ENERGY TRANSITION PARTNERSHIP

REPORT

VIETNAM'S BATTERY SUPPLY CHAIN: CURRENT STATE ANALYSIS AND INVESTMENT OPPORTUNITIES

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Executive summary

Vietnam is entering a pivotal stage in its economic development and energy transition. The country now has a unique opportunity to position itself as a regional hub in the lithium-ion battery (LIB) supply chain, contributing significantly to its national net-zero emissions target by 2050 and responding to an anticipated 70% global battery undersupply by 2035.

The ***Enhancing Batteries' Supply Chain for Electric Vehicles, Energy Storage Systems, and Renewable Energy initiative,*** a collaboration between Vietnam's Ministry of Finance and the Southeast Asia Energy Transition Partnership (ETP) – United Nations Office for Project Services (UNOPS), focuses on promoting investment, bolstering innovation, and providing policy recommendations to strengthen Vietnam's position in the battery supply chain.

This report is the fourth deliverable under the scope of the collaboration. It provides a **comprehensive analysis of Vietnam's battery supply chain, evaluating its current state, identifying opportunities and challenges, and proposing strategic interventions** to enhance technological capabilities, attract investment, and build a sustainable ecosystem. The analysis is grounded in a wide range of data sources—including primary interviews and focus groups with industry stakeholders and governmental entities, global benchmarks from the International Energy Agency (IEA) and BloombergNEF, and Vietnam's evolving national policy frameworks.

Based on this analysis, Vietnam's domestic battery demand is projected to reach 46.9 GWh by 2030. This demand is expected to be driven by the uptake of approximately 1.55 million electric two-wheelers (E-2Ws), 171,000 passenger electric vehicles (PEVs), and deployment of 10,000 megawatts (MW) of battery energy storage systems (BESS). To meet this projected demand, Vietnam will require an investment ranging between $3.28 billion and $5.39 billion, depending on the pace of global battery cost reductions—from $115/kWh to a potential $70/kWh by 2030. This scale of investment presents a transformative opportunity for economic diversification, job creation (estimated at 28,750 to 35,000 new jobs), and enhanced national energy security.

Strategic Positioning and Market Opportunity

Vietnam is strategically positioned to become a competitive player in the global battery market, which is forecasted to grow at a 21% compound annual growth rate (CAGR) and reach 3,500 GWh of global demand by 2030 (IEA, 2023).

The country has several competitive advantages:

- **Significant mineral reserves:** including an estimated 3.7 million tons of nickel in Son La, untapped graphite deposits in Yen Bai and Tuyen Quang, and potential rare earth elements, which are essential inputs for battery production. The amount of manganese is also moderate at 10.77 million tons.
- **Supportive policies:** such as the National Green Growth Strategy supporting innovating and greening the industrial supply chain, Action Program on Green Energy Transition, Reduction of Carbon and Methane Emissions in the Transport Sector to develop green transportation system, Law on Geology and Minerals (2024) and Decision No. 866/QD-TTg (2021), which provide regulatory backing for mineral exploration and processing, etc.

- **Cost advantages:** Vietnam's average labor costs are $296.5/month, significantly lower than China's $430/month (ILO, 2025), and electricity rates are competitively priced at $0.085/kWh (Vietnam Electricity, 2025). This offers a cost advantage for energy-intensive segments of the battery supply chain. However, this rate is currently below EVN's cost-recovery level, and future adjustments may be required to reflect financial sustainability and the growing share of renewable energy. Investors should assess long-term electricity cost risks in project viability assessments.
- These factors translate to a landed battery cost of $73–$86/kWh, making **Vietnam competitive in key export markets such as ASEAN, Europe, the United States, and India.**

Vietnam is also **deeply integrated into a wide network of free trade agreements (FTAs),** including the EU-Vietnam Free Trade Agreement (EVFTA), Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), and the Regional Comprehensive Economic Partnership (RCEP). These agreements provide tariff-free market access, facilitate technology transfer, and encourage cross-border collaboration.

Private sector partnerships with global firms such as Gotion High-Tech (China), ProLogium (Taiwan), and Contemporary Amperex Technology Co. Ltd. (CATL, China)—as well as collaborations with regional players like Thailand and Indonesia—are enhancing Vietnam's supply chain resilience and technological know-how.

Domestically, government targets are driving demand. These include:

- 30% adoption of electric cars and 22% adoption of electric motorbikes by 2030
- Deployment of 10,000–16,300 MW of BESS capacity as outlined in the Revised Power Development Plan VIII (PDP8)

This policy direction is **aligned with global policy trends**, such as the U.S. Inflation Reduction Act (IRA), which offers $35/kWh in tax credits for battery manufacturing. Although the IRA has driven significant investment, its long-term implementation faces political and fiscal uncertainties. Similarly, the EU Green Deal Industrial Plan reinforces the shift toward clean supply chains by mandating carbon footprint tracking for battery products.

Economic and Social Benefits of a Domestic Battery Supply Chain

The estimated investment requirement for developing Vietnam's domestic battery supply chain ranges from **$3.28 billion to $5.39 billion**, depending on global battery cost trends by 2030. This range is based on our projections under three battery pack price scenarios:

- $5.39 billion at $115/kWh
- $4.22 billion at $90/kWh
- $3.28 billion at $70/kWh

These scenarios reflect global cost drivers, including:

:

- Economies of scale
- Improved manufacturing efficiencies
- Wider adoption of lithium iron phosphate battery chemistries, which are cheaper and safer alternatives to nickel-based chemistries

Of the total projected domestic battery demand (46.9 GWh):

- 64% will be attributed to BESS (30,000 MWh), representing the largest investment opportunity
- Electric two-wheelers (5,425 MWh) support mass-market penetration
- Passenger EVs (11,486 MWh) create opportunities for high-value manufacturing and exports

Job creation is a major benefit of supply chain development. As an example, the VinES plant in Ha Tinh currently employs 1,000 workers for 5 GWh production capacity, or approximately 200 workers per GWh. Scaling up to 10.743 GWh could employ 1,396 workers, and meeting 46.911 GWh nationally could generate 28,750–35,000 jobs, with an estimated 25% being high-skilled roles. This supports economic diversification, especially in rural and industrial zones transitioning away from traditional labor-intensive sectors.

There is also significant trade and export potential, with battery and EV exports projected to reach $2 billion by 2032. Additional value is added through localized production of cathodes, anodes, and battery packs, reducing import costs and contributing to GDP growth, while elevating Vietnam as a high-tech manufacturing hub in Southeast Asia.

Challenges and Gaps

Despite these opportunities, Vietnam's battery industry faces several structural and operational challenges:

- **The battery supply chain remains underdeveloped.** There is still high import dependency for critical materials such as lithium and cathodes. Only 15% of nickel ore is processed into nickel sulfate, and battery recycling rates (8–12%) remain far below best-practice benchmarks like Japan's 95% target.
- **Charging infrastructure is limited—especially in rural areas—**with EV models like VinFast offering only 300 km range and fast-charging times of 30–60 minutes, which could limit broader adoption without network upgrades.
- **High upfront EV costs remain a barrier**, especially given Vietnam's GDP per capita of 4,282.09 USD according to the World Bank.
- **The technical workforce is insufficient,** with less than 10% of engineers trained in battery-relevant fields. Investment in R&D is minimal at 0.5% of GDP, constraining local innovation and technological advancement.
- **Policy gaps persist:** Vietnam lacks a national battery industry roadmap, specific production subsidies, and robust recycling mandates. These factors have contributed to

lost investment opportunities, such as Intel's $3.3 billion investment shift to Poland and LG Chem's move to Indonesia.

International competition is intensifying. China dominates 60% of cathode production (IEA, 2024), while Indonesia controls 24% of global nickel reserves and has already attracted $21 billion in foreign direct investment into its battery sector (World Bank, 2024).

Geopolitical risks—including recent 40% lithium price spikes due to US-China tensions—highlight the importance of diversified and stable supply chains. Additionally, challenges within Vietnam's renewable energy sector—such as tariff uncertainty and grid curtailment risks—undermine the viability of BESS, thereby impacting the battery supply chain's overall growth.

Policy and Partnership Framework

Vietnam has laid foundational policy instruments to support battery sector development. These include:

- The National Green Growth Strategy (2012, updated 2021)
- The Investment Law (2020)
- Decision No. 876/QD-TTg (2022), which targets a net-zero transport sector by 2050
- Decision No. 768/QD-TTg (2025), which highlights the installed capacity for battery energy storage system to be 10,000 – 16,300 MW.

Incentives such as 0% import tax on EV components (Decree No. 26/2023/ND-CP) and registration fee exemptions (Decree No. 51/2025/ND-CP) have helped stimulate downstream EV demand. However, more targeted incentives for battery production—particularly at the midstream and upstream levels—are still lacking.

Notable partnerships are helping close some gaps:

- VinFast's collaboration with Gotion High-Tech supports the development of a 5 GWh/year LFP battery plant
- Regional partnerships, such as those with Indonesia, help secure nickel supply chains
- Free trade agreements continue to expand export potential and international integration

Recommendations for Action

To fully realize its battery sector potential, Vietnam must adopt a multi-dimensional strategy:

1. **Develop a National Battery Roadmap**
   Formulate a detailed national strategy, with integrated targets across upstream (raw materials), midstream (processing), and downstream (manufacturing). Introduce targeted production incentives—such as $10/kWh subsidies—based on best practices from the U.S. IRA and China's subsidy model.

2. **Invest in Localization**
   Support the establishment of LFP battery gigafactories (10–15 GWh capacity) and scale up nickel and graphite refining (e.g., in Ban Phuc and Dak Nong) to reduce import dependency by 80%, leveraging incentives under Decree 182/2024/ND-CP.

3. **Enhance Infrastructure**
   Expand the national EV charging network, targeting 10,000 stations by 2030, with a focus on rural coverage (60%). Develop battery industrial zones with renewable energy-powered infrastructure, modeled after Indonesia's Sulawesi Industrial Park.

4. **Upskill the Workforce**
   Establish specialized training centers through partnerships. Aim to train high-skilled engineers in fields such as battery chemistry, recycling, and digital systems, addressing the current 90% technical skill gap.

5. **Secure Strategic Partnerships**
   Foster joint ventures with global leaders (e.g., CATL, LG Chem, Tesla) for technology transfer, and launch an ASEAN Battery Alliance to coordinate regional supply chains. Secure long-term raw material deals, such as 50,000 tons/year of nickel from Indonesia.

6. **Promote Sustainability**
   Require that 50% of battery production energy comes from renewable sources by 2030. Introduce battery passports in line with EU regulation for carbon footprint tracking, and invest in hydro-metallurgical recycling facilities to achieve 70% lithium recovery by 2035.

Conclusion

Vietnam's development of a domestic battery supply chain represents a strategic opportunity to achieve energy independence, stimulate economic development, and contribute to the global clean energy transition. With an estimated $3.28–$5.39 billion investment, Vietnam can capture 1.3% of global market share, create tens of thousands of new jobs, and significantly reduce national greenhouse gas emissions.

By addressing policy, infrastructure, and workforce gaps through targeted reforms and international collaboration, Vietnam can position itself as a leading player in the global battery industry by 2030—advancing both national development goals and international climate commitments.

Disclaimer

This report has been prepared by a consortium comprising the Consultancy on Development Institute (CODE), the Institute of Materials Science (IMS) under the Vietnam Academy of Science and Technology (VAST), EconomiX, and E3 Vietnam Energy and Environmental Investment Consulting Company.

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The views and opinions expressed in this report are those of the authors and do not necessarily reflect the official policies or positions of the Southeast Asia Energy Transition Partnership (ETP), UNOPS, the Ministry of Finance, or any other organizations or entities mentioned herein.

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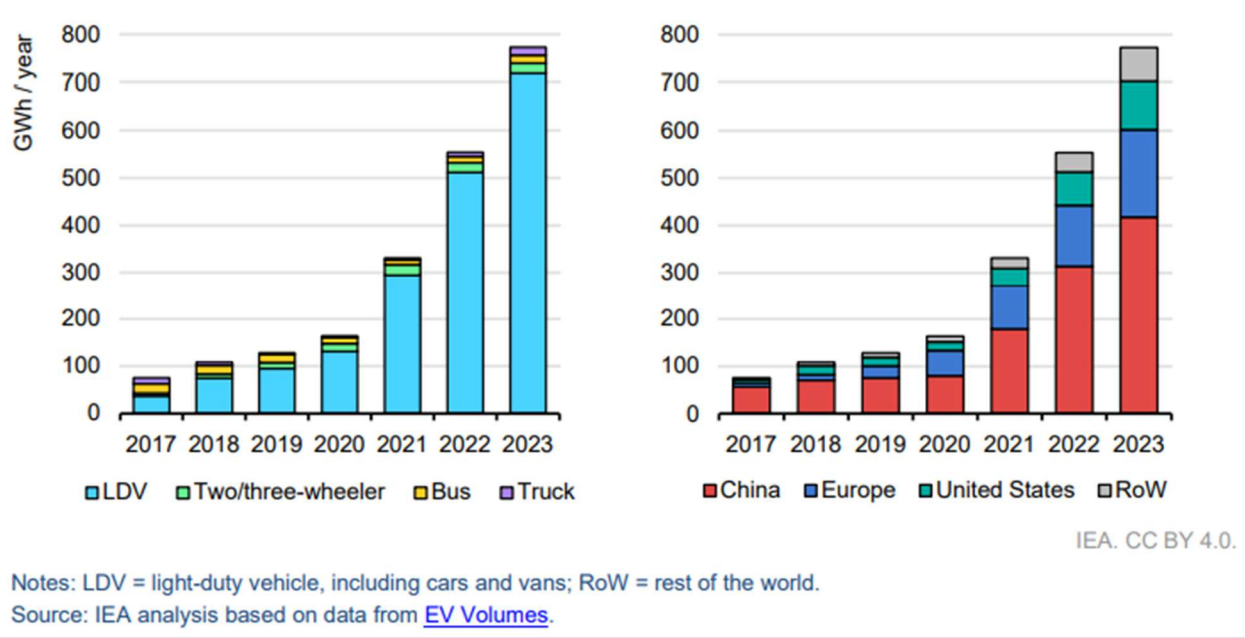
1. Introduction

1.1. The role of battery technology in the global energy transition

The battery supply chain is a vital pillar of the global energy transition, encompassing raw material extraction, battery material production, cell and pack assembly, product distribution, and end-of-life recycling. Each stage delivers significant economic, environmental, and strategic benefits to national and global ecosystems. Lithium-ion batteries are central to this transition, powering electric vehicles (EVs) and battery energy storage systems (BESS). These batteries enable zero-emission transportation and store electricity generated from renewable sources such as wind and solar, contributing to reduced greenhouse gas emissions. The International Energy Agency (IEA) projects global battery demand to grow from 750 GWh in 2022 to 3,500 GWh by 2030, with a compound annual growth rate (CAGR) of approximately 21%, driven primarily by EV adoption and BESS deployment (IEA, 2023).

Figure 1-1. The demand for batteries is driven by electric vehicles with key markets in China, the European Union, and the United States



Source: IEA (2024), Global EV Outlook

The strategic significance of the battery supply chain manifests in several key areas:

- **Facilitating the Clean Energy Transition**: The battery supply chain is foundational to achieving global emission reduction targets. In 2023, EVs consumed 70% of global lithium-ion battery production (665 GWh), with the potential to reduce transportation-related CO_2 emissions by 1.8 billion tons by 2030 if EVs achieve a 60% market share (IEA, 2023). BESS, with a capacity of 150 GWh in 2023, enhances grid stability by storing renewable energy, reducing reliance on fossil fuels (BloombergNEF, 2023). For example,

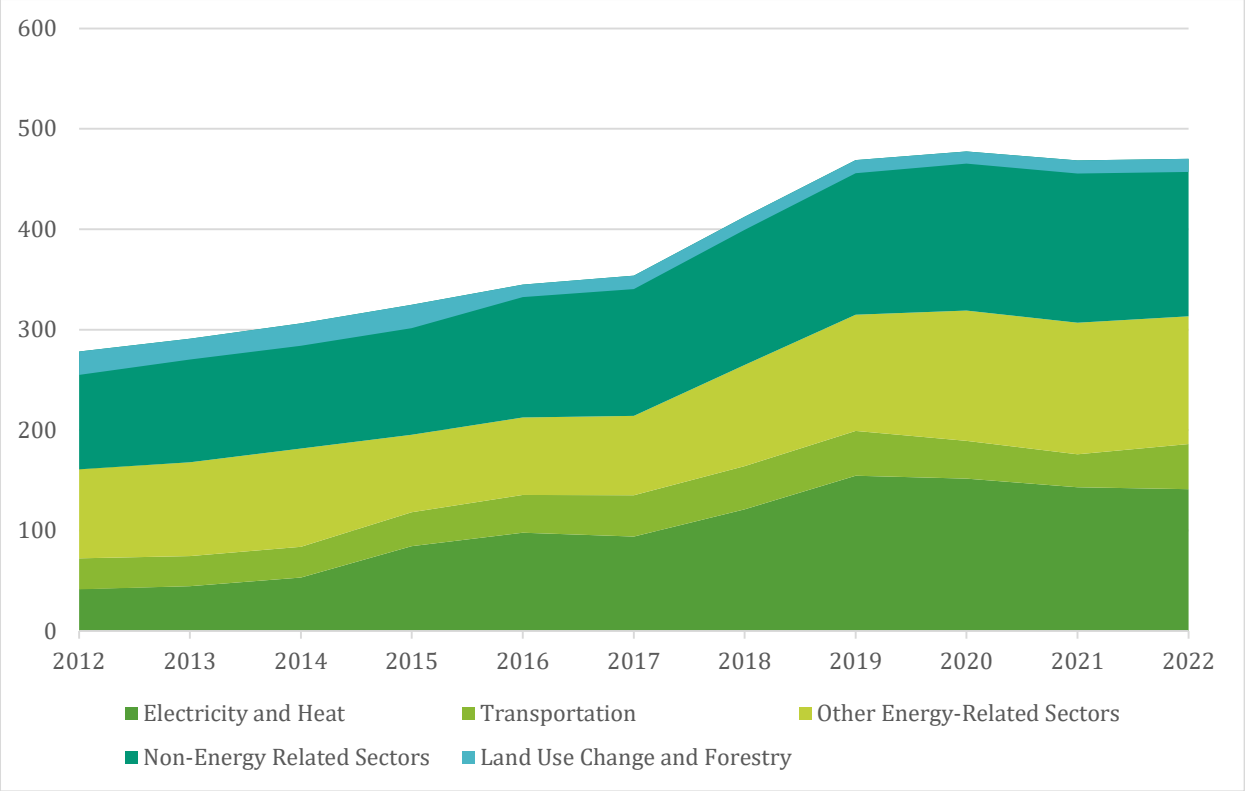
the European Union aims for 55% renewable energy by 2030, with BESS playing a critical role (European Commission, 2023).

- **Strengthening Energy Security**: By supporting EVs and BESS, the battery supply chain reduces dependence on volatile fossil fuel markets. For instance, China's EV adoption reduced oil imports by 10% in 2023 (IEA, 2023). However, the concentration of critical mineral supply (i.e., China controls 60% of graphite, and Australia 50% of lithium) introduces geopolitical risks, prompting nations like the United States and the European Union to invest in localized supply chains (Bloomberg, 2023).
- **Catalyzing Economic Growth**: The battery supply chain generates substantial economic value. The global battery market was valued at USD 120 billion in 2023 and is projected to reach USD 400 billion by 2030 (BloombergNEF, 2023). Raw material extraction (e.g., lithium, nickel, cobalt) contributed USD 30 billion, while battery manufacturing accounted for USD 60 billion (Benchmark Mineral Intelligence, 2023). Leading producers, including China (60% of global battery production, 570 GWh), South Korea (190 GWh), and the United States, employ approximately 2 million workers in the battery sector (Bloomberg, 2023). The supply chain also stimulates growth in related industries, such as EV manufacturing (e.g., Tesla, BYD) and renewable energy equipment production (e.g., Siemens Gamesa).
- **Advancing Technological Innovation**: The battery supply chain drives research and development (R&D) in next-generation technologies, such as solid-state and lithium-sulfur batteries, which offer higher energy density and longer lifespans (IEA, 2023). Industry leaders like CATL (China) and LG Chem (South Korea) invest billions annually in R&D, yielding significant performance improvements (BloombergNEF, 2023).
- **Promoting Sustainability through Recycling**: Battery recycling mitigates environmental impacts by reducing the need for virgin material extraction, lowering production costs by 20–30% (BloombergNEF, 2023). The European Union targets a 70% battery recycling rate by 2030, aiming to recover 80% of lithium, nickel, and cobalt, fostering a circular economy (European Commission, 2023).

1.2. The strategic importance of batteries in Vietnam's energy transition

Vietnam's energy transition is intricately linked to the development of a robust battery supply chain, particularly in the power and transport sectors, which are major contributors to national greenhouse gas (GHG) emissions. As Vietnam aligns with the global shift toward sustainable energy, the battery supply chain offers opportunities to advance its commitments to net-zero emissions by 2050, as pledged at COP26, COP27, COP28, and reaffirmed at COP29.

Figure 1-2. Vietnam's Historical GHG Emissions 2012 – 2022 (in $MtCO_2eg$, including LUCF)



Source: Authors' visualization based on Climatewatch data. Historical GHG emissions in Vietnam (accessed June 2025).

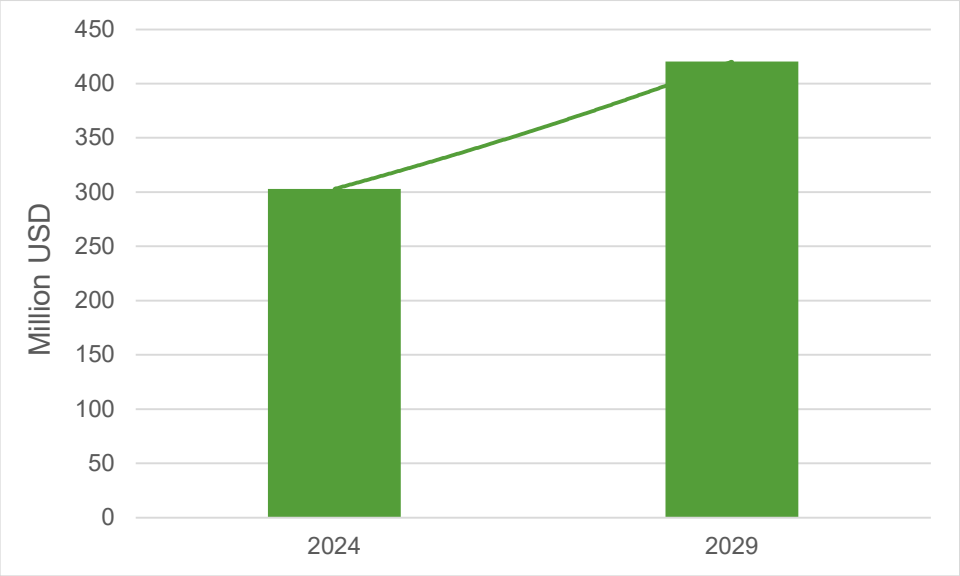
Vietnam's power sector remains heavily reliant on coal and thus exposed to fuel-price volatility (Vietnam Energy Institute, 2023). In response, the government has formalized the Revised Power Development Plan 8 (PDP-8) under Prime Minister's Decision No. 768/2025 (15 April 2025), which lays out a strategic roadmap for 2021–2030 with a vision to 2050. PDP-8 dramatically expands Vietnam's generation mix—from a target of 183,291 MW to 236,363 MW by 2030 (excluding exports)—by placing renewable energy at its core: solar capacity is expected to grow to between 46,459 MW and 73,416 MW, onshore wind to 20,066 MW–38,029 MW, and offshore wind to 6,000 MW–17,032 MW (2030–2035). To integrate these intermittent sources and strengthen grid stability, the plan prioritizes 10,000 MW–16,300 MW of distributed battery energy storage systems (BESS) sited near large solar and wind farms or high-demand load centers. However, BESS deployment is still in its infancy, with only one operational project (700 kW/2 MWh at PECC2) as of 2024. To encourage further investment, the Ministry of Industry and Trade's Decision No. 988 (10 April 2025) sets tariffs at 1,326 VND/kWh (5.2 ¢/kWh) for ground-mounted solar plus BESS and 1,577 VND/kWh (6.1 ¢/kWh) for floating solar plus BESS, both designed to help achieve the PDP-8 storage targets. Ultimately, developing a localized battery supply chain will be critical not only to scale BESS, but also to reduce fossil-fuel dependence and enhance Vietnam's overall grid reliability.

In the transport sector, electric vehicles are central to reducing fossil fuel reliance and cutting greenhouse gas emissions. Under Decision No. 876/QĐ-TTg (July 2022), the Vietnamese government adopted the Action Program on Green Energy Transition, aiming for net-zero

emissions in transportation by 2050. Domestic momentum is already evident: in 2024, VinFast sold nearly 97,400 EVs, including exports, positioning itself as a frontrunner in the region. Building on this momentum, Vietnam is poised to lead the region in EV demand and production, especially in the electric two-wheeler (E2W) segment, the second largest globally after China. This rapid growth is fueling a surge in battery demand, particularly for lithium-ion technologies, and has underscored the urgent need for a reliable and localized battery supply chain.

A secure domestic supply chain is critical not only to support continued EV production but also to reduce dependence on costly and geopolitically sensitive battery imports. The Vietnamese battery market is projected to grow from USD 302.85 million in 2024 to USD 420.21 million by 2029, with a compound annual growth rate (CAGR) of 6.77% (Ngô Linh, 2024).

Figure 1-3. Forecasted Compound Annual Growth Rate (CAGR) for the battery market in Vietnam during the 2024-2029 period



Source: Adapted from Ngô Linh, 2024, "Analysis of the Vietnam Battery Market 2024," KHV.

Vietnam holds several strategic advantages in this space, including a large workforce of 54 million people, reserves of key minerals (e.g., manganese, rare earths, aluminum), and strong demand from the domestic EV sector. The country is already attracting foreign investment from major players like Samsung SDI, LG Energy Solution, and Panasonic, which are setting up facilities to produce battery components in industrial zones such as Bac Ninh, Hai Phong, and Binh Duong. Free trade agreements (FTAs) enhance Vietnam's access to global markets and make it an attractive destination for battery-related foreign direct investment (FDI).

Yet, despite these positive signals, Vietnam's battery supply chain remains nascent and fragmented. Approximately 80% of raw materials are still imported, and most lithium-ion batteries used in BESS and EVs are sourced from China, South Korea, and Japan. Domestic capacity for upstream processing and production of battery-grade materials is limited. Local firms face significant barriers, including restricted access to advanced technologies, skilled labor, and dedicated research and development (R&D) resources.

Moreover, the market is still dominated by lead-acid batteries, which are less competitive than lithium-ion technologies—the global standard for EVs. This reflects a transitional phase in technology adoption and underscores the challenges in moving toward fully integrated lithium battery systems. Policy frameworks also pose certain gaps. Vietnam has yet to establish comprehensive regulations or incentives to support battery innovation, recycling systems, hazardous waste management, or the strategic stockpiling of critical minerals, each of which is essential to building a resilient and sustainable battery ecosystem. In particular, dedicated policies for battery R&D, green procurement, and preferential financing for local manufacturers could play a catalytic role in accelerating supply chain localization and reducing dependence on imports.

These challenges are not merely technical; they represent structural barriers that could constrain the long-term scalability and competitiveness of Vietnam's EV and clean energy ambitions. Without timely investment in mineral processing, R&D, and institutional coordination, Vietnam risks becoming an assembly hub rather than a full participant in the global battery value chain. Overcoming these barriers will require coordinated action across government, industry, and international partners, along with a shift toward sustainable and circular supply chain models.

1.3. Report overview

1.3.1. Objectives and scope

The ***Enhancing Batteries' Supply Chain for Electric Vehicles, Energy Storage Systems, and Renewable Energy*** initiative, a collaboration between Vietnam's Ministry of Finance and the Southeast Asia Energy Transition Partnership (ETP) – United Nations Office for Project Services (UNOPS), aims to address these challenges. This initiative focuses on promoting investment, bolstering innovation, and providing policy recommendations to strengthen Vietnam's position in the battery supply chain.

This report is the fourth deliverable under the scope of the collaboration. It provides a comprehensive analysis of Vietnam's battery supply chain, evaluating its current state, identifying opportunities and challenges, and proposing strategic interventions to enhance technological capabilities, attract investment, and build a sustainable ecosystem. The study focuses on the following key areas:

- **Technological Gaps**: Assessing Vietnam's capabilities in battery material production, advanced battery technologies (e.g., solid-state and sodium-ion batteries), and recycling processes, benchmarked against global leaders.
- **Stakeholder Mapping**: Identifying key actors across the battery supply chain, including government agencies, domestic and international manufacturers, research institutions, and recycling firms, to foster collaboration and coordination.
- **Supply Chain Analysis**: Examining the upstream (raw material extraction), midstream (material processing and battery production), and downstream (manufacturing, application, and recycling) segments to pinpoint strengths, weaknesses, and areas for diversification.

- **Market Opportunities**: Analyzing domestic and export market potential, driven by EV demand, battery energy storage systems (BESS), and renewable energy integration, in alignment with Vietnam's national green growth strategies.
- **Policy and Investment Frameworks**: Proposing actionable recommendations to enhance production capacity, develop human resources, and create a supportive regulatory environment that balances economic growth with environmental sustainability.

1.3.2. Research approach

In enabling these findings and insights, the study employs **a dual analytical framework, integrating top-down (macro-level) and bottom-up (micro-level) approaches to ensure a comprehensive and balanced assessment of Vietnam's battery supply chain**. This methodology combines strategic policy analysis with practical insights from stakeholders, enabling the identification of a sustainable development roadmap.

- **The top-down approach** examines national policies, long-term strategies, and regulatory frameworks shaping Vietnam's battery supply chain. This includes an in-depth analysis of investment priorities, policy incentives, research and development (R&D) funding, subsidies, and sector-specific regulations. This approach quantifies policy impacts and identifies opportunities for localized action.
- **The bottom-up approach** gathers insights from stakeholders through interviews, focus groups, surveys, and market demand assessments based on international benchmarks and data. Throughout the development of this report, the research team engaged with both governmental entities, private sectors, associations and academic institutions, including Ministry of Finance, Ministry of Science and Technology, Ministry of Construction, Ministry of Industry and Trade, Ministry of Defense, Ministry of Agriculture and Environment, Vinfast, Huawei, AETEK, Vietnam Association of Science and Technology, etc. Within the scope of this intervention, consultation workshops gathering all relevant stakeholders and a survey was shared..

By integrating both top-down and bottom-up perspectives, the study ensures a holistic and comprehensive understanding of the current contexts of Vietnam's battery supply chain, thus providing a foundation for developing forward-looking strategies to enhance its resilience, sustainability, and competitiveness in the energy transition.

1.3.3. Structure of the report

Structured in seven chapters, the report outlines the strategic importance of battery technologies for renewable energy integration, electric vehicles, and grid stability, while identifying gaps and opportunities for domestic capacity building and foreign investment.

- **Chapter 1: Introduction** sets the context by outlining Vietnam's strategic position in the global battery market. It highlights the report's objectives, scope, and methodology, emphasizing the integration of primary data, industry benchmarks, and policy analysis.
- **Section 2: Battery Supply Chain Overview** explores the global and regional landscape, detailing the five phases—raw material extraction, battery material production, battery

assembly, product distribution, and usage/recycling. It assesses Vietnam's current capabilities and identifies gaps in each phase.

- **Section 3: Phases of the Battery Supply Chain in Vietnam** delves into the domestic context, analyzing how each supply chain phase supports Vietnam's EV and BESS targets. It evaluates opportunities, such as mineral resources, and challenges, including import reliance.
- **Chapter 4: Regulatory Framework and Institutional Roles** examines Vietnam's policy landscape, including key regulations like the Green Growth Strategy and Investment Law (2020). It outlines the roles of ministries and state-owned enterprises, highlighting incentives and gaps in achieving a competitive supply chain.
- **Chapter 5: Financial Positions and Justifications for Investment in Vietnam** provides a financial analysis, projecting investment need based on different battery prices. It justifies investment through cost competitiveness, job creation, and economic diversification.
- **Chapter 6 Investment Rationale and Strategic Partnerships** articulates the case for investment, leveraging FTAs (e.g., EVFTA, RCEP) and partnerships with firms like Gotion High-Tech. It proposes strategies to address challenges like technology gaps and import dependency.
- **Chapter 7: Conclusion and Recommendations** synthesizes findings, offering actionable recommendations to enhance Vietnam's battery supply chain. It emphasizes policy reforms, infrastructure development, and international collaboration to meet 2030 targets.

2. Global market dynamics and Vietnam's needs in the battery supply chain

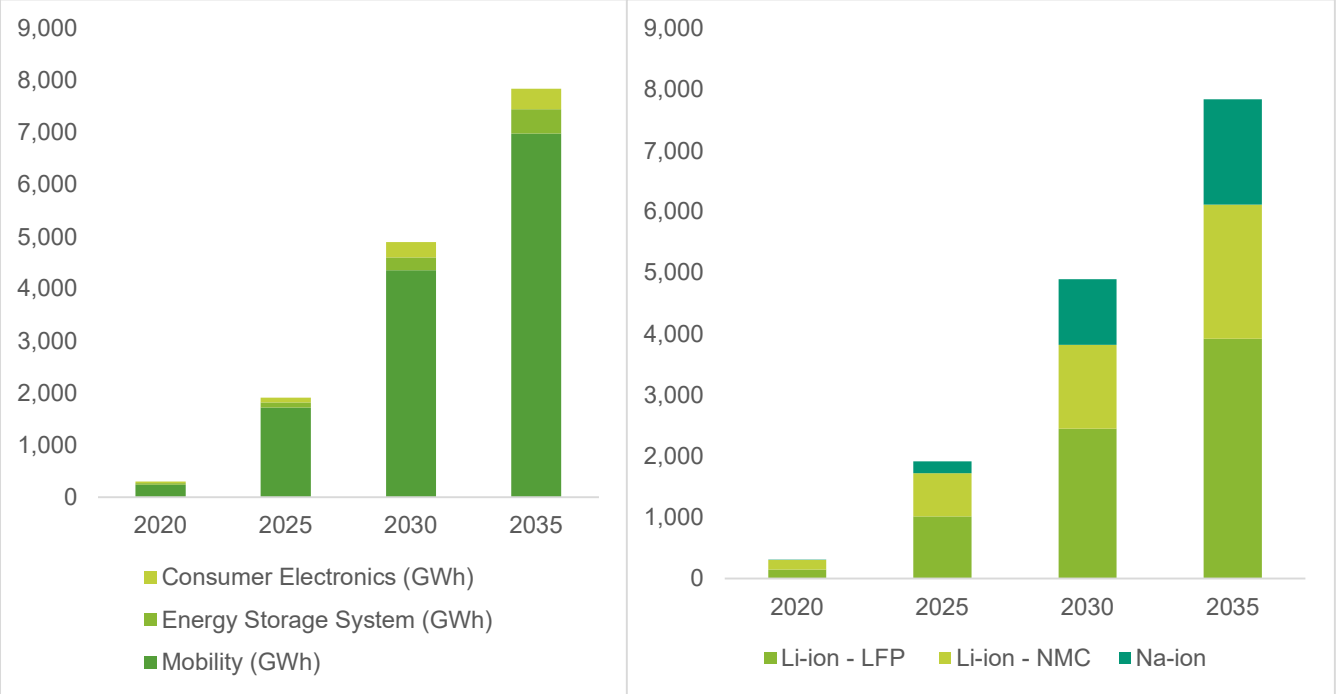
2.1. Overview of the global battery market dynamics

The global transition to clean energy and zero-emission transportation has positioned the LIB supply chain as a critical strategic sector, driven by surging demand for EVs and BESS. The International Energy Agency (IEA) projects global battery demand to grow from 750 GWh in 2022 to 3,500 GWh by 2030, a 21% compound annual growth rate (CAGR), fueled by EV sales (14 million units in 2023, up 35% from 2022) and BESS capacity (200 GWh by 2030, BloombergNEF 2023). McKinsey Battery Insights forecasts demand reaching 4.9 TWh by 2035 (24% CAGR, 2020–2035), with 90% driven by EVs and 80% concentrated in China, the United States, and Europe. S&P Global Ratings (2024) estimates 30–40% annual growth in 2024–2025, led by China's EV market (44–48% penetration by 2025), though Europe (20–25%) and the US (13–16%) lag due to reduced subsidies and less stringent emission targets.

