Value-added analysis of the electric vehicle battery industry in Indonesia

I Suherman*, S Rochani, and D Cahyaningtyas
Research and Development Center for Mineral and Coal Technology, Jl. Jenderal Sudirman No 623. Bandung, Indonesia 40211

*Corresponding author’s e-mail : ijiang.suherman@esdm.go.id

Abstract. The establishment of the Indonesian Battery Corporation is a step forward to make Indonesia a global player in the electric vehicle battery industry. This state-owned consortium is mandated to develop an integrated electric vehicle battery industry ecosystem from upstream to downstream. Indonesia has around six companies developing High-Pressure Acid Leach processing and refining projects. Battery production for Indonesian electric vehicles is estimated to contribute approximately 12.7% to the global market by 2035. A value-added analysis approach model is estimated to increase Gross Domestic Product by $21,434 billion. In addition, the impact on job creation is around 42,603 people. This estimation can be implemented with some supports, such as partners with proven technology and significant capital to build the precursor and cathode industries, battery cell and battery industries, and the electric vehicle industry and policies related to development.

1. Introduction
The law of Republic Indonesia, number 3 of 2020, regulates mineral and coal mining policies, among others the policy of increasing value-added. Increased mineral value-added is obtained through mineral processing with consideration of increasing economic value and market needs. This increase should not only stop at processing and/or refining but continue to the chain of an intermediate industry to a downstream industry [1–3]. Downstream industry policies can maximize profits for companies, communities, and governments. This encourages Indonesia to play a role in producing electric vehicle batteries on a global scale. In addition, government policy to develop environmentally-friendly transportation technology need to be implemented [4,5]. This commitment is also supported by the availability of domestic battery raw materials, such as nickel, cobalt, manganese, and copper. The market is well-defined apart from domestic and export, especially the ASEAN market. The challenge faced is the high investment cost of electric vehicles, especially in producing electric vehicle batteries [6]. The price of electric vehicle battery products is a determinant of competition [7–9]. The government should encourage research and development of technology and the economy of electric vehicle batteries [10–14].

The research will calculate the value-added estimates from the mining chain, processing/refining chain, precursor, and cathode industrial chain, to the cell and battery industrial chain. Furthermore, it will calculate the estimated benefits or impact of contributions to the increase in Gross Domestic Product (GDP), state revenues, and employment [15–17]. Therefore, the purpose of this analysis is to estimate the value-added supply chain of the electric vehicle battery industry and its impact on the national economy. As a novelty of this study, the method used in this research is a modification and
simplification of the previous method developed by Suherman [1]. This study is developing a method to calculate value-added for limited data.

2. Materials and methods

2.1. Materials

The materials of this study are data form of six High-Pressure Acid Leach (HPAL) development projects provided by the Directorate of Mineral and Coal, Ministry of Energy and Mineral Resources, and PT Halmahera Persada Lygent.

To date, there are only about six development projects for nickel processing and refining using HPAL technology in Indonesia, as shown in Table 1. The status of the six HPAL development projects includes three projects at the construction stage (two of which are in the Indonesia Morowali Industrial Park area in Morowali, Central Sulawesi. Another one is in Obi Island, South Halmahera. The three other projects are in the feasibility study stage, namely Weda Bay (Central Halmahera) and East Halmahera, North Maluku, and Pomalaa, Southeast Sulawesi. Soon PT Halmahera Persada Lygent is the company that is the readiest to produce nickel and cobalt mixture.

