

POLICY REPORT



Towards the Golden Indonesia 2045 Vision

Opportunities for Low-Carbon Building Materials in the Construction Industry

EXECUTIVE SUMMARY

Indonesia's construction sector is expanding at an unprecedented rate, contributing to increasing levels of greenhouse gas (GHG) emissions primarily through the use of carbon-intensive materials such as cement, steel, and concrete. These embodied emissions represent a significant proportion of the national carbon footprint, despite the building sector's relatively lower operational emissions. Low-carbon building materials (LCBM) offer an immediate and viable pathway to reduce this impact. Materials such as geopolymers made from fly ash, agricultural waste such as rice husk ash, and natural materials including bamboo and volcanic ash, present promising opportunities for substitution. Despite their potential, the uptake of LCBMs in Indonesia remains marginal. This is largely due to policy uncertainty, regulatory volatility, lack of industry awareness, limited research and development funding, and an underdeveloped supply chain. Through a combination of systematic literature review, field-based case studies, and stakeholder workshops, this policy report synthesises evidence to identify barriers and opportunities, and provides targeted policy recommendations. Recommendations include the establishment of LCBM-specific regulations, incentivising market adoption, creating regional innovation hubs, and enhancing bilateral cooperation with Australia.

THE HEADLINES

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Indonesia's construction sector is expanding rapidly, creating a growing demand for materials with high embodied carbon, especially cement and steel.

2

Low-carbon alternatives exist, particularly geopolymers made from waste materials such as: fly ash, Nickel sludge and rice husk ash, but uptake remains minimal due to regulatory uncertainty, market inertia, and technical challenges.

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Green building certification and provincial initiatives offer promise but are not yet mainstreamed into national construction and procurement policy.

5

Bilateral partnerships and innovation hubs can accelerate progress, especially through cooperation between Indonesia and Australia on knowledge sharing and demonstration projects.

INTRODUCTION & BACKGROUND

Globally, the building sector accounted for 30% of final energy demand and 37% of CO₂ emissions in 2022.¹ Material production for construction adds further emissions, especially from cement, steel, aluminum, and glass. With growing populations and economies, energy demand and emissions from buildings are projected to rise. While operational emissions have been targeted through energy performance measures and technologies such as solar rooftops, embodied carbon from materials remains a critical yet underexplored area. Cutting emissions across a building's full lifecycle requires new construction practices, transparent carbon disclosures, material efficiency, and the use of low-carbon building materials.²

Indonesia's construction sector is one of the most dynamic in Southeast Asia. Driven by rapid urbanisation, demographic expansion, and the state's ambitious infrastructure development programs under the Golden Indonesia 2045 Vision, the sector is projected to grow substantially in the coming decades. However, this growth is closely linked with high-carbon construction practices. Traditional building materials such as cement, concrete, and steel are not only resource-intensive but also major contributors to greenhouse gas emissions due to the high-energy processes involved in their production.

Although building sectors have lower operational carbon emissions than the other sectors, the embodied carbon emissions from the production and transportation of building materials are expected to contribute around 10% of global emissions,³ which in some cases can be up to 40% across the whole life cycle. In Indonesia, cement and concrete continue to dominate the share of building materials composition since these materials are used for flooring and walls in a typical tropical house. Table 1 shows the material intensity of typical brick and concrete houses in Indonesia taken from a study by Surahman, et al.⁴

Portland cement—responsible for up to 8% of global emissions—drives most embodied emissions due to its energy-intensive kiln process and CO₂ release during limestone decomposition.³ In 2022, emissions from 22 Indonesian cement facilities totaled 41.7 MtCO₂-e, with Heidelberg Cement, Semen Padang, and Semen Tonasa being top emitters.⁵ Embodied carbon varies across materials.