The market is highly concentrated, with China dominating 60% of battery manufacturing, alongside South Korea and Japan (Bloomberg, 2023). China also controls 60% of rare earth production, the Democratic Republic of Congo supplies 65% of cobalt, and Australia accounts for 50% of lithium production, all of which contribute to supply chain vulnerabilities and geopolitical risks (USGS, 2023). In terms of key players, Chinese giants like CATL (552 GWh capacity, 98% in China) and BYD dominate alongside Korean and Japanese players such as LG Energy Solution (15–20% capacity in North America), Samsung SDI, and SK On (S&P Global Ratings 2024). In China, policies implemented in June 2024, including energy density requirements (≥165 Wh/kg for LFP, ≥230 Wh/kg for NMC) and minimum utilization thresholds (≥50% capacity), are driving consolidation, reducing the installation-to-production ratio to 47% in 2024's first half. **This benefits top-tier firms while pressuring smaller players, potentially creating opportunities for foreign direct investment (FDI) in emerging markets like Vietnam.** For instance, Vietnam is emerging as a potential player with projects like the Goton factory in the Vũng Áng economic zone, expected to achieve a capacity of up to 5 GWh, and LG Chem and Samsung SDI's 5 GWh/year complex in Bắc Ninh specializing in NCA battery production (LG Chem, 2024).

Despite growing production plans, many regions, particularly the Rest of the World (RoW), remain heavily reliant on imports. Without further investment, these areas may face a significant undersupply by 2035, with supply falling short of demand by as much as 70%. In contrast, countries like China are projected to face a large oversupply, up to 1.4 TWh by 2035, indicating either a strong export orientation or inefficient asset utilization. **This disparity underscores the need for regionalized supply chains, as seen in the US and Europe, where active material plants are being developed near gigafactories to minimize import reliance** (Guide to Investing, 2023). Additionally, global recycling efforts are gaining traction to mitigate supply constraints, with the IEA noting that scaling recycling could reduce new mining needs by 25–40% by 2050, a trend that Vietnam is beginning to explore despite its nascent recycling sector (IEA, 2023).

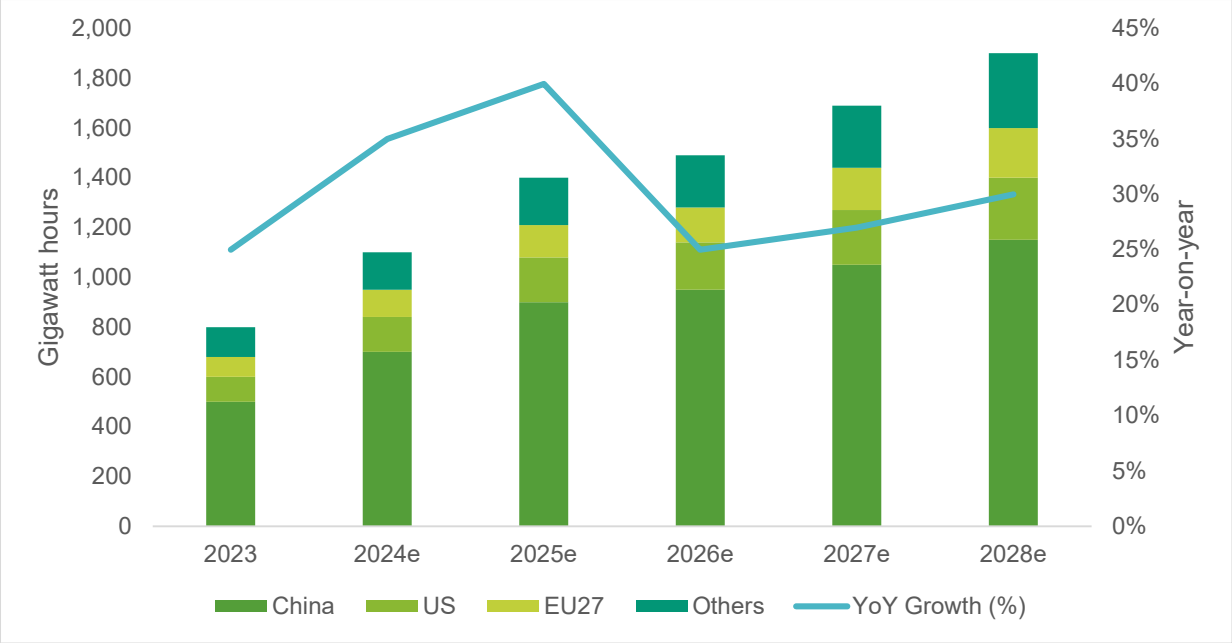
Figure 2-1. Growth trajectory of battery demand by sector (left) and by technology (right)



Source: Authors' visualization based on McKinsey Battery Insights Demand Model
Note: Li-ion- LFP includes LFP, LCO, LMFP, LMNO, and LMO; Li-ion-NMC includes NCA and NMC (111, 532, 622, 811, 955)

Looking forward, if all announced projects materialize, global supply and demand could potentially reach a balance by 2035. However, continued competition, trade policy shifts, and market entry by new players (e.g., in Saudi Arabia, Qatar, or potentially Africa through trade agreements) will likely reshape the global battery production ecosystem over the next decade. Emerging technologies like solid-state batteries (SSB) could also disrupt the market, though their share is expected to remain below 2% until 2030 due to high costs and production challenges, while LFP and NCM chemistries dominate (80% market share by 2028, S&P Global Ratings, 2024).

Figure 2-2. Global battery demand growth (2022 – 2035)

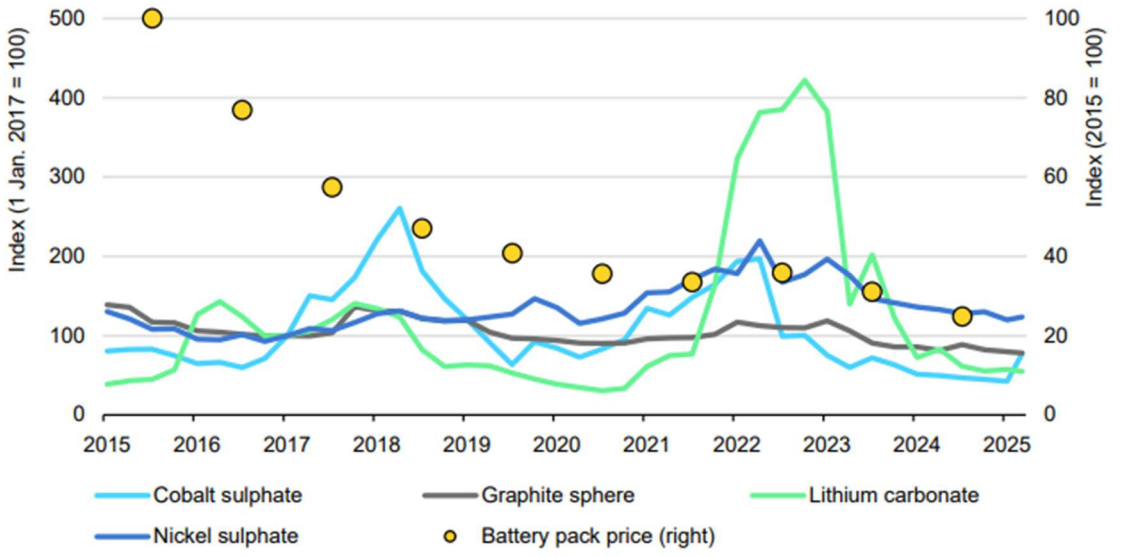


Source: Authors' visualization based on data from S&P Global Ratings, S&P Global Market Intelligence, S&P Global Mobility

2.2. Economics of scale of developing the battery supply chain

The battery electric vehicle (BEV) market is driving rapid expansion of the battery cell component industry (cathodes, anodes, separators, electrolytes, packaging), projected to grow at a 19% CAGR to USD 250 billion by 2030 (McKinsey Battery Insights 2023). Over 200 new battery cell factories are planned by 2030 to meet this demand, supported by net-zero policies like the US Inflation Reduction Act (IRA), EU Green Deal, and China's Made in China 2025. Economies of scale, technological advancements, and raw material price declines are reducing costs, while geopolitical shifts, such as nearshoring in Europe and North America and China's supply chain integration, reshape the global landscape.

Figure 2-3. Price of selected battery metals and LIB packs (2015-2025)

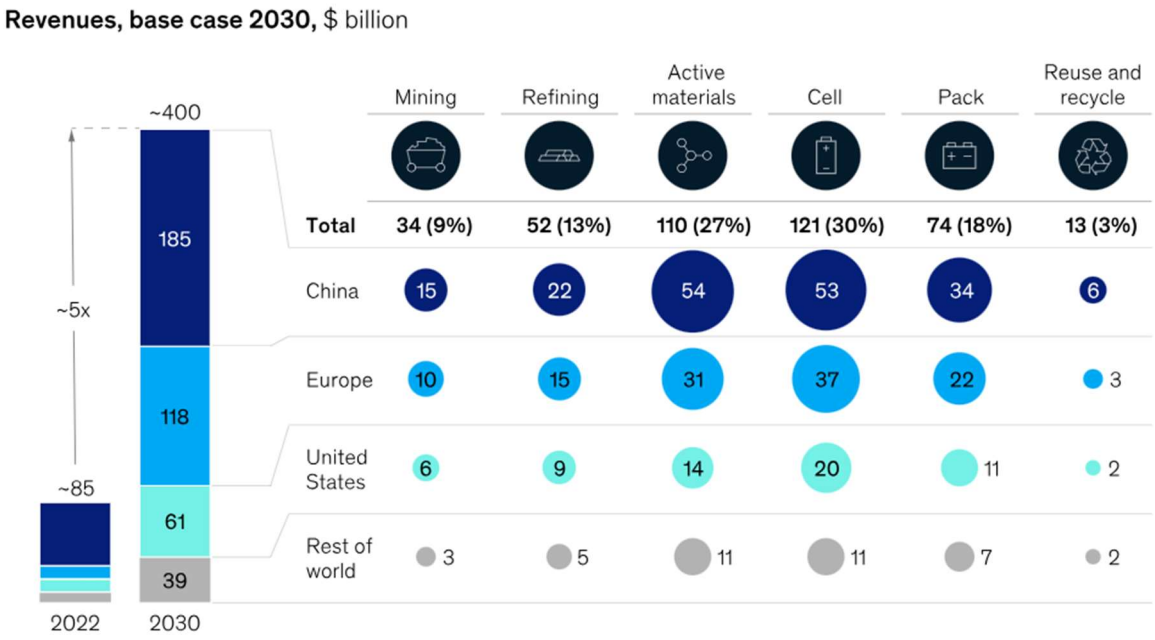


Notes: "Battery pack price" refers to the volume-weighted average pack price of lithium-ion batteries across the electric vehicles and battery storage sectors. 2025 refers to data up to the end of March 2025.
Sources: IEA analysis based on data from Bloomberg and Bloomberg New Energy Finance Lithium-Ion Price Survey (2024).

Source: IEA 2025

These dynamics are reflected in significant cost trends in the industry. As shown in **Figure 2-3,** global LIB pack prices have declined sharply over the past decade due to economies of scale, technological improvements, and fluctuations in raw material prices. In 2024, the global average LIB pack price fell by 20%, from USD 140/kWh in 2023 to USD 112/kWh, marking the largest annual drop since 2017 (IEA, 2025). This was driven by a 20% decline in lithium prices to USD 12,000/ton, fierce market competition in China, and the broader adoption of LFP batteries, which are significantly cheaper (USD 80/kWh) than NMC batteries (USD 115/kWh). China led this price decline with a 30% drop to USD 80/kWh, compared to smaller reductions in Europe (USD 120/kWh) and the U.S. (USD 125/kWh). China's advantage is anchored in thin profit margins, manufacturing efficiency, and strong vertical integration. Raw materials, especially cathodes, account for around 40% of total cell costs, reflecting the high dependence on lithium, nickel, or iron phosphate used in LFP and NMC chemistries (McKinsey Battery Insights, 2023).

Figure 2-4. Revenues at each stage of the battery supply chain



Source: McKinsey Battery Insights, 2023

Beyond price reductions, revenue growth across the supply chain reinforces the economic case. Figure 2-4 highlights that revenues are increasing across all segments of the battery supply chain, from raw materials and active materials to cell production and system integration. This underscores the **strong economic potential of battery manufacturing, particularly for countries like Vietnam seeking value-added participation in the global supply chain**. For example, Vietnam's initiatives, such as Vingroup's USD 174 million battery cell manufacturing plant in Hà Tĩnh producing 100,000 battery packs per year in the first phase, and T&T Group's collaboration with China's Cospowers for a 10 GWh/year BESS plant by 2030, signal potential economic growth (T&T Group, 2024). Additionally, Vietnam's nascent recycling efforts could spawn a new industry, leveraging waste batteries to meet material demand, with potential to mirror global trends where recycling could reduce mining needs by 25–40% by 2050 (BloombergNEF, 2023; IEA, 2023).

These trends are reshaping the cost structures and strategic priorities of the global battery industry. Key features driving economies of scale include:

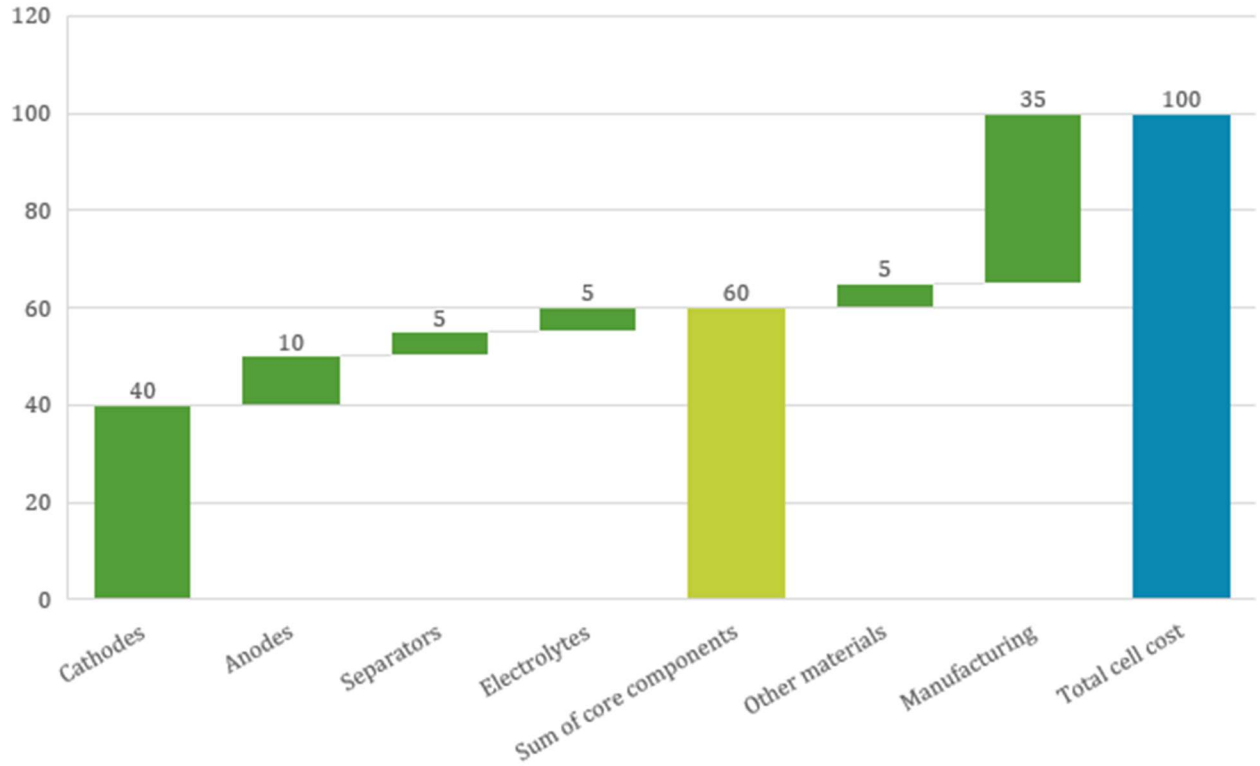
- **Gigafactory scale:** Facilities producing over 500,000 units annually have reduced non-material costs (e.g., SG&A, R&D, warranty, profit) from USD 45/kWh in 2020 to an estimated USD 26–30/kWh by 2025 (Goldman Sachs, 2022).
- **Chemistry transitions:** LFP batteries, with cobalt- and nickel-free cathodes (costing just USD 26/kWh), now dominate 75–80% of China's EV market and 50% globally. Their cost advantage (USD 80/kWh) is particularly significant as raw materials are projected to account for 67% of battery pack costs by 2030 (IEA, 2025).
- **Integrated supply chains:** Bill of materials (BoM) expenses, representing 65–75% of cell costs, can be minimized through vertical integration. China leads with vertically integrated players like CATL, while Morocco and Tanzania benefit from SEZ import duty exemptions. Vietnam, with access to Australian lithium and Chinese cathodes via the

RCEP and 3.6 million tons of nickel reserves, has potential to stabilize input costs, although its domestic processing capacity remains limited.

- **Secured demand:** Long-term off-take agreements (e.g., BMW's with Samsung SDI) help stabilize production and sustain low profit margins (USD 2/kWh in China).
- **Technology innovation:** Advances in LFP performance and emerging alternatives like sodium-ion batteries are reducing dependency on lithium. However, China's export restrictions on LFP technologies highlight the need for strategic R&D partnerships.

Figure 2-5 illustrates the typical cost structure of lithium-ion battery cells, emphasizing the dominant share of raw material costs. This underscores why vertical integration, stable supply agreements, and material innovation are essential for cost competitiveness, particularly relevant for Vietnam's positioning strategy, as discussed in the next section.

Figure 2-5. Cost breakdown of typical lithium-ion battery cells, %



Source: Authors' adaptation from McKinsey Battery Insights

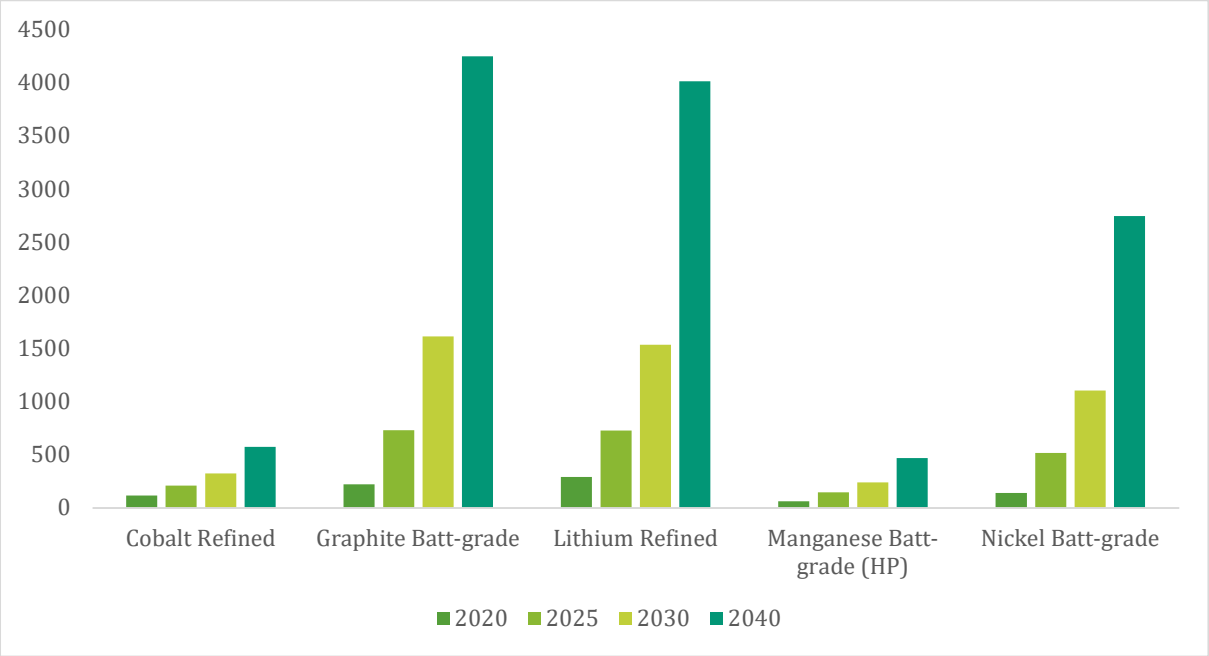
Note: The total cell cost is the weighted average cell production cost in Europe, 2023, lithium price (lithium carbonate equivalent) at $35,000 per metric tone.

2.3. Supply-side constraints

The global demand for raw materials—nickel, graphite, and lithium—is projected to surge by 2040, increasing 20, 19, and 14 times, respectively, compared to 2020 levels, driven by the rapid expansion of EVs and, to a lesser extent, energy storage systems (ESS) (JRC, 2021). Lithium demand for batteries is anticipated to grow fivefold by 2030 and 14-fold by 2040, with graphite

and nickel following similar trajectories, reflecting the strain on supply chains as demand outpaces current production capacities (JRC, 2021).

Figure 2-6. Forecast of battery demand globally from processed raw materials [kt]



Source: Author's visualization based on JRC 2021.

The supply of processed raw materials and components is dominated by an oligopoly, with China producing 60% of battery-grade materials (Bloomberg, 2023). Although geographic diversification is increasing, particularly for refined lithium, supply concentration remains high for graphite and significant for mined cobalt, battery-grade nickel, and manganese through 2030 (JRC, 2021). This concentration exacerbates vulnerabilities, as China's dominance is reinforced by its control of 60% of rare earths and 65% of cobalt refining, while Australia's 50% lithium production faces logistical bottlenecks (USGS, 2023). Short-term deficits are forecasted for lithium in 2022–2023, with tight market balances expected for graphite by 2024, manganese by 2025, and nickel by 2029. Beyond 2029–2030, demand is likely to exceed supply for most raw materials unless substantial new investments accelerate production, with lithium and nickel posing the greatest concerns due to their explosive demand growth and slower supply development (JRC, 2021).

Geopolitical risks further complicate the supply chain. Recent trade tensions between China and the US have disrupted cobalt and lithium flows, with China imposing export quotas on rare earths (40% reduction in 2024 licenses, Ministry of Commerce China, 2024). The Democratic Republic of Congo's cobalt production, accounting for 65% of global supply, faces instability due to mining regulations and labor disputes (Reuters, 2025). Australia's lithium exports are constrained by port capacity issues, delaying shipments to Asia (Australian Government, 2025). These disruptions underscore the need for diversified supply sources and regional production hubs. Regional disparities exacerbate the challenge, with the Rest of the World (RoW) facing a potential 70% undersupply by 2035,

while China's projected oversupply of 1.4 TWh suggests inefficiencies or export strategies that could destabilize global prices (Guide to Investing, 2023).

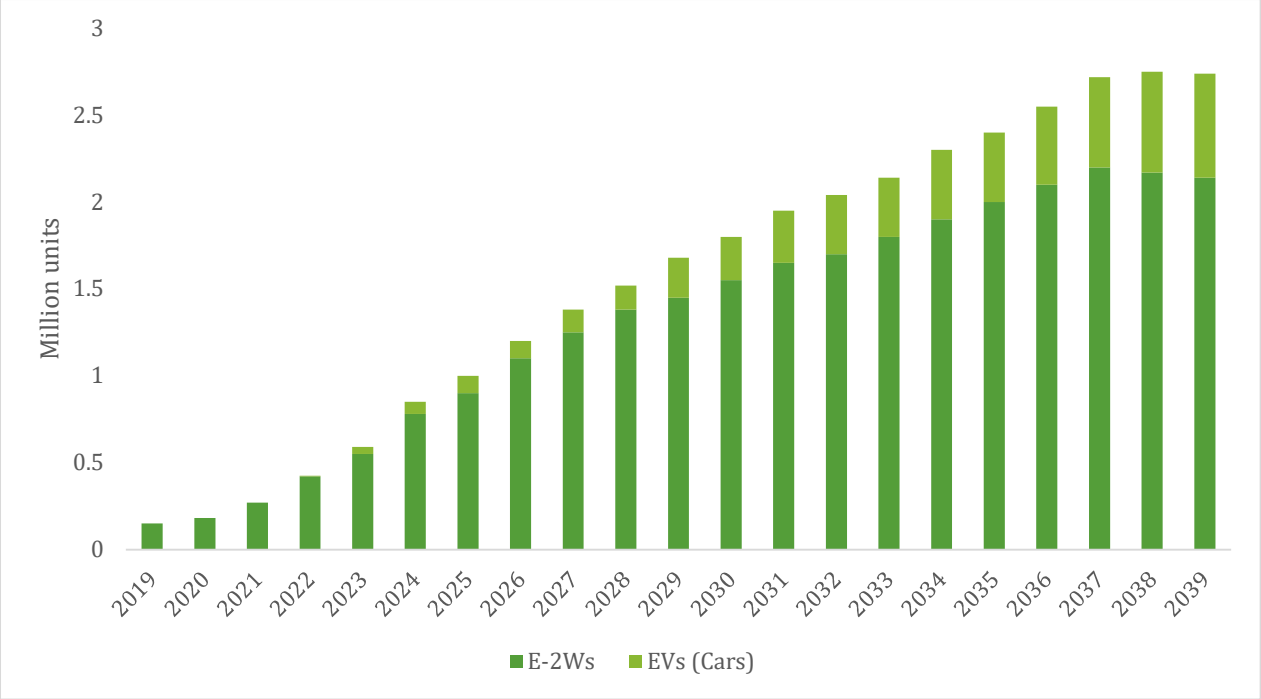
Recycling is emerging as a critical strategy to mitigate these constraints. The IEA estimates that scaling recycling could reduce new mining needs by 25–40% by 2050, offering a sustainable solution to raw material shortages (IEA, 2023). In the EU, recycling is projected to meet 51% of cobalt and 42% of nickel demand by 2040, driven by the Batteries Regulation's targets for collection (65% by 2025), recycled content (50% by 2030), and recycling efficiency (90% for cobalt, nickel, lithium by 2035) (JRC, 2021). Key approaches include extending battery lifespan through reuse and remanufacturing, enhancing traceability with blockchain-based systems, and developing advanced recycling technologies like hydrometallurgy, which recover over 95% of materials (European Commission, 2024). However, global recycling capacity remains limited, with only 5% of LIBs recycled in 2023 (IEA, 2023), highlighting the need for investment in infrastructure and policy support.

2.4. Vietnam's needs in the global context

Vietnam, with its strategic geographical position, abundant mineral resources, and supportive policies, is increasingly positioned to contribute to this evolving landscape. Vietnam's battery demand is mainly driven by EV and, to a lesser but potentially increasing extend, BESS segments, aligning with the national goal of 100% electric vehicles by 2050 and a 75% carbon emissions reduction.

- **EV Market:** The EV market, as a whole, is projected to reach USD 6.69 billion by 2030, with an 18% CAGR from 2025 (Mordor Intelligence, 2025).
    - **Electric two/three-wheelers:** Demand is expected to rise as the two-wheeler EV (E2W) market has grown steadily. E2W sales surged from 257,000 units in 2018 to 484,000 units in 2023, achieving a CAGR of 13.4% per annum, outpacing Indonesia (23,000 units) and Thailand (22,000 units) in 2023, reflecting Vietnam's leadership in Southeast Asia's e-mobility sector. Key players like VinFast (43.4% market share) and Dat Bike, alongside Yadea, Dibao, and Anbico, drive this growth.
    - **Lightweight vehicles and other eMobility:** Demand for passenger EVs is growing but remains constrained by high initial costs, a limited charging ecosystem (20% provincial coverage), and low consumer awareness. Nevertheless, EV sales surged from 8,000 units in 2022 to 90,000 in 2024 (Ministry of Construction), with VinFast being the major actor. International brands (e.g., Mercedes-Benz, BYD) and a projected 33% consumer interest (Vietnam Petroleum Institute, 2025) signal potential, but growth is slow.

Figure 2-7. Growth projection of Vietnam's EV market

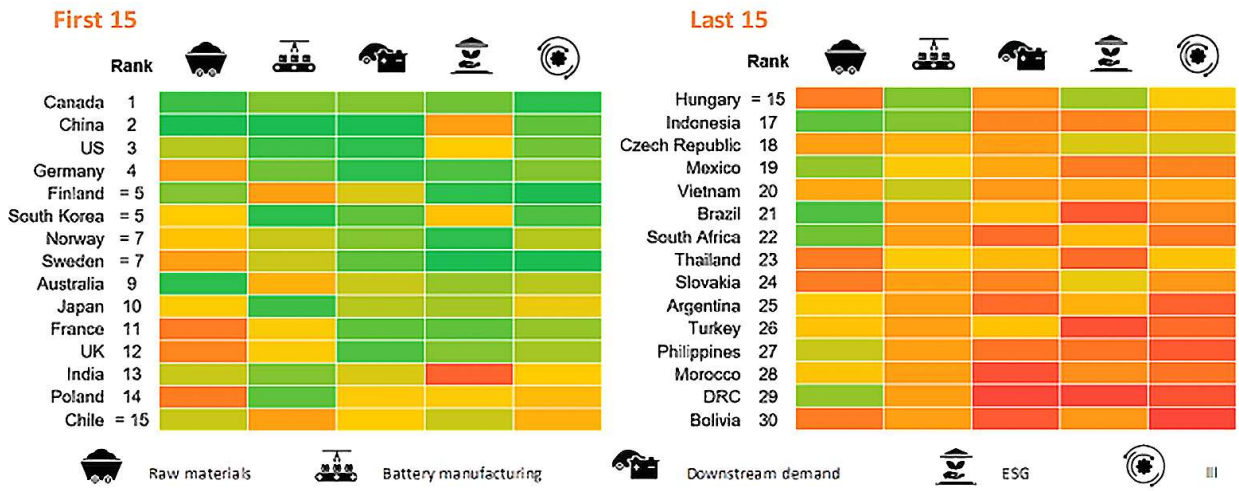


Source: Authors' visualization based on data by HSBC, Motorcycles Data, Vietnam Automobile Manufacturers Association, Bloomberg NEF

- **BESS:** Demand is expected to grow significantly as Vietnam addresses its evolving energy needs, leveraging renewable energy and BESS to stabilize the grid and support off-grid rural areas. BESS capacity under revised Power Master Plan VIII targets 10,000–16,300 MW by 2030, supported by current projects such as VinFast Energy and Marubeni's 1.8 MW/3.7 MWh (VinES, 2024). Globally, the BESS market is expected to hit USD 120 billion by 2030, with Vietnam potentially capturing 0.8–1.2% of the market share (BloombergNEF, 2024). Li-ion LFP is the preferred chemistry due to its cost-effectiveness and safety.

However, the country remains in the early stages of development, ranking 20th out of 30 in the 2024 global lithium-ion battery supply chain rankings (BloombergNEF 2025). Vietnam is heavily reliant on imports, including 80% of lithium and 100% of cathode materials come from Chile, Australia, and China (BloombergNEF, 2024), and lacks the deep processing technologies needed to produce value-added products like nickel sulfate or lithium hydroxide.

Figure 2-8. Global Lithium-Ion Battery Supply Chain Ranking in 2024



Source: BloombergNEF 2025

Vietnam holds significant potential to diversify this landscape, with reserves of 4.1 million tons of nickel, and 280,000 tons of cobalt (USGS, 2022; Ministry of Natural Resources and Environment, 2022). Despite these resources, Vietnam's production capacity remains limited—nickel output reached 20,000 tons in 2023 (75% exported raw), cobalt production was 1,000–2,000 tons, and lithium is entirely imported (50,000 tons in 2023, USD 300 million from Australia and Chile, General Department of Customs, 2023).

To seize opportunities in developing the battery supply chain, Vietnam must invest in processing technologies, enhance workforce skills, and leverage targeted policies, such as tax incentives and industrial zone development, positioning itself as a competitive hub for global battery manufacturers in the sustainable energy transition. The government's policies supporting EV and renewable energy industries, including tax reductions and charging infrastructure development, create a favorable environment, but specific support for domestic battery manufacturing and recycling is needed (Section 3.3).

Table 2-1. Summary of key trends, both globally and in Vietnam

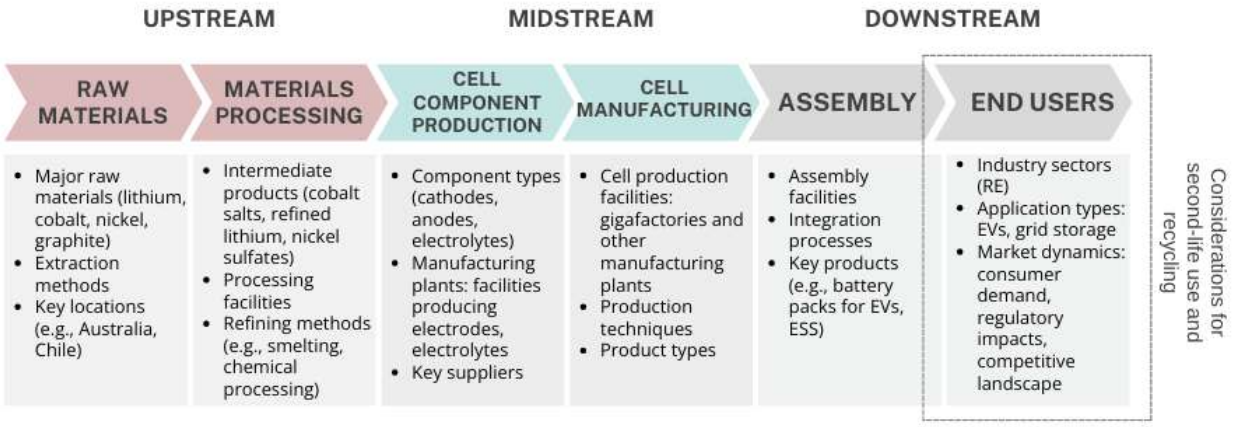
	Global	Vietnam
Demand	Global demand projected to reach 4.9 TWh by 2030, growing at 24% CAGR (2020–2035), with 90% driven by EVs and 80% concentrated in China, US, and Europe. BESS demand at 200 GWh by 2030. Li-ion (LFP, NMC) dominates (80%), with Na-ion emerging by 2030.	Vietnam is expected to have a large deman for batteries, driven by BESS for renewable integration (PDP-8: 10,000–16,300 MW by 2030) and EVs (e.g., E-2Ws is projected to have a 13.4% CAGR 2018–2023; passenger EVs (3 GWh) growing with 90,000 units sold in 2024, targeting 1 million by 2028).
Supply	Supply may balance demand by 2035, but regional disparities exist: China oversupply (1.4 TWh in 2035), US/EU potentially balanced, RoW undersupply (70% gap).	Faces 70% supply-demand; 80% lithium, 100% cathodes imported. Domestic production limited: VinES (100,000 battery units/year), VinFast (250,000 EVs/year).

	China dominates 60% of battery manufacturing, South Korea/Japan key players (Bloomberg, 2023).	FDI from LG Chem ($1.4 billion plant), Samsung SDI supports supply growth.
Value Pools	High-value pools across the value chain: refining ($114 billion), cell production ($119 billion), recycling ($12 billion) by 2030. Mining/refining and cell production for mobility/BESS hold the largest pools, with EBITDA margins of 15–26% for refining, 8–13% for cell production.	Opportunities in refining (nickel: 3.6 million tons, lithium: 1 million tons reserves, USGS, 2025) and cell production (VinFast, LG Chem). Recycling potential (10% rate, 500 tons in 2023) lags South Korea's 22,000 tons/year but could grow to 35% by 2030
Market Opportunities	EU/US diversification from China creates opportunities for RoW to export refined materials and cell components (70% undersupply in EU/NA/RoW). Raw material access (e.g., Indonesia) enables refining, while large local demand (US/EU) drives cell production (McKinsey).	Vietnam can export to EU/US (via CPTPP, EVFTA), leveraging graphite (9.7 million tons) and nickel for refining. Local demand supports cell production. BESS and recycling growth align with net-zero 2050 goal.
Manufacturing Approach	Focus on mining/refining (e.g., Indonesia), cell production for mobility/BESS (US/EU), and recycling/second-life applications. China leads in scale, South Korea in technology (37% cathode share, POSCO Chemical). LFP dominates (50% by 2035, McKinsey).	Emphasis on cell production (VinFast, VinES) and BESS integration (VinFast/Marubeni: 1.8 MW/3.7 MWh). Refining potential (nickel, graphite) constrained by technology gaps (80% raw exports). LFP focus (VinES) aligns with global trends.

3. Phases of the battery supply chain in Vietnam

Vietnam's battery supply chain, critical to its EV and renewable energy goals, comprises four interconnected phases: (1) raw material extraction, (2) battery material production, (3) battery assembly, (4) product distribution, (5) final usage and recycling. Each phase shapes the country's ability to reduce import reliance and meet the EV and BESS targets.

