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October 20, 2023

For attention: Deputy Secretary Wally Adeyemo

Department of the Treasury
1500 Pennsylvania Avenue, NW
Washington, D.C 20220

SUBJECT: How Section 45X of the Advanced Manufacturing Production Credit Could be Instrumental in Onshoring US Nickel Sulphate and Battery Precursor Production for US Batteries

Dear Secretary, Adeyemo,

Thank you again, sincerely, for inviting Talon Metals (USA) LLC to the cocktail reception on June 8, 2023.

By way of follow-up, please allow me to submit the below study and accompanying presentation to demonstrate how Section 45X would be instrumental in establishing US nickel sulphate and/or precursor production from US nickel ore/concentrates and recycled materials, by leveraging smelting and refining infrastructure of US Free Trade Agreement (FTA) partner countries and other US allies. Together with FTA partner countries, and other allies, the US could produce between 10 and 16 million nickel-based batteries per year, thereby reducing or eliminating dependence on China controlled Indonesian nickel.

Global Nickel Production Trends: Sources of Ore and Intermediate Products

Nickel is mined from either nickel sulphide ore or nickel laterite ore.

Nickel production from nickel sulphides has reduced from 60%[1] in 2009 to 20%[2] in 2022 due to a lack of new high-grade nickel sulphide discoveries. The Tamarack Intrusive Complex (TIC) in Minnesota (discovered in 2008) and the Eagle and Eagle/East Mines in Michigan (discovered in

[1] Extractive Metallurgy of Nickel, Cobalt and Platinum Group Metals, 2011, Page 2.
[2] Investment Horizon Outlook Q4, 2022, Page 5, Wood Mackenzie, March 2023.

2012/2016) are 2 out of only 5 discoveries made in the 21st century that are on infrastructure and able to achieve economies of scale.

The remaining 80% of global nickel production is from nickel laterites, *primarily* mined and refined in Indonesia by China owned (or co-owned) facilities.

The *Extractive Metallurgy of Nickel, Cobalt and Platinum Group* handbook comprises 37 chapters describing permutations of producing nickel. Below is a summary of the predominant processes.

Nickel Sulphides

High-grade nickel sulphide ore, such as the Tamarack Intrusive Complex (TIC) in Minnesota and the Eagle/Eagle East Mines in Michigan, has the lowest environmental footprint as the ore is upgraded 5x-6x using a simple, cost effective and environmentally friendly flotation process, making it the preferred feedstock for producing nickel. US produced nickel concentrates are shipped to Canada for smelting to produce nickel matte, followed by refining in Norway to produce 99%+ refined nickel. Presently there is no nickel sulphate production in the US. In Australia, BHP uses a hydrometallurgical process to convert refined nickel into nickel sulphates. Nickel sulphates are used to produce precursor which, in turn, are used to produce Cathode Active Materials (CAM) for batteries. Refined nickel (99%+) produced through the nickel sulphide supply chain produces approximately 7.5 tCO2e/t NiEq.[3] Terrafame in Finland produces 1.75 tCO2e/t NiEq[4] in nickel sulphate and Vale (Long Harbor) produces 4.4 tCO2e/tonne of refined nickel.[5]

Producing nickel sulphates from refined nickel to produce precursor is inefficient as 99%+ refined nickel is dissolved in sulphuric acid to produce a 22.3% nickel hexahydrate, which has to be further processed to remove the sulfur dioxide. It also requires crystalizing to nickel sulphates followed by a second crystallization process to produced precursor. We therefore expect future US precursor to be directly produced from refined nickel, instead of producing nickel sulphates first.