Table 1. HPAL development project in Indonesia.

| No | Company                        | Location     | Ni (Kt) | Co (Kt) | Capex (SB) | Year       | Product       | Technology Process |
|----|--------------------------------|--------------|---------|---------|------------|------------|---------------|-------------------|
| 1  | PT Halmahera Persada Lygend [18]| Obi Island   | 37      | 4.4     | 1,061      | 2021       | MHP/ NiSO4    | HPAL              |
| 2  | PT QMB New Energy [19]         | Morowali     | 50      | 4       | 998        | 2022       | MHP           | HPAL              |
| 3  | Huayue Nickel & Cobalt [19]    | Morowali     | 30      | 3       | 1,280      | 2022       | MHP           | HPAL              |
|    |                                |              | 30      | 3       | 2023       |            |               |                   |
| 4  | Vale/SMM [19]                  | Pomalaa      | 40      | 4       | 2,000      | 2024+      | MSP           | HPAL              |
| 5  | Huayou/Tsingshan [18]          | Weda Bay     | 50      | 5       | 1,000      | 2025+      | MHP           | HPAL              |
| 6  | BUMN                           | Haltim/Konut | 50      | 5       | 985        | 2024+      | MHP           | HPAL              |
|    |                                |              | 305     | 30.6    | 7,324      |            |               |                   |

2.2. Methods

Value-added from processing and/or refining can be defined as the difference between the product value and the cost value of raw materials and other inputs, excluding labor. In other words, the value-added of processing and/or refining can be obtained by adding up all the components of the value-added variable, namely labor costs, taxes, royalties, interest income, foreign exchange differences, regional assistance funds, and company profits. In line with this understanding, an alternative model for calculating the value-added approach for the supply chain of the electric vehicle battery industry is to add up the fixed compensation value and labor costs before interest, taxes, and amortization (EBITDA) (Equation 1). This methodological approach, due to existing and limited data.

\[ \text{Value added} = \text{Labor cost} + \text{EBITDA} \]  

(1)

3. Results and discussions

3.1. The supply chain of the electric vehicle battery industry

In the value-added analysis of the electric vehicle battery industry, it is necessary to know the supply chain. The supply chain consists of the upstream chain consisting of ore mining and processing processes, then the refining chain, the intermediate industrial chain consisting of the precursor and cathode manufacturing processes, and the downstream chain consisting of the manufacturing process of battery cells and battery units, and the end-user chain consisting of Electric Vehicles (EV) and Energy Storage Systems (ESS) [19,20]. Figure 1 shows the electric vehicle battery supply chain.
3.2. Value-added analysis of the electric vehicle battery industry

Simulation of the value-added calculation of the electric vehicle battery industry from upstream to downstream is conducted based on the existing HPAL project. In addition, the most popular type of cathode to be developed is Li-NMC. Li-NCM can save energy, cost, and moderate safety. Its cathode composition consists of 11% lithium, 72% nickel, 9% cobalt, and 8% manganese. With this type of cathode, it can optimize existing local resources in addition to its competitive economic value compared to the type of Li-NCA, LFP, LMO cathodes.

Several assumptions or parameters are needed to simulate the value-added of the electric vehicle battery industry project, as shown in Table 2. However, before analyzing the value-added, it is necessary to analyze the production development of each supply chain of electric vehicle battery raw materials.

Table 2. Assumptions/parameters for value-added calculation.

| Parameter                | Mining | HPAL | Cathode | Battery Pack |
|--------------------------|--------|------|---------|--------------|
| Production Development   | adjust | 80% of capacity [21] | adjust | adjust |
| Composition              | Limonite : Saprolite = 91.57% : 8.43% [18] | Ni sulfate = 4.491/t Ni Co Sulfate = 4.848 t Co [18] | Li : N : C : M = 11% : 72% : 9% : 8% [19] | 750 t Ni equivalent 1 GWh [21] |
| Price                    | Limonite: $ 12/t Co | NiSO₄ = 4,500t | CoSO₄ = 13,000t [21] | $ 22,500 - 24,147 t [21] | $ 113 -240/KWh |
| EBITDA                   | 40% [21] | 37% [21] | 12% [21] | 14% [21] |
| Labor Cost               | 13.14% | 6.54% [1] | 6.54% | 6.54% |
| Value Added              | 53.14% | 43.54% | 18.54% | 20.54% |

Table 3. The development of production volume according to the supply chain of electric vehicle battery raw materials in Indonesia.

