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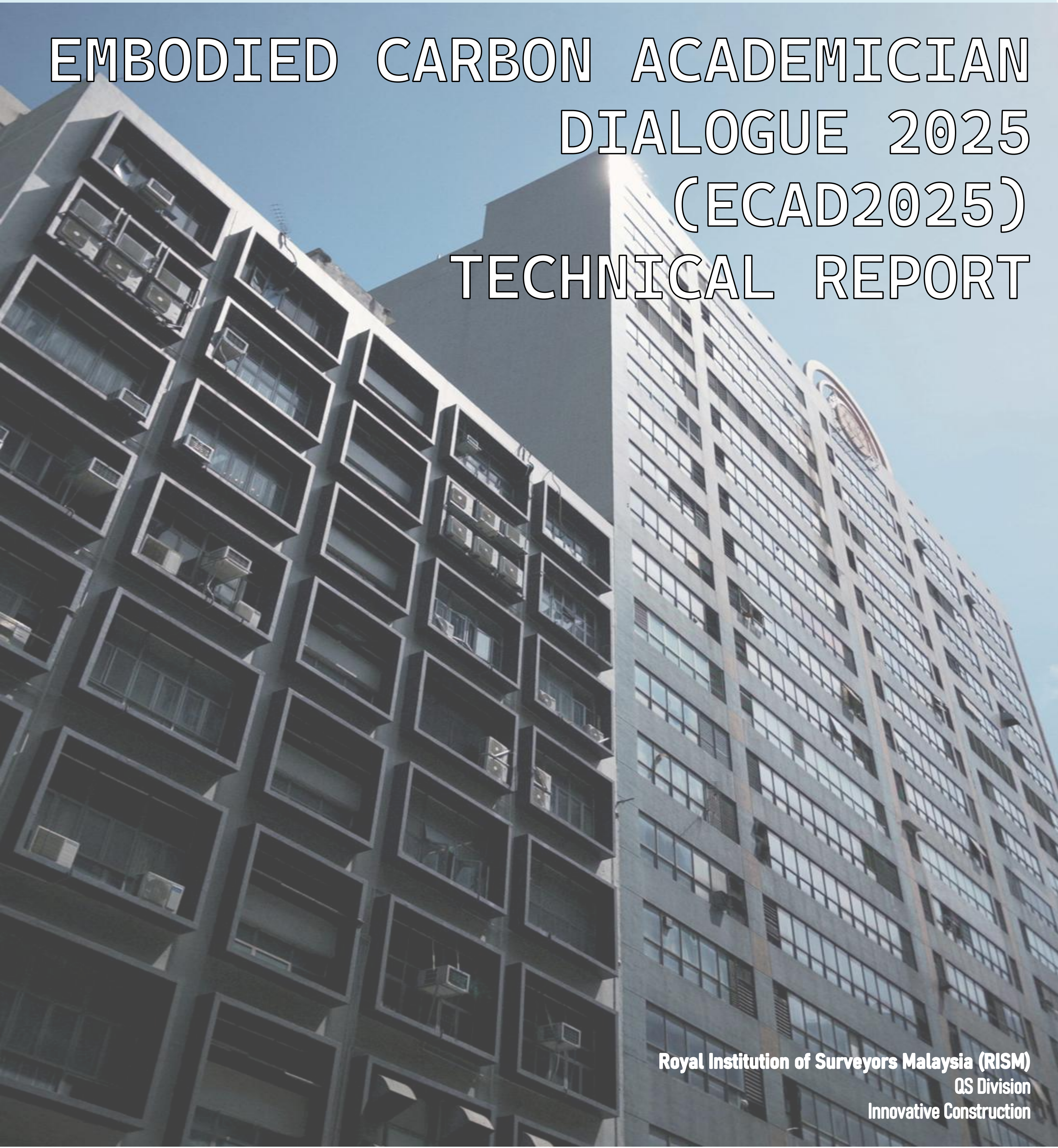
EMBODIED CARBON ACADEMICIAN DIALOGUE 2025 (ECAD2025) TECHNICAL REPORT



Royal Institution of Surveyors Malaysia (RISM)
QS Division
Innovative Construction

EMBODIED CARBON ACADEMICIAN DIALOGUE 2025 (ECAD2025) TECHNICAL REPORT

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FOREWORDS

Greetings,

It is both an honour and a privilege, in my capacity as Chair of the Quantity Surveying Division of the Royal Institution of Surveyors Malaysia (RISM), to present this 'Embodied Carbon Academician Dialogue 2025 Technical Report' which a pivotal outcome of the dedicated work undertaken by our RISM Innovative Construction Committee.

This report represents a vital milestone in our shared mission to address the significant challenges posed by embodied carbon in the built environment. I extend my heartfelt appreciation to the distinguished academicians who have joined us in this effort. Your steadfast commitment to sustainability, academic excellence, and the advancement of the Quantity Surveying profession is deeply valued.

I would like to convey special thanks to Asst. Prof. Sr Dr Norsyakilah Romeli, Raimi Fauzi, Adib Zhafry Rozy and M Syazwan Osman that has acted as an Editors of this report, whose dedication, perseverance, and professionalism have been instrumental in bringing this initiative to fruition. Your behind-the-scenes efforts are sincerely appreciated.

We are especially pleased to acknowledge the outputs of representatives from SIX (6) public institutions (IPTA) and SIX (6) private institutions (IPTS) offering Quantity Surveying program. The presence and engagement signify the growing importance placed on sustainability in both public and private education sectors. This collaboration between academia and industry is essential in bridging knowledge and practice. More than just a report, this engagement serves as a springboard for innovation. As we move toward decarbonizing the construction industry, this platform aims to:

i) Enhance understanding of current research and trends related to embodied carbon,
ii) Advance the development and harmonization of embodied carbon assessment methods, and
iii) Promote open discourse on pressing challenges, such as data accessibility, benchmarking mechanisms, and the integration of carbon literacy into QS education and professional frameworks.

I firmly believe that through collective efforts grounded in collaboration, data sharing, and academic rigour we can shape a more resilient and sustainable future for Malaysia's construction industry and beyond. Thank you.

Sr Nazir Muhamad Nor
Chair, QS Division, RISM
2025/2026

EXECUTIVE SUMMARY

This technical report, initiated under the auspices of the Royal Institution of Surveyors Malaysia (RISM) and driven by the Innovative Construction Committee that spearheaded by Sr Aminudin Yahia, presents a collective academic insight into the current state of research, practices, and challenges associated with embodied carbon within Malaysia's Quantity Surveying (QS) education landscape. It represents a key milestone in promoting sustainable construction practices and advancing the role of Quantity Surveyors in addressing climate change.

As the construction industry moves toward low-carbon and climate-resilient goals, embodied carbon, the greenhouse gas emissions associated with the production, transportation, and disposal of construction materials has emerged as a critical factor in reducing the environmental footprint of buildings and infrastructure. This report consolidates contributions from academicians across SIX (6) public and SIX (6) private higher education institutions in Malaysia offering Quantity Surveying programs, reflecting a diverse and multidisciplinary understanding of the issue.

Malaysian academicians have made notable progress in exploring embodied carbon, with research spanning life cycle assessment (LCA), green procurement, low-carbon material alternatives, and carbon benchmarking tools. However, the level of integration and institutional support varies significantly among institutions. While some QS programs incorporate sustainability-focused coursework and research projects, others are at the early stages of embedding embodied carbon into their curricula.

There remains a lack of standardized methods for calculating embodied carbon across academic institutions. Approaches currently used include cradle-to-gate life cycle assessments, simplified carbon calculators, and reliance on international databases. The absence of local emission factor data presents a key limitation, often requiring assumptions or adaptations from foreign datasets.

Academics and industry face multiple obstacles in fostering an embodied carbon culture within QS education and research, including limited access to reliable local data and carbon databases relevant to Malaysian construction materials and practices. Other than that, inconsistent understanding among students and practitioners regarding the significance and scope of embodied carbon. Where the gaps in policy support and industry collaboration, which hinders applied research and the translation of academic findings into practice, the constraints in curriculum design also exist due to existing professional accreditation requirements, which often priorities traditional QS competencies.

To strengthen Malaysia’s QS profession in tackling embodied carbon, this report recommends for development of a national embodied carbon database, tailored to Malaysian construction practices and materials. Other than that, Integration of embodied carbon literacy into QS curricula through workshops, elective modules, and case-based learning. Therefore, stronger collaboration between academia, industry, and policymakers to co-develop tools, guidelines, and pilot projects is required as the capacity building for educators and researchers is imperative to enable deeper engagement in international sustainability networks and research funding opportunities.

This report highlights the urgent need to embed embodied carbon awareness into the foundation of Quantity Surveying education and practice. The collaboration between RISM, academic institutions, and the construction industry will be instrumental in equipping future QS professionals with the tools and knowledge necessary to lead Malaysia's transition toward a low carbon-built environment.

Under this strategic undertaking, the Innovate Construction Committee aims to strengthen its strategic focus on establishing a National BIM Hub and advancing the Embodied Carbon Standard, Database, and Calculator. Ultimately, we seek to enhance the quantity surveying (QS) profession by cultivating specialists in embodied carbon (EC). Our goal is to spearhead this movement as the first professional body to formally advocate for EC specialization, ensuring the long-term relevance, resilience, and sustainability of the QS profession.

Through this initiative, RISM reaffirms its commitment to advancing sustainability, fostering academic excellence, and empowering the QS profession as a catalyst for climate-conscious development.

1 Current Research Trends on Embodied Carbon

1.2 Existing Standard and Regulations

The construction industry is a major contributor to global carbon emissions, with embodied carbon the total greenhouse gas (GHG) emissions generated to produce a built asset gaining increased attention as we strive toward net-zero targets. Embodied carbon includes emissions from material extraction, processing, transport, manufacturing, and construction. While operational emissions have historically dominated policy focus, it is now evident that early-life carbon emissions from buildings contribute significantly to climate change. As such, accurate measurement and reduction of embodied carbon are essential that can be seen as per Figure 1.

