



Environmentally Friendly Technology at PT Inalum: Implementation and Challenges within the Framework of Environmental Law in Indonesia

Aznina Lembayung Batubara^{1*}, Ali Alatas Hutapea², Aghyfariz Dittowisono³

^{1,2,3} Faculty of Law, Universitas Pelita Harapan, Indonesia

² aznina17@gmail.com

(* corresponding author)

Abstract

Environmental-friendly technology plays a crucial role in modern industries, including PT Inalum, a leading aluminum producer in Indonesia. The company has implemented various innovations to minimize environmental impacts, such as utilizing renewable energy sources, waste management systems, and emission reduction technologies. These efforts aim to comply with national environmental regulations, such as Law Number 32 of 2009 on Environmental Protection and Management, and international commitments like the Paris Agreement 2016. This study examines the challenges faced by PT Inalum in implementing sustainable technology. The research employs normative legal analysis and case study methods, focusing on regulatory reviews and corporate sustainability practices. Key challenges include regulatory uncertainty, overlapping government policies, and weak law enforcement mechanisms. Additionally, high investment costs for green technology adoption pose a significant barrier to achieving optimal environmental sustainability. The findings indicate that despite PT Inalum's commitment to environmentally friendly practices, legal and economic obstacles hinder full regulatory compliance. The study suggests the need for clearer policies, stronger enforcement mechanisms, and financial incentives to encourage sustainable industrial transformation. Enhanced collaboration between government authorities and industry stakeholders is essential to creating a more effective and efficient sustainability framework.

Keywords: Environmentally Friendly Technology; Environmental Law; Sustainability Policy

A. Introduction

Environmental issues are no longer peripheral concerns but have become central challenges facing industries across the globe. The aluminum sector, in particular, is recognized for its substantial environmental footprint due to high energy consumption, the emission of greenhouse gases (GHGs), and the generation of hazardous industrial waste. As the urgency to combat climate change intensifies, industrial sectors are under increasing pressure to adopt environmentally responsible practices. These include innovations in production technology,

supply chain sustainability, and emission management, all of which are essential to reducing ecological degradation and promoting long-term resilience.¹

The urgency of addressing environmental degradation is further underlined by global phenomena such as deforestation, climate-induced natural disasters, and the depletion of natural resources. These concerns have prompted various international agreements and national regulations aimed at ensuring a balance between development and sustainability.² For resource-intensive industries like aluminum production, environmental management is no longer a voluntary gesture but a mandated necessity under the law.³

In Indonesia, the industrial sector plays a critical role in economic growth, contributing significantly to GDP and employment. However, the environmental cost of this development trajectory has become increasingly apparent. The government, acknowledging the necessity for a more sustainable path, has enacted comprehensive environmental laws, notably Law Number 32 of 2009 on Environmental Protection and Management. This law mandates that every business or activity with potential environmental impact must conduct an environmental impact assessment (*Analisis Dampak Lingkungan* or AMDAL) and adhere to sustainable practices throughout its operations.⁴ The subsequent Government Regulation Number 22 of 2021 further refines implementation standards, including emissions thresholds, waste management procedures, and compliance monitoring mechanisms.⁵

PT Indonesia Asahan Aluminium (PT Inalum), as a state-owned enterprise and Indonesia's primary aluminum producer, operates at the intersection of industrial advancement and environmental responsibility. Its strategic role in national industrialization is paralleled by an equally significant obligation to align its operations with evolving environmental standards. The company's operations are highly energy-dependent, and the processes involved in aluminum smelting inherently generate air emissions, solid waste, and effluents. These operational characteristics place PT Inalum under regulatory scrutiny, particularly in the context of Indonesia's growing commitments to climate change mitigation, such as the ratification of the Paris Agreement in 2016 and the formal declaration of a Net Zero Emission (NZE) target by 2060.⁶

¹ United Nations Environment Programme (UNEP). *Global Environment Outlook 6: Healthy Planet, Healthy People* (Nairobi: UNEP, 2019).