Table 1. The material intensity of a typical Indonesian brick and concrete house⁴

Material	Jakarta: brick and concrete house		Bandung: brick and concrete house	
	kg/m ²	%	kg/m ²	%
Mortar	617.8	23.2	580.3	22.5
Cement	95.2	3.6	88.1	3.4
Sand	522.6	19.6	492.9	19.1
Soil	520.8	19.5	474.7	18.4
Stone	453.1	17.0	415.9	16.1
Concrete	426.9	16.0	432.9	16.8
Cement	69	2.6	69.4	2.7
Sand	132.6	5.0	134.6	5.2
Gravel	225.3	8.5	228.9	8.9
Clay brick	407.4	15.3	397.7	15.4
Wood	125.6	4.7	139.2	5.4
Ceramic tile	37.5	1.4	30	1.2
Steel	27	1.0	27.4	1.1
Clay roof	22.8	0.9	22.2	0.9
Asbestos roof	3.2	0.1	0.4	0.0
Paint/plaster	4.9	0.2	4	0.2
Zinc roof	0.5	0.0	0.4	0.0
Clear glass	0.9	0.0	1.8	0.1
Concrete roof	9.6	0.4	4.4	0.2
Gypsum	7.1	0.3	3.4	0.1
Concrete brick	0	0.0	3.6	0.1

Portland cement emits about 1.3 kg CO₂-e/kg, while wood and engineered timber products offer significantly lower emissions and can store carbon.³

Despite abundant natural and industrial by-products that can serve as low-carbon alternatives, their use remains limited due to regulatory uncertainties, lack of awareness, and fragmented supply chains. Indonesia's commitments under its Nationally Determined Contributions (NDCs) and the goal of reaching net-zero emissions by 2060 make it imperative to transition towards sustainable construction practices. Scaling the adoption of LCBMs represents a crucial step in this direction.



METHODS

This policy report is based on a triangulated research design incorporating literature review, field-based case studies, and stakeholder consultations.

1. **Systematic Literature Review:** A comprehensive review of 27 peer-reviewed articles was conducted to evaluate LCBM technologies, policy frameworks, and implementation challenges in Indonesia. Topics included geopolymers concrete, fly ash utilisation, rice husk ash concrete, and green certification systems.
2. **Field Visits:** Case studies were developed through field research in two resource-rich provinces—West Nusa Tenggara (NTB) and South Sulawesi. The regions were selected based on the availability of volcanic ash, pumice, fly ash, and nickel slag, as well as the presence of cement manufacturing facilities and government interest in low-carbon infrastructure.
3. **Stakeholder Workshop:** A governance-focused workshop was held in Perth, Australia, involving participants from Indonesian universities, local governments, the Indonesian Ministry of Energy and Mineral Resources, Western Australia State Government and Australian researchers. The discussions focused on identifying barriers to LCBM adoption, opportunities for pilot programs, and mechanisms for regional cooperation.

KEY FINDINGS

Abundant and Under-utilised LCBM Resources

Indonesia's geographic and industrial profile offers a substantial base of raw materials for low-carbon construction. The country hosts over 250 coal-fired power plants generating millions of tonnes of fly ash annually, a by-product that can be used in geopolymer concrete.³ Agricultural by-products such as rice husk ash, palm kernel shell ash, and coconut shell ash, are also abundant and reactive enough to replace traditional cement when properly processed. Regions including West Nusa Tenggara are rich in natural pozzolans such as volcanic ash, pumice, and scoria, which have historically been used in traditional construction but lack formal certification for modern applications. In industrial hubs such as South Sulawesi, nickel smelting operations produce significant volumes of nickel slag that are chemically suitable for alkali-activated binders.

Proven Technical Feasibility of LCBMs

Studies indicate that LCBMs using local resources can achieve compressive strengths of 10–30 MPa, comparable to traditional Portland cement.⁶ For example, paving blocks made with 30% fly ash substitution have shown favourable results in terms of strength and durability. Fly ash-based geopolymers demonstrate improved fire resistance, lower thermal conductivity, and better chemical resistance in tropical conditions. Several lab-scale demonstrations have validated the use of blended cements and aggregate replacements, showing that with proper mix design and curing, LCBMs can meet national building codes.