| Year | Ore (million tons) | Ni Sulphate (thousand tons) | Co Sulphate (thousand tons) | Cathode (thousand tons) | Battery (GWh) |
|------|--------------------|-----------------------------|-----------------------------|-------------------------|---------------|
|      | Domestic | Export | Total | Domestic | Export | Total | Domestic | Export | Total | Domestic | Export | Total | Domestic | Export | Total | Domestic | Export | Total |
| 2021 | 1,018    | -      | 1,018 | -        | 33      | 33    | 4      | 4        | -      | -      |
| 2022 | 4,237    | -      | 4,237 | -        | 138     | 138   | 15     | 15       | -      | -      |
| 2023 | 11,282   | -      | 11,282| -        | 368     | 368   | 42     | 42       | -      | -      |
| 2024 | 18,986   | -      | 18,986| -        | 620     | 620   | 63     | 63       | 46     | -      |
| 2025 | 24,489   | -      | 24,489| 33       | 766     | 799   | 83     | 87       | 65     | -      |
| 2026 | 30,818   | -      | 30,818| 47       | 959     | 1,006 | 5      | 104      | 99     | 93     |
| 2027 | 33,569   | -      | 33,569| 67       | 1,029   | 1,096 | 7      | 111      | 119    | 132    |
| 2028 | 33,569   | -      | 33,569| 95       | 1,001   | 1,096 | 10     | 108      | 119    | 187    |
| 2029 | 33,569   | -      | 33,569| 135      | 961     | 1,096 | 15     | 104      | 119    | 265    |
| 2030 | 33,569   | -      | 33,569| 191      | 905     | 1,096 | 21     | 98       | 119    | 376    |
| 2031 | 33,569   | -      | 33,569| 271      | 825     | 1,096 | 29     | 89       | 119    | 533    |
| 2032 | 33,569   | -      | 33,569| 384      | 712     | 1,096 | 42     | 77       | 119    | 756    |
| 2033 | 33,569   | -      | 33,569| 545      | 551     | 1,096 | 59     | 60       | 119    | 1,073  |
| 2034 | 33,569   | -      | 33,569| 773      | 323     | 1,096 | 84     | 35       | 119    | 1,522  |
| 2035 | 33,569   | -      | 33,569| 1,096    | 1,096   | 1,096 | 119    | 1,522    | 1,522  | 26     | 299    | 325    |

Figure 1. The supply chain of electric vehicle battery raw materials.

The development of production volume according to the supply chain of electric vehicle battery raw materials in Indonesia.
Conferring these assumptions, the development of production according to the supply chain for battery raw materials for electric vehicles in Indonesia can be estimated, as shown in Table 3. This production development was split for domestic needs and export. HPAL production, namely Ni Sulfate and Co Sulfate, can be exported after domestic markets are met. Figure 2 shows the developments of electric vehicle battery production for domestic and export. It is estimated that the domestic supply is 26 GWh and export is 299 GWh in 2035. Meanwhile, Figure 3 shows the projected development of the battery industry production in Indonesia and the world until 2035. It is estimated that Indonesia contributes up to 12.7% to the world.

![Figure 2. Projection of electric battery supply for domestic and export.](image)

![Figure 3. Projection development of electric battery production in Indonesia and the world.](image)

The projection of production value according to the supply chain of the electric vehicle battery industry in Indonesia is shown in Table 4.
Table 4. The development of production value according to the electric battery supply chain in Indonesia ($ billion).

|          | 2025   | 2030   | 2035   |
|----------|--------|--------|--------|
| Nickel ore | 0.329  | 0.451  | 0.451  |
| HPAL Ni Sulfate | 3.597  | 4.931  | 4.931  |
| Co Sulfate  | 1.127  | 1.543  | 1.543  |
| Cathode    | 1.527  | 8.768  | 35.496 |
| Battery    | 1.741  | 10.000 | 57.421 |
| Total      | 8.322  | 25.693 | 99.843 |