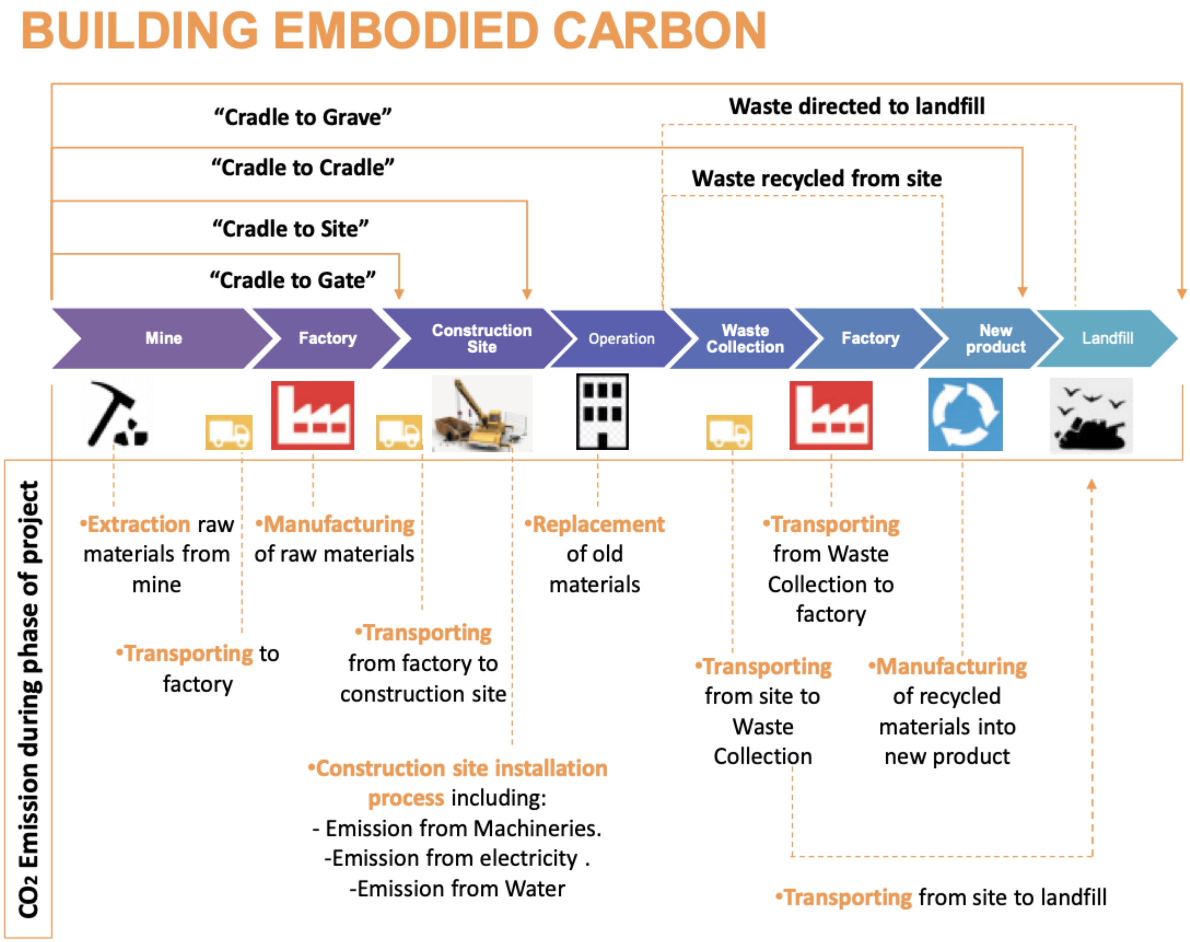

Figure 1 : Building Embodied Carbon

This technical report provides an overview of existing embodied carbon data sources and global benchmarking standards relevant to the Malaysian context. It also highlights contemporary research developments and how these can inform future carbon-conscious practices in construction.

Existing Data Sources on Embodied Carbon

A variety of reputable databases and tools exist to quantify embodied carbon. Among them are:

- ICE Database (Inventory of Carbon & Energy): Developed by the University of Bath, this is one of the most widely cited embodied carbon inventories. It provides carbon coefficients for a range of construction materials used globally.
- Ecoinvent Database: A Swiss-based life cycle inventory (LCI) database, offering comprehensive, peer-reviewed carbon emission data covering raw materials, energy, transport, and waste treatment processes.
- MYLCID (Malaysian Life Cycle Inventory Database): Tailored to Malaysia, MYLCID addresses regional disparities in emissions data by incorporating local material production and energy mixes.
- Integrated Carbon Matrix (ICM): An emerging tool aiming to support carbon accounting by integrating embodied and operational carbon across construction life cycles.
- Building for Environmental and Economic Sustainability (BEES): A U.S.-based tool that evaluates environmental and cost performance of building products using life-cycle assessment (LCA) methods.
- Building Research Establishment (BRE): Through tools like BRE Green Guide and Environmental Profiles, BRE supports the benchmarking of environmental impacts across construction products.
- Global Carbon Atlas: While broader in scope, this resource contextualizes embodied carbon in the global carbon cycle, offering macro-level insights into sectoral emissions, including construction.

These tools collectively provide a backbone for understanding material-specific and regional variations in embodied carbon, a crucial step in setting reduction targets and informing sustainable procurement.

Standards and Frameworks Guiding Measurement

To ensure consistency in quantifying embodied carbon, several standards and certification systems have been established:

- ISO 14040 / 14044 / 14067: These ISO standards define the principles and frameworks for life cycle assessment (LCA) and carbon footprinting. ISO 14067, in particular, sets requirements for quantifying and reporting carbon footprints of products, aligning with global GHG Protocol methodologies.
- EN 15804: This European standard lays the foundation for Environmental Product Declarations (EPDs) in construction. It standardises how to report environmental impacts of building materials, allowing for consistent comparison across products.
- PAS 2050: A specification developed by the British Standards Institution (BSI), PAS 2050 provides a method to assess the life cycle GHG emissions of goods and services, including construction materials.

- Green Building Certification Schemes (GBI, LEED, BREEAM, MyCREST): These rating tools, including Malaysia's own GBI and MyCREST, integrate embodied carbon considerations within broader sustainability metrics. While LEED and BREEAM have increasingly embedded EPDs and life-cycle carbon analysis, MyCREST incorporates local climate, materials, and socioeconomic factors in its evaluation.

These standards play a vital role in harmonising data, promoting transparency, and creating benchmarks for emission reduction targets in the built environment.

Embodied carbon is an increasingly critical metric in sustainable construction, especially as operational carbon is reduced through energy-efficient designs. With robust data sources and internationally recognized standards available, Malaysia is well-positioned to integrate embodied carbon assessments into mainstream construction practices. Leveraging tools such as MYLCID, ICE, and Ecoinvent, along with frameworks like ISO 14067 and EN 15804, professionals in the built environment can contribute to meaningful emissions reductions. Future policy and research must continue to support data transparency, regional benchmarking, and industry-wide adoption of low-carbon practices. Globally, the embodied carbon standard are tabulated as Table 1.

Table 1 : Embodied Carbon Standards

International Standards	European Standards	Regulatory Bodies
• ISO 14040: Environmental management Life cycle assessment Principles and framework • ISO 14044: Environmental management Life cycle assessment Requirements and guidelines • ISO 21930: Sustainability in buildings and civil engineering works Core rules for environmental product declarations of construction products and services	• EN 15804 + A2:2019: Sustainability of construction works - Environmental Product Declarations - Core rules for the product category of construction[10] products • EN 15978:2011: Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method	• PAS 2080: Carbon management in buildings and infrastructure (British) • RICS (Royal Institution of Chartered Surveyors) Whole life carbon assessment for the built environment

International Standards

- **ISO 14040 & ISO 14044** – Provide the foundation for Life Cycle Assessment (LCA)

- **ISO 21930** – Tailored for Environmental Product Declarations (EPDs) in construction

Significance:
These ISO standards are globally recognized and form the backbone of environmental performance assessment. They ensure consistency in how life cycle stages and emissions are defined and measured. ISO 14040 and 14044 are methodological, while ISO 21930 focuses specifically on the construction sector. These standards can be directly applied to Malaysian construction projects, especially in international developments or green certifications. They provide a trusted and neutral foundation that Malaysia can align with when developing or refining its national carbon assessment tools like MyCREST or the Carbon Score. Widespread local adoption is limited by technical complexity and the need for localized emission data. These standards often require advanced understanding of LCA methodologies, which may not be accessible to all stakeholders, particularly SMEs.

European Standards

- **EN 15804 + A2:2019** – Provides rules for EPDs in construction
- **EN 15978:2011** – Assesses environmental performance of buildings over their full life cycle

Significance:
European standards go further than ISO by offering *product-category-specific rules* (PCRs), particularly for construction products. EN 15804 is critical for creating consistent EPDs, while EN 15978 supports full building-level carbon assessments. Although regional, these standards are highly regarded worldwide and are often used in international certifications like BREEAM and LEED. Malaysia can reference EN standards as benchmarks in refining MyCREST or updating CIDB's LCA data for construction materials. These standards are based on European building practices, materials, and climate conditions, which may not align with local realities in Malaysia. Localization and adaptation are needed for practical use.

Regulatory and Professional Bodies

- **PAS 2080 (UK)** – Standard for carbon management in infrastructure
- **RICS Whole Life Carbon Assessment** – Guidance for evaluating carbon across all building phases

Significance:
These frameworks go beyond measurement and focus on **carbon management** strategies across project lifecycles. PAS 2080 promotes early-stage carbon planning, collaboration among stakeholders, and continuous improvement. RICS guidance helps define carbon boundaries and reporting for designers, quantity surveyors, and contractors. These tools are extremely valuable for integrating carbon thinking into project planning and cost management. Malaysian professionals, especially those in consultancy and project management, can apply these methodologies to support lifecycle-based sustainability goals and improve project

transparency. RICS guidance can directly inform local practice and education for Malaysian surveyors, while PAS 2080 can serve as a model for incorporating carbon accountability into procurement and infrastructure planning.