Regulatory and Institutional Gaps

Despite the technical potential, Indonesia lacks an integrated regulatory framework for LCBMs. Existing standards are outdated or not aligned with international certification systems, leading to a lack of trust among developers and contractors. Law No. 28/2002, once a cornerstone for building regulation, was revoked without establishing comprehensive guidelines for sustainable construction (Ministry of Public Works, 2002–2021). Current environmental regulations, while recognising the reuse of industrial waste, do not mandate their application in construction, creating policy ambiguity.

Fragmented Market and Weak Supply Chains

The LCBM supply chain is fragmented across multiple actors with minimal coordination. Material suppliers, processors, builders, and certifying bodies often work in silos, preventing economies of scale. Regional disparities exacerbate the issue: some areas have ample raw materials but lack processing infrastructure; others have demand but poor supplier access. Transporting bulky materials like fly ash across islands increases costs and emissions, undermining both economic and environmental viability.

Low Awareness and Capacity Gaps Across Stakeholders

The construction industry's reliance on conventional practices is deeply embedded. Builders, contractors, and local authorities often lack the knowledge and confidence to adopt new materials. Universities and vocational centres rarely include LCBMs in curricula.⁶ This creates a skills and trust deficit, where technically sound LCBMs are overlooked. Public awareness of the carbon impact of construction materials is low, reducing pressure on developers and officials to change practices.

Green Building Certifications and Incentives Remain Limited

The GREENSHIP certification system by the Green Building Council Indonesia (GBCI) promotes sustainable construction but is voluntary and mostly limited to upscale commercial projects.⁷ Without mandatory requirements or fiscal incentives, adoption remains low. Additionally, GREENSHIP's criteria for LCBM performance are limited. Although some regional governments are trialling green building policies, such initiatives remain fragmented and under-resourced.

LCBM Stakeholder Mapping in Indonesia

The stakeholder mapping for the transition to low-carbon building materials in Indonesia highlights a diverse ecosystem of actors essential for advancing sustainable construction practices (see Figure 1). At the core are industry stakeholders such as cement and concrete producers, industrial waste generators, construction companies, and the Green Building Council of Indonesia, who drive material production and on-site implementation. Government and regulatory bodies—including the Ministry of Environment and Forestry, Ministry of Public Works and Housing, the National Standardization Agency, and local governments—play a crucial role in policy formulation, standard-setting, and enforcement. Academia and research institutions, such as Universitas Hasanuddin, Badan Riset dan Inovasi Nasional, Institut Teknologi Surabaya contribute through research, innovation, and capacity building.

Financial institutions and development partners, including local banks, ESG funds, multilateral development banks (e.g., Asian Development Bank, World Bank), and the Australia–Indonesia Climate and Infrastructure Partnership (AI-CIP), provide the critical funding and incentives needed to support LCBM adoption. Civil society and end users—comprising NGOs, architects, engineers, and local communities can ensure that LCBM policies and practices are socially inclusive and grounded in local needs. This mapping underscores the importance of cross-sector collaboration to create enabling conditions and accelerate the widespread adoption of LCBMs in Indonesia.

Policy and Support for LCBMs in Indonesia

Indonesia's policy framework has increasingly promoted sustainable construction practices, including the use of renewable and locally sourced materials to support the adoption of low-carbon building materials. However, the frequent changes and revocations of key regulations over the past decade have created market instability and uncertainty for suppliers and developers.

The foundational regulation was Law No. 28/2002 on Buildings, which highlighted environmental impact control. It was followed by Government Regulation No. 36/2005, providing implementation details, though initially focusing more on energy efficiency than material sustainability. Later, Government Regulation No. 70/2009 on energy conservation introduced mandatory energy audits for buildings with high energy use but still lacked direct mandates on green materials.



4 Fig 1. Stakeholder Analysis

Attention to LCBMs gained momentum in the late 2000s, particularly with the establishment of the Green Building Council Indonesia (GBCI) in 2009. GBCI introduced the GREENSHIP certification in 2011, which included material resource criteria such as use of local, recycled, eco-certified, and renewable materials. Criteria vary for new and existing buildings, incentivising material circularity and sustainability.