² *Kyoto Protocol to the United Nations Framework Convention on Climate Change 1997.*

³ *Ibid.*

⁴ *Law No. 32 of 2009 on Environmental Protection and Management.*

⁵ *Government Regulation Number 22 of 2021 on Environmental Protection and Management Implementation.*

⁶ *Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC) 2016.*

To demonstrate environmental leadership, PT Inalum has undertaken various initiatives aimed at reducing its environmental impact. These include transitioning to renewable energy through the operation of the Asahan Hydroelectric Power Plant, developing gas cleaning systems to capture air pollutants, and implementing recycling technologies to manage industrial waste responsibly.⁷ These initiatives represent not only compliance with legal requirements but also efforts to align with global environmental standards and corporate sustainability principles.⁸

Nonetheless, the implementation of such technologies is far from straightforward. Industrial transformation toward sustainability is often hindered by complex and fragmented regulatory environments. Indonesia's decentralized governance system frequently results in overlapping regulations and inconsistent enforcement across regions.⁹ Furthermore, the financial burden of adopting new technologies, the limited availability of local green innovations, and bureaucratic inefficiencies pose significant obstacles to industries, including PT Inalum.¹⁰

This study focuses on the case of PT Inalum as a model to examine the broader challenges of implementing environmentally friendly technology within Indonesia's legal and institutional framework. Using a normative legal analysis coupled with a case study approach, this research aims to identify regulatory, structural, and financial factors that affect environmental compliance. In doing so, the study not only evaluates PT Inalum's internal initiatives but also provides recommendations for improving environmental governance and policy alignment in Indonesia's industrial sector.¹¹

By analyzing the gaps between legal frameworks and industrial realities, the study seeks to highlight opportunities for harmonizing environmental protection objectives with national industrial development goals. The findings are expected to contribute to the discourse on how Indonesian environmental law can evolve to effectively support sustainable industrial transformation in line with international expectations and commitments.¹²

⁷ PT Indonesia Asahan Aluminium (Inalum), "Laporan Keberlanjutan 2022," accessed September 17, 2025, <https://www.inalum.id/id/esg/hubungan-investor/laporan-berkelanjutan>.

⁸ European Aluminium Association. *Sustainability Roadmap for the Aluminium Industry in Europe* (Brussels: EAA, 2020).

⁹ Ministry of Environment and Forestry of the Republic of Indonesia. *Performance Report on Industrial Environmental Management in Indonesia* (Jakarta: KLHK, 2022).

¹⁰ World Bank. *State and Trends of Carbon Pricing 2020* (Washington DC: World Bank, 2020).

¹¹ A. T. Mulyono and R. K. Karo, "Questioning a Fair Settlement as the Legal Resolution of Global Interests," *IOP Conference Series: Earth and Environmental Science* 1270 (2023): 012025, <https://iopscience.iop.org/article/10.1088/1755-1315/1270/1/012025>.

¹² TMs Journals, "Review on Global Environmental Agreements and Legal Frameworks in Sustainable Development," *International Journal of Environmental Law* (2023).

B. Discussion

The strategic integration of environmentally friendly technologies by PT Inalum represents an important case study in industrial transformation within a legal regulatory framework. The company's reliance on hydropower from the Asahan Hydroelectric Power Plant is a notable example of renewable energy deployment in heavy industry.¹³ By prioritizing hydropower over fossil fuels, PT Inalum not only reduces its carbon intensity but also sets a precedent for other state-owned enterprises to follow.¹⁴ In this regard, the company aligns itself with Article 13 of the Paris Agreement, which encourages parties to adopt technology frameworks supportive of emission reduction.¹⁵

Emission control has also become a focal point of PT Inalum's environmental strategy. The implementation of a Gas Cleaning System (GCS) demonstrates the company's commitment to minimizing airborne pollutants, particularly sulfur dioxide and fluoride.¹⁶ These emissions are known to cause significant harm to surrounding communities and ecosystems, and their control is therefore a crucial compliance metric under Government Regulation Number 22 of 2021.¹⁷ By investing in such systems, PT Inalum not only reduces its environmental liability but also contributes to public health and air quality standards in the region.¹⁸

In terms of waste management, the company's effort to repurpose red mud—a highly alkaline and potentially toxic byproduct of aluminum refining—underscores a shift toward circular industrial practices.¹⁹ Instead of disposing of this material in landfills, which could lead to soil and water contamination, PT Inalum has piloted its use in construction materials. This innovation aligns with Sustainable Development Goal (SDG) 12 on responsible consumption and production, as well as with Indonesian waste management regulations. However, the scalability of these initiatives remains limited due to infrastructure gaps and market readiness for recycled industrial products.