The standard clustered into strength and limitation to ensure the suitability and relevance to Malaysian practice as per Table 2.

Table 2 : Overall Strength and Limitation

Standards	Strengths	Limitations
International Standards	Globally trusted, foundational, widely recognized	Require localization, can be complex and resource-intensive to implement
European Standards	Detailed product and building assessment methods, used in EPDs	Europe-specific assumptions may not align with Malaysian context
Regulatory Bodies/Tools	Practical guidance, life-cycle and carbon management focus	Need adaptation to local policy, data, and project delivery mechanisms

The standards and frameworks analysed offer a solid foundation for advancing embodied carbon practices in Malaysia. However, to maximize their impact, Malaysia must:

1. **Localize Standards** – Translate key elements of ISO, EN, and PAS into national guidelines suited to local construction practices, materials, and climate.
2. **Expand Local LCA Data** – Improve databases like MYLCID to support accurate assessments based on Malaysian-specific emission factors.
3. **Train Professionals** – Equip surveyors, engineers, and project managers with skills in LCA and whole life carbon assessment through CPD programs and integration into university curricula.
4. **Policy Alignment** – Integrate these standards into national procurement requirements, green certifications (e.g., MyCREST), and infrastructure policies.

By aligning global best practices with national priorities, Malaysia can develop a coherent, enforceable framework for embodied carbon reduction across its construction sector.

1.3 Research trends according to themes

Current Research and Applications

Recent studies increasingly focus on benchmarking embodied carbon across building typologies, material types, and regional contexts. In Malaysia, research is expanding to integrate MYLCID with BIM (Building Information Modelling) and digital twin technologies, enabling dynamic and real-time carbon accounting during design and construction.

Recent research on embodied carbon is increasingly focused on practical strategies for carbon reduction across the building lifecycle. A key trend is the use of comparative life cycle assessments (LCAs) to evaluate materials such as concrete, timber, and steel, specifically adapted to the ASEAN region's climate conditions and supply chains. Researchers are also exploring low-carbon design approaches, including adaptive reuse, modular construction, and other methods that reduce material consumption and construction emissions. Significant progress is being made in material innovation, with studies highlighting the potential of geopolymer concrete, recycled aggregates, and carbon-sequestering bio-based materials to lower embodied carbon footprints. On a global level, integration of embodied carbon into whole life-cycle carbon assessments is becoming the norm. Influential frameworks like the European Commission's Level(s) and the RICS Whole Life Carbon Assessment guidance are increasingly informing policy and industry practice offering a clear direction for Malaysia to follow as it strengthens its own sustainable construction policies. Therefore, the analysis explore on research trends according to themes in embodied carbon as per Table 3.

Table 3 : Research trends according to themes (Source : Science Direct/Emerald)

A	Foundational Concepts and Definitions
A1	**Defining Embodied Carbon:** Embodied carbon encompasses within the construction context, differentiating it from operational carbon, and outlining the system boundaries (e.g., cradle-to-gate, cradle-to-site, cradle-to-grave).
A2	**Significance of Embodied Carbon:** Articulate the contribution of embodied carbon in construction to overall greenhouse gas emissions and its growing importance in achieving climate targets as operational energy efficiency improves.
A3	**Life Cycle Assessment (LCA) Framework:** Methodological basis for assessing embodied carbon, including goal and scope definition, inventory analysis, impact assessment, and interpretation, as per ISO 14040 and ISO 14044 standards.
A4	**Units and Metrics:** Standardization of the units of measurement (e.g., $kgCO_2e/kg$, $kgCO_2e/m^2$) and key metrics used in embodied carbon assessment, such as Global Warming Potential (GWP).

B	Embodied Carbon Assessment Methodologies and Tools:
B1	**Data Source and Entry Analysis** Examining existing databases for embodied carbon factors of construction materials (e.g., ICE Database, Environmental Product Declarations (EPDs), national databases).
B2	Analyzing the scope, quality, and geographical relevance of available data.
B3	Addressing challenges related to data availability, consistency, and transparency.
B4	Exploring methods for collecting project-specific data and conducting material quantity take-offs.
B5	**Assessment Tools and Software** Reviewing various software tools and Building Information Modeling (BIM) plugins used for embodied carbon calculations.
B6	Evaluating their functionalities, data integration capabilities, and ease of use.
B7	Discussing the role of automation and visual programming in streamlining assessments.
B8	**Life Cycle Stages Consideration** a. **Material Production:** Emissions from raw material extraction, manufacturing, and processing. b. **Transportation:** Emissions associated with transporting materials to the construction site. c. **Construction:** Emissions from on-site activities, including assembly and installation. d. **Maintenance, Repair, and Replacement:** Emissions related to maintaining and replacing building components over their lifespan. e. **Demolition and End-of-Life:** Emissions or potential carbon sequestration/avoidance from deconstruction, waste processing, reuse, and recycling.
B9	1. **Attributional vs. Consequential LCA:** Differentiating between these approaches and their implications for embodied carbon research in the construction sector. 2. **Uncertainty Analysis:** Addressing the inherent uncertainties in embodied carbon data and assessment methodologies.

<table>
<tr><th>C</th><th>Factors Influencing Embodied Carbon in Construction</th></tr>
<tr><td></td><td>
1. Material Selection:
a. Investigating the embodied carbon footprints of various common construction materials (e.g., concrete, steel, aluminum, timber, glass, plastics).
b. Analyzing the impact of material specifications, recycled content, and sourcing on embodied carbon.
c. Exploring the potential of bio-based and low-carbon alternative materials (e.g., hempcrete, straw bale, engineered timber).
2. Building Design:
a. Examining how architectural and structural design choices (e.g., form, material efficiency, structural optimization) influence material quantities and embodied carbon.
b. Analyzing the benefits of lean design principles and modular construction.
c. Considering the role of design for disassembly and adaptability in reducing end-of-life impacts.
3. Construction Processes:
a. Evaluating the impact of construction methods, waste management practices, and on-site energy use on embodied carbon.
b. Exploring the potential of prefabrication and off-site manufacturing to reduce waste and emissions.
4. Transportation and Logistics:
a. Analyzing the influence of material sourcing distances and transportation modes on embodied carbon.
b. Investigating strategies for local sourcing and efficient logistics.
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<table>
<tr><th>D</th><th>Strategies and Solutions for Embodied Carbon Reduction</th></tr>
<tr><td></td><td>
1. Material Efficiency and Optimization: Research on designing structures and buildings with minimal material use.
2. Low-Carbon Material Substitution: Studies evaluating the performance and feasibility of replacing high-carbon materials with lower-carbon alternatives.
3. Increased Use of Recycled and Reused Materials: Research on the availability, quality, and application of recycled and reclaimed construction materials.
4. Carbon Sequestration in Materials: Investigating materials like timber and certain concretes that can sequester carbon dioxide.
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D	Strategies and Solutions for Embodied Carbon Reduction
	5. **Design for Circularity:** Exploring design approaches that facilitate material reuse, recycling, and component recovery at the end of a building's life. 6. **Policy and Regulatory Frameworks:** Analyzing existing and proposed policies, standards, and building codes aimed at reducing embodied carbon in construction. 7. **Benchmarking and Target Setting:** Research on establishing benchmarks and setting reduction targets for embodied carbon at building, sector, and national levels. 8. **Economic and Social Implications:** Examining the costs and benefits of embodied carbon reduction strategies and their wider social impacts.
E	**Case Studies and Best Practices:**
	1. In-depth analysis of specific building projects or infrastructure developments that have successfully implemented embodied carbon reduction strategies. 2. Highlighting innovative technologies, materials, and design approaches. 3. Documenting lessons learned and challenges encountered.

As global interest in sustainable construction deepens, embodied carbon has become a central focus of academic, technical, and policy-oriented research. In Malaysia and across the ASEAN region, embodied carbon research is evolving rapidly, covering foundational understanding to applied strategies for reduction. Below is a structured analysis of current research trends grouped under five key themes:

Foundational Concepts and Definition

Trend Overview:
This theme focuses on establishing a common understanding of what constitutes *embodied carbon*, its distinction from *operational carbon*, and its role within the broader concept of *whole life carbon*. Researchers continue to refine definitions, boundaries (cradle-to-gate vs. cradle-to-grave), and classification of carbon impacts in line with global standards such as ISO 14067 and RICS Whole Life Carbon Assessment. The key insight Is to Increased efforts to align Malaysian terminology and carbon accounting frameworks with international standards. Other than that, growing academic discussion on incorporating embodied carbon into sustainability metrics alongside traditional green building indicators like energy and water. This trends establishing consistent definitions is critical for standardization, comparison, and integration into regulatory and design frameworks.

Embodied Carbon Assessment Methodologies and Tools

Trend Overview:

This theme covers life cycle assessment (LCA) techniques, carbon databases, BIM-integrated tools, and digital solutions for embodied carbon estimation. Malaysian researchers are increasingly using hybrid approaches that combine process-based LCA, input-output analysis, and regional emission factors. The key insight explore on expansion of localized tools like MYLCID to improve the accuracy of carbon assessment for locally sourced materials. Other than that, emerging interest in integrating BIM (Building Information Modelling) with carbon assessment for early design-stage optimization with application of tools like One Click LCA, SimaPro, and OpenLCA for comparative analysis. Reliable and localized assessment tools are essential to support practitioners in quantifying and reducing embodied carbon at scale.

Factors Influencing Embodied Carbon in Construction

Trend Overview:

Research in this area investigates what drives higher or lower embodied carbon in construction, including material types, transportation distances, construction methods, and building typology. Studies in Malaysia have started to quantify the carbon intensity of various conventional and alternative materials within the local supply chain. This trends commonly explore on comparative studies evaluating concrete, steel, and timber, tailored to Malaysia's construction market. Other than that, analysis of transportation logistics, prefabrication, and material sourcing as key emission drivers by acknowledgment of building design, scale, and function as significant influencers of embodied carbon. Understanding these factors helps inform targeted interventions, such as low-carbon procurement or changes in structural design practices.