In 2015, the Minister of Public Works Regulation No. 02/PRT/M/2015 offered a comprehensive green building standard, encompassing energy, water, waste, and materials. It was later replaced in 2021 by Regulation No. 21/2021, which provided more detailed specifications for materials in non-residential buildings. These include requirements for sourcing materials locally, using International Organization for Standardization (ISO) 14001-certified products, and achieving minimum domestic content thresholds. Despite this progress, regulatory volatility remains a challenge. Core regulations such as Law No. 28/2002 and its associated decrees have been revoked and replaced under broader legal reforms (e.g., Job Creation Law, Government Regulation No. 33/2023), creating uncertainty around long-term enforcement and continuity.

emission sectors like cement and steel. For example, the Green Industry Standard for Portland Cement (Regulation No. 26/2018) caps emissions at 0.75 kg CO₂-e per kg of cement. However, this remains a voluntary target, and more robust, mandatory standards are needed to accelerate industry-wide decarbonisation. While Indonesia

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CASE STUDIES

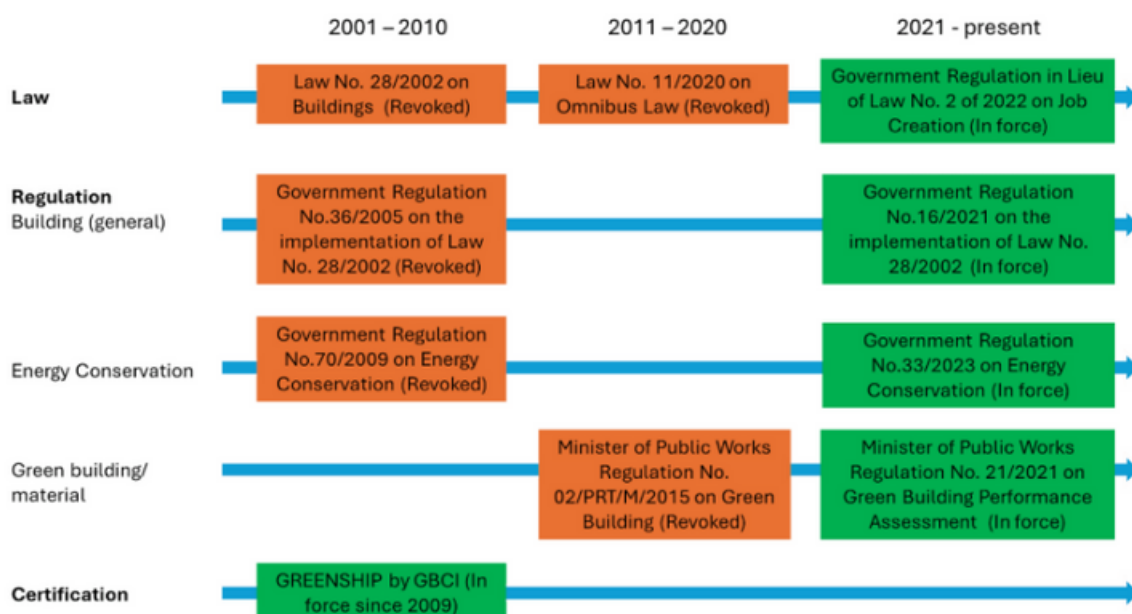
Case Study 1: West Nusa Tenggara (NTB)

West Nusa Tenggara is uniquely positioned to pioneer the development and deployment of LCBMs in Indonesia due to its abundant natural resources and local political commitment to sustainability. The province benefits from a rich deposit of volcanic ash, pumice, and scoria—materials that exhibit strong pozzolanic properties and can replace traditional Portland cement in concrete formulations.

In addition, the Jeranjang coal-fired power plant produces significant quantities of Class C fly ash, an industrial by-product suitable for geopolymers applications. The province also generates substantial rice husk ash, a result of its dominant agricultural sector.

Pilot projects in NTB have tested rice husk ash in combination with pumice to produce paving blocks and bricks. These initiatives, undertaken by Universitas Mataram and local Small and Medium-Sized Enterprises, demonstrated that LCBMs can

Fig 2. Regulation dynamics in terms of some building's related policies



match traditional materials in terms of compressive strength and durability while reducing embodied carbon by over 40%.