Nickel Laterites (Nickel Pig Iron and Nickel Matte)

Nickel laterites (saprolites) cannot be upgraded through flotation, so the ore is dried prior to smelting to produce Nickel Pig Iron (NPI). NPI produces 75-80 tCO2e/t NiEq[6] and contains 12% to 14% nickel in NPI. Until recently, NPI was the preferred feedstock to produce stainless steel (Class 2 nickel). To produce nickel for nickel sulphate production (Class 1 nickel), NPI is smelted to produce nickel matte, using a Rotary Kiln-Electric Furnace (RKEF). NPI RKEF (between 38% and 65% nickel in nickel matte)[7] produces 50 tCO2e/t NiEq,[8] in addition to the 75-80 tonnes of CO2e already produced to produce NPI. PT Vale Indonesia Btk produces a high-grade nickel matte

[3] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022
[4] Terrafame's nickel sulphate production offers the lowest carbon footprint in the industry - altogether 60% lower than in existing conventional processes, Terrafame.com, September 2020.
[5] Vale receives third-party assurance for additional low-carbon nickel products, Vale.com, May 2022.
[6] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022.
[7] Nickel Sulphate Cost Study, Roskill, Page 21, June 2018.
[8] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022.

(no NPI) which reduces CO2 to 27tCO2e/t NiEq.[9] Nickel sulphates are produced from RKEF nickel matte using a similar (or the same) process as nickel sulphides.

Nickel Laterites (MHP)

Nickel laterites (limonites) cannot be upgraded through flotation and are therefore refined using High Pressure Acid Leaching (HPAL) to produce a Mixed Hydroxide Product (MHP). The MHP is then converted into nickel sulphates using either ammonia or acid leaching and solvent extraction. MHP produces approximately 18 tCO2e/t NiEq.[10] MHP contains between 37.7% and 49%[11] nickel, and therefore its CO2 footprint (compared to nickel sulphates originating from nickel sulphide ore) is higher than 18 tCO2e/t NiEq.

Recycling

By 2030 approximately 2.5% of global nickel production will be from scrap increasing to 10% by 2040.[12] This document outlines why Section 45X is the key to establishing responsibly mined nickel production in the United States from 2027 through to 2050, when the majority of nickel will have to be mined and processed (through to nickel sulphate or directly to precursor) to support government EV adoption targets.

Electric Vehicle (EV) Battery Cathode Active Material (CAM) Trends

In Internal Combustion Engine (ICE) terms, there are 4-cylinder vehicles (analogy = LFP) and 8-cylinder vehicles (analogy = nickel). Tesla predicts two battery chemistries will dominate by 2050:[13]

- Nickel (Nickel Manganese Cobalt (NMC)): **24% by volume**;
- Lithium Iron Phosphate (LFP): **76% by volume**.

According to Tesla,[14] an additional 2.85mt of nickel production per year is required by 2050, assuming 24% of all EVs use nickel batteries. This forecast would require doubling of 2022 global nickel production.

The International Energy Association (IEA) corroborates the Tesla forecast calling for 2022 global nickel production of 2.8mt to increase to 6.1mt under the Net Zero Emissions (NZE) scenario.[15]

The table below shows the Nickel Demand Forecast (IEA) for each of 2030, 2040 and 2050.

Nickel Demand Forecast (Ktpa)	2030	2040	2050
Stated Policies Scenario (SPC)	3,900	4,800	4,800
Announced Pledges Scenario (APS)	4,500	6,100	6,500

[9] Annual Report 2022, PT Vale Indonesia Tbk, Page 284
[10] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022.
[11] Nickel Sulphate Cost Study, Roskill, Page 21, June 2018.
[12] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 23, Wood Mackenzie, August 2022.
[13] Tesla Master Plan Part 3, Sustainable Energy for All of Earth, Table 7, Page 22, April 5, 2023.
[14] Tesla Master Plan Part 3, Sustainable Energy for All of Earth, Table 7, Page 28, April 5, 2023.
[15] https://www.iea.org/data-and-statistics/data-tools/critical-minerals-data-explorer.

Net Zero Emissions Scenario (NZE)	5,800	6,500	6,100

Based on Tesla's forecast, if LFP batteries were not available, 76% of the global fleet would be without batteries if 2022 nickel production doubled by 2050.

