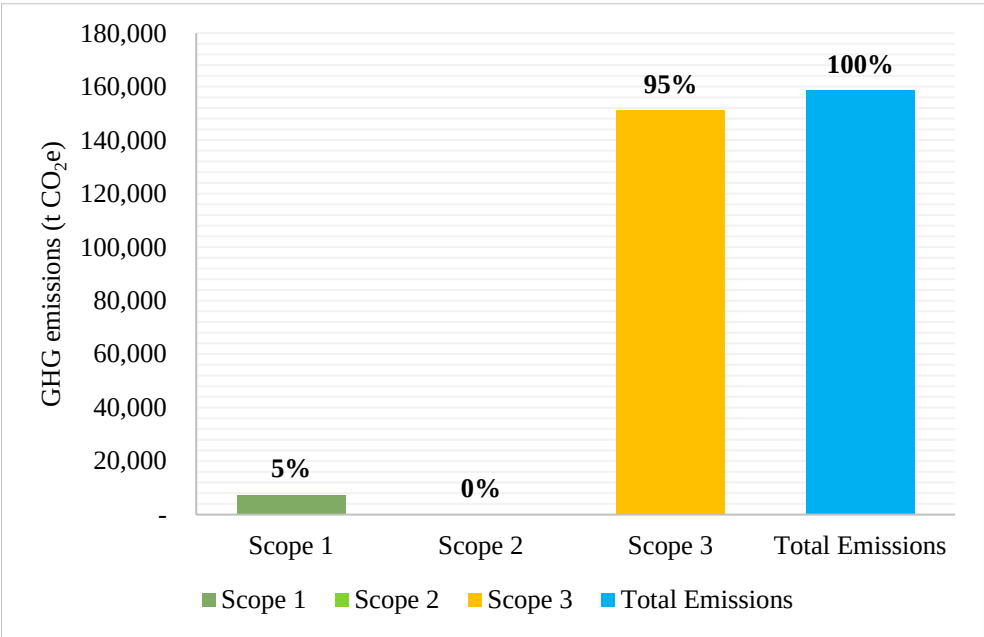


Figure 3: Organizational greenhouse gas emissions by scope and total emissions for the baseline year, expressed in tonnes CO₂e.

The organization sources certified renewable electricity, which significantly reduces reported Scope 2 emissions under the market-based accounting approach. Although this procurement lowers reported operational emissions, the overall emissions profile remains dominated by upstream material supply chains. This indicates that operational decarbonization alone is insufficient to achieve significant emissions reductions in material-intensive manufacturing systems. Raw material production, especially steel and aluminium, is identified as the largest contributor to total emissions. Material inputs alone account for more than 80% of the organization’s carbon footprint, reflecting the high embodied emissions associated with metal production.

5 DISCUSSION

The findings show that compliance-focused reporting that captures only Scope 1 and Scope 2 emissions reflects only a small part of the organization’s overall climate impact. The predominance of upstream supply-chain emissions highlights that effective decarbonization strategies must focus on: supplier engagement, material substitution, procurement policies, and logistics optimization, rather than relying solely on internal operational efficiency improvements. The analysis also emphasizes the importance of data quality in complex supply chains. While higher-tier datasets and supplier-specific information were prioritized, variations in supplier reporting maturity still pose an inherent challenge. Enhancing supplier



transparency and standardizing reporting practices will therefore be essential for strengthening future organizational carbon assessments.

6 CONCLUSION

This study evaluated the full greenhouse gas inventory of an automotive component manufacturer, focusing on the significance of value-chain emissions and their implications for corporate decarbonization strategies. The results show that upstream supply-chain emissions account for the majority of the organization's carbon footprint, with raw material production as the primary source. Operational emissions, including electricity use, contribute less to the overall impact. These findings suggest that effective industrial decarbonization requires extending mitigation efforts beyond internal operations to include supplier engagement, material choices, and procurement decisions. Although demonstrated within an automotive manufacturing context, the methodological approach can aid broader organizational carbon assessments, especially in sectors with material-intensive production and global supply chains.

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