Oikonomia:Jurnal Manajemen

Volume 22, No. 1
Jan 2026, pp. 1-16

http://journal.unas.ac.id/oikonamia/index

Strategic Gaps in Indonesia's Nickel and Electric Vehicle Battery Downstreaming: Implications for Investment Readiness

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Received 10 December 2025 /accepted 24 March 2026 /available online 2 May 2026

Article type: Short/Brief Report

DOI http://dx.doi.org/10.47313/oikonomia.v22i1.4454

ABSTRAK

Tujuan-Studi ini mengkaji kesenjangan strategis yang memengaruhi kesiapan investasi dalam ekosistem hilirisasi nikel dan baterai kendaraan listrik (EV) di Indonesia. **Metodologi-** Studi ini menggunakan desain deskriptif kualitatif dengan pendekatan komparatif. Data diperoleh dari dokumen kebijakan dan industri, literatur akademis, tolok ukur internasional (mencakup Tiongkok, Korea Selatan, Chili, Australia, dan Republik Demokratik Kongo), serta wawancara dengan dua informan kunci industri. Public Governance Canvas dioperasionalkan menjadi Investment–Governance Canvas untuk menganalisis kondisi regulasi, kelembagaan, pembiayaan, dan kesiapan proyek. **Temuan-** Enam kesenjangan utama yang saling terkait meliputi pendanaan, teknologi, energi dan ESG, regulasi dan kelembagaan, modal manusia, serta infrastruktur dan logistik. Kesenjangan pendanaan tidak hanya mencerminkan keterbatasan modal, tetapi juga risiko non-keuangan yang menurunkan kelayakan pembiayaan proyek. Kebaruan studi ini adalah mengintegrasikan seluruh kesenjangan tersebut dalam perspektif kesiapan investasi. **Saran-** Penelitian di masa mendatang sebaiknya melibatkan pemangku kepentingan yang lebih luas dan mengembangkan indikator kesiapan investasi yang terukur di berbagai proyek dan

Kata kunci: Hilirisasi nikel; baterai EV; kesiapan investasi; tata kelola investasi; kesenjangan strategis.

ABSTRACT

Purpose *This study examines the strategic gaps affecting investment readiness in Indonesia's nickel and electric vehicle (EV) battery downstreaming ecosystem.* ***Methodology:*** *The study employed a qualitative descriptive design with a comparative approach. Data were obtained from policy and industry documents, academic literature, international benchmarking of China, South Korea, Chile, Australia, and the Democratic Republic of the Congo, and interviews with two key industry informants. The Public Governance Canvas was operationalized as an Investment–Governance Canvas to analyze regulatory, institutional, financing, and project-readiness conditions.* ***Findings*** *Six interrelated gaps were identified: financing, technology, energy and ESG, regulatory and institutional arrangements, human capital, and infrastructure and logistics. The financing gap reflects not only limited capital, but also unresolved non-financial risks that weaken project bankability. The study's novelty lies in integrating these gaps within an investment-readiness perspective rather than treating them as isolated constraints.* ***Suggestion*** *Future research should involve broader stakeholders and develop measurable indicators of investment readiness across projects and regions.*

Keywords*: nickel downstreaming; EV battery; investment readiness; investment governance; strategic gaps.*

p-ISSN: 0215-143X | e-ISSN: 2797-8966

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INTRODUCTION

The move to electric mobility globally has increased the strategic importance of critical minerals and has in turn accelerated the development of EV battery supply chains. Nickel is a key mineral in this transition, being used in the NMC and NCA cathode chemistries for lithium-ion batteries. The growth of the EV market has seen mineral producing countries looking to get more involved in battery manufacturing and in other high value industrial activities. The development of a competitive battery supply chain is not simply a matter of having the minerals. It's about having the technology, the industrial base, the investment and the integration of production across the value chain. Konewka et al. (2021) stress the need for Indonesia to develop competitive advantages in its nascent EV battery industry through foreign investment, industrial partnerships and technological development. Nurdiawati and Agrawal (2022) point out that battery value chain development must take into account the technology, the materials and the end of life in order to ensure long term industrial sustainability. These points all underline the importance of looking at battery industrialisation as an integrated process which encompasses the availability of resources, the capability to manufacture and the changing technology.