Water efficiency is another critical dimension of PT Inalum's environmental strategy. Through a closed-loop water management system, the company has significantly reduced its

¹³ PT Inalum, *Laporan Keberlanjutan 2022*.

¹⁴ *Ibid.*

¹⁵ *Paris Agreement 2016*.

¹⁶ PT Inalum, *Laporan Keberlanjutan 2022*.

¹⁷ *Government Regulation Number 22 of 2021*.

¹⁸ *Ibid.*

¹⁹ PT Inalum, *Laporan Keberlanjutan 2022*.

freshwater intake and improved wastewater management.²⁰ This system mitigates the risk of contamination in nearby water bodies and aligns with best practices in resource conservation. The water-saving strategy is particularly important given that many industrial operations are located in regions facing seasonal water stress, where competition for water between industries and communities is intensifying.²¹

However, the adoption and institutionalization of these green technologies face regulatory bottlenecks. Regulatory uncertainty—stemming from overlapping mandates between the Ministry of Environment and Forestry (*Kementerian Lingkungan Hidup dan Kehutanan* or KLHK), local environmental agencies, and sector-specific ministries—has created implementation delays and compliance confusion. For example, local governments may issue permits or requirements that conflict with national standards, creating legal ambiguity for corporations. These discrepancies undermine the predictability that industries need when planning long-term investments in sustainable technology.²²

Enforcement challenges further compound these problems. Environmental laws in Indonesia often suffer from weak implementation due to under-resourced regulatory bodies, limited technical expertise, and inconsistent monitoring practices. Even when violations occur, the penalties imposed are often insufficient to deter future infractions.²³ As a result, companies that voluntarily comply with environmental standards may find themselves at a competitive disadvantage compared to non-compliant operators who externalize environmental costs without repercussions.²⁴

Financial constraints remain one of the most significant barriers to green technology adoption. The initial capital required for installing renewable energy systems, upgrading emission control infrastructure, and integrating recycling technologies can be prohibitively high. For a company like PT Inalum, which is relatively well-capitalized, these investments are achievable, but for smaller manufacturers and suppliers in the aluminum value chain, access to financing remains a serious challenge. Indonesia lacks a comprehensive green financing framework, and while initiatives like green bonds and sustainability-linked loans have been introduced, they remain underutilized.²⁵

²⁰ *Ibid.*

²¹ *Ibid.*

²² *Ministry of Environment and Forestry of the Republic of Indonesia Regulation No. 15 of 2019 on Industrial Emission Standards.*

²³ Mulyono, *Questioning*.

²⁴ *Ibid.*

²⁵ International Aluminium Institute (IAI), *Aluminium Carbon Footprint Technical Support Document* (London: IAI, 2021).

Technological dependence is another concern. Many advanced environmental technologies used by PT Inalum are imported, particularly from countries with well-established green industries such as Germany, Japan, and Canada. This reliance not only increases operational costs but also limits the domestic diffusion of green technology know-how. Furthermore, the absence of domestic R&D capabilities in this field hinders innovation and local adaptation, which are essential for ensuring long-term sustainability.²⁶

From a comparative perspective, PT Inalum's sustainability performance is commendable but still falls short of global leaders in the aluminum industry.²⁷ Companies such as Norsk Hydro, Alcoa, and Rio Tinto have embraced low-carbon smelting processes using inert anode technology and have achieved substantial reductions in carbon intensity per ton of aluminum produced. PT Inalum could benefit from benchmarking its operations against such companies and investing in collaborative ventures or technology transfers to accelerate its green transition.

Furthermore, the role of community participation in environmental oversight remains limited. Although Law Number 32 of 2009 recognizes the rights of communities to access environmental information and participate in environmental governance, in practice, public involvement is minimal. Strengthening participatory mechanisms—such as public consultations, environmental forums, and grievance redress systems—could enhance transparency and social legitimacy of PT Inalum's sustainability initiatives.²⁸ This is particularly crucial in areas where industrial operations intersect with local livelihoods, traditional land rights, and environmental justice concerns.

Another dimension worth highlighting is the growing relevance of international legal norms and soft law instruments in shaping corporate environmental behavior. As global ESG (Environmental, Social, and Governance) standards become more influential in investment decisions and trade policies, companies like PT Inalum are increasingly expected to comply not only with domestic law but also with international best practices. Failure to align with these expectations could result in reputational damage, restricted market access, or reduced investor confidence.