LFP is therefore not replacing nickel batteries for EVs: LFP is fit for purpose (160 Wh/kg (LFP) compared to 250Wh/kg (NMC Cylindrical)).[16]

The History and Future of Nickel in Indonesia: Expected Outcome

Indonesian NPI and Nickel Matte

China's dominance in the nickel market traces back to stainless steel. China's growth economy required a significant increase in stainless steel production, starting in the 1990s. In fact, until recently, nickel has been primarily used in stainless steel: In 2018, only149.5kt[17] of nickel out of 2.1mt[18] of global nickel production (7.2%) was directed to the production of nickel sulphates for batteries.

China's demand for nickel in stainless steel drove nickel prices to $55,000/tonne of refined nickel[19] in 2008.

In response, China rapidly increased Direct Shipping Ore (DSO) production of saprolite ore in Indonesia, requiring wholesale deforestation and the shipping of enormous quantities of ore for NPI production in China, primary using blast and electric arc furnaces. As stated above, NPI (12% to 14% nickel in NPI) produces 75-80 tCO2e/t of NiEq.[20]

Indonesia banned the export of DSO in 2014, and this led China's Foreign Direct Investment (FDI) into Indonesia as a percentage of total FDI to increase from approximately 10% (2009-2012) to 62% (2013-2016) to 70%+ (2017-2019) between 2017 and 2019,[21] with China investing over $20 billion in Indonesia from 2013-2019, predominantly to establish NPI and Ferro-Nickel (FeNi) nickel production. Nickel in NPI production (Indonesia) is expected to increase from 200ktpa to 1mtpa between 2018 and 2024[22].

Despite all of these developments, however, NPI (Class 2 nickel) is not suitable for producing nickel sulphates used in precursor for batteries, and an additional step (RKEF) is used to convert

[16] Trends in Automotive Battery Cell Design: A Statistical Analysis of Empirical Data, Christoph Neef, Tim Wicke, Page 9, 2023.
[17] Nickel Sulphate Cost Study, Roskill, Page 13, June 2018.
[18] USGS, 2018 Minerals Yearbook, Nickel, Table 10.
[19] Intratec Service, Nickel Prices.
[20] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022.
[21] How Indonesia Used Chinese Industrial Investments to Turn Nickel into the New Gold, Angela Tritto, April 11, 2023.
[22] Nickel Market Outlook, Macquarie, April 2020, Page 25.

NPI to nickel matte (with a 75-80 tCO2e/t[23] of NiEq footprint), which further increases the CO2 footprint by approximately 50 tonnes of CO2e/t of NiEq.[24]

Cost to Produce Indonesian NPI and/or Nickel Matte

The cost structure of the China-owned Indonesian nickel supply chain is opaque; however, we believe Nickel Industries, Merdeka Battery Materials and PT Vale Indonesia Btk, are good proxies for understanding the different supply chain cost structures. For the year ending 2022:

- Nickel Industries,[25] an Indonesian NPI producer, produced NPI (13.76% nickel in NPI) at a "cost of revenue" of $13,247/tonne. Nickel Industries also produced high-grade nickel matte at a cost of $15,563/tonne. The % nickel in nickel matte was not specified.
- Merdeka Battery Materials[26] (also an Indonesian NPI producer), produced NPI (13.4% nickel in NPI) at a cash cost of $13,775/tonne.
- PT Vale Indonesia Tbk[27] produced nickel matte (78% nickel in matte) at $14,410/tonne. Note that PT Vale Indonesia TbK does not produce NPI. Eighty percent of nickel matte is sold to Vale Canada Limited (VCL) at 78% of the LME price[28] and 20% to Sumitomo Mining Metals Company (SMM). VLC uses Indonesian nickel matte as a feedstock for Vale owned refineries outside of Indonesia.