Indonesia is well positioned in the global battery industry because of its huge nickel endowment and mineral processing capacity. Still, mineral processing capacity alone is not sufficient to create an integrated domestic battery manufacturing ecosystem. The government's downstreaming strategy, which bans unprocessed nickel exports and promotes domestic processing and battery manufacturing, is intended to build a more integrated battery value chain. Pandyaswargo et al (2021) note that the ban on nickel ore exports has led to a boom in downstream activity and has been a significant driver of investment in the EV and battery sectors. Lahadalia et al (2024) point out that the downstreaming strategy is designed to increase domestic value creation through industrial policy and to build sustainability into EV industry development. Moving on to higher value activities (i.e. battery grade material processing, cathode manufacturing, battery cell manufacturing and recycling) will require advanced technology, good industrial infrastructure, market access and good coordination between the various institutions and industry players. Any assessment of Indonesia's nickel downstreaming industry should therefore focus not just on processing capacity but on the ecosystem's ability to support investment across the full battery value chain.

The development of Indonesia's battery ecosystem will depend on more than foreign and institutional collaboration. It will also depend on whether those partnerships build domestic capabilities. Astuti and Putra (2024) analyze the collaboration between Indonesia Battery Corporation (IBC) and Hyundai in the development of the EV battery industry, showing that cooperation among state-owned enterprises, foreign investors and technology providers facilitates the formation of an integrated battery value chain. Their discussion also points to the need for domestic technological capability and coordination to integrate the various stages of production. Haryadi et al. (2024) identify technological capability, skilled labour and supporting infrastructure as key factors in increasing Indonesia's competitiveness in the global battery market. Konewka et al. (2021) similarly argue that while FDI can provide access to capital and technology, sustainable competitive advantage will ultimately depend on the domestic industry's ability to strengthen its position within the global production

network. In sum, while Indonesia's nickel resources and FDI provide a basis for industrial development, an integrated battery ecosystem will only be possible through complementary domestic capabilities and effective coordination across the value chain.

Beyond industrial capacity, Indonesia's nickel downstreaming strategy faces growing uncertainty from technological shifts and evolving battery-market demand. Although nickel-based batteries remain relevant for applications requiring higher energy density, lithium iron phosphate (LFP) batteries have gained market acceptance because of their cost advantages and suitability for various EV applications. Unlike NMC and NCA batteries, LFP batteries do not require nickel or cobalt in their cathode materials. Nurdiawati and Agrawal (2022) show that changes in battery technology and material composition can substantially shape future mineral requirements and battery value-chain development. In the Indonesian context, Wijayanto et al. (2024) highlight the implications of increasing LFP battery adoption for a downstreaming strategy that relies heavily on nickel as its principal resource advantage. These technological developments add complexity to investment planning because the commercial viability of nickel-based battery projects depends on alignment among production capabilities, battery chemistry, and market demand. Consequently, investment in nickel-processing and battery manufacturing facilities must account not only for current technological requirements but also for how changing battery technologies could affect future material demand and industrial competitiveness.

Beyond technological and market uncertainties, Indonesia's nickel downstreaming industry faces governance, international investment, and industrial coordination challenges. Wijaya and Sinclair (2025) examine the relationship between resource-based industrialization, state intervention, and international investment in Indonesia's EV battery industry, illustrating the complex interactions among government institutions, domestic industrial actors, and foreign companies in the development of battery value chains. From a geopolitical perspective, Soamole (2025) examines Indonesia's nickel downstreaming strategy in relation to foreign investment, global production networks, and the country's position within the international EV battery industry. These studies highlight the importance of understanding downstream industrialization within broader institutional and international economic relationships. However, expanding investment and industrial partnerships also requires coordination among regulatory institutions, technology providers, financing entities, and project developers. Differences in institutional responsibilities, technological capabilities, and industrial development priorities may complicate implementing integrated investment projects. Accordingly, investment governance must address not only attracting capital but also the institutional and operational conditions needed to translate investment commitments into functioning industrial facilities.