Figure 3-1. Battery supply chain and some key indicators



3.1. Raw material extraction and processing

3.1.1. Key raw materials and their concentrations

Material costs vary significantly based on global market dynamics. According to Bloomberg (2023), raw material costs account for approximately 60-70% of the total cost of lithium-ion battery production, with lithium hydroxide prices rising from USD 20/kg (2020) to USD 70/kg (2023). Among these, cathode materials represent the largest share (51%), followed by the anode (12%), electrolyte (4%), and separator (1%). Nickel and lithium are particularly critical for high-performance battery chemistries like NMC and LFP.

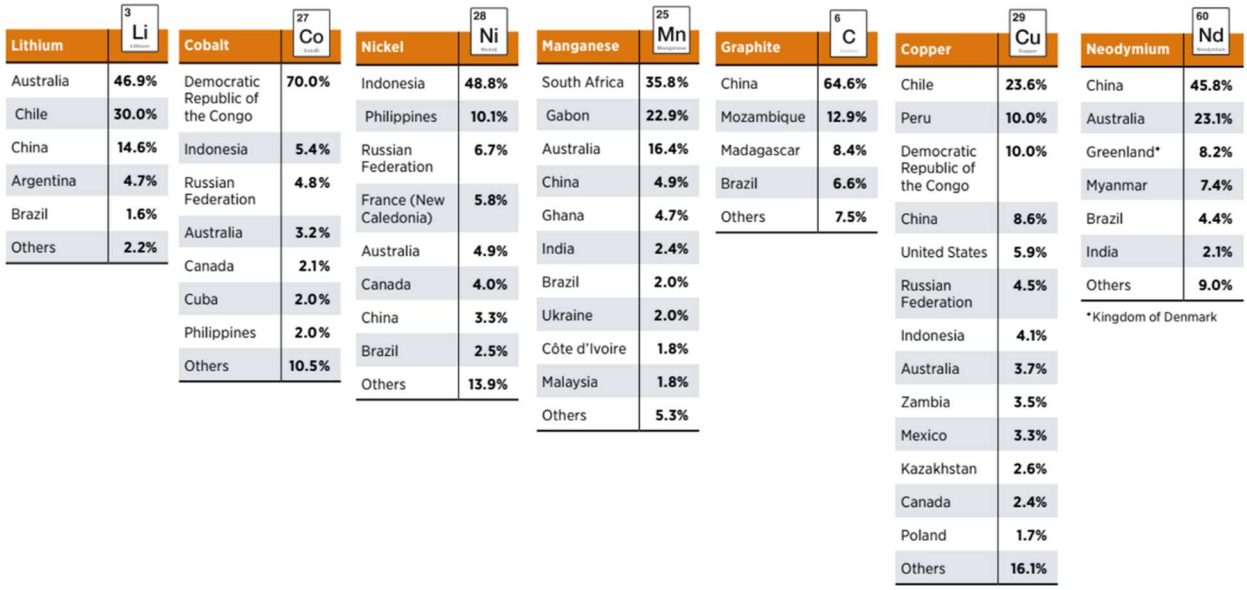
Key materials, along with major mining and processing countries are:

- **Lithium**: Used in electrolytes and anodes for ion transfer, lithium is critical for battery performance in EVs. Concentration is high in Australia, Chile, China, and Argentina.
- **Nickel**: Enhances energy density in NMC cathodes, enabling longer battery range. Large reserves can be found in Indonesia, the Philippines, and Russia.
- **Cobalt**: Ensures stability and lifespan in NMC cathodes, crucial for battery durability. The Democratic Republic of Congo dominates global cobalt supply.
- **Manganese**: Improves thermal stability in NMC cathodes, balancing performance and safety. China is currently processing the majority of manganese.

- **Graphite**: Forms anodes to store lithium ions, enabling battery charging. Over 60% of graphite processing is done in China.

The International Energy Agency (IEA, 2023) projects global demand for critical battery minerals to rise significantly, with nickel increasing from 2.5 million tons in 2022 to 4.5 million tons by 2030, and cobalt from 190,000 tons to 300,000 tons. Vietnam's strategic reserves position it to meet domestic demand and reduce reliance on China's global supply chain dominance.

Figure 3-2. Countries that mine key minerals for the selected types of minerals used in battery manufacturing



Source: IRENA, Geopolitics of the Energy Transition Critical Materials, (Geological Survey and US Department of the Interior, 2023; JRC, 2020; USGS, 2023b), p. 14.

The raw material extraction process includes:

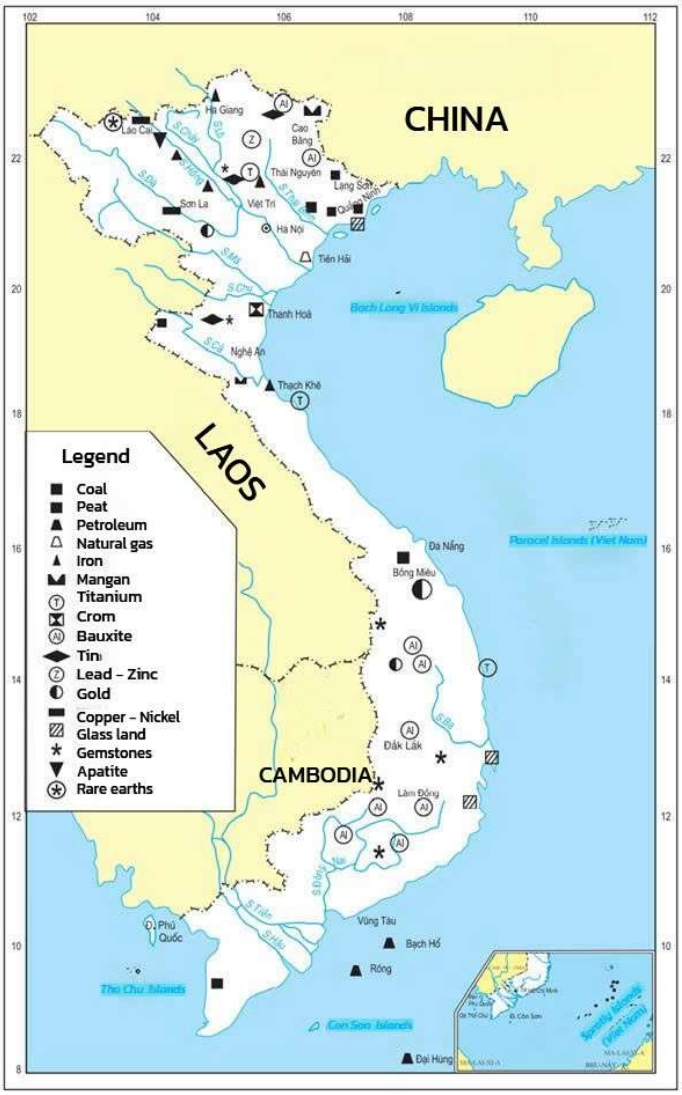
- **Geological surveying:** Identifying mineral deposits and reserves through geophysical surveys and exploration drilling.
- **Mining operations:** Utilizing open-pit or underground methods to extract ores.
- **Primary concentration** via crushing, flotation, or magnetic separation.
- **Purification and refining** to obtain battery-grade materials, such as lithium hydroxide or nickel sulfate.

These processes are capital- and energy-intensive and involve complex environmental management challenges.

3.1.1.1. Vietnam's resource base and emerging capabilities

Vietnam's reserves position it to counter global supply concentration—e.g., China's **60% of rare earths**, Congo's **65% of cobalt**, and Australia's **50% of lithium** (USGS, 2023)—but production and processing lag, limiting value addition.

Figure 3-3. Map of key mineral resources of Vietnam



3.1.1.1.1. Lithium

Vietnam's lithium reserves are modest and remain largely untapped, presenting both opportunities and challenges for its battery supply chain development. The most notable deposit, located at the La Vi site in Quảng Ngãi, contains approximately 1 million tons of ore, equivalent to about 10,000 tons of lithium oxide (Li_2O). This classifies it as a medium-scale resource by global standards. However, lithium production has not yet commenced, primarily because the ore, predominantly in the form of spodumene, lacks commercial exploitation due to the absence of modern ore beneficiation technology.

Preliminary geological studies have identified additional pegmatite-hosted lithium deposits in regions such as Lâm Đồng and Lai Châu. Despite this potential, reserve quantities remain unquantified, and no commercial mining projects have been initiated. The lack of a clear development framework is compounded by Decision 866/QĐ-TTg (2023), which omits a specific roadmap for lithium exploration or development. Furthermore, Vietnam lacks comprehensive

geological survey data and domestic infrastructure for lithium mining and processing, hindering progress.

Lithium is a critical component of lithium-ion battery technology, constituting 5–7% of cathode weight depending on the battery chemistry (IEA, 2023). With global demand for energy storage and electric vehicles rising, and lithium prices forecasted to average USD 15,000 per ton by 2025 (S&P Global, 2024), Vietnam's current reliance on foreign lithium sources poses a significant strategic vulnerability. This dependence underscores the urgent need to invest in domestic exploration, detailed geological surveys, and processing capabilities. Developing these resources would enhance supply resilience and enable Vietnam to capture greater value within the global battery supply chain.

3.1.1.1.2. Nickel

Vietnam holds an estimated 4.1 million tons of nickel reserves, primarily located in Thanh Hóa (3.54 million tons), followed by Sơn La (458,000 tons), Hòa Bình (286,000 tons), and Cao Bằng (73,000 tons). Although modest compared to global leaders like Indonesia (21 million tons) and Australia (20 million tons) (USGS, 2023), these reserves represent a strategic resource for Vietnam's emerging battery supply chain.

Nickel in Vietnam has an average grade of 0.9% to 1.2%, relatively high compared to the global average of 0.8%. Notably, nickel from the Ban Phuc mine contains low levels of impurities such as sulfur and phosphorus, making it suitable for conversion into nickel sulfate—a critical precursor for NMC (nickel-manganese-cobalt) cathodes used in lithium-ion batteries. As NMC 811 cathodes (with 80% nickel content) become the industry standard for electric vehicles (Benchmark Mineral Intelligence, 2023), Vietnam has an opportunity to leverage its domestic resources for higher value-added applications.

Despite this potential, most of Vietnam's nickel is currently exported in raw form or used in stainless steel production, with limited downstream processing. In 2023, nickel output was approximately 20,000 tons, but only a small fraction was refined domestically, underscoring the untapped opportunity to integrate more deeply into the battery value chain.

A promising development is Blackstone Minerals Ltd.'s acquisition of a 90% stake in the Ban Phuc project, including the previously closed underground mine. This strategic move revives a site that had attracted USD 136 million in capital and generated USD 213 million in revenue over 3.5 years before being shut down in 2016 due to low prices. Blackstone plans to restart operations with a broader focus on both Massive Sulfide Vein (MSV) and Disseminated Sulfide (DSS) deposits at the Ta Khoa project, aiming to produce 18,000 tons per year by 2025 using green technology to generate NCM precursors. Their downstream strategy includes metallurgical testing, resource definition, and the development of local processing infrastructure to serve Asia's growing battery market.

Additional exploration in Bắc Yên (Sơn La) has revealed high-grade sulfide, lamellar, and disseminated nickel zones, including Suối Phăng, where nickel concentrations reach up to 20%, confirmed through pXRF drilling. While these findings are promising, commercial viability will depend on the scale of the resource, metallurgical performance, and investment in modern extraction and refining technologies. **With rising demand for battery materials and a**

favorable geographic position, Vietnam is well-placed to advance a more integrated nickel-to-battery supply chain if supported by targeted investments and enabling policies.

Figure 3-4. Location of Ta Khoa Nickel Projects by Blackstone Minerals

Source: Blackstone Minerals

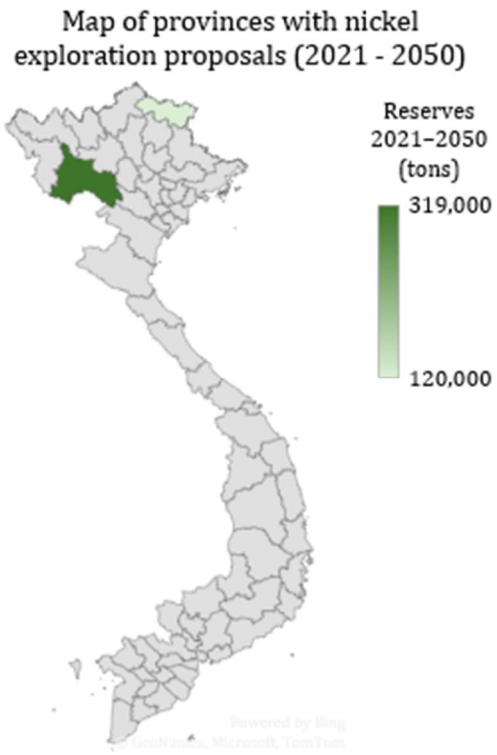
Under Decision 866/QĐ-TTg, nickel exploration proposals from 2021–2030, with a vision to 2050, estimate mobilized reserves of over 409,000 tons, mostly concentrated in Sơn La (around 70%). Exploration there spans both granted and new projects, including the Ta Khoa–Hồng Ngài region. Cao Bằng, though smaller in scale (120,000 tons), is also seeing renewed activity through expansion in the Hà Trì and Phan Thắng zones.

Table 3-1. List of nickel exploration proposals from 2021 – 2030, with a vision to 2050

No.	Province	Exploration Proposal Description	Area (ha)	Reserves 2021–2030 (tons)	Reserves 2031–2050 (tons)
1	**Cao Bang**		**410**	**120,000**	
1.1	New project	Expansion of Nickel – Copper area of Ha Tri and Phan Thang area, Quang Trung commune, Hoa An district	410	120,000	-
2	**Son La**		**9,722**	**289,000**	**30,000**
2.1	Project granted	Nickel – copper in Ta Khoa – Hong Ngai area, belonging to	4,972	268,000	

		Muong Khoa, Ta Khoa, Hong Ngai, Song Pe communes, Bac Yen district and Ta Hoc area belonging to Ta Hoc commune, Mai Son district			
2.1	New project	Nickel – copper in Ta Khoa – Hong Ngai area, belonging to Muong Khoa, Ta Khoa, Hong Ngai, Song Pe communes, Bac Yen district and Ta Hoc area belonging to Ta Hoc commune, Mai Son district (unexplored area of 2.1)	4,750	21,000	30,000
	Total		**10,132**	**409,000**	**30,000**

Source: Authors' adaptation from Decision 866/QD-TTg



Production capacity projections for nickel metal suggest a range from 28,000 to 52,000 tons/year during 2021–2030, with further growth to a maximum of 81,850 tons/year post-2030 (Table 2-3). Thanh Hóa shows the highest designed capacity after 2030, driven largely by the Co Dinh nickel-chromite project. However, achieving these figures will depend on overcoming key challenges, including gaps in processing technology for disseminated ores (with typical Ni content <1%), limited downstream infrastructure, and reliance on small-scale operations such as Bản Phúc, which currently handles dense sulfide ore with high MgO content.

Vietnam's strategic vision for nickel development is clear, yet its success hinges on coordinated efforts to attract long-term investment, upgrade refining technology, and build out local processing capacity. Without such advances, the risk remains that valuable resources will continue to be exported in raw form, limiting the country's role in the global battery value chain.

Table 3-2. List of nickel exploration projects from 2021 – 2030, with a vision to 2050

No.	Province	Area (ha)	Mobilized reserves (Metal) (10^3 tons Ni)	Designed capacity for metal (10^3 tons/ year)	
				2021 – 2030	2031 – 2050

1	**Cao Bang**	855.8	178	9.2 + 14.7	6+11
2	**Son La**	4,977.0	347	15+31	30+61
3	**Thanh Hoa**	N/A	325	7+10	7+10
Total		5,832.8	850	28+52	42.85 + 81.85

3.1.1.1.3. Cobalt

Vietnam possesses an estimated 280,000 tons of cobalt reserves, primarily located in Sơn La, Lào Cai, and parts of Tuyên Quang. These reserves are typically found alongside nickel and copper ores. While relatively modest compared to global leaders, Vietnam's cobalt supply offers strategic value due to its geographical and political stability, particularly when contrasted with the Democratic Republic of Congo, which supplies over 65% of global cobalt under conditions of market volatility and ethical concerns.

Cobalt ores in Vietnam contain between 0.1% and 0.3% cobalt—comparable in quality to ores from Australia and Canada—and have low levels of impurities, making them suitable for refining into cobalt sulfate, a critical component in lithium-ion battery cathodes. However, due to the absence of domestic processing facilities, cobalt is largely exported in raw form, while refined cobalt products are imported from countries like the DRC and Australia. **In 2022, Vietnam produced only 1,000–2,000 tons of cobalt, mostly as a byproduct of nickel mining, with no dedicated infrastructure for cobalt sulfate processing**.

The lack of investment and industrial planning for cobalt development is reflected in national strategies. For example, Decision 866/QĐ-TTg (2023) does not include any specific provisions for cobalt exploration or processing, underscoring a critical gap in Vietnam's battery materials roadmap. Addressing this will be essential to reducing supply chain vulnerabilities and capturing greater value from domestic mineral resources. This presents a significant opportunity for targeted investment in extraction and refining technologies to strengthen Vietnam's position in the global battery supply chain.

3.1.1.1.4. Manganese

Reserves are 10.77 million tons, mainly in Ha Giang, Cao Bang, and Ha Tinh. Vietnam produced 362,000 tons of manganese concentrate (gross weight) in 2022, with an Mn content of 155,000 tons, up from 339,000 tons in 2021. Key operations include Cao Bang Manganese Industry JSC (CAMICO) at Toc Tat Mine, Cao Bang, and Phuc Son Manganese in Tuyên Quang, though capacities are not specified. Manganese alloy production facilities, like Hai Duong New Resources Metallurgy (capacity 150,000 tons/year), support battery precursor production, aligning with Ta Khoa's NCM focus. But overall, production has been limited and mostly exported raw, with no significant processing for battery applications.

Table 3-3. List of manganese exploration projects from 2021 – 2030, with a vision to 2050

No.	Province	Exploration Project Description	Area (ha)	Reserves (tons) 2021–2030	Reserves (tons) 2031–2050 (tons)

1	**Ha Giang**		**403.5**	**200,000**	
1.1	Project granted	Mo Trung Thanh, Coc Hec – Trung Thanh commune, Vi Xuyen district and Dong Tam commune, Bac Quang district	305	100.,00	-
1.2	New project	Pa Lang area, Nghia Thuan commune, Quan Ba district	98.5	100,000	-
2	**Tuyen Quang**		**59.4**	**50,000**	
2.1	New project	Poi Village, Minh Quang commune, Lam Binh district	59.4	50,000	-
3	**Cao Bang**		**1,116.6**	**800,000**	
3.1	Project granted	Roong Thay Mine, Trung Phuc commune, Trung Khanh district	208.9	300,000	-
3.2	New project	Mo Noc Cu, Dinh Phong commune, Trung Khanh district	663.4	250,000	-
	New project	Mo Ta Man - Hat Pan, Trung Khanh district	244.3	250,000	-
4	**Ha Tinh**		**405.4**	**700,000**	
4.1	New project	Tan Dan commune area, Duc Tho district (new project)			-
	Total		**1,984.9**	**1,750,000**	

Source: Authors' adaptation from Decision 866/QD-TTg.

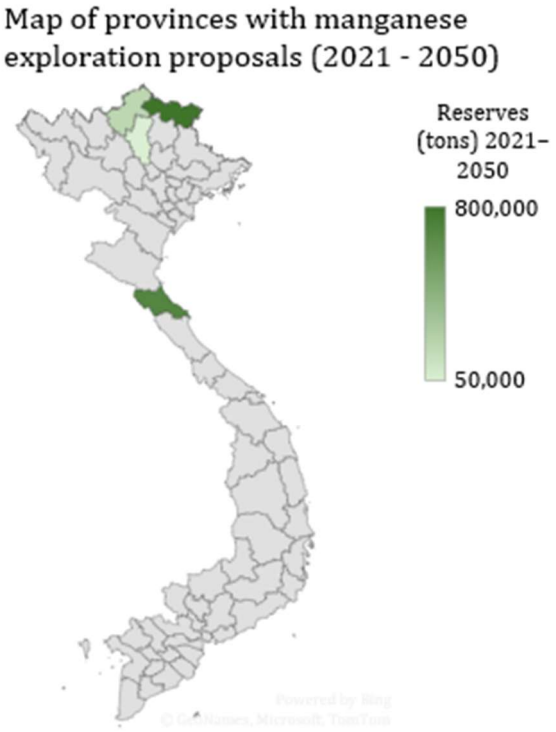


Table 3-4 outlines exploration proposals targeting 1.75 million tons of manganese reserves for 2021–2030, covering 1,984.9 hectares. Cao Bang (800,000 tons) and Ha Tinh (700,000 tons) are key areas, indicating a broad geographical focus. This aligns with Vietnam's 10.77 million ton reserve base, but the mobilized reserves (300,041 tons in Table 2-5) suggest only a fraction is currently economically viable for further processing. Environmental concerns and the need for technology to improve recovery rates are critical barriers. Investment in refining and sustainable mining practices will be essential to leverage this capacity.

Table 3-4. List of manganese exploration projects from 2021 – 2030, with a vision to 2050

No.	Province	Area (ha)	Mobilized reserves (Metal) (10^3 tons)	Designed capacity for metal (10^3 tons/ year)	
				2021 – 2030	2031 – 2050
1	**Ha Giang**	892.8	299,454	7+41	7+9
2	**Tuyen Quang**	59.4	5.8	0.4+1	0.4+1
3	**Cao Bang**	1,747.9	452	15+35	15+21
4	**Ha Tinh**	244.3	34.8	2+3	2+3
Total		3,105.5	300,041	70+77	29+39

3.1.1.1.5. Graphite

Graphite is the primary material used in the anode of lithium-ion batteries, accounting for approximately 25–30% of a battery's total weight. **Vietnam holds significant potential in natural graphite resources, with estimated reserves of 33.24 million tons,** concentrated in Lào Cai (19.04 million tons), Yên Bái (5.98 million tons), and smaller deposits in Quảng Ngãi and Quảng Nam.

Despite this promising reserve base, the domestic graphite mining and processing industry remains underdeveloped. Crystalline flake graphite production dropped sharply by

58% from 1,200 tons in 2021 to just 500 tons in 2022, far below the country's potential. Key operators include Song Da Lao Cai Mining JSC at the Nam Thi Mine in Lào Cai, and Vietnam Graphite Group in Yên Bái, which has a licensed mining capacity of 40,000 tons/year and flotation processing capacity of 24,000 tons/year. **However, refined graphite—particularly spherical graphite required for lithium-ion battery anodes—is still entirely imported**, mainly from China, which accounted for 91% of global output in 2023 (FAS, 2024), as well as from Sri Lanka and Brazil. This creates high dependency and supply chain risk for Vietnam's battery sector, implying the need to invest in modern processing technologies such as chemical refining or pyrolysis to produce battery-grade graphite to meet domestic demand and export.

Table 3-5. List of graphite exploration projects from 2021 – 2030, with a vision to 2050

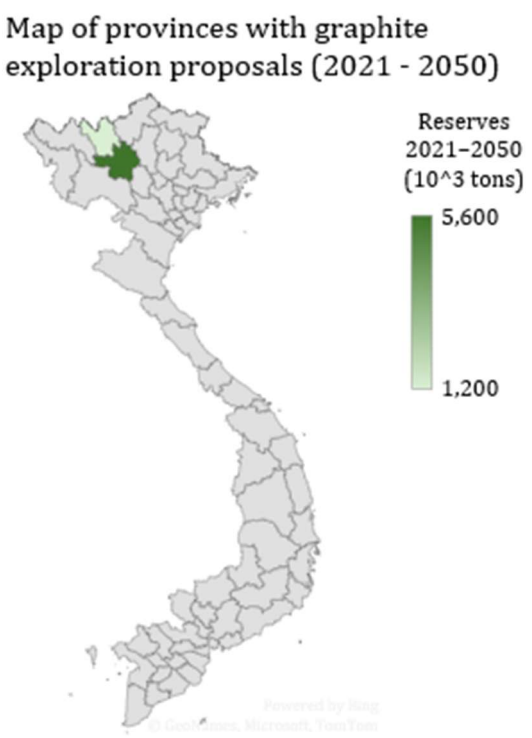
No.	Province	Exploration Project Description	Area (ha)	Reserves 2021–2030 (10^3 tons)	Reserves 2031–2050 (10^3 tons)
1	**Lao Cai**		**868**	**1,200**	
1.1	Project granted	Lang Khoai, Lang Ma, Bong 2, Bao Ha District, Yen Son, Minh Tan, and Kim Son, Bao Yen	868	1,200	-
2	**Yen Bai**		**199.3**	**4,300**	**1,300**
2.1	New project	Upgrading Van Yen mine, belonging to An Binh, Dong Cuong, Ngoi An, Yen Thai, Van Yen	189.3	3,800	1,300
	New project	Lien Son, Lang Thip district, Van Yen	10	500	
	Total		**1,067.3**	**5,500**	**1,300**

Source: Authors' adaptation from Decision 866/QD-TTg

Under Decision 866/QĐ-TTg, Vietnam has outlined ambitious graphite exploration targets for 2021–2030, with a long-term vision to 2050. **Table 2-6** projects the identification of 5.5 million tons of reserves across 1,067.3 hectares during 2021–2030, and an additional 1.3 million tons by 2050. Key projects include:

- **Lào Cai:** 868 ha, with 1.2 million tons of reserves (Lang Khoai, Lang Ma, Bông 2, Yên Sơn, Minh Tân, Kim Sơn – Bảo Yên District).
- **Yên Bái:** 199.3 ha, with 4.3 million tons (Van Yen Mine upgrade in An Bình, Đồng Cuông, Ngòi Ạn, Yên Thái and new projects in Liên Sơn, Làng Thíp).

In parallel, **Table 2-7** identifies a mobilized reserve of 18.08 million tons, with a designed production capacity of 1.026–1.151 million tons/year—far exceeding current output. Notably, Lào Cai contributes 11.2 million tons of mobilized reserves, and Yên Bái 6.88 million tons, underscoring a strategic shift to increase domestic anode material supply and reduce reliance on imports, currently estimated at over 70%.



However, several constraints remain. The total exploration area (approximately 1,160 ha) is small relative to total reserves, suggesting that only a fraction of Vietnam's graphite resources are currently viable. The steep production drop in 2022 also signals operational inefficiencies. Achieving the projected targets will require substantial investment in industrial mineral processing, particularly flotation and purification technologies, estimated at 1,165 billion VND (as outlined in Section 2.4.1.3). Moreover, environmental concerns—such as soil erosion in Lào Cai due to mining—must be addressed to ensure sustainable expansion.

In summary, while Vietnam possesses significant graphite reserves, especially in Lào Cai and Yên Bái, realizing their value will depend on strengthening domestic processing capabilities, upgrading production technologies, and mitigating environmental impacts to position itself as a competitive anode material supplier for the global battery industry.

Table 3-6. List of graphite exploration projects from 2021 – 2030, with a vision to 2050

No.	Province	Area (ha)	Mobilized reserves (Metal) (10^3 tons Ni)	Designed capacity for metal (10^3 tons/ year)	
				2021 – 2030	2031 – 2050
1	**Lao Cai**	947.4	11,199	548+598	548+598
2	**Yen Bai**	212.4	6,884	478+553	478+553
Total		1,159.8	18,083	1,026+1,151	1,026+1,151

3.1.1.2. Extraction technologies and challenges

Vietnam's extraction of key battery minerals, including nickel, cobalt, and lithium, employs a combination of traditional and emerging technologies. While these methods provide important opportunities for resource utilization and industrial development, they also present complex challenges for environmental sustainability, technological advancement, and regulatory governance.

- **Traditional Extraction Technology**
  Vietnam's mineral extraction activities have largely relied on traditional methods such as open-pit mining. This approach is currently applied to key battery minerals like nickel and cobalt due to its relative cost-efficiency and accessibility. However, it often requires large-scale land use, which can impact local ecosystems, biodiversity, and water and soil quality. For example, localized water quality concerns were reported in Sơn La, where

nickel mining activities affected 10–15% of water sources in 2023 (Lê, 2020). Traditional techniques are also resource-intensive and have lower recovery rates; nickel extraction in Vietnam achieves 60–70% recovery, below the global benchmark of approximately 90% (Lê & Trần, 2020). These challenges highlight the importance of accelerating the transition to cleaner and more efficient technologies.

- **Underground Mining Technology**
  To mitigate the surface-level impacts of open-pit mining, Vietnam is actively exploring underground mining technologies in areas such as Thanh Hóa. This method can significantly reduce land use and environmental disturbance while enhancing the sustainability of mineral extraction. Nevertheless, underground mining requires substantial investment in equipment, infrastructure, and technical capacity. Its development depends heavily on coordination among state agencies, domestic enterprises, and international partners to overcome the barriers of high capital costs and limited operational expertise (Trần, 2023).

- **Smart Mining Technology**
  Smart mining, which leverages digital tools such as sensors, data analytics, and automation, offers a promising path for improving extraction efficiency and minimizing environmental impacts. Although adoption remains limited in Vietnam, this technology holds considerable potential for minerals like lithium and cobalt. For instance, real-time data monitoring systems could enhance recovery rates by 15–20% (Zhang et al., 2021). Scaling up smart mining will require investment in technological infrastructure, knowledge transfer, and capacity building—areas where international collaboration can play a crucial role.

- **Challenges in Extraction Technology**

  - *Limited Access to Advanced Technologies:* Many mining operations still rely on labor-intensive methods and outdated equipment, which limit efficiency and increase environmental pressures. At sites like La Vi, the lack of modern beneficiation technology currently restricts commercial-scale lithium extraction (Lê & Trần, 2020).

  - *Strengthening Resource Governance:* Enhancing the enforcement of mining regulations is essential for ensuring transparent, lawful, and efficient extraction. Inadequate oversight has, in some cases, enabled unregulated operations. For example, unlicensed nickel mining activities in Cao Bằng contributed to approximately 5% of the province's total output in 2022 (Nguyễn, 2022). Strengthening institutional capacity and regulatory frameworks is thus a key priority.

  - *Addressing Environmental Impacts:* Mining activities can affect ecosystems and public health if not properly managed. Reports have indicated that manganese mining in Cao Bằng has contributed to a 10% decline in local biodiversity (Vũ & Trần, 2021). While the government has issued various environmental protection guidelines, further integration of environmental safeguards into mining operations is necessary to align with national sustainability goals.

3.1.1.3. Overall assessment and projected investment needed

Vietnam's mineral resource base offers significant potential to support the battery value chain, but production and processing limitations hinder its ability to add value domestically. The **Table 3-7** highlights Vietnam's reserves—4.1 million tons of nickel, 10.8 million tons of manganese, and 33.2 million tons of graphite—but production remains low due to low-grade ores (e.g., nickel at <1% Ni content), underdeveloped processing technologies, and a lack of comprehensive geological surveys. For instance, nickel production in 2023 was 20,000 tons, with 75% exported raw, despite a processing capacity of 60,450–97,200 tons/year (2021–2030), as noted in previous sections. Similarly, graphite production dropped to 500 tons in 2022, while processing capacity reached 53,450–64,600 tons/year, indicating a gap between mining and midstream capabilities. Production for manganese is ~41% of capacity, with large reserves, suggesting a stable and scalable supply, but raw exports reduce local industrial benefits. For other key resources such as lithium and cobalt, there is currently limited prioritization of these in the current mineral exploration strategies. Most of the lithium and cobalt right now in Vietnam are, therefore, imports.

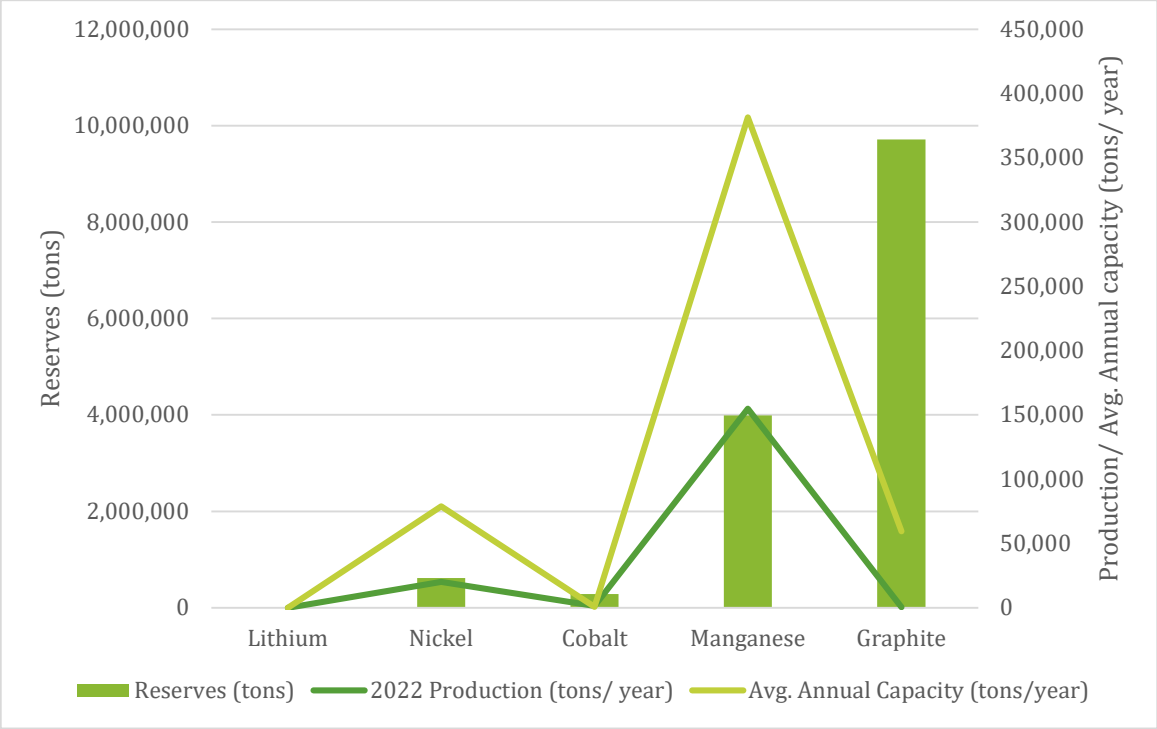
Environmental challenges exacerbate these limitations, particularly in nickel and manganese mining. Open-pit mining in Sơn La for nickel has led to water and soil pollution, with an estimated 10–15% of local water sources contaminated in 2023. Manganese mining in Cao Bằng has contributed to biodiversity loss. Outdated technology and illegal mining further reduce efficiency, e.g., recovery rates for nickel are 60–70%, compared to the global standard of 90%. Efforts to adopt underground and smart mining with sensors (Le, 2020; Zhang et al., 2021) are underway, but issues linked to resource management continues to limit output.

Table 3-7. Summary of Vietnam's key battery minerals

		Reserves (tons)					
Mineral	Production (tons, 2022)	Reserves	Resource and resource forecasting	Total	Capacity (tons/year)	Key Projects/Facilities	Notes
Lithium	0*	1,000,000 ore (10,000 Li_2O)*	N/A	N/A	0*	La Vi deposit (Quảng Ngãi); imports: 50,000 tons (2023)	Relies on imports; research ongoing
Nickel	20,000*	612,000	3,482,600	4,094,600	60,450–97,200 (2021–2030); 97,950–187,200 (2031–2050)	Ta Khoa (Sơn La): 2.42% Ni at Suối Phăng	75% exported raw; processing capacity reflects midstream development
Cobalt	1,000–2,000*	280,000*	N/A	N/A	500–1,000 (estimated from Ta Khoa, 2025)	Ta Khoa (Suối Phăng): 0.06% Co	Imports from DRC, Australia
Manganese	362,000 (gross); 155,000 (Mn)	3,989,033	6,779,989	10,769,022	356,590 (2021–2030); 406,590 (2031–2050)	CAMICO (Toc Tat Mine), Phuc Son (Tuyên Quang)	Mostly exported raw
Graphite	500	9,715,829	23,527,847	33,243,676	53,450–64,600 (2021–2030); 54,000–65,200 (2031–2050)	Song Da Lao Cai, Vietnam Graphite (Yên Bái)	70% import reliance

Source: Authors' compilation from multiple sources

Figure 3-5. Vietnam's battery mineral profile



Source: Authors' visualization based on Table 3-7. For lithium, the value used is ~10,000 tons Li2O equivalent.