The cost to produce Indonesian NPI and nickel matte is summarized in the table below (as per each company's 2022 Annual Report):

Indonesian Company	Product	Ni%	Cost	Profit % (1)	Profit % (2)
Nickel Industries	NPI	13.76%	13,247	24.08%	29.61%
Merdeka Battery Materials	NPI	13.40%	13,775	9.76%	12.99%
PT Vale Indonesia Tbk	Nickel Matte	78%	14,410	26.58%	40.51%

Notes to the above table:

(1): Profit % with depreciation *(2): Profit % without depreciation*

PT Vale Indonesia Tbk nickel matte is refined by Vale outside of Indonesia to 99%+ refined nickel at approximately $2,373 /tonne[29] nickel in refined nickel.

PT Vale Indonesia Tbk nickel matte has a CO2 footprint of 27 tCO2e/t[30] of NiEq because Vale owns and operates three hydro power plants. The CO2 footprint would be 65 tCO2e/t[31] of NiEq if hydro power was replaced by coal.

[23] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022.
[24] Global net zero carbon by 2050 and warming limited to 1.5ºC, Page 26, Wood Mackenzie, August 2022.
[25] Annual Report 2022, Nickel Industries and its Subsidiaries, Pages 3-7.
[26] Annual Report 2022, Merdeka Battery Materials Tbk, Pages 69,70,184.
[27] Annual Report 2022, PT Vale Indonesia Tbk, Page 49.
[28] Annual Report 2022, PT Vale Indonesia Tbk, Page 51.
[29] Estimate based on available information .
[30] Annual Report 2022, PT Vale Indonesia Tbk, Page 284
[31] Annual Report 2022, PT Vale Indonesia Tbk, Pages 285.

As stated above, PT Vale Indonesia Tbk does not produce NPI followed by the production of nickel matte as Vale produces nickel matte (from nickel laterites). (In the case of NPI the CO2 footprint is 75-80 tonnes of CO2e/tonne of NiEq plus 50 tonnes of CO2e/tonne of NiEq to covert NPI to nickel matte).

Indonesian High Pressure Acid Leaching (HPAL): History and Cost

Altogether, 11 Indonesian HPAL plants are to be constructed in Indonesia.[32] HPAL operations in Indonesia are financed and owned (or co-financed and co-owned) by Chinese companies. These facilities primarily consume limonite ore (typically the layer above the saprolite mined for producing NPI and FeNi).

HPAL facilities typically produce Mixed Hydroxide Product (MHP), which is 37.7%-49% nickel in MHP[33] at an estimated cost of $14,587/tonne.[34] Historically, however, HPAL had significant cost overruns,[35] and most were unable to achieve nameplate capacity.

During 2022, MHP sold for approximately 70% of the LME nickel price.[36] The cost of converting MHP to nickel sulphates using sulfuric acid, is estimated to be $1,913/tonne.[37] When LME nickel prices exceeded $30,000/tonne in 2022, nickel sulphate prices went from a premium to LME nickel prices to a discount to LME nickel prices until the LME nickel price reduced to below $30,000/tonne. The next inflection point was at around $26,000/tonne for LME nickel.[38]

China-owned (or co-owned) Indonesian MHP production, which is exported to for example China and South Korea where it is converted to nickel sulphates, thereby bypassing the LME market's high prices and enables China to sell nickel sulphates at a discount to the LME nickel price while still making significant profit.

Nickel sulphate prices have been trending upwards as LME nickel prices are trending downwards, and we therefore expect nickel sulphates to again sell at a slight premium to LME nickel.

Companies who produce nickel sulphates from refined nickel, therefore face great difficulty as they are either unable to compete against nickel sulphates produced from MHP, due to higher feedstock prices (refined nickel versus MHP) or they have to rely on competing Indonesian China owed (or co-owned) facilities to supply them with MHP. In this way, China is able to stifle US nickel sulphate production.

[32] Nickel for the Energy Transition, a Development Perspective, German Federal Ministry for Economic Cooperation and Development, page 31.
[33] Nickel Sulphate Cost Study, Roskill, Page 21, June 2018, Page 21.
[34] Scoping Study, Nickel Laterite Project, Hatch, 2010, Adjusted by PPI with 30% Contingency.
[35] HPAL, Upping the Pressure, Global Mining Research, 2018.
[36] Commodities Comment, Macquarie, March 2023, Page 6.
[37] Nickel Sulphate Cost Study, Roskill, Page 21, June 2018, Pages 4 and 6.
[38] Nickel sulphate and LME metal price convergence after LME debacle, Benchmark.