Environmental sustainability is another major issue in the development of

Indonesia's nickel and EV battery ecosystem. The environmental advantages of electric mobility have to be balanced against the environmental impacts of mining, processing, energy use and battery manufacturing. Hardiyan et al. (2025) look at the environmental implications of Indonesia's EV policy and stress the need for the development of electric mobility to be in line with sustainability and conservation. Wijayanto et al. (2024) likewise point to energy efficiency, use of renewable energy and sustainable recycling as key elements of environmentally sound nickel industrialisation. Based on stakeholder interviews and an analysis of the nickel supply chain, Malik (2024) identifies a number of environmental and social issues relating to the expansion of nickel mining and processing and highlights the importance of good governance, supply chain transparency and responsible industry practices. The upshot of all this is that environmental sustainability should be an integral part of the assessment of downstream industrial development rather than a separate issue. For investment projects the availability of appropriate energy infrastructure, environmental management capability and compliance with relevant sustainability requirements could all have an impact on project implementation costs, operational risk and access to international markets. Environmental and energy related factors are therefore key considerations in the assessment of the readiness of nickel downstreaming projects.

The earlier work has looked at a number of different aspects of Indonesia's nickel and EV battery downstreaming industry. There's been work on industrial policy and the development of domestic battery manufacturing (Pandyaswargo et al., 2021; Lahadalia et al., 2024), international partnerships and the competitiveness of the industry (Konewka et al., 2021; Astuti & Putra, 2024; Haryadi et al., 2024), the technology and the changing requirements for battery materials (Nurdiawati & Agrawal, 2022; Wijayanto et al., 2024), investment governance and the broader international economic context (Wijaya & Sinclair, 2025; Soamole, 2025) and the environmental impacts of nickel based industrialisation (Malik, 2024; Hardiyan et al., 2025). All of this is of course very useful in terms of understanding the development of the downstreaming industry. The problem is that the earlier work tends to look at the various aspects in isolation. It doesn't really address the issue of how a gap in one area might impact the investment readiness of another. This is particularly relevant in a capital intensive industry where you have to consider technological viability, regulatory certainty, operational readiness, environmental compliance and market potential as well as the availability of finance.

This study examines the strategic gaps affecting investment readiness in Indonesia's nickel and EV battery downstreaming ecosystem. It highlights that investment interest does not always mean a project is ready to implement, as issues like unresolved licensing, technology gaps, infrastructure needs, and human capital deficiencies can delay progress. The assessment, based on a 2025 qualitative study using document analysis, international benchmarking, and

interviews, reviews six strategic areas: funding, technology, ESG, regulatory arrangements, human capital, and infrastructure. The Public Governance Canvas framework is used to explore how these factors interact and impact project implementation. The goal is to provide a holistic understanding of investment constraints and offer insights for developing a more integrated and sustainable downstreaming ecosystem in Indonesia.

METHODOLOGY

Research Design and Analytical Framework

This study employed a qualitative descriptive design with a comparative approach to examine strategic gaps in Indonesia's nickel and electric vehicle (EV) battery downstreaming ecosystem and their implications for investment readiness. A qualitative descriptive design was adopted to facilitate a contextual examination of industrial conditions, governance arrangements, and implementation constraints while keeping the interpretation closely connected to the available evidence (Sandelowski, 2010). The comparative component was used to examine international approaches to industrial development and investment governance as a basis for identifying relevant lessons for Indonesia.

The study used the Public Governance Canvas (PGC) as its principal analytical framework. In the context of nickel and EV battery downstreaming, the PGC was operationalized as an Investment–Governance Canvas to examine the relationships among industrial actors, institutional arrangements, resources, financing mechanisms, and project implementation. The analysis focused on four interacting governance domains: regulation, institutional coordination, financing and risk-reduction mechanisms, and project readiness and implementation. This framework enabled the study to examine how conditions across the downstreaming ecosystem may facilitate or constrain the preparation and execution of investment projects.