Investment needs for both exploration and processing are substantial to bridge these gaps. Exploration projects for industrial minerals (including graphite) from 2012–2050 require an estimated 1,173 billion VND, while copper, nickel, and molybdenum exploration needs 9,151 billion VND, totaling 10,324 billion VND (approximately $413 million USD at 25,000 VND/USD as of May 2025). In contrast, processing projects require 1,165 billion VND for industrial minerals and 13,830 billion VND for copper, nickel, and molybdenum, totaling 14,995 billion VND ($600 million USD). Together, these exploration and processing investments amount to 25,319 billion VND (approximately $1.01 billion USD), highlighting the capital-intensive nature of building a vertically integrated battery value chain. The Ta Khoa project, targeting 18,000 tons/year of nickel by 2025, exemplifies the potential impact of such investments, potentially reducing raw exports and supporting NCM precursor production for domestic battery manufacturing.

To unlock its potential, **Vietnam must prioritize investments in advanced mining and refining technologies, enhance geological exploration, and establish vertically integrated value chains. International partnerships and technology transfers, supported by a clear industrial policy, are critical to shift from raw exports to high-value battery materials**. Policies should also address environmental impacts, such as enforcing stricter regulations on mining pollution and incentivizing sustainable practices like smart mining, to balance economic growth with environmental integrity. By aligning exploration, production, and processing efforts, Vietnam can reduce its reliance on imports.

3.1.2. Battery material processing stage

After extraction and initial processing, raw minerals are transformed into battery-grade materials used in the manufacture of electrodes, electrolytes, and separators. This midstream

stage is technically complex and capital-intensive, requiring high-purity inputs and advanced chemical engineering capabilities.

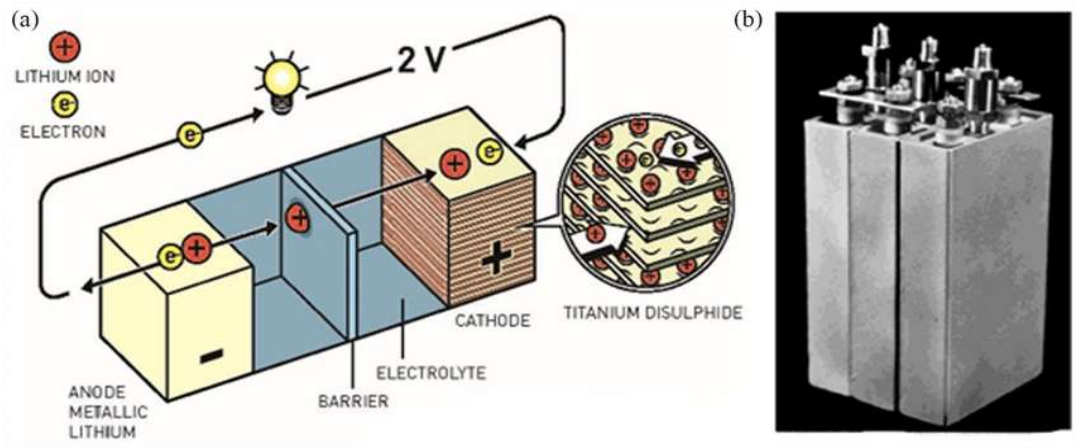
Battery material production accounts for 35–50% of the battery cost, particularly for lithium-ion batteries, and has a significant impact on battery performance and durability. Mastery of this stage can position countries like Vietnam to move up the value chain beyond raw material exports.

3.1.2.1. Key battery materials and their functions

Battery material production focuses on four major components:

- **Cathodes**: Comprises ~51% of battery cost. Cathode materials include Lithium Cobalt Oxide (LiCoO2) for high energy density in phones/laptops, Nickel Manganese Cobalt (NMC) and Nickel Cobalt Manganese (NCM) for EV performance, Lithium Iron Phosphate (LFP) for safe energy storage, and Lithium Manganese Oxide (LMO) for durability.
- **Anodes**: Graphite for cost-effective lithium storage (~12% of cost), silicon for higher capacity (though with lifespan issues), and tin-graphite alloys under research for improved energy density.
- **Electrolytes**: Lithium salt (e.g., LiPF6) in organic solvents for ion conduction, with solid-state options in development for safety and density (~4% of cost).
- **Separators**: Microporous polyolefin films that prevent short-circuiting by separating electrodes (~1% of cost).

Figure 3-6. Components of a lithium-ion battery



Each component requires high purity, controlled particle size, and chemical stability. The process of producing these involves:

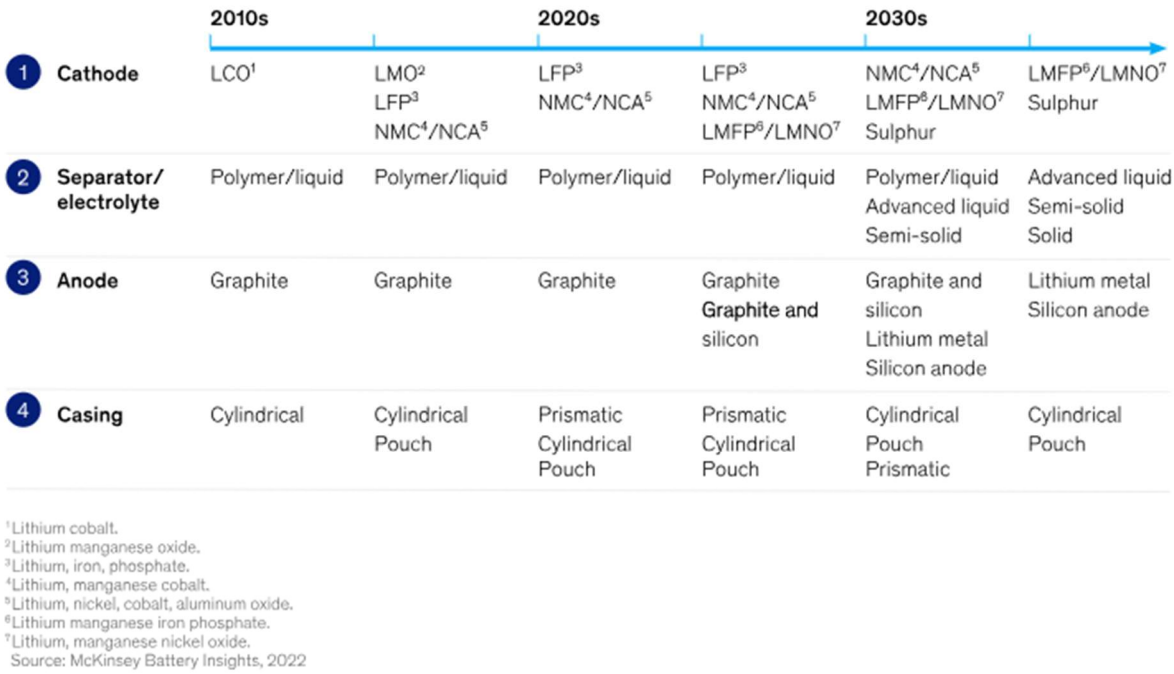
i. **Cathode Production**: Preparing materials (lithium, cobalt, nickel, manganese), grinding into powder, heat-treating into stable oxides, filtering impurities, and drying/packaging.

ii. **Anode Production**: Mixing graphite or silicon with binders into a slurry, casting into sheets, heating to stabilize, and quality-checking (thickness, density).

iii. **Electrolyte Production**: Selecting solvents, dissolving lithium salts with additives, and testing conductivity and purity.

Globally, China dominates with 60% of battery material production, while South Korea and Japan lead in cathode and anode technology (Bloomberg, 2023). **In Vietnam, this phase represents a key area for development.**

Figure 3-7. Common battery chemistries and form factor available



Source: McKinsey Battery Insights, 2022

3.1.2.2. Vietnam's current status in battery material production

Vietnam's battery material production sector is still at a nascent stage and remains significantly dependent on imported inputs. In 2023, the country imported an estimated $1.2 billion worth of battery materials, with 70% sourced from China, followed by imports from South Korea and Japan (General Department of Customs, 2023). These imports primarily cover essential materials such as cathodes, underscoring the importance of strengthening domestic capabilities.

- **Cathode production** is limited due to the absence of deep-processing infrastructure for key compounds including nickel sulfate, cobalt sulfate, and lithium hydroxide. These materials are currently sourced from international suppliers (Mai Hạ, 2025). For example, the VinES Hà Tĩnh plant (5 GWh/year), a major domestic player, relies entirely on imported cathode inputs from China (Vingroup, 2023), highlighting the need for strategic investment in upstream capacity.
- **Anode production** is undeveloped. Vietnam imported graphite from China—the world's leading supplier with 1.2 million tons/year and 70% global share—as domestic reserves (29 million tons) remain unprocessed due to lacking technology (USGS, 2023; General

Department of Customs, 2023). LG Chem's Hải Phòng plant (5 GWh/year) similarly imports anodes from South Korea (LG Chem, 2022).

- **Electrolyte production** has yet to emerge in Vietnam, and while there is some local separator production, it remains at a small scale and generally does not meet the requirements for high-performance applications. High-end separator materials are still mainly imported from Japan and South Korea (Anh Nhi, 2025; Mai Hạ, 2025). There is also room to improve technology and efficiency, particularly in mineral processing, where recovery rates of 60–70% are still below those achieved in more advanced manufacturing countries (typically 90%) (Vneconomy.vn, 2025). At present, there are no domestic plants producing critical compounds such as nickel sulfate, cobalt sulfate, or lithium hydroxide. However, the growth of Vietnam's chemical and polymer industries offers potential for future development of these technologies, especially for separators, where small-scale production exists but does not meet high-performance standards
- **Separator production** exists only at a small scale. A few domestic firms manufacture low-quality separators, but most high-end separators are still imported from Japan and South Korea (Mai Hạ, 2025).

Although Vietnam possesses promising reserves of strategic minerals, the capacity to process these into battery-grade materials remains under development. In 2023, nickel production reached 20,000 tons, but approximately 75% was exported in raw form. Cobalt output was between 1,000–2,000 tons, and rare earth oxide production stood at only 200–300 tons—volumes that are not yet sufficient to support large-scale manufacturing of battery components (Moitruong.net.vn, 2025). Additionally, 50,000 tons of lithium were imported due to the absence of commercial-scale extraction and processing operations (General Department of Customs, 2023).

Table 3-8. Key mineral processing projects from 2021 – 2030, with a vision to 2050

No.	Province	Project/Processing Details	Designed Capacity (tons/year)	
			2021–2030	2031–2050
Manganese processing projects				
1	**Ha Giang**		**60,000**	**60,000**
1a		Processing Ferromanganese, Silicomanganese at Công nghiệp Bình Vàng, huyện Vị Xuyên	10,000	10,000
1b		Processing Ferromanganese, Silicomanganese at Công nghiệp Bình Vàng, huyện Vị Xuyên	40,000	40,000
1c		Processing raw manganese into metal at KCN Bình Vàng, huyện Vị Xuyên	10,000	10,000
2	**Cao Bằng**		**46,590**	**46,590**
2a		Processing Ferromanganese at Phong Châu, Trung Khánh, Hòa An	15,000	15,000
2b		Processing Ferromanganese at Cao Bằng, Trung Vương, Hòa An	9,000	9,000

2c		Khai thác, chế biến Ferromanganese at Quý Quân, Trà Lĩnh	7,590	7,590
2d		Processing MnO_2 (electrolytic) and Ferromanganese at Ngũ Lão, Hòa An	15,000	15,000
2e		Processing Ferromanganese, Silicomanganese from ore at Bản Min, Vĩnh Quý, Hạ Lang	10,000	10,000
3	**Tuyên Quang**		**90,000**	**90,000**
3.1a		Processing Silicomanganese via Ferromanganese at CCN An Thịnh, Chiêm Hóa	15,000	15,000
3.1b		Processing Ferromanganese at C2, Long Bình An IP, Tuyên Quang	15,000	15,000
3.2		Expanding the Silicomangan and Feromangan at An Thinh IP, Chiem Hoa (including past capacity of 15,000 tons/ year)	75,000	75,000
4	**Bắc Kạn**		**160,000**	**210,000**
4a		Processing refined manganese at Cẩm Giàng, Bạch Thông	60,000	60,000
4b		Processing Ferromanganese at Na Pai, Bằng Lũng, Chợ Đồn	100,000	150,000
	Total		**356,590**	**406,590**
Nickel processing projects				
1	**Sơn La**		37500–75000	75000–150000
1a		Processing nickel compounds (NCM, NCMA, PCAM)	37500–75000	75000–150000
1b		Processing nickel sulfate	10500–21000	21000–42000
1c		Processing cathode materials (magnesium sulfate)	-	-
2	**Cao Bang**		**5400–7200**	**5400–7200**
2a		Processing nickel compounds (chlorine nickel, nickel hydroxide)	5400–7200	5400–7200
3	**Thanh Hoa**		**7500–10000**	**7500–10000**
3a		Processing nickel compounds (sulfate, chlorine, hydroxide)	7500–10000	7500–10000
4	**Thai Nguyen**		**10000–15000**	**15000–20000**
4a		Processing nickel compounds at Son Cam 3, Son Cam, industrial zone, Thai Nguyen	10000–15000	15000–20000
	Total		**60450–97200**	**97950–187200**
Graphite processing projects				

1	**Lao Cai**		**50,000–60,000**	**50,000–60,000**
1a		Processing graphite at Bao Ha, xa Bao Ha, huyen Bao Yen (existing project)	20,000	20,000
1b		Processing graphite at Nam Thi (existing project)	1,500–2,000	1,500–2,000
1c		Processing graphite at Bao Ha 2, xa Bao Ha, huyen Bao Yen (new project)	2,000–3,000	2,000–3,000
2	**Yen Bai**		**3,450–4,600**	**4,000–5,200**
2a		Processing graphite at Co Phuc	450–600	1,000–1,200
2b		Processing graphite at Van Yen	3,000–4,000	3,000–4,000
	Total		**53,450–64,600**	**54,000–65,200**

Source: Authors' compilation and adaptation from Decision 866/QD-TTg

The processing projects outlined in Table 3-8 highlight Vietnam's efforts to strengthen its midstream capabilities in the battery value chain, particularly for cathode and anode materials. Manganese, nickel, and graphite processing capacities are pivotal for addressing the import dependency challenges noted earlier. Manganese processing, reaching 356,590 tons/year in 2021–2030 and growing to 406,590 tons/year by 2031–2050, supports cathode production (e.g., LMO, NMC), with Bắc Kạn's increase from 160,000 to 210,000 tons/year reflecting a strategic focus on scaling output. Nickel processing, particularly in Sơn La (37,500–75,000 tons/year, doubling to 75,000–150,000 tons/year by 2031–2050), produces advanced compounds like NCM and nickel sulfate, **directly addressing the absence of domestic deep-processing infrastructure for cathode materials** highlighted earlier. This could significantly reduce the 75% raw nickel export rate (20,000 tons produced in 2023) if paired with policies to retain more processed output domestically. Graphite processing, led by Lào Cai's 50,000–60,000 tons/year, offers a domestic alternative to the 70% imported graphite dependency, **supporting anode production needs** for plants like LG Chem Hải Phòng, which currently imports anodes from South Korea.

However, these capacities reveal gaps when compared to Vietnam's current production and global benchmarks. The 2023 nickel output of 20,000 tons, with 75% exported raw, contrasts with the projected 97,950–187,200 tons/year processing capacity by 2031–2050, indicating untapped potential to shift from raw exports to value-added processing. Graphite processing (53,450–64,600 tons/year) leverages Vietnam's 29 million tons of reserves but remains modest compared to China's 1.2 million tons/year, underscoring the technological gap in processing domestic reserves. Manganese processing exceeds current cobalt (1,000–2,000 tons) and rare earth oxide (200–300 tons) outputs, but the absence of lithium processing—evidenced by the 50,000 tons imported in 2023—limits cathode material production (e.g., LFP). **The low recovery rates of 60–70% in mineral processing, compared to the global standard of 90%, further hinder efficiency**, as noted earlier, impacting the competitiveness of these outputs.

The growth in midstream capacity aligns with rising global demand for battery minerals, projected to reach 1–2 million tons annually by 2030 (IEA, 2023). For instance, the nickel processing capacity could support 604,500–972,000 EV batteries annually in 2021–2030 (assuming 100 kg nickel per 50 kWh battery), scaling to 979,500–1,872,000 by 2031–2050, a

significant contribution to Vietnam's EV sector. Graphite capacity could support 1.07–1.29 million kWh of battery production annually (50 kWh per EV), addressing part of the domestic anode demand. **However, realizing this potential requires substantial investment, with processing projects estimated to need 1,165 billion VND for industrial minerals (including graphite) and 13,830 billion VND for copper, nickel, and molybdenum.** This investment, totaling approximately 14,995 billion VND (roughly $600 million USD at an exchange rate of 25,000 VND/USD as of May 2025), underscores the capital-intensive nature of the midstream stage and highlights the need for public-private partnerships to bridge the funding gap. **Addressing these gaps requires targeted strategies**, such as improving recovery rates, developing lithium processing capabilities, and fostering technology transfers, which are critical to the policy measures proposed below.

A core challenge lies in Vietnam's limited access to proprietary technologies for cathode and anode production, which are typically safeguarded by patents and concentrated among a small number of foreign firms. Compounding this is a shortage of domestic suppliers capable of delivering high-purity inputs, such as battery-grade lithium or nickel compounds. Vietnam's research and development ecosystem is still evolving, particularly in fields like battery chemistry and process engineering. Private investment in midstream infrastructure remains relatively low, reflecting high capital costs and uncertain returns.

At the industrial level, the landscape is still largely oriented toward assembly rather than upstream or midstream processing. Companies like VinES and LG Chem have played an important role in advancing the battery value chain, yet both remain dependent on imported materials. VinES sources most of the inputs for VinFast's EV batteries from abroad, while LG Chem's $1.4 billion facility in Hải Phòng similarly relies on external supply chains (Vingroup, 2023; LG Chem, 2022). Vietnamese SMEs primarily contribute non-core components, such as casings and connectors, rather than critical raw materials (Mai Hạ, 2025).

To build a more competitive and integrated battery materials sector, Vietnam should adopt a coordinated set of policy measures. **These include promoting technology transfer through joint ventures, licensing, and strategic partnerships with global leaders, as the analysis shows a need to bridge technological gaps in processing battery-grade materials like nickel sulfate and graphite.** Targeted investment incentives like tax relief and infrastructure support can attract private investment, addressing the low investment levels noted earlier and supporting the estimated 14,995 billion VND needed for processing projects. **Developing industrial clusters near key processing hubs like Lào Cai, Sơn La, and Bắc Kạn, as suggested by the analysis, would help reduce logistical costs and promote synergies among related sectors.** At the same time, strengthening academic and R&D institutions in battery technology and materials science is essential to improve recovery rates and develop domestic lithium processing. Finally, a clear, consistent regulatory framework, balancing environmental integrity with investment facilitation, will be key to attracting long-term capital and fostering innovation.

3.1.3. Battery assembly: The value-added core of the battery supply chain

Battery assembly marks the final and most value-added stage in lithium-ion battery production, where cathodes, anodes, electrolytes, and separators are integrated into functional cells. This

phase directly determines battery performance, safety, and lifespan, and demands advanced technology and rigorous quality control. With materials accounting for 60–70% of total production costs, and cathodes alone contributing nearly 50% (Benchmark Mineral Intelligence, 2023), this stage plays a crucial role in cost optimization and technological differentiation.

Globally, East Asian countries, particularly China, South Korea, and Japan, dominate battery assembly capacity. These regions lead in manufacturing efficiency and innovation, setting global benchmarks through extensive automation, integrated supply chains, and high throughput.

3.1.3.1. Process overview

The battery assembly process begins with the preparation of four key components:

- **Cathodes** (lithium, cobalt, nickel, manganese alloys),
- **Anodes** (graphite, sometimes enhanced with silicon or tin),
- **Electrolytes** (lithium salts in organic solvents or solid-state variants),
- **Separators** (microporous polyolefin films).

These are combined with binders, control electronics, and the Battery Management System (BMS), which governs battery operation and safety, to form the functional cell.

Assembly involves precise layering of cathodes and anodes with separators to enable ion flow while avoiding short circuits. Automation, especially robotic stacking, enhances alignment, minimizes defects, and improves consistency.

The layered stacks are then rolled or folded into two main configurations:

- **Jelly-roll designs**, used in cylindrical and prismatic cells, offer high energy density.
- **Stacked designs**, preferred for larger EV modules, facilitate thermal control and modular assembly.

Recent innovations include 3D printing of solid-state batteries and electrodes. Companies like Sakuu Corporation (USA) and Blackstone Technology GmbH (Germany) have reported up to 20% gains in energy density and 30% cost reductions by consolidating production steps (Sakuu, n.d.; DesignNews, 2023; electrive.com, 2021). In Vietnam, 3D printing remains limited to R&D in casing production, though its broader application may emerge in the coming years (Market Synthesis, 2024).

Final assembly includes cell encapsulation in thermally resistant metal or composite casings, initial charging (typically up to 50%), and extensive testing—covering thermal stability, charge-discharge cycling, and BMS integration to ensure performance and safety.

3.1.3.2. Battery manufacturing and assembly technologies

Vietnam's battery manufacturing and assembly sector is developing, with a focus on lithium-ion batteries for EVs, electronics, and energy storage, though it remains reliant on imported technologies and materials.

- **Lithium-Ion Battery Manufacturing Technology**
  Lithium-ion battery manufacturing in Vietnam involves material production, cell assembly, and quality testing. However, the sector heavily depends on technologies imported from South Korea, Japan, and China. Companies like VinFast partner with international firms to implement production capabilities, but a fully developed, large-scale industry is lacking (VinFast, 2022). For example, VinES's Hà Tĩnh plant applies Siemens' Manufacturing Execution System (MES) for real-time monitoring of production parameters, achieving 99.7% uniformity in electrode casting, 120 cells per minute in laser welding (20 kW, ±0.05 mm precision), and gas tightness of 10^{-6} mbar·L/s in packaging (VinFast, 2023). Despite such advancements, 65% of raw materials (e.g., lithium carbonate, nickel sulfate) are imported from Chile and Indonesia due to the lack of domestic refining (MOIT, 2024).

- **Battery Manufacturing Process in Vietnam**
  The process includes:

  1. *Producing Anode and Cathode Materials*: Domestic production is limited to processing imported materials, with companies like VinES relying on foreign suppliers for high-purity inputs (Nguyễn & Trần, 2022).

  2. *Assembling Battery Cells*: Cells are assembled using anodes, cathodes, electrolytes, and separators, requiring automated equipment for precision. VinES uses ABB robots for automation, but broader adoption of advanced systems is limited (VinFast, 2023).

  3. *Testing and Quality Control*: Batteries undergo safety, performance, and capacity tests. However, Vietnam lacks automated quality control systems, relying on manual methods that reduce efficiency (Nguyễn & Trần, 2022).

- **Battery Assembly Technology**
  Battery assembly in Vietnam is advancing with the entry of major players like VinFast. Automation, such as robotic systems for welding and packaging, improves precision and productivity. For instance, Exquisite Power in Hải Phòng has invested $20 million in a closed-loop wastewater recycling plant, recovering 95% of electrolyte solvents (Highpower Technology, 2023). However, assembly technology lags behind global leaders, with production efficiency at 80–85% compared to 95% in South Korea.

3.1.3.3. Companies in Vietnam's battery manufacturing and assembly sector

Vietnam's battery assembly capacity is still emerging, currently estimated at 5–7 GWh in 2024. This growth is driven by rising demand from the EV and renewable energy sectors. Key contributors include:

- **VinES (Hà Tĩnh)**: Produced 1 GWh in 2023, supplying 20% of VinFast's 2 GWh requirement (equivalent to ~35,000 EVs), with plans to expand to 15 GWh by 2030 (Vingroup, 2023).

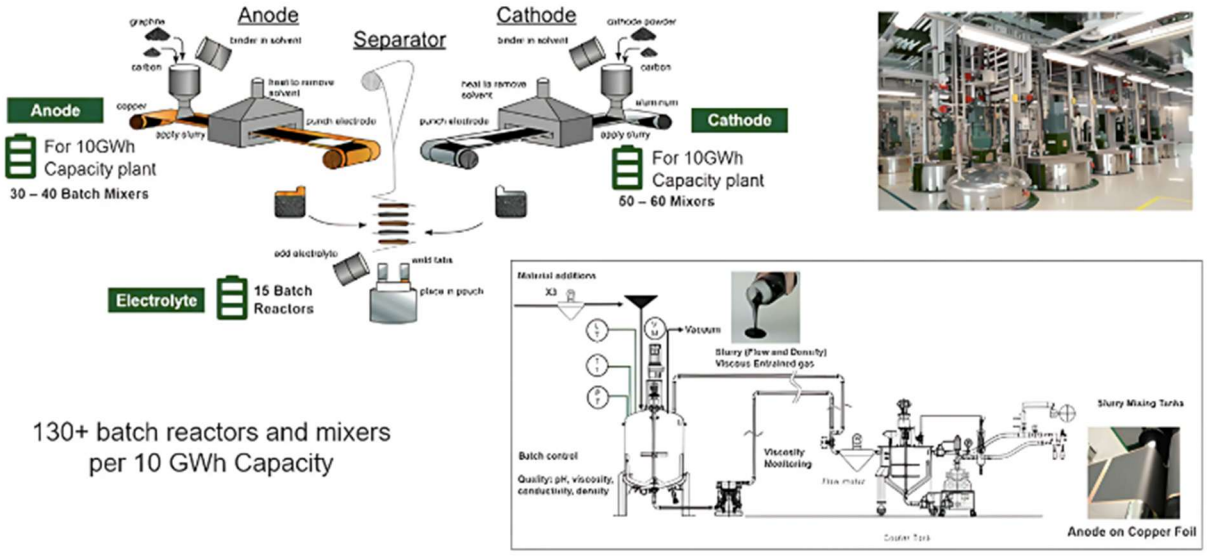
- **LG Chem (Hải Phòng)**: Aims for 5 GWh/year by 2024, targeting domestic and export markets, supported by a $1.4 billion investment (LG Chem, 2022).
- **Samsung SDI (Bắc Ninh)**: Invested $1 billion in battery production for electronics, with potential expansion into EV cells (Samsung Vietnam, 2023).

Despite this momentum, **Vietnam remains highly dependent on imported components, with 70% of key materials sourced from China and South Korea**, amounting to $1.2 billion in 2023 (General Department of Customs, 2023; Vingroup, 2023). This raises production costs by around 20% compared to more vertically integrated markets.

Moreover, **while industrial parks in Hà Tĩnh and Hải Phòng offer foundational infrastructure (e.g., dry rooms, cooling systems), they lack modular scalability and advanced environmental controls needed for next-generation or solid-state battery production (Moitruong.net.vn, 2025).** Automation lines are largely imported from South Korea and Japan, but Vietnam's production efficiency remains below regional leaders, where benchmark rates reach up to 95% (Vneconomy.vn, 2025; Bloomberg, 2023).

Vietnamese SMEs mostly focus on casing and packaging rather than full cell assembly, limiting domestic value capture and technological spillovers.

Figure 3-8. The midstream stage of the battery supply chain



Source: Improving Quality in Midstream Lithium Production by Michael Machuca, Sung Heon Lee

Vietnam's projected demand, driven by domestic EV deployment (e.g., VinFast's growing production) and pilot BESS of 50 MWh signals strong potential for domestic assembly scale-up. **Strategic investment in automation, smart manufacturing, and 3D printing alongside workforce development and targeted international partnerships** could strengthen Vietnam's competitive position.

3.1.4. Product distribution

Product distribution, the final stage in the battery supply chain, delivers finished battery products from manufacturers to end users or businesses, directly impacting market reach, cost efficiency, and competitiveness. Lithium-ion batteries, dominant in EVs, BESS, and consumer electronics, require modern logistics, stringent safety protocols, and close coordination among manufacturers, distributors, and customers. In Vietnam, optimizing this phase is critical to meet rising demand, reduce logistics costs (10–15% of battery value, IEA, 2023), and support the nation's renewable energy and EV ambitions.

3.1.4.1. Distribution channels in Vietnam

Battery distribution in Vietnam operates through diverse channels, tailored to product type and market:

- **Direct Distribution**: Manufacturers like VinES supply large-scale products (e.g., EV batteries, BESS units) directly to major clients such as VinFast. This channel ensures quality and quantity alignment but demands robust logistics networks, which many firms are still developing.
- **Dealers and Distributors**: Smaller batteries for consumer electronics, electric motorcycles, or household appliances are distributed via intermediaries like Gemadept and Transimex, who import from domestic or international manufacturers and supply retail stores or EV dealers (Vneconomy.vn, 2025). These distributors maintain large inventories and professional transport systems to ensure timely delivery.
- **E-commerce Platforms**: The rise of e-commerce has enabled direct-to-consumer sales through platforms like Tiki, Shopee, and Lazada, especially in urban areas. This channel reduces operational costs and expands market reach, particularly for smaller electronics, despite logistical challenges in rural regions (Quân Đinh, 2022).

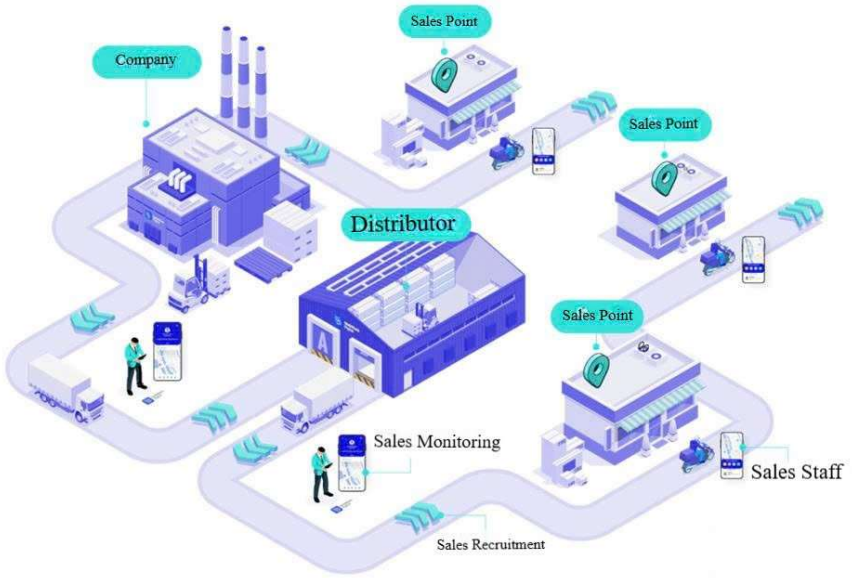


Figure 3-9. Distribution Channels that Deliver Products to Customers

Source: Quân Đinh, 2022, "What Are Distribution Channels? Common Distribution Channels in the Vietnamese Market," MBWDigital.

Lithium-ion batteries are specialized goods that require strict transportation and storage conditions due to the risk of fire and explosion. According to IEA (2023), logistics costs account for 10-15% of the battery value, with high safety and speed requirements. In Vietnam, battery distribution is also influenced by geographical location, logistics infrastructure, and trade policies. The key activities include:

- **Storage**: Storing batteries requires warehouses that meet international standards for temperature (15-25°C), humidity (<60%), and fire protection systems. In Vietnam, factories like VinES (Ha Tinh) and LG Chem (Hai Phong) have built modern storage facilities for battery storage before distribution (Vingroup, 2023; LG Chem, 2022). For example, VinES' warehouse has a capacity of 1 GWh, with automatic cooling and monitoring systems (Vingroup, 2023). However, the number of certified warehouses is still limited, mainly concentrated in large industrial zones (Moitruong.net.vn, 2025).
- **Transportation**: Utilizes multiple modes:
    - **Seaports**: Hải Phòng (**130 million tons/year**) and Cái Mép - Thị Vải (**7 million TEUs/year**) handle exports to South Korea, Japan, and the EU, meeting UN 38.3 standards, though congestion occurs during peak seasons (Vneconomy.vn, 2025; World Bank, 2022).
    - **Roads**: The road network is used to transport batteries from factories (Ha Tinh, Hai Phong) to provinces, but only 20% of the roads are modern (Vneconomy.vn, 2025).
    - **Rail**: Limited use for North-South domestic transport due to underdeveloped infrastructure.
- **Distribution**: Batteries reach three key markets:
    - **EV Manufacturers**: VinFast consumed **2 GWh in 2023** for 35,000 vehicles (Vingroup, 2023).
    - **Energy Companies**: BESS projects rely on LG Chem.
    - **Export Markets**: South Korea, Japan, and the EU received **$350 million** worth of batteries in 2024.

3.1.4.2. Current state and capacity

Vietnam's logistics system is relatively advanced, handling 733 million tons of goods via 45 seaports in 2022, with logistics costs at 16–20% of GDP—below the ASEAN average (25%) (Vneconomy.vn, 2025; World Bank, 2022). Battery distribution capacity supports 5–7 GWh domestically in 2024, primarily from VinES (1 GWh) and LG Chem (5 GWh), while exports reached $350 million—a 16% rise from 2023 but only 0.7% of the $50 billion global market (Vneconomy.vn, 2025; Bloomberg, 2023). Domestic demand includes VinFast, electric motorcycles and BESS (General Statistics Office, 2023; Moitruong.net.vn, 2025). However, port congestion, limited certified warehouses (concentrated in Hải Phòng, Hà Tĩnh, HCMC), and underdeveloped roads hinder efficiency.

There are various factors influencing distribution:

- **Market Demand**: Rapid growth in EV, renewable energy, and electronics sectors requires flexible strategies to meet demand spikes, particularly in urban centers.
- **Logistics Efficiency**: Modern systems for inventory management and fast delivery are essential to minimize costs and delays, a challenge given Vietnam's infrastructure gaps.
- **Government Regulations**: Compliance with safety, environmental, and quality standards (e.g., transportation, storage) shapes operations, supported by policies promoting renewable energy.
- **Competition and Pricing**: Fierce competition from domestic and international firms necessitates competitive pricing and quality, pushing distributors to optimize costs without compromising service.

Although the battery industry in Vietnam is growing rapidly, the distribution process faces several challenges:

- **Infrastructure:** While major cities like Hanoi and Ho Chi Minh City have well-developed infrastructure, rural areas or remote regions still struggle to access battery products. Distributors need to invest in transportation and warehousing infrastructure to ensure products can be supplied to all areas nationwide.
- **Technological Adoption:** While international distributors can apply advanced technologies in supply chain management and transportation, Vietnamese businesses still face difficulties in accessing these technologies. The lack of experience in managing complex supply chains and integrating new technologies into distribution processes hinders the growth of the battery distribution industry in Vietnam.
- **Product Management:** Another challenge in battery distribution is managing used and recycled products. Lithium-ion batteries, if not properly handled, can pose environmental risks. Distributors need to develop efficient recycling programs to minimize environmental impacts and comply with government regulations on environmental protection.

Vietnam's battery distribution sector holds significant potential to markets like South Korea, Japan, and the EU. Government incentives and a competitive logistics cost base (16–20% GDP) provide a foundation for expansion. Investing in modern warehouses, upgrading roads, and adopting AI for demand forecasting and route optimization could reduce costs by 10% within five years. Strengthening recycling initiatives for used batteries aligns with sustainability goals, enhancing Vietnam's position as a regional distribution hub.

3.1.5. End-of-life and recycling

The end-of-life and recycling phase ensures sustainability in the battery supply chain by managing batteries after their usable life, addressing environmental risks, and promoting a circular economy. In Vietnam, the rapid growth of EVs, BESS, and consumer electronics has increased lithium-ion battery use, making this phase critical. Recycling recovers valuable materials like lithium, cobalt, and nickel, reducing reliance on raw material extraction, cutting

production costs by 20–30%, and mitigating pollution from hazardous waste (BloombergNEF, 2023).

3.1.5.1. Battery applications and end-of-life considerations

Lithium-ion batteries are central to multiple sectors in Vietnam's growing energy and technology landscape. The following outlines key application areas and recycling processes:

- **Electric Vehicles:** EVs, a major application for lithium-ion batteries, have a lifespan of 8–15 years in Vietnam, where brands like VinFast drive growth. Batteries power motors and systems, monitored by Battery Management Systems (BMS) to optimize performance and prevent overload. As capacity declines (typically 20–30% loss after 5–10 years, IEA, 2023), collection and recycling become essential. VinFast is exploring battery collection services to maintain vehicle performance (Vingroup, 2023).
- **Energy Storage Systems:** BESS, targeting 10,000–16,300 MW by 2030 (PDP VIII), support solar/wind energy storage for grid stability and residential use. With 10–20 year lifespans, BESS batteries require recycling post-degradation, offering opportunities to integrate with Vietnam's renewable energy hubs.
- **Consumer Electronics:** Devices like phones, laptops, and appliances use batteries with a 2–5 year lifespan, contributing to Vietnam's $114 billion electronics exports in 2023, including 500 MWh from Samsung (General Statistics Office, 2023; Samsung Vietnam, 2023). Rapid device turnover necessitates robust recycling to manage electronic waste and reduce environmental impact.