If the electric vehicle battery industry project is implemented, it is estimated that the value-added created is as follows. By 2025 the value-added of the mining chain is $0.175 billion, the HPAL processing and refining chain is $2.057 billion, the cathode industrial chain is $0.283 billion, and the battery industry chain is $0.358 billion. The total value added of the electric vehicle battery supply chain is estimated to reach $2.873 billion by 2025. This condition will continue to increase until 2035, as shown in Figure 4, namely for mining $0.240 billion, processing and refining HPAL $2.819 billion, the cathode industry $6.581 billion, and the electric battery industry $11.798 billion, or a total of $21.434 billion. Table 5 shows the increase in value-added from mining to the battery, which is 49 times.

Table 5. Value-added by electric vehicle battery supply chain in Indonesia ($ billion).

|          | 2025   | 2030   | 2035   | multiples (x) |
|----------|--------|--------|--------|---------------|
| Nickel Ore | 0.175  | 0.240  | 0.240  | 1              |
| HPAL      | 2.057  | 2.819  | 2.819  | 12             |
| Cathode   | 0.283  | 1.626  | 6.581  | 27             |
| Battery   | 0.358  | 2.054  | 11.784 | 49             |
| Total     | 2.873  | 6.738  | 21.434 |               |

Figure 4. The development of value-added raw materials for electric vehicle batteries in Indonesia.
3.3. Analysis of the impact of the electric vehicle battery industry project on the economy

The establishment of the electric vehicle battery industry chain in Indonesia will have an impact on the economy. These impacts include investment absorption, employment, potential state revenues, and the impact on increasing Gross Domestic Product (GDP). The construction of 6 HPAL industries will absorb a total investment of around $7,424, while the investment value for other industrial chains is not yet known. Labor absorption is estimated at 18,761 people in 2025, then increases to 28,932 people in 2030 and 42,603 people in 2035, as shown in Table 6. The potential state revenue is estimated at $0.213 billion in 2025, increasing to $0.501 billion in 2030 and $1.600 billion in 2035. The impact on GDP is equal to the value-added created, namely for 2025, 2030, and 2035 respectively, $2.873 billion, $6.738 billion, and $21.434 billion, as shown in Figure 5.

Table 6. The labor by electric vehicle battery supply chain in Indonesia (person).

|                   | 2025   | 2030   | 2035   |
|-------------------|--------|--------|--------|
| Nickel Ore        | 9,173  | 12,575 | 12,575 |
| HPAL              | 8,851  | 12,132 | 12,132 |
| Cathode           | 654    | 3,756  | 15,203 |
| Battery           | 82     | 470    | 2,697  |
| Total             | 18,761 | 28,932 | 42,603 |

Figure 5. The impact of the battery industry project for electric vehicles the national economy.

4. Conclusions

The government's commitment to establishing an integrated electric vehicle battery factory, from the upstream industry to the downstream industry, in the country is a step forward. Indonesia has the opportunity to become a producer of electric vehicle batteries on a global scale, considering the availability of raw materials and prospects for domestic and world markets. Indonesia has a strong position for critical raw materials in the upstream chain. Estimated value added assuming that the production of 325 GWh of electric batteries will create US$21,434 in 2035. The potential absorption of the domestic market is around 26 GWh, while the export market is about 299 GWh. This value-added can potentially increase GDP, and another impact is the increase of value-added can create jobs
for 42,603 workers. Based on this result, partners with proven technology and significant capital are needed to build the precursor and cathode industries, battery cell and battery industries, and the electric vehicle industry. In line with this, policies related to development need to be prepared.

This research needs to be followed up with more complete and representative data and other analytical models. Future research could add variables to improve the models, such as variable labor costs, taxes, royalty, income from interest, local assistance funds/Corporate Social Responsibility, and corporate profits.