Institutionally, Indonesia needs stronger inter-agency coordination to streamline environmental governance. The current legal landscape is fragmented, with various ministries, such as the Ministry of Industry, the Ministry of Energy and Mineral Resources, and KLHK,

²⁶ European Aluminium Association, *Sustainability Roadmap*.

²⁷ *Ibid.*

²⁸ PT Inalum, *Laporan Keberlanjutan 2022*.

issuing overlapping or conflicting guidelines. Establishing a centralized environmental compliance monitoring body—integrated with digital reporting systems—could significantly improve data consistency, reduce administrative burdens, and enhance law enforcement efficiency. Additionally, regular capacity building for government inspectors and legal professionals is needed to interpret and apply environmental law in a technically sound and context-sensitive manner.

In conclusion, while PT Inalum has made demonstrable progress in its adoption of environmentally friendly technologies, sustaining and expanding this progress will require overcoming structural, legal, and financial challenges.²⁹ More coherent and predictable regulations, access to green finance, increased R&D investments, international collaboration, and empowered community engagement are key components for long-term environmental governance in Indonesia's aluminum industry.

PT Inalum has demonstrated substantial progress in integrating environmentally friendly technologies into its operations. This includes the utilization of renewable energy from the Asahan Hydroelectric Power Plant (*Pembangkit Listrik Tenaga Air* or PLTA), the deployment of emission control measures such as the Gas Cleaning System (GCS), and the implementation of industrial waste recycling initiatives. These efforts reflect the company's proactive approach to reducing its environmental footprint and aligning with national environmental regulations.³⁰

PT Inalum's environmental performance demonstrates a commendable degree of initiative in addressing the environmental consequences of aluminum production. The company's reliance on renewable energy through the Asahan Hydroelectric Power Plant represents a significant shift toward carbon-neutral energy sourcing in an energy-intensive industry.³¹ Likewise, the implementation of a Gas Cleaning System (GCS) has significantly contributed to the reduction of airborne pollutants such as sulfur dioxide and fluoride—both of which have direct implications for air quality, public health, and compliance with regulatory thresholds outlined in Government Regulation Number 22 of 2021.³²

Furthermore, the company's efforts in solid waste management, particularly the repurposing of red mud into construction material, demonstrate alignment with circular

²⁹ *Ibid.*

³⁰ PT Inalum, *Laporan Keberlanjutan 2022*.

³¹ *Ibid.*

³² *Government Regulation Number 22 of 2021 on Environmental Protection and Management Implementation.*

economy principles.³³ Such practices are consistent with both Sustainable Development Goal (SDG) 12 on sustainable consumption and production, and national environmental targets articulated in Indonesia's Long-Term Development Plan (*Rencana Pembangunan Jangka Panjang* or RPJP). These initiatives, when viewed collectively, signal PT Inalum's increasing recognition of the need to integrate sustainability into its operational DNA, rather than treating environmental compliance as a peripheral obligation.³⁴

Nevertheless, the findings also expose persistent and systemic challenges that hinder the full realization of environmentally responsible industrial practices. Chief among these is the fragmented and often inconsistent enforcement of environmental laws. Despite comprehensive legislation such as Law Number 32 of 2009, the practical application of environmental regulations remains uneven due to limited institutional capacity, overlapping regulatory mandates, and weak inter-agency coordination.³⁵ For example, contradictions between regional and national permitting processes continue to create legal ambiguities and operational inefficiencies, ultimately discouraging proactive investment in green infrastructure.³⁶

The enforcement deficit is compounded by a lack of punitive strength. In cases of environmental non-compliance, penalties are often lenient and do not reflect the environmental and social costs incurred. This has led to a regulatory climate where compliance is seen as optional, and where companies willing to invest in green technologies—such as PT Inalum—are not adequately incentivized or rewarded. In this context, the absence of clear financial mechanisms such as carbon pricing, green tax reform, or sustainability-linked lending further limits the diffusion of environmentally friendly technologies across the industrial sector.³⁷

From an economic standpoint, green industrial transformation in Indonesia is hampered by high technology costs and limited domestic R&D capacity. Many of the technologies deployed by PT Inalum—such as the GCS system or waste recovery technologies—are imported, raising the costs of implementation and reducing opportunities for local innovation. This reliance on imported systems also implies limited knowledge transfer, thereby inhibiting the development of a skilled domestic workforce capable of maintaining and advancing green

³³ Kementerian Lingkungan Hidup dan Kehutanan, *Kajian Implementasi Prinsip Ekonomi Sirkular di Sektor Industri* (Jakarta: KLHK, 2022).