Data Sources and Collection

The study drew on documentary evidence and two key informant interviews conducted in 2025. Documentary sources included government policy documents, institutional publications, industry reports, statistical data, and relevant academic literature concerning nickel downstreaming, battery manufacturing, investment governance, and the EV supply chain. The documents were examined to establish the industrial and regulatory context, identify reported constraints, and assess the conditions affecting downstream investment. Document analysis was used as a systematic procedure for selecting, examining, and interpreting relevant documentary evidence (Bowen, 2009).

International benchmarking was conducted through a comparative review of documentary sources concerning China, South Korea, Chile, Australia, and the Democratic Republic of the Congo. The comparison focused on industrial and investment governance practices relevant to Indonesia, including institutional coordination, financing arrangements, technological development, market access, and sustainability requirements. Benchmarking findings were used to contextualize Indonesia's downstreaming conditions and identify relevant approaches to addressing investment-related constraints.

The documentary assessment was complemented by two interviews with informants directly involved in the battery industry. The first interview, conducted on 23 December 2025, involved a representative of a domestic battery industry institution (KI-01). The second interview, conducted on 24 December 2025, involved a representative of an international battery technology company (KI-02). The interviews were used to obtain informed perspectives on industrial coordination, technology and supply-chain integration, market demand, investment requirements, and project implementation challenges. The selection of informants was based on the relevance of their institutional knowledge and practical involvement in the issues under investigation, consistent with the use of expert interviews to obtain specialized and process-related knowledge (Bogner et al., 2018). To protect the informants' identities, their names, specific positions, and organizational affiliations are not disclosed in this article.

Data analysis

Data analysis combined documentary review, international benchmarking, and interpretation of the key informant interviews. Documentary evidence was examined to identify conditions and constraints affecting Indonesia's nickel and EV battery downstreaming ecosystem. The study organized and compared relevant information across sources to develop an integrated account of the industrial, institutional, and investment-related issues under investigation. The analysis of documents was informed by Bowen's (2009) discussion of the systematic examination, selection, and interpretation of documentary evidence.

The findings were synthesized into six strategic gap dimensions: funding; technology; energy and environmental, social, and governance (ESG) requirements; regulatory and institutional arrangements; human capital; and infrastructure and logistics. Within each dimension, the analysis examined the conditions reported in the available evidence, the requirements associated with downstream industrial development, and the constraints that could affect investment preparation or project implementation. Particular attention was given to relationships among the dimensions, including how regulatory and institutional conditions may influence financing, how technological and workforce capabilities may affect operational preparedness, and how energy, ESG, and infrastructure requirements may shape project implementation.

The Investment–Governance Canvas connected the identified gaps to the four governance domains: regulation, institutional coordination, financing and risk reduction, and project readiness and implementation. International benchmarking findings provided comparative context, while the interview accounts and documentary evidence were examined together to deepen the interpretation of investment-related constraints and identify issues less apparent in published sources. Where interview accounts and documentary sources differed, the information was assessed in light of its source and context rather than treated as interchangeable evidence.

The resulting synthesis assessed the implications of the identified gaps for investment readiness, defined in this study as the alignment of institutional, financial, technological, operational, and market-related conditions needed to support project preparation and implementation. The analysis was interpretive rather than a statistical test of relationships among the gap dimensions. Given the limited number of interviews, informant accounts provided contextual insight and were not treated as representative

of all actors in Indonesia's downstreaming industry.

DISCUSSION

Strategic Gaps in Indonesia's Nickel–EV Battery Downstreaming Ecosystem

The study identified six interlinked strategic gaps in Indonesia's nickel and EV battery downstreaming: funding; technology; energy and environmental (ESG); regulatory and institutional arrangements; human capital; and infrastructure and logistics. These gaps have been derived from a combined analysis of documentary evidence, international benchmarking and key informant interviews. They are not independent of each other; together, they determine how far downstream a project can go from policy commitment/investment intention to a bankable, executable project.