Strategies and Solutions for Embodied Carbon Reduction

Trend Overview:

This theme explores how embodied carbon can be minimized through material innovation, design strategies, construction practices, and policy mechanisms. There is growing interest in integrating embodied carbon strategies into Malaysia's green building frameworks such as MyCREST and GBI. This trends coves on promising research on geopolymer concrete, recycled aggregates, bamboo, and other bio-based materials. Investigations into adaptive reuse, modular construction, and design for disassembly as methods to reduce material demand and extend building lifespan. Call for carbon-conscious procurement policies, and incentives for using low-carbon products. These strategies offer practical pathways to reducing emissions in both new construction and retrofitting, especially as part of Malaysia's roadmap to net-zero carbon buildings.

Case Studies and Best Practices

Trend Overview:

Case-based research focuses on applying embodied carbon methodologies in real-world projects, both within Malaysia and internationally. These studies provide empirical data, lessons learned, and benchmarking opportunities. The studies provides the case studies from public buildings, infrastructure, and institutional facilities showcase measurable carbon savings through thoughtful material selection and reuse. The trends explore on the international best practices, such as the use of Level(s) by the European Commission or RICS frameworks, are increasingly referenced to shape Malaysian practices. Pilot projects under MyCREST and collaborations with IRDA (Iskandar Regional Development Authority)are emerging as test beds for embodied carbon tracking and reporting are prevalent under this theme. Real-world case studies help validate theoretical approaches and demonstrate feasibility, while providing reference points for industry-wide adoption.

Embodied carbon research is becoming increasingly comprehensive and action-oriented. Early efforts focused on definitions and tools are now giving way to applied research on materials, methods, and policy integration. As Malaysia aligns itself with global carbon neutrality goals, continued research under these five themes will be crucial to drive innovation, build capacity, and support the development of national frameworks for carbon accountability in the built environment. The Royal Institution of Surveyors Malaysia (RISM) encourages deeper collaboration between academia, industry, and government to bridge knowledge and practice in this critical area.

1.4 International Research trends

As climate change mitigation becomes a global imperative, the building and construction sector is under increasing pressure to address embodied carbon the emissions associated with material extraction, manufacturing, transport, and construction processes. Across the globe, researchers are advancing the field of embodied carbon through innovative methods, tools, materials, and policy frameworks. Below are the major international research trends shaping this area as per tabulated in Table 4.

Table 4 : International research trends (Source : Science Direct/Emerald)

Year	Title	Affiliation	Main Area of Research	Relevance to Malaysian Construction Industry
2023	*On the Promise and Pitfalls of Optimizing Embodied Carbon*	University of Massachusetts Amherst	Exploring the **challenges and opportunities in optimizing embodied carbon** in computing infrastructure	Highlights the need for cautious and realistic carbon optimization strategies in Malaysian infrastructure planning. Useful for public works and highway projects.
2023	*Embodied Carbon Accounting Through Spatial-Temporal Embodied Carbon Models*	Various International Institutions	Developing **models to account** for spatial and temporal variations in **embodied carbon emissions**	Encourages Malaysia to develop localized and time-specific carbon data (e.g., seasonal transport impacts, local grid intensity). Can improve MYLCID accuracy.
2024	*Systematic Review of Embodied Carbon Assessment and Reduction in Buildings*	National Institute of Standards and Technology (NIST), USA	Reviewing methods, tools, and strategies for assessing and reducing **embodied carbon in buildings**.	A valuable reference for Malaysia in updating and aligning its national tools (e.g., MyCREST, Carbon Score) with global best practices.

Year	Title	Affiliation	Main Area of Research	Relevance to Malaysian Construction Industry
2024	*Considering Critical Building Materials for Embodied Carbon Reduction Using Machine Learning*	Various International Institutions	Utilizing **machine learning** to predict and minimize **embodied carbon at the design stage**.	Encourages adoption of digital tools and AI for material selection. Could support early-stage design optimization in Malaysian architectural and QS practices.
2024	*Embodied Carbon Emissions of Buildings: Taking a Step Towards Net Zero*	Various International Institutions	Introducing practical approaches for evaluating and **reducing embodied carbon in residential buildings**	Offers strategies directly applicable to Malaysia's housing sector. Supports net-zero goals under MyCREST and national sustainability targets.

These studies provide important insights into data-driven tools**,** AI integration, material innovation, and regional carbon modelling all of which can enhance Malaysia's embodied carbon assessment frameworks and guide future policies in the built environment sector. Adapting these trends will help Malaysia stay aligned with global climate targets and construction best practice.

1.5 Local Research Trends

In line with global sustainability efforts, Malaysia has begun placing greater emphasis on understanding and reducing embodied carbon within the construction sector. Though still developing in depth and scale, local research and institutional initiatives have laid a strong foundation for integrating embodied carbon considerations into practice, policy, and design. The following key trends highlight how Malaysian research is shaping the national conversation around low-carbon construction:

Development of National Embodied Carbon Data Inventory

One of the most significant advancements in Malaysia's embodied carbon research is the creation of a localized data inventory by the Construction Research Institute of Malaysia (CREAM) under CIDB. This initiative, known as the Embodied Carbon Inventory, includes over 500 data points for commonly used construction materials. By offering Malaysia-specific emission factors, it enables more accurate carbon assessments aligned with the national context. This effort supports the development of green policies and tools like MyCREST**,** and bridges the data gap that has previously limited accurate life cycle assessments (LCAs) in the country.

Establishing Benchmarks for Commercial Buildings

Benchmarking studies are emerging as a key trend to provide reference values for carbon performance in various building types. Notably, **Klufallah et al (2016)** developed a benchmark model for **purpose-built office buildings** in Malaysia, showing that buildings under **30,000 m²** typically emit between **3,000–9,999 tonnes of CO_2 equivalent**, averaging **0.340 tCO_2eq/m^2**. These findings are essential for setting embodied carbon limits, comparing project designs, and guiding developers towards carbon-efficient building practices.

Embodied Carbon in Low-Cost Housing

Another critical area of research has focused on **low-cost housing**, a dominant segment of Malaysia's built environment. Using **Building Information Modeling (BIM)** tools, studies have analyzed the embodied carbon of **single-storey low-cost houses**, revealing that **bricks, concrete, and steel** are the main contributors to emissions. This research underscores the importance of **material selection** in early design stages, particularly for government-led affordable housing schemes. The use of BIM for carbon estimation also signals a shift toward digital adoption in carbon tracking, even in lower-cost projects.

Integration into Green Building Rating Systems

Recent studies have examined how **embodied carbon is addressed in green building certification systems** such as **LEED, BREEAM, GBI,** and **MyCREST**. The research identified **six categories of embodied carbon** across the building lifecycle and proposed improvements for how rating tools assess these emissions. These insights are essential as Malaysia looks to strengthen the **MyCREST** framework and align it with international best practices. By integrating embodied carbon into rating systems, the research supports more holistic sustainability evaluations and drives carbon accountability in project certification.

Embodied carbon research in Malaysia is rapidly evolving from foundational data collection to practical application in design, assessment, and policy. Key trends include:

- The development of localized carbon inventories
- Benchmarking emissions in commercial and residential buildings
- Promoting BIM and digital tools for carbon estimation
- Enhancing green building certifications to incorporate embodied carbon criteria

These initiatives reflect growing national momentum toward low-carbon construction and provide the basis for future regulations, procurement policies, and industry standards. The Royal Institution of Surveyors Malaysia (RISM) encourages continued cross-sector collaboration to accelerate embodied carbon research and implementation nationwide. Table 5 shows local research trends on embodied carbon.

Table 5 : Local research trends (Source : Science Direct/Emerald)

Year	Title	Affiliation	Main Area of Research
2014	*Assessment of Carbon Emission Reduction for Building Projects in Malaysia: A Comparative Analysis*	Universiti Teknologi PETRONAS (UTP), Universiti Teknologi MARA (UiTM)	Building sector emissions, low-carbon construction strategies

Year	Title	Affiliation	Main Area of Research
2019	*Assessment of Embodied Energy: The Missing Piece – The Recurring Embodied Energy*	Taylor's University	Recurring embodied energy (REE)- Life Cycle Assessment (LCA)- Sustainable material selection- Building energy performance
2020	*Estimating Embodied Carbon in Building Materials in Malaysia*	Universiti Teknologi Malaysia (UTM)	**Embodied carbon in construction**, lifecycle analysis
2021	*Embodied Carbon Inventory Data for Construction Materials*	Construction Industry Development Board (CIDB) Malaysia	Developing a comprehensive **database of embodied carbon** for over 500 construction materials to support policy and industry practices.
2022	*Embodied Carbon Potential of Conventional Construction Materials Used in Typical Malaysian Single Storey Low Cost House Using Building Information Modeling (BIM)*	Universiti Teknologi Malaysia (UTM)	**Assessing embodied CO_2 emissions** in low-cost housing using BIM for material optimization

Year	Title	Affiliation	Main Area of Research
2022	*Decarbonizing Malaysia's Power Sector: Policy and Technology Options*	Energy Commission of Malaysia, Tenaga Nasional Berhad (TNB)	Renewable energy, energy mix, emissions reduction in energy sector
2023	*The Development of Embodied Carbon Emission Benchmark Model for Purpose-Built Offices in Malaysia*	Universiti Teknologi PETRONAS (UTP)	Establishing **benchmark models for embodied carbon** in office buildings to guide sustainable design practices
2024	*Carbon Neutrality in Malaysia and Kuala Lumpur: Insights from Stakeholder-Driven Integrated Assessment Modeling*	Universiti Teknologi Malaysia (UTM), Stockholm Environment Institute, Lawrence Berkeley National Laboratory	Carbon neutrality pathways, energy modeling, policy integration

Malaysian Embodied Carbon Research Trends (2014–2024)

Early Focus (2014–2019): Awareness and Concept Development

- Research between 2014 and 2019 focused on raising awareness of carbon emissions in the building sector and introducing basic concepts such as; Low-carbon construction strategies (2014 – UTP, UiTM). Other than that, recurring embodied energy (REE) and its role in life cycle assessments (LCA) (2019 – Taylor's University). This period laid the groundwork by highlighting the need to look beyond operational energy and consider materials and construction impacts**.**

Mid-Stage Growth (2020–2022): Quantification and Tool Development

- Research shifted toward quantifying embodied carbon in materials and applying digital tools such as Lifecycle carbon analysis of materials (2020 – UTM), Creation of a carbon inventory database for over 500 types of materials (2021 – CIDB), Use of Building Information Modeling (BIM) to estimate embodied carbon in low-cost housing (2022 – UTM). This reflects growing industry interest in data-driven approaches and policy-support tools, with a strong institutional push such as CIDB national database.