³⁴ United Nations, "Sustainable Development Goal 12: Ensure Sustainable Consumption and Production Patterns," accessed September 17, 2025, <https://sdgs.un.org/goals/goal12>

³⁵ Bappenas, *Rencana Pembangunan Jangka Panjang Nasional (RPJPN) 2005–2025 dan Pembaruan Arah Pembangunan Jangka Panjang Berkelanjutan* (Jakarta: Bappenas, 2020).

³⁶ Law No. 32 of 2009 on Environmental Protection and Management.

³⁷ A. Suryadi, "Weak Enforcement in Indonesian Environmental Law: Institutional and Structural Barriers," *Indonesian Journal of Environmental Law* 6, no. 1 (2020): 45–60.

technologies.³⁸ Without dedicated public investment in environmental innovation ecosystems—such as national green tech incubators or university-industry collaboration hubs—this technological dependence is likely to persist.³⁹

Internationally, the role of global environmental governance frameworks cannot be overstated. The Paris Agreement, Kyoto Protocol, and various conventions under the United Nations Framework Convention on Climate Change (UNFCCC) have established a global normative framework that exerts soft but significant influence on national regulatory systems.⁴⁰ PT Inalum's commitment to renewable energy use and emission reduction reflects an awareness of these frameworks and Indonesia's national obligations under them. However, the lack of direct legal linkages between international norms and domestic enforcement weakens the integrative potential of global environmental law, particularly in decentralized governance settings like Indonesia.⁴¹

In comparing PT Inalum with international industry leaders, a performance gap remains evident. Multinational aluminum producers such as Alcoa and Norsk Hydro have implemented low-carbon smelting technologies, adopted AI-based energy management systems, and committed to science-based emission reduction targets. These companies benefit from supportive policy environments in their respective jurisdictions, which include carbon pricing schemes, dedicated green infrastructure funds, and streamlined regulatory processes. Indonesia's current regulatory and financial ecosystem has yet to reach such maturity, leaving domestic enterprises like PT Inalum to navigate a challenging operational landscape with limited state support.⁴²

The analysis also brings to attention the socio-environmental dimension of industrial operations. Although legal compliance forms the backbone of environmental governance, public participation, transparency, and community engagement are equally critical. Law Number 32 of 2009 mandates that communities have the right to information and to be involved in environmental decision-making processes. However, in practice, local stakeholders are often excluded from meaningful dialogue, and environmental impact assessments (AMDAL) are

³⁸ N. Fatimah, "Legal Uncertainty in Environmental Licensing in Indonesia: The Clash between Central and Regional Authority," *Journal of Law and Policy Reform* 12, no. 3 (2019): 89–102.

³⁹ R. Nurhidayat and A. Prasetyo, "Evaluasi Sanksi Administratif terhadap Pelanggaran Lingkungan di Indonesia," *Jurnal Hukum Lingkungan* 5, no. 2 (2021): 133–148.

⁴⁰ OECD, *Green Growth Policy Review of Indonesia* (Paris: OECD Publishing, 2021).

⁴¹ *Ibid.*

⁴² R. P. Sari and F. Hutagalung, "Public Participation in Environmental Impact Assessment (AMDAL) Process in Indonesia: Legal Reality and Practice," *Journal of Environmental Policy and Law* 17, no. 1 (2020): 102–115.

conducted in a top-down manner.⁴³ For PT Inalum, strengthening mechanisms for community engagement could improve trust, foster social license to operate, and reduce conflict with local populations, particularly in areas where traditional land rights or resource access are affected.⁴⁴

Institutionally, the way forward requires not only legislative reform but a more holistic transformation of Indonesia's environmental governance paradigm. This includes capacity-building for local environmental agencies, harmonization of national and subnational regulatory frameworks, digitalization of monitoring systems, and cross-sectoral policy integration that aligns environmental, industrial, and fiscal goals.⁴⁵ Equally important is the creation of a dedicated green industry roadmap—backed by measurable targets, timelines, and inter-ministerial coordination mechanisms—to guide Indonesia's transition to a low-carbon economy.⁴⁶