The funding gap is not simply a case of lack of capital. The evidence suggests that difficulties in securing finance often come down to unaddressed project risk. Projects in cessing and battery materials, in particular, will require significant development cycles and need financing that can address various forms of technological, construction, operational, market, regulatory, etc. Where permits, energy, logistics, market access, and technical standards are in doubt, risk premiums are high and conventional finance will be difficult to obtain or very expensive. Funding is therefore best viewed as a bankability issue, where access to finance depends in part on the state of readiness of the non-financial project conditions.

The technology gap is about Indonesia's ability to go beyond just expanding its mineral processing capacity to actually develop deeper technological capabilities in the battery space. The study shows that Indonesia is still very much dependent on foreign technology and foreign expertise for the more advanced processing. The domestic capacity in the areas of testing, pilot scale, advanced labs and technology adaptation is very limited. The issue is therefore not so much about access to technology per se as it is about the ability to absorb, adapt, improve and ultimately develop technology that is capable of responding to changes in battery chemistry and market demands. That's a significant issue as the commercial value of nickel is going to be heavily dependent on the evolution of the battery technology itself (the competition between nickel rich chemistries and LFP being a case in point).

The energy and ESG gap represents another critical constraint. Downstream mineral processing is energy intensive, while international battery markets increasingly emphasize carbon intensity, traceability, responsible sourcing, and environmental performance. The study found tension between the need for reliable, cost-competitive energy and the growing requirement for lower-carbon production. This tension affects not only environmental performance but also commercial and financial viability because energy reliability and ESG compliance increasingly influence access to global markets and investment. Interviews conducted for the study also indicated that uncertainty regarding green thresholds or the economic value of cleaner production can complicate long-term investment decisions.

The regulatory and institutional gap pertains to policy coherence and coordination among institutions. The findings reveal substantial fragmentation across regulatory

domains and levels of government, including implementation, technical standards, local content requirements, and project support arrangements. This fragmentation elevates non-technical project risk, as investors must assess both the formal regulatory regime and the predictability and coordination of its implementation. As a result, regulatory uncertainty may influence project timelines, infrastructure decisions, financing, and market strategies.

The human capital gap is closely associated with the technology gap. The study indicates that the supply of skilled technicians, operators, engineers, and specialists in advanced processing and battery materials remains insufficient relative to the requirements for advanced downstream development. Consequently, reliance on foreign expertise continues, and technology and knowledge transfer have not always been adequately institutionalized to foster sustainable domestic capability. This condition increases operational risks and may impede technological advancement.

The final issue concerns the infrastructure and logistics gap, which encompasses the condition of the transport network, ports, industrial utilities, water supply, energy systems, and other supporting infrastructure. Assessment of a downstream project cannot be based solely on its processing capacity; the project's success also depends on the availability of broader industrial infrastructure. In regions where infrastructure development lags behind industrial growth, higher costs and increased uncertainty in project implementation are likely. Therefore, infrastructure readiness constitutes a critical component of investment readiness, rather than merely representing a physical asset.

Table 1. Strategic Gaps and Their Implications for Investment Readiness

Strategic gap	Main finding	Implication for investment readiness
Funding	Financing constraints reflect project risk and limited availability of suitable de-risking mechanisms, not only capital scarcity.	Weakens bankability and increases financing costs.
Technology	Advanced processing and battery-related capabilities remain dependent on foreign technology, with limited domestic testing, adaptation, and innovation capacity.	Increases technology and operational risk and limits deeper value-chain upgrading.
Energy and ESG	Reliable and competitive energy must increasingly be reconciled with carbon, traceability, and sustainability requirements.	Affects operating costs, ESG compliance, market access, and financing.
Regulatory and institutional	Policy implementation and coordination remain fragmented across institutions and regulatory domains.	Raises non-technical risk and reduces predictability for investors.
Human capital	Skilled personnel for advanced	Increases operational

	processing and battery-material activities remain insufficient, while knowledge transfer is not yet fully institutionalized.	dependence and constrains technology absorption.
Infrastructure and logistics	Supporting utilities and logistics do not always develop at the same pace as downstream facilities.	Raises project costs and delays implementation.