Recent Advances (2023–2024): Benchmarking and Integrated Carbon Planning

- The latest research focuses on benchmarking embodied carbon and policy-level integration for example the development of a benchmark model for purpose-built offices (2023 – UTP). Other than that, Carbon neutrality modelling using integrated assessments (2024 – UTM, SEI, LBNL) This trend shows a move from measurement to strategic planning, aiming to align with Malaysia's national carbon neutrality goals.

Over the last decade, Malaysian embodied carbon research has evolved from foundational studies to actionable models and national tools. The direction is clearly moving toward standardization, benchmarking, and integration into national sustainability strategies, supporting Malaysia's broader carbon neutrality and green development goals**.**

1.6 Emerging Topics on Malaysian construction research

Malaysia's construction industry is undergoing a pivotal shift toward sustainability, with embodied carbon reduction gaining growing attention. Local research efforts ranging from material innovation to carbon quantification are beginning to intersect with advanced international studies and emerging technologies. This alignment opens critical opportunities for Malaysia to modernize its green building agenda, adopt cutting-edge tools, and prepare for future carbon regulations. Table 6 explain on Emerging Topics on Malaysian construction research.

Table 6 : Emerging Topics on Malaysian construction research

Ongoing Research in Malaysia	Relevant International Research	Emerging Topics
Estimation and optimization of embodied carbon reduction cost	Technologies in net-zero embodied carbon in buildings	Carbon trading
Environmental Product Declarations (EPDs) for Malaysian adaptation	Lifecycle carbon assessment in diverse building types (Singapore)	Blockchain in carbon tracking
Information management in carbon emissions quantification	AI predictive carbon optimization (Singapore)	Circular economy
Low-carbon materials in Malaysia	Mapping material use and embodied carbon (UK)	Data analytics in green supply chain

Estimation and Optimization of Embodied Carbon Reduction Cost

- Local research is actively investigating how to calculate and optimize the cost-effectiveness of embodied carbon reduction strategies, especially in public housing and infrastructure. Advanced economies are applying net-zero construction technologies to assess embodied carbon against lifecycle costs. Emerging Opportunity can be seen as carbon trading becomes more prominent globally, understanding the cost of embodied carbon reduction gives Malaysian developers and policymakers a strategic advantage in a future carbon pricing or offset market. By integrating cost-carbon optimization into construction practices will help make green building financially viable, especially for SMEs and public procurement.

Environmental Product Declarations (EPDs) for Malaysian Adaptation

- Research is ongoing to localize EPD frameworks for commonly used Malaysian materials (e.g., concrete, steel, brick). Globally, countries like Singapore, the EU, and the UK are using EPD-backed LCAs to set mandatory carbon benchmarks for buildings. The integration of blockchain in carbon tracking offers Malaysia a secure, transparent system to verify EPDs and track carbon in the supply chain. Adaptation of EPDs will not only improve LCA accuracy but also enhance transparency in government procurement, green certifications (MyCREST, GBI), and future digital material passports.

Information Management in Carbon Emissions Quantification

- There is increasing interest in using BIM and digital databases for embodied carbon tracking in real-time. Globally, singapore is pioneering AI-assisted carbon optimization tools that work within BIM environments to guide design decisions. Coupling this with circular economy principles could lead to smarter lifecycle planning and material reuse within Malaysian projects. Betterment in carbon information management supports data-driven decision-making, streamlines compliance with future regulations, and encourages digital transformation of the construction industry.

Low-Carbon Materials in Malaysia

- In Malaysian context**,** an active research explores geopolymer cement, recycled aggregates, and bio-based alternatives suited for Malaysia’s climate and construction methods. Globally, the UK and EU are mapping material flows and embodied emissions to reduce material demand through design optimization and reuse strategies. Data analytics in green supply chains offers Malaysia a pathway to monitor, predict, and reduce embodied carbon across the construction value chain. Low-carbon materials are essential for mass-market housing, government infrastructure, and export-oriented developers aiming to meet global ESG (Environmental, Social, Governance) standards.

Relevance of Emerging Topics to Malaysian Construction Research

From the emerging topic, the strategic significance to Malaysian construction industry has been explained and tabulated in Table 7.

Table 7 : Strategic Significance to Malaysia

Emerging Topic	Strategic Significance to Malaysia
Carbon Trading	Prepares the sector for future carbon markets; incentivizes reductions via financial mechanisms.
Blockchain in Carbon Tracking	Enhances material transparency and trust, especially in green-certified procurement and export projects.

Emerging Topic	Strategic Significance to Malaysia
Circular Economy	Promotes waste minimization and material reuse—key for aligning with Malaysia's waste-to-wealth and construction waste reduction targets.
Green Supply Chain Analytics	Enables smarter, real-time supply chain decisions that reduce emissions from material transport and procurement.

The convergence of ongoing domestic research, international best practices, and emerging global innovations offers Malaysia a unique opportunity to leapfrog into data-driven, low-carbon construction. Key actions include:

- Accelerating EPD development through public-private partnerships.
- Embedding carbon tracking in BIM and procurement platforms.
- Strengthening cost-benefit studies of carbon reduction in national planning.
- Adopting digital technologies like AI, blockchain, and analytics for proactive carbon management.

By embracing these areas, Malaysia can strengthen its leadership in sustainable construction within the ASEAN region and meet its national low-carbon goals.

1.6 Underexplored Areas and Gaps

As Malaysia intensifies its commitment to sustainable development, embodied carbon the carbon emissions associated with material extraction, production, transport, and construction has emerged as a critical factor in building performance evaluation. While awareness has grown, the depth and breadth of current research, policy integration, and practical application remain uneven. A number of significant gaps persist across key domains, limiting progress toward comprehensive carbon reduction in the built environment. This analysis identifies and explores six crucial underdeveloped areas in embodied carbon assessment and management in Malaysia.

Table 8 : Underexplored Area and Gaps

Area	Gap Identified	Why It Matters?
Standardization of Embodied Carbon Metrics	Lack of unified guidelines across projects and sectors	Makes comparison, benchmarking, and policy implementation difficult
Lifecycle Carbon Integration (Embodied + Operational)	Most studies separate embodied carbon from operational energy	Integrated lifecycle carbon analysis is needed for full sustainability picture
Local Material LCA (Life Cycle Assessment) Data	Limited lifecycle data for local construction materials	Inhibits accurate calculation of embodied carbon
SME Adoption of BIM for Carbon Estimation	Focus is on large-scale or institutional buildings	Small and medium projects dominate the Malaysian built environment
Policy Integration	Research rarely links findings to building codes or procurement practices	Bridging the research-policy gap is crucial for enforcement

Area	Gap Identified	Why It Matters?
End-of-Life Carbon Accounting	Very few studies assess demolition, reuse, and recycling impacts	Key for circular economy and full carbon accountability

Standardization of Embodied Carbon Metrics

There is currently no unified national standard for measuring or reporting embodied carbon across different construction projects and sectors. The absence of standardization leads to inconsistencies in data collection, calculation methodologies, and reporting formats. This hinders the ability to benchmark performance across projects, compare design alternatives reliably, or implement enforceable policy mandates. Without clear baselines or performance thresholds, setting meaningful carbon reduction targets becomes difficult. While global standards like ISO 14067 and EN15804 exist, their application in Malaysia is often inconsistent or not adapted to local conditions. A unified national framework is essential to align practices across the public and private sectors.

Integration of Lifecycle Carbon (Embodied + Operational)

Embodied carbon and operational energy are often treated as separate domains in both academic research and project assessments. Buildings must be evaluated holistically through a lifecycle carbon lens from cradle to grave. Focusing only on operational energy efficiency can lead to unintended trade-offs, such as increased embodied carbon through the use of high-tech but carbon-intensive materials. Without integrated assessments, design decisions may inadvertently shift emissions from the operational phase to the embodied phase, negating overall carbon benefits. Lifecycle thinking enables designers and policymakers to make truly sustainable decisions that optimize total carbon performance.

Limited Local Life Cycle Assessment (LCA) Data for Materials

There is a lack of region-specific LCA data for construction materials, especially those sourced, manufactured, and transported within Malaysia. Embodied carbon values are highly sensitive to local variables such as electricity grid intensity, transportation distances, and production methods. Relying on international databases like ICE or Ecoinvent without localization can result in inaccurate or misleading estimates. Although CIDB has initiated the Malaysian Life Cycle Inventory Database (MYLCID), its coverage remains limited. Expanding local LCA datasets is essential for accurate carbon accounting and informed material selection in Malaysian projects.

Low SME Adoption of BIM for Carbon Estimation

Building Information Modelling (BIM) tools for carbon estimation are mostly used in large-scale or government projects, with limited uptake among small and medium-sized enterprises (SMEs). The Malaysian built environment is predominantly shaped by SME developers, contractors, and consultants. Without accessible and user-friendly tools, these players are excluded from participating meaningfully in carbon-conscious design. Furthermore, cost and technical barriers to adopting BIM-based carbon tools limit widespread implementation. Encouraging SME-friendly platforms and training is vital to mainstream embodied carbon management across all tiers of the construction industry.

Lack of Policy Integration and Regulatory Enforcement

Research on embodied carbon is rarely linked to national building codes, procurement frameworks, or enforcement mechanisms. Scientific and technical advances in embodied carbon measurement often remain within academic or pilot project contexts. Without integration into statutory frameworks such as building regulations, project approvals, or public procurement standards their real-world impact remains limited. Bridging this research-policy gap is essential to drive adoption at scale and to ensure that carbon reductions are measurable, reportable, and verifiable.