In light of these findings, several policy recommendations can be reaffirmed and further specified. First, regulatory harmonization should be pursued through the establishment of a centralized legal framework that overrides conflicting regional regulations while ensuring consistency in environmental standards across provinces.⁴⁷ Second, fiscal and non-fiscal incentives must be introduced to lower the financial burden of adopting sustainable technologies. This may include tax deductions for green R&D, accelerated depreciation for environmental equipment, and government guarantees for sustainability-linked bonds.⁴⁸

Third, law enforcement mechanisms should be reinforced through independent audit agencies, public disclosure of compliance data, and performance-based penalties that reflect the true cost of environmental damage. Fourth, Indonesia must invest in building domestic capacity for green technology through enhanced funding for environmental research, university-industry partnerships, and national training programs for environmental engineers and compliance professionals.⁴⁹

Finally, the government and key stakeholders should work together to establish a public-private sustainability platform for the aluminum industry. This platform would serve as a collaborative space for sharing best practices, addressing systemic challenges, and

⁴³ R. Anderson and A. Wicaksono, "Social License to Operate and Indigenous Rights in Resource-Dependent Regions of Indonesia," *Asia Pacific Journal of Environmental Law* 22, no. 3 (2019): 187–204.

⁴⁴ *Ibid.*

⁴⁵ Bappenas, *Integrasi Kebijakan Sektor untuk Mendukung Transisi Ekonomi Hijau di Indonesia* (Jakarta: Bappenas, 2023).

⁴⁶ Kementerian Perindustrian, *Peta Jalan Industri Hijau Nasional 2022–2030* (Jakarta: Kementerian Perindustrian, 2022).

⁴⁷ *Ibid.*

⁴⁸ OECD, *Incentives for Green Innovation: A Toolkit for Developing Countries* (Paris: OECD Publishing, 2021).

⁴⁹ Bappenas, *Roadmap Inovasi Teknologi Lingkungan 2023–2045* (Jakarta: Bappenas, 2023).

coordinating pilot projects that align environmental goals with industrial competitiveness.⁵⁰ PT Inalum, given its scale and public ownership, could serve as the anchor institution for such a platform.

In conclusion, PT Inalum stands at a pivotal juncture—one where past progress must be accelerated through structural, regulatory, and technological reforms. The company's journey reflects both the promise and the complexity of achieving industrial sustainability in a developing country context.⁵¹ While regulatory compliance remains essential, the broader vision must be to position PT Inalum as a pioneer of green industrial transformation in Indonesia and beyond. Achieving this will require coordinated action from policymakers, industry leaders, civil society, and international partners, all working toward a shared goal of environmental resilience, economic prosperity, and social equity. Beyond the internal adjustments required within PT Inalum and the industrial sector more broadly, the state's role remains indispensable in orchestrating a coordinated and long-term green transition. A fundamental reorientation of national development priorities is needed—one that places environmental sustainability at the core of Indonesia's industrialization model. The case of PT Inalum shows that technological adaptation is possible and already underway, but institutional inertia and insufficient cross-sectoral collaboration continue to hamper broader structural reform.⁵²

Equally important is the integration of environmental governance with Indonesia's energy transition agenda. PT Inalum, as a major industrial energy consumer, plays a strategic role in the state's plan to decarbonize the national energy mix. The company's use of hydropower sets a strong example of industrial alignment with renewable energy sources. However, Indonesia's broader dependency on coal-fired power plants still presents a contradiction to long-term emission reduction goals. Therefore, companies like PT Inalum should not only align their internal energy use but also advocate for and support national policy shifts toward clean energy infrastructure and grid decarbonization. From a regional perspective, Indonesia can also learn from neighboring countries in Southeast Asia that are advancing in environmental policy integration. For example, Malaysia's Green Technology Master Plan and Thailand's Bio-Circular-Green (BCG) Economy Model demonstrate how environmental objectives can be institutionalized across ministries and linked to trade, finance, and education.

⁵⁰ World Economic Forum, *Public-Private Collaboration for Green Industrial Transformation* (Geneva: WEF, 2021).

⁵¹ United Nations Industrial Development Organization (UNIDO), *Green Industry Platform: A Global Initiative to Advance Sustainable Industrialization* (Vienna: UNIDO, 2022).