In 2022, approximately 50% of global nickel production was produced in Indonesia.[39] We expect China to continue to aggressively invest in Indonesian nickel production expansion to ensure security of supply for its own stainless steel and battery industries.

Implementation of Section 45X: The Key to Establishing a US Nickel Supply Chain for Producing Cathode Active Materials (CAM)

The table below summarizes the input cost for three nickel supply chains that are the most likely to serve the US:

(1) US mined nickel ore to US made nickel sulphate with smelting of the nickel concentrate (produced in the US from US mined nickel ore) occurring in Canada to produce a nickel matte that is shipped to Norway for refining to 99%+ nickel[40]. The refined nickel could be shipped to the US, serving as a feedstock for producing US nickel sulphates or most likely precursor for cathode active materials. In the case of Tesla, refined nickel instead of nickel sulphates could be used to manufacture precursor battery materials.[41]

(2) PT Vale Indonesia Btk nickel matte produced from Indonesian mined nickel laterite ore shipped to Vale refining facilities (outside of Indonesia) and processed to produce 99%+ refined nickel, which could be shipped to the US to serve as a feedstock for producing US nickel sulphates or most likely precursor. PT Vale Indonesia Btk **together with Huayou of China** also announced 180,000[42] of future nickel in MHP production in Indonesia.

(3) China owned HPAL producing MHP which is shipped to South Korea to serve as a feedstock for producing nickel sulphates or direct precursor battery materials (in South Korea).[43]

[39] 2022 Annual Report, PT Vale Indonesia Tbk, Page 134.
[40] US Mine, Ore Transport and Processing Cost, including depreciation and contingency as per Talon forecast. Canada smelting and Norway refining costs are estimates based on available information
[41] Tesla Battery Day, Page 53, September 22, 2020.
[42] PT Vale Indonesia Tbk, Briefing Book, 2023, Page 19.

(1) US Ore to US Nickel Sulphate ($/tonne Nickel)		**(2) Indonesia Nickel Matte to Canadian Nickel Sulphate ($/tonne Nickel)**		**(3) Indonesia MHP to South Korean Nickel Sulphate ($/tonne Nickel)**	
Mining, Transportation and Processing of US Ore to US Nickel Concentrate including Depreciation	13,774	Mining, smelting and converting from nickel laterites to nickel matte (PT Vale Indonesia Btk) including Depreciation	14,410	Mining and HPAL including Depreciation	14,587
Transport of US Nickel Concentrate to Canada	521	Transport of Indonesian Nickel Matte to Vale Refinery (Outside of Indonesia)			
Nickel Concentrate Profit	1,739	Nickel Matte Profit	1,926	Indonesian MHP Profit	3,036
Nickel Concentrate Revenue	**16,034**		**16,336**	**Indonesian MHP Revenue**	**17,623**
Production Cost of Nickel Matte from US Nickel Concentrate in Canada	1,435	**Indonesian Nickel Matte Revenue**			
Production Cost of Refined Nickel (99%+) from Nickel Matte in Norway	2,373	Production Cost of Refined Nickel (99%+) from Nickel Matte in Indonesia	2,373		
Smelter and Refiner Profit	1,101	Refiner Profit	2,234		
Feedstock Cost of Refined Nickel with Mined Originating in the US	**20,944**	**Feedstock Cost of Refined Nickel**	**20,944**		
Production Cost of Nickel Sulphates in the US (from US Nickel Concentrate routed through Canada and Norway)	892	Production Cost of Nickel Sulphates in the US (from Indonesian Nickel Matte Refined in Canada)	892	Cost to convert MHP to nickel sulphates using sulfuric acid	1,913
Total Cost	21,836	Total Cost	21,836	Total Cost	19,536
Nickel sulphate profit	822	Nickel sulphate profit	822	Nickel sulphate profit	3,122
Nickel sulphate price (2022)	**22,658**	**Nickel sulphate price (2022)**	**22,658**	**Nickel sulphate price (2022)**	**22,658**
Total cost of the fragmented supply chain	18,996	Total cost of the supply chain	17,675	Total cost of the supply chain	16,500
Total profit of the fragmented supply chain	3,662	Total profit of the supply chain	4,983	Total profit of the supply chain	6,158
Total revenue of the fragmented supply chain	22,658	Total revenue of the supply chain	22,658	Total revenue of the supply chain	22,658