Neglect of End-of-Life Carbon Accounting

Few studies or assessments account for emissions related to demolition, material recovery, reuse, recycling, or landfill disposal. Embodied carbon is not confined to the construction phase. End-of-life processes can have significant emissions impacts, but also offer opportunities for mitigation through material reuse and recycling. Ignoring this phase undermines circular economy strategies and leads to incomplete carbon accounting. Lifecycle approaches must include end-of-life scenarios to support adaptive reuse, design for disassembly, and effective material recovery systems.

The path to decarbonizing Malaysia’s built environment requires a concerted effort to address these underexplored areas. By closing the gaps in standardization, lifecycle integration, localized data, SME accessibility, policy alignment, and end-of-life considerations, Malaysia can develop a robust embodied carbon framework tailored to its unique development context. The Royal Institution of Surveyors Malaysia (RISM) advocates for collaborative research, industry education, and regulatory reform to ensure that embodied carbon reduction becomes a central pillar of sustainable construction nationwide.

2 Embodied Carbon Calculation Method

2.1 Existing Method Implementation

As Malaysia moves toward sustainable development goals and carbon neutrality, there is increasing emphasis on reducing carbon emissions from the construction sector. While operational energy efficiency has been addressed through green building designs and renewable energy integration, *embodied carbon* the emissions associated with material extraction, manufacturing, transportation, and construction processes remains under-addressed. Recognizing the significant climate impact of embodied carbon, several national and regional initiatives have been launched to standardize its measurement, improve data transparency, and support sustainable decision-making in the built environment as traditionally calculated as per Figure 2.

TYPES	MARKET PRICE	EMBODIED CARBON FACTOR	FUNCTIONAL UNIT
General aggregate and sand*	RM 34 / tonne	0.0049	$kgCO_2e/kg$
Marine sand and aggregate	RM 34 / tonne	0.01	$kgCO_2e/kg$
Recycled aggregate without heat treat	RM 34 / tonne	0.01	$kgCO_2e/kg$
Recycled aggregate with heat treat	RM 34 / tonne	0.12	$kgCO_2e/kg$
Secondary aggregate and sand	RM 21 / tonne	0.06	$kgCO_2e/kg$
Secondary and recycled aggregate and sand	RM 21 / tonne	0.01	$kgCO_2e/kg$
Gravel, crushed	RM 33 / tonne	0.01	$kgCO_2e/kg$
Gravel, unspecified	RM 33 / tonne	0.01	$kgCO_2e/kg$
Gravel, round	RM 33 / tonne	0.01	$kgCO_2e/kg$
Recycled aggregate	RM 21 / tonne	0.01	$kgCO_2e/kg$

*Commonly used/ traditional material

Figure 2 : Traditional Material Embodied Carbon Calculation

The key initiatives within Malaysia that aim to establish robust carbon calculation frameworks, focusing on tools and rating systems tailored to local contexts.

MyCREST: Malaysian Carbon Reduction and Environmental Sustainability Tool

Developed by: Construction Industry Development Board (CIDB) Malaysia and Public Works Department (JKR)

MyCREST is Malaysia's flagship green building framework designed specifically to integrate *carbon reduction targets* into construction and infrastructure development. Unlike traditional green rating tools, MyCREST embeds embodied carbon accounting as a central performance metric throughout the project lifecycle.

Key features of MyCREST include:

- Integrated Carbon Calculation Modules: Covers both operational and embodied carbon footprints.
- Life Cycle Assessment (LCA) Approach: Encourages carbon tracking from design through decommissioning.
- Carbon Metrics Benchmarking: Allows comparison across different projects and building types.
- Tiered Certification System: MyCREST awards certifications based on achievement in resource efficiency, carbon savings, and sustainability practices.

The implementation of MyCREST by federal agencies signals a commitment to institutionalizing carbon measurement in government projects, with the long-term aim of standardizing carbon performance in both public and private developments.

CASBEE Iskandar: Localized Sustainability Rating System

Developed in partnership with: Japan's Institute for Building Environment and Energy Conservation (IBEC) & Iskandar Regional Development Authority (IRDA)

CASBEE Iskandar is a *region-specific adaptation* of Japan's Comprehensive Assessment System for Built Environment Efficiency (CASBEE), mandated for implementation in the Iskandar Malaysia region of Johor. It is poised to become a regulatory requirement for all future developments in that region.

Distinctive aspects include:

- Emphasis on Carbon Efficiency: Combines *Built Environment Efficiency (BEE)* metrics with localized carbon emission factors.
- Embodied Carbon Consideration: Includes metrics for carbon emissions from materials and construction activities.
- Policy Integration: Supports the regional carbon roadmap and complements Johor's broader environmental and economic development strategy.

CASBEE Iskandar offers a regional policy-driven approach to decarbonising construction and sets an example for other Malaysian states to adopt similar frameworks.

Carbon Score by the Malaysian Green Building Council (MGBC)

Initiative by: Malaysian Green Building Council (MGBC)

The *Carbon Score* is an evolving tool developed by MGBC aimed at simplifying embodied carbon assessments and promoting awareness across the industry. Designed as a *performance indicator*, it helps developers, architects, and engineers evaluate the carbon impact of construction materials and design decisions.

The key highlight are including:

- Material Carbon Scoring System: Provides a simplified rating of carbon intensity for common construction materials.
- Voluntary Tool with Educational Value: While not yet a mandatory certification system, it is valuable in capacity-building and early-stage decision-making.
- Alignment with Global Best Practices: Designed to be compatible with international standards like ISO 14067 and EN 15804.

The Carbon Score contributes to the wider push for transparency and industry adoption of embodied carbon tracking without imposing high barriers for entry.

Embodied Carbon Inventory Data for Construction Materials (CIDB)

Maintained by: Construction Industry Development Board (CIDB)

CIDB has taken the lead in compiling the Embodied Carbon Inventory Data, a national-level initiative to create reliable, Malaysia-specific emissions factors for key construction materials. This database provides foundational data for LCA studies and carbon accounting within the local context.

The salient features are as follows:

- Local Contextualization: Accounts for Malaysian energy grid mix, local production practices, and transportation distances.
- Supports MyCREST and Other Frameworks: Data feeds directly into carbon calculation modules in MyCREST and supports other green certifications.
- Ongoing Development: Updates are made periodically to include new materials, technologies, and regional data variations.

Such localized inventory data is critical for accurate carbon accounting and sets the stage for integrating embodied carbon into public procurement and infrastructure planning.

Malaysia has made significant strides in establishing embodied carbon frameworks that reflect both global best practices and local realities. Initiatives like MyCREST and the CIDB's Embodied Carbon Inventory create strong institutional foundations, while CASBEE Iskandar and MGBC's Carbon Score offer targeted solutions for regional and voluntary applications. As embodied carbon continues to gain recognition in global climate discourse, these Malaysian initiatives demonstrate forward-thinking leadership. The Royal Institution of Surveyors Malaysia (RISM) fully supports these frameworks and encourages continued industry adoption, research, and policy integration to achieve meaningful decarbonization in the built environment.

2.2 New Calculation Method Proposed

As Malaysia intensifies its efforts toward carbon neutrality and sustainable development, the construction industry plays a pivotal role in addressing climate impacts. Embodied carbon greenhouse gas emissions associated with the production, transportation, and installation of building materials has become a key focus area, especially given its significant contribution to a building's overall carbon footprint. While traditional carbon accounting has emphasized operational emissions, there is now an urgent need to adopt robust methods for measuring and managing embodied carbon in construction projects.

This section presents a set of recommended embodied carbon calculation methods tailored to the Malaysian construction context. Drawing on global best practices and adapting them to local conditions, the approach emphasizes the use of Hybrid Life Cycle Assessment (LCA), integration with Building Information Modelling (BIM), and the adoption of practical tools like CarbonScore and the SIRIM Carbon Calculator. It also supports the development of a Malaysian embodied carbon database and the incorporation of carbon data directly into standard project documents such as Bills of Quantities (BQ). These strategies aim to build local capacity, enhance decision-making, and align construction practices with Malaysia's sustainability goals.

Hybrid Life Cycle Assessment (Hybrid LCA) as Recommended Core Method

The methods is imperatives as it featured Combines Process-based LCA (PLCA) with Input-Output LCA (IOLCA). Other than that, it captures both direct and indirect emissions from construction activities and materials. It provides a comprehensive coverage of emissions across the supply chain and believe to assimilate and adaptable to the Malaysian context where it uses local Input-Output economic data from the Department of Statistics Malaysia. Essentially, it integrates real Malaysian energy or material consumption and specific emission factors from CIDB or SIRIM.

BIM-Integrated LCA – For Design Stage Optimization

This method links Building Information Modelling (BIM) (e.g., Revit models) with LCA tools like Tally, One Click LCA, or EC3. Likely, this method enables rapid embodied carbon calculation based on actual material quantities which allowing design professionals to test multiple design/material options early in planning. While it providing a distinctive features, the recommendation is to utilise in large-scale or government-led projects with Implementation of pilot studies with local universities and councils. Thus, the development of training programs to build industry capability is recommended to mandate this method substantially.

CarbonScore (MGBC) & SIRIM Carbon Calculator – Practical Web Tools

Promising feature that can be use readily available project data for instance like integrating with Bills of Quantity (BQ) according to material quantities. This methods refer to Malaysian carbon emission factors where it contribute for greater function for preliminary estimation and design comparison. Incorporating practical web tools and system development is highly recommended to ensure the carbon calculation is convenient and comprehensive for daily used and in the long run, it will become a culture among the construction communities.

Embodied Carbon Coefficient / Database Method For Simpler Estimation

This method is recommended to utilise average carbon emission factors per unit material**,** transportation and labour for example $kgCO_2e/m^3$ concrete, and then multiply by quantity to estimate total emissions. The holistic fundamental of estimation including spectrum of cost estimation in quantity surveying. Factoring the carbon factor with the holistic quantum of estimation is recommended.