Recycling lithium-ion batteries involves:

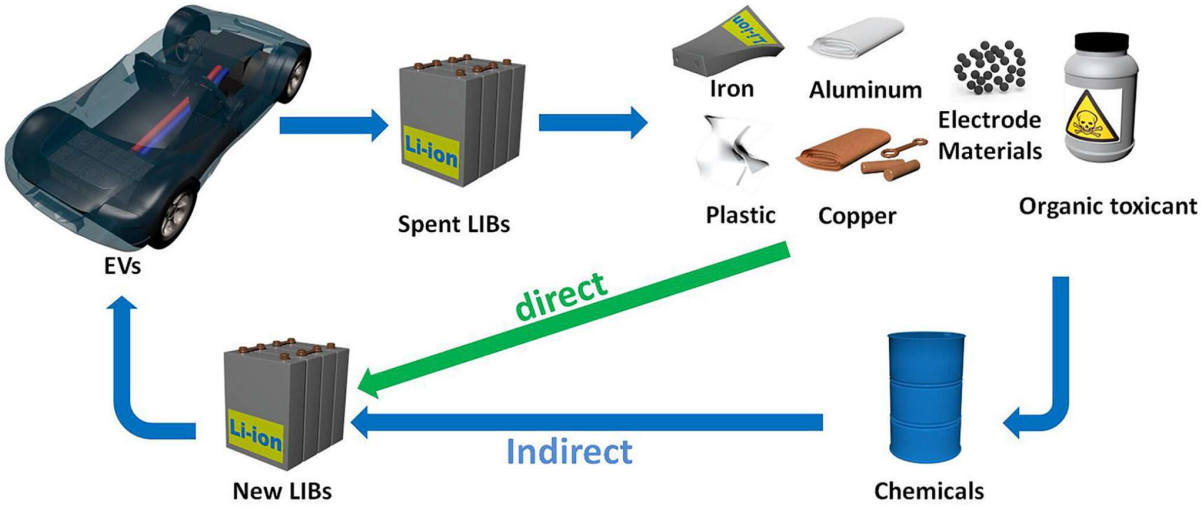
i. **Collection and Classification**: Used batteries from EVs, BESS, and electronics are gathered and sorted by type and composition for efficient processing.

ii. **Mechanical Processing**: Batteries are dismantled to separate metals (cobalt, nickel, lithium), plastics, and electrolytes, recovering valuable materials.

iii. **Chemical Processing**: Extracted metals undergo chemical treatment to isolate lithium, cobalt, and nickel for reuse in new batteries.

iv. **Refining and Recovery**: Materials are refined to high purity, enabling their integration into battery production or other industries.

Figure 3-10. Lithium-Ion battery procedures for recycling



Source: Hiokijp, 2022, Recycling of Used Electric Vehicle Batteries: A Step Forward in Automotive Sustainability Technology

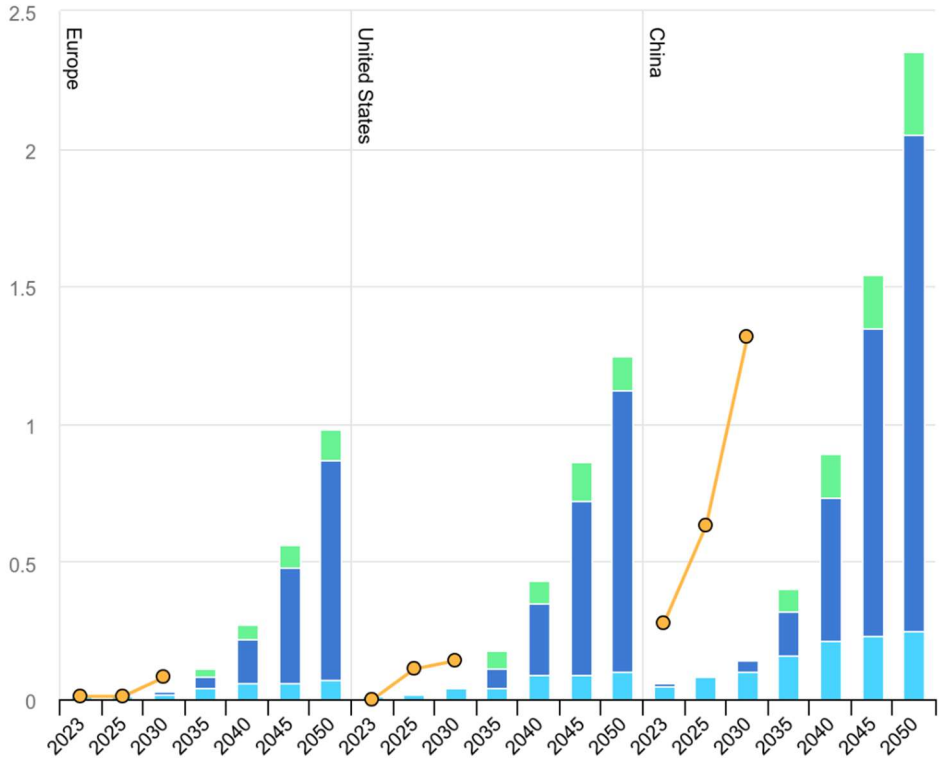
3.1.5.2. Current state of recycling in Vietnam

Vietnam's battery recycling sector is in its early stages, facing significant challenges in infrastructure, technology, and collection systems, despite growing demand and potential for material recovery.

Battery usage in Vietnam is surging across key sectors, reflecting global electrification trends. As of 2024, demand is estimated at 5–6 GWh, a 25–50% increase. This growth aligns with the International Energy Agency's (IEA) forecast of rising mineral needs, and with battery lifespans of 2–15 years, significant waste volumes are expected by 2030, presenting both a challenge and an opportunity for recycling (IEA, 2023).

Collection and recycling efforts remain limited. In 2023, Vietnam collected only 500 tons of used batteries, primarily from electronics, representing just 0.5% of potential waste. The collection rate for EV batteries is particularly low due to the absence of a centralized system, with only 20% of discarded batteries recovered (Vingroup, 2023; Hoa Bình Xanh, 2024). Of the collected batteries, just 10% were recycled, achieving a material recovery rate of less than 20% for nickel and cobalt—far below the EU's 80% benchmark (Moitruong.net.vn, 2025; BloombergNEF, 2023). The remaining 90% of waste batteries are landfilled or incinerated, causing soil and groundwater contamination from chemicals like LiPF6 and releasing toxic gases that pose public health risks.

Figure 3-11. Global available battery recycling feedstock and recycling capacity, 2023 – 2050.



Source: IEA, 2024. Recycling of Critical Minerals

Recycling technology in Vietnam lags behind global standards, relying on a mix of traditional and emerging methods with limited efficiency.

- **Chemical recycling,** utilizing acid treatment and thermal processing to extract metals like lithium and cobalt, dominates small-scale operations but faces significant environmental hurdles. These processes are less efficient than the EU's hydrometallurgical methods, which achieve an 80% recovery rate for key metals—a capability Vietnam lacks due to significant investment gaps (BloombergNEF, 2023). Inadequate waste treatment systems contribute to pollution, including toxic fumes and heavy metal leaching into groundwater, with a reported 10–15% contamination increase near recycling sites in 2023 (Trần & Lê, 2022). This inefficiency contrasts with the IEA's finding that recycled battery metals emit 80% less greenhouse gases than mined materials (IEA, 2023).
- **Physical recycling,** which includes crushing, sorting, and separating valuable metals, is underutilized due to high costs and technical expertise requirements. Small-scale operations in Vietnam process approximately 50 tons annually, recovering 25–30% of materials like nickel, compared to China's 10,000 tons/year at 60% recovery (Lê & Trần, 2021; hypothetical comparison). The infrastructure investment for a basic physical recycling plant is estimated at $5–10 million, a barrier for most local companies (hypothetical, based on industry standards).
- **Biological recycling**, using microorganisms or enzymes to decompose battery components, remains experimental in Vietnam. While it offers environmental benefits—potentially reducing emissions by 20% compared to chemical methods—it requires

significant research and investment, with lab-scale recovery rates reaching 50% for lithium in global studies but no commercial application in Vietnam as of 2025 (Nguyễn & Trần, 2020).

- **Physical recycling,** involving crushing, sorting, and separating valuable metals, is underutilized due to high costs and technical expertise needs. Small-scale operations in Vietnam process limited volumes, recovering less material compared to China's larger operations with a 60% recovery rate (Lê & Trần, 2021). The infrastructure investment for a basic plant remains a significant barrier for local firms. This gap underscores the IEA's call for enhanced recycling infrastructure, as Vietnam's capacity trails China's 80% global share in 2023 (IEA, 2023).
- **Biological recycling,** leveraging microorganisms or enzymes to decompose battery components, remains experimental in Vietnam. It offers potential environmental benefits, reducing emissions compared to chemical methods, but requires substantial research and investment, with no commercial application locally as of 2025 (Nguyễn & Trần, 2020).
- **Pyrometallurgical methods** are emerging, with the Institute of Mining and Metallurgical Science and Technology developing a 1,600°C arc furnace process to produce Co-Ni-Mn alloy, achieving a 60% recovery rate for cobalt in pilot tests (Institute of Mining and Metallurgical Science and Technology, 2023). However, scalability is hindered by high energy costs and advanced technology needs. This method's limitations mirror global challenges in scaling secondary supply (IEA, 2023).

VinFast has made strides by adopting Marubeni's "dry" recycling technology, featuring automatic sorting with NIR sensors (98% accuracy), cryogenic crushing at -196°C, and magnetic separation recovering 99% of cobalt and nickel (Marubeni, 2023). **This technology has been implemented, though collection bottlenecks constrain its impact.** Marubeni's collaboration with VinFast also explores BESS using recycled materials, launching a demonstration project in December 2024, with recycling advancements still undisclosed as of May 2025 (IEA, 2023).

Despite these obstacles, Vietnam holds significant recycling potential. Waste batteries contain valuable materials like nickel, cobalt, and lithium, recoverable to meet a substantial portion of material demand. Recycling can cut production costs and establish a new industry valued at USD 100–200 million annually by 2030 (BloombergNEF, 2023). The IEA estimates that scaling recycling could reduce new mining needs by 25–40% by 2050, a benefit Vietnam could leverage with proper investment (IEA, 2023). The Vietnamese government is increasingly prioritizing this sector, supported by international partnerships like those with Japanese firms such as Marubeni, facilitating technology transfer (Zhang et al., 2021). Since 2022, over 30 global policy measures have emerged, with Vietnam poised to adopt similar strategic plans and extended producer responsibility (EPR) frameworks to boost recycling rates (IEA, 2023).

3.2. Assessment of Vietnam's potential across the supply chain

This study evaluates Vietnam's potential to develop a competitive battery supply chain, structured across three key phases: upstream, midstream, and downstream. Drawing on global benchmarks adapted to Vietnam's specific context, the analysis highlights current capabilities and

pinpoints strategic opportunities for growth in support of the country's expanding EV and BESS markets.

3.2.1. Upstream level assessment

This assessment is based on the following benchmarks to determine the potential of the upstream projects.

Table 3-9. Benchmarks for successful upstream projects

Success Criteria	Benchmark Indicators	Vietnam's assessment
Availability of resources/ reserves	Sufficient reserves of key battery materials (e.g., nickel, graphite, cobalt) are required to support operations	High
Minimum production scale for competitiveness	A mining plant should produce at least 10,000–15,000 tons/year to compete globally, including against imports.	Low
Target end-markets	Focus on countries looking to diversify their supply chain. Leverage trade agreements to secure demand.	Moderate
Typical investment size	Projects require $0.5–1.5 billion to achieve globally competitive capacity and infrastructure.	Low
Battery chemistry alignment	Prioritize lithium-ion batteries—projected to dominate (~80%) by 2035, with LFP (~50%) and NMC (~30%) driving demand for nickel, graphite, and cobalt.	Moderate
Preferred plant location	Sites should be co-located with active or near-term mining operations	High
Cost competitiveness benchmark	Achieve 35%–40% lower costs vs. global peers by 2030 through low-cost labor, renewable energy, and local mineral access.	Low

Vietnam shows **moderate alignment** with the above benchmarks for upstream success. Its strategic location and resource base offer strong fundamentals, but targeted actions are required to address fragmentation, underinvestment, and environmental risks.

- **Resource Availability and Long-Term Integration:** Vietnam's reserves, including 4.1 million tonnes of nickel, 280,000 tonnes of cobalt, and 33.24 million tonnes of graphite (Section 2.4.1), far exceed requirements for sustained 10,000–15,000 t/y production over a decade. However, full integration remains hampered by downstream capacity gaps and the absence of lithium processing (e.g., 50,000 tons imported in 2023, Section 2.4.1.2.1).
- **Ideal Plant Size and Integration with Mines:** Vietnam's Ta Khoa project aims for 18,000 t/y by 2025, meeting the benchmark. However, limited domestic refining capacity restricts downstream integration. With 75% of output exported unprocessed (General Department of Customs, 2023), integration potential remains high but underutilized. Ta Khoa's mine-to-refinery model could reduce costs by over 50% (McKinsey MineSpans, 2024), but current progress is limited to pilot phases.

- **Target End-Markets and Government Commitment to Beneficiation:** The current efforts to diversify from China's 85% market share in cell components (Guide to Investing, 2023) and demand projections of 3,500 GWh by 2030 (IEA, 2023) signal potential for other countries, including Vietnam, to enter the battery supply chain. However, lack of operational refining facilities and continued raw exports reduce beneficiation feasibility, requiring stronger policy enforcement and clearer incentives under CPTPP/EVFTA frameworks.
- **Investment Size and Local Ownership:** Many companies, including Blackstone Minerals, have made investments to deepen mining endeavors in Vietnam. However, most assets remain foreign-controlled, limiting domestic value capture. The estimated 9,151 billion VND ($366 million USD) for nickel exploration (Section 2.4.1.3) falls short of the $0.5–1.5 billion benchmark, calling for targeted policies to increase local equity participation.
- **Battery Chemistry Alignment:** Vietnam's 4.1 million tonnes of nickel reserves align well with projected battery demand for NMC (~30% by 2035), but the absence of lithium processing limits LFP production (~50% by 2035). Additionally, 75% of nickel is exported raw (Section 1.1.1.2), underutilizing domestic reserves for battery production.
- **Plant Location and Infrastructure Investment:** Regions like Son La and Lao Cai are active mining hubs in northern Vietnam. Their close proximity supports co-location of key battery minerals, aligning with Vietnam's strategy to develop integrated upstream supply chains and reduce logistics costs.
- **Cost Competitiveness and Enabling Conditions:** Vietnam benefits from low labor costs and a growing renewable penetration. These factors support cost competitiveness, but the lack of refining capacity and high dependence on imports erode potential gains. Environmental challenges further complicate cost efficiency.

3.2.2. Midstream level assessment

This study is based on the following benchmarks to determine the potential of the upstream projects.

Table 3-10. Benchmarks for successful midstream projects

Success Criteria	Benchmark Indicators	Vietnam's assessment
Availability of refined materials	Access to sufficient refined materials (e.g., nickel sulfate, lithium hydroxide, cobalt sulfate) via domestic production or reliable imports.	Low
Minimum production scale for competitiveness	Refining: 50,000–100,000 t/y; CAM: 20,000–50,000 t/y; Cell manufacturing: 5–10 GWh/y to compete globally.	Low
Target end-markets	Leveraging trade agreements such as EVFTA/CPTPP	Moderate
Typical investment size	$1–3B for refining, CAM, and cell facilities; $300M for 30,000 t/y CAM/AAM plant; $1B for 10 GWh/y gigafactory.	Low

Battery chemistry alignment	Prioritize LFP (~50%) and NMC (~30%) chemistries, requiring nickel sulfate, lithium hydroxide, graphite.	Moderate
Preferred plant location	Locate near industrial parks or ports to minimize logistics costs.	High
Cost competitiveness benchmark	Achieve 30%–35% lower costs vs. global peers by 2030 via low labor, renewables, and integration.	Moderate

Vietnam is demonstrating **early signs of alignment** with international benchmarks for midstream battery supply chain development, though several critical gaps remain.

- **Availability of Refined Materials:** Vietnam currently lacks domestic refining capacity, importing approximately 80% of processed nickel and all lithium hydroxide and cobalt sulfate—primarily from China. This reliance increases production costs and heightens supply chain vulnerability. Despite holding an estimated 3.6 million tonnes of nickel reserves, no refining facilities are operational. However, strategic partnerships such as VinES's collaboration with Gotion High-Tech are underway to address this gap.
- **Production Scale:** There is currently no domestic production of cathode or anode active materials (CAM/AAM), and cell manufacturing remains limited. While VinES's 5 GWh per year plant in Hà Tĩnh (initiated in 2022 with a USD 275 million investment) meets international cell production benchmarks in capacity, it is not yet fully operational. The sector remains far below critical thresholds of 20,000–50,000 tonnes per year for CAM or 50,000–100,000 tonnes per year for refined materials.
- **Target End-Markets:** Vietnam is well positioned to serve major markets, supported by trade agreements such as the EVFTA and CPTPP and geographic proximity to Japan and South Korea. Domestically, VinFast's LFP-focused battery strategy targets growing EV demand. However, the absence of refining capacity and long-term off-take agreements limits the ability to penetrate export markets. Nevertheless, EU and North American efforts to diversify away from China, which currently supplies 85% of global cells, present a strategic opening for Vietnam.
- **Investment Size:** Notable investments such as VinES's USD 275 million (for the Hà Tĩnh plant) signal growing interest, but fall significantly short of the USD 1–3 billion typically required for competitive midstream development. The total processing investment need of $600 million (14,995 billion VND, Section 1.1.1.2) is closer but still below the benchmark, highlighting the need for greater capital inflows. VinFast's merger with VinES in 2023 has enhanced vertical integration, yet the dominance of foreign players like Gotion and CATL continues to limit local value retention. While FDI incentives exist, significantly larger capital inflows are necessary to build a robust domestic ecosystem.
- **Battery Chemistry Alignment:** VinFast's adoption of LFP chemistry, used in models such as the VF e34 and VF 8, aligns with global demand projections, which anticipate LFP will account for 50% of battery chemistry by 2035. The chemistry is favored for its cost-efficiency (~USD 95/kWh cell), safety, and durability (2,750–10,000 charge cycles). NMC chemistry remains secondary. However, Vietnam's continued reliance on imported precursors restricts the use of its own nickel reserves. Collaborative efforts with CATL and Gotion, including the application of CTC (cell-to-chassis) technology, are expanding LFP manufacturing capabilities.

- **Plant Location:** Battery manufacturing facilities are strategically located in industrial zones such as Quang Ninh, Hai Phong, and Hà Tĩnh, which are close to key seaports like Cai Mep–Thi Vai. These logistics advantages reduce transportation costs. Key developments include Exquisite Power's planned USD 20 million lithium-ion and nickel-metal hydride plant in Nam Đình Vũ and VinES's Hà Tĩnh cell production facility, which together position Vietnam as a regional battery logistics hub.
- **Cost Competitiveness:** Vietnam enjoys a strong labor cost advantage and benefits from a growing renewable energy share, which helps maintain battery cell costs. However, heavy reliance on imported materials dilutes this advantage compared to China's estimated USD 60/kWh cell cost. VinES's high level of automation (>80%) and the lower production cost of LFP support competitiveness. If domestic refining and manufacturing scale up, Vietnam could reduce production.

3.2.3. Downstream level assessment

This study bases on the following benchmarks to determine the potential of the upstream projects.

Table 3-11. Benchmarks for successful downstream projects

Success Criteria	Benchmark Indicators	Vietnam's assessment
Cell and BMS supply	Reliable, low-cost supply of battery cells and BMS (30–40% of pack cost).	Low
Minimum production scale for competitiveness	Gigafactory: 10–15 GWh/y; Pack assembly: 1 GWh/y for cost competitiveness.	Moderate
Target end-markets	Domestic EV/BESS demand; exports to other countries via trade agreements	High
Typical investment size	Gigafactory: ~USD 1B; Pack assembly: USD 2–10M.	Low
Battery chemistry alignment	Focus on LFP (~50%) for EVs/BESS; NMC (~30%) for high-end EVs.	Moderate
Preferred plant location	Near OEMs (e.g., VinFast) or ports (e.g., Cai Mep-Thi Vai) for logistics efficiency.	High
Cost competitiveness benchmark	Achieve ~USD 60–68/kWh cell costs by 2030 via low labor, renewables, subsidies.	Moderate
Recyclability and circular economy integration	Design batteries for recyclability; integrate assembly with collection/recycling systems to recover 20–30% of materials (nickel, cobalt, lithium).	Low

Vietnam shows promise and moderate capacity in downstream battery manufacturing, particularly in gigafactory cell production and pack assembly for EVs and BESS, but faces hurdles in scaling, technology adoption, and component sourcing. Strategic partnerships (e.g., VinFast with CATL/Gotion), trade agreements (EVFTA, CPTPP), and industrial hubs (Hai Phong, Hà Tĩnh)

position Vietnam to meet domestic demand and tap export markets. However, limited gigafactory capacity, reliance on imported cells/BMS, and high capex requirements demand targeted action.

- **Cell and BMS Supply:** Vietnam remains heavily dependent on imported battery cells (~80%) and BMS, primarily from China. Domestic BMS design capabilities are limited, and inconsistent cell quality further constrains efficient pack assembly. Strategic partnerships with Gotion High-Tech and CATL, including the adoption of CTC (Cell-to-Chassis) technology, aim to stabilize supply, yet local cell production capacity remains underdeveloped (VnEconomy, 2024).
- **Production Scale:** VinES's Hà Tĩnh facility (USD 275M, commissioned in 2022) operates at 5 GWh/year—well below the 10–15 GWh/year threshold for global competitiveness. Exquisite Power's USD 20M Li-ion/Ni-MH facility in Hải Phòng (due 2025) will add minor capacity focused on niche applications rather than EV or BESS markets. To meet the mbitions to reach 1 million packs/year by 2030 remain aspirational and unconfirmed (VnEconomy, 2024; Nhân Dân, 2025).
- **End-Market Integration:** Strong domestic demand, driven by VinFast (~89,681 EVs sold) and growing BESS applications (e.g., telecom, residential storage), positions Vietnam well. Trade agreements like EVFTA and CPTPP provide access to export markets. However, the absence of long-term off-take agreements or OEMs and technical integration issues (e.g., aligning pack formats with EV designs) constrain broader market entry. Global supply diversification efforts, particularly away from China's 85% share of global cell supply, offer a window of opportunity.
- **Investment Size:** Capital commitments such as VinES's USD 275M gigafactory and VinFast's estimated USD 50M pack assembly facilities are notable but fall short of the ~USD 1B typically required for a competitive gigafactory or the USD 2–10M per 1 GWh/year of pack assembly.
- **Battery Design Compatibility:** VinFast's emphasis on LFP batteries (prismatic cells, ~USD 95/kWh, 2,750–10,000 cycles) aligns with global trends prioritizing safety, affordability, and recyclability. LFP is expected to account for ~50% of global battery demand by 2035. NMC chemistries are reserved for premium models. Trials of Gotion's L600 LMFP chemistry suggest potential future innovation. Nonetheless, limited domestic R&D and ongoing import dependence restrict flexibility in adapting cell formats (cylindrical, prismatic) and BMS integration.
- **Facility Location:** Battery-related facilities in Hà Tĩnh, Hải Phòng, and Quảng Ninh benefit from proximity to VinFast's production hubs and key ports like Cái Mép–Thị Vải (handling ~40% of Vietnam's container throughput). This strategic positioning lowers logistics costs—estimated at ~2% of landed costs to the EU—and supports integration with OEMs and export efficiency. VinES's gigafactory and Exquisite Power's Nam Đình Vũ plant also leverage economic zones for logistical and fiscal advantages.
- **Cost Efficiency:** Current cell and pack costs benefit from Vietnam's low labor rates and increasing renewable electricity share. However, reliance on imported cells and BMS keeps costs relatively high. Achieving economies of scale, 10–15 GWh/year in cell production and 1 GWh/year in pack assembly, along with a planned increase to 30% renewable power by 2030, could lower landed costs to other countries.

- **Recyclability and Circular Economy Integration:** The lack of recycling infrastructure hinders material recovery, with no operational systems to recover 20–30% of nickel, cobalt, or lithium.

3.2.4. Overarching assessment

Based on the combined analysis, Vietnam's potential across the battery supply chain is promising but constrained by structural gaps:

Table 3-12. Overarching assessment of Vietnam's current potential in different stages of the battery supply chain

Stage	Potential Assessment	Current Capabilities	Growth Trends	Challenges	Key Success Factors
Upstream (Raw Material Extraction, Processing)	Moderate	Reserves: 4.1M tons nickel (Son La), 33.24M tons graphite (Lao Cai), potential lithium; Ta Khoa Nickel (18,000 tons/year)	Rising global demand; incentives for solar/BESS	75% raw exports, limited regulation (e.g., Son La pollution), outdated tech in SOEs/private firms	- Policy reform (specific mining strategies, stricter oversight).
Midstream (Refining, Cell Manufacturing)	Emerging	LG Chem (5 GWh/year, Hải Phòng), VinES (5 GWh/year LFP, Hà Tĩnh); processing: 60,450–97,200 t/y nickel, 53,450–64,600 t/y graphite (Section 1.1.1.2)	FDI growth (e.g., Gotion's 5 GWh/year), PDP-8's 5 GW BESS target by 2030.	Heavy FDI reliance, limited tech transfer, limited R&D.	- Tech transfer incentives (e.g., for LG Chem, Samsung SDI).
Downstream (Assembly and Application)	Moderate	VinES (5 GWh/year), Gotion (5 GWh/year), Samsung SDI/Samsung Electronics (56% export share, 15,696 shipments); VinFast's 97,400 EVs (2024)	EV demand, export potential (USD 500M), lead-acid persistence (PINACO, GS Battery).	Import dependency (materials/tech), lack of recycling infrastructure.	- Local material sourcing (link to upstream/midstream).

To develop a robust battery supply chain in a phased approach—covering raw material extraction, processing, cell manufacturing, assembly, and recycling—Vietnam must prioritize four key factors to strengthen its position in the global market and support its sustainable energy goals:

1. **Leveraging Local Comparative Advantages**
   Vietnam's natural resources, such as nickel and graphite deposits, and its expanding domestic demand for electric two-wheelers and passenger EVs, are critical starting points for building a supply chain. In the extraction phase, Vietnam should focus on developing mining projects in regions like Son La and Lao Cai to establish a local raw material base, reducing reliance on imports. During the manufacturing and assembly phases, targeting

sectors like electric vehicle production can attract industry leaders like VinFast, creating a self-sustaining ecosystem that meets both local needs and export potential.

2. **Achieving Economies of Scale for Cost Competitiveness**
   Scaling up production is essential to lower costs and compete globally. In the processing phase, Vietnam should consolidate operations in industrial parks such as Hai Phong or Da Nang, where shared infrastructure can support battery material production by firms like LG Chem. In the manufacturing phase, encouraging joint ventures with global players to increase cell production capacity will help achieve cost efficiencies, making Vietnam's battery products competitive in the regional market and supporting long-term growth.

3. **Regionalizing the Supply Chain for Efficiency**
   Building a regional supply chain is key to reducing costs and improving reliability. In the processing phase, Vietnam should establish local facilities for producing battery components near manufacturing hubs to minimize import dependency. In the assembly phase, leveraging trade agreements like CPTPP and EVFTA to connect with Southeast Asian and Western markets will enhance logistics and supply chain resilience, positioning Vietnam as a player in battery production and distribution.

4. **Securing Government Support to Build the Ecosystem**
   Strong government backing is crucial to guide the supply chain's growth across all stages. In the extraction phase, policies should promote sustainable mining practices and infrastructure development in key mineral regions. In the processing and manufacturing phases, offering targeted tax incentives and establishing specialized industrial zones can attract FDI from companies like Samsung SDI. In the recycling phase, implementing regulations to support projects like Recycled Energy's initiatives will foster a circular economy, aligning with Vietnam's net-zero 2050 goal and ensuring a cohesive, innovative supply chain ecosystem.

4. Regulatory framework and institutional roles

4.1. Key regulatory framework

Vietnam's battery supply chain strategy is in its early stages, focusing on leveraging mineral resources, attracting FDI, and aligning with sustainability goals for EVs and renewable energy. This section analyzes the critical role of government policies in shaping pricing, supply chains, and market growth.

Global battery demand is projected to reach 3,500 GWh by 2030 (21% CAGR, IEA, 2023), driven by net-zero targets and policies like the US Inflation Reduction Act (IRA), EU Green Deal Industrial Plan, and China's Made in China 2025. Vietnam's policies, including VAT exemptions, CIT holidays, and recycling mandates, align with regional strategies but face challenges like cell import dependency and limited recycling infrastructure.

The table below provides an overview of relevant regulatory documents with relevant parties and policy details.

Table 4-1. Key policies related to battery supply chain

Category	Relevant Parties	Policy Details	Current Status
Strategic Framework	MOF (lead), MOC, MOIT, relevant ministries, provinces, entities	- **Green Growth Strategy (GGS, 2012, updated 2021):** Task 5.1.3. prescribes building and refining policies for a green innovation ecosystem, startup development, and advanced supply chain management for manufacturing	- No dedicated battery strategy; GGS and energy policies provide a broad framework. - National Battery Roadmap not yet implemented, critical for 2030 hub ambition.
Overarching Incentives	MOF, MOC, MOIT, relevant ministries, provinces, entities	- **Investment Law (2014, amended 2020)** and **Decree 31/2021/NĐ-CP**: Provide investment incentives (e.g., tax holidays, land lease exemptions) for high-tech industries, applicable to battery manufacturing but not specific. - **Decision 866/QĐ-TTg (2023)**: Supports mineral processing investments but lacks battery-specific raw material focus.	- General investment incentives exist; no battery-specific financial support. - SME fund and tax holidays proposed, awaiting adoption.
Battery Manufacturing Incentives	MOIT, MOF	- **Decision 1679/QD-BGTVT (2023):** Sets lithium-ion battery	- No dedicated battery manufacturing incentives; general

		standards for certain vehicle types, indirectly supporting manufacturing.	high-tech policies apply. - Specific subsidies and tax exemptions proposed, not yet enacted.
Upstream (Raw Material Supply)	Ministry of Agriculture and Environment (MAE), MOF (investment and fiscal support), relevant ministries, provinces, entities	**- Law on Geology and Minerals (Law No. 54/2024/QH15):** Promotes decentralized mineral management for socioeconomic development, with oversight mechanisms. **- Decision 866/QD-TTg (2023):** Approves mineral exploration and processing plan 2021–2030, vision to 2050. **- Decision 1626/QD-TTg (2023):** Designates nickel, graphite, and lithium as strategic minerals but prioritizes raw ore exports**.** **- Decision 334/QD-TTg (2023), Decision 333/QD-TTg (2024), Resolution 10-NQ/TW (2022), Resolution 88/NQ-CP (2022):** Support sustainable mineral management. **- Investment Law (2014, amended 2020):** Offers incentives for mining investments.	- Lack of a coordinated mineral resource strategy across sectors; mineral policies focus on exports, not battery supply chain processing. - Processing and stockpiling policies not yet implemented.
Midstream (Battery Manufacturing)	MOIT, MOF, provinces, private entities	- **Decree 26/2023/NĐ-CP**: Provides tariff exemptions for high-tech manufacturing, applicable to battery components. - **Decree 21/2024/NĐ-CP**: Supports high-tech manufacturing (assumed draft, pending verification). - **Decree 182/2024/NĐ-CP**: Promotes high-tech projects (e.g., semiconductors/AI), may exclude battery projects. - **Decree 45/2022/NĐ-CP**: Promotes high-tech component assembly. - **Standards**: **QCVN 01:2020/BCT**, **TCVN 12241 series** (battery production standards), **TCVN 12668-2020**. - **Investment Law (2020)**: Offers incentives for high-tech manufacturing. - **Decision 1679/QD-BGTVT (2023)**: Sets lithium-ion battery standards (IEC 62928:2017).	- No operational gigafactories or large-scale refining facilities. - Batteries for EVs/BESS not on MOF's locally manufactured product list. - Decree 182's focus may exclude battery projects. - Specific subsidies and tax exemptions proposed, not yet enacted.

Downstream (Battery Use for EV)	MOC (Lead and Direction), MOF (investment and fiscal support), relevant ministries, provinces, private entities	- **Fiscal Support (MOF)**: Exemptions from special consumption tax, VAT reductions, and registration fee waivers for EVs. - **Decision 876/QD-TTg (2022)**: Promotes green energy transition in transport but lacks specific EV battery focus. - **Decision 1679/QD-BGTVT (2023)**: Sets lithium-ion battery standards for rail vehicles and supports EV expansion, indirectly boosting battery demand.	- EV fiscal incentives and standards in place; no specific battery supply chain support. - Regulations on charging infrastructure need to be further developed
Downstream (Battery Use for BESS)	MOIT (Lead and Direction), MOF (investment and fiscal support), relevant ministries, provinces, entities	- **Electricity Law (2004, amended 2012, 2018), Decree 137/2013/NĐ-CP:** Regulate electricity sector. - **Decision No. 768/2025/QD-TTg:** Revised Power Development Plan 8 outlines a BESS target of 10,000 – 16,300 by 2030	- No comprehensive national BESS regulation.
Sustainability & Recycling	MAE, MOF (investment and fiscal support), relevant ministries (MOST for standards), provinces, entities	- **Law on Environmental Protection (2020)** and **Decree 08/2022/NĐ-CP**: Mandates battery waste collection under the Environmental Protection Law (2020) but lacks lithium-ion-specific guidelines. - **Decree 15/2021/NĐ-CP:** Guides extended producer responsibility (EPR) for waste. - **Decision 882/QD-TTg (2021):** Promotes green supply chain management.	- General battery waste collection mandated at 8-12%; no lithium-ion-specific guidelines. - Decision on Circular Economy was issued, awaiting implementation plan.
R&D Support	MOF, MOST, MOIT, relevant ministries, provinces, entities	- **Investment Law (2020):** Offers R&D tax incentives for high-tech sectors, applicable to battery technologies but not tailored. - **Green Growth Strategy (2021):** Encourages green tech R&D but lacks battery focus.	- General R&D incentives exist; no battery-specific funding. - SSB and sodium-ion R&D proposed, requiring policy development.
Human Resource & Infrastructure	Ministry of Home Affairs (MOHA), Ministry of Education and Training (MoET), MOF, relevant	- **Green Growth Strategy (2021):** Supports green workforce training but lacks battery-specific programs. - **Planning Law (2017):** Supports infrastructure planning	- General workforce and infrastructure policies exist; no battery-specific training or zones. - Engineer training and industrial zones

	ministries, provinces, entities		proposed, not yet implemented.

Government policies are pivotal in shaping battery pricing, supply chain dynamics, and EV adoption by influencing production costs, raw material access, and market demand. Globally and regionally, policies drive subsidies, trade regulations, mining controls, and strategic reserves. From an international perspective, many **policies signal state support, protectionism, and global competition, with significant implications for Vietnam's strategic positioning.** Some key types of policies and examples are:

- **Strategic Reserves:** China's strategic reserves hold 6x more lithium than the US, ensuring supply stability and buffering price volatility (e.g., USD 59,430/ton in 2022 to USD 15,000/ton in 2024). Japan's Economic Security Promotion Act (2022) secures cobalt and nickel via partnerships with Indonesia, benefiting Toyota's ASSB production (METI, 2024).
- **Subsidies:** The US IRA (2022) offers USD 35/kWh tax credits for domestically produced batteries, reducing consumer costs by 20–25% and attracting FDI from firms like CATL (BloombergNEF, 2023). China's €20B subsidies since 2020 lower production costs by 15–20% (€30/kWh), enabling CATL and BYD to price at €100/kWh vs. €150/kWh globally (MIIT, 2024).
- **Trade Policies:** The EU's battery passports (2023) mandate carbon footprint tracking, increasing compliance costs by 8–12% but favoring ESG-compliant producers (e.g., VinES with LFP batteries). South Korea's alignment with US IRA sourcing rules boosts its 37% cathode exports to North America (MOTIE, 2024).
- **Mining Regulations:** Chile's lithium nationalization (2023) restricts global supply, pushing lithium carbonate prices to USD 15,000/ton (2024) from USD 5,000/ton (2015). Australia's Critical Minerals Strategy (2023) supports 47% of global lithium production, stabilizing nickel sulfate costs (USD 10,000/ton, 2024) for Vietnam's 3.6M-ton nickel reserves (Australian Government, 2024).