Despite these advantages, several barriers persist. These include the absence of accredited material testing laboratories, lack of standards for rice husk ash and volcanic ash, and limited awareness among local contractors. However, with targeted investment in local capacity and clearer guidance from national authorities, NTB could serve as a replicable model for other provinces.

Case Study 2: South Sulawesi

South Sulawesi, home to major cement producers and nickel smelters, presents a different but complementary opportunity for LCBM development. The region generates high volumes of industrial by-products, particularly nickel slag from PT Huadi Nickel-Alloy and fly ash from power plants such as PLTU (electric steam power plant) Jeneponto.⁸ These materials are ideal for use in alkali-activated concrete systems and blended cements.

Research collaborations between Universitas Hasanuddin, Murdoch University, and local industry have successfully piloted geopolymers concrete slabs for public footpaths and the foundations of small buildings. These trials used locally sourced fly ash and nickel slag with sodium hydroxide and sodium silicate activators. Results showed compressive strengths above 25 MPa and reduced curing times when ambient conditions were optimised.

However, challenges remain in mainstreaming these innovations. These include the absence of industrial symbiosis platforms, lack of traceability tools for material provenance, and regulatory ambiguity surrounding the classification of nickel slag as a non-hazardous waste. Nonetheless, South Sulawesi's strong industrial infrastructure and academic engagement make it a strategic site for scaling up LCBM deployment. In both regions, public procurement policies, targeted subsidies, and stronger linkages between waste generators and construction firms are essential to accelerating adoption.

Drivers for LCBM Adoption

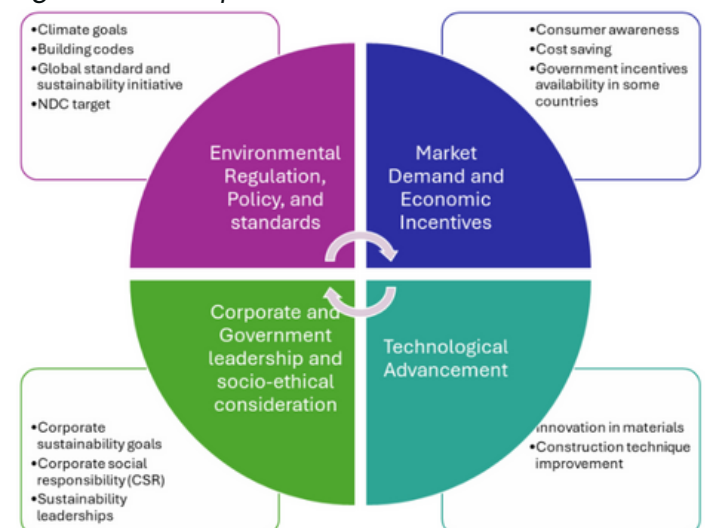
The adoption of LCBMs driven by four interconnected enabling factors that shape a supportive environment for sustainable construction. Firstly, Environmental Regulation, Policy, and Standards provide the regulatory backbone through climate targets, building codes, global sustainability initiatives, and Nationally Determined Contributions (NDCs), ensuring that environmental objectives are embedded in the construction sector.

Secondly, Market Demand and Economic Incentives play a pivotal role, as increasing consumer awareness, potential for cost savings, and the presence of government incentives in some countries help to stimulate demand for greener alternatives.

Thirdly, Technological Advancement contributes through innovations in material science and improvements in construction methods, making low-carbon solutions more accessible and effective. Finally, Corporate and Government Leadership with Socio-Ethical Considerations drives change through sustainability commitments, CSR programs, and forward-thinking leadership that prioritizes environmental responsibility.

These four enablers are visually represented in the above diagram as interdependent components of a circular system. The diagram emphasizes that progress in one area can reinforce and catalyse developments in the others, highlighting the need for an integrated approach to successfully scale LCBM adoption in the built environment.

Fig 3. LCBM Adoption Enablers



RECOMMENDATIONS

To catalyse the mainstreaming of LCBMs in Indonesia, an integrated set of policy, financial, and institutional actions is required. The following recommendations are designed to align national goals with local capabilities and global best practices.