Table 9 : Proposed Embodied Carbon Coefficient

Item	Description	Quantity	Embodied Carbon Factor (Material, Transportation & Labour)	Total Carbon ($kgCO_2e$)
Concrete	Grade 30	100 m^3	270 $kgCO_2e/m^3$	27,000

Regardless, Malaysia currently relies on international databases for example from **ICE**, **Australasian EPDs**, where local adjustment is required to find the absolute carbon coefficient factorial basis. Thus, establishment of a national embodied carbon database, sourced from local manufacturers and suppliers is required as it will bring the varies coefficient factors according to country basis. In the same time, it encourage adoption of EPDs (Environmental Product Declarations) in the Malaysian construction sector.

PAS 2080 & RICS WLCA Framework: International Best Practices Adapted Locally

The method embedded PAS 2080 that focused on carbon management in infrastructure meanwhile RICS WLCA: Recognized global standard for full life cycle carbon assessment. It is recommended to adopt these frameworks with localization of adjusted emission factors that align with Malaysian construction methods, materials, and project delivery.

Carbon Column in Bill of Quantities (BQ) : Simple Integration for Projects

Additional Embodied carbon factor for simple integration for projects as the awareness of the embodied carbon is promoted via details out Bills of Quantities (BQ).

Table 10 : Example Additional Carbon Column in BQ

Item	Description	Unit	Qty	Rate	Amount	Embodied Carbon Factor ($kgCO_2e$/unit)	Total Carbon ($kgCO_2e$)

The merit from this method is encourage the construction practice keeping with familiar BQ format while integrating carbon data. Other than that, it supports dual visibility of cost and environmental impact while it is useful for contractors, quantity surveyors, and project managers. In summary, the calculation methods consolidated summarised as per Table 11 below.

Table 11 : Key summary for Embodied Carbon Calculation Method

Area	Recommendation
Core Method	Use Hybrid LCA for complete emission coverage.
Design Optimization	Implement BIM-integrated tools (e.g., Tally, EC3).
Practical Tools	Use CarbonScore, Sirim Calculator for early-stage estimates.
Data Source	Develop a local embodied carbon database using real Malaysian data.
Simplified Estimation	Adapt RICS/ICE methods with Malaysian coefficients.
Tender Stage	Add a carbon column in BQ to standardize reporting.

The integration of embodied carbon assessment into Malaysia's construction industry is both a necessary and achievable step toward sustainable development. By adopting a Hybrid LCA approach, leveraging BIM-based tools, and incorporating simplified estimation methods such as carbon-adjusted BQs, the industry can transition toward more responsible and data-informed project planning. Although the current reliance on international emission factors presents challenges, these can be addressed through the gradual development of a localized carbon database, supported by primary data from Malaysian suppliers and government agencies.

As climate action becomes a national priority, embedding embodied carbon metrics into construction processes not only strengthens environmental accountability but also creates new opportunities for innovation, efficiency, and competitiveness in the sector. The proposed methods provide a scalable, adaptable framework to help stakeholders from policymakers and developers to engineers and quantity surveyors achieve lower carbon outcomes across the built environment.

3 Challenges for Embodied Carbon Culture

Despite increasing global and regional attention on decarbonizing the built environment, the Malaysian construction industry continues to face significant barriers in implementing effective embodied carbon (EC) assessment and reduction strategies. While research and pilot initiatives have progressed, systemic challenges persist across economic, social, regulatory, and technical dimensions.

Economically, the high upfront costs of low-carbon materials, a lack of financial incentives, and the limited availability of local data or tools hinder widespread EC adoption. Socially, industry professionals often lack awareness or training, and traditional material preferences continue to dominate. On the regulatory front, the absence of mandatory EC reporting and inconsistent standards across voluntary tools create confusion and weak enforcement. Furthermore, outdated databases, fragmented stakeholder collaboration, and a lack of transparency and technical capacity severely limit progress toward a standardized national framework for EC measurement and mitigation.

This section outlines the key barriers to EC implementation in Malaysia, drawing insights from academic literature, industry reports, and recent stakeholder assessments, and highlights the urgent need for structural reforms, coordinated leadership, and digital integration to close these gaps as per Table 12.

3.1 Challenges

Table 12 : Challenges for Embodied Carbon Calculation Culture

Domain	Challenges to Implementation	Sources
Economic	• High upfront cost for low-carbon materials and circular construction (e.g., reused elements). • Lack of financial incentives such as carbon pricing, green procurement preferences, or tax breaks. • Insufficient data/tools to conduct reliable EC assessments (e.g., lack of, local benchmarks).	Berglund-Brown et al. (2024); The Edge Malaysia (2023) CIDB (2021); Climate Governance Malaysia (2021) Taylor's University (2023); Planning Malaysia Journal (2024)

Domain	Challenges to Implementation	Sources
Social	• Low awareness among industry professionals about embodied carbon and its significance. • Cultural preference for conventional materials (e.g., concrete and steel over timber). • Fragmented stakeholder collaboration; clients, contractors and suppliers not aligned on EC goals.	Planning Malaysia Journal (2024); Climate Governance Malaysia (2021) Berglund-Brown et al. (2024); Netherlands RVO (2022) Planning Malaysia Journal (2024); The Edge Malaysia (2023)
Regulatory	• Absence of mandatory EC reporting requirements in construction policy. • Voluntary tools (GBI, MyCREST, GreenRE) vary in approach, causing confusion and inconsistent adoption. • Regulatory restrictions (e.g., UBBL) that hinder circular practices.	Netherlands RVO (2022); CIDB (2021) Taylor's University (2023); The Edge Malaysia (2023) Berglund-Brown et al. (2024); Climate Governance Malaysia (2021)
Others	• Database is obsolete then need to Integrate / update– future research • Update on new materials into the database. Example fly ash based cement recycle steel sustainable timber, hybrid materials, precast materials. • Ensure updated document provided based on emission of materials related to SMM (suppliers need to comply with required input parameters in SMM) • Lack of collaborations in the industry - Stakeholders technical working group. Lack of alignment between stakeholders (mainly CIDB, JKR and various local authorities) to reach consensus on the direction of standardized carbon emission quantification • Lack of centralized and transparent database on sustainable construction materials • Lack of real-time data for more accurate emission factor (Suggestion:	Climate Governance Malaysia (2021) Taylor's University (2023); Planning Malaysia Journal (2024)

Domain	Challenges to Implementation	Sources
	incorporation of digital technologies to support real-time data) • Lack of qualification transparency on green consultants, contractors, manufacturers and suppliers • Lack of green requirements in tender preparation, selection and procurement • Lack of established training modules and certifications tailored for QS services related to sustainability expertise • Provision in the contract on the requirement to consider carbon emissions reduction • Certifier of embodied carbon	

The transition to a low-carbon construction sector in Malaysia is hampered by deeply rooted challenges that span economic constraints, institutional fragmentation, regulatory gaps, and a lack of technical infrastructure. While awareness of embodied carbon is growing, especially within academia and policy circles, real progress demands a coordinated national effort to overcome these persistent barriers.

To move forward, Malaysia must invest in updating and centralizing embodied carbon databases, promote digital solutions for real-time carbon tracking, and introduce clear policy mandates backed by financial and procurement incentives. Collaboration among key stakeholders such as CIDB, JKR, local authorities, and the private sector is essential to develop standardized tools, consistent benchmarks, and enforceable guidelines. Additionally, building industry capacity through targeted training and certification, especially for quantity surveyors and sustainability consultants, will be vital.

Addressing these challenges holistically will position Malaysia to not only meet its climate targets but also enhance the resilience, competitiveness, and sustainability of its construction sector in the years to come.

3.2 Proposed Solution Implementation

As Malaysia advances its sustainability agenda in the built environment, addressing the issue of embodied carbon (EC) is becoming increasingly urgent. While awareness of EC is growing, its practical implementation remains limited due to economic, social, and regulatory constraints. To bridge this gap, a set of targeted strategies has been proposed to accelerate EC integration across policy, practice, and education.

This section outlines domain-specific implementation measures designed to support the adoption of EC assessment and reduction. Economically, the focus is on financial incentives, integration of local EC databases into cost planning, and demonstration projects to showcase viability. Socially, capacity building through education and professional collaboration is key to fostering industry-wide commitment. On the regulatory front, mandatory EC reporting, harmonized sustainability rating tools, and policy updates to support circular practices are recommended. These interventions aim to create a structured and enabling environment that drives carbon accountability throughout the construction life cycle as per tabulated according to domain at Table 13.

Table 12 : Proposed Solution Embodied Carbon Calculation Culture

Domain	Proposed Solution Implementation	Sources
Economic	Introduce fiscal incentives (tax breaks, rebates) for low-carbon procurement and reuse. Develop and mandate use of local EC databases and integrate with QS cost planning tools. Support industry demonstration projects to prove cost-effectiveness of circular design.	CIDB (2021); The Edge Malaysia (2023) Planning Malaysia Journal (2024); Taylor's University (2023) Berglund-Brown et al. (2024); Climate Governance Malaysia (2021)
Social	Implement EC-focused CPD modules and embed EC in university curricula for BE professionals. Facilitate early collaboration among QS, architects, engineers, and contractors to align on EC targets.	Planning Malaysia Journal (2024); Netherlands RVO (2022) Berglund-Brown et al. (2024); The Edge Malaysia (2023) Planning Malaysia Journal (2024)
Regulatory	Mandate EC reporting in government-led construction projects. Standardize EC metrics across GBI, MyCREST, and GreenRE for clarity and comparability. Update UBBL and codes to allow use recycled and reused materials.	Netherlands RVO (2022); CIDB (2021) Taylor's University (2023); The Edge Malaysia (2023) Climate Governance Malaysia (2021); Netherlands RVO (2022)

Implementing embodied carbon strategies in Malaysia requires coordinated, multi-level action across economic, social, and regulatory domains. The proposed measures including tax incentives, localized data integration, curriculum reform, and mandatory EC reporting offer a clear roadmap to embed carbon-conscious decision-making across the construction sector.

Crucially, success will depend on the ability of stakeholders to align policy with practice. Government agencies, industry bodies, academic institutions, and private sector actors must collaborate to mainstream EC principles through incentives, regulation, and education. By doing so, Malaysia can shift from isolated pilot efforts to a systemic, scalable approach positioning its construction sector as a proactive player in national and global climate goals.