With nickel prices trending downwards since the highs of 2022, and nickel sulphate prices trending upwards, this document uses a:

- Nickel sulphate price of 90% of the average 2022 LME nickel price of $25,175/tonne nickel
- Long-term LME nickel price of $20,943/tonne nickel, resulting in a 8% premium to LME.

The Indonesia MHP to South Korean nickel sulphate supply chain is expected to return approximately double the profit of the US ore to US nickel sulphate supply chain, without Section 45X.

Conclusion

Section 45X is therefore the key to establishing a US nickel ore to US nickel sulphate or precursor supply chain, as illustrated below:

(1) US Ore to US Nickel Sulphate ($/tonne Nickel)	Production Cost	45X Credit
Mining, Transportation and Processing of US Ore to US Nickel Concentrate including Depreciation	13,774	1,377
Transport of US Nickel Concentrate to Canada	521	52
Nickel Concentrate Profit	1,739	0
Nickel Concentrate Revenue	16,034	0
Production Cost of Nickel Matte from US Nickel Concentrate in Canada	1,435	0
Production Cost of Refined Nickel (99%+) from Nickel Matte in Norway	2,373	0
Smelter and Refiner Profit	1,101	0
Feedstock Cost of Refined Nickel with Mined Originating in the US	20,944	2,094
Less 45X Claimed on US Mining, Transportation and Processing of US Ore to US Nickel Concentrate including Depreciation		(1,377)
Less 45X Claimed on Transport of US Nickel Concentrate to Canada		(52)
45X Claimed by Nickel Sulphate Producer on Feedstock Cost		665
Production Cost of Nickel Sulphates in the US (from US Nickel Concentrate routed through Canada and Norway)	892	89
Total 45X	21,836	2,184
Nickel sulphate profit	822	0
Nickel sulphate price (2022)	22,658	2,184

As per the table above, Section 45X is granted on ONLY US production cost, being:

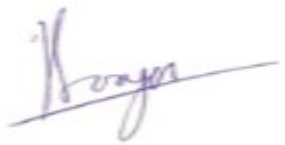
- Mining, Transportation and Processing of US Ore to US Nickel Concentrate including Depreciation.
- Transport of US Nickel Concentrate to Canada;
- Feedstock Cost of Refined Nickel with Mined Originating in the US **less 45X credits claimed upstream;**
- Production Cost of Nickel Sulphates in the US (from US Nickel Concentrate routed through Canada and Norway).

The total credit of $2,184/tonne nickel increases the total US supply chain profit to $5,845/tonne nickel compared to $6,158/tonne in the case of the Indonesia MHP to South Korea nickel sulphate supply chainchain, thereby creating an even playing field and stimulating onshoring of US nickel production for US battery manufacturing from refined nickel.

Together with FTA partner countries, and other allies, the US could produce between 10 and 16 million nickel-based batteries per year, thereby reducing or eliminating dependence on China controlled Indonesian nickel.[44]

We strongly recommend that Section 45X also be applied to producing precursor directly from refined nickel, as it is likely that the nickel sulphate step will be removed to decrease cost and increase efficiencies in the US.

Sincerely,



Henri van Rooyen, CEO
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[44] Talon Metals (USA) LLC Presentation: "How Section 45X of the Advanced Manufacturing Production Credit Could be Instrumental in Onshoring US Nickel Sulphate and Battery Precursor Production for US Batteries", slide 13, October 20, 2023.