⁵² *Ibid.*

While each country's context differs, Indonesia could adapt similar integrative frameworks to reinforce alignment between its environmental laws and industrial development goals. Moreover, fostering ASEAN-level cooperation on industrial sustainability—such as through a regional green technology innovation fund—could accelerate the collective shift toward low-carbon economies.⁵³

Another critical point to emphasize is the importance of environmental transparency and data governance. Reliable, publicly accessible environmental data remain scarce in Indonesia, limiting accountability, inhibiting civil society participation, and weakening the feedback loop necessary for regulatory improvement. For PT Inalum, publishing detailed sustainability metrics aligned with international standards such as the Global Reporting Initiative (GRI) or the Task Force on Climate-related Financial Disclosures (TCFD) would not only enhance its corporate credibility but also help establish best practices across the sector. Digital platforms that allow real-time environmental monitoring and public access to compliance data can also serve as powerful tools for community empowerment and environmental justice. Furthermore, human capital development must be recognized as a pillar of sustainable industrial transformation. Indonesia's technical workforce needs to be upskilled to handle green technologies, conduct environmental audits, and manage sustainability reporting. Universities and vocational institutions should align their curricula with evolving green industry needs. For PT Inalum, partnering with higher education institutions to create sustainability-focused internships, scholarships, and joint research initiatives would create a pipeline of environmental professionals while simultaneously fostering a culture of innovation.⁵⁴

In addition, the role of civil society and local communities must be strengthened in shaping the environmental performance of industries. Mechanisms for social oversight—such as independent environmental watchdogs, participatory AMDAL forums, and community-based monitoring—should be institutionalized and well-resourced. Ensuring that affected communities are not merely consulted but also meaningfully involved in decision-making processes can reduce conflict, build social capital, and ensure that sustainability initiatives reflect local needs and values. PT Inalum has the opportunity to be a pioneer in advancing

⁵³ *Regional Cooperation on Green Technology and Circular Economy in ASEAN* (2023).

⁵⁴ Kementerian Pendidikan, Kebudayaan, Riset dan Teknologi, *Program Kampus Merdeka: Inovasi Hijau dan Kemitraan Industri* (Jakarta: Kemdikbudristek, 2023).

corporate-community environmental co-governance, especially in North Sumatra where its operations are located.⁵⁵

A forward-looking approach would also consider the intersection of gender, environment, and industry, which remains largely overlooked in policy and practice. Research has shown that women and marginalized groups are often disproportionately affected by environmental degradation but underrepresented in formal decision-making structures. Therefore, a truly inclusive green transition requires that gender equity and social inclusion be mainstreamed into environmental policy, workforce planning, and community engagement strategies—both at PT Inalum and across the industrial sector. Lastly, in the context of post-pandemic recovery and green economy transformation, PT Inalum's commitment to environmentally friendly technology places it in a unique position to lead Indonesia's industrial reorientation toward sustainability. The COVID-19 pandemic has underscored the fragility of global supply chains and the importance of building domestic resilience. Investing in green infrastructure, technology innovation, and sustainable supply chains not only addresses environmental risk but also creates new economic opportunities, diversifies export potential, and attracts impact-oriented investment.⁵⁶

C. Conclusion

PT Inalum's experience illustrates both the potential and complexity of embedding environmental responsibility in industrial operations. The company's actions provide an emerging model of how state-owned enterprises in Indonesia can align with national and international environmental expectations. However, realizing this vision on a systemic scale requires structural reform, policy coherence, and multi-level governance improvements. To move forward, a multi-pronged strategy is necessary—one that includes: strengthening legal and institutional clarity; embedding environmental responsibility into national industrial strategies; establishing enabling financial mechanisms; fostering inclusive and participatory environmental governance; and cultivating a culture of innovation and sustainability leadership. Through these concerted efforts, not only can PT Inalum advance its own

⁵⁵ R. Sihombing, "Community Engagement in Resource Extraction Zones: The Case of North Sumatra," *Journal of Regional Development* 19, no. 2 (2021): 45–60.

⁵⁶ "From Recovery to Resilience: The Development Response to COVID-19 in East Asia," ASEAN, 2021, <https://asean.org/wp-content/uploads/2024/05/The-ASEAN-Issue-No.-37-From-Recovery-to-Resilience-1.pdf>.

environmental performance and industrial competitiveness, but it can also serve as a catalyst for Indonesia's broader transformation toward a green and just economy. In the global context of escalating climate crises and shifting trade standards, such leadership is not only desirable—it is imperative.

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