4 Recommendation for Future Enhancement

As the construction sector continues to be a major contributor to greenhouse gas emissions, addressing embodied carbon (EC) has become a national priority in achieving Malaysia's climate goals under the National Construction Policy 2030 and broader sustainability commitments. While current efforts have largely focused on operational energy, embodied emissions from materials, construction processes, and supply chains represent a substantial portion of the building lifecycle's total carbon footprint.

To overcome the economic, technical, and institutional barriers that limit EC implementation, the government must play a central role in creating an enabling ecosystem. This includes establishing policy direction, providing fiscal and regulatory support, enhancing data transparency, and strengthening the professional capacity of industry players particularly Quantity Surveyors (QS) to integrate carbon considerations into project planning and delivery. The following proposals outline specific government-led actions to accelerate the mainstreaming of embodied carbon practices in Malaysia's construction industry.

4.1 Proposed Government Roles to Enhance Embodied Carbon Implementation in Malaysia

Recognize and Support the Expanding Role of Quantity Surveyors (QS)

- Endorse the inclusion of QS in sustainability-related scopes such as embodied carbon advisory, material selection, and waste minimization planning.
- Include QS as key professionals in green construction guidelines and project teams.

Develop and Implement Training and Certification Programs

- Establish government-backed training modules and certification schemes specifically tailored for QS and other built environment professionals focused on embodied carbon and sustainability.
- Allocate Continuous Professional Development (CPD) points for upskilling in carbon accounting and green cost planning.

Adjust Professional Fee Guidelines

- Review and revise the current professional fee structure to reflect the expanded scope of QS services related to sustainability and embodied carbon reporting.

Standardize Qualifications for Green Professionals

- Develop transparent and verifiable qualification systems for green consultants, contractors, manufacturers, and suppliers.
- Establish national registries or accreditation schemes for professionals and firms with verified sustainability credentials.

Integrate Green Requirements into Public Procurement:

- Mandate the inclusion of green criteria and embodied carbon considerations in all government tender documents, contractor selection processes, and procurement policies.

Develop a National 5-Year Blueprint for Embodied Carbon Reduction

- Align the blueprint with the National Construction Policy 2030 to provide a strategic direction and measurable goals for EC reduction in the construction industry.
- Ensure the blueprint includes timelines, milestones, and accountability frameworks.

Establish a Dedicated Taskforce for Implementation

- Form a taskforce comprising government agencies, academia, industry bodies (e.g., RISM, CIDB), and professional institutions to oversee and coordinate the blueprint's implementation.

Introduce Financial and Policy Incentives

- Provide tax breaks, grants, or recognition schemes for industry players who voluntarily conduct carbon accounting or adopt low-carbon construction practices.

Support the Development of Environmental Product Declarations (EPDs)

- Facilitate and fund the creation of EPDs for commonly used construction materials in Malaysia by engaging with local manufacturers and industry associations.

Invest in a National Automated Carbon Calculation Platform

- Develop a centralized, user-friendly digital system that automates embodied carbon assessments using standardized data and local benchmarks.

Embed Embodied Carbon in Educational Curricula

- Collaborate with academic institutions to integrate embodied carbon topics into built environment and engineering programs to prepare future professionals.

Empower Professional Institutions as Key Partners

- Provide policy support and funding for RISM and similar institutions to collect and validate primary data from material suppliers and construction firms, develop a localized embodied carbon database, create a national framework for embodied carbon reporting and deliver specialized training and certification for Quantity Surveyors as official certifiers of embodied carbon values.

Accelerating embodied carbon integration in the Malaysian construction sector requires bold and coordinated government leadership. Through strategic interventions such as mandating EC in procurement, standardizing qualifications, updating fee structures, and supporting local data and tool development the government can drive a meaningful shift toward low-carbon, resource-efficient construction practices.

Empowering professional bodies like RISM, incentivizing early adopters, and embedding EC into both education and digital infrastructure will ensure long-term capacity and accountability. With a dedicated 5-year blueprint and taskforce to guide implementation, these government actions can lay the foundation for a construction industry that is not only economically competitive but also environmentally responsible and aligned with national and global climate objectives.

4.2 Construction Stakeholder Roles in Embodied Carbon Implementation

In the effort to decarbonize Malaysia's built environment, construction stakeholders including developers, consultants, contractors, material suppliers, and facility managers play a crucial role in addressing embodied carbon (EC). Their actions directly influence carbon emissions across the entire building lifecycle, from design and procurement to construction and in-use phases.

To align with Malaysia's sustainability goals and support the implementation of the National Construction Policy 2030, construction stakeholders must actively contribute to low-carbon initiatives. This involves integrating carbon considerations into decision-making processes, collaborating on data transparency, and adopting effective carbon accounting and monitoring practices. The following roles and responsibilities outline how various stakeholders can support the mainstreaming of EC reduction practices in the industry.

Prepare Low Carbon Design Briefs

- Developers and consultants should incorporate low-carbon objectives at the project inception stage by clearly defining carbon performance expectations in the project brief.
- Encourage early-stage collaboration among architects, engineers, and quantity surveyors to align carbon reduction goals with design and cost strategies.

Establish Project-Specific Carbon Baselines

- Design teams and QS professionals should work together to establish an initial carbon baseline using local data or adjusted international benchmarks.
- This baseline serves as the reference point to measure progress toward carbon reduction targets throughout the project lifecycle.

Implement Carbon Reduction Strategies

- Consultants and designers must identify and integrate carbon-saving strategies such as passive design, material reuse, and low-carbon construction methods.
- Contractors should adopt sustainable construction techniques and minimize onsite emissions through efficient machinery and logistics.

Set Measurable Carbon Reduction Targets

- Project teams should define clear, achievable carbon reduction targets in alignment with national goals and certification systems (e.g., GBI, MyCREST).
- Targets must be included in design and contract documentation to ensure accountability.

Select Low Carbon and Circular Materials

- Material suppliers, architects, and QS should prioritize locally sourced, recycled, or certified low-carbon materials.
- Environmental Product Declarations (EPDs) should be used to guide procurement decisions.

Measure and Quantify Carbon Throughout the Lifecycle

- Quantity surveyors and sustainability consultants should use Life Cycle Assessment (LCA) tools or embodied carbon databases to calculate emissions at design, construction, and post-construction stages.
- Encourage the integration of carbon data into BIM platforms for more accurate and automated assessments.

Conduct As-Built and In-Use Carbon Performance Appraisals

- Upon project completion, actual material quantities and construction processes should be used to generate as-built carbon reports.
- Facility managers and engineers should monitor operational energy to assess total lifecycle carbon performance.

Monitor Carbon During Construction and Occupancy

- Contractors and site managers should track carbon emissions during construction (e.g., fuel use, waste, transportation).
- Post-occupancy monitoring should assess in-use carbon performance to inform future design and maintenance strategies.

Construction stakeholders hold the key to driving embodied carbon reduction from theory to practice. By taking ownership of carbon-conscious decisions across all phases of a project from design to construction and operation that can significantly contribute to a more sustainable, low-carbon built environment in Malaysia.

Through structured roles such as setting baselines, applying reduction strategies, choosing low-carbon materials, and tracking carbon performance, the industry can build consistency and accountability into everyday construction practices. With collaboration, training, and commitment to transparent measurement, these stakeholder-driven efforts will be instrumental in achieving Malaysia's low-carbon goals and strengthening the resilience of its construction sector for the future.

5 Report Summary and Conclusion

5.1 Summary

This technical report is developed under the guidance of the Royal Institution of Surveyors Malaysia (RISM) and consolidates a nationwide academic dialogue on embodied carbon involving public and private institutions offering Quantity Surveying (QS) programs. As global and national efforts intensify toward decarbonising the built environment, this report sheds light on the crucial role of QS education in supporting low-carbon construction practices in Malaysia.

Through contributions from SIX (6) public universities (IPTA) and SIX (6) private institutions (IPTS), the report provides a comprehensive overview of:

- Current Academic Research: A variety of research initiatives are being conducted across Malaysian institutions, addressing life cycle assessment (LCA), sustainable construction materials, carbon footprint estimation tools, and green procurement strategies. However, the depth and scope of such research are uneven, indicating the need for broader academic integration.
- Calculation Methodologies: Institutions use different tools and frameworks to calculate embodied carbon, most relying on international datasets. A major challenge identified is the absence of a Malaysian-specific embodied carbon database, which limits accuracy and contextual relevance in both teaching and research.
- Cultural and Educational Challenges: Integrating embodied carbon into QS education faces obstacles such as limited awareness, data inaccessibility, curriculum rigidity, and weak industry-academic collaboration.
- Forward-Looking Recommendations: The report calls for collaborative efforts to develop national benchmarking tools, embed carbon topics in QS curricula, promote cross-sector data-sharing, and enhance educator capacity through training and professional development.

5.2 Conclusion

This report clearly illustrates the importance of aligning Quantity Surveying education in Malaysia with the national and global agenda for sustainable development. The growing body of academic work reflects a positive trajectory; however, to fully equip future QS professionals with the knowledge and tools to measure and manage embodied carbon, deeper institutional reform and industry engagement are essential.

By bridging research with practice and fostering stronger cooperation among academia, government, and industry stakeholders, Malaysia can take a leadership role in promoting low-carbon construction practices. RISM reaffirms its commitment to supporting this transition by championing sustainable innovation, academic excellence, and professional empowerment within the Quantity Surveying community.

VISION

- To be recognised as an innovative and dynamic world-class professional surveying Institution.
- To provide quality, value-added and comprehensive services.
- To be the centre of excellence in surveying.

MISSION

- To continuously improve the standards of professional practice and ethics.
- To promote the welfare and professional development of members.
- To expand by incorporating related disciplines into our profession.
- To continue to be relevant and of benefit to the public.

VALUES

- We recognised the need to be honest and accommodate in all undertakings.
- We respect the equality of individuals on gender, cultures and beliefs and have a high sense of social responsibility.
- We seek quality in technology, standards and services.

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