These findings broadly align with previous work on Indonesia's EV battery ecosystem. Pandyaswargo et al. (2021) found that Indonesia's nickel endowment and export restrictions create opportunities to develop a domestic EV battery industry, although technological, infrastructural, and industrial capability constraints remain significant (Konewka et .al., 2021) similarly point to the need for foreign investment, technological capability, partnerships, and government support to build Indonesia's position in the regional EV battery value chain (Haryadi et .al., 2024) identify technology mastery, human resource capability, infrastructure, and regulatory consistency as key areas where Indonesia needs to improve to strengthen its competitiveness in the global battery market.

These findings align with evidence from other emerging battery ecosystems. In the Indian context, Dhairiyasamy et al. (2024) identify massive investment needs, rapidly evolving technologies, infrastructure constraints, fragmented supply chains, environmental issues, and a lack of skilled workforce as interlocking problems. They note that battery manufacturing requires investment in infrastructure, advanced technology, and human capital simultaneously, rather than intervention in any one element in isolation. So Indonesia's problem isn't the lack of individual industrial assets. The real issue is whether the pieces needed for downstream development are in place to create an investable ecosystem.

Interconnections Among Strategic Gaps and Investment Readiness

A central finding of this study is that the six strategic gaps should not be interpreted independently. The downstreaming ecosystem functions as an interconnected system in which weakness in one domain can amplify risks in another. In particular, the evidence suggests that regulatory and institutional uncertainty, inadequate enabling infrastructure, energy and ESG requirements, technological capability, and human capital ultimately affect projects' risk profile and, therefore, their ability to obtain financing.

This interpretation changes the way the funding gap should be understood. Rather than treating finance as an isolated input that can be resolved primarily through additional lending or investment incentives, the results indicate that financing becomes more accessible when fundamental project risks are reduced. A project with unclear permitting, uncertain energy supply, inadequate logistics, unproven technological capability, or insufficient market absorption is inherently harder to finance, regardless of the nominal availability of capital. Consequently, improving bankability requires reducing uncertainties before, or at the same time as, providing financing.

This result is reinforced by recent literature on critical-mineral markets. Kannan and Toman (2025) show that critical-mineral investment faces both quantity and price

risks, and that mineral-price volatility can amplify financial and investment risk for new extraction and processing projects. Their analysis also cautions that large investments in processing capacity themselves carry risk, particularly when capacity expansion is not closely aligned with demand conditions. This perspective matters for Indonesia because downstream investment should not be assessed only by installed processing capacity; it must also account for technological trajectories, market absorption, and projects' ability to remain commercially viable as mineral and battery markets change.

The interplay between technology and market conditions is important. Battery technologies don't create a uniform demand for nickel. Different chemistries will have different mineral requirements and technological innovation can in fact reduce the need for certain minerals. Kilinc and Fikru (2025) show that the challenges of mineral sourcing are co-determined by geographic concentration, geopolitical issues, ESG risks and technological constraints. They contend that if you treat these challenges in isolation you're going to end up with a fragmented and sub-optimal response. Their framework also shows that innovation in battery chemistry can reduce the need for certain scarce minerals, while insufficient R&D investment can continue to leave the supply chain vulnerable.

This is highly relevant to Indonesia’s technology gap. The investment case for deeper nickel downstreaming depends not simply on producing more processed nickel but on maintaining alignment with evolving battery technologies and commercial demand. Cheng et al. (2024) similarly show that battery chemistry shapes supply-chain vulnerabilities because different chemistry choices change exposure to specific critical materials. Therefore, technological capability should be viewed as an element of investment risk management: the more capable the domestic ecosystem is of adapting to chemistry shifts, processing standards, and product specifications, the lower the risk of investing in assets that become commercially misaligned.