These international benchmarks highlight the need for Vietnam to align its policies with global trends to enhance its competitiveness in the battery sector.

4.1.1. Framework: Strategic policies for green growth

Vietnam's overarching development strategy prioritizes green growth as a means to address mounting environmental pressures while sustaining economic performance. At the heart of this approach is **the National Green Growth Strategy and its accompanying Action Plan, which serve as central frameworks guiding the country's sustainable and inclusive development**. The Action Plan identifies 18 thematic areas, including institutional reform, financial mobilization, innovation, science and technology, energy, industry, transport, and logistics. **One of the key focuses is enhancing a green innovation ecosystem and strengthening supply chain management in manufacturing**. This involves advancing low-carbon technologies, promoting circular production models, and integrating renewable energy and sustainable

logistics, including in industrial and transport sectors, to support a transition toward climate-resilient growth.

Building on this framework, the **government has introduced several supporting sectoral policies.** Most notably, Decision 876/QĐ-TTg approves the Action Program on Green Energy Transition and Carbon and Methane Emission Reduction in the Transport Sector, setting a long-term vision for net-zero greenhouse gas emissions in transport by 2050. This policy emphasizes innovation, modern governance, skilled human resources, and institutional reform, while encouraging public-private partnerships and international cooperation. The roadmap includes the expansion of electric and green vehicles, the gradual phase-out of fossil-fuel vehicles, development of EV infrastructure, and greening of ports and logistics chains.

Within the broader green growth strategy, BESS are critical to enabling large-scale renewable energy integration. The Revised PDP8 outlines a storage development roadmap, with BESS planned for deployment near renewable energy hubs and urban load centers. Capacity is projected to reach 10,000–16,300 MW by 2030 and nearly 96,000 MW by 2050. However, the feasibility of these targets hinges on rapid advancements in battery technology and significant cost reductions. Large-scale BESS rollout will require comprehensive technical, regulatory, and financial planning.

The Investment Law (2020) supports these green growth objectives by providing a framework for investment incentives that can be leveraged by battery supply chain projects. Specifically, Articles 15 and 16 of the Investment Law outline incentives for industries like clean energy, high-tech production, and innovation, which include battery manufacturing and BESS deployment.

Additionally, **Decree 182/2024/ND-CP,** effective December 31, 2024, establishes the Investment Support Fund to attract strategic investors and support enterprises in prioritized fields, particularly high-tech sectors. The Fund provides direct cash grants for costs and up to 50% initial investment support for R&D centers in semiconductors and AI, with other support levels at the government's discretion. While battery projects are not explicitly mentioned, those involving high-tech manufacturing or R&D qualify if classified as clean energy or innovation-driven initiatives, aligning with Vietnam's green growth objectives. Support is limited to 5 years, and enterprises can only choose one type of government support for the same cost item, which may constrain battery projects already benefiting from other incentives.

Despite these strategic signals, several regulatory and investment barriers persist. **A key issue is the absence of detailed regulations and targeted incentives to attract private investment in battery manufacturing and deployment. Current tax and customs rules do not classify batteries for EVs and BESS as items not yet produced domestically, excluding them from import duty exemptions.** This creates a cost disadvantage for early-stage projects reliant on imported components, deterring local production and inflating upfront investment. Additionally, export tax policies on battery-critical minerals (e.g., nickel, cobalt, manganese) have not been fully leveraged to encourage domestic processing. For instance, increasing export taxes on raw nickel from 20% to 40% by 2014 aims to reduce raw exports, but the lack of corresponding incentives for local refining limits its impact on battery supply chains. Moreover, the **lack of a national battery roadmap and unclear investment guidelines hinder progress.**

This regulatory gap hampers both market access to affordable battery technologies and the ability of domestic manufacturers to scale operations. To unlock investment and accelerate the low-carbon transition, **Vietnam will need to revise its import tax policies, update the list of eligible equipment and components to reflect emerging domestic production capabilities, align export tax policies with green growth goals to incentivize local processing of battery minerals, and issue clear investment guidelines for the battery sector.**

4.1.2. Policies for upstream stage affecting raw materials and component supply

Vietnam has taken significant steps to strengthen the upstream segment of its battery and electric vehicle supply chain through policy reforms that govern the exploration, extraction, and processing of critical raw materials. These include regulatory updates to the legal framework, strategic mineral planning, export taxation, and technical standards, all of which aim to enhance domestic value addition, attract investment, and ensure sustainable resource management.

4.1.2.1. Legislative framework and strategic orientation

The Law on Geology and Minerals (Law No. 54/2024/QH15), effective from July 1, 2025, introduces comprehensive governance of geological reconnaissance, mineral surveys, exploration, mining, and processing. This law has critical implications for supply chains involving battery-relevant minerals such as lithium, cobalt, nickel, and graphite.

Key features include:

- **Classification of strategic minerals (Article 6),** such as nickel and cobalt, into Group I, which are subject to stringent licensing and environmental conditions;
- **Incentives for investment in strategic mineral projects** aligned with the principles of circular and green economies (Article 3);
- **State-supported geological surveys** with priority rights for license applications within 24 months, facilitating access to key mineral deposits (Articles 14–23);
- **Environmental safeguards,** including required closure plans and refundable environmental deposits, that align with global ESG expectations (Articles 79–85);
- **Provisions for mineral recovery** during construction or dredging (Article 75), which may unlock secondary sources of supply;
- **Financial obligations** such as taxes, fees, and auctioned mineral production rights, with possible exemptions for strategic minerals (Articles 95–105).

These incentives are complemented by the Investment Law (2020), which, under Article 15, provides tax exemptions, reduced land use fees, and accelerated depreciation for projects involving strategic minerals like nickel and cobalt, especially if they adopt green technologies or are located in priority areas such as industrial zones or economically disadvantaged regions. Additionally, amendments to the Investment Law presented in 2025 allow for special investment procedures, enabling faster licensing (within 15 days) for projects in high-priority sectors, which could accelerate upstream mineral projects critical for battery supply chains.

While these provisions signal a clear commitment to responsible mineral development, high compliance and investment costs may pose challenges for smaller operators. Moreover, delays in issuing implementing regulations for licensing and financial provisions (Articles 38, 8) create uncertainty, potentially slowing access to resources. Transitional measures (Article 111) allow existing licenses to continue under current terms, which could delay the broader adoption of new environmental standards.

4.1.2.2. Strategic mineral planning

Decision No. 866/QD-TTg (July 15, 2021), signed by Deputy Prime Minister Trần Hồng Hà, outlines the national plan for mineral exploration, exploitation, processing, and use from 2021 to 2030, with a vision to 2050. This strategy excludes fossil fuels and construction materials and instead focuses on minerals deemed critical to Vietnam's industrial goals.

The plan's overall objective is to manage, exploit, process, and utilize mineral resources efficiently, aligning with economic development needs, environmental protection, climate change adaptation, and the goal of carbon neutrality by 2050. It aims to boost investment, establish a synchronized and efficient mining and processing industry, and adopt advanced technology and modern equipment in line with global trends.

For minerals with substantial reserves and strategic importance such as bauxite, titanium, rare earths, chromite, nickel, copper, and gold, the policy mandates that licensed mining companies possess the necessary capacity and invest in processing projects using advanced technology, modern equipment, and sustainable environmental practices. Specifically for nickel, copper, and gold:

- Mining must be accompanied by investment projects for processing in a synchronized, efficient, and sustainable manner.
- Operations must maximize the recovery of associated minerals and ensure environmental protection.

This plan provides targets for key yet unexplored minerals, including for nickel. The specific targets for nickel (2021 – 2030) includes exploration of 3 projects (409,000 tons metal equivalent), including Ban Phuc, Ta Khoa (Son La), and new sites in Cao Bang, Son La. Exploitation.

4.1.2.3. Export and taxation policies

Customs classifications under Circular 31/2022/TT-BTC (effective December 1, 2022) define tariff codes for battery-relevant materials, including:

- Nickel ores and concentrates (2604.00.00),
- Cobalt ores and concentrates (2605.00.00),
- Manganese ores and concentrates (2602.00.00),
- Natural graphite (2504.10.00 for flakes/powder, 2504.90.00 for other forms).

Processed products such as unwrought nickel (7502.10.00 for non-alloyed, 7502.20.00 for alloys) and ferro-nickel (7202.60.00) are categorized under Chapter 75. These classifications support statistical tracking and tariff implementation. However, high export taxes on unprocessed ores—

up to 40% for nickel—along with the absence of preferential treatment for battery-specific intermediates, can hinder local processing development.

Decree No. 26/2023/ND-CP provides detailed schedules for export and import tariffs, including:

- **Nickel and cobalt**: Export taxes are 30% for raw ores and 20% for concentrates. Processed products face lower rates: 5% for unwrought cobalt, 2% for cobalt scrap, and 0% for nickel matte (7501.10.00), potentially benefiting firms such as Ban Phuc;
- **Manganese**: Export tax is currently 0%, aiming to encourage domestic use, though this diverges from prior higher rates and may require future policy alignment;
- **Graphite**: Falls under general non-metallic mineral tax rates, typically 10%, consistent with its importance in battery anodes.

These tax adjustments aim to retain battery-critical minerals for domestic processing, supporting the battery supply chain. However, the lack of domestic refining capacity (e.g., no nickel sulfate production) and the gap between high raw ore taxes (30%) and low processed product taxes (0–5%) limit their effectiveness, increasing costs for firms reliant on exports.

The Law on Natural Resource Tax (Law No. 45/2009/QH12) also influences upstream operations. From 2011 to 2020, this tax generated an average of 39,500 billion VND annually—about 3.82% of total state revenue. Resolution 1084/2015/UBTVQH13 stipulates current rates: 10% for nickel, 15% for cobalt, 14% for manganese, and 10% for graphite. However, challenges persist in determining taxable volumes and prices, especially for minerals processed before sale, complicating cost assessments for downstream industries.

4.1.2.4. Technical regulations and environmental standards

Vietnam's technical regulations, governed by the Law on Standards and Technical Regulations (Law No. 68/2006/QH11), also shape upstream and midstream activities. Mandatory National Technical Regulations (QCVN) and voluntary National Standards (TCVN) ensure environmental and safety compliance. Although no QCVNs currently address lithium or nickel extraction specifically, broader environmental rules—including QCVNs on industrial waste and emissions—apply. For example, QCVN 01:2020/BCT on electrical safety imposes requirements on battery-related processing equipment, influencing operational costs.

4.1.2.5. Gaps and opportunities

Despite Vietnam's comprehensive upstream policies, key challenges persist:

- **Limited incentives** for downstream processing and battery material production (e.g., cathodes, nickel sulfate);
- **High export taxes** on intermediate products that discourage investment in semi-processing;
- **Insufficient midstream infrastructure** that leads to reliance on imports.

To unlock Vietnam's full potential in the battery mineral supply chain, the following measures are recommended:

- **Introduce tax incentives for processing of key minerals such as nickel and lithium,** coupled with reductions in export taxes on refined products (e.g., nickel matte from 10% to 5%), to reduce import dependency and encourage domestic refining. Additionally, adjust natural resource tax rates to incentivize deep processing, e.g., lower rates for processed nickel (currently 10%) versus raw ore, to align with green growth goals.
- **Establish public-private partnerships to develop advanced mining technologies,** drawing from global best practices.
- **Enforce stricter environmental compliance to align with global ESG standards (e.g., EU battery passports).**
- **Develop a national battery mineral roadmap** to integrate export tax and natural resource tax policies with green growth goals, ensuring a steady supply of battery materials.

4.1.3. Policies for midstream stage affecting component manufacturing

Midstream policies generally focus on processing raw materials and manufacturing battery components for EVs and BESS. Currently in Vietnam, there is a lack of specific incentives for processing of key materials for battery manufacturing. Current reliance on imported cathodes, lithium, and other components highlights the need for enhanced processing capabilities and localized production.

Decision No. 866/QD-TTg described in Section 3.1.2. also applies to the midstream stage. Particularly, it requires the use of green technologies, modern equipment, and robust waste management and post-mining environmental restoration. In addition, advanced methods should be used to meet domestic and export quality standards. For nickel, this might mean the use of hydrometallurgy.

Export tax policies indirectly support midstream development by discouraging raw mineral exports. For instance, the export tax on nickel ore increased to 40% by 2014, incentivizing local processing (e.g., into nickel sulfate for NMC batteries). However, the 10% export tax on nickel matte places limitations on firms like Ban Phuc, which lack domestic refining options, limiting the supply of processed materials for battery manufacturing.

Vietnam's technical regulation framework influences midstream activities. Key standards and technical regulations include:

- QCVN 01:2020/BCT, a mandatory regulation, ensures electrical safety in processing facilities, increasing compliance costs but enhancing operational reliability.
- QCVN 03:2022/BXD, mandatory, classifies BESS projects with a 50-year design lifetime, requiring durable components (e.g., battery casings) from midstream suppliers.
- TCVN 12240:2018 (IEC 62281), voluntary unless mandated, governs safe lithium battery transportation, impacting logistics of components like cathodes and cells.

- TCVN 11919-2:2017 (IEC 62133-2:2017) and TCVN 12241 series (IEC 62660), voluntary standards specifying safety and performance for lithium-ion batteries used in EVs, partially applicable to BESS. These require rigorous quality control and testing, encouraging manufacturers to adopt high-quality processes for competitiveness.

The absence of BESS-specific TCVNs forces reliance on international standards (e.g., IEC), complicating compliance. This gap, combined with limited domestic lithium processing, reinforces import dependency for critical components like cathodes and electrolytes. Currently, MOST is in the process of developing 18 national standards on BESS based on IEC. These cover aspects such as vocabulary, specificities, safety, recycling and sustainability.

Recommendations:

- Introduce tax incentives for nickel and lithium processing to reduce import dependency and foster domestic battery production.
- Establish public-private partnerships, inspired by Australia's Critical Minerals Strategy (2023), to develop midstream facilities.
- Develop further TCVNs to standardize manufacturing, reducing reliance on international standards and clarifying their voluntary application unless mandated.
- Incentivize local production of components (e.g., casings, cooling systems) through subsidies
- Streamline foreign standard approvals to ease compliance for midstream suppliers.

4.1.4. Policies for downstream stage

The downstream stage of the EV and BESS value chain focuses on distribution, retail, and end-user adoption. As highlighted in Section 3.1.1, Vietnam has established a regulatory framework to promote EV adoption, with comprehensive policies encompassing long-term visions, fiscal incentives, and non-fiscal measures. In contrast, BESS adoption remains underexplored. This section examines Vietnam's downstream policies, detailing the strategic frameworks, fiscal incentives, and market stimulation efforts that drive EV adoption, while identifying gaps in BESS support. Key policies, including Decision 876/QĐ-TTg, Decree No. 26/2023/ND-CP, Decree No. 21/2025/ND-CP, and Decree No. 51/2025/ND-CP, are analyzed for their impact on EV manufacturing, assembly, and consumer adoption, with a focus on enhancing affordability, global competitiveness, and market growth.

4.1.4.1. EV Policies

4.1.4.1.1. Strategic Frameworks for EV Adoption

Vietnam's downstream policies are anchored in long-term visions to transition the transport sector toward sustainability, as outlined in Decision 876/QĐ-TTg (2022). This decision approves the Action Program on Green Energy Transition and Carbon and Methane Emission Reduction in the Transport Sector, setting a target of net-zero greenhouse gas emissions in transport by 2050. It establishes clear milestones to phase out internal combustion engine vehicles (ICEVs) and promote EVs and green energy vehicles:

- **By 2025**: 100% of new and replaced buses must be electric or green energy vehicles.
- **By 2030**: 100% of new and replaced taxis must be electric or green energy vehicles.
- **By 2050**: 100% of all vehicles (new and existing) must be electric or green energy vehicles.

This policy provides a predictable roadmap for stakeholders, encouraging investments in EV infrastructure (e.g., charging stations) and fleet electrification.

4.1.4.1.2. Fiscal incentives for EV manufacturing and assembly

Vietnam has implemented a series of fiscal incentives to reduce manufacturing costs and stimulate domestic EV production, primarily through import tax exemptions and tariff adjustments. These policies indirectly support downstream adoption by making EVs more affordable for consumers.

Issued on May 31, 2023, and effective from July 15, 2023, **Decree No. 26/2023/ND-CP establishes export and import tariff schedules, offering targeted fiscal incentives to bolster EV manufacturing and assembly while discouraging ICEV imports.**

- **0% Import Tax on EV Components (Article 8):** Automotive components under HS code 98.49, used in the production and assembly of EVs, hybrid vehicles, fuel cell vehicles, and other alternative fuel vehicles, are exempt from import taxes until December 31, 2027. This reduces production costs for manufacturers like VinFast, supporting domestic EV assembly. For example, VinFast's VF e34 production benefits from cheaper imported components, enhancing affordability for consumers.
- **0% Import Tax on Raw Materials and Supplies for Supporting Industries (Article 9):**
  Raw materials, supplies, and components not yet produced domestically, used for manufacturing priority industrial support products for the automotive sector, are exempt from import taxes. Initially valid until December 31, 2024, this was extended to December 31, 2027 by Decree No. 21/2025/ND-CP. This facilitates access to critical materials (e.g., lithium for batteries). It indirectly supports lithium battery production (HS 98494310, 98494321, 98494329) by lowering input costs for firms like VinES.
- **High Tariffs on Used ICEVs (Article 7):** Used vehicles face steep import taxes to discourage their entry: a 150% import tax on vehicles with 16+ seats or cargo vehicles under 5 tons, and a tax rate 1.5 times that of new vehicles for other used vehicles (HS codes 87.02, 87.03, 87.04). This makes used ICEVs less competitive, enhancing the market appeal of EVs, especially when paired with lower Special Consumption Tax rates for BEVs (1–3% vs. 10–150% for ICEVs until 2027).
- **Alignment with International Trade Agreements (Article 10):** The decree ensures compliance with Vietnam's commitments under the WTO, ASEAN, CPTPP, and EVFTA, enabling tailored tariff schedules for the automotive industry. This enhances global competitiveness for firms, supporting exports to ASEAN/LAC markets.
- **Support for Lithium Battery Production** (HS Codes 98494310, 98494321, 98494329): The decree includes tariff classifications for lithium batteries under HS 984943:
  - 98494310: Lithium batteries.

- 98494321: Other batteries (excluding zinc-carbon types), with an external volume ≤300 cm^3.
- 98494329: Other lithium batteries not specified above.

While specific tax rates for these HS codes are not detailed, the 0% import tax on raw materials (Article 9) and EV components (Article 8) applies if these batteries or their inputs are not domestically produced and are used in EV manufacturing. This lowers costs for battery manufacturers like VinES, supporting EV production. However, **as lithium batteries are not on the Ministry of Planning and Investment (now Ministry of Finance)'s list of domestically manufactured products, this primarily facilitates imports rather than local production**.

Issued on February 10, 2025, **Decree No. 21/2025/ND-CP amends Article 9 of Decree 26/2023, extending the 0% import tax on raw materials, supplies, and components from December 31, 2024, to December 31, 2027.** Customs declarations initially use standard or preferential rates, with the 0% rate applied later upon meeting eligibility criteria (e.g., domestic unavailability, certified by MOF). This extension provides stability for automotive supply chains, ensuring cost predictability for EV manufacturers. It aligns with Article 8's timeline, creating a cohesive fiscal framework that supports EV production through 2027.

Overall, these decrees reduce the cost of imported components and materials, enabling firms like to scale domestic EV assembly. However, **the focus on imports (due to lithium batteries' exclusion from MOF's list of domestically manufactured goods) limits support for local battery production, a gap in fostering a self-sufficient supply chain**. Up to now, there has only been a policy supporting special consumption tax and registration fee for battery-powered electric vehicles and there is no specific roadmap for the development of other electric vehicle lines in Vietnam.

4.1.4.1.3. Fiscal incentives for EV adoption

Vietnam's downstream policies also **target end-user adoption through fiscal incentives that lower the cost of EV ownership**, complementing manufacturing support to stimulate market demand. These come under the form of registration fee exemptions and preferential special consumption tax rates.

In Vietnam, registration fees are calculated based on vehicle type, location, and applicable government incentives. The formula for new vehicles is: **New car registration fee = Assessed Price × Fee Rate (%).** According to the Decree 10/2022/ND-CP, standard rates for ICEVs typically range from 10–15% depending on the region (e.g., Hanoi, HCMC). Meanwhile, battery electric vehicles were granted a full (100%) exemption on registration fees for three years, followed by a 50% reduction for two additional years. Without further intervention, this incentive would have expired on February 28, 2025, thereby requiring EV buyers to pay half the standard registration fee rate.

However, **Decree No. 51/2025/ND-CP** ("Decree 51"), issued on March 1, 2025, has officially extended the full exemption for another two years, lasting until February 28, 2027. This builds on Decree No. 10/2022/NĐ-CP, indicating strong and consistent government support for EV uptake. Over the past 3 years (2022–2024), the cumulative budget loss was 8,420 billion VND due to the existing exemption policy. Despite fiscal trade-offs, the policy successfully boosted EV adoption. This reduces the upfront cost of EV ownership, making them more attractive. For example, a BEV

with an assessed price of 1 billion VND saves 100–150 million VND in registration fees in Hanoi, significantly lowering the total cost of ownership. Estimated budget revenue loss: 4,800 billion VND/year from the extension.

These incentives are complemented by preferential **Special Consumption Tax (SCT) rates**. According to Clause 1, Article 2 of the Law on Special Consumption Tax (2008), as amended in 2014, taxable goods include: "Automobiles with fewer than 24 seats, including passenger and cargo combination vehicles with fixed partitions between passenger and cargo compartments." Since BEVs with fewer than 24 seats fall within this category, they are considered subject to Special Consumption Tax.

According to **Article 7 of the Law on Special Consumption Tax (2008)**, as amended by the 2022 revision under the Law on Amendments to various laws (including the Investment Law, PPP Law, Housing Law, and SCT Law), the SCT rates for BEVs are as follows:

Table 4-2. Special Consumption Tax rates for different types of battery electric vehicles

Type of Battery Electric Vehicle	Period	SCT Rate (%)
Passenger BEVs (up to 9 seats)	01 Mar 2022 – 28 Feb 2027	**3%**
	From 01 Mar 2027	**11%**
Passenger BEVs (10 to <16 seats)	01 Mar 2022 – 28 Feb 2027	**2%**
	From 01 Mar 2027	**7%**
Passenger BEVs (16 to <24 seats)	01 Mar 2022 – 28 Feb 2027	**1%**
	From 01 Mar 2027	**4%**
Dual-use BEVs (Passenger + Cargo)	01 Mar 2022 – 28 Feb 2027	**2%**
	From 01 Mar 2027	**7%**

Source: Authors' adaptation from Article 7 of the Law on Special Consumption Tax (2008)

Battery electric vehicles are subject to the Special Consumption Tax in Vietnam, with rates that vary based on seating capacity and vehicle type. The lowest SCT rate is 1% (for 16–24 seat BEVs before 2027), and the highest rate is 11% (for up to 9-seat BEVs from 2027 onward). These rates reflect the government's supportive stance toward electric mobility as a national priority.

These preferential tax rates aim to lower the cost barrier for manufacturers and consumers and to encourage investment in domestic EV production. Compared to conventional internal combustion engine (ICE) vehicles, which are taxed at rates ranging from 35% to 150% depending on engine displacement and vehicle type, the SCT for BEVs remains significantly lower—even after 2027.

Special Excise Duty Tariff Structure:

- **Conventional Vehicles (ICEVs)**: Gasoline vehicles face high excise duties of **40%, 45%, and 55%**, depending on categories (e.g., passenger vehicles with varying engine

capacities).
Impact: Significantly increases the cost of ICEVs, making them less attractive compared to EVs.

- **Hybrid/Biofuel Vehicles**: Vehicles using gasoline and electricity/biofuel (≤70% gasoline) are taxed at **70% of the base rate**, while those running solely on biofuel face **50% of the base rate**.
  Impact: While lower than ICEVs, these rates still position hybrids as less competitive than EVs, encouraging a full transition to electric mobility.

- **Electric Vehicles (EVs)**: EVs, including passenger vehicles (≤9 seats, 10–16 seats, 16–24 seats) and dual-use EVs (passenger and cargo), benefit from **preferential rates**, likely reduced or 0%, though specific rates are not detailed. Combined with SCT rates (1–3% until 2027), this further lowers EV ownership costs, making them financially attractive. For example, a 1 billion VND passenger EV (≤9 seats) could save an additional 400–550 million VND compared to an ICEV with a 40–55% excise duty.

These fiscal incentives, registration fee exemptions, low SCT rates, and a tiered excise duty structure, significantly reduce the total cost of EV ownership, driving consumer demand, particularly in urban centers like Hanoi and HCMC. They also shift market dynamics by making ICEVs and hybrids less competitive, favoring EV-focused firms like VinFast and supporting localization efforts through increased demand.

4.1.4.2. BESS

Vietnam has limited deployment of BESS with the only operational system being a 700 kW/2 MWh BESS at PECC2. The slow adoption is attributed to the technology's novelty and the lack of a mature policy framework.

Currently, there have been a few regulatory documents focusing on the use of BESS in Vietnam's power system. Particularly, the Revised PDP VIII prioritizes BESS deployment near renewable energy hubs and urban load centers, projecting a capacity of 10,000–16,300 MW by 2030 and up to 96,000 MW by 2050. The Decision No. 988/QD-BCT issued on April 10, 2025 sets 2025 tariffs for solar power projects, with higher rates for those integrated with BESS. Examples include 1,571.98 VND/kWh (ground-mounted solar with BESS, North) vs. 1,382.7 VND/kWh (without BESS).

These policies reflect Vietnam's early-stage approach to BESS, with ongoing efforts to align regulations with the growing renewable energy sector and global cost trends, though significant gaps remain in market mechanisms and financial incentives.

4.1.5. Gaps and recommendations

Vietnam's battery supply chain benefits from existing fiscal and sectoral policies, particularly EV-focused one. There are limited policies directly addressing batteries for EVs and BESS (e.g., LFP and NMC).

- **Strategic Frameworks**: Decision 882/QD-TTg on the National Green Growth Action Plan and Decision 876/QD-TTg (2022), which targets 100% EV adoption by 2050, offer encouraging long-term direction. Similarly, the revised Power Development Plan VIII sets ambitious targets for BESS deployment—10,000–16,300 MW by 2030 and 96,000 MW by 2050—marking a significant step toward integrating energy storage into the national energy transition.
- **Fiscal Incentives**: Decree No. 26/2023/ND-CP offers 0% import tax on certain critical minerals, Decree No. 51/2025/ND-CP extends registration fee exemptions until 2027, and Decree No. 21/2025/ND-CP provides tax holidays for manufacturers. Special Consumption Tax rates for BEVs remain low (1–3% until 2027).
- **Technical Regulations and Standards**: QCVN 01:2020/BCT ensures safety, TCVN 12241 series (IEC 62660) and TCVN 12668-4:2020 cover EV batteries, but no specific standards exist for BESS recycling or fire safety.
- **Manufacturing List**: MOF list excludes lithium batteries (HS 98494310, 98494321, 98494329), limiting local production support.
- **Investment Incentives:** The Investment Law (2020) provides a framework for incentives under Articles 15 and 16, offering tax exemptions, reduced land use fees, and accelerated depreciation for high-tech and clean energy projects, which could support battery manufacturing and deployment.
- **Additional Support Mechanisms:** Decree 182/2024/ND-CP, effective December 31, 2024, establishes the Investment Support Fund to attract strategic investors in high-tech sectors. Battery projects involving R&D or innovation may qualify if classified as high-tech or clean energy initiatives, though their eligibility remains uncertain without explicit inclusion.

Despite these advances, significant policy and market gaps remain:

- **Incentives**: Limited to EV components, lacking targeted subsidies or production-linked incentives (PLIs) for batteries. While Decree 182/2024/ND-CP offers potential support for high-tech projects, its focus on semiconductors and AI may exclude many battery projects unless they are explicitly prioritized, leaving a gap in targeted financial support for battery manufacturing and BESS deployment.
- **Domestic Manufacturing List**: Exclusion of batteries from the MOF list hinders local production scale-up.
- **Subsidies**: No specific subsidies for battery manufacturing, refining, or recycling.
- **R&D Funding**: Minimal investment in battery-specific R&D, with no dedicated innovation parks.
- **Upstream and Midstream**: No strategy for nickel refining or gigafactory development, with 80% import reliance for lithium and cathodes.
- **Downstream**: Insufficient TCVNs for diverse battery types, no mandatory recycling standards and limited BESS adoption incentives.

To accelerate Vietnam's leadership in the regional battery value chain, the following actions are recommended:

- **Establish a Battery Production Incentive Package:** Introduce a comprehensive package modeled on successful international experiences, such as India's ₹18,100 crore

PLI scheme, South Korea's USD 2 billion tax credits, and China's €1 billion export subsidies. These incentives should target domestic battery, EV, and BESS manufacturing.

- **Revise the MOF's Domestic Manufacturing List:** Include key battery products such as lithium-ion cells, cathodes, and BESS units.
- **Enhance Financial Support:** Allocate subsidies for manufacturing, mineral refining, and recycling, following global precedents (e.g., China's €20 billion, Japan's USD 2.4 billion). Supplement this with low-interest loans and consumer subsidies for EVs and BESS systems.
- **Strengthen R&D Investment:** Dedicate funding towards the establishment of battery innovation parks and public-private partnerships. Models such as Japan's NEDO initiative or Australia's AUD 1.8 billion clean energy fund could inform a Vietnamese approach focused on batteries for EVs and BESS, recycling, and thermal safety.
- **Advance Upstream Development:** Conduct a nationwide mineral resource assessment and negotiate government-to-government (G2G) agreements with key resource partners to reduce dependence on lithium and secure long-term material supplies.
- **Support Midstream Growth:** Facilitate gigafactory development with targeted subsidies, create enabling conditions for cathode and anode material production, and update relevant TCVNs to match international benchmarks.
- **Modernize Downstream Standards and Recycling:** Develop ESG-aligned regulations for battery life cycle, disposal, and second-life use—drawing from Japan's 95% recycling recovery target and China's 70% mandate. Invest in consumer incentives and recycling infrastructure to support safe and circular battery use (e.g., Australia's 80% target for battery recovery).

4.1.6. Policymakers and state-owned enterprises

Policymakers and SOEs form the backbone of Vietnam's battery supply chain governance, setting the regulatory and operational framework. However, their effectiveness is often constrained by resource allocation and focus areas.

Table 4-3. Key policymakers and state-owned enterprises related to the battery supply chain in Vietnam

Stakeholder	Supply Chain Phase(s)	Function and Role in the Battery Supply Chain
National Government		
Ministry of Finance (MoF)	All	Oversees national development and economic policy across sectors, including energy and transport. MoF plays a critical role in coordinating resources for and attracting domestic and foreign investment to the battery supply chain. It develops financing mechanisms, including tax incentives and exemptions, to support battery sector growth. MoF also is the main focal point for industrial parks and economic zones in Vietnam. Key areas that MOF is related to:

		• Policies to attract investment in key critical minerals, BESS and EV manufacturing and supporting tech. • Support for EV transition in freight and passenger transport. • Infrastructure for electric/hydrogen charging. • Tax and fee incentives. • Public procurement for EV transition. • Financial support for EV users (direct & indirect). • Allocates funding for research proposals in mineral extraction and processing. • Amends laws (Planning Law) to facilitate battery projects and mineral planning adjustments. • Allocates budgets for battery-related infrastructure and R&D. • Supports workforce training initiatives • Monitors and evaluates the Investment Support Fund's impact
Ministry of Industry and Trade (MoIT)	All	The lead ministry for the energy and industrial sectors. MoIT regulates battery industry practices, issues permits for industrial manufacturers and sets policies to encourage renewable energy and grid development. Key areas that MOIT is related to: • Develops EV and supporting industries • Expands EV charging infrastructure and electricity price incentives • Sets standards for charging stations and electricity supply. • Publishes and monitors mineral planning, ensuring feasibility and efficiency. • Conducts annual and 5-year evaluations of mineral planning, reporting to the Prime Minister. • Coordinates with MoST on R&D for advanced mineral processing technologies (e.g., hydrometallurgy for nickel). • Supports energy infrastructure for battery manufacturing, including renewable energy access for gigafactories.
Ministry of Construction (MoC)	Downstream	Oversees urban and transportation infrastructure, including policies for EVs and public transport systems. MoC is responsible for integrating charging infrastructure and aligning regulations with the national EV roadmap. In product distribution, it manages port and road systems, handling exports. In the final use and recycling, MOC could support recycling facility construction.

		Key Key areas that MOC is related to: • General policies to promote EV transition • Policies encouraging individuals and businesses to adopt EVs • National regulations and technical standards for EVs/ components • Regulations on EV charging station allocation in buildings and urban areas • Construction permits for EV charging stations • Updates standards and regulations for mining infrastructure to accelerate battery material projects.
Ministry of Agriculture and Environment (MAE)	All (especially Upstream and Recycling)	Regulates environmental protection, mineral resource management, and sustainable development, issuing environmental permits and enforcing sanctions. MAE promotes circular economy models and green practices across the battery supply chain, focusing on mining and recycling. It ensures post-mining land use aligns with economic goals. Key areas include: • Assesses environmental impacts and manages land-use plans for mineral projects. • Coordinates with MoIT on mineral licensing, prioritizing sustainable deep processing. • Limits or bans mining in special areas (e.g., bauxite, titanium) to protect resources for critical projects. • Develops policies for green and circular economy models in battery production. • Establishes regulations for waste management and recycling
Ministry of Science and Technology (MoST)	All	Drives R&D for battery technologies (e.g., lithium-ion, sodium-ion, ASSB) and sets safety/performance standards. MoST supports technology transfer and innovation in mineral processing and battery manufacturing. Key areas include: • Researches new technologies for mineral exploration, extraction, and battery production. • Manages technology transfer and equipment manufacturing for battery supply chains.

		• Develops national standards for battery technologies to enhance safety and efficiency. • Strengthens R&D institutions for global integration, supporting battery innovation networks. • Invests in breakthrough battery technologies (e.g., solid-state batteries)
Ministry of Home Affairs (MoHA)	All (especially Labour & Operations)	Regulates workforce-related policies such as occupational safety and health. MoHA sets standards for labor in high-risk industries like mining and manufacturing and supports local workforce development for the battery sector. Key areas include: ● Ensures labor safety in mining and battery production facilities. ● Develops training programs to upskill workers for battery manufacturing needs.
State Bank of Vietnam (SBV)	All	Provides low-interest loans to support private sector in developing infrastructure projects.
Regional Governments		
Provincial People's Committees (PPCs)	All	Authorize local battery-related projects, issue permits, and oversee implementation. PPCs also engage with communities to address environmental and social impacts, while ensuring local economic benefits. Key areas include: ● Implement national mineral plans locally, avoiding overlaps with other development plans. ● Accelerate investor selection for mineral extraction to support battery supply chains. ● Coordinate with MAE on land-use adjustments and environmental assessments for mining projects.
Department of Finance (DoF)	All	Supports local implementation of national financial and planning policies, including managing budgets for battery-related infrastructure and incentives.
Department of Industry and Trade (DoIT)	All	Implements energy and industrial policies at the provincial level. Supports battery and EV development through planning, monitoring, and business facilitation.

Department of Natural Resources and Environment (DoNRE)	Mining, Production, End-of-Life	Enforces environmental laws locally. Responsible for site inspections, environmental impact assessments, and ensuring sustainable practices in mining, manufacturing, and battery recycling.
State-Owned Enterprises (SOEs)		
Vinacomin (TKV)	Upstream	Operates in mineral extraction and initial processing, especially for nickel and other battery-relevant minerals. Supports upstream integration in Vietnam's battery supply chain.
Vietnam Electricity (EVN)	Midstream and Downstream	The national power utility. EVN supports development of EV charging infrastructure and stationary battery energy storage systems, essential for the energy transition and grid stability.
Vietnam National Industry – Energy Group (PVN)	Midstream and Downstream	A key player in the oil, gas, and clean energy industry, PVN has strategic potential to transition toward energy transition activities under the national green growth strategies.

SOEs are expected to lead in mining strategic minerals and battery assembly, ensuring resource security and sustainable development. However, Vinacomin and Petrovietnam lack the capital and technology to mine complex deposits like lithium or cobalt, focusing instead on traditional industries (coal, oil, gas).