References

[1] Suherman I and Saleh R 2018 Supply chain analysis for Indonesian nickel Indones. Min. J. 21 59–76
[2] Coffin D and Horowitz J 2018 The supply chain for electric vehicle batteries the supply chain for electric vehicle batteries J. Int. Commer. Econ.
[3] Haryadi H and Yunianto B 2017 Analysis on terms of trade of Indonesia’s nickel Indones. Min. J. 19 51–64
[4] Ahmad A, Khan Z A, Saad Alam M and Khateeb S 2018 A review of the electric vehicle charging techniques, standards, progression and evolution of ev technologies in Germany J. Smart Sci. 6 36–53
[5] Blatt D N 2018 Law and policy on the development and promotion of the new energy vehicle (NEV) market in China J. Asian Electr. Veh. 16 1781–8
[6] Tulus Pangapoi Sidabutar V 2020 Kajian pengembangan kendaraan listrik di Indonesia: prospek dan hambatannya J. Paradig. Ekon. 15 21–38
[7] Horowitz J, Coffin D and Taylor B 2021 Supply chain for EV batteries: 2020 trade and value-added update
[8] Abas A E P, Yong J, Mahlia T M I and Hannan M A 2019 Techno-economic analysis and environmental impact of electric vehicle IEEE Access 7 98565–78
[9] Berckmans G, Messagie M, Smekens J, Omar N and Vanhaverbeke L 2017 Cost projection of state of the art lithium-ion batteries for electric vehicles up to 2030 Energies 10 1314
[10] Prasetiyo P 2017 Tidak sederhana mewujudkan industri pengolahan nikel laterit kadar rendah di Indonesia sehubungan dengan Undang-Undang Minerba 2009 J. Teknol. Miner. dan Batubara 12 195–207
[11] Sutopo W, Nizam M, Purwanto A, Atikah N and Putri A S 2016 A cost estimation application for determining feasibility assessment of Li - Ion battery in mini plant scale Int. J. Electr. Eng. Informatics 8 189–99
[12] Khan M R, Nielsen M P and Kær S K 2014 Feasibility study and techno-economic optimization model for battery thermal management system Proc. 55th Conf. Simul. Model. (SIMS 55), Model. Simul. Optim. 16–27
[13] D’Souza R, Patsavellas J and Salonitis K 2020 Automated assembly of Li-ion vehicle batteries: A feasibility study Procedia CIRP 93 131–6
[14] Das A, Li D, Williams D and Greenwood D 2018 Joining technologies for automotive battery systems manufacturing World Electr. Veh. J. 9 22
[15] Suherman I and Saleh R 2018 Analisis rantai nilai besi baja di Indonesia J. Teknol. Miner. dan Batubara 14 233–52
[16] Yunianto B 2015 Implementation of value added minerals policy in Indonesia Proceedings of tekMIRA Colloquium 2015 pp 149–59
[17] Yunianto B 2014 Analisis dampak kebijakan nilai tambah mineral Indonesia terhadap ekspor dan ketenagakerjaan J. Teknol. Miner. dan Batubara 10 127–41
[18] PT Halmahera Persada Lygend 2020 Pemanfaatan nikel kadar rendah dan status perkembangan pabrik HPAL di Pulau Obi untuk peningkatan nilai tambah dalam menunjang industri strategis nasional (Exposure material at the electric battery supply chain discussion group forum in Indonesia on October 20, 2020)
[19] Direktorat Jenderal Mineral dan Batubara 2020 *Pengembangan Program hilirisasi dengan teknologi HPAL* (Exposure material on the future webinar of Indonesia's nickel downstream on October 13, 2020)

[20] Kementerian Energi dan Sumber Daya 2020 *Perkembangan hilirisasi nikel Indonesia* (Exposure material on the future webinar of Indonesia's nickel downstream on October 13, 2020)

[21] MIND ID 2020 *Rencana pengembangan ekosistem industri baterai KBL terintegrasi BUMN* (Exposure material at forum group discussion supply chain baterai listrik di Indonesia pada 20 Oktober 2020)