Technology is also inextricably linked to human capital. You can certainly set up advanced processing facilities via foreign investment, but sustainable technological capability is predicated on the domestic ability to operate the technology, to adapt it, to troubleshoot it and to improve it. Dhairiyasamy et al. (2024) in the Indian battery industry find that a lack of skilled manpower in the areas of battery technology, power electronics and the related technical disciplines can be a major impediment to industry growth and to the uptake of technology. They stress the need for targeted education, vocational training and knowledge transfer. Haryadi et al. (2024) in Indonesia come to a similar conclusion, asserting that technology mastery and continuous human resource development are absolutely essential to the strengthening of the country's battery industry.

A similar interaction exists between energy, ESG, regulation, and market access. Indonesia’s resource advantage can be weakened if processed materials fail to satisfy the environmental and traceability requirements of target markets. Lahadalia et al. (2024) highlight ESG-related externalities and carbon-footprint challenges within Indonesia’s nickel downstreaming strategy. Hardiyan et al. (2025) also point to environmental consequences associated with nickel extraction, coal-intensive electricity, and end-of-life battery management. These considerations imply that ESG performance is no longer detached from investment competitiveness; environmental standards increasingly form

part of the conditions under which downstream products obtain access to markets and finance.

The emerging international battery regulatory environment reinforces this connection. Sustainability requirements increasingly encompass carbon-footprint reporting, supply-chain traceability, responsible sourcing, and lifecycle accountability. Kilinc and Fikru (2025) note that responsible sourcing increasingly requires transparency, traceability, and ESG integration across the mineral supply chain. This supports the study's interpretation that project planning must incorporate energy and ESG readiness before expanding downstream capacity, rather than addressing them only after facilities become operational.

Taken together, the evidence suggests that investment readiness is systemic. Funding, technology, human capital, infrastructure, regulation, energy, ESG, and market conditions jointly determine whether a project is sufficiently prepared to move toward financial commitment and implementation. This systemic interpretation is consistent with Kilinc and Fikru's (2025) conclusion that mineral-EV supply chains are characterized by interdependencies among sourcing, sustainability, geopolitics, technology, and market dynamics rather than by isolated constraints.

Implications for Investment Readiness

The key point from this is that Indonesia's downstreaming agenda needs to be able to tell the difference between attracting investment and being investment ready. Nickel in the ground, downstreaming mandates, announced investment and processing capacity in itself doesn't mean that the wider ecosystem is capable of supporting the increasingly complex battery projects that are going to be required. Investment readiness will require regulatory certainty, institutional coordination, technically credible projects, reliable energy and infrastructure, a capable workforce, ESG compliance and identifiable markets/offtake.

This is of course relevant in the context of Indonesia's success in attracting investment into mineral processing. There's ample evidence from prior work that downstreaming policies and the establishment of partnerships have seen Indonesia move well beyond its position as a simple supplier of raw ore and have in fact generated investment in processing (Lahadalia et al., 2024; Pandyaswargo et al., 2021). Soamole (2025) however contends that this very process of downstreaming also gives rise to new forms of strategic dependence and exposes Indonesia to new geopolitical and market risks as it becomes more embedded in the global EV battery value chains. The takeaway is that the next phase of downstreaming should be concerned not just with the amount of investment that is attracted but with the quality of that investment, the depth of the technology, the range of markets it serves and the resilience of that investment.

International experience further demonstrates that having a mineral endowment in itself does not lead to competitive downstream industries. George (2024) makes the point that competitive battery supply chains are the result of sustained investment in processing, manufacturing capacity, technological know-how, skills and supportive policy rather than simply having access to the raw materials. The article goes on to suggest that investment in domestic refining and in advanced cell or cathode manufacturing are key elements of a strategy to reduce strategic supply chain dependence. The policy context is of course different in Indonesia but the conclusion is

the same i.e. value chain positioning is a function of industrial capability and not simply of resource ownership.

The Indonesia example demonstrates the need for a phased approach to investment readiness. The priority must be on the bottlenecks that actually impact the execution of the project and its bankability (regulatory certainty, energy and utility readiness, logistics, ESG, market/offtake). Technology and human capital development will take longer to achieve but these should be pursued in parallel as they are fundamental to Indonesia building up its value chain and reducing its ongoing dependence on capabilities that are externally controlled.