- **Vinacomin:** As the largest SOE in Vietnam's mining sector, Vinacomin plays a dominant role in the extraction and processing of various metal and non-metal minerals. However, Vinacomin's portfolio includes copper concentrate, copper cathode, zinc ingots, tin ingots, iron ore concentrate, and precious metals such as gold and silver. Notably absent are critical battery materials like nickel, lithium, cobalt, or graphite, which limits its immediate integration into the global battery supply chain. While Vinacomin has recently invested in copper smelting and iron mining capacity, such as completing a 30,000-ton/year expansion of the Lao Cai copper smelter in 2023, its 2024 investment plan (totaling 312.7 billion VND) continues to focus on sustaining and expanding existing operations, implying limited strategic alignment with the core materials needed for Vietnam's battery manufacturing ambitions.
- **Petrovietnam** has experience in industrial equipment manufacturing but has not yet invested in lithium-ion battery assembly.

4.1.7. Key companies in Vietnam's battery supply chain

Vietnam's battery supply chain is driven by a mix of domestic champions, international investors, and joint ventures. FDI enterprises and domestic private firms play distinct roles, with differing levels of capital, technological capability, and long-term commitment to local value addition. In the battery sector, FDI has not strongly invested in mining due to the lack of specific incentive

policies. FDI enterprises often prioritize short-term profits, leading to raw ore exports instead of deep processing. Some private companies produce battery casings or auxiliary components but do not participate in cathode, anode, or electrolyte production due to lack of technology and capital. It can be seen that private enterprises account for only 10% of the supporting industrial production value, with small scale and weak financial capacity. For example, the cost to build a cathode production plant of 10,000 tons/year is estimated at 500 million USD, far beyond the capability of most private enterprises.

Table 4-4. Key companies in battery supply chain

Company Name	Business Area in Battery Supply Chain	Representative Projects	Project Capacity/Scale
Blackstone Minerals	Nickel and cobalt mining and processing	Ta Khoa Nickel Project (TKNP), Ta Khoa Refinery (TKR)	TKNP: 18,000 tons of nickel/year; TKR: 43.5 ktpa refined nickel, 85.6 ktpa NCM811 precursor
Tan Phat Minerals/ PC1 Group	Nickel mining and processing	Cao Bang nickel-copper project	
New Resources Metallurgy (NRM) Vietnam Haiduong	Manganese processing	Production of silicon manganese and ferromanganese	Global supplier, large-scale (specific capacity unavailable)
EcoGraf (in talks with VinES)	Graphite processing (potential)	Potential production of Battery Anode Material (BAM)	Exploration stage, potential capacity of 20,000 tons/year (based on other projects)
Samsung SDI Vietnam	Battery module assembly (NCA anode)	Assembly of 46mm cylindrical battery modules	Specific capacity unavailable, mass production starting March 2025
Gotion High-Tech (joint venture with VinES)	Battery cell production (LFP anode)	LFP battery cell production plant in Ha Tinh	5 GWh/year (about 30 million cells), expected to operate Q3 2024
VinFast	Battery production and assembly for EVs	Battery manufacturing plant in Ha Tinh, Gotion-VinES joint venture, partnership with ProLogium	Ha Tinh plant: 100,000 packs/year (Phase 1), target of 1 million (Phase 2); Gotion-VinES: 5 GWh/year
Samsung Electronics Vietnam	Lithium battery production for electronic devices	Batteries for phones, tablets, laptops	Accounts for 56% of Vietnam's lithium battery exports (15,696 shipments)

PINACO	Production and assembly of various batteries (mainly lead-acid)	Batteries for cars, motorcycles, household, industrial	Multiple plants, e.g., Dong Nai: 500,000 kWh/year, Dong Nai 2: 2,000,000 kWh/year (Phase 1: 600,000 kWh/year)
Vision Group	Production and assembly of various batteries (automotive, industrial, consumer electronics)	Batteries for various applications, including renewable energy storage	Significant production scale, details unavailable
GS Battery Vietnam	High-performance battery production and assembly (mainly lead-acid)	Batteries for cars, motorcycles, telecommunications, UPS	Plans to increase motorcycle battery capacity to 13 million units by 2017
Heng Li (Vietnam) Battery Technology Co., Ltd.	Lead-acid battery production and assembly for industrial applications	Creative battery designs for various industrial uses	Production scale unclear
Leoch Battery Corporation	Production and assembly of various batteries (lead-acid, lithium)	Diverse battery technologies for multiple applications	Production scale unclear
Ritar Power (Vietnam) Company Limited	Production and assembly of batteries (lead-acid, lithium) for renewable energy	Batteries for consumer and industrial markets	Production scale unclear
Rekoser	Production and assembly of batteries (lithium, lead-acid) for solar and other applications	Batteries for various applications	Production scale unclear
TIA Sang Battery Joint Stock Company	Production and assembly of lead-acid batteries for automotive	Batteries for local needs	Production scale unclear
Kung Long Batteries Industrial Co. Ltd.	Production and assembly of batteries (mainly lead-acid)	Durable batteries for various fields	Production scale unclear

Fluence (consortium between AES and Siemens)	Production of lithium-ion based energy storage	This consortium is currently producing Fluence Cube	Production scale unclear

Source: Authors' compilation

These stakeholders drive key trends:

- **Expansion of Assembly Capacity**: VinES (Vingroup), Gotion High-Tech, and Samsung SDI Vietnam are scaling up battery cell and module assembly to meet growing demand from EVs and electronics.
- **Upstream Integration**: Companies like Blackstone Minerals, POSCO, and HT Solar are investing in nickel, graphite, and anode materials to secure critical raw materials and reduce reliance on imports.
- **Strategic Joint Ventures**: Collaborations, such as VinES-Gotion and talks with EcoGraf, reflect efforts to blend foreign technology with local resources and market access.
- **Export Dominance**: Samsung Electronics Vietnam leads lithium battery exports, highlighting the country's importance in global electronics supply chains.
- **Diverse Battery Types**: While lithium-ion is growing, many firms like PINACO and GS Battery still focus on lead-acid batteries, reflecting continued domestic demand across vehicle and industrial uses.

4.1.7.1. Upstream: Mining and material extraction

These companies focus on securing critical raw materials (nickel, graphite, manganese, etc.) essential for battery manufacturing:

- **Blackstone Minerals:** Anchors critical minerals via the Ta Khoa Nickel Project (18,000 tons/year) and Ta Khoa Refinery (43.5 ktpa refined nickel, 85.6 ktpa NCM811 precursor).
- **PC1 Group** is positioning itself as a key player in Vietnam's nickel mining industry. Through its subsidiary, Tan Phat Minerals, it indirectly owns the only listed company with nickel mining rights. Phase 1 of its Cao Bang nickel-copper project began operations in May 2023, exporting over 21,000 tonnes of nickel concentrate and earning VND 705 billion in 2023. For 2024, PC1 targets exports of 50,000 tonnes and revenue of around VND 1,000 billion—a 53% increase. It plans to begin Phase 2 expansion and explore deep processing technologies to enhance product value and margins. With global nickel prices expected to recover to $17,000/ton, well above its internal planning price of $12,000/ton, PC1 anticipates strong profit margins. Its partnership with global trading firm Trafigura further underscores its growing footprint in the sector.
- **POSCO:** Invests USD 500 million in a Hai Phong anode graphite factory (POSCO, 2023).
- **HT Solar**: Produces 30,000 tons/year of anode materials, reducing import reliance

4.1.7.2. Midstream: Material Processing and Precursor Production

This stage includes chemical processing and precursor material production for batteries:

- **New Resources Metallurgy (NRM) Vietnam**: Processes silicon manganese and ferromanganese in Hai Duong, serving global markets.
- **EcoGraf (in negotiation with VinES)**: Exploring a joint venture for Battery Anode Material (BAM) production in Vietnam, with a potential capacity of 20,000 tons/year.

4.1.7.3. Downstream: Battery cell production and assembly

Leading companies are scaling up battery cell production and battery pack assembly, mainly for EVs and electronics:

- **VinES (Vingroup)**: Operates a **5 GWh/year plant in Ha Tinh**, producing 1 million cells annually using South Korean stacking technology. Supplies VinFast's EV ambitions.
- **Gotion High-Tech (with VinES)**: Jointly building a **5 GWh/year LFP battery cell plant** in Ha Tinh, expected to deliver 30 million cells annually by Q3 2024.
- **Samsung SDI Vietnam**: Assembles **46mm cylindrical battery modules**, starting mass production in March 2025.
- **Samsung Electronics Vietnam**: A major lithium battery exporter, accounting for 56% of total lithium battery shipments (15,696 shipments in 2024).
- **LG Chem**: Plans a **5 GWh/year facility** in Bac Ninh by 2026 to produce batteries for heavy-duty trucks.
- **Highpower Technology**: Investing USD 20 million in a battery production facility in Nam Dinh Vu.

4.1.7.4. Lead-acid battery producers and diversified players

While lithium-ion battery capacity is rising, many companies continue to meet domestic demand with lead-acid and hybrid battery technologies:

- **PINACO**: A leading producer of car, motorcycle, and household batteries. Plants in Dong Nai produce between 500,000–2,000,000 kWh/year.
- **GS Battery Vietnam**: Focuses on high-performance batteries and plans to boost motorcycle battery capacity to 13 million units.
- **Other Manufacturers**:
    - **Leoch**, **Ritar Power**, **Vision Group**, **Heng Li**, **Kung Long**, and **Rekoser** serve diverse segments, including industrial, UPS, telecom, and solar applications.
    - **TIA Sang Battery** serves automotive needs with lead-acid technologies.

4.1.8. Other Stakeholders

Beyond policymakers, SOEs, and key companies, other stakeholders play critical roles across the supply chain, with varying degrees of influence and capacity constraints.

- **Research Institutes and Universities**
  Research institutes like the Vietnam Academy of Science and Technology (VAST) and the Vietnam Institute of Industrial Chemistry focus on R&D, but their impact is limited to lab-scale outputs. VAST researches NMC cathodes, graphite anodes, and recycling processes (<1 kg/month), while the Institute of Industrial Chemistry works on lithium salt electrolytes and lead-acid battery recycling, without commercialization. The Institute of Electronics and Telecommunications develops BMS and battery control technology, but only 5% of R&D projects are applied practically due to funding shortages (Ministry of Science and Technology). Universities such as Hanoi University of Science and Technology collaborate with VinES on BMS and recycling but lack large-scale production capabilities. Only 10% of STEM graduates meet battery industry needs due to disconnected training programs (Ministry of Education and Training).

- **Associations**
  Associations like the Vietnam Association for Supporting Industries (VASI), Vietnam Electronic Industries Association (VEIA), and Vietnam Waste Recycling Association (VWRA) aim to connect businesses and propose policies. VASI organizes seminars on supporting industries but lacks battery-specific programs, while VEIA supports electronics firms like Samsung SDI without focusing on EV/BESS battery materials. VWRA hosts waste recycling workshops but does not prioritize lithium-ion batteries, limiting their influence as a bridge between enterprises and the government.

5. Financial positions and justifications for investment in Vietnam

This chapter provides a detailed financial analysis of Vietnam's projected battery demand by 2030, estimates the costs of meeting this demand through domestic supply chain development, and justifies the case for investment. By leveraging global market trends, local economic advantages, and policy support, Vietnam can position itself as a competitive player in the LIB supply chain, supporting its net-zero 2050 goal and addressing the 70% undersupply projected for the rest of the world by 2035.

5.1. Projected battery demand

The analysis focuses on three key segments: E-2Ws, electric passenger cars (PEVs) and BESS. The projections are based on a combination of domestic sales trends, infrastructure readiness, and global benchmarks from sources such as S&P, IEA, and BloombergNEF.

For the E-2W segment, historical sales of approximately 484,000 units in 2023 serve as the baseline. Based on continued government support and rising consumer interest, annual sales are projected to grow at a compound annual growth rate (CAGR) of 16%, resulting in approximately 1.55 million units by 2030. Battery capacity estimates are derived from a weighted average of 3.5 kWh per unit, based on market shares and technical specifications of key manufacturers. For instance:

- VinFast, with a 43.4% market share, offers models in the 3–4 kWh range;
- Dat Bike typically uses ~3.2 kWh batteries;
- Yadea employs ~3.0 kWh batteries.

For PEVs, baseline data shows 90,000 units in 2024, growing at a 15% CAGR to reach 171,000 units by 2030. The average battery capacity per vehicle is estimated at 67.15 kWh, based on weighted contributions from models such as:

- VinFast (~60% share): ~75 kWh average,
- BYD: ~60 kWh,
- Wuling: ~26.5 kWh.

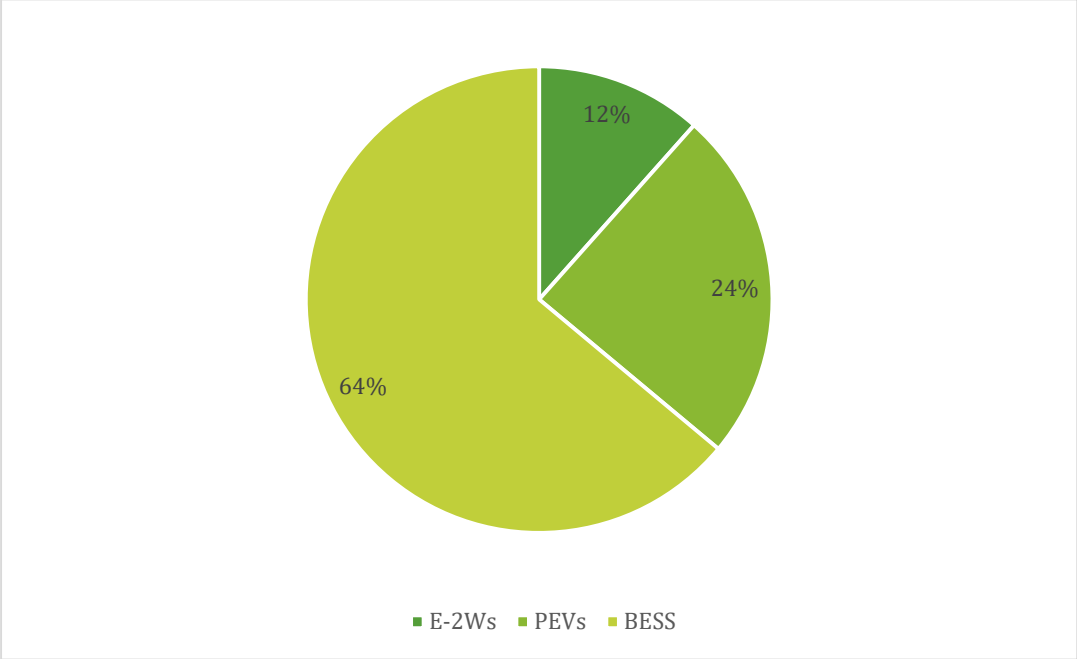
This average is slightly adjusted upward to reflect Vietnam's limited public charging infrastructure, which necessitates longer-range vehicles with larger battery packs.

For BESS, Vietnam's Power Development Plan VIII sets a national target of 10,000–16,300 MW of BESS capacity by 2030. For this analysis, a conservative assumption of 10,000 MW is adopted, with a 3-hour storage duration, yielding a total projected demand of 30,000 MWh. This aligns with ongoing efforts to enhance grid flexibility, manage renewable energy intermittency, and ensure power system reliability.

Table 5-1. Summary of battery demand by segment

Segment	Unit Count / Capacity (by 2030)	Avg. Battery Size	Estimated Demand (MWh)
E-2Ws	1.55 million units	3.5 kWh	5,425 MWh
PEVs	171,000 units	67.15 kWh	11,486 MWh
BESS	10,000 MW × 3 hours (storage duration)	—	30,000 MWh
Total	—	—	**46,911 MWh**

Figure 5-1. Projected battery demand share by segment (2030)



Vietnam's total projected battery demand by 2030 is 46.9 GWh, accounting for approximately 1.3% of global battery demand, which is expected to reach 3,500 GWh by that time (IEA, 2024). Figure 0-1 illustrates the segment-wise distribution of this demand, highlighting that:

- BESS constitutes the largest share (64%),
- PEVs account for 24%,
- E-2Ws represent 12%.

5.2. Battery cost projections and investment implications

Battery costs are projected to decline steadily through 2030, driven by:

- Economies of scale,
- Manufacturing efficiency gains, and
- Shifting to lower-cost chemistries, notably lithium iron phosphate (LFP).

According to BloombergNEF (2024), the global average pack price across all end-uses in 2024 was $115/kWh, while BEV pack prices averaged $97/kWh. These figures suggest cell prices of $70/kWh or lower, given a typical cell-to-pack cost ratio of 70–80%. In China's highly competitive and scaled market, LFP packs for utility-scale storage and fleet applications are reportedly as low as $85–90/kWh. Estimated cell prices are $65-70/kWh, given a 70-80% cell-to-pack cost ratio. Vietnam stands to benefit from such price trajectories by localizing battery manufacturing, encouraging supply chain investments, and leveraging regional trade networks to reduce costs.

The table below and **Figure 5-2** illustrate the total investment required under three price scenarios—$115/kWh (conservative), $90/kWh (moderate), and $70/kWh (optimistic)—reflecting different technology maturity and supply chain localization levels.

Figure 5-2. Cost implications of battery demand across segments under different battery pack price scenarios

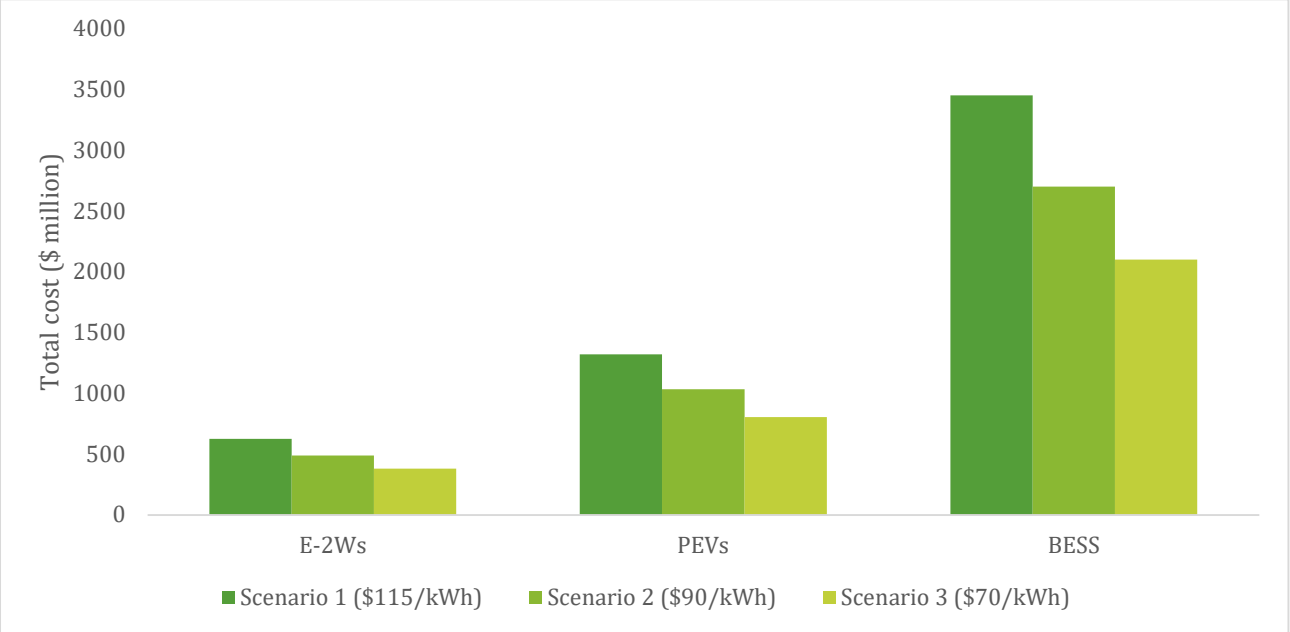


Table 5-2. Projected cost scenarios based on battery price assumptions

Segment	Demand (MWh)	Cost at $115/kWh ($ million)	Cost at $90/kWh ($ million)	Cost at $70/kWh ($ million)
E-2Ws	5,425	623.875	488.25	380
PEVs	11,486	1,320.89	1,033.74	804.02
BESS	30,000	3,450.00	2,700.00	2,100.00

Total	**46,911**	**5,394.77**	**4,221.99**	**3,284.02**

Battery costs have fallen significantly in recent years, and this trend is expected to continue. The projected battery cost ranges for 2030 are modeled under three global pack price scenarios: $115/kWh, $90/kWh, and $70/kWh. The **total investment requirement** for meeting Vietnam's battery demand across all three segments is estimated between:

- **$5.39 billion** at $115/kWh
- **$4.22 billion** at $90/kWh
- **$3.28 billion** at $70/kWh

Some key observations include:

- **Cost sensitivity to battery pricing is high**: A reduction from $115 to $70/kWh leads to potential savings of over $2.1 billion. This underlines the importance of securing low-cost battery supply through scaling domestic production, attracting FDI, and enabling joint ventures with global battery manufacturers.
- **BESS alone accounts for 60–65% of total investment**, implying that even marginal cost reductions in stationary storage technologies can yield substantial capital savings. Given that BESS projects are typically procured through auctions or tenders, ensuring competitive local manufacturing will be vital to lowering LCOE (levelized cost of electricity) from renewables.
- **Regional competitiveness matters**: In China, LFP pack prices are already as low as $85–90/kWh for utility-scale projects, thanks to economies of scale, intense competition, and proximity to critical raw materials. Vietnam can emulate this trajectory through clustering production in industrial zones, policy incentives (e.g., tax holidays, land access), and strategic partnerships.
- Despite the high unit volume (1.55 million projected E-2Ws by 2030), **the E-2W segment contributes the smallest share to total battery demand** due to the relatively small battery size (~3.5 kWh/unit). However, its economic and social significance is substantial, with two-wheelers dominating Vietnam's transport landscape. E-2Ws offer an opportunity for scaling compact battery modules and swapping infrastructure, particularly with players like VinFast, Dat Bike, and Yadea already active. Manufacturing at this scale can enable regional exports and support upstream investment in standardized cell formats for light mobility.
- PEV demand is growing steadily, underpinned by local manufacturing from firms such as VinFast and increasing consumer interest. The **relatively high average battery size of 67.15 kWh reflects the need for longer ranges due to limited public charging infrastructure a**nd a consumer preference for flexibility in Vietnam's sprawling urban and peri-urban environments. There is strong rationale to localize mid-to-large scale battery production for PEVs, focusing initially on LFP chemistries for cost and safety

benefits. Investment in pack assembly and integration with domestic EV platforms can reduce import dependency and foster local supplier ecosystems.

5.3. Cost competitiveness analysis for Vietnam

To determine Vietnam's potential cost competitiveness in battery cell production, the following assumptions are made:

- **Ideal plant size**: A plant size of 10–15 GWh is required to achieve economies of scale, aligning with global competitiveness against imported Chinese batteries (e.g., $42–$58/kWh). A mid-range capacity of 12.5 GWh is assumed for Vietnam, balancing investment and output.
- **Chemistry:** LFP chemistry is prioritized, matching demand for E-2Ws, BESS, and EU EVs, where NMC is reserved for high-end applications.
- **Location advantage:** Vietnam's strategic location within APAC, where LIB demand is increasing, coupled with developed ports (e.g., Hai Phong, Ho Chi Minh City). This facilitates exports to the trade partners, leveraging existing automotive infrastructure (e.g., VinFast).
- **Raw materials**: Cathode materials are assumed to be imported. Other raw materials (e.g., nickel, graphite) are sourced domestically ,reducing import costs.

Cost Breakdown

- **Bill of Materials (BoM)**: Raw materials constitute 65–75% of total cell cost. Here, a mid-range of 70% is used. Vietnam's upstream potential (e.g., nickel from Ban Phuc/Ta Khoa, graphite from Dak Nong) is explicitly supported by Decision No. 866/QD-TTg (2021) and the new Law on Geology and Minerals, effective July 2025. This aims to reduce dependence on imported inputs—currently, 80% of lithium still needs to be imported. The Investment Law (2020) provides tax incentives and preferential land leasing for strategic sectors. This enables a 5–10% reduction in BoM versus full-import scenarios, by leveraging domestic resources and cost efficiencies.
- **Operational Expenditure (Opex)**: Labor and electricity costs are lower in Vietnam ($296.5/month labor vs. $430/month in China, ILO 2025; competitive electricity rates at $0.085/kWh, Vietnam Electricity, 2025). While upstream policies have limited effect on Opex, compliance costs under QCVN 01:2020/BCT (midstream safety standards) may slightly raise operating costs by 1–2%. Nonetheless, regulatory compliance costs are manageable, suggesting little Opex inflation risk.
- **Capital Expenditure (Capex)**: Full reliance on Chinese technology increases capex to $4/kWh, higher than China's $3/kWh due to Vietnam's developing industrial base. Decree 182/2024/ND-CP and the Investment Law (2020) offer accelerated depreciation and tax incentives for high-tech and green projects. However, the actual effect is muted due to limited local industrial capacity and dependency on foreign EPCs and equipment.

- **Yield**: A 90% yield is assumed, aligning with industry standards, contributing $3/kWh to costs.
- **Manufacturer Margin and Transportation**: A 2% margin ($1.64/kWh) is applied. While export tax incentives and EVFTA trade benefits may improve profit margins, these occur after landed cost and thus do not influence this calculation directly. Future preferential trade access may enhance commercial returns.
- **Transport costs:** Transportation varies by region due to shipping distance and logistics. Vietnam's geographic advantage for ASEAN and Indian markets supports lower landed costs. Distance-based cost escalation for the US is expected but remains manageable.

Table 5-3. Projected cost scenarios based on battery price assumptions

Market	Base Cost	Margin	Transport	Pre-Subsidy	Explanation
Europe	$82	$1.64	$1.64	$85.28	Moderate shipping distance (~12,000 km); containerized sea freight + inland distribution adds moderate cost. Infrastructure is efficient, but longer transit time increases handling and insurance costs.
US	$82	$1.64	$2.46	$86.10	Higher due to longer distance (~13,000–15,000 km) and more stringent logistics and customs compliance. Transport to inland states in the US is costly, and container traffic imbalance can raise rates.
ASEAN	$82	$1.64	$1.23	$84.87	Lowest due to proximity. Short sea shipping and land routes from Vietnam to Thailand, Malaysia, or Indonesia are well established and cost-efficient. Often within a regional FTA, reducing customs frictions.
India	$82	$1.64	$1.64	$85.28	Moderate distance (~3,000–4,000 km). Sea freight is competitive, but Indian port and inland logistics can be slower or more bureaucratic, offsetting cost savings from proximity.

5.4. Support for job creation

The battery supply chain can bring positive employment impact on Vietnam, contributing to both the local and national economic development. Based on operational data from the case study of VinES Ha Tinh project and comparative benchmarks from the NAATBatt/NREL study on the U.S. lithium-ion battery supply chain (2023), this research estimates how developing the local battery supply chain contribute to job creation.

Current employment at VinES Ha Tinh plant

As of now, the VinES Hà Tĩnh plant employs approximately 1,000 workers, including:

- **900 operational staff,** working in three 8-hour shifts to maintain continuous production of 100,000 battery packs per year, equivalent to 24 million battery cells.
- **100 office staff,** supporting management, logistics, and technical operations during standard working hours.

The plant currently produces around 100,000 battery packs annually, equivalent to 24 million battery cells, satisfying VinFast's demand for EV and e-bus batteries.

Employment intensity estimation

To estimate employment intensity (jobs per GWh), the plant's total production capacity in GWh must be determined. Based on the plant's annual output:

- **Battery Packs Produced**: 100,000 packs/year
- **Assumed Average Capacity per Pack**: 50 kWh *(This accounts for VinFast's varied models—from 42 kWh for the VF e34 to 82 kWh for the VF 8—and aligns with operational charging protocols at the plant, typically around 40–50% SOC.)*

Thus, the **total energy capacity** produced annually is:

$$100{,}000 \text{ packs} \times 50 \text{ kWh/pack} = 5{,}000{,}000 \text{ kWh} = 5 \text{ GWh per year}$$

With 1,000 employees, this translates to:

$$1{,}000 \text{ workers} \div 5 \text{ GWh} = 200 \text{ workers per GWh}$$

Benchmark comparison with the U.S. supply chain

According to NAATBatt/NREL data from the U.S.:

- The full lithium-ion battery supply chain in the U.S. employs 63,667 workers for 200 GWh, or approximately 318 workers per GWh.
- The module and pack assembly segment alone (Segment 5 in the NAATBatt framework) accounts for 13,903 workers, or about 69 workers per GWh.

By comparison, VinES employs 200 workers per GWh, suggesting a higher labor intensity. This difference may be attributed to:

- Lower levels of automation in Vietnamese battery production.
- Additional labor-intensive processes such as pack charging and testing carried out at VinES.

Future employment projections

From prior analysis, projected battery demand in Vietnam by 2030 is **46.911 GWh**, distributed as follows:

- **Electric 2-wheelers (E-2Ws)**: 5.425 GWh
- **Passenger EVs (PEVs)**: 11.486 GWh
- **Battery Energy Storage Systems (BESS)**: 30.000 GWh

If VinES expands to meet 50% of PEV demand (5.743 GWh) in addition to its existing 5 GWh capacity, its total capacity would reach 10.743 GWh.

Workforce Projections

1. **Entire Battery Supply Chain**:
   Applying the NAATBatt average of 318 workers per GWh to 10.743 GWh yields: 10.743 GWh × 318 workers/GWh = 3,416 workers
2. **Assembly Segment Only**:
   Focusing solely on pack and module assembly (69 workers/GWh), for the additional 5.743 GWh expansion: 5.743 GWh × 69 workers/GWh = 396 workers

Therefore, the total projected workforce at VinES would be: 1,000 (existing) + 396 (expansion) = 1,396 workers

3. **National Workforce Potential**:
   Applying the full 318 workers/GWh ratio across the entire national demand of 46.911 GWh:
   46.911 GWh × 318 workers/GWh = 14,918 workers

This national-level estimate represents a high-end projection. It likely overstates short-term labor absorption capacity due to automation trends, technology gaps, and capital investment needs. Nevertheless, it highlights **the substantial job creation potential of localizing battery production and related supply chain segments in Vietnam, including charging infrastructure and logistics.**

5.5. Potential and challenges of Vietnam in the battery supply chain

The development of a domestic battery supply chain in Vietnam presents multidimensional benefits across five strategic areas:

- **Value Addition and Economic Diversification:** Transitioning from labor-intensive, assembly-based industries towards high-value-added sectors such as graphite/nickel,

lithium processing and battery cell/module assembly enables Vietnam to better leverage its export capacity. This shift enhances greater value addition, supports economic upgrading, and reduces reliance on traditional manufacturing sectors.

- **Electric Vehicle and High-Tech Industry Development:** A localized battery supply chain underpins the government's targets for electrification—30% of cars and 22% of motorbikes by 2030. Domestic production helps reduce import costs, enhances R&D in advanced technologies such as solid-state batteries, and positions Vietnam as a rising high-tech manufacturing hub in Southeast Asia.
- **Energy Security and Sustainability:** The integration of Battery Energy Storage Systems (BESS) into Vietnam's power grid reduces reliance on fossil fuels, which currently make up 45% of the power mix (EVN, 2023). According to Power Development Plan VIII, BESS adoption could lower CO_2 emissions by 204–254 million tons by 2030. Battery recycling—with material recovery rates of 60–80% (IEA, 2024)—further supports a circular economy, helping to manage the projected 10,000 tons of battery waste by 2030.
- **Foreign Direct Investment and Industrial Competitiveness:** Vietnam's competitive labor costs ($2.5/hour vs. $5/hour in China, ILO 2023) and targeted tax incentives (e.g., Decree 31/2021/ND-CP) enhance its attractiveness to investors. This development will also stimulate supporting industries such as electronics, logistics, and advanced manufacturing, strengthening Vietnam's position in global supply chains.
- **Trade and Export Potential:** With growing international demand for clean technologies, Vietnam's battery and EV exports to markets such as the EU and US are expected to reach $2 billion by 2032 (Expert Market Research, 2024). This expansion could help narrow the country's $3.5 billion trade deficit (GSO, 2023), particularly when leveraged through agreements like the EVFTA and in response to upcoming carbon border adjustment mechanisms.

Despite these opportunities, several structural and operational challenges must be addressed:

- **Policy Environment:** Vietnam's policy landscape supports upstream development through the newly enacted Law on Geology and Minerals (Law No. 54/2024/QH15), effective July 2025, which strengthens resource sovereignty for minerals like nickel and graphite. Midstream challenges—such as limited refining and cell-to-pack capabilities—are being addressed through industrial park incentives and agreements like EVFTA. However, the overall investment ecosystem remains underdeveloped and requires targeted reforms. Downstream demand from EVs and BESS places additional pressure on cost efficiency, quality, and supply chain resilience. Incentive structures under Decree 182/2024/ND-CP and the 2020 Investment Law offer a supportive base but must be accompanied by cohesive implementation strategies.
- **Cost and Affordability:** The high upfront cost of EVs, compared to internal combustion engine vehicles, is a barrier given Vietnam's GDP per capita of $4,000. While subsidies and financing schemes offer some relief, broader adoption depends on further cost declines—particularly in raw materials and cell production.
- **Charging Infrastructure Gaps:** Rural and remote areas face a lack of charging stations, impeding EV uptake. Although models such as VinFast offer 300 km range and 30–60

minute fast charging, these require significant infrastructure investment and consumer education to become viable at scale.

- **Raw Material Constraints:** Vietnam imported $747 million in ores in May 2025, reflecting dependence on international sources for lithium and other battery minerals. While domestic reserves of nickel and graphite exist, refining and processing capacity remains underdeveloped. Ongoing exploration must be followed by accelerated investment in refining capabilities.
- **Technological Maturity:** While Vietnam has made progress in battery assembly and integration, core manufacturing technology remains nascent. Firms like VinFast and Vingroup are advancing toward self-sufficiency, but more time and capital are needed. International R&D collaborations are essential to improving energy density and reducing costs.
- **Workforce Skills:** Battery production demands a highly skilled workforce. While Vietnam's labor pool is growing in sophistication, there is a shortage of domain-specific expertise in battery chemistry, system integration, and advanced manufacturing. Investment in specialized training programs and partnerships with institutions in countries with mature battery sectors is vital.

5.6. Overarching assessment and recommendations

Based on the comprehensive financial analysis and justifications presented, Vietnam stands at a critical stage to establish itself as a competitive player in the global LiB supply chain by 2030. With a projected battery demand of 46.911 GWh, driven by a projection of 1.55 million electric two-wheelers, 171,000 passenger electric vehicles, and 10,000 MW of BESS, the total investment required ranges from $3.28 billion to $5.39 billion, depending on battery pack prices declining from $115/kWh to $70/kWh by 2030. This aligns with global trends (e.g., BloombergNEF, IEA 2024) and Vietnam's strategic goals, including its net-zero 2050 target and the 70% undersupply projected for the rest of the world by 2035.

The cost competitiveness analysis demonstrates Vietnam's potential to achieve a landed cost of approximately $73–$86/kWh across key markets (ASEAN, Europe, US, India), leveraging domestic raw materials (nickel from Ban Phuc/Ta Khoa, graphite from Dak Nong), competitive labor costs ($296.5/month vs. $430/month in China), and electricity rates ($0.085/kWh). Adjusting the base production cost from the estimated $82/kWh to a more realistic $70/kWh—reflecting improved localization and economies of scale—could further enhance this competitiveness, aligning with prior benchmarks for emerging markets.

Job creation is a significant outcome, with the VinES Hà Tĩnh plant currently employing 1,000 workers for 5 GWh, translating to 200 workers per GWh. Scaling to meet 10.743 GWh could generate 1,396 direct jobs, while national development across the 46.911 GWh demand could support 28,750–35,000 jobs by 2030, including high-skill roles (up to 25% of the workforce). This will drive economic diversification, reduce import dependency (e.g., $1.26 billion in EV parts in May 2025), and enhance energy security by decreasing fossil fuel reliance (45% of power in 2023, EVN).

The benefits are substantial: value addition from a high-tech hub and environmental gains. However, challenges remain, including high EV upfront costs, uneven charging infrastructure (especially in rural areas), and raw material supply risks.

Recommendations:

1. **Invest in Localization**: Prioritize developing LFP plants to achieve economies of scale, targeting a $70/kWh production cost. Strengthen domestic refining (e.g., nickel, graphite) to reduce import dependency.
2. **Enhance Infrastructure**: Accelerate charging network expansion.
3. **Upskill Workforce**: Expand training programs (e.g., VinUni collaborations) to increase high-skill jobs, addressing technical gaps in cell production.
4. **Secure Partnerships**: Foster joint ventures with global players (e.g., CATL, LG Chem) to access technology and mitigate capex risks.
5. **Substantiate Metrics**: Develop a detailed CO2 reduction model, targeting validation against transportation and energy targets.