1. Establish National LCBM Standards and Certification Systems

- Develop official definitions, classifications, and performance benchmarks for LCBMs aligned with SNI (Indonesian National Standard) and international codes.
- Formalise reuse guidelines for fly ash, slag, and agricultural waste materials through the Ministry of Environment and Forestry.
- Integrate LCBM standards into green building and procurement criteria to ensure compliance and quality assurance.

2. Integrate LCBMs into Public Procurement and Building Codes

- Mandate minimum LCBM content in government-funded infrastructure and social housing projects.
- Require life-cycle carbon assessments (LCA) and embodied carbon reporting in tenders for major construction projects.
- Provide model clauses for regional governments to incorporate LCBM use in local building regulations.

3. Support Regional Innovation Hubs and Material Testing Facilities

- Establish accredited LCBM testing labs in NTB and South Sulawesi, co-located with universities.
- Fund pilot projects to demonstrate field performance, cost competitiveness, and community impact.
- Promote academic-industry-government partnerships to fast-track innovation and workforce readiness.
- Share information by developing a database for different products and materials, including their monitoring and tracking systems

4. Provide Financial Incentives and Market Signals

- Introduce green tax incentives, such as VAT exemptions or reduced corporate income tax for certified LCBM products.
- Offer blended finance and loan guarantees through ESG-aligned banks and climate finance mechanisms (e.g., AI-CIP, ADB).
- Create a national LCBM innovation fund to support SMEs, start-ups, and local initiatives.

5. Build Capacity and Awareness Across the Supply Chain

- Develop vocational training modules for LCBM construction, including safety and quality control.
- Support certification programs for engineers, architects, and contractors in green material specification.
- Launch national awareness campaigns targeting consumers, procurement officers, and urban planners.

6. Strengthen International Collaboration and Policy Alignment

- Deepen engagement with the Australia–Indonesia Climate and Infrastructure Partnership (AI-CIP) to share standards, data, and co-develop pilot infrastructure projects.
- Coordinate LCBM agendas through ASEAN's Sustainable Urbanisation and Green Materials Platforms.
- Align Indonesia's regulatory reforms with SDGs, COP commitments, and the GlobalABC framework for buildings and construction.

RECOMMENDATION HIGHLIGHTS

1. Establish National LCBM Standards and Certification Systems
2. Integrate LCBMs into Public Procurement and Building Codes
3. Support Regional Innovation Hubs and Material Testing Facilities
4. Provide Financial Incentives and Market Signals
5. Build Capacity and Awareness Across the Supply Chain
6. Strengthen International Collaboration and Policy Alignment

Conclusion

Indonesia's construction sector stands at a crossroads. With increasing pressure to decarbonise and a national commitment to achieving net-zero emissions by 2060, transforming how buildings are designed and built is no longer optional—it is essential. Low-carbon building materials offer a high-impact, low-regret pathway toward this transformation. They can reduce embodied carbon, promote industrial symbiosis, stimulate local economies, and align construction practices with sustainability objectives. This policy report has shown that Indonesia possesses both the material resources and institutional knowledge needed to become a regional leader in sustainable construction. However, current adoption of LCBMs remains constrained by fragmented regulations, underdeveloped supply chains, weak certification systems, and limited awareness among stakeholders.

The case studies from West Nusa Tenggara and South Sulawesi demonstrate that localised innovation—supported by partnerships between government, academia, and industry—can overcome many of these barriers. With targeted investments, clear national standards, and strategic use of public procurement, LCBMs can shift from niche pilots to mainstream practice. To achieve this, Indonesia must adopt a systems-thinking approach. Policy coherence across ministries, strong governance mechanisms, and long-term capacity building are essential. International cooperation, particularly with Australia through the AI-CIP framework, offers valuable avenues for knowledge sharing, technical support, and financing. Scaling LCBMs is not only a climate imperative; it is an economic and developmental opportunity. Indonesia can lead the way in building a resilient, low-carbon construction industry—laying the foundation for greener cities, healthier communities, and a sustainable future.

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