The findings point to the need for financing instruments to be directly linked to project risk reduction. Blended finance, guarantees, public-private partnerships and a range of other de-risking mechanisms could be used to this end. They are however not sufficient in themselves to deal with the range of unresolved regulatory, technological, market and implementation issues. This is consistent with Kannan and Toman (2025) who caution that policy responses to critical mineral security need to take into account the costs and risks of building substantial new processing capacity, rather than simply assume that the expansion of capacity is a good thing.

Investment readiness must remain responsive to technological and market developments. Although Indonesia's nickel resources offer a strategic advantage, the EV battery market continues to evolve. Nurdiawati and Agrawal (2022) show that shifts in battery chemistry, recycling, second-life applications, and circular-economy strategies can significantly influence future demand for primary battery materials. Similarly, Kilinc and Fikru (2025) emphasize that alternative battery chemistries and technological innovation may reduce dependence on minerals such as nickel and cobalt. Therefore, a robust downstreaming strategy should not assume the permanence of current technology configurations but should instead foster capabilities that enable adaptation across materials, battery chemistries, recycling, and alternative end uses.

In summary, the findings indicate that Indonesia's central issue is not merely attracting investment. Instead, it is the capacity to transform investment commitments into projects that are bankable, technologically relevant, environmentally credible, and commercially sustainable. Investment readiness, in this context, is defined by the convergence of industrial policy, governance, financing, technology, infrastructure, human capability, and market conditions. This perspective offers a more integrated understanding of Indonesia's downstreaming challenge compared to approaches that evaluate each constraint in isolation.

CONCLUSION

The key issue in Indonesia's nickel and EV battery downstreaming is not the existence of any one isolated constraint but rather the interaction of a number of strategic gaps which in aggregate determine investment readiness. The gaps identified in funding, technology and energy (including ESG), regulatory and institutional arrangements, human capital, and infrastructure and logistics are all inter-related. The funding gap in particular is shown to be largely driven by the unresolved non-financial risks which in turn reduce project bankability and implementation readiness. The way forward is to work in a coordinated fashion to improve governance, project preparation, technological

capability, infrastructure, human capital, ESG compliance and market certainty. Investment alone will not be sufficient to drive downstreaming unless these conditions are in place to turn investment into bankable, executable and commercially viable projects.

Limitations of Research and Suggestions

This study has several limitations. The analysis relies primarily on documentary evidence, international benchmarking, and a limited number of key informant interviews; therefore, the findings should not be interpreted as representative of all actors in Indonesia's nickel and EV battery ecosystem. In addition, rapid changes in battery technologies, market preferences, ESG standards, and global supply-chain dynamics may shift the relative importance of the identified gaps over time. Future research should therefore involve a broader range of stakeholders, including government agencies, financial institutions, technology providers, downstream manufacturers, and local industry actors. It may also examine the identified gaps across specific projects or regions. Further studies could develop more explicit indicators of investment readiness and assess how improvements in specific gap dimensions affect project bankability and implementation outcomes over time.

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First publication right: Oikonomia: Jurnal Manajemen

How to cite
Indriyanto, E., Yustika, A.D., Prayitno, H., Setiawan, D., Dewi, D.N.A.M. (2026). Strategic Gaps in Indonesia's Nickel and Electric Vehicle Battery Downstreaming: Implications for Investment Readiness. *Oikonomia: Jurnal Manajemen*, 22(1), 1-16.
http://dx.doi.org/10.47313/oikonomia.v18i1.4454

Competing interests

The authors declare that they have no competing interests.

Funding

This research was funded by the Ministry of Energy and Mineral Resources of the Republic of Indonesia (KESDM).

Ack nowledgements

The authors would like to express their sincere appreciation to the Task Force of the Ministry of Energy and Mineral Resources of the Republic of Indonesia for its support and coordination throughout the research process. The authors also extend their gratitude to all research team members, institutional partners, and other stakeholders whose collaboration and contributions supported the successful completion of this study.