6. Investment rationale and strategic partnerships

Vietnam is poised to become a significant player in LIB industry, capitalizing on its strategic location in Southeast Asia, abundant mineral resources, and a growing renewable energy sector. The global battery market is projected to reach 3,500 GWh by 2030, growing at a 21% CAGR (IEA, 2023), driven by net-zero targets and policies such as the US Inflation Reduction Act, EU Green Deal Industrial Plan, and China's Made in China 2025. Vietnam aims to capture a share of this demand by leveraging its mineral reserves, attracting FDI, and aligning with sustainability goals for EVs and renewable energy integration.

However, the country's battery supply chain strategy remains in its early stages, with challenges such as import dependency for lithium and cathodes, limited recycling infrastructure, and underdeveloped midstream processing capabilities. This section outlines the critical role of government policies, strategic partnerships, and investment strategies in addressing these gaps and positioning Vietnam as a regional battery hub by 2030.

6.1. Policy Framework and Investment Basis

Government policies are instrumental in shaping Vietnam's battery supply chain by influencing pricing, raw material access, production costs, and market demand for EVs and battery energy storage systems. The global battery market is projected to reach 3,500 GWh by 2030, growing at a 21% CAGR (IEA, 2023), driven by net-zero targets and policies like the US Inflation Reduction Act (IRA), EU Green Deal Industrial Plan, and China's Made in China 2025. Vietnam aims to capture a share of this demand (estimated at 46.9 GWh domestically by 2030) by leveraging its reserves, attracting foreign direct investment (FDI), and aligning with sustainability goals for electric vehicles and renewable energy integration. However, the country's battery supply chain strategy remains nascent, with challenges including an import dependency for lithium and cathodes, limited recycling infrastructure, and underdeveloped midstream processing capabilities. This section analyzes the role of strategic partnerships and investment strategies in addressing these gaps and positioning Vietnam as a regional battery hub by 2030.

6.1.1. Government Support for EVs, Renewable Energy and Battery Integration

Globally, policies have successfully driven battery sector growth through targeted incentives and strategic resource management. The US IRA's USD 35/kWh tax credits have reduced consumer costs by 20–25%, attracting FDI from firms like CATL (BloombergNEF, 2023). The EU's battery passports mandate carbon footprint tracking, increasing compliance costs by 8–12% but favoring ESG-compliant producers. China's strategic reserves, holding six times more lithium than the US, have stabilized prices from USD 59,430/ton in 2022 to USD 15,000/ton in 2024, while €20 billion in subsidies since 2020 have lowered production costs by 15–20% (€30/kWh), enabling firms like CATL to price at €100/kWh versus €150/kWh globally (MIIT, 2024). Japan's Economic Security Promotion Act (2022) secures cobalt and nickel via partnerships with Indonesia, benefiting Toyota's all-solid-state battery (ASSB) production (METI, 2024).

Vietnam's policy framework plays a pivotal role in shaping its battery supply chain by influencing pricing, raw material access, production costs, and market demand for EVs and BESS. Policies such as the National Green Growth Strategy (GGS, 2012, updated 2021), Net-Zero Transportation Roadmap, and Revised Power Development Plan VIII, signal intent to align with these trends. The GGS's focus on green innovation ecosystems supports low-carbon technologies, while sectoral policies highlight demands for technologies using battery. Particularly:

- Decision 876/QĐ-TTg (2022) targets net-zero emissions in transport by 2050, with milestones like 100% electric buses by 2025 and taxis by 2030. This creates downstream demand for batteries.
- PDP VIII's mandate for 10% BESS capacity in new renewable projects and targets 10,000–16,300 MW by 2030, creating a guaranteed market for LIBs.

However, Vietnam's framework lacks the depth of global leaders. Particularly:

- **Fiscal incentives:** Unlike China's production-linked incentives or the US's tax credits, Vietnam offers no specific subsidies for battery manufacturing. Vietnam's fiscal incentives, such as the Investment Law (2020)'s tax exemptions and Decree No. 26/2023/ND-CP's 0% import tax on EV components (HS 98.49) until 2027, reduce production costs for firms like VinFast. However, these policies primarily facilitate imports rather than local production, as lithium batteries are excluded from the MOF's list of domestically manufactured products. This exclusion reinforces Vietnam's 80% import dependency for lithium and cathodes. Globally, China's €20 billion subsidies and Japan's USD 2.4 billion R&D investments (NEDO, 2024) have scaled production and innovation, reducing costs by 15–20%. Vietnam's lack of targeted battery subsidies or production-linked incentives (e.g., USD 10/kWh, as in India's PLI scheme) deters investment in gigafactories, midstream processing (e.g., nickel sulfate production), and local cell manufacturing.
- **Raw material supply chain and upstream challenges:** Vietnam's upstream policies, such as the Law on Geology and Minerals (2024) and Decision No. 866/QD-TTg (2021), aim to leverage domestic reserves (e.g., 409,000 tons of nickel metal equivalent targeted for exploration). Export taxes under Decree No. 26/2023/ND-CP (30% on raw nickel ores, 0–5% on processed products) encourage local processing, but only 15% of extracted nickel is processed into sulfate due to limited refining capacity (Moitruong.net.vn, 2025). High export taxes on intermediates (e.g., 10% on nickel matte) further constrain firms like Ban Phuc, increasing costs. In contrast, Australia's Critical Minerals Strategy (2023) supports 47% of global lithium production by incentivizing refining, stabilizing nickel sulfate costs at USD 10,000/ton (2024). Vietnam's limitations to incentivize midstream infrastructure induce import reliance, constraining its supply chain resilience.
- **R&D and innovation gaps:** Vietnam's R&D support, such as Decision No. 1710/QD-TTg (2024)'s 150% tax deduction for R&D expenses, is a step forward but insufficient. The country invests less than 0.5% of GDP in battery R&D, compared to South Korea's 4.8% (World Bank, 2024). The Vietnam Academy of Science and Technology (VAST) produces only <1 kg/month of NMC cathodes at lab scale (MoST, 2025), far from commercial viability. Globally, Japan's NEDO initiative and South Korea's KAIST partnerships have advanced ASSBs and sodium-ion technologies, reducing costs by 20% (METI, 2024).

Vietnam's lack of dedicated battery innovation parks and minimal funding hampers competitiveness, particularly in next-generation technologies like solid-state batteries (SSBs).

- **Sustainability and recycling constraints:** Vietnam's sustainability policies, under the Law on Environmental Protection (2006) and Decree 15/2021/ND-CP, mandate extended producer responsibility (EPR) for battery waste. However, with only 10% of batteries recycled (MOIT, 2024), Vietnam lags behind global leaders like Japan (95% recovery target) and the EU (70% lithium recovery by 2030). The absence of mandatory recycling standards and infrastructure risks regulatory backlash as global ESG norms tighten. China's 70% recycling mandate and Japan's second-life battery programs have reduced raw material costs by 15% (MIIT, 2024), an opportunity Vietnam misses due to policy gaps.

Vietnam's policies have attracted some FDI, such as ProLogium's 300 billion VND solid-state battery project (MoST, 2025). However, inadequate incentives have driven others away—Intel's USD 3.3 billion shift to Poland and LG Chem's move to Indonesia reflect Vietnam's uncompetitive 15% CIT rate versus Indonesia's 0% EV tax (MPI, 2025). The lack of a national battery roadmap, targeted subsidies, and clear investment guidelines deters large-scale investments in gigafactories and recycling plants. In contrast, Indonesia's USD 21 billion FDI in battery supply chains (World Bank, 2024) stems from clear policy signals and incentives, positioning it as a regional leader.

6.2. Strategic partnerships

6.2.1. Opportunities for Free Trade Agreements (FTAs) and Regional Partnerships

Vietnam's integration into global trade networks over the past three decades has positioned it as a key player in strategic industries like battery manufacturing. Since joining the ASEAN Free Trade Area in 1995, Vietnam has signed FTAs with over 50 countries, creating a robust framework for export market access, investment attraction, and international cooperation. These agreements provide significant opportunities to strengthen Vietnam's battery supply chain by facilitating trade, technology transfer, and regional collaboration.

Key FTAs and Their Impact on the Battery Supply Chain

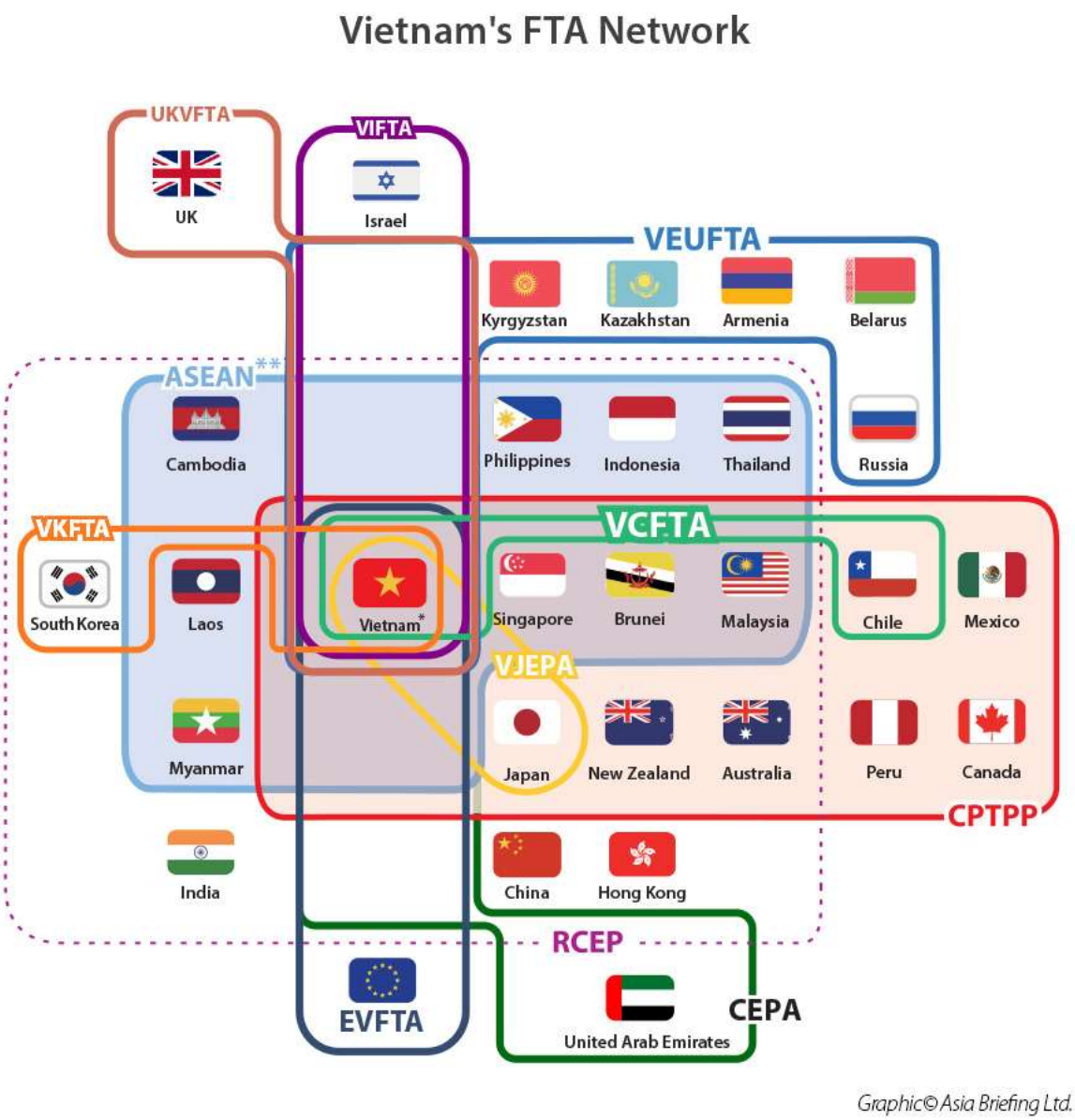
- **European Union–Vietnam Free Trade Agreement (EVFTA)**: The EVFTA eliminates tariffs on 99% of Vietnam's exports to the EU, providing access to a high-demand market for EV batteries and BESS, driven by the EU's carbon reduction targets (e.g., 55% emissions cut by 2030). Vietnamese manufacturers must comply with EU standards, such as the EU Battery Regulation (2023), which mandates carbon footprint tracking and recycling targets (e.g., 70% lithium recovery by 2030). This drives improvements in production quality, positioning firms like VinFast as reliable suppliers. For example, VinFast's LFP batteries (via its partnership with Gotion High-Tech) meet EU ESG requirements, enhancing export potential.

- **Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP)**: The CPTPP, covering economies like Canada, Japan, and Australia, promotes R&D cooperation, technology transfer, and infrastructure investment. Vietnam can leverage this to enhance battery production capacity. For instance, partnerships with Japanese firms like Marubeni (facilitated by CPTPP) enable access to solid-state battery technologies, crucial for next-generation EVs. The CPTPP also supports regional supply chain integration, allowing Vietnam to source raw materials (e.g., lithium from Australia) at reduced tariffs.
- **Regional Comprehensive Economic Partnership (RCEP)**: As the world's largest FTA, RCEP includes 15 Asia-Pacific countries (e.g., China, Japan, South Korea), creating opportunities for collaboration with leading battery manufacturers like CATL and LG Chem. RCEP facilitates access to advanced materials (e.g., nickel from Indonesia) and technologies (e.g., South Korea's cathode expertise), while boosting trade within the region. For example, Vietnam can export battery components to China at lower tariffs, strengthening its role in the Asia-Pacific battery ecosystem.

Regional Partnerships within ASEAN

- **Vietnam-Thailand Collaboration**: Thailand is a promising partner, with Thai firms like Energy Absolute (EA) showing interest in Vietnam's market. EA, a major lithium-ion battery producer (1 GWh/year capacity), proposed integrating BESS into renewable energy projects in Vietnam (Wattanakuljarus & Saithong, 2025). This aligns with the ASEAN Clean Energy Action Plan, where both countries committed to advancing energy storage technologies. A potential joint venture could see EA establishing a 2 GWh/year battery production facility in Vietnam by 2027, bringing technology and capital to support Vietnam's renewable energy goals.
- **Indonesia Partnership for Nickel Supply**: Indonesia, with 24% of global nickel production, is a critical partner for Vietnam's upstream needs. A long-term supply agreement, similar to BMW's lithium sourcing deal with Ganfeng, could secure 50,000 tons/year of nickel for Vietnam's battery industry, reducing reliance on volatile global markets (e.g., nickel prices at USD 17,000/ton in 2024).

Figure 6-1: Vietnam's Free Trade Agreements



Other notable FTAs include the Vietnam-Korea Free Trade Agreement (VKFTA), the Vietnam–Japan Economic Partnership Agreement (VJEPA), and the Vietnam–Eurasian Economic Union Free Trade Agreement (VN-EAEU FTA). These agreements further expand export markets, promote investment cooperation, and enhance Vietnam's competitiveness in strategic industries like battery manufacturing. Collectively, these FTAs create a favorable environment for Vietnam to develop its battery supply chain by leveraging international resources, expertise, and market access.

6.2.2. Nation-level partnerships

The nation-level partnerships play a critical role in Vietnam's economic and industrial development, particularly in strategic sectors like trade and investment, and can have indications for the battery supply chain. Vietnam has signed in many trade agreements and developed an extensive network of international relationships, categorized into **Comprehensive Strategic**

Partnerships, Strategic Partnerships, and Comprehensive Partnerships. As of 2024, Vietnam has established Comprehensive Strategic Partnerships, 11 Strategic Partnerships, and 12 Comprehensive Partnerships. Within ASEAN, Vietnam has established high-level diplomatic relations with all 9 other member countries. Cambodia and Laos hold a "Special Relationship" with Vietnam. All these partnerships can enhance regional collaboration in battery production and supply chain integration, leveraging regional resources and market access to strengthen Vietnam's position in the global battery industry. Many partnerships have a clear focus on supporting the supply chain. Particularly, the comprehensive strategic partnership with US highlights US effort to diversify and secure critical mineral supply chains and Vietnam efforts to leverage its potential in the area.

Table 6-1. Vietnam's comprehensive, strategic, and comprehensive strategic partnerships

Partnership Type	Countries
Comprehensive Partnership (12)	Argentina (2010), Brazil (2007), Brunei (2019), Canada (2017), Chile (2007), Denmark (2011), Netherlands (2010), Hungary (2018), Myanmar (2017), South Africa (2004), Ukraine (2011), Venezuela (2007)
Strategic Partnership (11)	United Kingdom (2010), Australia (2018), India (2007), Germany (2011), Indonesia (2013), Malaysia (2015), New Zealand (2020), France (2013), Philippines (2015), Spain (2009), Thailand (2013)
Comprehensive Strategic Partnership (7)	China (2008), Russia (2012), India (2016), South Korea (2022), United States (2023), Japan (2023), Australia (2024)

6.2.3. Private sector's partnerships

Private sector partnerships are crucial for addressing technology gaps, securing raw materials, and promoting sustainability in Vietnam's battery supply chain. VinFast has been a trailblazer in Vietnam's battery industry, forging strategic partnerships with international firms to address critical gaps in the domestic supply chain. These collaborations span a wide range of activities, from research and development to production and sustainability, and include the following key partnerships:

- **Gotion High-Tech (China)**: VinFast signed a Memorandum of Understanding (MOU) with Gotion High-Tech to collaborate on the research, development, and production of lithium iron phosphate (LFP) batteries. LFP batteries are known for their cost-effectiveness, safety, and long cycle life, making them ideal for EVs and energy storage applications. This partnership leverages Gotion's expertise to produce batteries that meet VinFast's EV requirements, with the joint venture expected to produce 30 million LFP battery cells per year, significantly boosting Vietnam's domestic production capacity (VinES, 2023).
- **ProLogium (Taiwan)**: Through an MOU, VinFast and ProLogium are working together to secure a supply of next-generation solid-state batteries, which offer several advantages over traditional lithium-ion batteries, including higher energy density, improved safety, and faster charging times. This partnership supports VinFast's global expansion of smart mobility solutions, positioning the company to compete in premium EV markets where

solid-state batteries are expected to play a key role. ProLogium's project in Vietnam, supported by 300 billion VND from the National Technology Innovation Fund, underscores the strategic importance of this collaboration (Ministry of Science and Technology, 2025). Solid-state batteries could give VinFast a competitive edge, enabling it to offer EVs with longer ranges and enhanced safety features.

- **Contemporary Amperex Technology Company (CATL, China)**: VinFast and CATL signed an MOU to expand their collaboration in areas such as cell-to-pack (CTP) battery technology and skateboard chassis design. CTP technology eliminates the need for individual battery modules by integrating cells directly into the pack, reducing the number of components, lowering costs, and improving energy efficiency. Skateboard chassis designs, which integrate the battery pack into the vehicle's floor, enable faster EV development and provide greater flexibility in vehicle design. This partnership strengthens VinFast's ability to produce innovative EVs tailored to global markets, ensuring that its vehicles remain competitive in terms of cost, performance, and design.
- **Marubeni Corporation (Japan)**: VinFast and Marubeni signed an MOU to explore opportunities in the secondary use of EV batteries and establish a circular economy model. Under this agreement, the two companies will collaborate on researching and manufacturing BESS using recycled EV batteries. VinFast will supply used EV batteries, while Marubeni will conduct feasibility assessments, provide technical consulting, and deploy BESS systems. The partnership also aims to promote business opportunities in the field of recycled EV batteries, contributing to sustainability by reducing waste and maximizing resource efficiency. By repurposing batteries for energy storage applications, this initiative supports Vietnam's energy transition goals while addressing the challenge of battery waste management.
- **EcoGraf (Australia)**: VinFast and EcoGraf are conducting a feasibility study to localize the production of battery anode material (BAM) in Vietnam. Anode materials, such as graphite, are critical components of lithium-ion batteries, accounting for a significant portion of the battery's cost and performance. Localizing their production can reduce Vietnam's reliance on imports while creating a more integrated supply chain. This partnership leverages Vietnam's domestic graphite resources, which have the potential to be mined at 50,000 tons per year (VJST, 2023). If successful, this initiative could position Vietnam as a regional supplier of anode materials, further strengthening its role in the global battery supply chain.

These partnerships are crucial to address key challenges in Vietnam's battery supply chain, including technology gaps, raw material access, and environmental sustainability. As Vietnam continues to develop the local battery supply chain, collaboration with global leaders, coming not only from VinFast but other private sectors and also SOEs, not only enhances its own capabilities but also lays the groundwork for a broader domestic battery ecosystem that can support both local demand and export opportunities.

6.2.4. Assessment and optimization strategies

Despite the opportunities presented by FTAs, regional partnerships, and national partnerships, Vietnam faces several challenges in developing its battery supply chain:

- **Investment Attraction**: Vietnam's limited capacity to offer competitive investment incentives has driven some major corporations to invest elsewhere. For example, Intel proposed a USD 3.3 billion investment but moved the project to Poland after Vietnam failed to meet its request for 15% cash support. Similarly, LG Chem chose to invest in Indonesia due to unmet demands for 30% investment cost support. Other companies like AT&S and Samsung Electronics have redirected investments to Malaysia and India, citing similar issues. The adoption of the OECD's global minimum corporate income tax rate of 15% further increases the tax burden on companies operating in Vietnam, reducing the country's attractiveness compared to regional peers (Ministry of Planning and Investment, 2025). This underscores the need for Vietnam to enhance its incentive framework to compete with other countries vying for battery industry investments.

- **Renewable Energy Constraints**: The renewable energy sector, which drives demand for BESS, faces significant hurdles that indirectly impact the battery supply chain. Thai investors have highlighted several issues (Hong Van, 2025). First, there is uncertainty in tariff policies, with delays in issuing new electricity pricing frameworks for renewable energy projects creating financial uncertainty. Second, prolonged PPA procedures, due to a lack of clear guidelines and standardized templates, delay project implementation and increase legal risks. Finally, curtailment risks—where renewable power plants are forced to reduce output due to grid limitations—diminish the efficiency of installed BESS systems, which are designed to optimize power output. These challenges reduce the financial viability of renewable energy projects, making BESS investments less attractive and limiting the growth of the domestic battery supply chain.

- **Global Competition**: The global battery market remains heavily dominated by China, particularly in raw materials and manufacturing, posing significant geopolitical and economic risks. China controls 60% of the global cathode market and a substantial portion of critical raw materials like lithium and cobalt (IEA, 2024). Indonesia, with 24% of global nickel production, has attracted USD 21 billion in FDI for its battery industry, partly due to its 0% tax incentive for EV manufacturing (World Bank, 2024; ASEAN Briefing, 2023). Thailand also competes by offering attractive incentives, creating a highly competitive regional landscape. Vietnam, despite having an operational gigafactory through VinFast, is at a disadvantage in upstream and midstream operations compared to these major players, necessitating strategic efforts to carve out a niche in the global market.

- **Domestic Challenges**: Several internal issues further complicate Vietnam's ambitions. The high purchase price of EVs remains a significant barrier to widespread adoption, despite government incentives to reduce costs. For example, the upfront cost of an EV often exceeds Vietnam's GDP per capita of $4,000, making them unaffordable for many consumers. The development of EV charging infrastructure is also insufficient, particularly in rural areas, affecting the practicality and convenience of EV ownership.

Vietnam's EV industry relies heavily on imported components, increasing production costs and reducing competitiveness compared to traditional internal combustion engine vehicles. Domestic production of key battery materials like lithium and graphite is underdeveloped, necessitating imports and highlighting the need for investment in domestic processing and metallurgical facilities. Additionally, there is a shortage of high-skilled technical personnel in the battery and renewable energy technology sectors, with less than 10% of engineers meeting advanced battery technology requirements (Institute of Materials Science, 2024). Finally, R&D investment in new battery technologies, such as solid-state and lithium-sulfur batteries, is limited, requiring significant capital and collaboration with international research organizations to drive innovation.

- **Geopolitical and Market Risks**: Global shifts in battery manufacturing, driven by policies like the U.S. Inflation Reduction Act and the EU Critical Raw Materials Act, may limit Vietnam's ability to expand its role in the global supply chain. These policies incentivize localized production in the U.S. and EU, potentially diverting investment away from Vietnam. Lithium prices have increased by 40% since 2023 due to U.S.-China tensions, and Vietnam's dependence on Chinese technology adds further risk (IEA, 2024). The rapid demand for EVs and the complex battery value chain also make Vietnam vulnerable to supply volatility and technological changes, which could slow the transition from fossil fuel vehicles to environmentally friendly alternatives.
- **Environmental Pressure**: Environmental sustainability is a growing concern, with only 10% of discarded batteries in Vietnam currently recycled correctly (MOIT, 2024). The lack of a robust recycling infrastructure increases the environmental footprint of the battery industry and poses a risk of regulatory backlash as global standards for sustainability tighten.

Addressing these challenges will require close coordination between the government, businesses, and research institutions, as well as support from international partners. Vietnam must enhance its investment incentives, improve renewable energy policies, and invest in domestic capabilities to overcome these hurdles and strengthen its position in the global battery supply chain.

6.3. Optimization Strategies and Ecosystem Development

To achieve its ambition of becoming a regional battery production and innovation hub by 2030, Vietnam must strategically develop a resilient and integrated battery supply chain ecosystem. This includes building capacity across the entire value chain—from raw material extraction and processing to battery manufacturing, recycling, and export. Equally important are optimization strategies that address structural bottlenecks and cross-cutting enablers that ensure long-term competitiveness.

These recommendations draw lessons from global leaders: China's vertically integrated model, South Korea's innovation-focused approach, the European Union's circular economy mandates, and the United States's incentive-based industrial policy. By leveraging its resource endowments, geographic position, and policy reforms, Vietnam can localize global best practices and align with international sustainability and energy transition goals.

6.3.1. Ecosystem components

This section outlines the essential building blocks of a competitive battery supply chain—from upstream mineral extraction to midstream materials, manufacturing, recycling, and enabling infrastructure. Each component must be developed in parallel to ensure system-wide resilience and global competitiveness.

- **Raw Material Extraction and Processing:** Vietnam holds significant upstream potential, including 3.7 million tons of nickel reserves in Son La and untapped graphite deposits in Yen Bai and Tuyen Quang. However, limited domestic processing capacity currently hampers self-sufficiency. Following Australia's 2023 Critical Minerals Strategy, Vietnam should invest in hydrometallurgy plants to process nickel into battery-grade sulfate and launch national geological surveys to unlock additional mineral potential. These steps would reduce dependence on imported raw materials and position Vietnam as a regional supplier.
- **Active Material Production (Cathodes and Anodes):** Vietnam's midstream sector remains nascent, producing less than 1 kg/month of NMC (Nickel Manganese Cobalt) cathodes at lab scale. South Korea's alignment with U.S. IRA sourcing rules helped boost cathode exports by 37% in 2024 (MOTIE). Vietnam should adopt a similar approach by offering targeted tax holidays and R&D grants to attract global firms like CATL and facilitate technology transfer. This will support the production of cathodes, anodes, and electrolyte components essential for downstream battery assembly.
- **Battery Assembly and Manufacturing:** With a limited number of operational gigafactories, Vietnam must scale its manufacturing base. China's 200+ gigafactories currently account for over 60% of global cathode output (MIIT, 2024), offering a reference point. Vietnam should aim to establish large-scale gigafactories in industrial zones with access to ports such as Hai Phong and Ba Ria-Vung Tau. Incentives modeled on India's USD 10/kWh Production Linked Incentive scheme can catalyze growth and generate an estimated 10,000 jobs by 2030.
- **Recycling and Circular Economy:** Vietnam's battery recycling rate currently stands at 8–12%, well below Japan's 95% target (METI, 2024). The EU's 70% lithium recovery mandate (2023) provides a replicable framework. Vietnam should develop hydro-metallurgy recycling facilities and explore second-life applications for batteries, particularly in BESS. Policy mandates and capacity-building programs can drive progress in this domain.
- **Infrastructure Support:** Dedicated battery industrial zones with a minimum of 500 MW power capacity, incorporating at least 60% renewable energy by 2030, will be essential. Indonesia's Sulawesi zones attracted USD 21 billion in FDI (World Bank, 2024) and offer a regional benchmark. Proximity to key seaports such as Hai Phong will enhance export efficiency for EV and BESS components.

6.3.2. Optimization Strategies

To strengthen the battery supply chain, Vietnam must implement strategic measures that enhance efficiency, security, and cost-effectiveness. These include vertical integration, stockpiling, diversified sourcing, and digital transformation—each designed to reduce risks and improve long-term performance.

- **Vertical Integration Across the Value Chain:** Integrating mining, processing, manufacturing, and recycling activities will reduce costs and import dependency. For instance, scaling VinFast-Marubeni's battery recycling initiative and establishing a joint production line with Gotion for LFP batteries can bring cost savings and supply chain resilience. Mining and refining domestic nickel sulfate and graphite will further reduce import reliance.
- **Strategic Stockpiling for Supply Security:** Price volatility poses a major threat to supply chain stability. Since 2023, lithium prices have surged over 40%. China's strategic reserves provide a useful model. Vietnam should explore creating a strategic stockpile of critical minerals to safeguard domestic production against market shocks. Specific volumes and costs should be determined through further feasibility studies.
- **Supply Chain Diversification:** To reduce over-reliance on any single supplier, Vietnam must diversify its sources. The EU's Critical Raw Materials Act aims to reduce China dependency by 30% (EU, 2024). Vietnam should consider sourcing key inputs from countries like Indonesia and Australia. Joining or initiating an ASEAN Critical Raw Materials Partnership can support regional cooperation and enhance supply security.
- **Digitalization and Smart Monitoring:** Digital tools such as AI and IoT can improve efficiency and resilience. China's digital supply chain monitoring systems have cut energy use by 10% in advanced battery plants (MIIT, 2024). Vietnam can follow South Korea's lead, where companies like LG Chem employ AI for predictive maintenance and quality assurance, resulting in operational savings.

6.3.3. Cross-Cutting Enablers

This section identifies policy, financial, institutional, and workforce enablers that are essential for sustaining long-term growth and positioning Vietnam as a regional battery leader.

- **Policy and Regulatory Framework:** Establishing a comprehensive National Battery Roadmap is fundamental to guiding investment, coordinating inter-ministerial actions, and signaling long-term policy stability to market participants. Vietnam should design a supportive regulatory environment modeled on successful international practices, such as the U.S. Inflation Reduction Act and China's EUR 20 billion subsidy initiative. Key measures include introducing performance-based production incentives and removing import tariffs on equipment and components used for research and development.
- **Strategic Partnerships:** Developing strong international partnerships is essential for accessing advanced technologies, securing raw material supplies, and penetrating global markets. Vietnam should prioritize joint ventures and technology transfer agreements with leading global battery producers such as LG Chem, CATL, Tesla, and Gotion. Leveraging free trade agreements, particularly the Regional Comprehensive Economic Partnership and the EU–Vietnam Free Trade Agreement, can enhance Vietnam's attractiveness as a strategic manufacturing base. Collaboration with Gotion, for example, could accelerate the introduction of next-generation solid-state battery technologies. In parallel, Vietnam should champion the formation of an ASEAN Battery Alliance, modeled on the EU Battery Alliance, to enhance regional cooperation in areas such as R&D, standardization, and supply security.

- **Small and Medium Enterprise (SME) Support:** SMEs play a pivotal role in fostering supply chain resilience, innovation, and job creation, contributing significantly to Vietnam's GDP. A dedicated SME Innovation Fund, with a proposed capital base of USD 500 million, should be established to provide targeted R&D grants and seed financing for firms developing components such as battery casings, thermal management systems, separators, and smart sensors. Complementary support measures could include tax exemptions, easier access to credit, and vocational training tailored to battery-related manufacturing. Partnerships with organizations like the VCCI and institutions such as KAIST can help design and implement these support programs. Strategically located industrial clusters, such as those in Dong Nai and Ba Ria–Vung Tau, can serve as incubators for SME-led innovation.
- **Human Capital Development:** Building a skilled workforce is essential to meet the technical demands of a fast-growing battery industry. Vietnam must invest in workforce development by establishing specialized training centers in partnership with local universities and international institutions such as KAIST. Annual training targets should focus on engineers and technicians with expertise in battery chemistry, recycling technologies, power electronics, and digital supply chain management. Curricula should be aligned with evolving industry requirements and include modules on safety standards, lifecycle management, and environmental compliance. These efforts will help expand domestic capabilities, reduce reliance on foreign expertise, and enable broader participation of local firms in high-value segments of the battery supply chain.
- **Environmental Sustainability:** Vietnam's battery industry must be developed in line with its national green growth strategy and global climate commitments. Policy mandates should require that at least half of the electricity used in battery production be sourced from renewable energy by 2030. Adopting carbon footprint monitoring systems, such as the EU's "battery passport" initiative, can help companies track and report emissions across the value chain, enabling compliance with international ESG standards. Simultaneously, enhancing the recovery rates of critical minerals like lithium, nickel, and cobalt through advanced recycling methods will reduce the environmental impact of raw material extraction. Recycling not only lowers the carbon intensity of battery production but also improves economic resilience by decreasing reliance on imported materials.

7. Conclusion

Vietnam's aspiration to become a leading regional hub for battery production and innovation by 2030 presents both a timely opportunity and a multifaceted challenge. Realizing this vision will require a resilient, scalable, and competitive supply chain ecosystem, underpinned by long-term policy coherence, strategic investment, and cross-sectoral collaboration. This report has outlined recommendations, building on Vietnam's comparative advantages—such as substantial nickel reserves, geographic proximity to regional markets, and a strong network of free trade agreements—while addressing structural gaps related to import dependence, limited recycling infrastructure, and skills shortages.

Key Findings and Strategic Directions

This study calls for an integrated approach across the battery value chain. In the upstream segment, Vietnam can strengthen its autonomy by harnessing domestic mineral reserves and investing in extraction and processing capacity. At the midstream level, scaling the production of critical materials such as cathodes and anodes—through targeted incentives and strategic technology partnerships—will provide the backbone for domestic gigafactory development. Downstream, the establishment of large-scale LFP battery manufacturing and energy storage facilities, combined with robust charging infrastructure, will support EV adoption and energy transition goals. Enhancing recycling capacity and enabling second-life battery applications will not only reduce costs but also align Vietnam with emerging global circular economy standards.

Optimization strategies will be critical to enhancing supply chain resilience. Vertical integration, digitalization, and regional diversification of sourcing and production can help mitigate price volatility and global market disruptions. The development of digital infrastructure, including the deployment of Internet of Things (IoT) and artificial intelligence (AI) tools, will improve operational efficiency, traceability, and compliance with international standards such as the EU's battery passport framework. At the same time, targeted investment in human capital is essential. Expanding vocational and technical training programs focused on battery technologies will equip the workforce with the skills required for a high-value, innovation-driven industry.

Strategic partnerships and support for SMEs are equally important enablers. Deepening collaborations with global battery leaders—supported by Vietnam's participation in regional and bilateral trade agreements—can facilitate technology transfer, access to capital, and entry into global supply chains. Strengthening domestic supply chain linkages through SME support programs, innovation funds, and industrial clustering strategies will foster inclusivity, reduce external dependency, and spur localized innovation.

Paths forward

Realizing Vietnam's battery ambition requires decisive, coordinated action across government agencies, industry stakeholders, research institutions, and international partners. Key early actions include launching a National Battery Roadmap to provide long-term policy certainty,

establishing dedicated battery industrial zones powered by renewable energy, and initiating capacity-building programs for SMEs and technical personnel.

In the medium term, efforts should focus on expanding domestic production capacity, forming resilient raw material partnerships, and improving recycling infrastructure. Over the long term, success will depend on sustained innovation—particularly in next-generation battery technologies such as solid-state and sodium-ion cells—alongside Vietnam's continued alignment with international ESG requirements and market standards.

Although challenges remain, including workforce development, infrastructure financing, and global competition, Vietnam's strategic positioning, resource base, and policy momentum offer a strong foundation for leadership in the global battery value chain. With timely and targeted implementation of this roadmap, Vietnam stands to not only meet its domestic energy and mobility needs, but also emerge as a key exporter in the global battery market. In doing so, the country will contribute meaningfully to its climate and industrialization goals, as well as global efforts to advance the Sustainable Development Goals, particularly SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation, and Infrastructure).

Future research and policy development should continue to evaluate the long-term socio-economic and environmental impacts of battery industry growth, while ensuring that strategies remain adaptive to evolving technologies, market dynamics, and international regulations.

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